

ELECTROMAGNETIC EMISSIONS COMPLIANCE REPORT



Applicant: Qualcomm Technologies, Inc.
5775 Morehouse Drive, San Diego, CA 92121-1714, United States

Manufacturer: Qualcomm Technologies, Inc.
5775 Morehouse Drive, San Diego, CA 92121-1714, United States

Product Name: Tri-Radio LGA Module for IoT applications

Brand Name: Qualcomm

Model No.: QCC744M-0

Report Number: TERF2411003344E2

FCC ID J9C-QCC744M0

Date of EUT Received: Nov. 06, 2024

Date of Test: Nov. 07, 2024 ~ Nov. 29, 2024

Issue Date: Dec. 13, 2024

Approved By

Jay Lin

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 C63.10:2020 and the energy emitted by the sample EUT comply with FCC rule part §15.247.

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

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Revision History

Report Number	Revision	Description	Issue Date	Revised By	Remark
TERF2411003344E2	00	Original	Dec. 09, 2024	Yami Kuo	
TERF2411003344E2	01	Revise address	Dec. 13, 2024	Yami Kuo	*

Note:

- 1、The remark "*" indicates modification of the report upon requests from certification body.

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1 GENERAL INFORMATION

1.1 Product Description

Product Name:	Tri-Radio LGA Module for IoT applications
Brand Name:	Qualcomm
Model No.:	QCC744M-0
HW SKU:	QCC744M-0U, QCC744M-0B, QCC748M-0U, QCC748M-0B
Hardware Version:	N/A
Firmware Version:	N/A
EUT Series No.:	03B221949800GL
Power Supply:	3.3Vdc
Test Software (Name/Version)	QConn RCT 1.8.9

1.2 RF Specification

Radio Technology:	BT BR+EDR
Channel number:	79 channels
Modulation type:	GFSK + $\pi/4$ DQPSK + 8DPSK
Transmit Power:	12.65 dBm
Frequency Range:	2.402GHz – 2.480GHz
Dwell Time:	$\leq 0.4s$

1.3 HW SKU Difference Table:

HW SKU	Antenna Type	Impedance	Chip design
QCC744M-0U	3 types: PIFA, Monopole, Dipole	C21=1.86pF, C20=1.89pF	Does not support USB pinout
QCC744M-0B	1 type: PCB	C21=1.52pF, C20=2.05pF	Does not support USB pinout
QCC748M-0U	3 types: PIFA, Monopole, Dipole	C21=1.86pF, C20=1.89pF	Support USB pinout
QCC748M-0B	1 type: PCB	C21=1.52pF, C20=2.05pF	Support USB pinout

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1.4 Antenna Designation

Antenna Type	Antenna Model No.	Freq. (MHz)	Peak Antenna Gain (dBi)
PCB Antenna	RFIQM0744010NB001	2.4GHz	2.52
PIFA Antenna	RFPCA441010EMABY01		3.19
Dipole Antenna	RFPCA521010EMABY01		3.37
Monopole Antenna	RFPCA501010EMABY01		3.12

Note:

1. Pre-scanned was done on the above antennas, measurements were demonstrated by using the antenna with the highest gain as the worst case scenarios.
2. Antenna information is provided by the applicant.

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1.5 Test Methodology of Applied Standards

FCC Part 15, Subpart C §15.247

FCC KDB 558074 D01 15.247 Meas. Guidance v05r02

ANSI C63.10:2020

1.6 Test Facility

Laboratory	Test Site Address	Test Site Name	FCC Designation number	IC CAB identifier
SGS Taiwan Ltd. Central RF Lab. (TAF code 3702)	No.134, Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan.	SAC 1	TW0027	
		SAC 2		
		SAC 3		
		Conduction 1		
		Conducted 1		
		Conducted 2		
		Conducted 3		
		Conducted 4		
		Conducted 5		
		Conducted 6		
	No.2, Keji 1st Rd., Guishan District, Taoyuan City, Taiwan 333	Conduction C	TW0028	TW3702
		SAC C		
		SAC D		
		SAC G		
		Conducted A		
		Conducted B		
		Conducted C		
		Conducted D		
		Conducted E		
		Conducted F		
		Conducted G		

Note: Test site name is remarked on the equipment list in each section of this report as an indication where measurements occurred in specific test site and address.

1.7 Special Accessories

There is no special accessory used while test was conducted.

1.8 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*6m*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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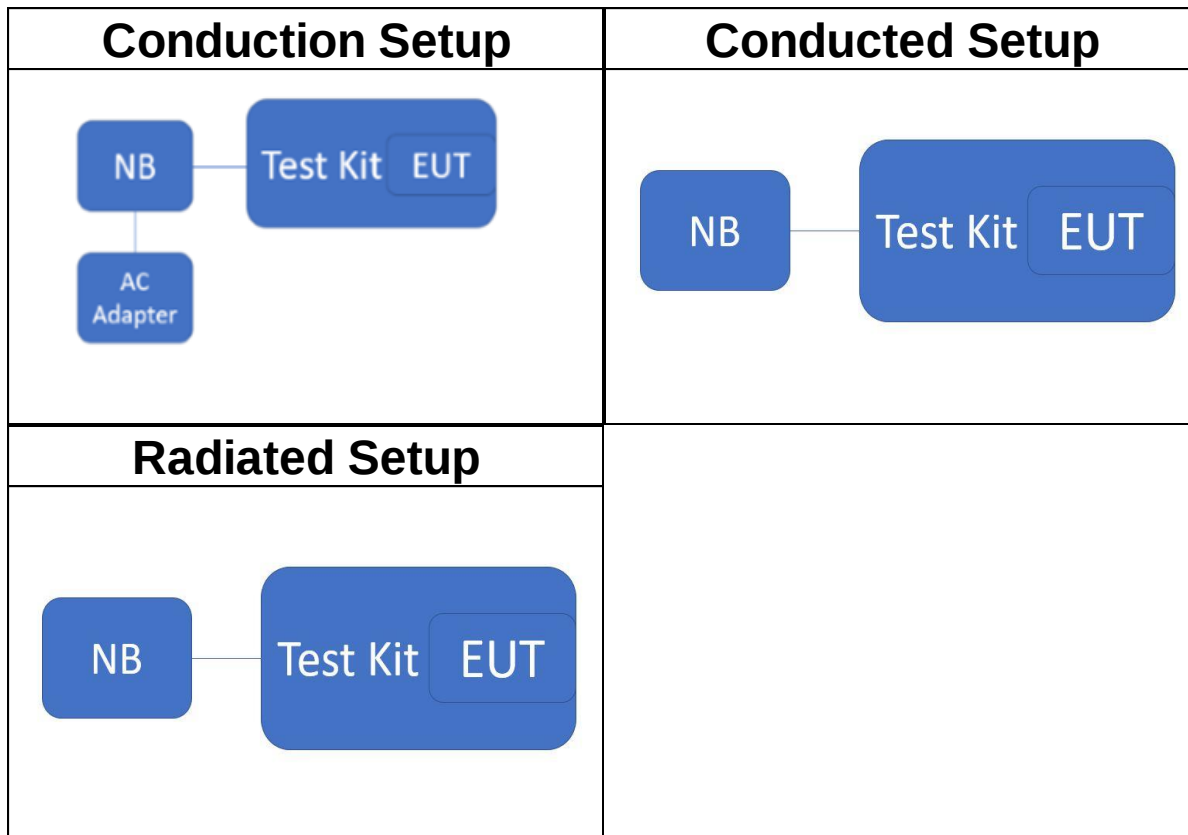
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2.5 Test Configuration



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2.6 Control Unit(s)

AC Power-Line Conducted Emission Test Site: Conduction C					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Notebook	Lenovo	T470	P0001293	N/A	N/A
Adapter	Lenovo	ADLX65YLC3D	N/A	N/A	N/A
QCC74X Module Development Kit Board	Walsin	QCC744-DVK	N/A	N/A	N/A
USB Cable	Fong Hua	USB-C18	128342	N/A	N/A
Conducted Emission Test Site: Conducted C					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL. (mm/dd/yyyy)	CAL DUE. (mm/dd/yyyy)
Notebook	Lenovo	T14	P0003332	N/A	N/A
USB Cable	Mcdodo	CA-6390	N/A	N/A	N/A
QCC74X Module Development Kit Board	Walsin	QCC744-DVK	N/A	N/A	N/A
Radiated Emission Test Site: SAC D					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Notebook	Lenovo	T470	P0001293	N/A	N/A
QCC74X Module Development Kit Board	Walsin	QCC744-DVK	N/A	N/A	N/A
USB Cable	Fong Hua	USB-C18	128342	N/A	N/A

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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)	Emission Bandwidth	Compliant
§15.247(d) §15.209	Conducted Band Edge and Spurious Emission	Compliant
§15.247(d) §15.209	Radiated Spurious Emission	Compliant
§15.205	Restricted Bands	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

2400~2483.5 MHz							
CH	Freq. (MHz)	CH	Freq. (MHz)	CH	Freq. (MHz)	CH	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		

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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 The field strength of radiated emission was measured as the EUT positioned in different orthogonal planes (E1/E2/H) based on actual usage of the EUT to pre-scan the emissions for determining the worst case scenario.
- 4 Investigation has been done on all the possible configurations for searching the worst case.

ANTNNA PORT CONDUCTED TEST				
MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION	PACKET TYPE
Peak Output Power, 20dB Band Width, Spurious Emission				
Bluetooth	0 to 78	0,39,78	GFSK	DH5
	0 to 78	0,39,78	$\pi/4$ -DQPSK	2DH5
	0 to 78	0,39,78	8-DPSK	3DH5
Band Edge				
Bluetooth	0 to 78	0,78	GFSK/8-DPSK	DH5/3DH5
Frequency Separation				
Bluetooth	0 to 78	0,1,2, 38,39,40, 76,77,78	GFSK	DH5
			$\pi/4$ -DQPSK	2DH5
			8-DPSK	3DH5
Number of Hopping Frequency, Hopping Band edge				
Bluetooth	0 to 78	0 to 78	GFSK/8-DPSK	DH5/3DH5
Time of Occupancy(Dwell time)				
Bluetooth	0 to 78	39	GFSK	DH1/DH3/DH5
			$\pi/4$ -DQPSK	2DH1/2DH3/2DH5
			8-DPSK	3DH1/3DH3/3DH5

MODE	AVAILABLE CHANNEL	TESTED CHANNEL	MODULATION	PACKET TYPE
TRANSMIT EMISSION TEST (BELOW 1 GHz)				
Bluetooth	0 to 78	39	8-DPSK	3DH5
TRANSMIT EMISSION TEST (ABOVE 1 GHz)				
Bluetooth	0 to 78	0,39,78	GFSK/8-DPSK	DH5/3DH5

NOTE:

- 1.The field strength of radiation emission was measured as EUT stand-up position (H mode) and lie down position (E1, E2 mode) for channel Low, Mid and High, the worst case position was reported.
- 2.Radiated test was done with 50ohm terminator on antenna port

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5 MEASUREMENT UNCERTAINTY

Test Items	Uncertainty
AC Power Line Conducted Emission	+/- 1.54 dB
Output Power measurement	+/- 0.97 dB
Emission Bandwidth	+/- 1.38 Hz
Conducted emission measurement	+/- 0.77 dB
Frequency Separation	+/- 1.48 Hz
Number of hopping frequency	+/- 1.48 Hz
Time of Occupancy	+/- 1.48 Hz
Temperature	+/- 0.6 °C
Humidity	+/- 3 %
DC / AC Power Source	+/- 1 %

Radiated Spurious Emission Measurement Uncertainty			
Polarization: Vertical	+/-	1.89 dB	9kHz~30MHz
	+/-	4.15 dB	30MHz - 1000MHz
	+/-	3.43 dB	1GHz - 18GHz
	+/-	3.86 dB	18GHz - 40GHz
Polarization: Horizontal	+/-	1.89 dB	9kHz~30MHz
	+/-	4.02 dB	30MHz - 1000MHz
	+/-	3.43 dB	1GHz - 18GHz
	+/-	3.86 dB	18GHz - 40GHz
Radiated Spurious Emission	+/-	2 dB	33GHz-50GHz
	+/-	1.59 dB	50GHz-60GHz
	+/-	1.7 dB	60GHz-90GHz
	+/-	1.64 dB	90GHz-140GHz
	+/-	3.83 dB	140GHz-220GHz

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 MEASUREMENT EQUIPMENT USED

6.1 Emission from AC power line

AC Power-Line Conducted Emission Test Site: Conduction C					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Coaxial Cable	EC Lab	RF-HY-CAB-250	RF-HY-CAB-250-01	03/27/2024	03/26/2025
EMI Test Receiver	R&S	ESCI	101342	04/29/2024	04/28/2025
LISN	SCHWARZBECK Mess-Elektronik	NSLK8127	973	04/22/2024	04/21/2025
Pulse Limiter	EC Lab	VTSD 9561F-N	485	03/27/2024	03/26/2025
TEMPERATURE	N/A	EC-RFHY-05	N/A	05/22/2024	05/21/2025
SMA Termination	RF Microwave WOKEN	WTER-18S2	N/A	N/A	N/A
Test Software	audix	e3	E3 20923 SGS Ver.9 (C)	N.C.R	N.C.R

6.2 Conducted Measurement

Conducted Emission Test Site: Conducted C					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL. (mm/dd/yyyy)	CAL DUE. (mm/dd/yyyy)
Attenuator	Woken	WATT-218FS-10	RF19	11/15/2023	11/14/2024
Attenuator	Woken	WATT-218FS-10	RF19	11/14/2024	11/13/2025
DC Block	PASTERNAK	PE8210	RF155	11/15/2023	11/14/2024
DC Block	PASTERNAK	PE8210	RF155	11/14/2024	11/13/2025
Power Meter	Anritsu	ML2496A	1804002	04/26/2024	04/25/2025
Power Sensor	Anritsu	MA2411B	1726105	04/26/2024	04/25/2025
Power Sensor	Anritsu	MA2411B	1726106	04/26/2024	04/25/2025
Spectrum Analyzer	KEYSIGHT	N9010B	MY59071570	06/25/2024	06/24/2025
Test Software	SGS Taiwan	Radio Test Software	Ver.21	N.C.R	N.C.R

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6.3 Radiated Measurement

Radiated Emission Test Site: SAC D					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
3m Site NSA	SGS	966 chamber D	N/A	04/30/2024	04/29/2025
Active Loop Antenna	COM-POWER	AL-130R	10160105	12/04/2023	12/03/2024
Attenuator	Woken	WATT-218FS-10	RF17	11/14/2024	11/13/2025
Band Rejection Filter	Micro-Tronics	G008	RF205	11/14/2024	11/13/2025
Broadband Antenna	SCHWARZBECK	VULB 9168	9168-617	12/14/2023	12/13/2024
Coaxial Cable	Huber+Suhner	EMC106-SM-SM-7200	150703	11/14/2024	11/13/2025
Coaxial Cable	Huber+Suhner	RG 214/U	W21.01	11/14/2024	11/13/2025
Highpass Filter	R&S	F13 HPF 3GHz	RF175	11/14/2024	11/13/2025
Horn Antenna	Schwarzbeck	BBHA9120D	1341	05/30/2024	05/29/2025
Horn Antenna	Schwarzbeck	BBHA9170	184	12/28/2023	12/27/2024
Lowpass Filter	Woken	EWT-56-0019	RF173	11/14/2024	11/13/2025
Pre-Amplifier	EMC Instruments	EMC12630SE	980273	11/14/2024	11/13/2025
Pre-Amplifier	EMC Instruments	EMC9135	980234	11/14/2024	11/13/2025
Spectrum Analyzer	KEYSIGHT	N9010A	MY57120200	04/03/2024	04/02/2025
SMA Termination	RF Microwave WOKEN	WTER-18S2	N/A	N/A	N/A
Test Software	audix	e3	E3 20923 SGS Ver.9 (C)	N.C.R	N.C.R

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

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7 CONDUCTED EMISSION TEST

7.1 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

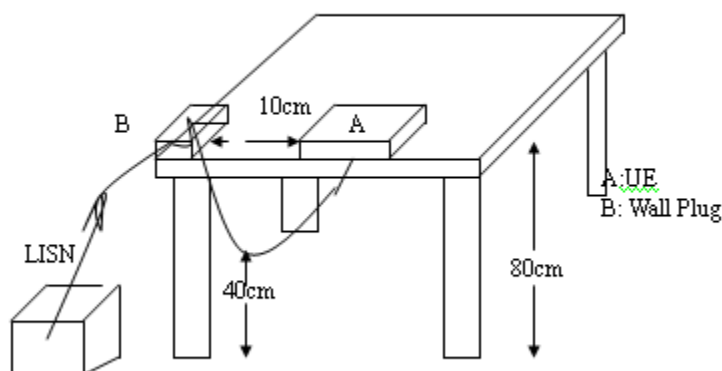
Note

- 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.

7.2 EUT Setup:

1. The conducted emission tests were performed in the test site, using the setup in accordance with the ANSI C63.10:2020.
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.

7.3 Test Setup



7.4 Measurement Procedure

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

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7.5 Measurement Result

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

Note2: The * reveals the worst-case results that closest to the limit.

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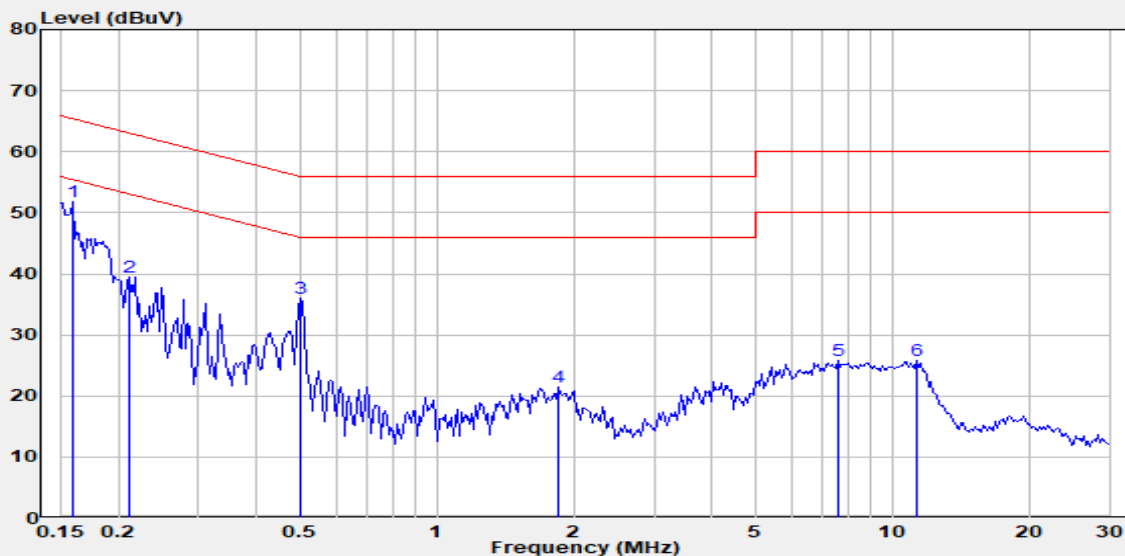
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AC POWER LINE CONDUCTED EMISSION TEST DATA

Report Number	:TERF2411003344E2	Test Site	:Conduction C
Test Mode	:EDR 3M	Test Date	:2024-11-18
Power	:120V/60Hz	Temp./Humi.	:21.5°C/62%
Probe	:L1	Engineer	:Pony Chen



Freq.	Detector	Spectrum	Factor	Actual	Limit	Margin
MHz	Mode	Reading Level		FS		
	PK/QP/AV	dBμV	dB	dBμV	dBμV	dB
0.158	Peak	41.27	10.65	51.92	65.56	-13.64
0.211	Peak	28.91	10.65	39.56	63.18	-23.63
0.502	Peak	25.27	10.62	35.88	56.00	-20.12
1.848	Peak	10.72	10.76	21.48	56.00	-34.52
7.646	Peak	14.82	10.96	25.78	60.00	-34.22
11.317	Peak	14.73	11.00	25.73	60.00	-34.27

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Report Number :TERF2411003344E2

Test Site :Conduction C

Test Mode :EDR 3M

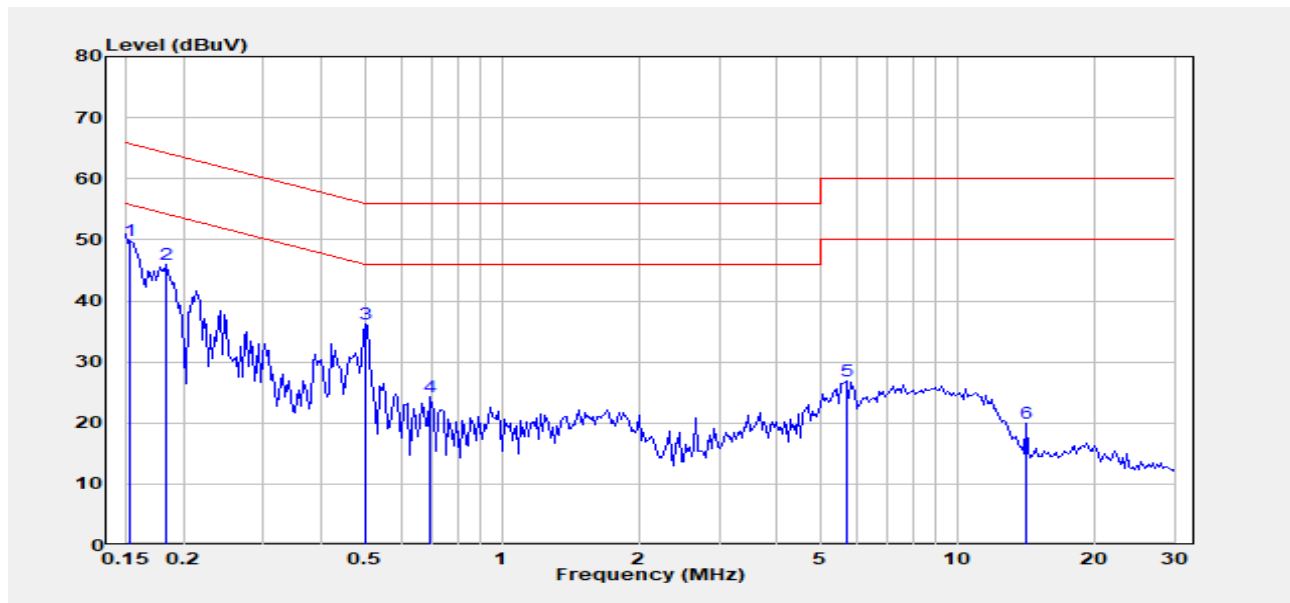
Test Date :2024-11-18

Power :120V/60Hz

Temp./Humi. :21.5°C/62%

Probe :N

Engineer :Pony Chen



Freq.	Detector	Spectrum	Factor	Actual	Limit	Margin
MHz	Mode	Reading Level		FS		
	PK/QP/AV	dB μ V	dB	dB μ V	dB μ V	dB
0.153	Peak	39.20	10.66	49.86	65.82	-15.96
0.183	Peak	35.35	10.65	46.00	64.33	-18.33
0.502	Peak	25.60	10.60	36.20	56.00	-19.80
0.697	Peak	13.61	10.63	24.25	56.00	-31.75
5.744	Peak	15.92	10.94	26.86	60.00	-33.14
14.138	Peak	8.80	11.05	19.86	60.00	-40.14

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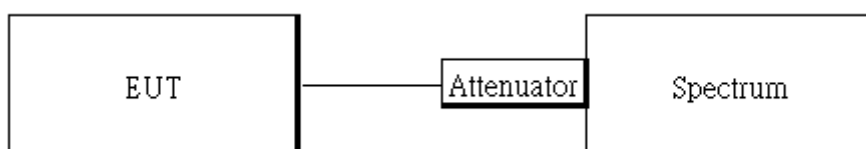
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8 FREQUENCY SEPARATION

8.1 Standard Applicable

Frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

8.2 Test Setup



8.3 Measurement Procedure

1. Place the EUT on the table and set it in transmitting mode.
2. The testing follows ANSI C63.10:2020.
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 RBW approximately 30% of the channel spacing, $VBW \geq RBW$.
6. Adjust Span to Wide enough to capture the peaks of two adjacent channels.
7. Sweep = auto.
8. Max hold. Mark 3 Peaks of hopping channel and record the 3 peaks frequency.

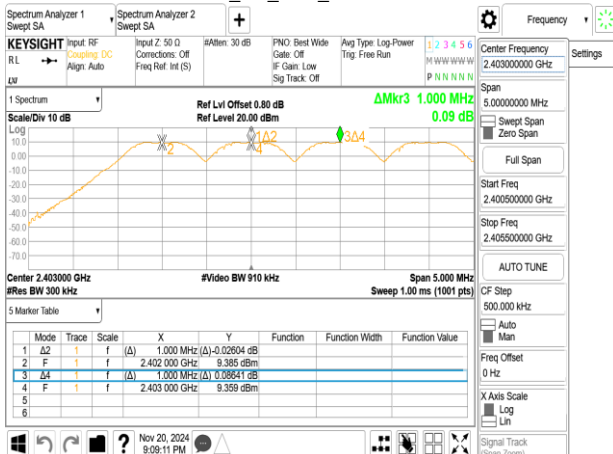
8.4 Measurement Result

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

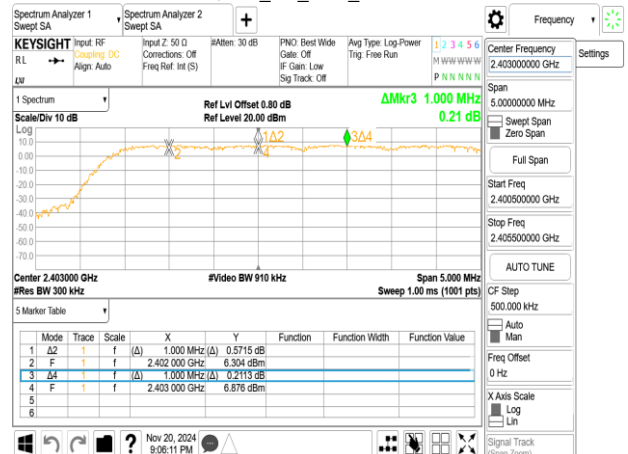
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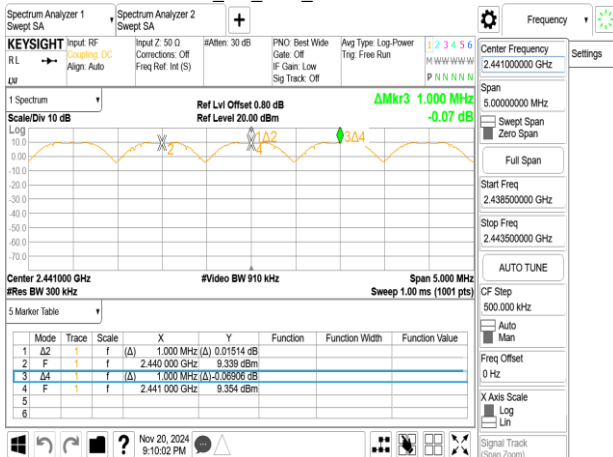
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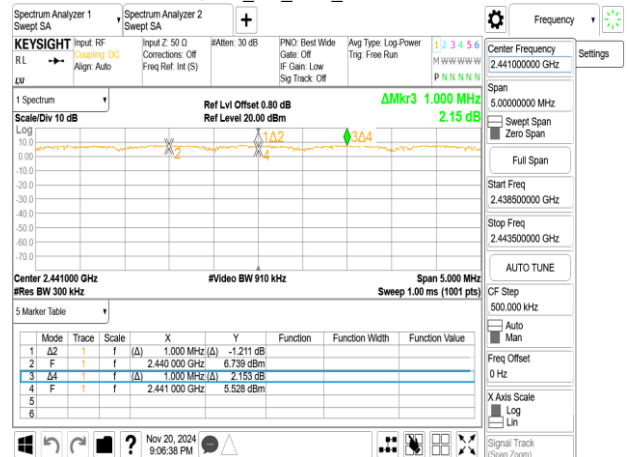
π/4DQPSK_2M_DH5_CH0CH1CH2



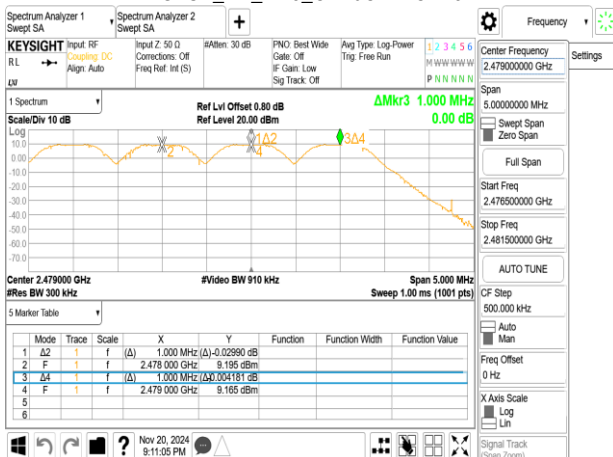
GFSK_1M_DH5_CH38CH39CH40



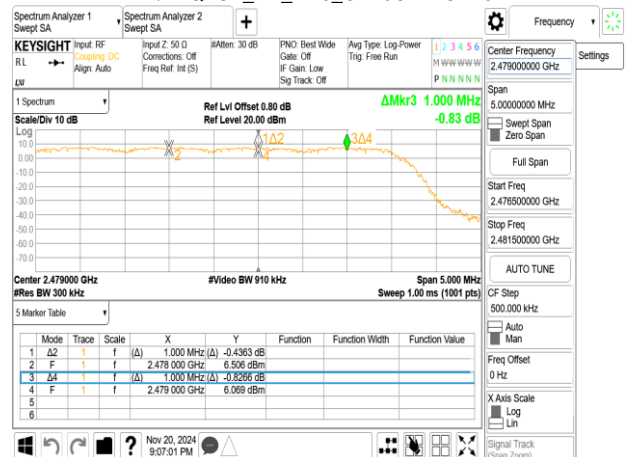
π/4DQPSK_2M_DH5_CH38CH39CH40



GFSK_1M_DH5_CH76CH77CH78



π/4DQPSK_2M_DH5_CH76CH77CH78

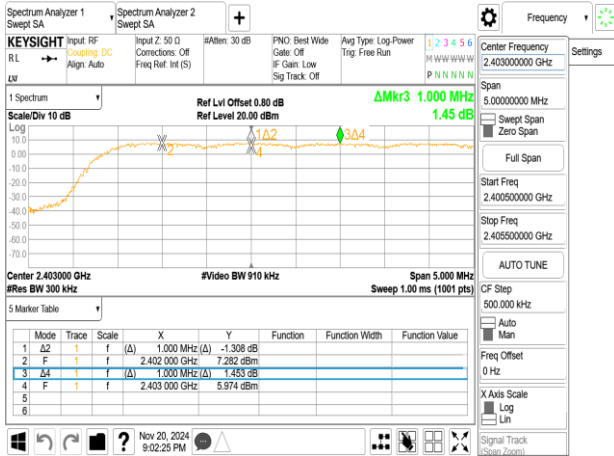


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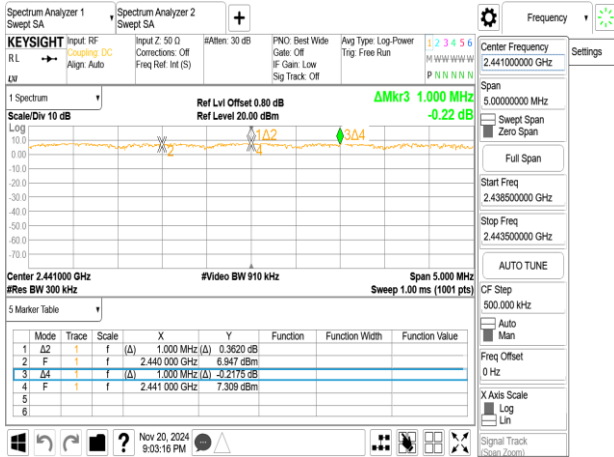
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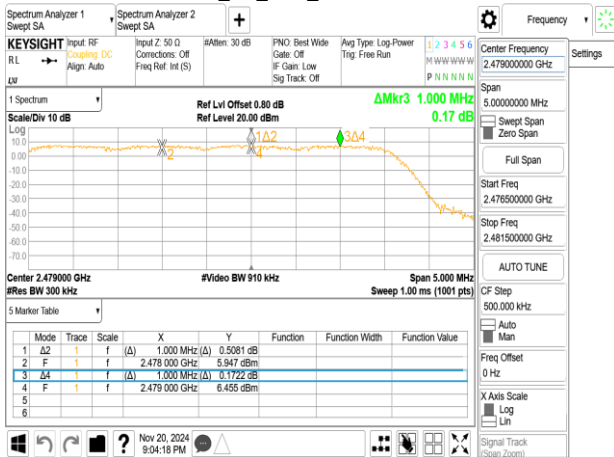
8DPSK_3M_DH5_CH0CH1CH2



8DPSK_3M_DH5_CH38CH39CH40



8DPSK_3M_DH5_CH76CH77CH78



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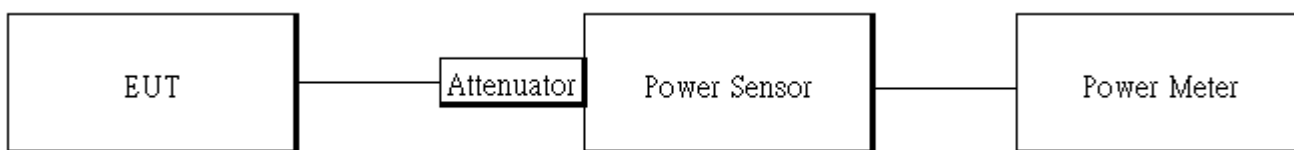
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9 PEAK OUTPUT POWER MEASUREMENT

9.1 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.

9.2 Test Setup



9.3 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. Duty cycle of test signal is < 98 %, duty factor shall be considered, test methodology follow 14.3.
4. 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)
5. Record the max. reading.
6. Repeat above procedures until all default test channel is completed.

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9.4 Peak & Average Power Measurement Result

	Duty Cycle (%) = Ton / (Ton+Toff)	Duty Factor (dB) =10*log (1/Duty Cycle)
DH5	76.80	1.15
2DH5	76.80	1.15
3DH5	76.80	1.15

1M BR mode (Peak):

CH	Freq. (MHz)	Power Setting	Peak Output Power (dBm)	Output Power (mW)	Limit (mW)
0	2402	10	9.37	8.650	1000
39	2441	10	9.68	9.290	1000
78	2480	10	9.36	8.630	1000

1M BR mode (Average):

CH	Freq. (MHz)	Power Setting	Avg. Output Power (dBm)	Output Power (mW)	Limit (mW)
0	2402	10	9.34	8.583	1000
39	2441	10	9.65	9.218	1000
78	2480	10	9.32	8.544	1000

2M EDR mode (Peak):

CH	Freq. (MHz)	Power Setting	Peak Output Power (dBm)	Output Power (mW)	Limit (mW)
0	2402	10	11.82	15.205	125
39	2441	10	12.12	16.293	125
78	2480	10	11.79	15.101	125

2M EDR mode (Average):

CH	Freq. (MHz)	Power Setting	Avg. Output Power (dBm)	Output Power (mW)	Limit (mW)
0	2402	10	9.45	8.803	125
39	2441	10	9.75	9.433	125
78	2480	10	9.44	8.783	125

3M EDR mode (Peak):

CH	Freq. (MHz)	Power Setting	Peak Output Power (dBm)	Output Power (mW)	Limit (mW)
0	2402	10	12.36	17.219	125
39	2441	10	12.65	18.408	125
78	2480	10	12.33	17.100	125

3M EDR mode (Average):

CH	Freq. (MHz)	Power Setting	Avg. Output Power (dBm)	Output Power (mW)	Limit (mW)
0	2402	10	9.50	8.905	125
39	2441	10	9.77	9.476	125
78	2480	10	9.46	8.823	125

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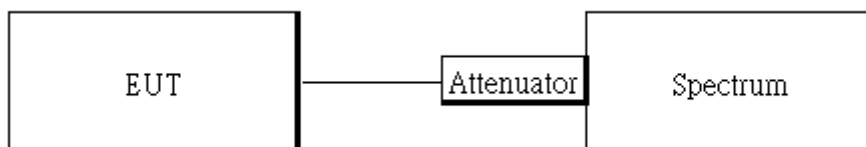
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10 EMISSION BANDWIDTH MEASUREMENT

10.1 Standard Applicable

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

10.2 Test Setup



10.3 Measurement Procedure

1. Place the EUT on the table and set it in transmitting mode.
2. The testing follows ANSI C63.10:2020.
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. Set the spectrum analyzer as
RBW= 1 % to 5% of 99% Bandwidth ,
VBW $\geq$ 3 X RBW,
Span= large enough to capture all products of the modulation process,
Sweep=auto,
Detector = Peak, and Max hold for 99% Bandwidth test.
7. Mark the peak frequency and 99%dB (upper and lower) frequency
8. Repeat above procedures until all test default channel is completed

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10.4 20dB Bandwidth

GFSK

CH	20 dB BW (MHz)	2/3 BW (MHz)
0	0.9323	0.62
39	0.932	0.62
78	0.9315	0.62

 $\pi/4$ -DQPSK

CH	20 dB BW (MHz)	2/3 BW (MHz)
0	1.286	0.86
39	1.285	0.86
78	1.286	0.86

8-DPSK

CH	20 dB BW (MHz)	2/3 BW (MHz)
0	1.302	0.87
39	1.302	0.87
78	1.301	0.87

10.5 99% Bandwidth

GFSK

CH	99% BW (MHz)
0	0.81842
39	0.81952
78	0.81817

 $\pi/4$ -DQPSK

CH	99% BW (MHz)
0	1.1804
39	1.1819
78	1.1810

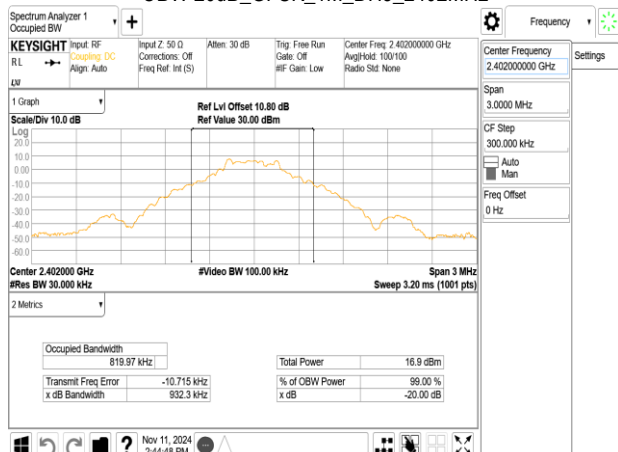
8-DPSK

CH	99% BW (MHz)
0	1.1829
39	1.1825
78	1.1828

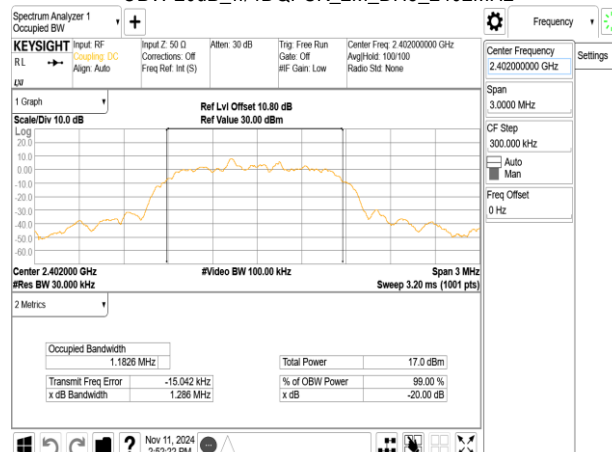
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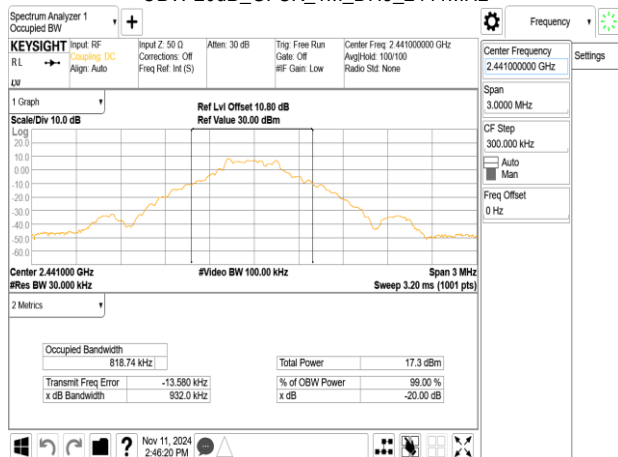
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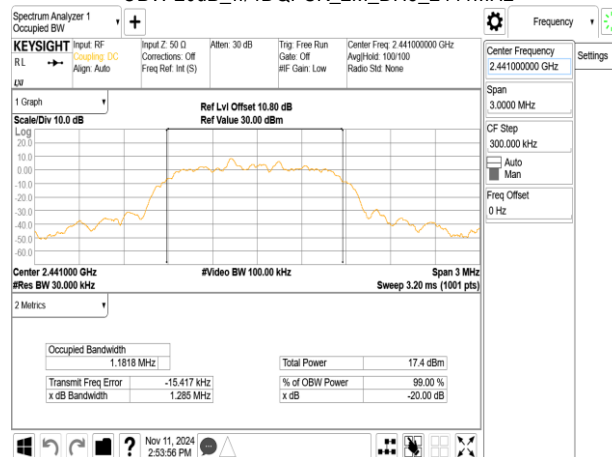
OBW 20dB_π/4DQPSK_2M_DH5_2402MHz



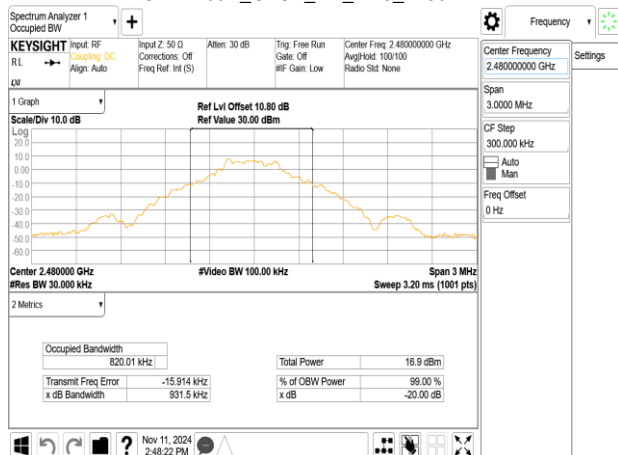
OBW 20dB_GFSK_1M_DH5_2441MHz



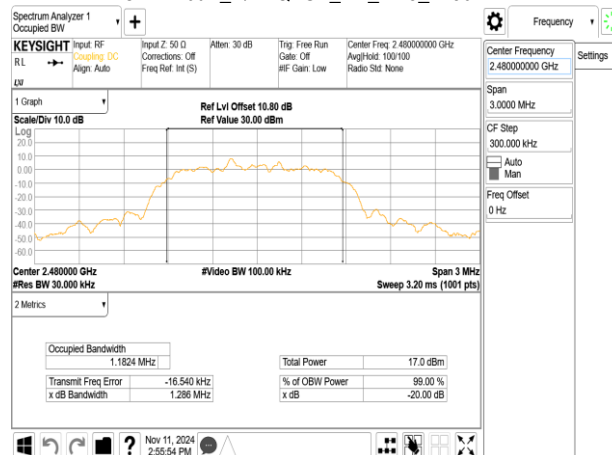
OBW 20dB_π/4DQPSK_2M_DH5_2441MHz



OBW 20dB_GFSK_1M_DH5_2480MHz



OBW 20dB_π/4DQPSK_2M_DH5_2480MHz

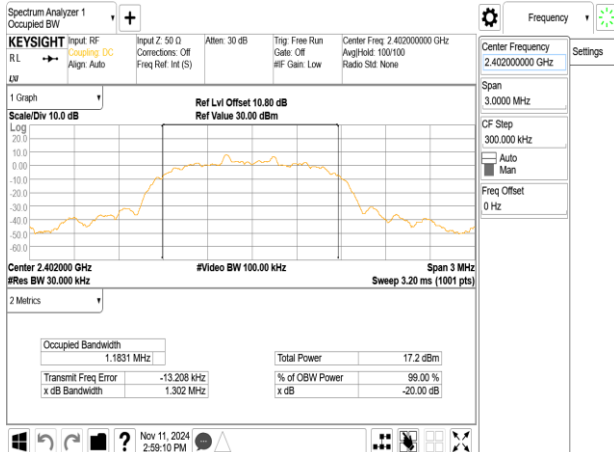


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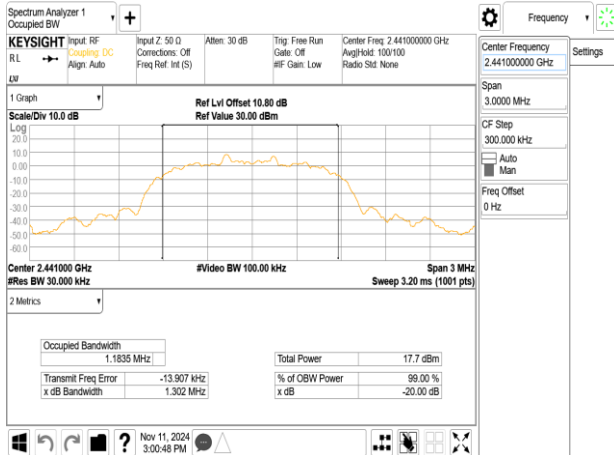
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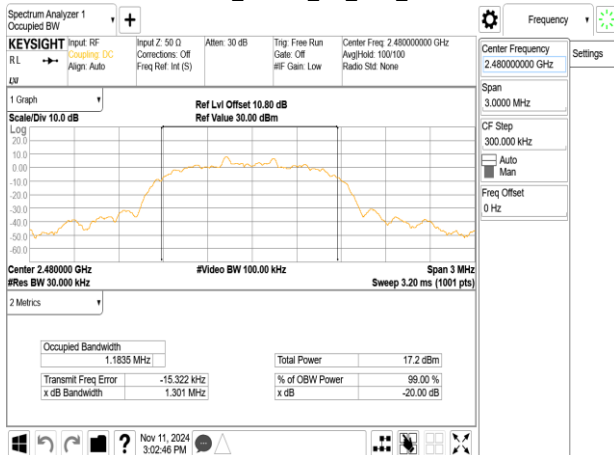
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OBW 20dB_8DPSK_3M_DH5_2441MHz



OBW 20dB_8DPSK_3M_DH5_2480MHz

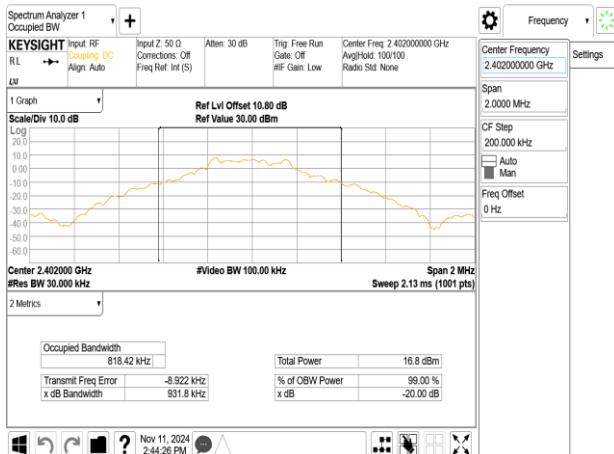


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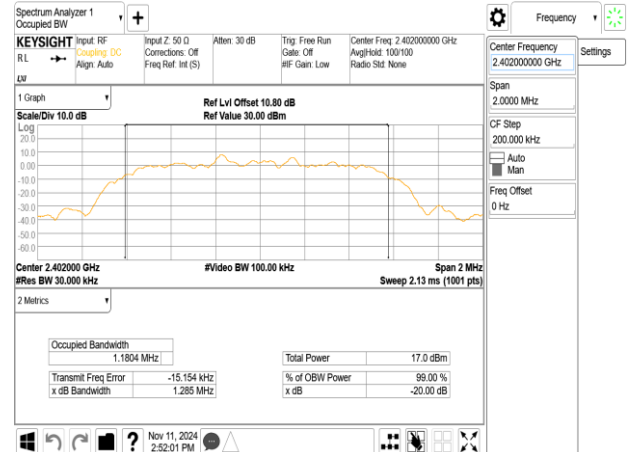
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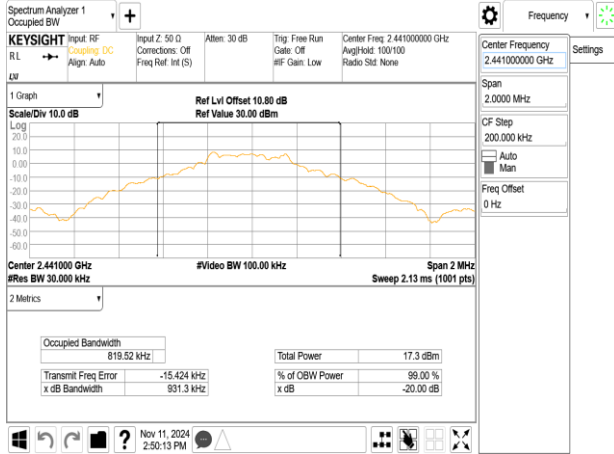
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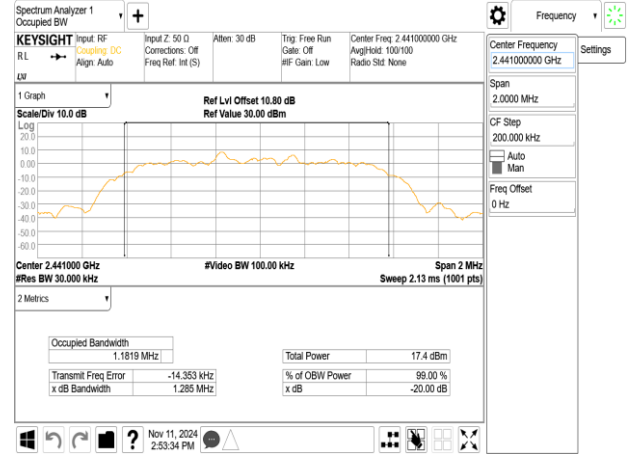
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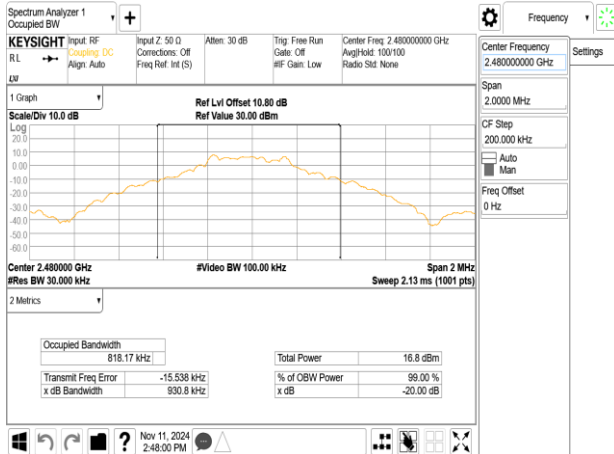
IC OBW 99%_GFSK_1M_DH5_2441MHz



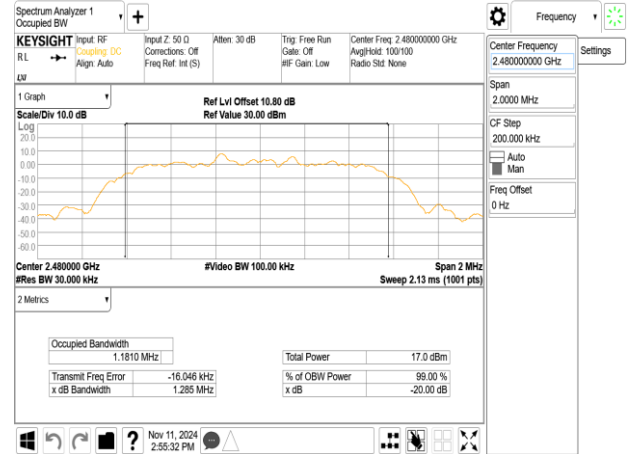
IC OBW 99%_π/4DQPSK_2M_DH5_2441MHz



IC OBW 99%_GFSK_1M_DH5_2480MHz



IC OBW 99%_π/4DQPSK_2M_DH5_2480MHz

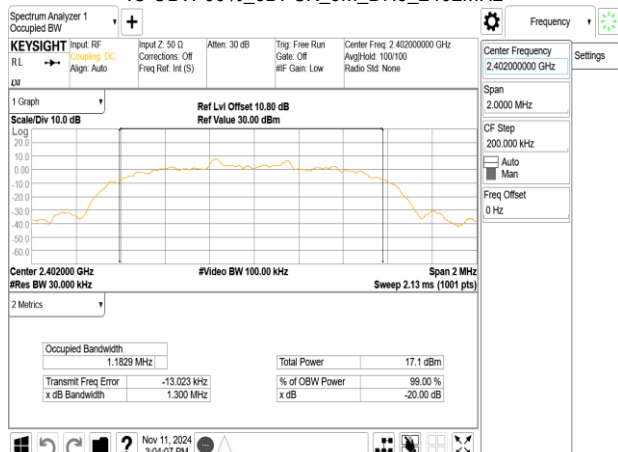


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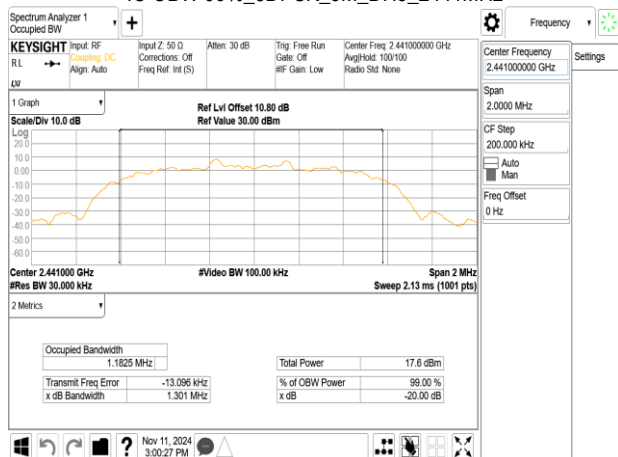
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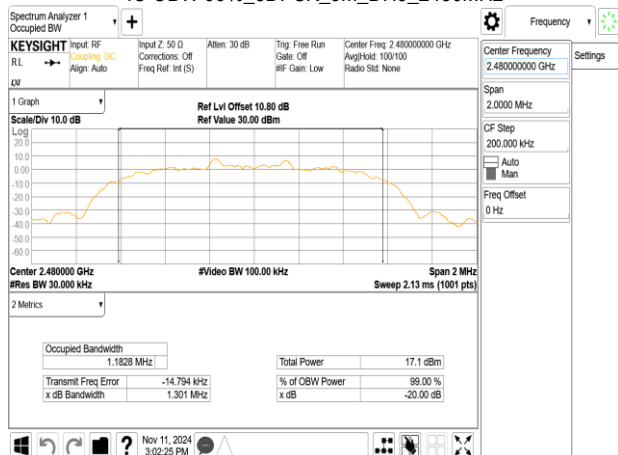
IC OBW 99%_8DPSK_3M_DH5_2402MHz



IC OBW 99%_8DPSK_3M_DH5_2441MHz



IC OBW 99%_8DPSK_3M_DH5_2480MHz



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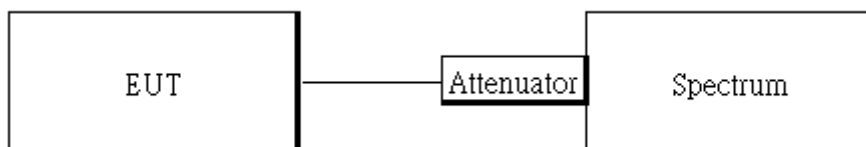
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11 CONDUCTED BAND EDGES AND SPURIOUS EMISSION MEASUREMENT

11.1 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).

11.2 Test Setup



11.3 Measurement Procedure

11.3.1 Conducted Band Edge:

In any 100 kHz bandwidth outside the frequency band

1. Place the EUT on the table and set it in transmitting mode.
2. The testing follows ANSI C63.10:2020.
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=100 kHz, VBW=300 kHz, Sweep = auto
5. Mark Peak, below 2.4GHz and above 2.4835GHz and record the max. level.
6. Repeat above procedures until all frequency measured were complete.

11.3.2 Conducted Spurious Emission:

1. To connect Antenna Port of EUT to Spectrum.
2. The testing follows ANSI C63.10:2020.
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.

11.4 Measurement Result

See next page for test plots.

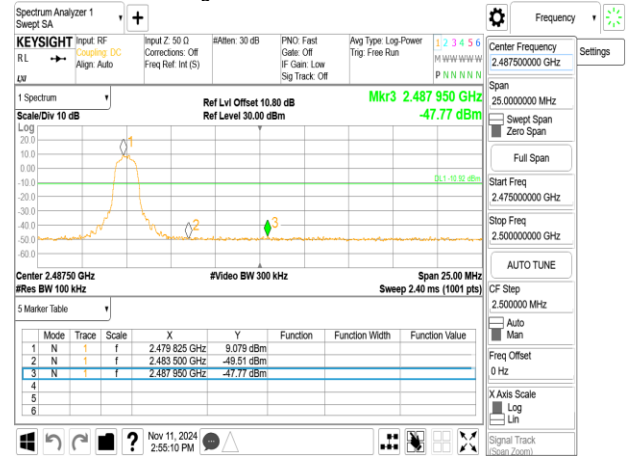
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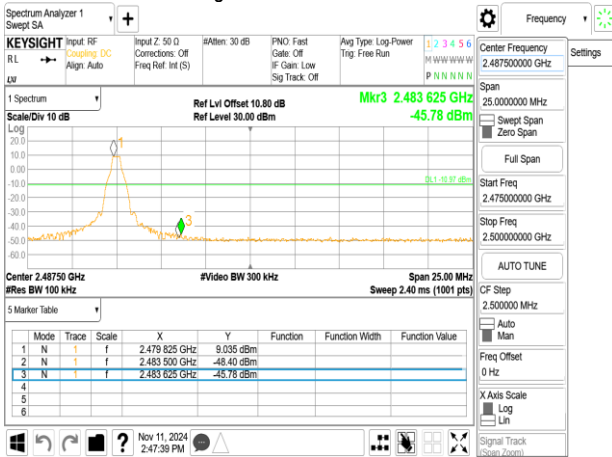
Band Edge_GFSK_1M_DH5_2402MHz



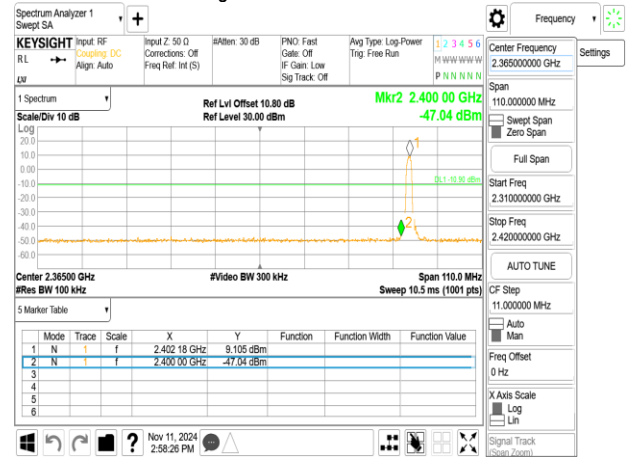
Band Edge_π/4QPSK_2M_DH5_2480MHz



Band Edge_GFSK_1M_DH5_2480MHz



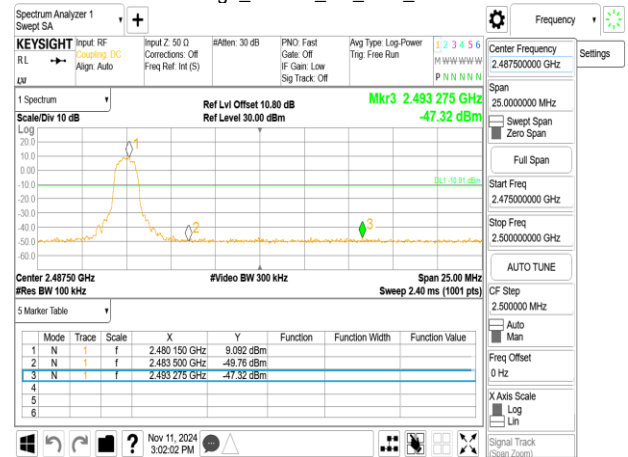
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Band Edge_π/4QPSK_2M_DH5_2402MHz



Band Edge_8DPSK_3M_DH5_2480MHz

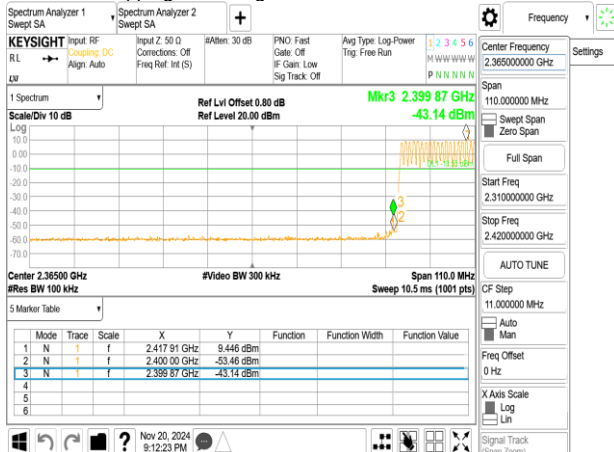


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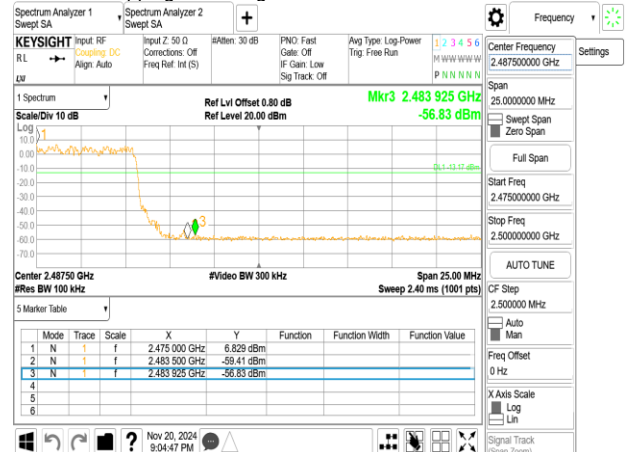
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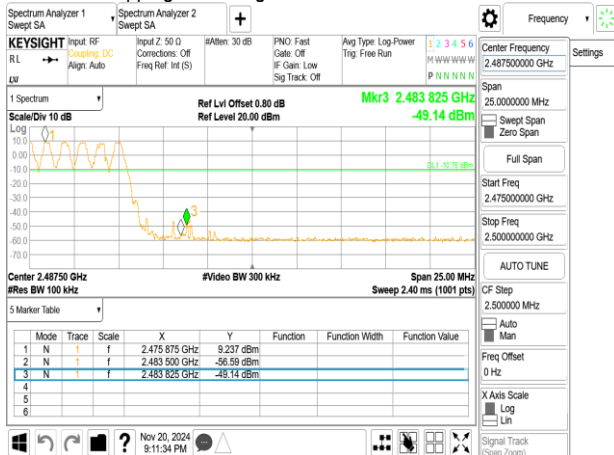
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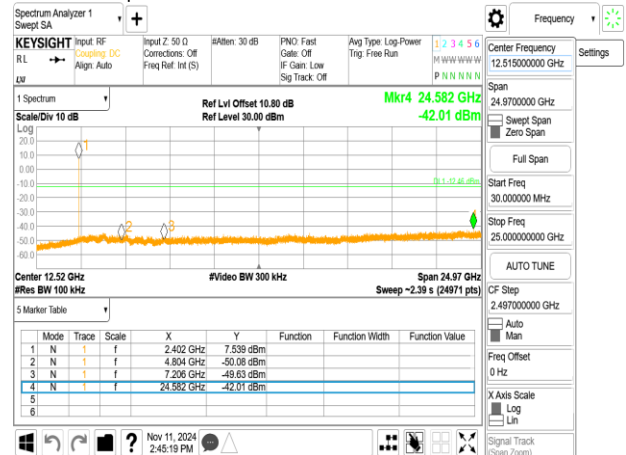
Hopping Band Edge_8DPSK_3M_DH5_2480MHz



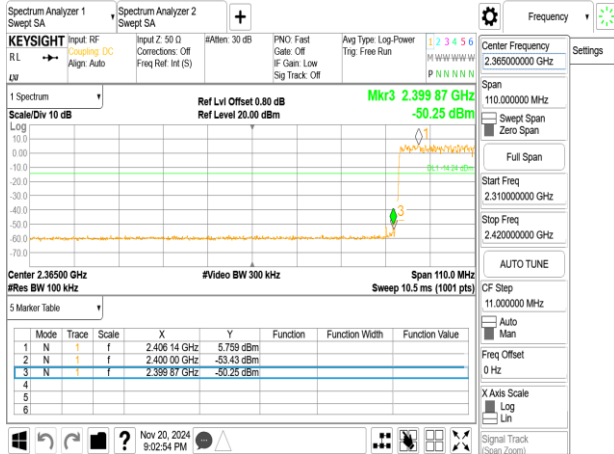
Hopping Band Edge_GFSK_1M_DH5_2480MHz



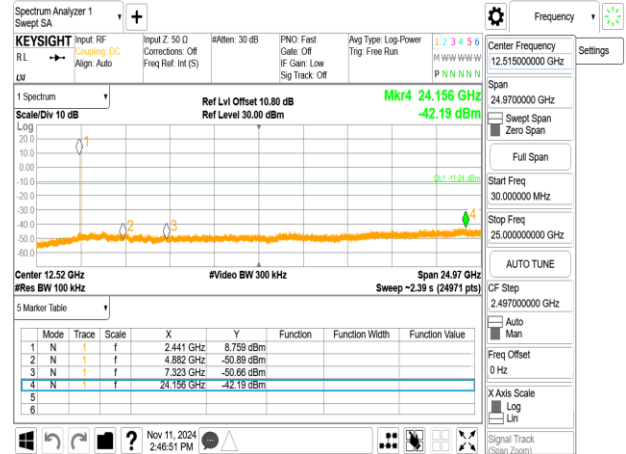
Spurious Emission_GFSK_1M_DH5_2402MHz



Hopping Band Edge_8DPSK_3M_DH5_2402MHz



Spurious Emission_GFSK_1M_DH5_2441MHz



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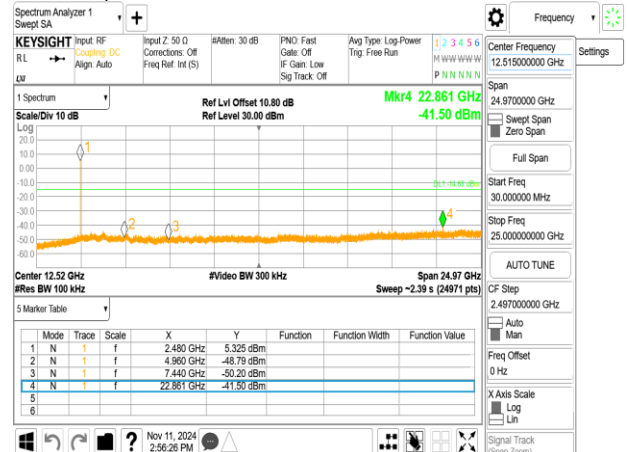
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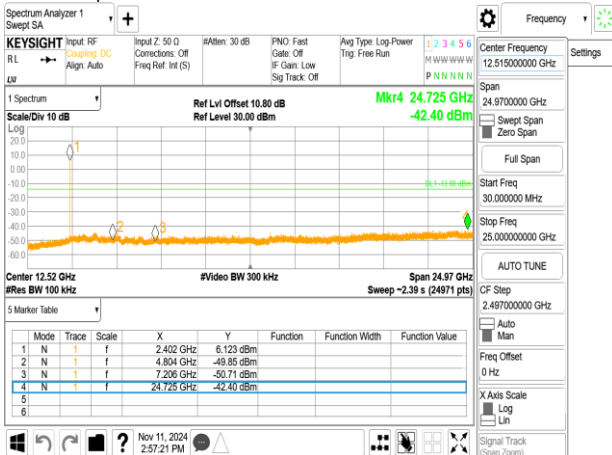
Spurious Emission_GFSK_1M_DH5_2480MHz



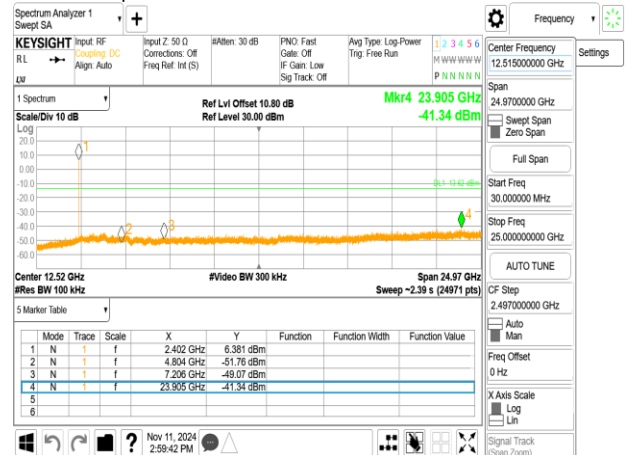
Spurious Emission_π/4QPSK_2M_DH5_2480MHz



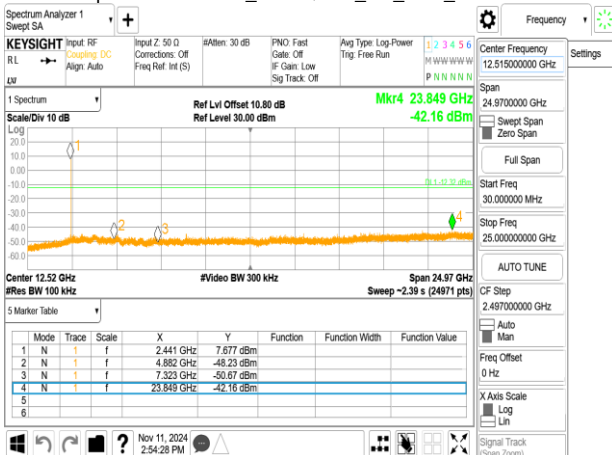
Spurious Emission_π/4QPSK_2M_DH5_2402MHz



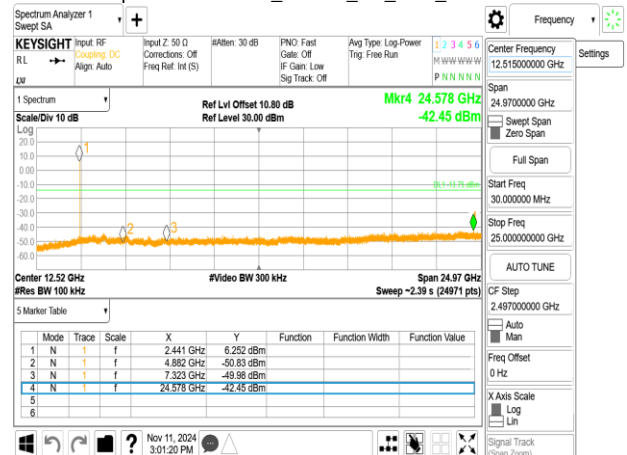
Spurious Emission_8DPSK_3M_DH5_2402MHz



Spurious Emission_π/4QPSK_2M_DH5_2441MHz



Spurious Emission_8DPSK_3M_DH5_2441MHz



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Spurious Emission_8DPSK_3M_DH5_2480MHz



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12 BANEDGE AND SPURIOUS EMISSION MEASUREMENT

12.1 Standard Applicable

12.1.1 Duty Cycle Correction Factor

According to 15. 35(c), the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification.

12.1.2 Spurious Emission

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.

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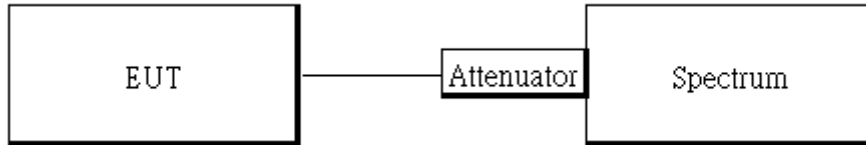
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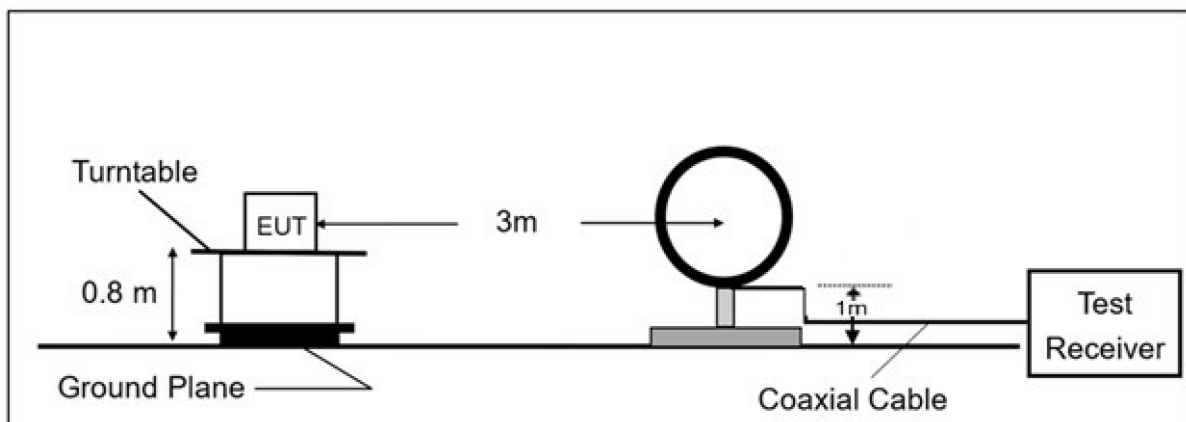
12.2 Test Setup

12.2.1 Duty Cycle Correction Factor, Band edge, Emission

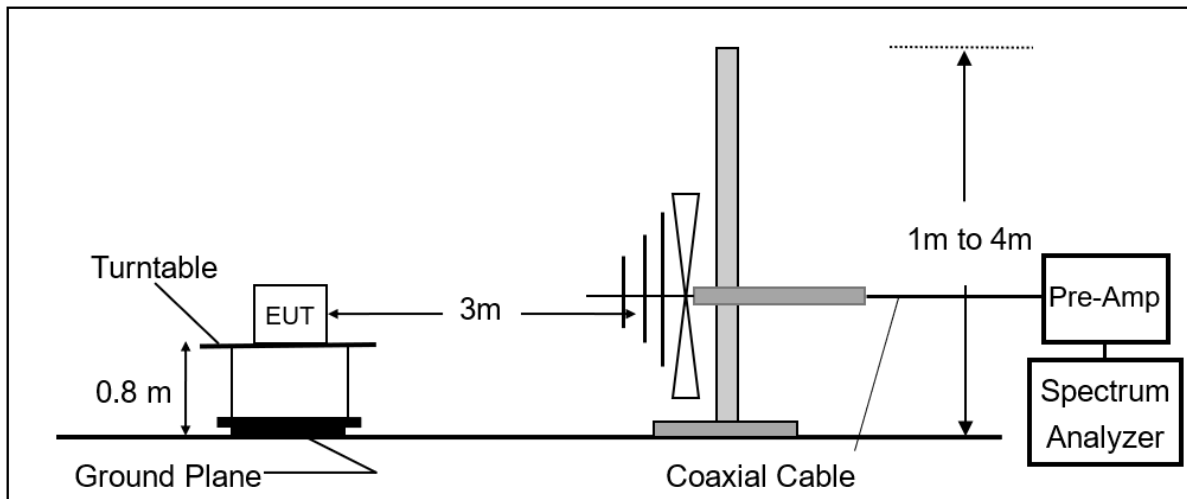


12.2.2 Radiated Emission

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



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

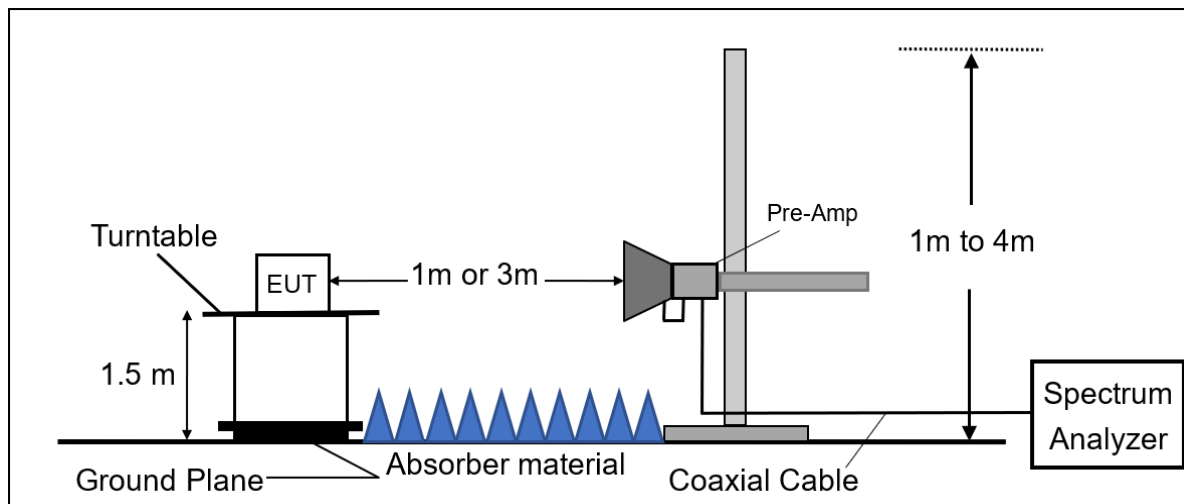


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(C) Radiated Emission Test Set-Up, Frequency Above 1 GHz.



12.3 Measurement Procedure

12.3.1 Duty Cycle Correction Factor

1. Adjust and configure any EUT switches, controls, or input data streams to ensure that the EUT is transmitting or encoded to obtain the “worst-case” pulse ON time.
2. The testing follows ANSI C63.10:2020.
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=100ms.
6. Repeat above procedures until all frequency of the interest measured were complete.

12.3.2 Band edge and Spurious Emission

1. Set the spectrum analyzer as RBW=100 kHz and VBW=300 kHz for Peak Detector (PK) at frequency between 30MHz and 1 GHz.
2. Use receiver mode as RBW=120 kHz for Quasi-peak (QP) at frequency between 30MHz and 1 GHz.
3. Set the spectrum analyzer as RBW=1 MHz, VBW=3 MHz, Detector = Peak for Maximum Emission Measurements at frequency above 1 GHz.
4. According to C63.10:2020 Section 7.5 Procedure for determining the average value of pulsed emissions with duty cycle correction factor $20 \log (T_{on}/100ms)$

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12.3.3 Radiated Spurious Emissions measurements

1. The testing follows the Measurement Procedure of ANSI C63.10:2020.
2. The EUT was placed on a turn table with 0.8m for frequency < 1GHz and 1.5m for frequency > 1GHz above ground plane.
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. 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.
6. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
7. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
8. Repeat above procedures until all default test channel measured were complete.

12.4 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)

Average value(dBμV/m) = Peak Actual FS(dBμV/m) + Duty Cycle Correction Factor(dB)

Duty Cycle Correction Factor(dB) = $20 \log(T_{on}/100 \text{ ms})$

12.5 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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12.6 Measurement Result:

12.6.1 Duty Cycle Correction Factor

Bluetooth 1M_BR

Time ON of 100ms: 5.800 ms

Duty Cycle=5.8ms / 100ms= 0.058

Duty Cycle correction factor=20 LOG 0.058 = -24.73 dB

Bluetooth 3M_EDR

Time ON of 100ms: 5.800 ms

Duty Cycle=5.8ms / 100ms= 0.058

Duty Cycle correction factor=20 LOG 0.058 = -24.73 dB

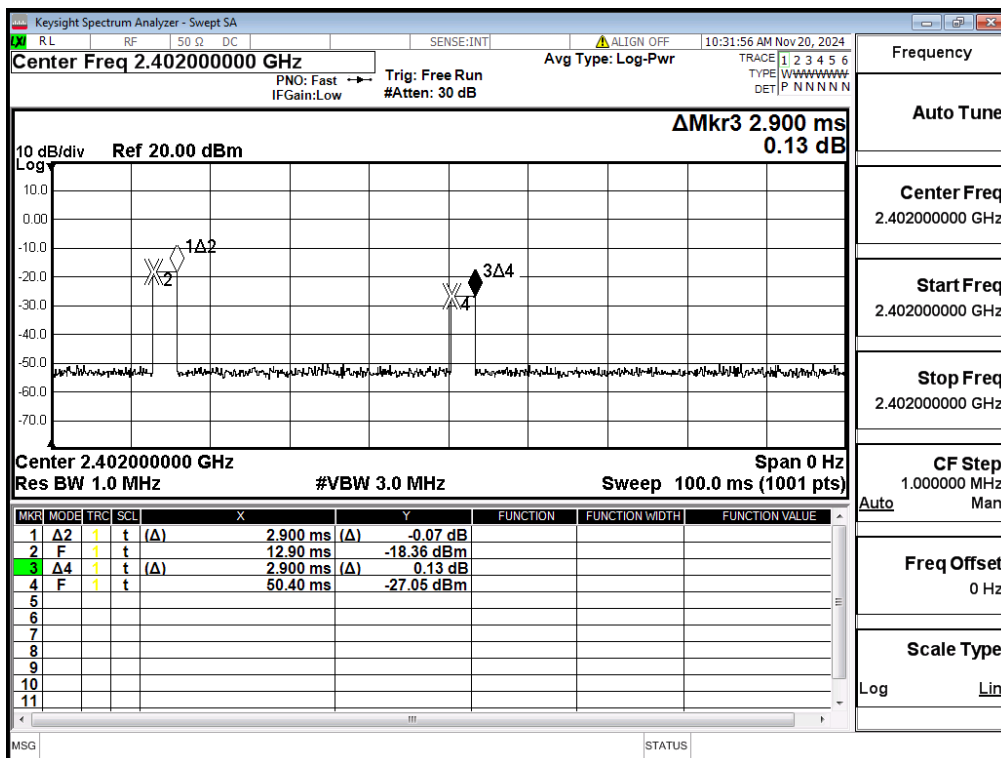
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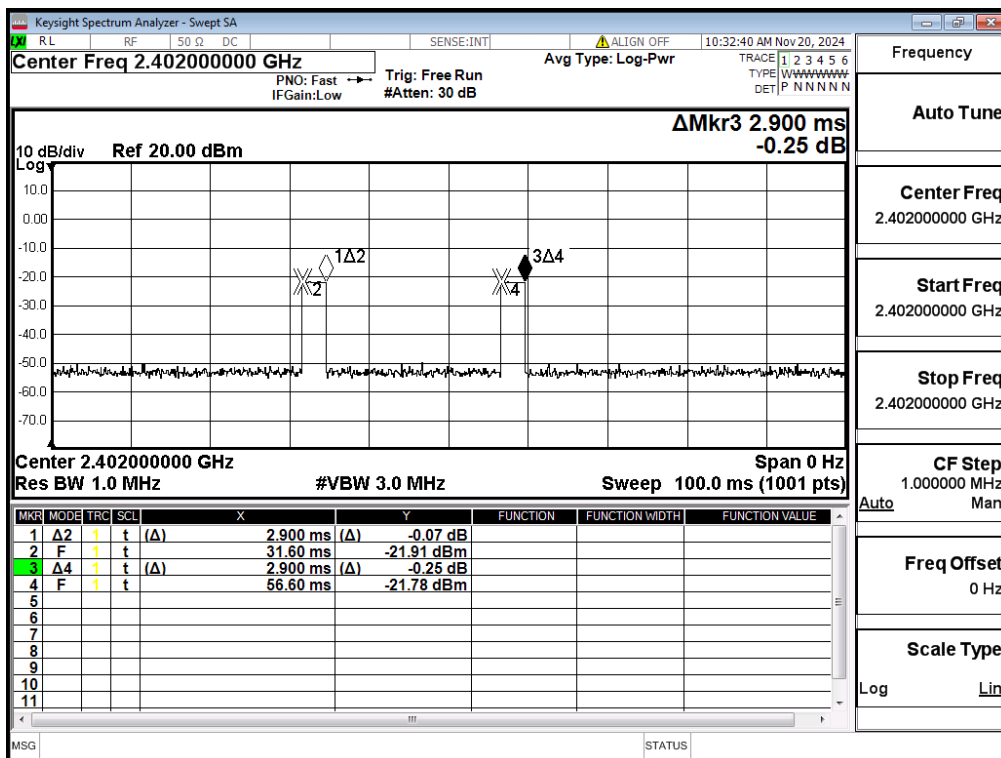
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12.6.2 Duty Cycle test plot

BR



EDR



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12.6.3 CBE

BT_1M_BR

Channel	Frequency (MHz)	Raw Value(dBm)	Duty factor (dB)	Antenna Peak Gain (dBi)	EIRP (dBm)	Emission Level (dBuV/m)	Margin (dB)	Limit (dBuV/m)	
		Chain 0		Chain 0					
0	2402	-47.290	-	3.37	-43.92	51.28	-22.72	74	PK
		-	-24.73	3.37	-68.65	26.55	-27.45	54	AV
78	2480	-30.700	-	3.37	-27.33	67.87	-6.13	74	PK
		-	-24.73	3.37	-52.06	43.14	-10.86	54	AV

Average Duty Factor=-24.73(dB)

Average Level=Peak Level+Duty Factor

BT_3M_EDR

Channel	Frequency (MHz)	Raw Value(dBm)	Duty factor (dB)	Antenna Peak Gain (dBi)	EIRP (dBm)	Emission Level (dBuV/m)	Margin (dB)	Limit (dBuV/m)	
		Chain 0		Chain 0					
0	2402	-47.410	-	3.37	-44.04	51.16	-22.84	74	PK
		-	-24.73	3.37	-68.77	26.43	-27.57	54	AV
78	2480	-36.080	-	3.37	-32.71	62.49	-11.51	74	PK
		-	-24.73	3.37	-57.44	37.76	-16.24	54	AV

Average Duty Factor=-24.73(dB)

Average Level=Peak Level+Duty Factor

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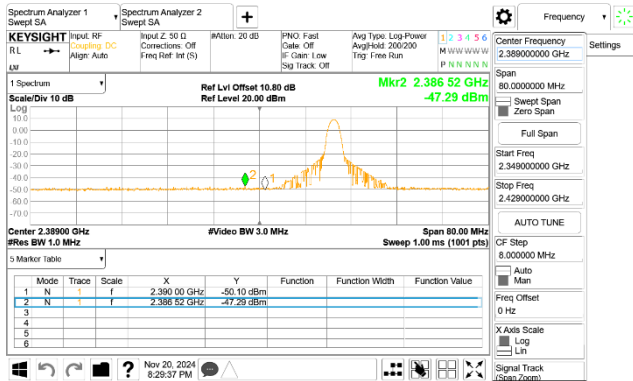
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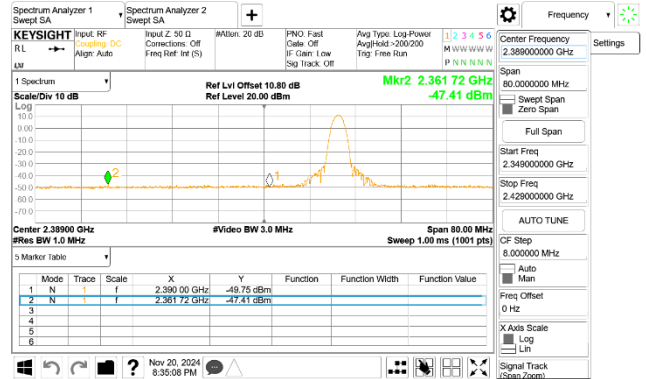
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CBE_GFSK_1M_DH5_2402MHz



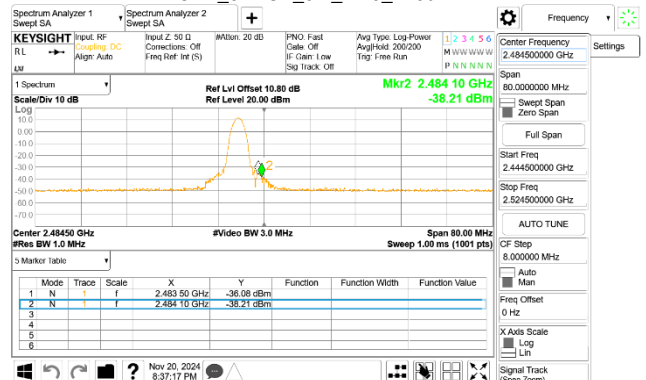
CBE_8DPSK_3M_DH5_2402MHz



CBE_GFSK_1M_DH5_2480MHz



CBE_8DPSK_3M_DH5_2480MHz



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12.6.4 Conducted Emission

BT_3DH5

Channel	Frequency (MHz)	Raw Value(dBm)	Correction Factor(dB)	EIRP (dBm)	Emission Level (dBuV/m)	Margin (dB)	Limit (dBuV/m)	
		Chain 0	Chain 0					
39	2441	-82.040	8.07	-73.97	21.23	-18.77	40	PK
		-78.800	8.07	-70.73	24.47	-19.03	43.5	PK
		-86.220	8.07	-78.15	17.05	-28.95	46	PK
		-65.950	8.07	-57.88	37.32	-8.68	46	PK
		-86.800	8.07	-78.73	16.47	-29.53	46	PK
		-83.670	8.07	-75.60	19.60	-34.40	54	PK

Note:

Correction Factor=maximum ground reflection factor+Antenna Gain

BT_DH5

Channel	Frequency (MHz)	Raw Value(dBm)	Duty factor (dB)	Antenna Peak Gain (dBi)	EIRP (dBm)	Emission Level (dBuV/m)	Margin (dB)	Limit (dBuV/m)	
		Chain 0		Chain 0					
0	2402	-43.070	-	3.37	-39.70	55.50	-18.50	74	PK
		-	-24.73	3.37	-64.43	30.77	-23.23	54	AV
39	2441	-41.780	-	3.37	-38.41	56.79	-17.21	74	PK
		-	-24.73	3.37	-63.14	32.06	-21.94	54	AV
78	2480	-42.670	-	3.37	-39.30	55.90	-18.10	74	PK
		-	-24.73	3.37	-64.03	31.17	-22.83	54	AV

BT_3DH5

Channel	Frequency (MHz)	Raw Value(dBm)	Duty factor (dB)	Antenna Peak Gain (dBi)	EIRP (dBm)	Emission Level (dBuV/m)	Margin (dB)	Limit (dBuV/m)	
		Chain 0		Chain 0					
0	2402	-41.950	-	3.37	-38.58	56.62	-17.38	74	PK
		-	-24.73	3.37	-63.31	31.89	-22.11	54	AV
39	2441	-42.860	-	3.37	-39.49	55.71	-18.29	74	PK
		-	-24.73	3.37	-64.22	30.98	-23.02	54	AV
78	2480	-42.160	-	3.37	-38.79	56.41	-17.59	74	PK
		-	-24.73	3.37	-63.52	31.68	-22.32	54	AV

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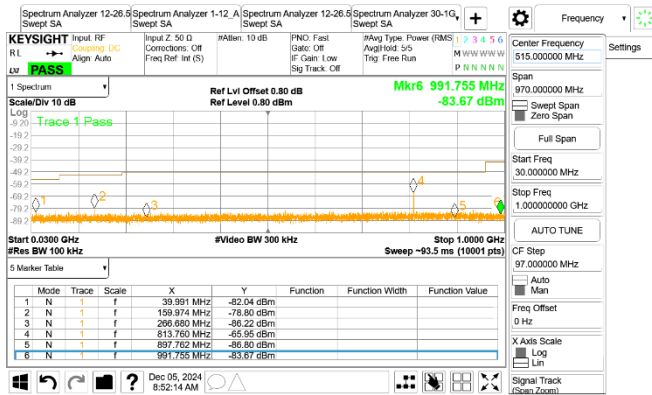
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Peak (30MHz~1GHz)

2441MHz



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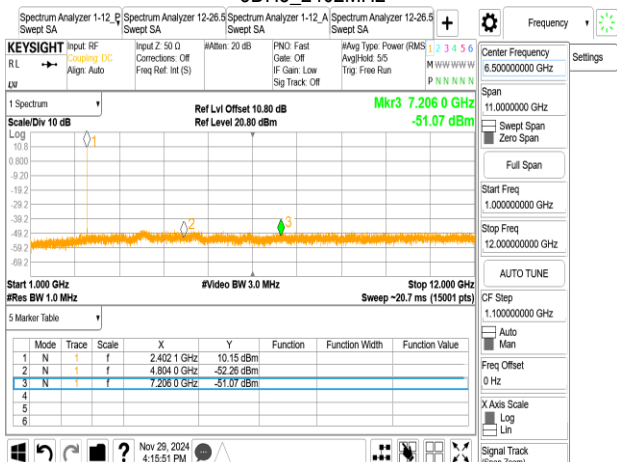
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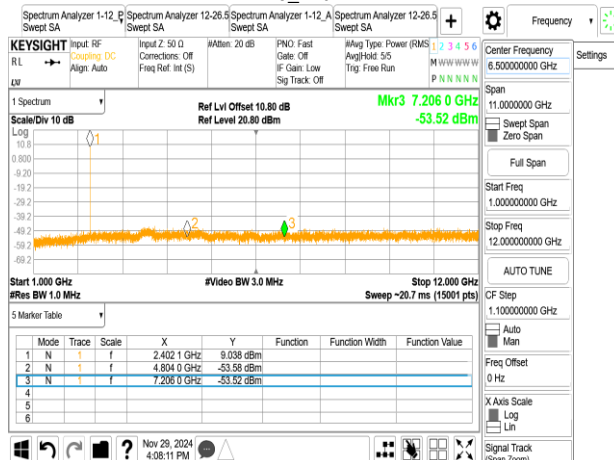
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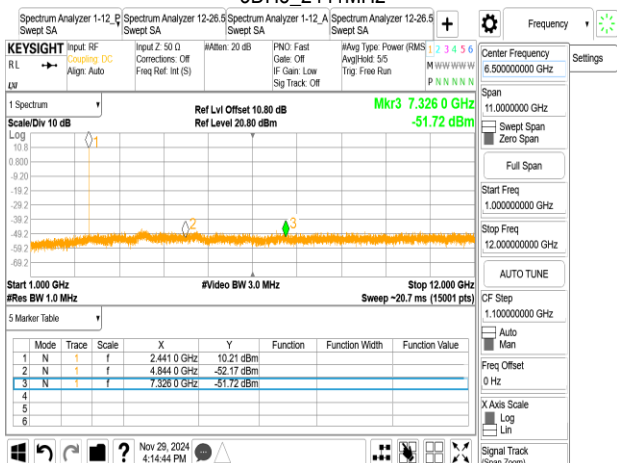
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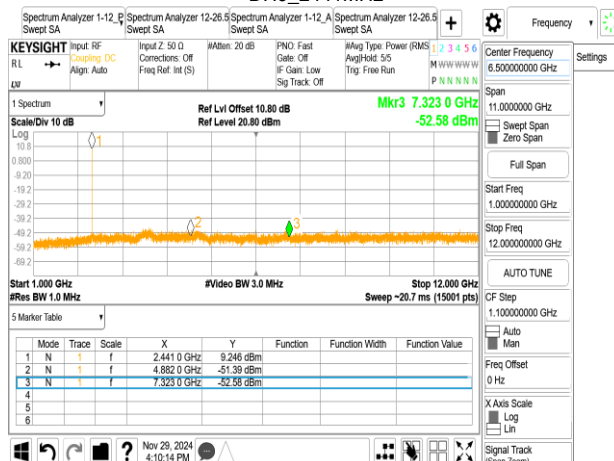
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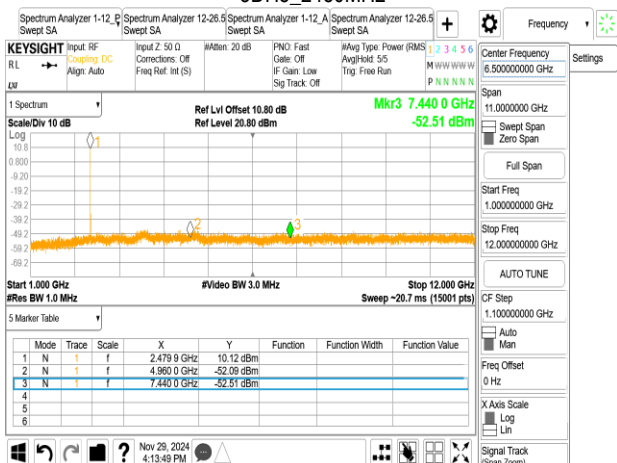
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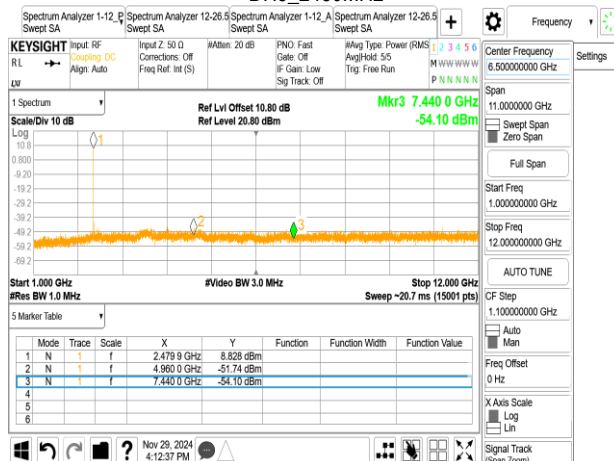
DH5_2441MHz



3DH5_2480MHz



DH5_2480MHz



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