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Atlas Compliance & Engineering, Inc.

Test Report

FCC CFR 47 Subpart C Section 15.247
ISED RSS-Gen and RSS-247
Bluetooth BDR EDR

Applicant:
Silent Beacon LLC
9200 Corporate Blvd. STE 250
Rockville, MD 20850

Product:
Silent Beacon 2.0
Model:
SB2.0

FCC ID:	2AIND03021958SBL
IC:	21917-03021958SBL
Test Report Number:	2310SBLsb20_247bt
Date Product Tested:	February 27 to April 3, 2023
Date of Report:	April 3, 2023

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Change History

2310SBLsb20_247bt

Rev.	Change Description	Reason/Application	Date	Appvd.
Draft	Report for review	Applies to SB2.0	April 3, 2023	MEB
C1	Released report	Applies to SB2.0	April 3, 2023	MEB
C2	Date update	Update to Test equipment	May 1, 2023	MEB

Test Certificate

APPLICANT:	Silent Beacon LLC 9200 Corporate Blvd. STE 250 Rockville, MD 20850
Trade Name:	Silent Beacon LLC
Model:	SB2.0
FCC ID:	2AIND03021958SBL
IC:	21917-03021958SBL

I HEREBY CERTIFY THAT:

The measurements shown in this report were made in accordance with the procedures indicated and that the energy emitted by this equipment, as received, was found to be within the FCC CFR 47 Part 15 Rules and Regulations Subpart C requirements and Industry Canada RSS-247 and RSS-Gen requirements. Additionally, it should be noted that the results in this report apply only to the items tested, as identified herein.

I FURTHER CERTIFY THAT:

On the basis of the measurements taken at the test site, the equipment tested is capable of operation in compliance with the requirements set forth in FCC CFR 47 Part 15.207, 15.209 and 15.247 Rules and Regulations and Industry Canada RSS-247 and RSS-Gen requirements.

On this Date: April 3, 2023

Bruce Smith
Atlas Compliance & Engineering, Inc.

Atlas Compliance & Engineering, Inc.
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Test Equipment

The following list contains the test equipment that was utilized in making the measurements in this report.

Description _ Model	Serial	Manufacturer	Calibration Due
BiLog Antenna with SA3NS-04 Attn CHL157.1 30-1000MHz _ 3143B	00217636	ETS Lindgren	5/24/24
Active Loop Antenna _ 6502	9108-2669	EMCO	5/24/24
Double Ridge Guide Horn Antenna 1-18GHz _ 3117	00218932	EMCO	7/23/23
Double Ridge Active Horn Antenna 18-40GHz _ AHA-840	10100003	Com-Power	7/23/23
Pre amp 9kHz-2GHz _ CPA9231A	3259	Schaffner	11/14/23
EMI Test Receiver 9 kHz - 2500 MHz _ ESPC	DE15934 845296/0024	Rohde & Schwarz	11/14/23
Pre amp 1Ghz-26.5GHz _ 8449B	3008A00910	HP	11/14/23
Signal Analyzer 10Hz - 40GHz option B4, B5, B24, B29, K54 Firmware 3.40 _ FSV40	101735	Rohde & Schwarz	11/15/23
Spectrum Analyzer 9kHZ - 2.9GHz ver 950914 _ 8594E	3543A02886	HP	11/14/23
Temperature and humidity probe _ RH-85	140020	Omega Engineering	10/26/23
RF Cable 45 ft. _ KPS-1571-5400-KPS	2040	IW Microwave	11/15/23
RF Cable 19m _ NPS-2801-1900M-NPS	1805	IW Microwave	11/15/23
Digital Voltmeter _ 179	15400440	Fluke	11/19/23
10dB attenuator	2		CBU
Thermal Chamber _ 107	0700496	Test Equity	CBU

CBU – characterized before use

General Information

Applicant:	Silent Beacon LLC 9200 Corporate Blvd. STE 250 Rockville, MD 20850
Contact Person	Kenny Kelley
Purpose of Test:	To demonstrate the compliance of the Silent Beacon 2.0, SB2.0, with the requirements of FCC CFR 47 Part 15 Rules and Regulations to the limits of Subpart C 15.207, 15.209, 15.247 and Canada RSS-Gen, RSS-247 using the procedure stated in ANSI C63.10 and FCC KDB 558074 D01
Equipment Tested:	Silent Beacon 2.0
Trade Name:	Silent Beacon
Model:	SB2.0
Power Supply Rating:	3.7Vdc VBAT
Transmitter Frequency:	2402 – 2480 MHz
Transmitter Channels:	79 Channels, 1 MHz spacing
Modulation Type:	GFSK, $\pi/4$ DQPSK, 8DPSK
Modulation Technology:	FHSS
Transfer Rate:	1/2/3Mbps
Frequency Range Investigated:	9 KHz to 24.835 GHz
FCC ID:	2AIND03021958SBL
IC:	21917-03021958SBL
Test Site Locations:	ISED number 3655A Field Strength Measurement Facility: Atlas Compliance & Engineering, Inc. 726 Hidden Valley Road Royal Oaks, California 95076 Conducted Measurement Facility: Atlas Compliance & Engineering, Inc. 1792 Little Orchard Street San Jose, California 95125
Test Personnel:	Bruce Smith EMC Engineer

Bluetooth Test Results

47 CFR Part 15, Subpart C (Section 15.247), ISED RSS-Gen, RSS-247			
Clause	Test Parameter	Result	Remarks
15.203, RSS-Gen 6.8	Antenna requirement	Pass	No antenna connector used, permanently attached antenna
15.205/15.209, RSS-Gen 8.9/8.10 RSS-247 5.5	Radiated Emissions	Pass	Meets the requirement
15.207, RSS-Gen 8.8	AC Power Conducted Emissions	Pass	Meets the requirement
15.247(a)(1)(iii), RSS-247 5.1 (d)	Number of Hopping Frequency Used	Pass	Meets the requirement
15.247(a)(1)(iii), RSS-247 5.1 (d)	Dwell Time on Each Channel	Pass	Meets the requirement
15.247(a)(1), RSS-247 5.1 (a)	Hopping Channel 20 dB bandwidth	Pass	Meets the requirement
RSS-Gen 6.7	Occupied bandwidth (or 99% emissions bandwidth)	Pass	Meets the requirement
15.247(a)(1), RSS-247 5.1 (a) (b)	Hopping Channel Separation	Pass	Meets the requirement
15.247(a)(1), RSS-247 5.5	Spectrum Bandwidth of a Frequency Hopping Sequence Spread Spectrum System	Pass	Meets the requirement
15.247(b)(1), RSS-247 5.4 (b)	Maximum Peak Output Power	Pass	Meets the requirement
15.247(d), RSS-247 5.5	Band Edge Measurement	Pass	Meets the requirement
15.247(d), RSS-247 5.5	Antenna Port Emission	Pass	Meets the requirement
15.215, RSS-Gen 6.11 8.11	Transmitter frequency Stability	Pass	Meets the requirement

Note:
If the frequency hopping system operating in 2400-2483.5 MHz band and the output power less than 125mW, the hopping channel carrier frequencies separated by a minimum of 25kHz or two-thirds of the 20dB bandwidth of the hopping channel whichever is greater.

Test setup for conducted antenna port measurements

Characterization of cable and attenuator

The RF cable and 10dB external attenuator used during the conducted measurements was characterized as follows:

Cable Loss +Attenuator

Correction factor = 10.55dB

Temperature and Humidity

The ambient temperature of the actual EUT was within the range of 10° to 40° C (50° to 104° F) unless the particular equipment requirements specify testing over a different temperature range. The humidity levels were within the range of 10% to 90% relative humidity unless the EUT operating requirements call for a different level.

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Test Configuration

Customer:	Silent Beacon LLC
Test Date:	February 27 to April 3, 2023
Specification:	FCC CRF 47 Part 15.247 Limits, ANSI C63.10 Methods

Operational Description:

The Silent Beacon 2.0 is a Bluetooth personal safety device that pairs to your smartphone or tablet. It is used as a wearable panic button.

The Silent Beacon 2.0 uses a chip antenna to provide connectivity to the smartphone or tablet. The technology allows you to call any number, including 911, at the touch of a button. Simultaneously, it can send any family, friends or emergency services you have chosen, texts, push notification and email alerts accompanied by your current GPS location allowing you to receive help faster.

EUT Description / Note:

The EUT, SB2.0, a Silent Beacon 2.0, was powered up and the Bluetooth transmitter was in a continuous transmitting mode at full power for emissions measurements. The EUT interface was through the host laptop USB port to send commands to place it in the different operating modes. The power for the EUT was supplied by the on board 3.7Vdc battery. The chip antenna on the transmitter is a Johanson Technology Ceramic Antenna
P/N: 2450AT18D0100E-AEC. The peak gain of the antenna is 1.5dBi.

EUT Support Program

The EUT was tested at lowest channel, 2402 MHz, mid channel, 2441 MHz, and highest channel, 2480 MHz in a continuous transmit mode. The transmitter was at full power and 100% modulation. The test software commands were set with the following commands:

```
CFG_FREQ
        TX/RX Int            1us
Execute
CFG_FREQ_MS
        TX/RX Int            1us
Execute
CFG PKT
        Packet Type          DH5     2-DH5    3-DH5
        Packet Size          339     679      1021
Execute
TXDATA1
        LO Freq (MHz)        2402 or 2441 or 2480
        Power (Atn,Mag,EXP)  2-5-0
Execute
```

The EUT was then operated to find worst case levels of unwanted emissions. Preliminary radiated tests were performed to identify which operating mode produced the worst case (maximum) transmit level. Using this mode the EUT was tested to find maximum transmit level. Tests were performed while attached to a laptop computer to place the EUT in the different transmit channels.

EUT Modifications for Compliance

There were no modifications performed on the EUT. The test results state the emission levels of the EUT in the condition as it was received.

Measurement Uncertainty

Measurement uncertainty is caused by random effects and imperfect correction of systematic effects. The measurement uncertainties stated were calculated with a confidence level of approximately 95%, using a coverage factor of k = 2.

Expanded Measurement Uncertainty at 95% confidence probability;
Radiated emissions = ±3.92dB
Conducted emissions = ±1.16dB

EUT Support Devices

Table 1 – Support Equipment Used For Test

Model:	Description:	S/N	FCC ID#
N16Q2	Acer Aspire F5-573 series laptop computer	NXGD7AA004651 01FFD7600	PPD-QCNFA435

I/O Ports and Cables

Table 2 – EUT Port Termination's

I/O Port	Cable Type	Length	Connector	Termination
USB	Shielded	1 M	USB	SA or Charger

Table 3 – Host Port Termination's

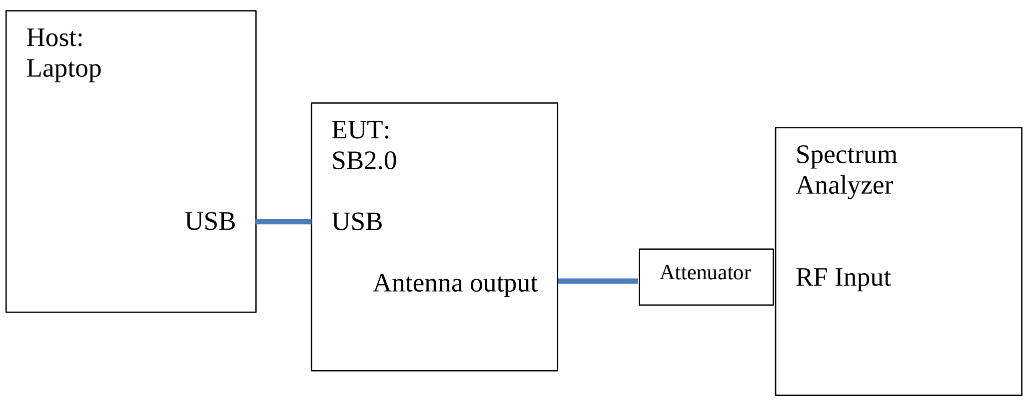
I/O Port	Cable Type	Length	Connector	Termination
USB	Shielded	1 M	USB	EUT

Test Setup Diagram

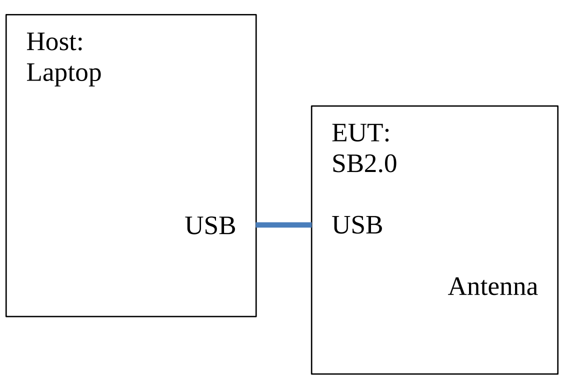
Following is the block diagram of the test setup.

Figure 1 – Test Setup Diagram

Conducted antenna port measurements



Radiated emissions measurements



Antenna Requirement

Stated in FCC 47 CFR §15.203:
"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section."

Stated in RSS-Gen Issue 5 (Section 6.8):
The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.
For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).
When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.
The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.

Table 4 – Antenna Requirement

Antenna used:	
Permanently attached antenna	Complies with requirement
Johanson Technology P/N:	2450AT18D0100E-AEC
Peak Gain:	1.5dBi

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79 Test Channels

Table 5 – Test Channels

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

Test Mode:
Power line conducted emissions
Antenna port conducted emissions
Transmitter Radiated emissions

The EUT is configured to transmit continuously (i.e., with a duty cycle of greater than or equal to 98 %) at the maximum power control level over a random symbol set.

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Restricted Bands

Frequency Band used 2400-2483.5 MHz

Table 6 – FCC Restricted Bands

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6
13.36-13.41			

Table 7 – RSS-Gen Restricted Frequency Bands

MHz	MHz	MHz	GHz
0.090 - 0.110	13.36 - 13.41	960 - 1427	9.0 - 9.2
0.495 - 0.505	16.42 - 16.423	1435 - 1626.5	9.3 - 9.5
2.1735 - 2.1905	16.69475 - 16.69525	1645.5 - 1646.5	10.6 - 12.7
3.020 - 3.026	16.80425 - 16.80475	1660 - 1710	13.25 - 13.4
4.125 - 4.128	25.5 - 25.67	1718.8 - 1722.2	14.47 - 14.5
4.17725 - 4.17775	37.5 - 38.25	2200 - 2300	15.35 - 16.2
4.20725 - 4.20775	73 - 74.6	2310 - 2390	17.7 - 21.4
5.677 - 5.683	74.8 - 75.2	2483.5 - 2500	22.01 - 23.12
6.215 - 6.218	108 - 138	2655 - 2900	23.6 - 24.0
6.26775 - 6.26825	149.9 - 150.05	3260 - 3267	31.2 - 31.8
6.31175 - 6.31225	156.52475 - 156.52525	3332 - 3339	36.43 - 36.5
8.291 - 8.294	156.7 - 156.9	3345.8 - 3358	Above 38.6
8.362 - 8.366	162.0125 - 167.17	3500 - 4400	
8.37625 - 8.38675	167.72 - 173.2	4500 - 5150	
8.41425 - 8.41475	240 - 285	5350 - 5460	
12.29 - 12.293	322 - 335.4	7250 - 7750	
12.51975 - 12.52025	399.9 - 410	8025 - 8500	
12.57675 - 12.57725	608 - 614		

AC Power Line Conducted Emissions

§15.207 Conducted limits.

(c) Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtaining their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

RSS-Gen 8.8 AC power-line conducted emissions limits

Unless stated otherwise in the applicable RSS, for radio apparatus that are designed to be connected to the public utility AC power network, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the range 150 kHz to 30 MHz shall not exceed the limits in table 4, as measured using a 50 μH / 50 Ω line impedance stabilization network. This requirement applies for the radio frequency voltage measured between each power line and the ground terminal of each AC power-line mains cable of the EUT.

For an EUT that connects to the AC power lines indirectly, through another device, the requirement for compliance with the limits in table 4 shall apply at the terminals of the AC power-line mains cable of a representative support device, while it provides power to the EUT. The lower limit applies at the boundary between the frequency ranges. The device used to power the EUT shall be representative of typical applications.

AC Power Line Conducted Emissions Limits

	Conducted limit (dBμV)	
Frequency of emission (MHz)	**Quasi-peak**	**Average**
0.15 – 0.5	66 to 56*	56 to 46*
0.5 - 5	56	46
5 - 30	60	50

* The level decreases linearly with the logarithm of the frequency.

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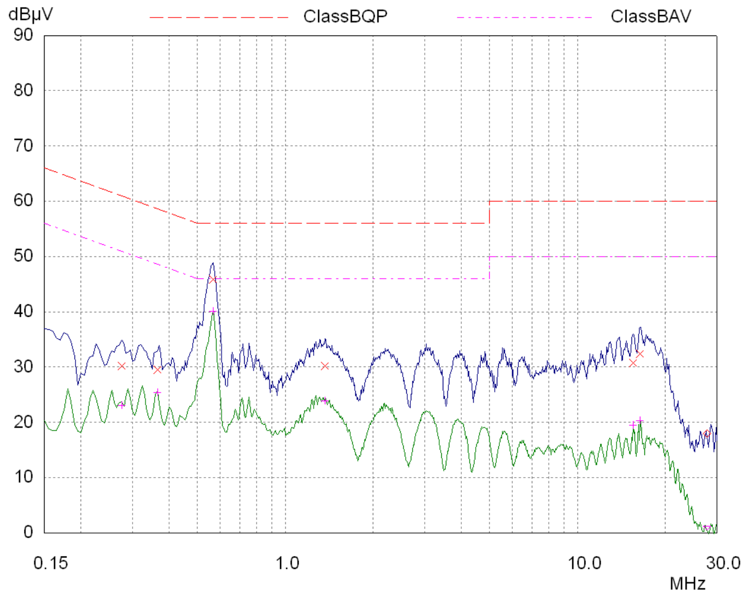
AC Power Line Conducted Data for Line

Figure 2 – Line Scan



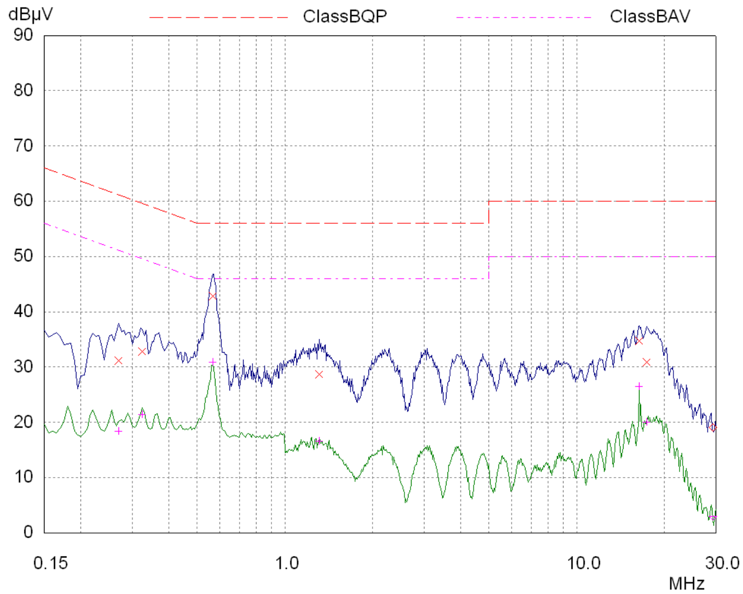
Blue Trace: Peak Measurement Green Trace: Average Measurement
Final Measurement: x = QP / + = AV at 2 second measurement time.

Table 8 – Line Scan Data

Frequency MHz	Level dBµV	Detector	Limit dBµV	Margin dB	Phase	PE
0.275	30.14	QP	60.97	30.83	L1	fl
0.365	29.56	QP	58.61	29.05	L1	fl
0.565	45.89	QP	56.00	10.11	L1	fl
1.37	30.16	QP	56.00	25.84	L1	fl
15.565	30.79	QP	60.00	29.21	L1	fl
16.41	32.42	QP	60.00	27.58	L1	fl
0.275	23.08	AV	50.97	27.89	L1	fl
0.365	25.36	AV	48.61	23.25	L1	fl
0.565	40.08	AV	46.00	5.92	L1	fl
1.37	23.90	AV	46.00	22.10	L1	fl
15.565	19.42	AV	50.00	30.58	L1	fl
16.41	20.26	AV	50.00	29.74	L1	fl

AC Power Line Conducted Data for Neutral

Figure 3 – Neutral Scan



Blue Trace: Peak Measurement Green Trace: Average Measurement
Final Measurement: x = QP / + = AV at 2 second measurement time.

Table 9 – Neutral Scan Data

Frequency MHz	Level dBµV	Detector	Limit dBµV	Margin dB	Phase	PE
0.27	31.13	QP	61.12	29.99	N	fl
0.325	32.76	QP	59.58	26.82	N	fl
0.565	42.89	QP	56.00	13.11	N	fl
1.31	28.61	QP	56.00	27.39	N	fl
16.455	34.74	QP	60.00	25.26	N	fl
17.385	30.83	QP	60.00	29.17	N	fl
0.27	18.31	AV	51.12	32.81	N	fl
0.325	21.40	AV	49.58	28.18	N	fl
0.565	30.82	AV	46.00	15.18	N	fl
1.31	16.52	AV	46.00	29.48	N	fl
16.455	26.50	AV	50.00	23.50	N	fl
17.385	20.00	AV	50.00	30.00	N	fl

Number of Hopping Frequencies Used

§15.247 (a) (1) (iii)

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

RSS-247 5.1 (d)

FHSs operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

ANSI C63.10-2013
7.8.3 Number of hopping frequencies
The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a) Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
b) RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
c) VBW ≥ RBW.
d) Sweep: Auto.
e) Detector function: Peak.
f) Trace: Max hold.
g) Allow the trace to stabilize.

It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies. Compliance of an EUT with the appropriate regulatory limit shall be determined for the number of hopping channels. A plot of the data shall be included in the test report.

Table 10 – Number of Hopping Frequencies Used

Mode	GFSK	π/4DQPSK	8DPSK
Number of hopping frequencies	79	79	79

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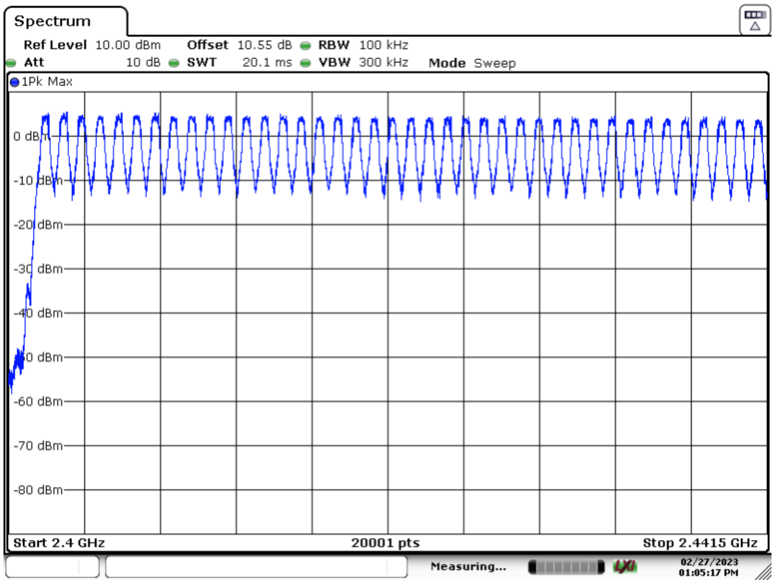
GFSK – 79 USED



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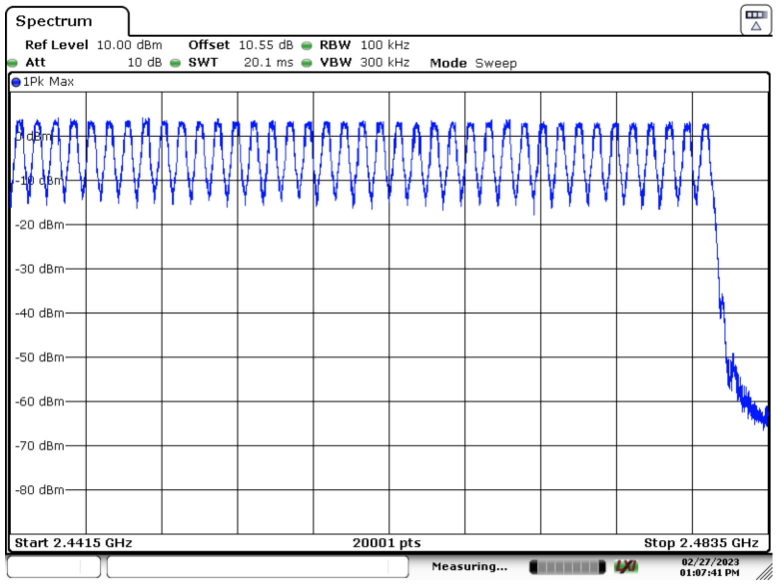

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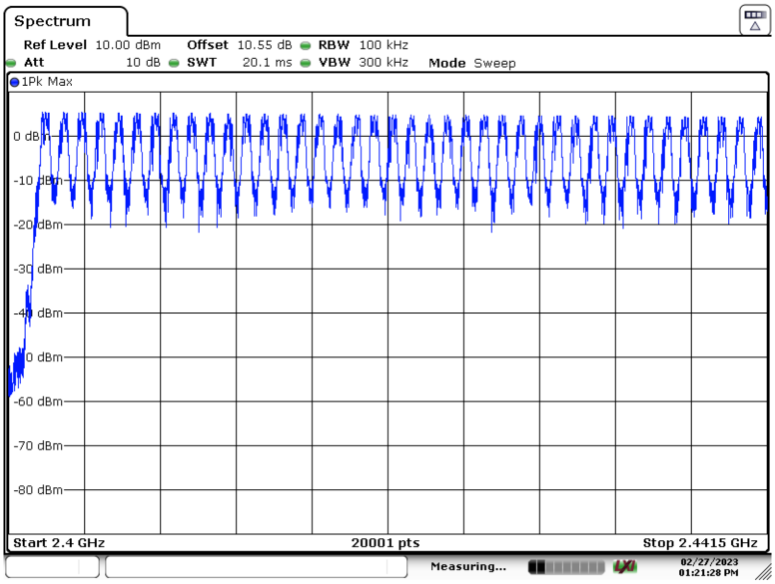
π/4DQPSK – 79 USED



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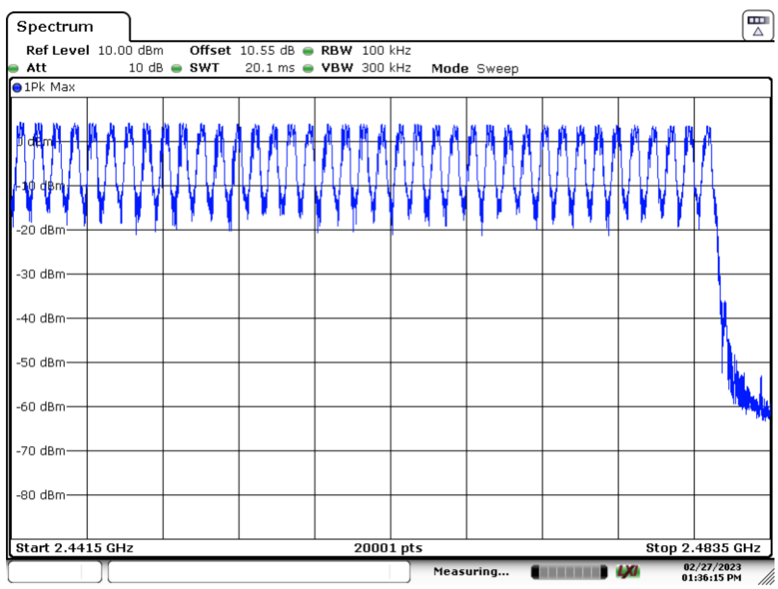

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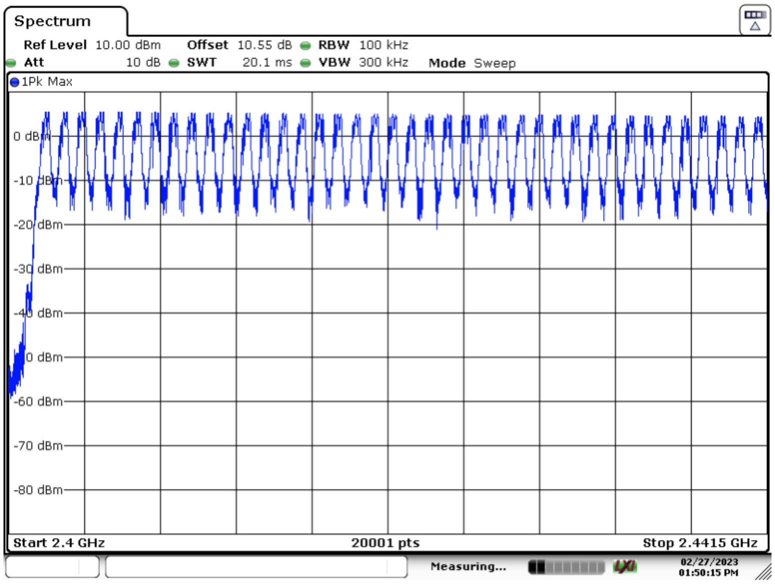
8DPSK – 79 USED



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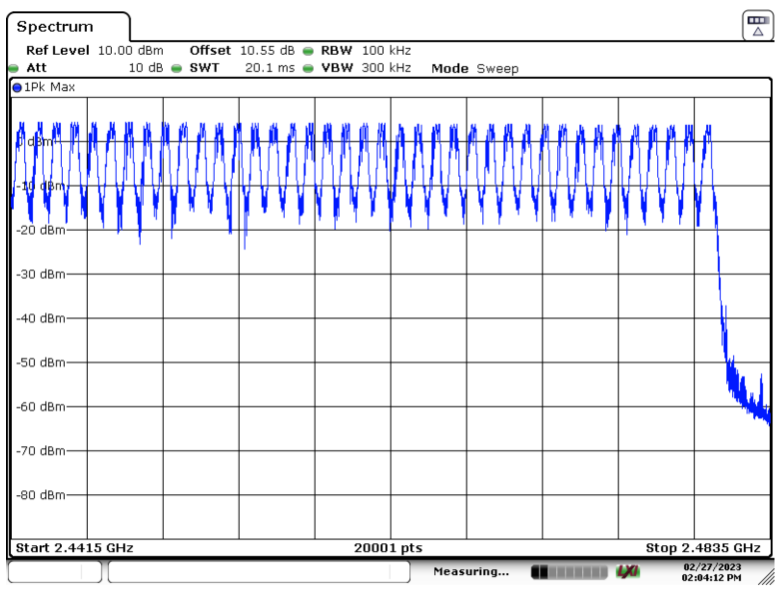

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Dwell Time on Each Channel

§15.247 (a) (1) (iii)

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

RSS-247 5.1 (d)

FHSs operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

ANSI C63.10-2013

7.8.4 Time of occupancy (dwell time)

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a) Span: Zero span, centered on a hopping channel.
b) RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
c) Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
d) Detector function: Peak.
e) Trace: Max hold.

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

(Number of hops in the period specified in the requirements) =
(number of hops on spectrum analyzer) × (period specified in the requirements / analyzer sweep time)

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the requirements. If the number of hops in a specific time varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation.

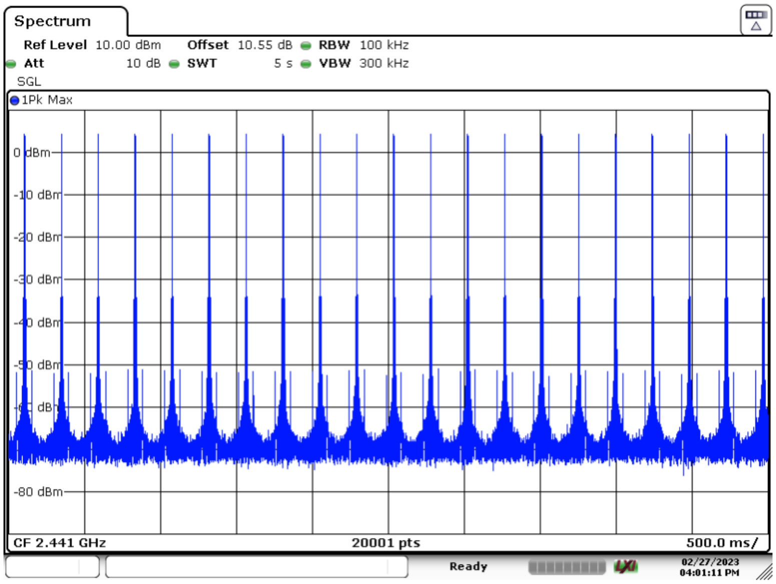
The measured transmit time and time between hops shall be consistent with the values described in the operational description for the EUT.

Table 11 – Dwell Time on Each Channel

Mode	GFSK	π/4DQPSK	8DPSK
Number of transmissions in 31.6 seconds	132.72	132.72	132.72
Length of transmission (msec)	2.9115ms	2.9055ms	2.909ms
Result (transmissions * length msec)	386.41428ms	385.61796ms	386.08248ms
Limit	400	400	400
	Pass	Pass	Pass

GFSK

79 channels * 0.4sec = 31.6sec, 31.6s / 5s = 6.32
21 (transmissions / 5sec) * 6.32 = 132.72 transmissions in 31.6 sec
132.72 * 2.9115ms (width) = 386.41428ms



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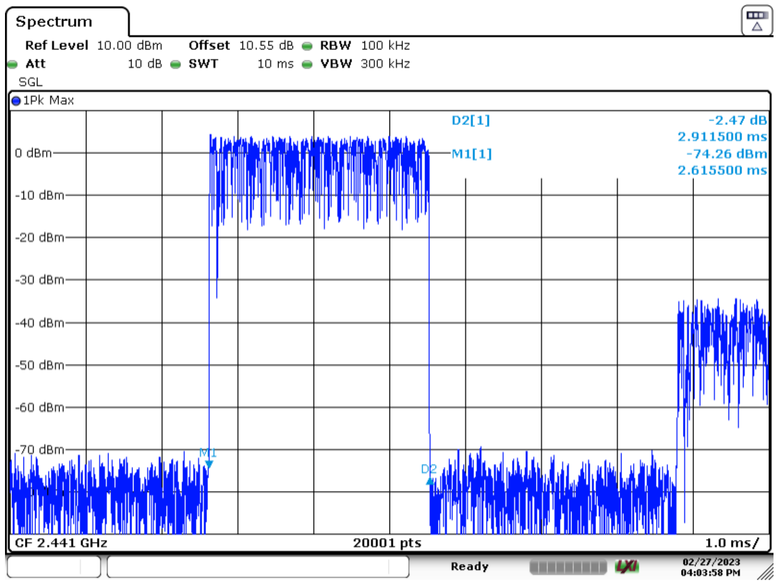

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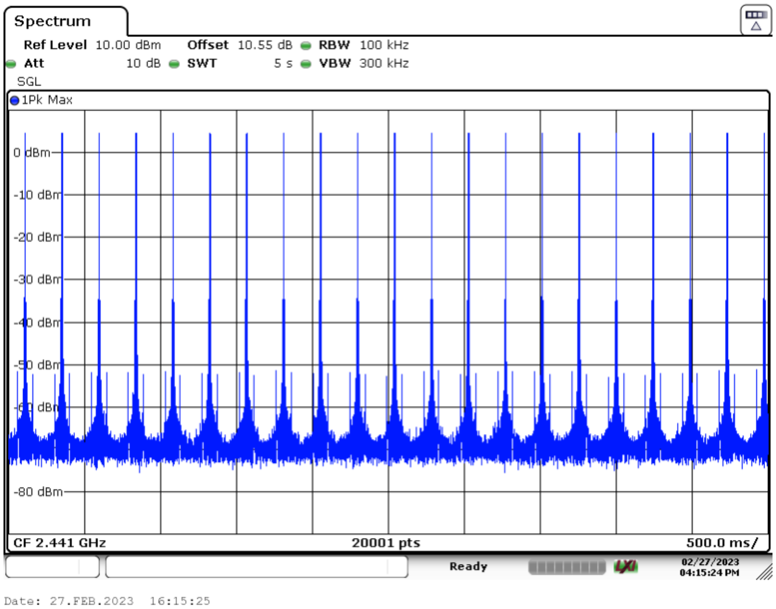
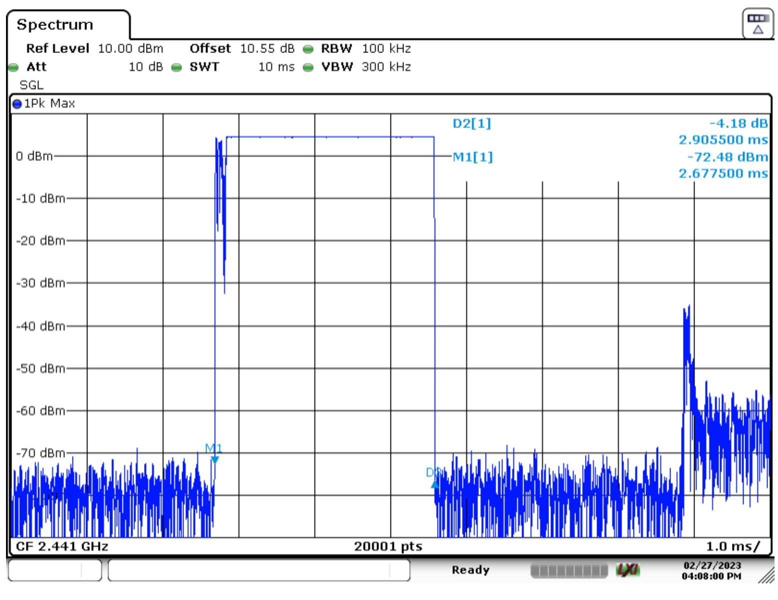
π/4DQPSK

79 channels * 0.4sec = 31.6sec, 31.6s / 5s = 6.32
21 (transmissions / 5sec) * 6.32 = 132.72 transmissions in 31.6 sec
132.72 * 2.9055ms (width) = 385.61796ms





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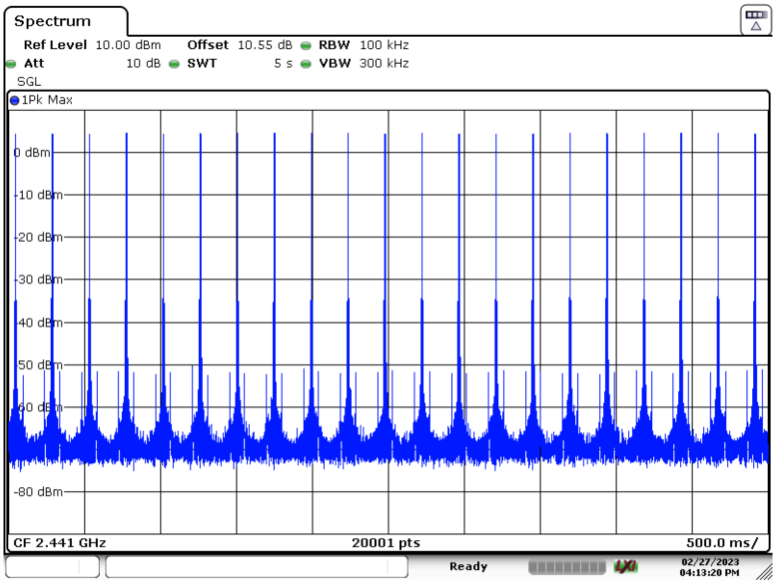
8DPSK

79 channels * 0.4sec = 31.6sec, 31.6s / 5s = 6.32
21 (channels / 5sec) * 6.32 = 132.72 transmissions in 31.6 sec
132.72 * 2.909ms (width) = 387.01152ms



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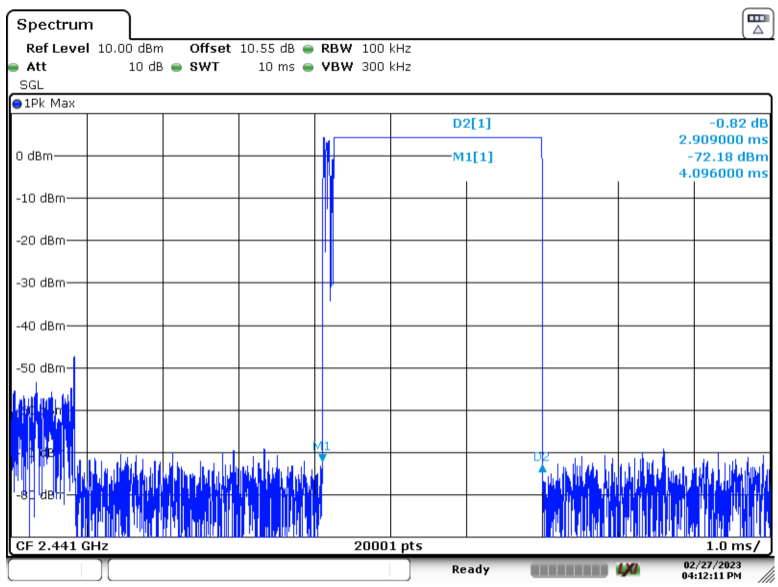

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Hopping Channel Separation

§15.247 (a) (1)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

RSS-247 5.1 (b)

FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400-2483.5 MHz 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 that the systems operate with an output power no greater than 0.125 W.

ANSI C63.10-2013
7.8.2 Carrier frequency separation
The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

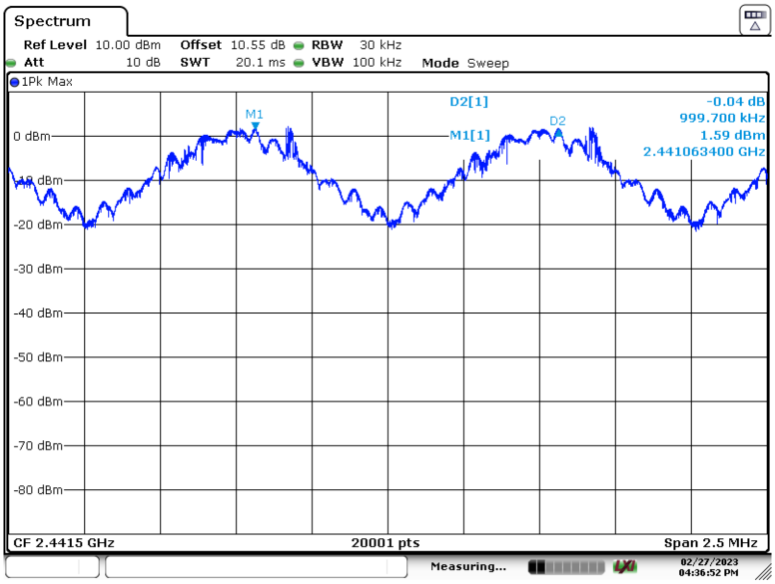
a) Span: Wide enough to capture the peaks of two adjacent channels.
b) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
c) Video (or average) bandwidth (VBW) ≥ RBW.
d) Sweep: Auto.
e) Detector function: Peak.
f) Trace: Max hold.
g) Allow the trace to stabilize.

Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.

Table 12 – Hopping Channel Separation

Mode	GFSK	π/4DQPSK	8DPSK
Hopping Channel Separation	999.7 kHz	999.7 kHz	999.45 kHz

GSFK



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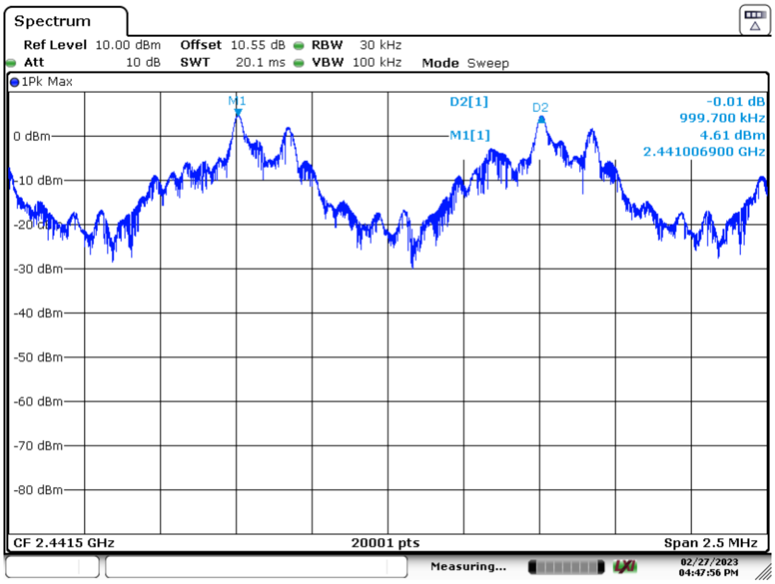
π/4DQPSK



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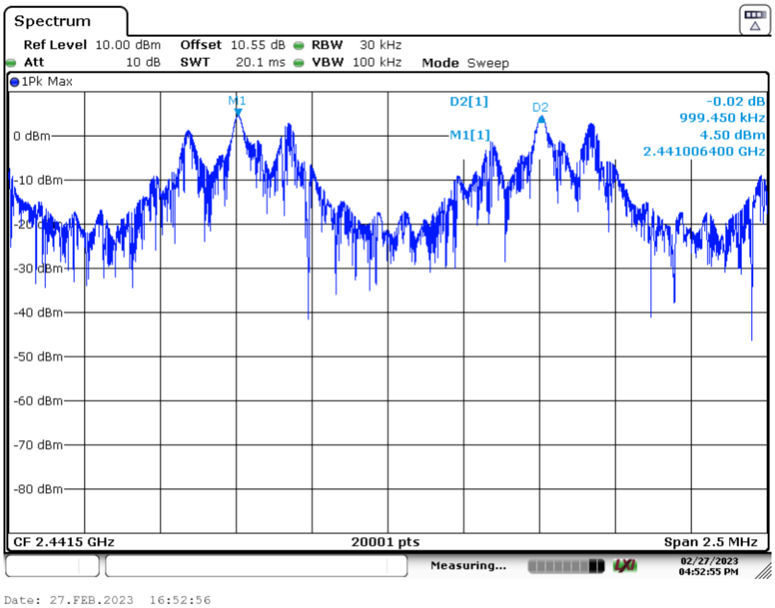
8DPSK



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Maximum Peak Output Power

§15.247 (b)(1)

The maximum peak conducted output power of the intentional radiator shall not exceed the following:
(1) For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 nonoverlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

RSS-247 5.4 (b)

For FHSs operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

ANSI C63.10-2013
7.8.5 Output power test procedure for frequency-hopping spread-spectrum (FHSS) Devices(73)
This is an RF-conducted test to evaluate maximum peak output power. Use a direct connection between the antenna port of the unlicensed wireless device and the spectrum analyzer, through suitable attenuation. The hopping shall be disabled for this test:

a) Use the following spectrum analyzer settings:
    1) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel.
    2) RBW > 20 dB bandwidth of the emission being measured.
    3) VBW ≥ RBW.
    4) Sweep: Auto.
    5) Detector function: Peak.
    6) Trace: Max hold.
b) Allow trace to stabilize.
c) Use the marker-to-peak function to set the marker to the peak of the emission.
d) The indicated level is the peak output power, after any corrections for external attenuators and cables.
e) A plot of the test results and setup description shall be included in the test report.

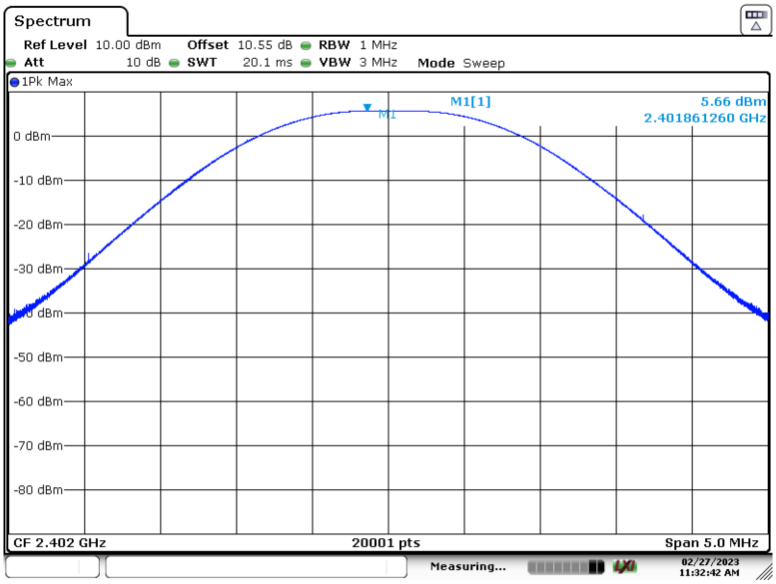
NOTE—A peak responding power meter may be used, where the power meter and sensor system video bandwidth is greater than the occupied bandwidth of the unlicensed wireless device, rather than a spectrum analyzer.

Table 13 – Maximum Peak Output Power

Maximum Peak Output Power Mode	GFSK	π/4DQPSK	8DPSK
2402 MHZ	5.66 dBm	5.58 dBm	5.74 dBm
2441 MHz	4.63 dBm	4.57 dBm	4.59 dBm
2480 MHz	3.79 dBm	3.86 dBm	3.77 dBm

GFSK

Low



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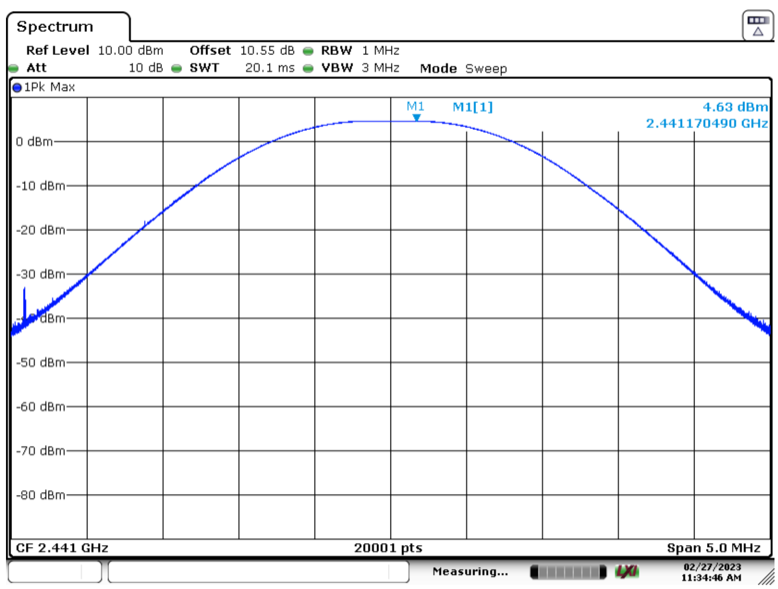
Mid



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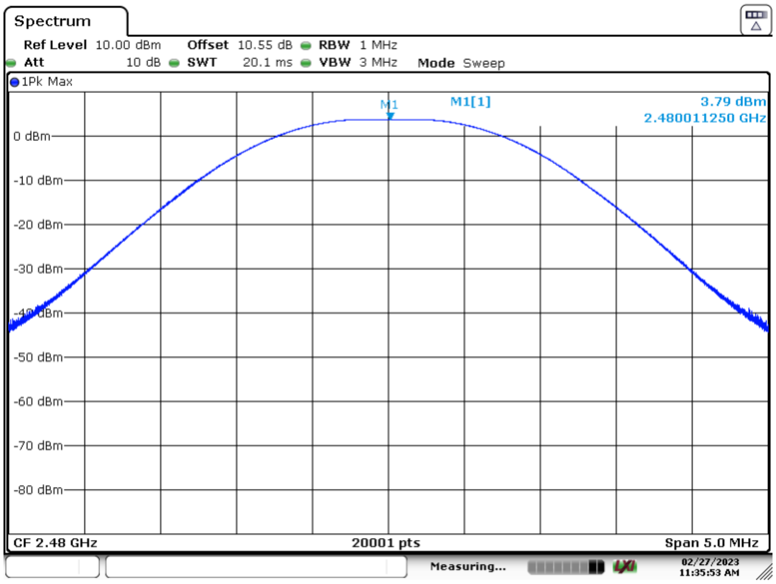
GFSK

High



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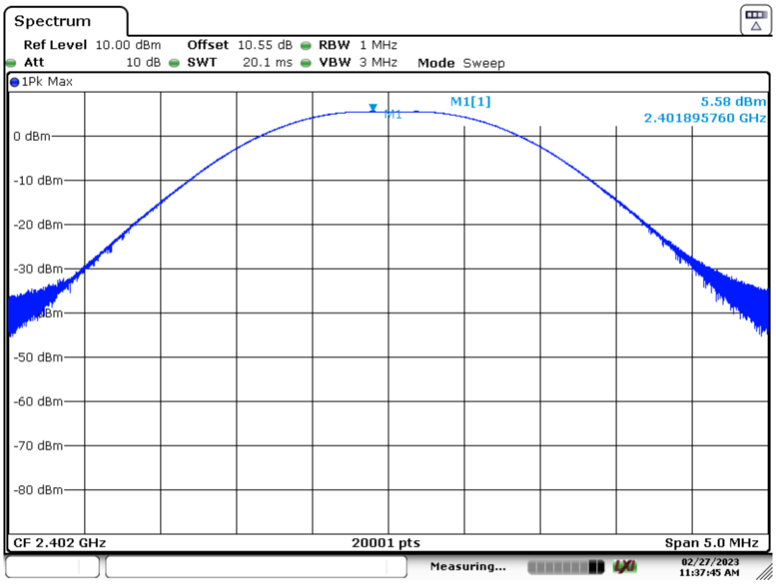
π/4DQPSK

Low



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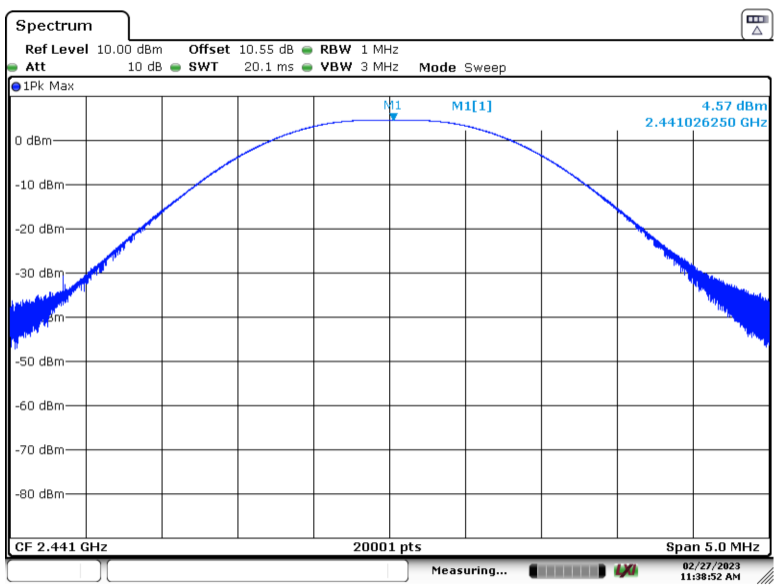

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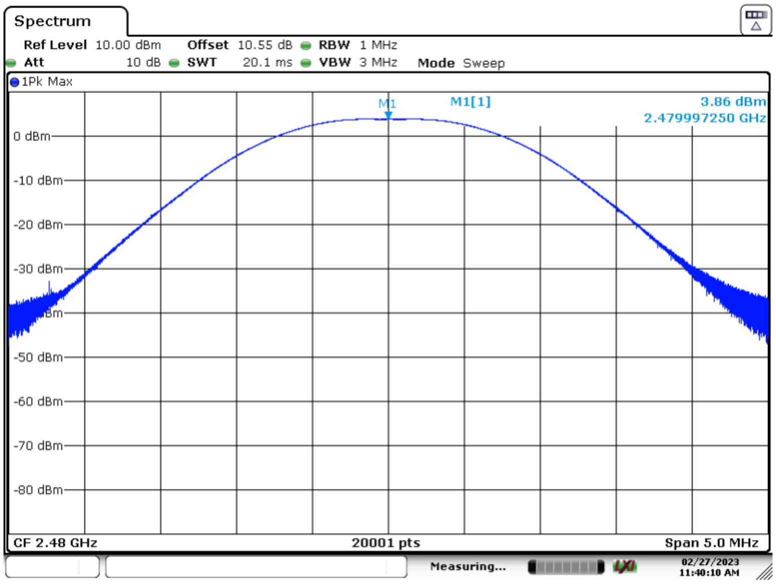
π/4DQPSK

High



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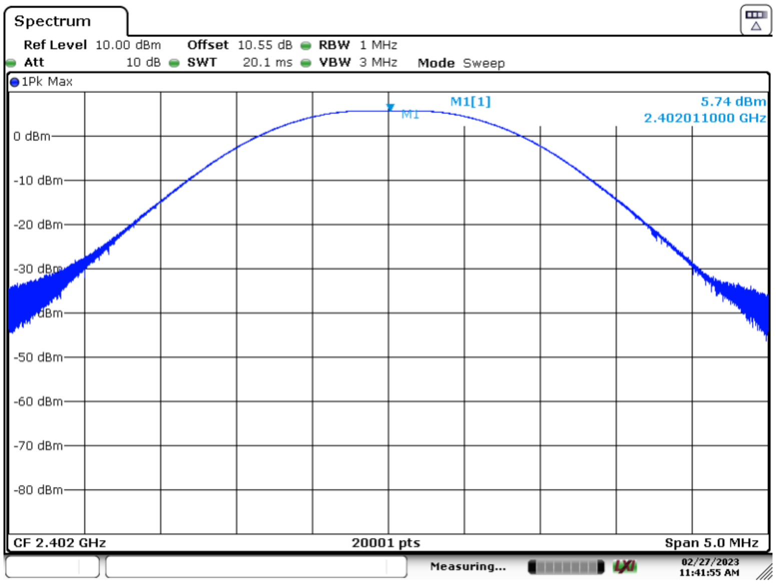
8DPSK

Low



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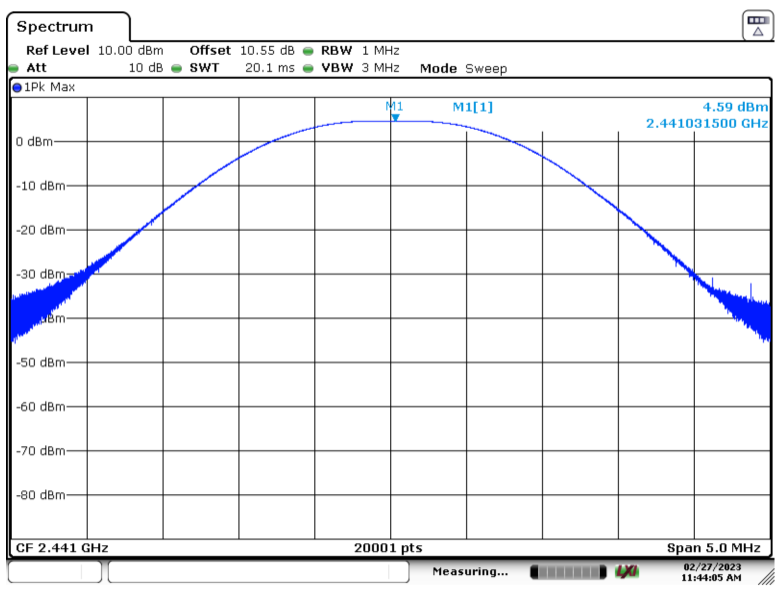
Mid



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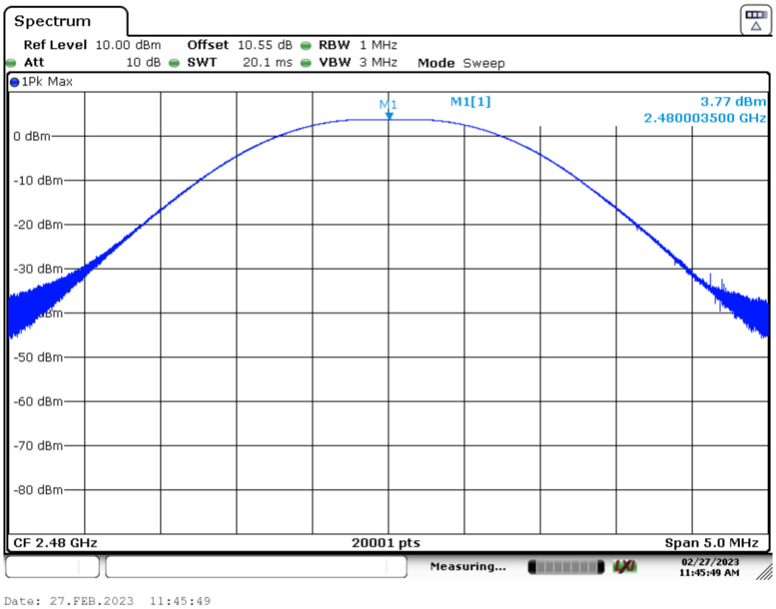
8DPSK

High



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Equivalent Isotropically Radiated Power

ANSI C63.10 G.3 Power approach (logarithmic terms)

ERP/EIRP = $P_T + G_T - L_C$ (G.3)

where

ERP/EIRP is the equivalent (or effective) radiated power [in same units as P_T, typically dBW, dBm, or power spectral density (psd)], relative to either a dipole antenna (ERP) or an isotropic antenna (EIRP)

P_T is the transmitter output power, in dBW, dBm, or psd (power over a specified reference bandwidth)

G_T is the gain of the transmitting antenna, in dBd (ERP) or dBi (EIRP)

L_C is the signal attenuation in the connecting cable between the transmitter and the antenna, in dB

G.4 Relationship between ERP and EIRP

The numeric gain of an ideal half-wave dipole antenna is 1.64, and the numeric gain of an ideal isotropic antenna is 1.0. The gain of an ideal half-wave dipole antenna relative to an ideal isotropic antenna is [10 log (1.64)] or 2.15 dBi. Therefore, if the antenna gain in dBd is unknown, it may be determined from the gain in dBi via the following relationship in Equation (G.4):

G_T(dBd) = G_T(dBi) – 2.15 dB (G.4)

Alternatively, the EIRP may be determined from Equation (G.3) and then converted to ERP based on the maximum antenna gain relationship by applying Equation (G.5):

ERP = EIRP – 2.15dB (G.5)

Similarly, the EIRP may be determined from the ERP as follows in Equation (G.6):

EIRP =ERP +2.15dB (G.6)

The antenna used is a 2.45 GHz SMD Antenna from Johanson Technology P/N: 2450AT18D0100E-AEC with 1.5 dBi peak gain.

Table 14 – Equivalent Isotropically Radiated Power

EIRP =	5.74dBm + 1.5dBi - 0 = 7.24 dBm =	0.0052966344 Watts

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Band Edge Measurement

§15.247 (d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

RSS-247 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

ANSI C63.10-2013
7.8.6 Band-edge measurements for RF conducted emissions
For band-edge measurements, use the band-edge procedure in 6.10. Band-edge measurements shall be tested both on single channels, and with the EUT hopping.

6.10 Band-edge testing
The following procedure shall be used when band-edge measurements are required. Table A.2 gives a useful guide for determining which band-edge procedure shall be used for each type of unlicensed wireless device.
6.10.1 Band-edge data reporting requirements
These reporting requirements are applicable to all devices for which band-edge measurements are required. On each operating frequency measured, band-edge emissions shall be reported by providing plots of the measuring instrument display. The axes, the scale units per division, and the limit shall be clearly labeled in the test report. Tabular data are not suitable for reporting band-edge emissions.

Table A.2

#	FCC rule section(s)	Description/application (do = ditto)	Selected requirement(s) and/or measurand(s)	ANSI C63.10 subclause(s)	Remarks
59	15.247	Frequency hopping and digitally modulated devices in 902 MHz to 928 MHz, 2400 MHz to 2483.5 MHz, and 5725 MHz to 5850 MHz	DTS procedure, multioutput devices, beamforming, and so on.	7.7, Clause 11; Clause 13; Clause 14, 6.10.5/6.10.6 for 2400 MHz to 2483.5 MHz band	Band-edge occupied BW: Minimum 6 dB BW is 500 kHz for DTS devices. Band-edge attenuation: –20 dB or –30 dB in a 100 kHz BW relative to highest fundamental channel PSD in 100 kHz (based on power measurement method used). Band edge: 15.209 applies to adjacent and nearby restricted bands for 2400 MHz to 2483.5 MHz band operations.

6.10.5 Restricted-band band-edge measurements

These procedures are applicable for determining compliance at band edges of restricted bands.

6.10.5.1 Test setup

Restricted-band band-edge tests shall be performed as radiated measurements, on a test site meeting the specifications in 5.2 at the measurement distances specified in 5.3.(57)

The instrumentation shall meet the requirements in 4.1.1 using the bandwidths and detectors specified in 4.1.4.2. Considering the requirements of 5.8, the antenna(s) shall be connected to the antenna ports. When performing radiated measurements, the measurement antenna(s) shall meet the specifications in 4.3. The EUT shall be connected to an antenna and operated at the highest power settings following procedures in 6.3, and the relevant procedure in 6.4, 6.5, or 6.6.

6.10.5.2 Test methodology

The following test methodology shall be used for the restricted-band band-edge measurements:

a) For frequency-hopping systems, the hopping shall be turned OFF during this test.
b) Configure the spectrum analyzer settings as described in step e) (be sure to enter all losses between the unlicensed wireless device output and the spectrum analyzer).
c) Set the unlicensed wireless device to the lowest frequency channel.
d) Set the unlicensed wireless device to operate at maximum output power and 100% duty cycle, or equivalent “normal mode of operation” as specified in 6.10.3.
e) Perform the test as follows:
    1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.
    2) Reference level offset: Corrected for gains and losses of test antenna factor, preamp gain and cable loss, so as to indicate field strength, in units of dBμV/m at 3 m, directly on the instrument display. Alternatively, the reference level offset may be set to zero and calculations shall be provided showing the conversion of raw measured data to the field strength in dBμV/m at 3 m.
    3) Reference level: As required to keep the signal from exceeding the maximum spectrum analyzer input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.
    4) Attenuation: Auto (at least 10 dB preferred).
    5) Sweep time: Coupled.
    6) Resolution bandwidth:
        i) Below 150 kHz: 300 Hz or CISPR 200 Hz (CISPR 200 Hz required if using QP detector)
        ii) 150 kHz to 30 MHz: 10 kHz or CISPR 9 kHz, (CISPR 9 kHz required if using QP detector)
        iii) 30 MHz to 1000 MHz: 100 kHz or CISPR 120 kHz, (CISPR 120 kHz required if using QP detector)
        iv) Above 1 GHz: 1 MHz
    7) Video bandwidth:
        i) VBW for Peak, Quasi-peak, or Average Detector Function: 3 × RBW
        ii) VBW for alternative average measurements using peak detector function; refer to 4.1.4.2.3
    8) Detector (unless specified otherwise):
        i) QP below 1 GHz (however, peak detector measurements may be used to determine compliance with QP requirements).
        ii) Peak and average above 1 GHz
    9) Trace: Max hold for final measurement; a combination of two traces, clear-write and max hold, is recommended for maximizing the emission.
f) Using the applicable procedure(s) of 6.4, 6.5, or 6.6, orient the EUT and measurement antenna positions to produce the highest emission level.

g) Set the marker on the emission at the restricted band edge, or on the highest modulation product within the restricted band, if this level is greater than that at the band edge.
h) Repeat step d) through step g) for every applicable modulation.
i) Repeat step d) through step h) for the highest gain of each type of antenna to be used with the EUT.
j) Set the EUT to the highest frequency channel and repeat step d) through step i).
k) The band-edge measurement shall be reported by providing plot(s) of the measuring instrument display; the axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

6.10.6 Marker-delta method

6.10.6.1 General requirements

In making radiated band-edge measurements, there can be a problem obtaining meaningful data because a measurement instrument that is tuned to a band-edge frequency might also capture some in-band signals when using the specified RBW. In an effort to compensate for this problem, the following technique has been developed for determining band-edge compliance.

This method may be used only when the edge of the occupied bandwidth of the emission falls within two "standard bandwidths" of the restricted-band band-edge frequency, where "standard bandwidth" is the RBW required by the measurement procedure (generally, the "standard bandwidth," i.e., reference bandwidth, is 10 kHz for measurements below 30 MHz, 100 kHz for measurements between 30 MHz and 1000 MHz, and 1 MHz for measurements above 1 GHz). For this purpose, the occupied bandwidth is based on the 99% power bandwidth. Detailed explanations and examples of these constraints are given subsequently.

For example, for band-edge measurements in the restricted band that begins at 2483.5 MHz, a measurement bandwidth of 1 MHz is required. Therefore the "delta" technique may be used if the upper frequency edge of the occupied bandwidth of the fundamental emission is greater than or equal to 2481.5 MHz (2 MHz removed from the band edge). If the upper frequency edge of the occupied bandwidth is less than 2481.5 MHz, then radiated emissions within the restricted band shall be measured in the conventional manner. The report shall include photographs or plots of the measuring instrument display, with the lower and/or upper frequency limit(s), as applicable, clearly labeled.

Additionally this method may be used only when the emission being measured falls within two "standard bandwidths" of the restricted band band-edge frequency. For example, for band-edge measurements in the restricted band that begins at 2483.5 MHz, a measurement bandwidth of 1 MHz is required. Therefore the "delta" technique may be used if the restricted-band emission is between 2483.5 MHz and 2485.5 MHz. If the restricted-band emission is at a frequency greater than 2485.5 MHz, then radiated emissions within the restricted band shall be measured in the conventional manner.

6.10.6.2 Marker-delta procedure

The following procedure shall be used for the marker-delta method:

a) Perform an in-band field strength measurement of the fundamental emission using the RBW and detector function required for the frequency being measured. For example, for a device operating in the 902 MHz to 928 MHz band, use a 120 kHz RBW with a CISPR QP detector (a peak detector with 100 kHz RBW alternatively may be used). For transmitters operating above 1 GHz, use a 1 MHz RBW, a 3 MHz VBW, and a peak detector, as required.(See 47 CFR 15.35) Repeat the measurement with an average detector (or alternatively, a peak detector and reduced VBW). For pulsed emissions, other factors shall be included; see 4.1.4.2.6.

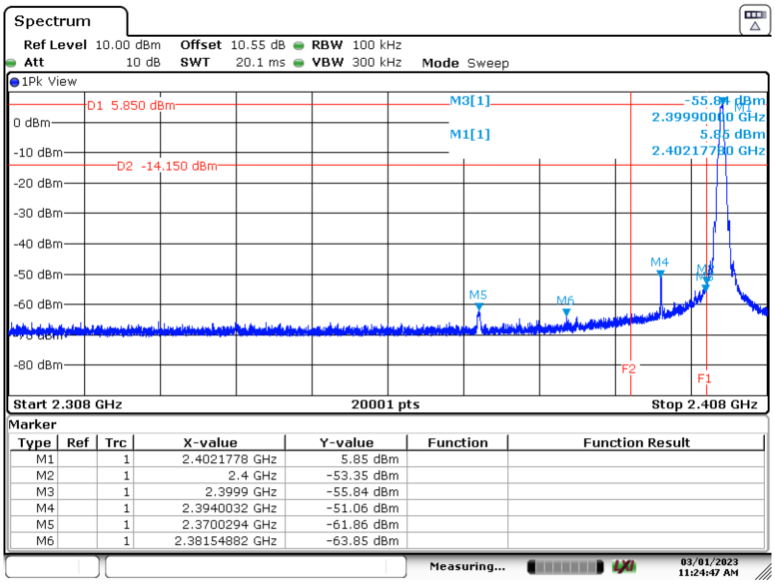
b) Choose an EMI receiver or spectrum analyzer span that encompasses both the peak of the fundamental emission and the band-edge emission under investigation. Set the instrument RBW to 1% of the total span (but never less than 30 kHz), with a VBW equal to or greater than three times the RBW. Record the peak levels of the fundamental emission and the relevant band-edge emission (i.e., run several sweeps in peak hold mode). Observe the stored trace and measure the amplitude delta between the peak of the fundamental and the peak of the band-edge emission. This is not an absolute field strength measurement; it is only a relative measurement to determine the amount by which the emission drops at the band edge relative to the highest fundamental emission level.

c) Subtract the delta measured in step b) from the field strengths measured in step a). The resulting field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge emissions compliance, where required.(See 47 CFR 15.205 or RSS-Gen.)

RF Conducted Emissions Plots

GFSK – RF conducted measurement

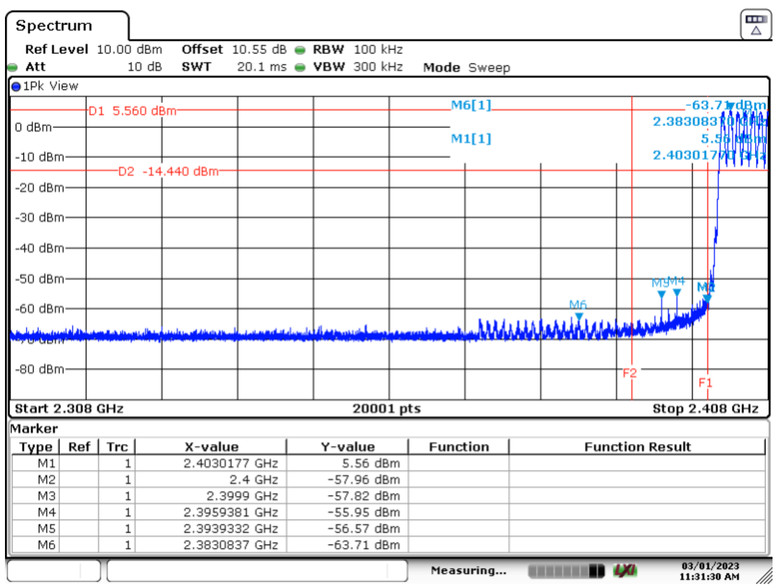
Low not hopping



Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4021778 GHz	5.85 dBm		
M2		1	2.4 GHz	-53.35 dBm		
M3		1	2.3999 GHz	-55.84 dBm		
M4		1	2.3940032 GHz	-51.06 dBm		
M5		1	2.3700294 GHz	-61.86 dBm		
M6		1	2.38154882 GHz	-63.85 dBm		

Date: 1.MAR.2023 11:24:47

Low hopping

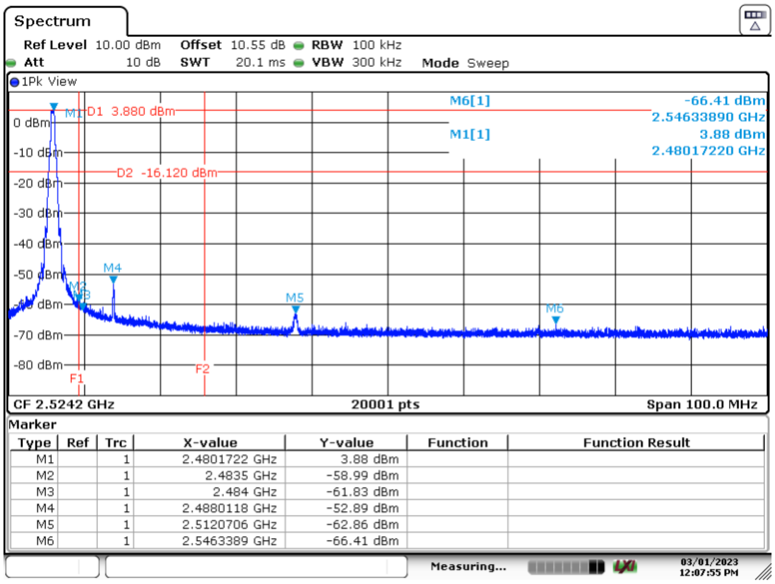


Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4030177 GHz	5.56 dBm		
M2		1	2.4 GHz	-57.96 dBm		
M3		1	2.3999 GHz	-57.82 dBm		
M4		1	2.3959381 GHz	-55.95 dBm		
M5		1	2.3939332 GHz	-56.57 dBm		
M6		1	2.3830837 GHz	-63.71 dBm		

Date: 1.MAR.2023 11:31:30

GFSK – RF conducted measurement

High not hopping



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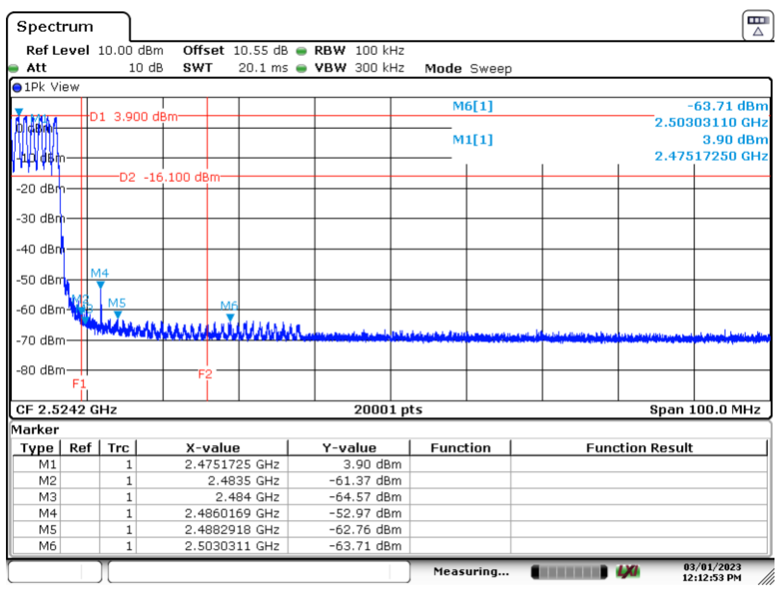
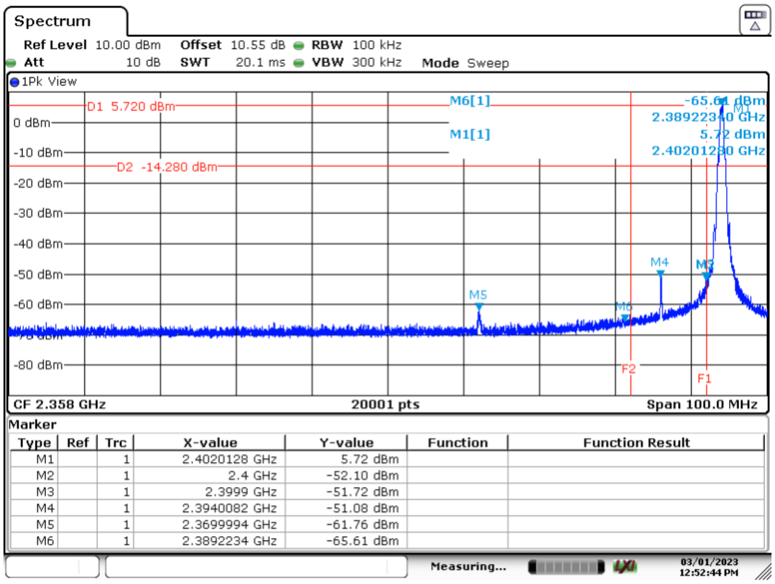


Date: 1.MAR.2023 12:12:53

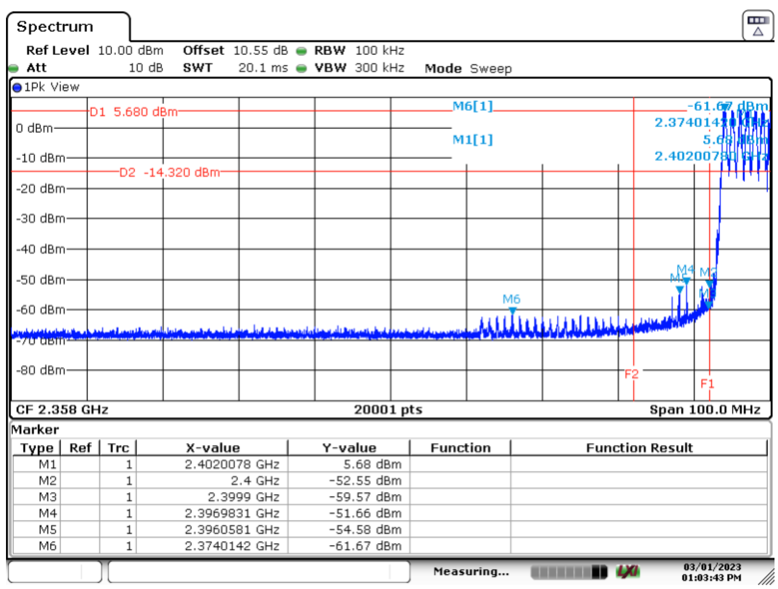
π/4DQPSK – RF conducted measurement

Low not hopping



Date: 1.MAR.2023 12:52:45

Low hopping



Date: 1.MAR.2023 13:03:44

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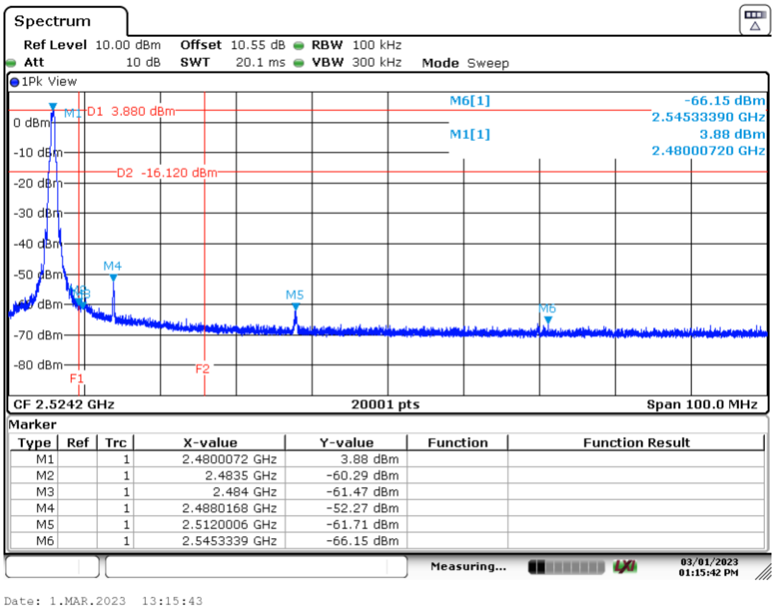
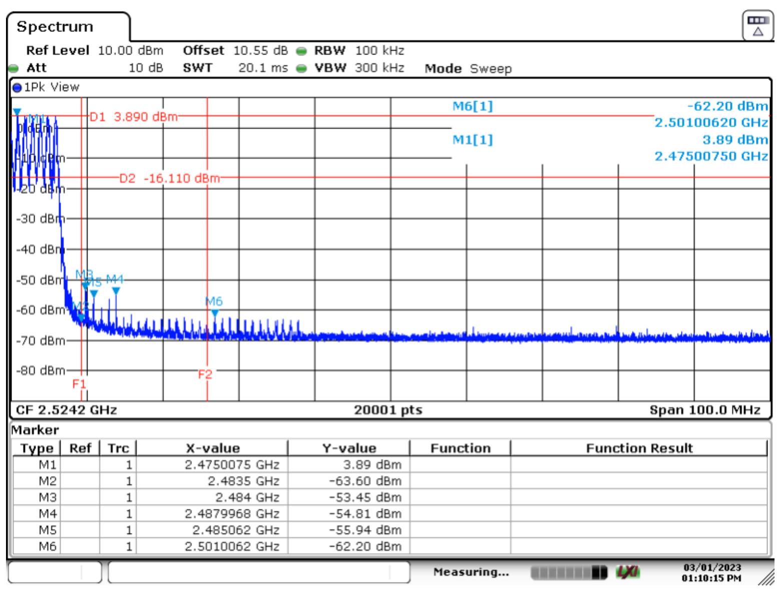
π/4DQPSK – RF conducted measurement

High not hopping

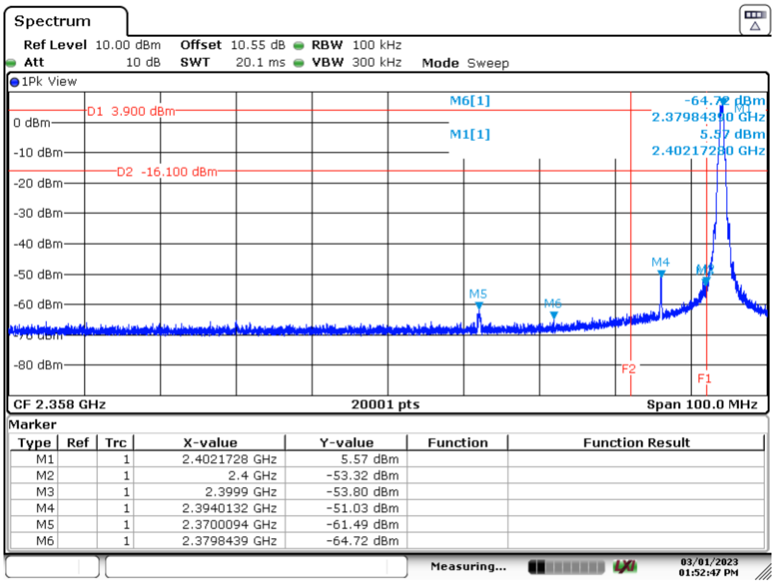


High hopping



8DPSK – RF conducted measurement

Low not hopping



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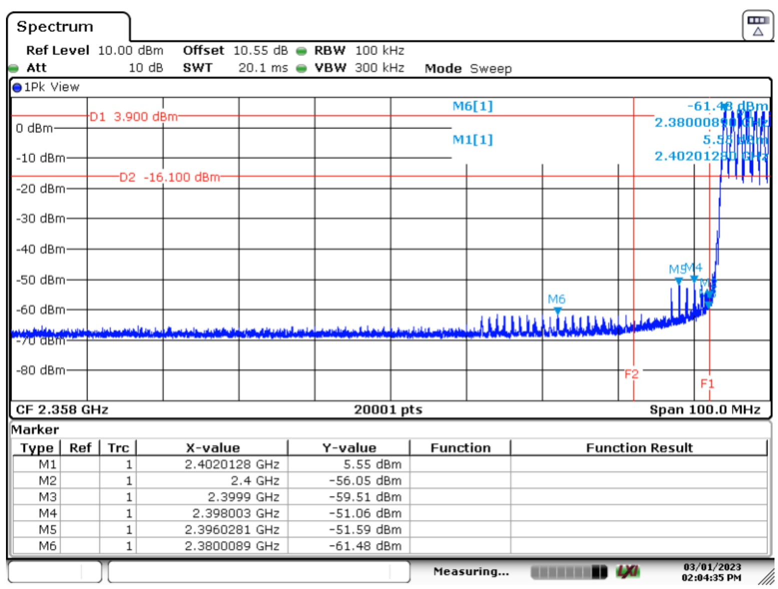
Low hopping



Date: 1.MAR.2023 14:04:36

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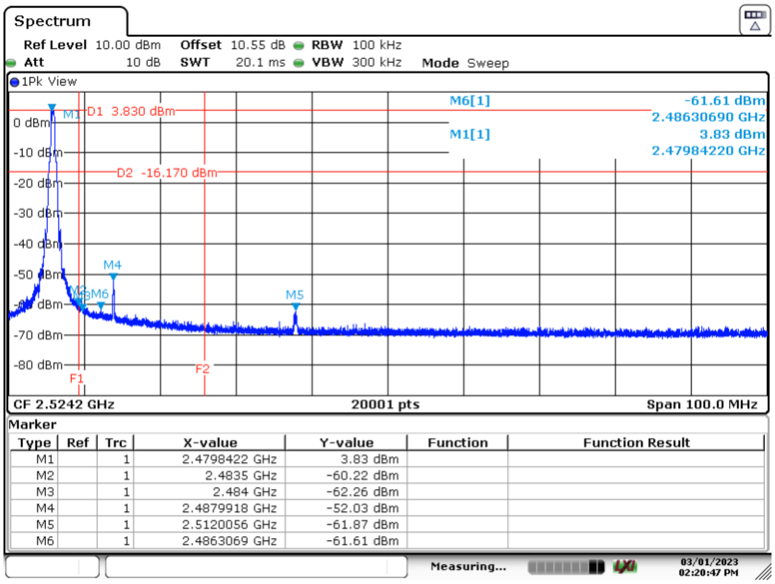
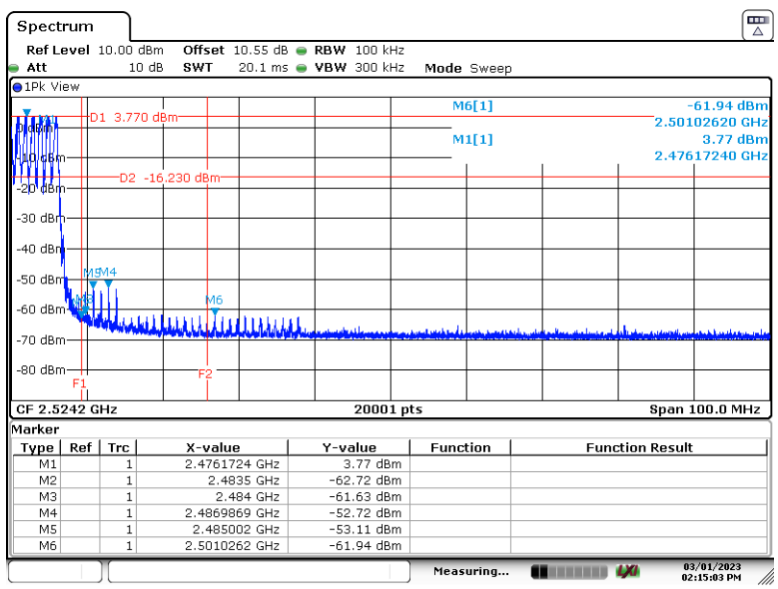
8DPSK – RF conducted measurement

High not hopping



Date: 1.MAR.2023 14:20:47

High hopping



Date: 1.MAR.2023 14:15:03

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Radiated Emissions

Transmitter Emission

§15.209 Radiated emission limits; general requirements.

(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

(b) In the emission table above, the tighter limit applies at the band edges.

(c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

(d) The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 990 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

(e) The provisions in §§15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part. i.e. When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements).

(f) In accordance with §15.33(a), in some cases the emissions from an intentional radiator must be measured to beyond the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator because of the incorporation of a digital device. If measurements above the tenth harmonic are so required, the radiated emissions above the tenth harmonic shall comply with the general radiated emission limits applicable to the incorporated digital device, as shown in §15.109 and as based on the frequency of the emission being measured, or, except for emissions contained in the restricted frequency bands shown in §15.205, the limit on spurious emissions specified for the intentional radiator, whichever is the higher limit. Emissions which must be measured above the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator and which fall within the restricted bands shall comply with the general radiated emission limits in §15.109 that are applicable to the incorporated digital device.

(g) Perimeter protection systems may operate in the 54-72 MHz and 76-88 MHz bands under the provisions of this section. The use of such perimeter protection systems is limited to industrial, business and commercial applications.

RSS-Gen 8.9 Transmitter Emission Limits

Except where otherwise indicated in the applicable RSS, radiated emissions shall comply with the field strength limits shown in table 5 and table 6. Additionally, the level of any transmitter unwanted emission shall not exceed the level of the transmitter's fundamental emission.

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RSS-Gen Table 5 – General field strength limits at frequencies above 30 MHz

Frequency (MHz)	Field strength (µV/m at 3 m)
30 – 88	100
88 – 216	150
216 – 960	200
Above 960	500

RSS-Gen Table 6 – General field strength limits at frequencies below 30 MHz

Frequency	Magnetic field strength (H-Field) (µA/m)	Measurement distance (m)
9 - 490 kHz [1]	6.37/F (F in kHz)	300
490 - 1705 kHz	63.7/F (F in kHz)	30
1.705 - 30 MHz	0.08	30

Note 1: The emission limits for the ranges 9-90 kHz and 110-490 kHz are based on measurements employing a linear average detector.

Report of Measurements Radiated Data

Exploratory radiated emissions measurements of the transmitter frequencies were made to determine the maximum transmit level of the EUT. All frequencies were searched for any emissions from the EUT.

The EUT was tested in all 3 orthogonal axes to determine the orientation that produced the maximum emission levels. The X axis was found to produce the maximum emission level. This orientation was used to test for radiated emissions.

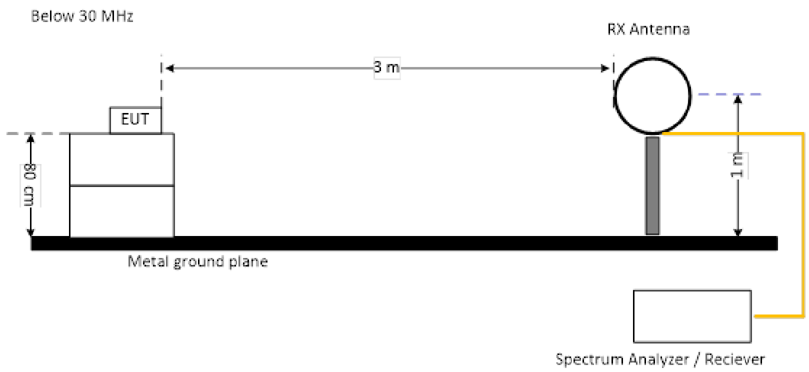
Radiated emissions measurements were performed from 9 kHz to 30 MHz at 3-meter distance. The loop antenna was placed at 1-meter height and was rotated about its vertical axis. The EUT was placed on the test table at 0.8 meter high and also rotated 360 degrees in front of the measurement antenna and tested in all 3 orthogonal axes. **No emissions were observed from the EUT in this frequency range.**

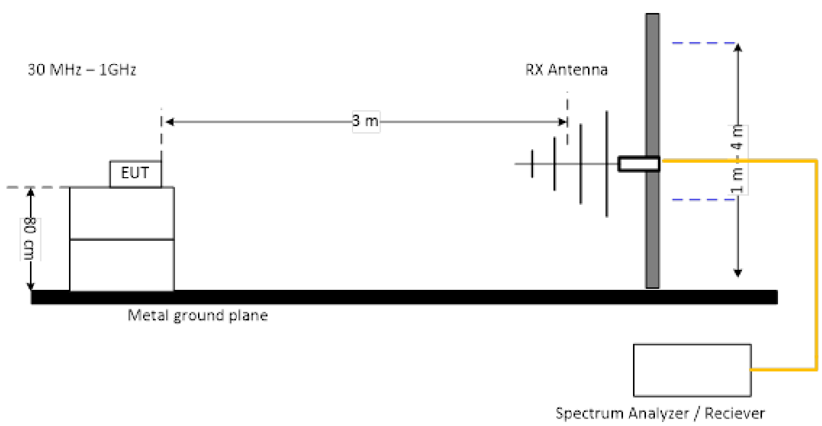
Measurements were performed in the frequency range of 30 MHz to 1 GHz at 3-meter distance. The Bilog antenna was searched from 1 to 4 meters in height in both horizontal and vertical orientation. The EUT was placed on the test table at 0.8 meter high and also rotated 360 degrees in front of the measurement antenna and tested in all 3 orthogonal axes. **No emissions were observed from the EUT in this frequency range.**

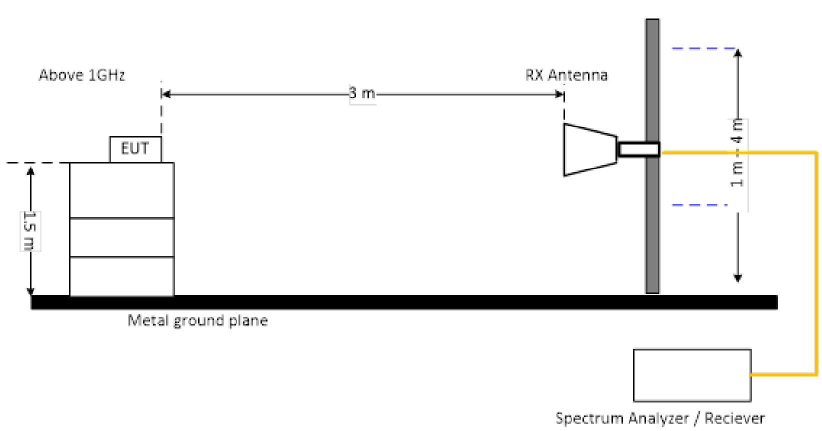
Measurements were performed in the frequency range of 1 GHz to 24.835 GHz at 3-meter distance. The Horn antenna was searched from 1 to 4 meters in height in both horizontal and vertical orientation. The EUT was placed on the test table at 1.5 meter high and also rotated 360 degrees in front of the measurement antenna and tested in all 3 orthogonal axes. **Only the second and third harmonics of the transmitter was observed, all others were baseline of the noise floor measurements. No emissions were observed above the third harmonic of the fundamental frequency.**

No other emissions were observed.

Test Setup


Below 30 MHz
RX Antenna
3 m
EUT
80 cm
1 m
Metal ground plane
Spectrum Analyzer / Reciever


30 MHz – 1GHz
RX Antenna
3 m
EUT
80 cm
1 m - 4 m
Metal ground plane
Spectrum Analyzer / Reciever


Above 1GHz
RX Antenna
3 m
EUT
1.5 m
1 m - 4 m
Metal ground plane
Spectrum Analyzer / Reciever

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Radiated Worst Case Data

Table 15 – Radiated Data

GFSK -

Frequency MHz	Quasi-Peak Level dBµV/m	Site CF	Corrected Level dBµV/m	Limit	Margin dB	Antenna, Polarization Azimuth, Height
2400	47.58	5.09	52.67	54.00	-1.33	H AV, 338, 1.4
2400	42.72	5.09	47.81	54.00	-6.19	V AV, 135, 1.7
2400	56.65	5.09	61.74	74.00	-12.26	H PK, 338, 1.4
2400	52.35	5.09	57.44	74.00	-16.56	V PK, 135, 1.7
2390	36.76	5.07	41.83	54.00	-12.17	H AV, 338, 1.4
2390	36.51	5.07	41.58	54.00	-12.42	V AV, 135, 1.7
2390	46.13	5.07	51.20	74.00	-22.80	H PK, 338, 1.4
2390	47.35	5.07	52.42	74.00	-21.58	V PK, 135, 1.7
2483.5	38.04	5.35	43.39	54.00	-10.61	H AV, 338, 1.4
2483.5	37.4	5.35	42.75	54.00	-11.25	V AV, 135, 1.7
2483.5	47.4	5.35	52.75	74.00	-21.25	H PK, 338, 1.4
2483.5	50.36	5.35	55.71	74.00	-18.29	V PK, 135, 1.7
2500	37.12	5.37	42.49	54.00	-11.51	H AV, 338, 1.4
2500	36.82	5.37	42.19	54.00	-11.81	V AV, 135, 1.7
2500	47.86	5.37	53.23	74.00	-20.77	H PK, 338, 1.4
2500	47.6	5.37	52.97	74.00	-21.03	V PK, 135, 1.7

π/4DQPSK -

Frequency MHz	Quasi-Peak Level dBµV/m	Site CF	Corrected Level dBµV/m	Limit	Margin dB	Antenna, Polarization Azimuth, Height
2400	45.47	5.09	50.56	54.00	-3.44	H AV, 338, 1.6
2400	40.27	5.09	45.36	54.00	-8.64	V AV, 135, 1.5
2400	56.21	5.09	61.30	74.00	-12.70	H PK, 338, 1.6
2400	48.74	5.09	53.83	74.00	-20.17	V PK, 135, 1.5
2390	36.75	5.07	41.82	54.00	-12.18	H AV, 338, 1.6
2390	36.91	5.07	41.98	54.00	-12.02	V AV, 135, 1.5
2390	47.62	5.07	52.69	74.00	-21.31	H PK, 338, 1.6
2390	47.44	5.07	52.51	74.00	-21.49	V PK, 135, 1.5
2483.5	37.7	5.35	43.05	54.00	-10.95	H AV, 338, 1.6
2483.5	37.49	5.35	42.84	54.00	-11.16	V AV, 135, 1.5
2483.5	47.58	5.35	52.93	74.00	-21.07	H PK, 338, 1.6
2483.5	47.57	5.35	52.92	74.00	-21.08	V PK, 135, 1.5
2500	37.21	5.37	42.58	54.00	-11.42	H AV, 338, 1.6
2500	37.23	5.37	42.60	54.00	-11.40	V AV, 135, 1.5
2500	47.22	5.37	52.59	74.00	-21.41	H PK, 338, 1.6
2500	48.26	5.37	53.63	74.00	-20.37	V PK, 135, 1.5

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8DPSK -

Frequency MHz	Quasi-Peak Level dBµV/m	Site CF	Corrected Level dBµV/m	Limit	Margin dB	Antenna, Polarization Azimuth, Height
2400	44.77	5.09	49.86	54.00	-4.14	H AV, 338, 1.4
2400	40.3	5.09	45.39	54.00	-8.61	V AV, 135, 1.6
2400	57.07	5.09	62.16	74.00	-11.84	H PK, 338, 1.4
2400	48.46	5.09	53.55	74.00	-20.45	V PK, 135, 1.6
2390	36.68	5.07	41.75	54.00	-12.25	H AV, 338, 1.4
2390	36.51	5.07	41.58	54.00	-12.42	V AV, 135, 1.6
2390	47.35	5.07	52.42	74.00	-21.58	H PK, 338, 1.4
2390	46.13	5.07	51.20	74.00	-22.80	V PK, 135, 1.6
2483.5	37.91	5.35	43.26	54.00	-10.74	H AV, 338, 1.4
2483.5	37.13	5.35	42.48	54.00	-11.52	V AV, 135, 1.6
2483.5	48.83	5.35	54.18	74.00	-19.82	H PK, 338, 1.4
2483.5	47	5.35	52.35	74.00	-21.65	V PK, 135, 1.6
2500	37.13	5.37	42.50	54.00	-11.50	H AV, 338, 1.4
2500	37.14	5.37	42.51	54.00	-11.49	V AV, 135, 1.6
2500	47.41	5.37	52.78	74.00	-21.22	H PK, 338, 1.4
2500	49.26	5.37	54.63	74.00	-19.37	V PK, 135, 1.6

Site CF = antenna factor, cable loss, preamp gain
H = Horizontal, V = Vertical
AV = Average. PK = Peak

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Radiated Worst Case Data Spurious

Table 16 – Spurious Radiated Data

GFSK -

Frequency MHz	Quasi-Peak Level dBμV/m	Site CF	Corrected Level dBμV/m	Limit	Margin dB	Antenna, Polarization Azimuth, Height
4804	33.36	10.52	43.88	54.00	-10.12	H AV, 315, 1.4
4804	32.54	10.52	43.06	54.00	-10.94	V AV, 135, 1.7
4804	43.9	10.52	54.42	74.00	-19.58	H PK, 315, 1.4
4804	44.24	10.52	54.76	74.00	-19.24	V PK, 135, 1.7
7206	32.51	13.98	46.49	54.00	-7.51	H AV, 315, 1.4
7206	32.64	13.98	46.62	54.00	-7.38	V AV, 135, 1.7
7206	42.91	13.98	56.89	74.00	-17.11	H PK, 315, 1.4
7206	44.97	13.98	58.95	74.00	-15.05	V PK, 135, 1.7
4882	33.2	10.69	43.89	54.00	-10.11	H AV, 315, 1.4
4882	32.82	10.69	43.51	54.00	-10.49	V AV, 135, 1.7
4882	44.32	10.69	55.01	74.00	-18.99	H PK, 315, 1.4
4882	43.98	10.69	54.67	74.00	-19.33	V PK, 135, 1.7
7323	32.81	14.13	46.94	54.00	-7.06	H AV, 315, 1.4
7323	33.97	14.13	48.10	54.00	-5.90	V AV, 135, 1.7
7323	44.54	14.13	58.67	74.00	-15.33	H PK, 315, 1.4
7323	45.47	14.13	59.60	74.00	-14.40	V PK, 135, 1.7
4960	32.96	10.90	43.86	54.00	-10.14	H AV, 315, 1.4
4960	33.02	10.90	43.92	54.00	-10.08	V AV, 135, 1.7
4960	44.73	10.90	55.63	74.00	-18.37	H PK, 315, 1.4
4960	45.08	10.90	55.98	74.00	-18.02	V PK, 135, 1.7
7440	33.09	14.38	47.47	54.00	-6.53	H AV, 315, 1.4
7440	34.09	14.38	48.47	54.00	-5.53	V AV, 135, 1.7
7440	45.8	14.38	60.18	74.00	-13.82	H PK, 315, 1.4
7440	44.65	14.38	59.03	74.00	-14.97	V PK, 135, 1.7

π/4DQPSK -

Frequency MHz	Quasi-Peak Level dBμV/m	Site CF	Corrected Level dBμV/m	Limit	Margin dB	Antenna, Polarization Azimuth, Height
4804	33.26	10.52	43.78	54.00	-10.22	H AV, 315, 1.6
4804	32.55	10.52	43.07	54.00	-10.93	V AV, 135, 1.7
4804	43.91	10.52	54.43	74.00	-19.57	H PK, 315, 1.6
4804	43.68	10.52	54.20	74.00	-19.80	V PK, 135, 1.7
7206	33.1	13.98	47.08	54.00	-6.92	H AV, 315, 1.6
7206	33.01	13.98	46.99	54.00	-7.01	V AV, 135, 1.7
7206	44.06	13.98	58.04	74.00	-15.96	H PK, 315, 1.6
7206	43.67	13.98	57.65	74.00	-16.35	V PK, 135, 1.7
4882	33	10.69	43.69	54.00	-10.31	H AV, 315, 1.6

4882	32.8	10.69	43.49	54.00	-10.51	V AV, 135, 1.7
4882	46.3	10.69	56.99	74.00	-17.01	H PK, 315, 1.6
4882	43.68	10.69	54.37	74.00	-19.63	V PK, 135, 1.7
7323	33.26	14.13	47.39	54.00	-6.61	H AV, 315, 1.6
7323	34.8	14.13	48.93	54.00	-5.07	V AV, 135, 1.7
7323	44.11	14.13	58.24	74.00	-15.76	H PK, 315, 1.6
7323	44.78	14.13	58.91	74.00	-15.09	V PK, 135, 1.7
4960	32.6	10.90	43.50	54.00	-10.50	H AV, 315, 1.6
4960	33.33	10.90	44.23	54.00	-9.77	V AV, 135, 1.7
4960	44.1	10.90	55.00	74.00	-19.00	H PK, 315, 1.6
4960	44.32	10.90	55.22	74.00	-18.78	V PK, 135, 1.7
7440	33.08	14.38	47.46	54.00	-6.54	H AV, 315, 1.6
7440	34.24	14.38	48.62	54.00	-5.38	V AV, 135, 1.7
7440	45.07	14.38	59.45	74.00	-14.55	H PK, 315, 1.6
7440	45.2	14.38	59.58	74.00	-14.42	V PK, 135, 1.7

8DPSK -

Frequency MHz	Quasi-Peak Level dBµV/m	Site CF	Corrected Level dBµV/m	Limit	Margin dB	Antenna, Polarization Azimuth, Height
4804	33.29	10.52	43.81	54.00	-10.19	H AV, 315, 1.6
4804	33.18	10.52	43.70	54.00	-10.30	V AV, 135, 1.7
4804	44.43	10.52	54.95	74.00	-19.05	H PK, 315, 1.6
4804	44.27	10.52	54.79	74.00	-19.21	V PK, 135, 1.7
7206	33.78	13.98	47.76	54.00	-6.24	H AV, 315, 1.6
7206	33.52	13.98	47.50	54.00	-6.50	V AV, 135, 1.7
7206	44.48	13.98	58.46	74.00	-15.54	H PK, 315, 1.6
7206	45.06	13.98	59.04	74.00	-14.96	V PK, 135, 1.7
4882	33.04	10.69	43.73	54.00	-10.27	H AV, 315, 1.7
4882	33.08	10.69	43.77	54.00	-10.23	V AV, 135, 1.7
4882	45.75	10.69	56.44	74.00	-17.56	H PK, 315, 1.7
4882	44.13	10.69	54.82	74.00	-19.18	V PK, 135, 1.7
7323	33.4	14.13	47.53	54.00	-6.47	H AV, 315, 1.7
7323	34.83	14.13	48.96	54.00	-5.04	V AV, 135, 1.7
7323	45.19	14.13	59.32	74.00	-14.68	H PK, 315, 1.7
7323	45.76	14.13	59.89	74.00	-14.11	V PK, 135, 1.7
4960	33.7	10.90	44.60	54.00	-9.40	H AV, 315, 1.7
4960	33.33	10.90	44.23	54.00	-9.77	V AV, 135, 1.6
4960	45.11	10.90	56.01	74.00	-17.99	H PK, 315, 1.7
4960	44.66	10.90	55.56	74.00	-18.44	V PK, 135, 1.6
7440	33.87	14.38	48.25	54.00	-5.75	H AV, 315, 1.7
7440	33.83	14.38	48.21	54.00	-5.79	V AV, 135, 1.6
7440	44.21	14.38	58.59	74.00	-15.41	H PK, 315, 1.7
7440	45.55	14.38	59.93	74.00	-14.07	V PK, 135, 1.6

Site CF = antenna factor, cable loss, preamp gain
H = Horizontal, V = Vertical
AV = Average. PK = Peak

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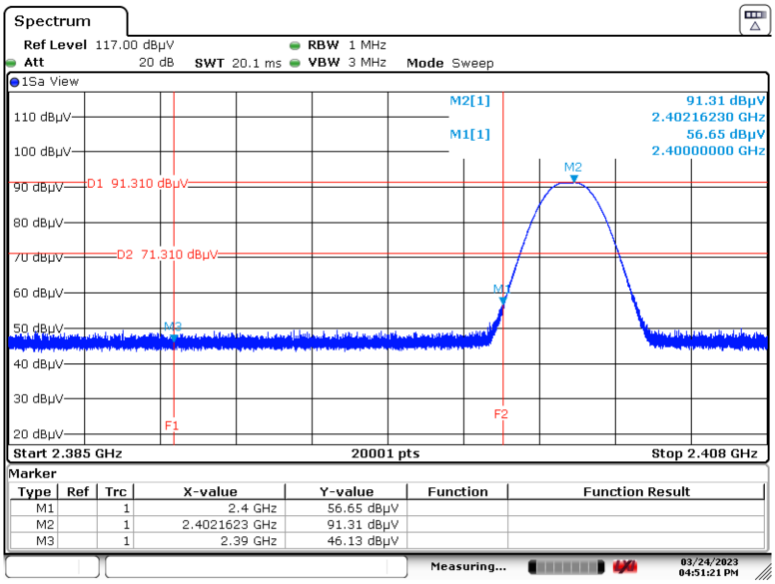
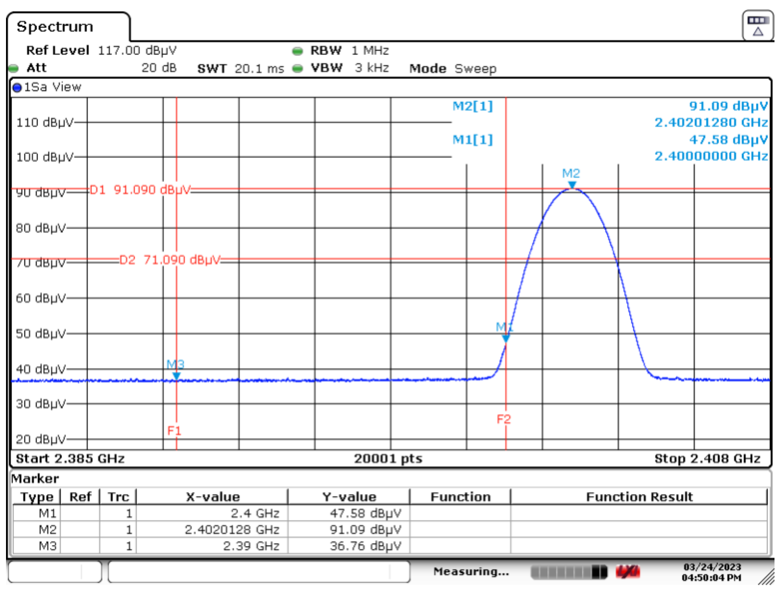
GFSK – Radiated measurement

Horizontal Peak low channel



Date: 24.MAR.2023 16:51:21

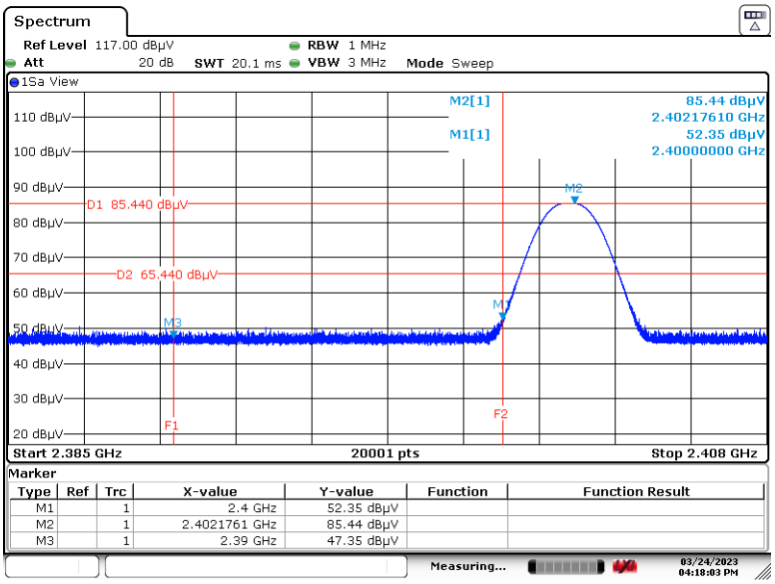
Horizontal Average low channel



Date: 24.MAR.2023 16:50:04

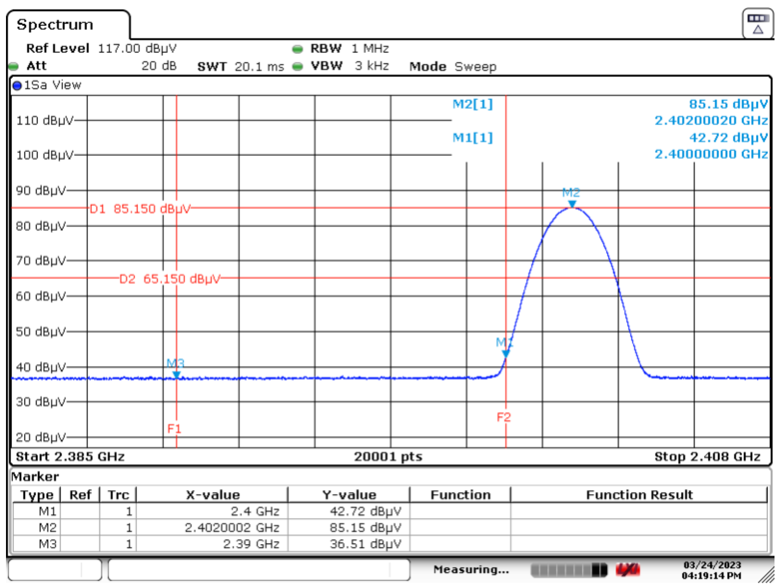
GFSK – Radiated measurement

Vertical Paek low channel



Date: 24.MAR.2023 16:18:04

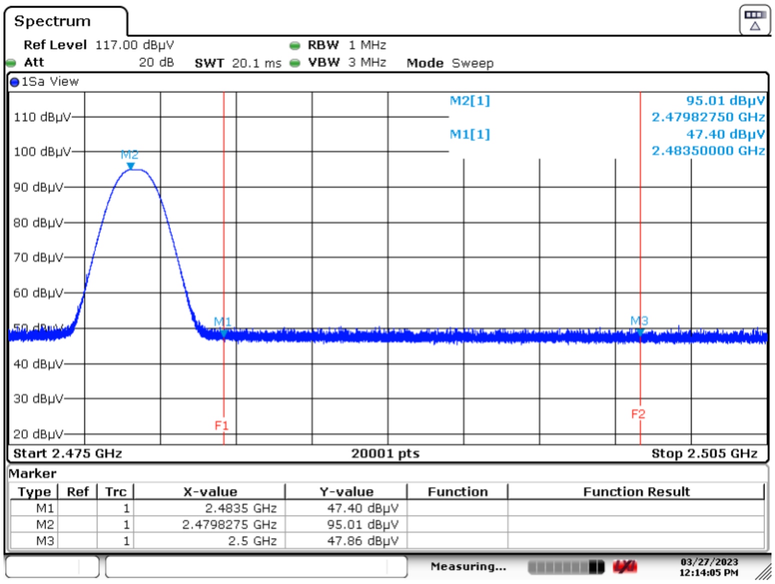
Vertical Average low channel



Date: 24.MAR.2023 16:19:14

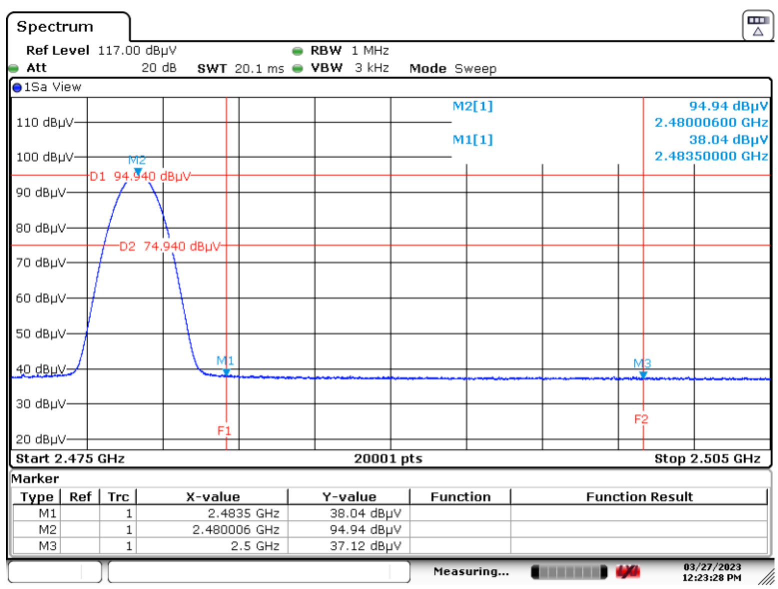
GFSK – Radiated measurement

Horizontal Peak high channel



Date: 27.MAR.2023 12:14:05

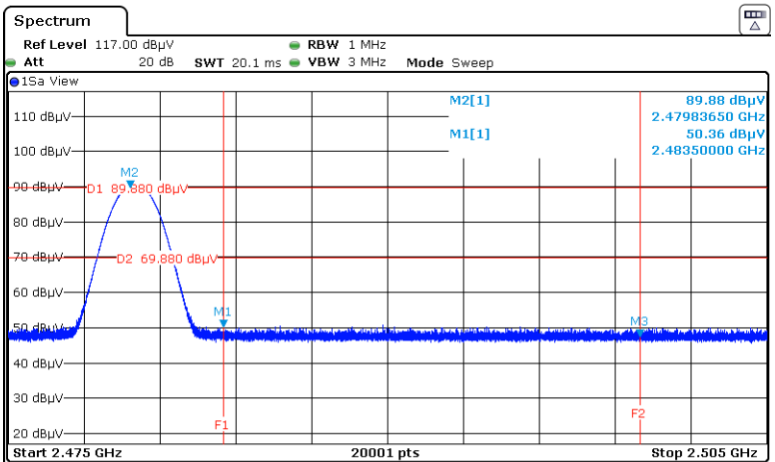
Horizontal Average high channel



Date: 27.MAR.2023 12:23:28

GFSK – Radiated measurement

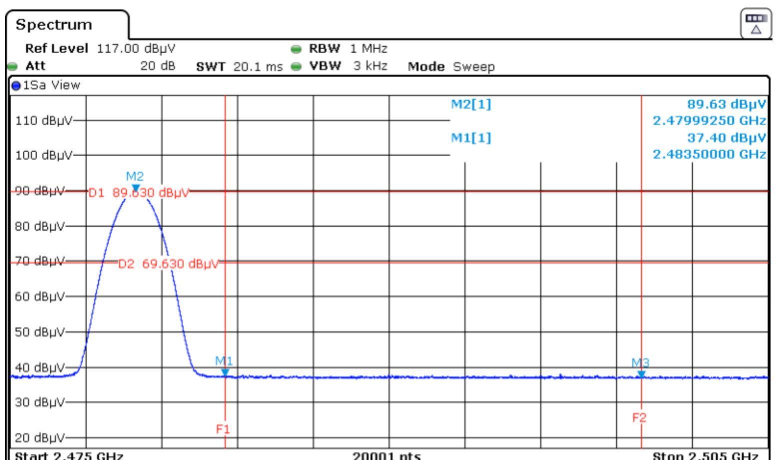
Vertical Peak high channel



Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4835 GHz	50.36 dBµV		
M2		1	2.4798365 GHz	89.88 dBµV		
M3		1	2.5 GHz	47.60 dBµV		

Date: 27.MAR.2023 12:32:18

Vertical Average high channel



Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4835 GHz	37.40 dBµV		
M2		1	2.4799925 GHz	89.63 dBµV		
M3		1	2.5 GHz	36.82 dBµV		

Date: 27.MAR.2023 12:30:17

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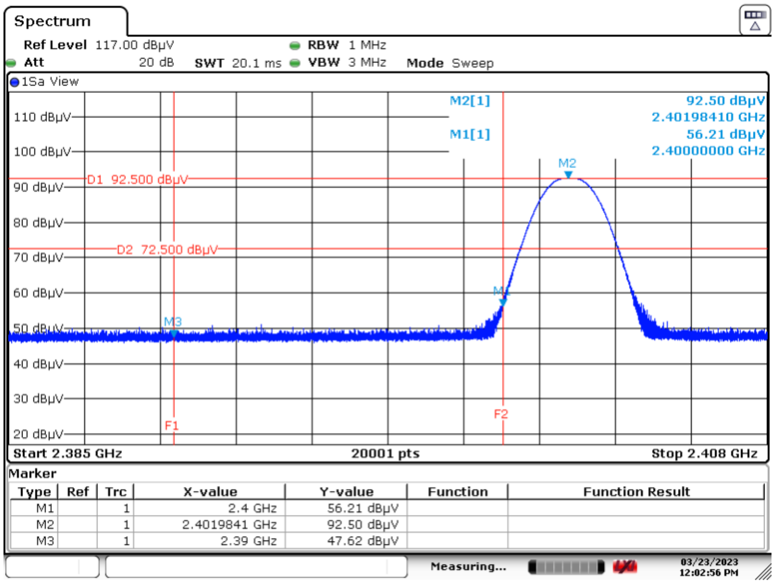
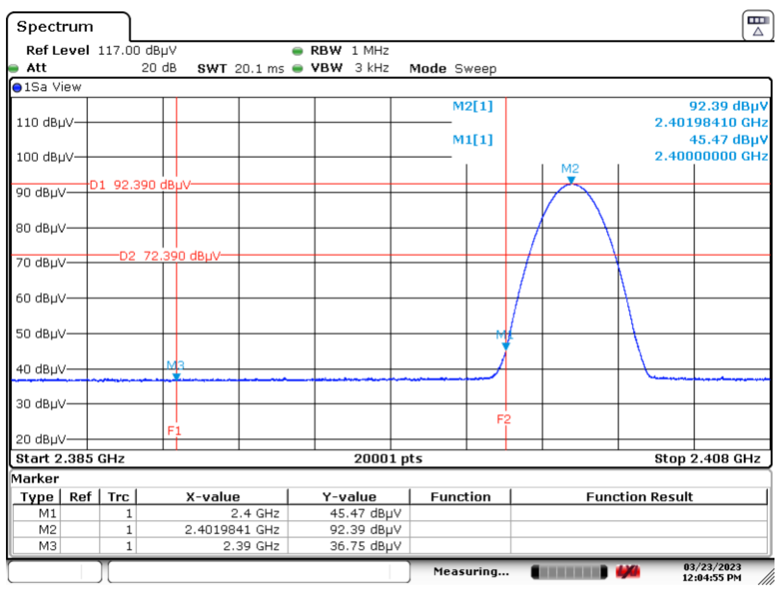
π/4DQPSK – Radiated measurement

Horizontal Peak low channel



Date: 23.MAR.2023 12:02:56

Horizontal Average low channel



Date: 23.MAR.2023 12:04:55

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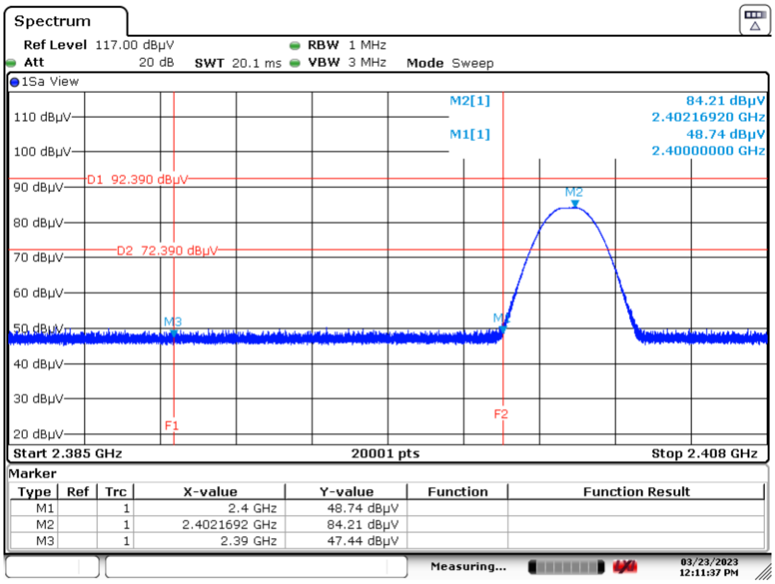
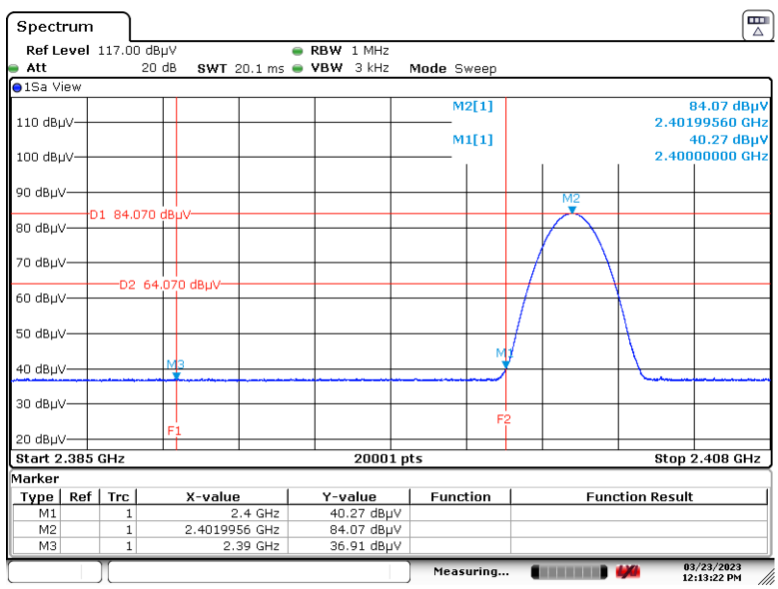
π/4DQPSK – Radiated measurement

Vertical Peak low channel



Date: 23.MAR.2023 12:11:37

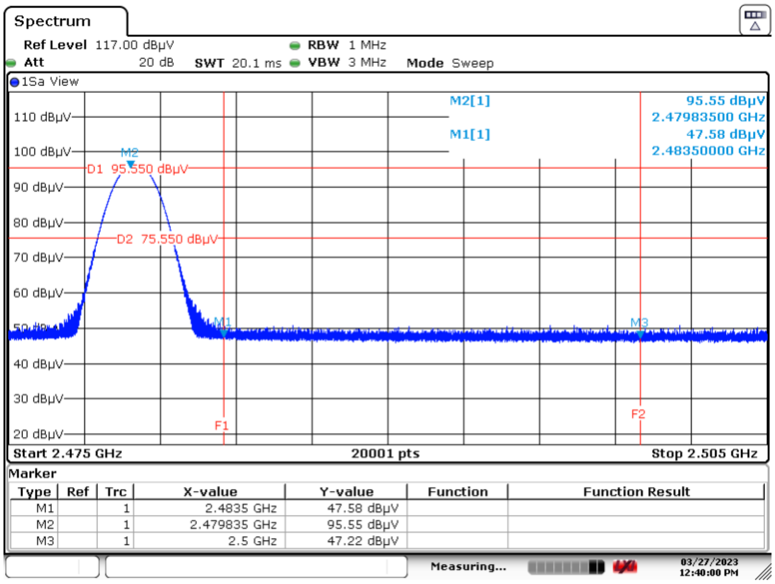
Vertical Average low channel



Date: 23.MAR.2023 12:13:22

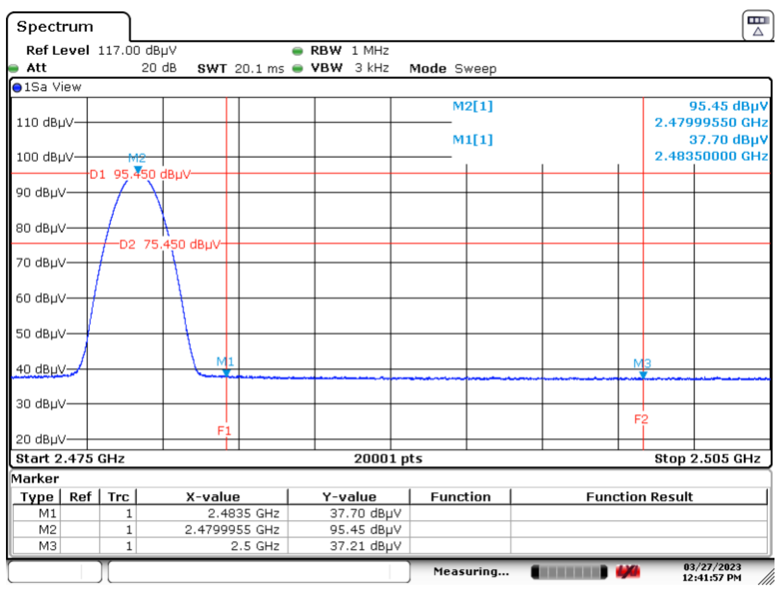
π/4DQPSK – Radiated measurement

Horizontal Peak high channel



Date: 27.MAR.2023 12:40:00

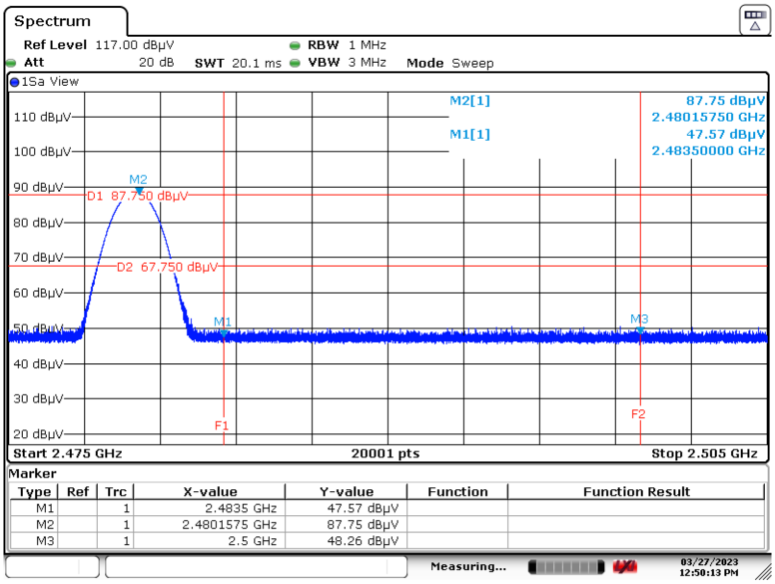
Horizontal Average high channel



Date: 27.MAR.2023 12:41:57

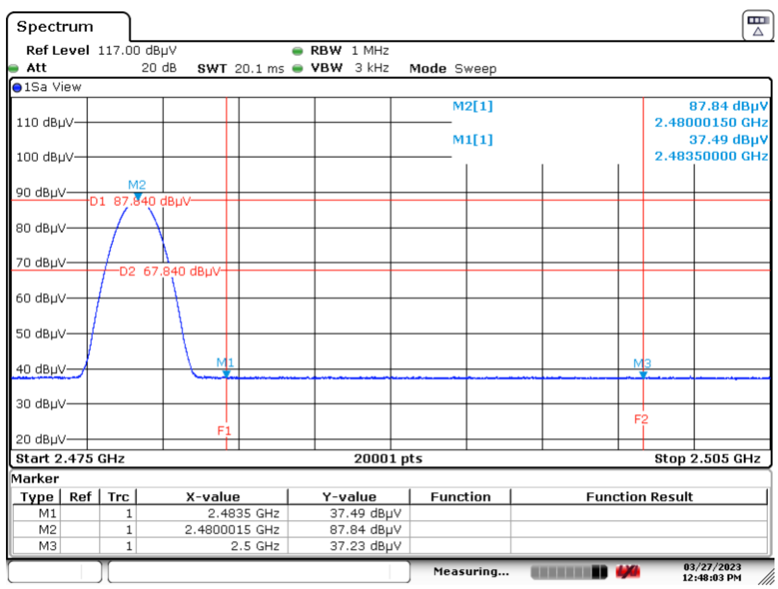
π/4DQPSK – Radiated measurement

Vertical Peak high channel



Date: 27.MAR.2023 12:50:13

Vertical Average high channel



Date: 27.MAR.2023 12:48:03

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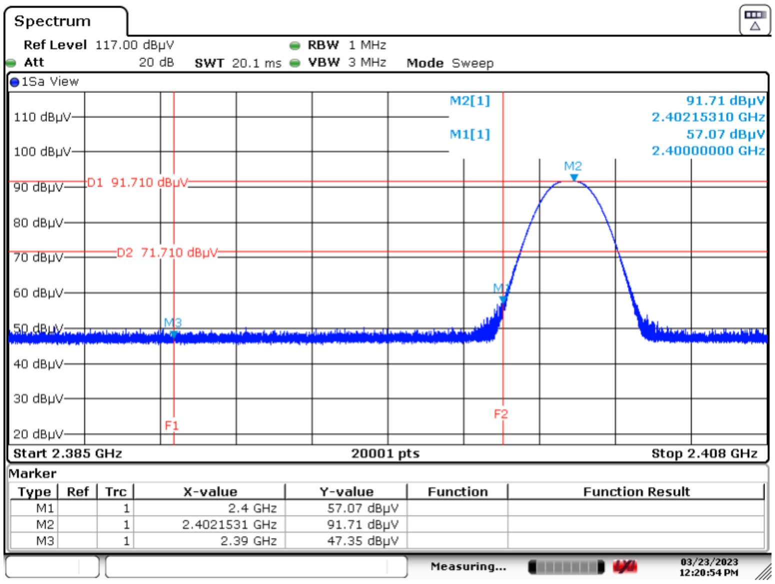
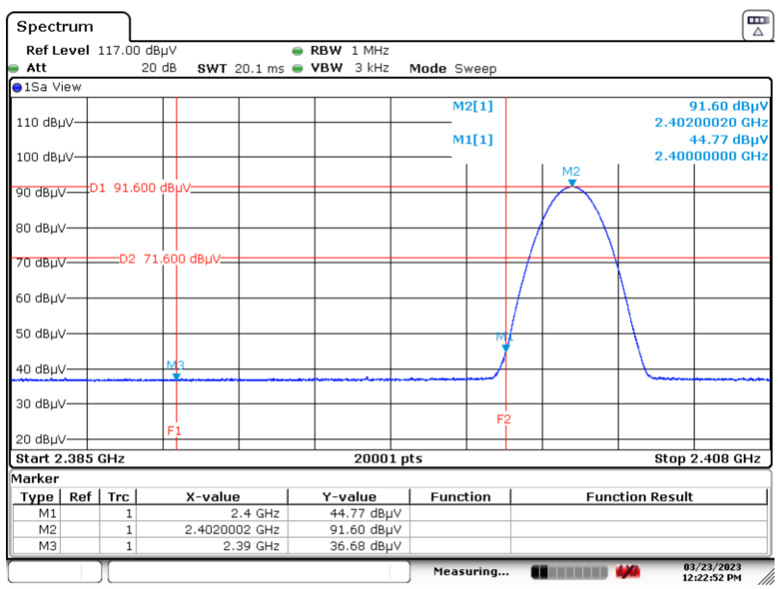
8DPSK – Radiated measurement

Horizontal Peak low channel



Date: 23.MAR.2023 12:20:54

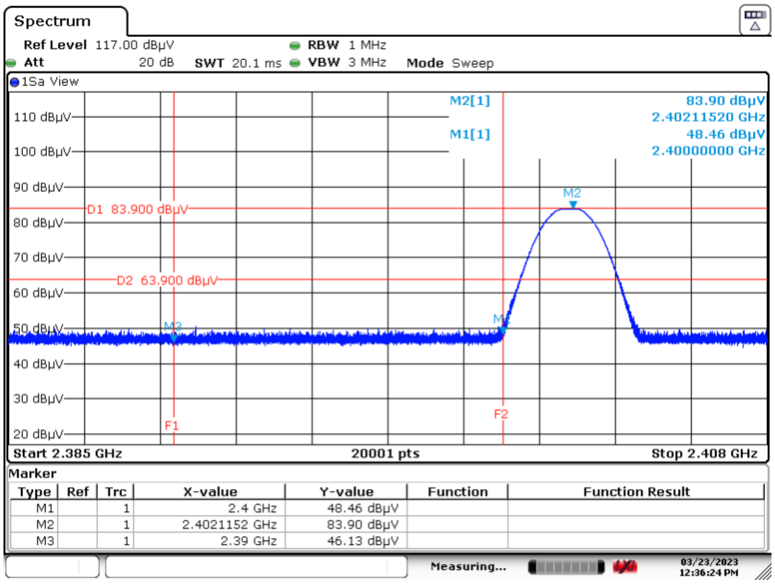
Horizontal Average low channel



Date: 23.MAR.2023 12:22:53

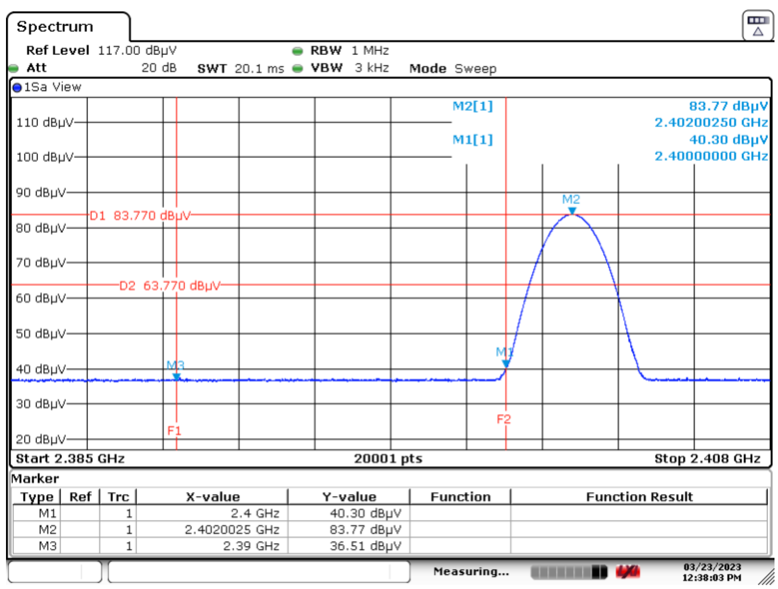
8DPSK – Radiated measurement

Vertical Peak low channel



Date: 23.MAR.2023 12:36:24

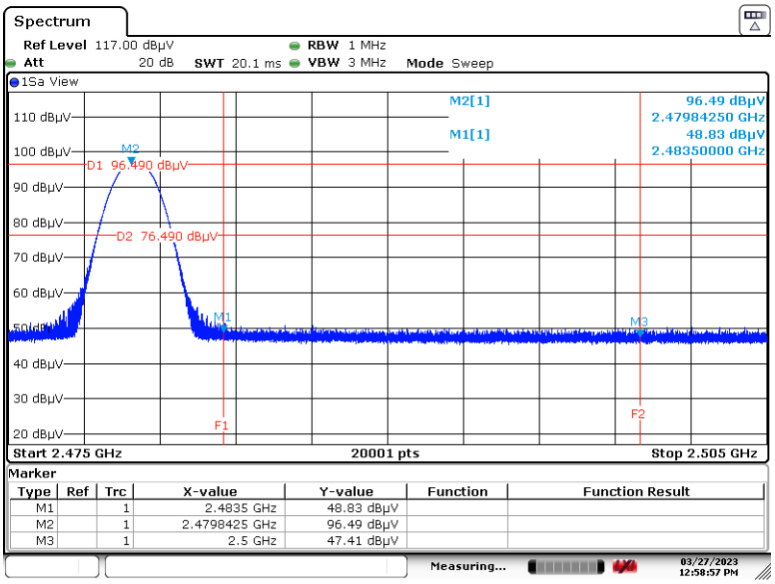
Vertical Average low channel



Date: 23.MAR.2023 12:38:04

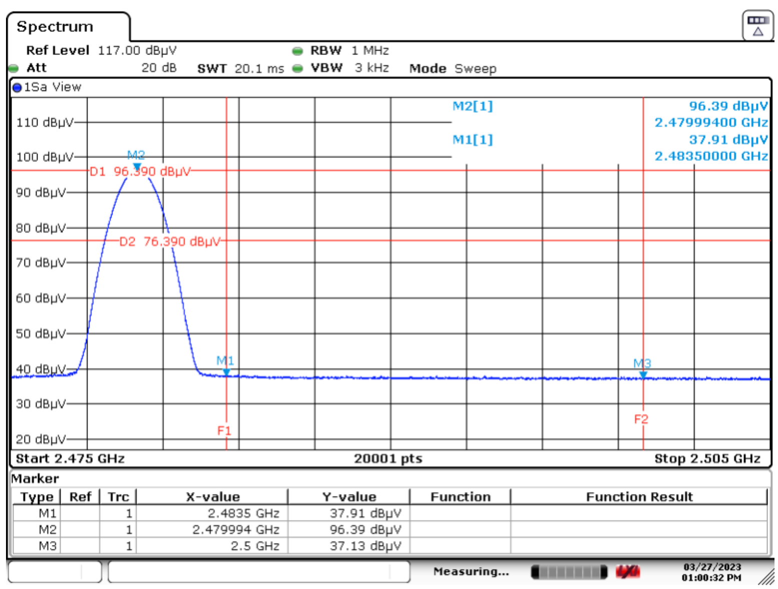
8DPSK – Radiated measurement

Horizontal Peak high channel



Date: 27.MAR.2023 12:58:57

Horizontal Average high channel



Date: 27.MAR.2023 13:00:32

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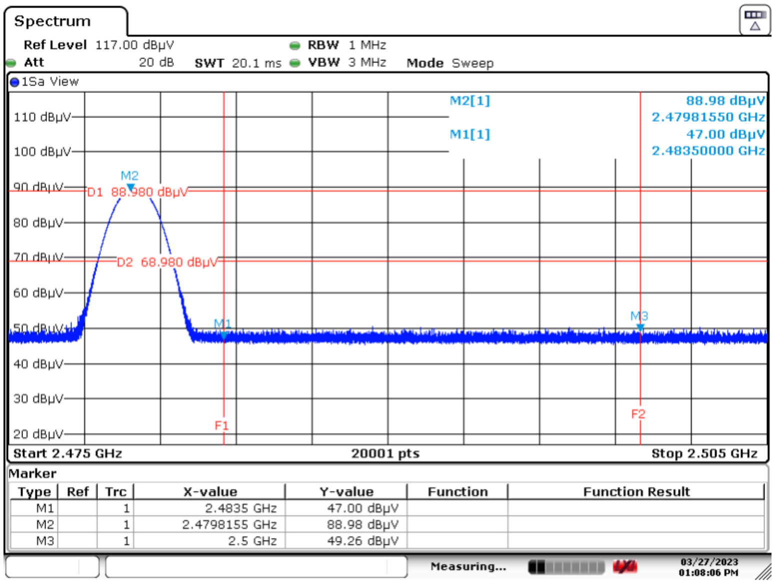
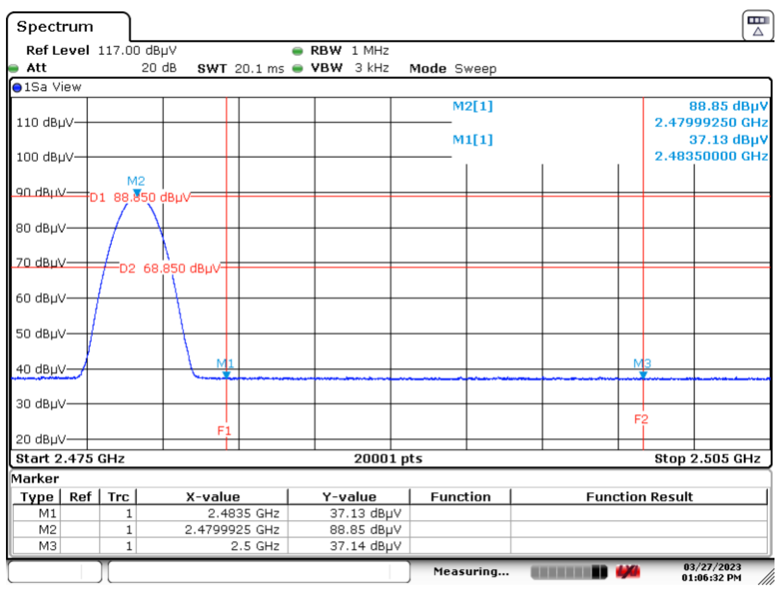
8DPSK – Radiated measurement

Vertical Peak high channel



Date: 27.MAR.2023 13:08:06

Vertical Average high channel



Date: 27.MAR.2023 13:06:32

Antenna Port Emission

§15.247 (d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

RSS-247 5.5

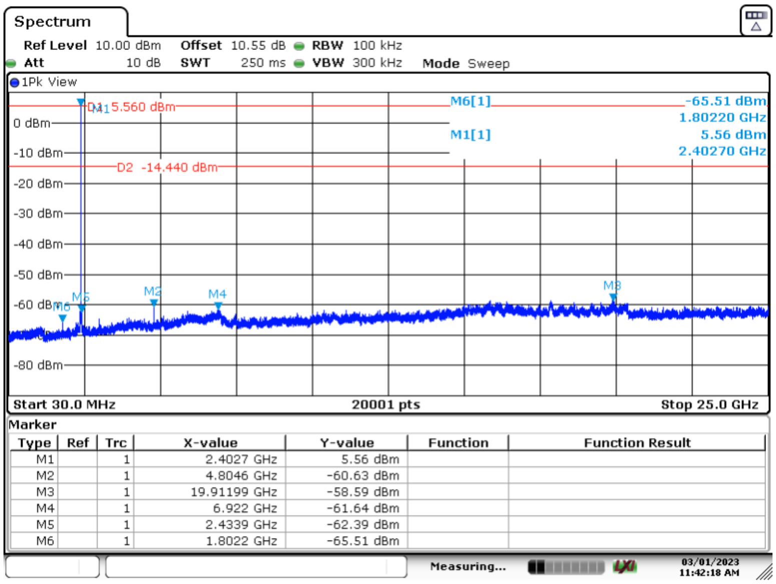
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

ANSI C63.10-2013
7.8.8 Conducted spurious emissions test methodology
Conducted spurious emissions shall be measured for the transmit frequency, per 5.5 and 5.6, and at the maximum transmit powers.
Connect the primary antenna port through an attenuator to the spectrum analyzer input; in the results, account for all losses between the unlicensed wireless device output and the spectrum analyzer. The instrument shall span 30 MHz to 10 times the operating frequency in GHz, with a resolution bandwidth of 100 kHz, video bandwidth of 300 kHz, and a coupled sweep time with a peak detector. The band 30 MHz to the highest frequency may be split into smaller spans, as long as the entire spectrum is covered.

GFSK

RF conducted measurement

Low

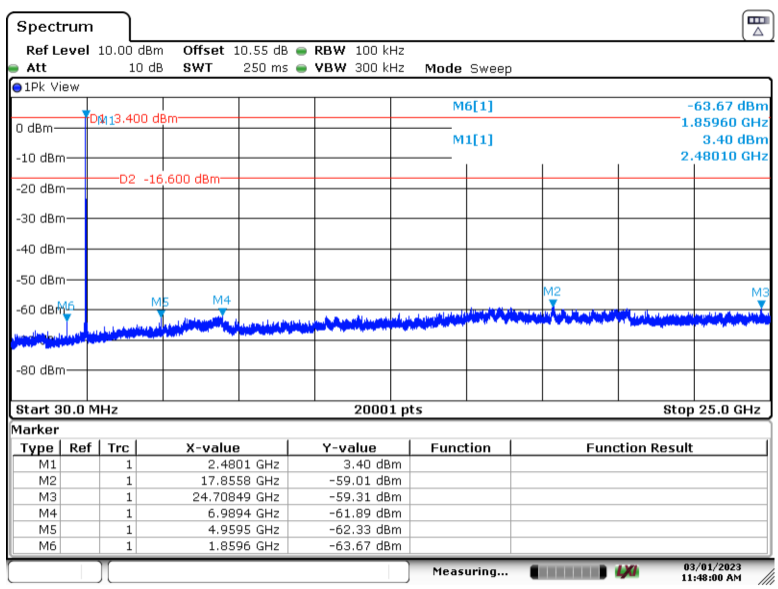


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4027 GHz	5.56 dBm		
M2		1	4.8046 GHz	-60.63 dBm		
M3		1	19.91199 GHz	-58.59 dBm		
M4		1	6.922 GHz	-61.64 dBm		
M5		1	2.4339 GHz	-62.39 dBm		
M6		1	1.8022 GHz	-65.51 dBm		

Date: 1.MAR.2023 11:42:18

High



Marker

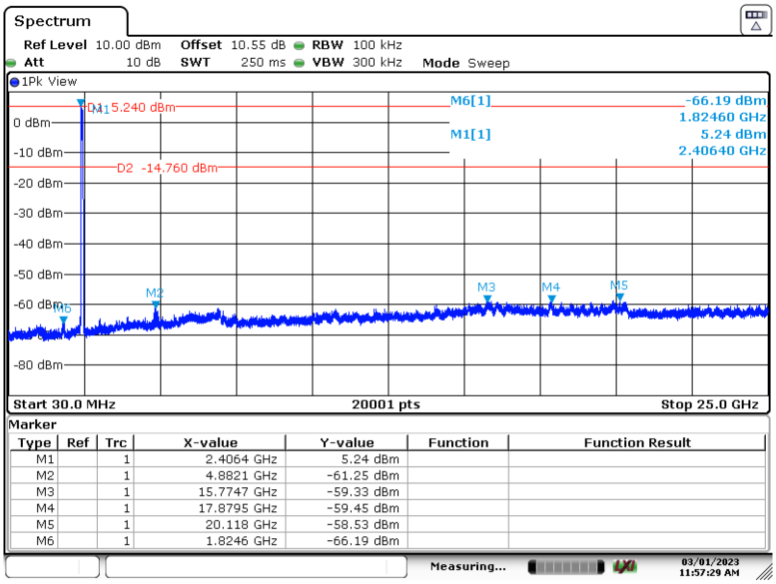
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4801 GHz	3.40 dBm		
M2		1	17.8558 GHz	-59.01 dBm		
M3		1	24.70849 GHz	-59.31 dBm		
M4		1	6.9894 GHz	-61.89 dBm		
M5		1	4.9595 GHz	-62.33 dBm		
M6		1	1.8596 GHz	-63.67 dBm		

Date: 1.MAR.2023 11:48:00

GFSK

RF conducted measurement

Hopping



Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4064 GHz	5.24 dBm		
M2		1	4.8821 GHz	-61.25 dBm		
M3		1	15.7747 GHz	-59.33 dBm		
M4		1	17.8795 GHz	-59.45 dBm		
M5		1	20.118 GHz	-58.53 dBm		
M6		1	1.8246 GHz	-66.19 dBm		

Date: 1.MAR.2023 11:57:29

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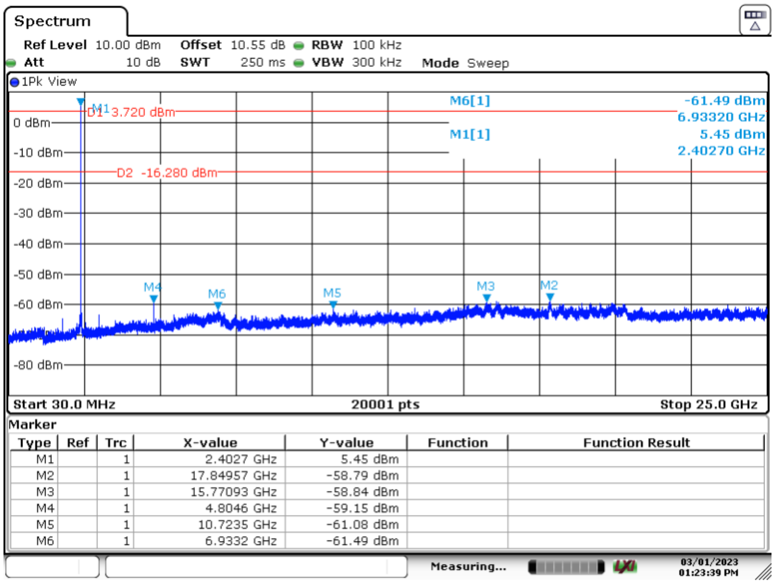
π/4DQPSK

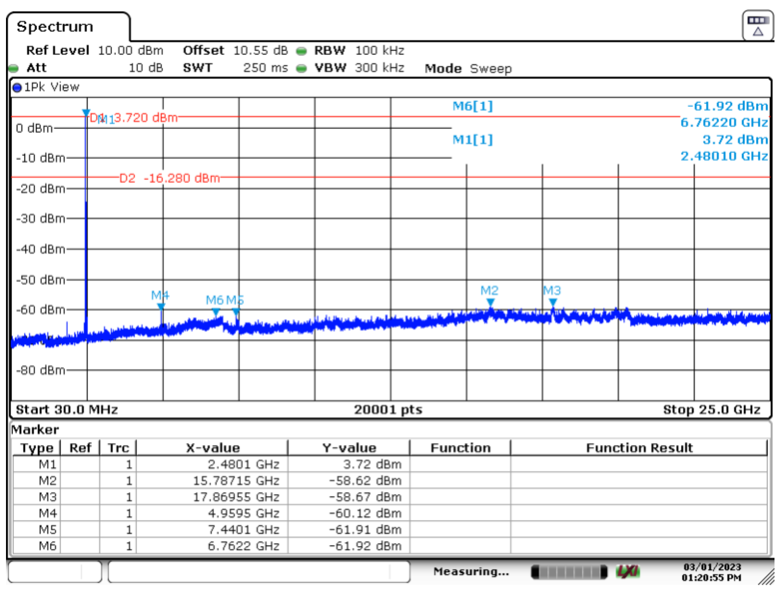
RF conducted measurement

Low



Date: 1.MAR.2023 13:23:40

High

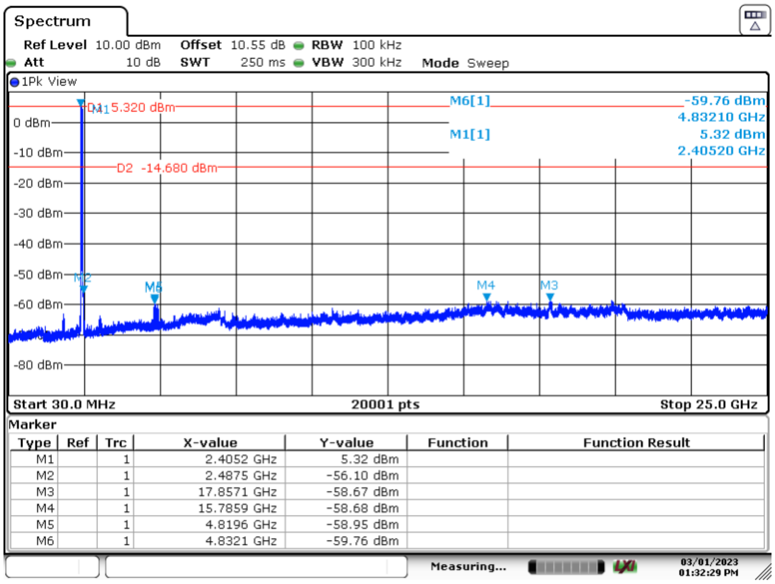


Date: 1.MAR.2023 13:20:56

π/4DQPSK

RF conducted measurement

Hopping



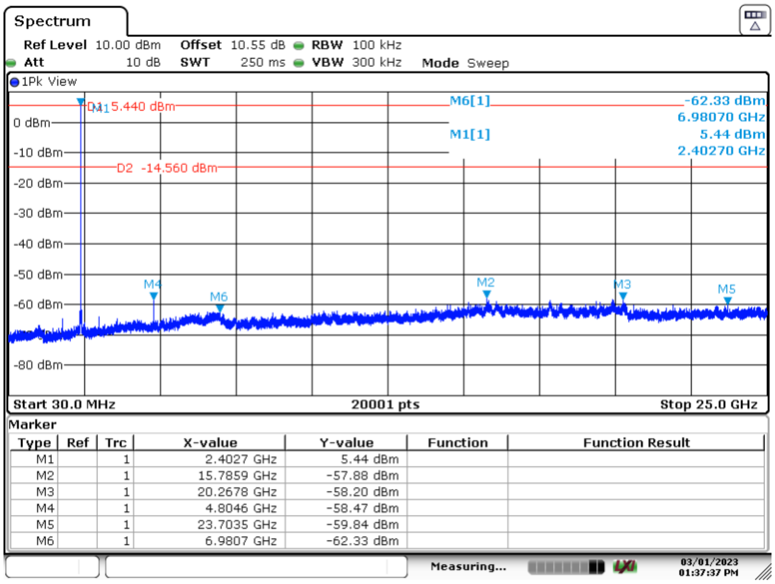
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4052 GHz	5.32 dBm		
M2		1	2.4875 GHz	-56.10 dBm		
M3		1	17.8571 GHz	-58.67 dBm		
M4		1	15.7859 GHz	-58.68 dBm		
M5		1	4.8196 GHz	-58.95 dBm		
M6		1	4.8321 GHz	-59.76 dBm		

Date: 1.MAR.2023 13:32:29

8DPSK

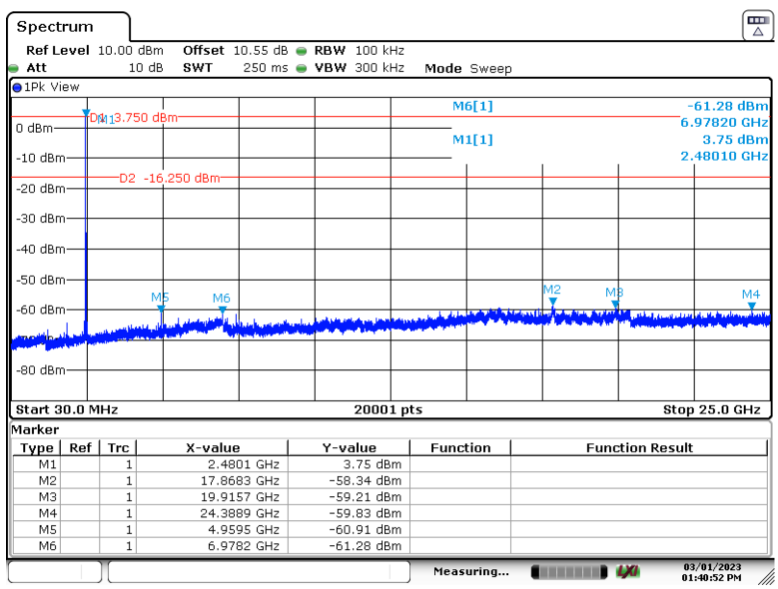
RF conducted measurement

Low



Date: 1.MAR.2023 13:37:37

High

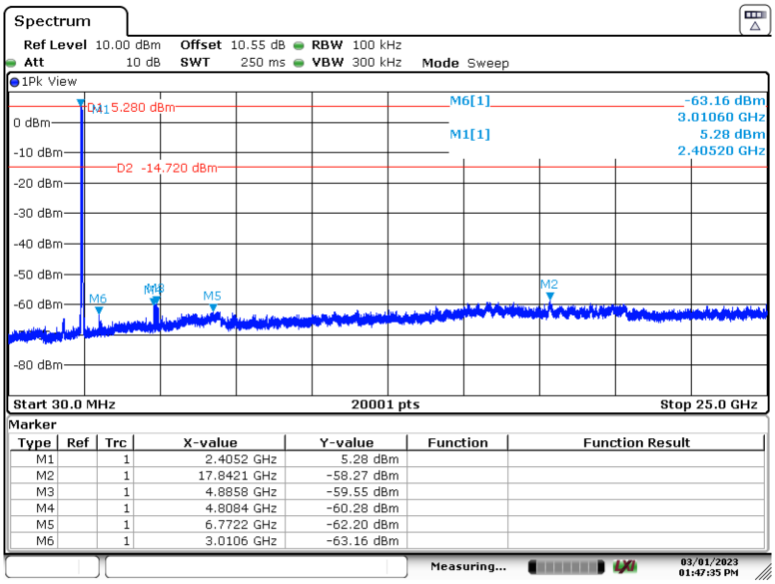


Date: 1.MAR.2023 13:40:52

8DPSK

RF conducted measurement

Hopping



Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4052 GHz	5.28 dBm		
M2		1	17.8421 GHz	-58.27 dBm		
M3		1	4.8858 GHz	-59.55 dBm		
M4		1	4.8084 GHz	-60.28 dBm		
M5		1	6.7722 GHz	-62.20 dBm		
M6		1	3.0106 GHz	-63.16 dBm		

Date: 1.MAR.2023 13:47:36

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Occupied Bandwidth

RSS-Gen 6.7

The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

ANSI C63.10-2013
7.8.7 Occupied bandwidth
For occupied bandwidth measurements, use the procedure in 6.9.2.

6.9.2 Occupied bandwidth—relative measurement procedure
The occupied bandwidth is measured as the width of the spectral envelope of the modulated signal, at an amplitude level reduced from a reference value by a specified ratio (or in decibels, a specified number of dB down from the reference value). Typical ratios, expressed in dB, are −6 dB, −20 dB, and −26 dB, corresponding to 6 dB BW, 20 dB BW, and 26 dB BW, respectively. In this subclause, the ratio is designated by "−xx dB." The reference value is either the level of the unmodulated carrier or the highest level of the spectral envelope of the modulated signal, as stated by the applicable requirement. Some requirements might specify a specific maximum or minimum value for the "−xx dB" bandwidth; other requirements might specify that the "−xx dB" bandwidth be entirely contained within the authorized or designated frequency band.(53)

a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The span range for the EMI receiver or spectrum analyzer shall be between two times and five times the OBW.
b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW and video bandwidth (VBW) shall be approximately three times RBW, unless otherwise specified by the applicable requirement.
c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.
d) Steps a) through c) might require iteration to adjust within the specified tolerances.
e) The dynamic range of the instrument at the selected RBW shall be more than 10 dB below the target "−xx dB down" requirement; that is, if the requirement calls for measuring the −20 dB OBW, the instrument noise floor at the selected RBW shall be at least 30 dB below the reference value.
f) Set detection mode to peak and trace mode to max hold.
g) Determine the reference value: Set the EUT to transmit an unmodulated carrier or modulated signal, as applicable. Allow the trace to stabilize. Set the spectrum analyzer marker to the highest level of the displayed trace (this is the reference value).
h) Determine the "−xx dB down amplitude" using [(reference value) − xx]. Alternatively, this calculation may be made by using the marker-delta function of the instrument.
i) If the reference value is determined by an unmodulated carrier, then turn the EUT modulation ON, and either clear the existing trace or start a new trace on the spectrum analyzer and allow the new trace to stabilize. Otherwise, the trace from step g) shall be used for step j).
j) Place two markers, one at the lowest frequency and the other at the highest frequency of the envelope of the spectral display, such that each marker is at or slightly below the "−xx dB down amplitude" determined in step h). If a marker is below this "−xx dB down amplitude" value, then it shall be as close as possible to this value. The occupied bandwidth is the frequency difference between the two markers. Alternatively, set a marker at the lowest frequency of the envelope of the spectral display, such that the marker is at or slightly below the "−xx dB down amplitude" determined in step h). Reset the marker-delta function and move the marker to the other side of the emission until the delta marker amplitude is at the same level as the reference marker amplitude. The marker-delta frequency reading at this point is the specified emission bandwidth.

k) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

Table 17 – Occupied Bandwidth

Low	GFSK	870.059497175 kHz
Mid	GFSK	867.656617169 kHz
High	GFSK	864.056797160 kHz
Low	Π/4 DQPSK	837.153142093 kHz
Mid	Π/4 DQPSK	834.558272087 kHz
High	Π/4 DQPSK	827.358632068 kHz
Low	8DPSK	777.761111945 kHz
Mid	8DPSK	775.561221939 kHz
High	8DPSK	772.961351933 kHz

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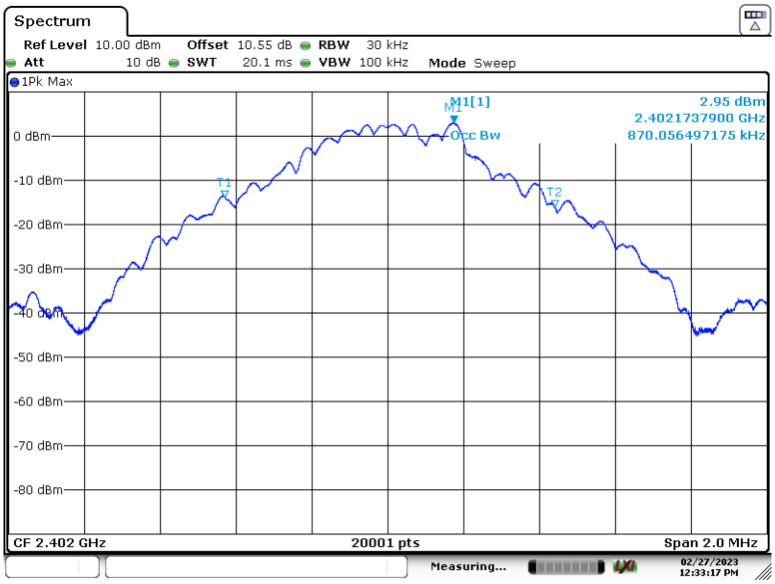
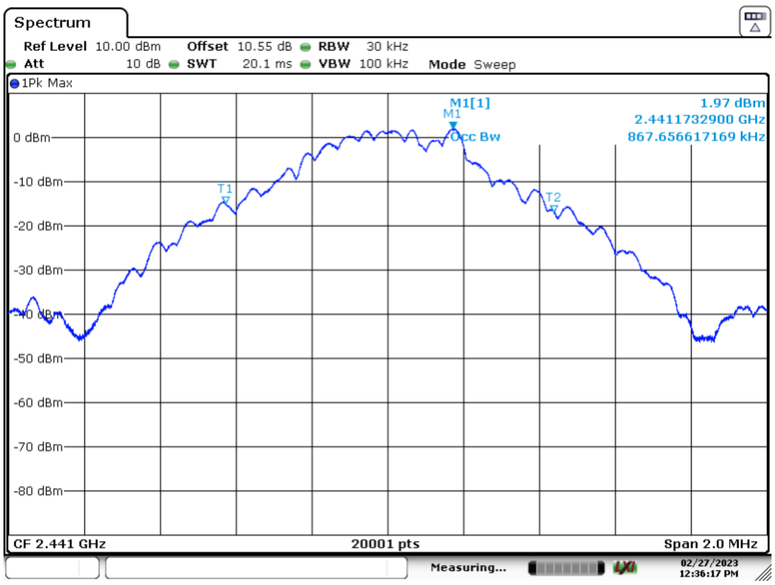
GFSK

Low



Date: 27.FEB.2023 12:33:17

Mid



Date: 27.FEB.2023 12:36:17

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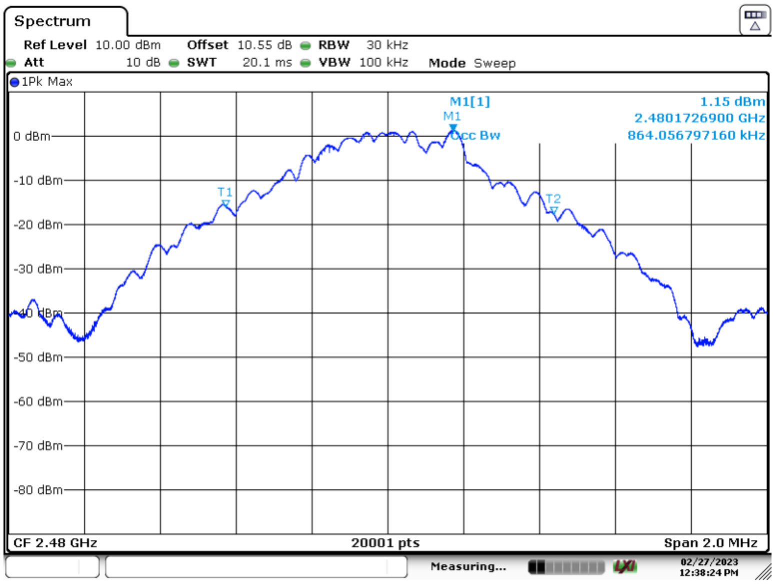
GFSK

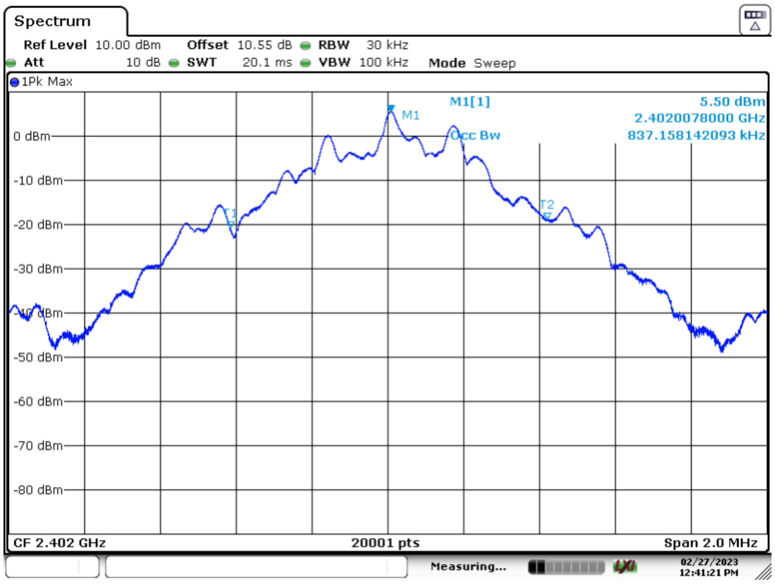
High



Date: 27.FEB.2023 12:38:24

π/4DQPSK

Low



Date: 27.FEB.2023 12:41:21

Mid

Date: 27.FEB.2023 12:44:18

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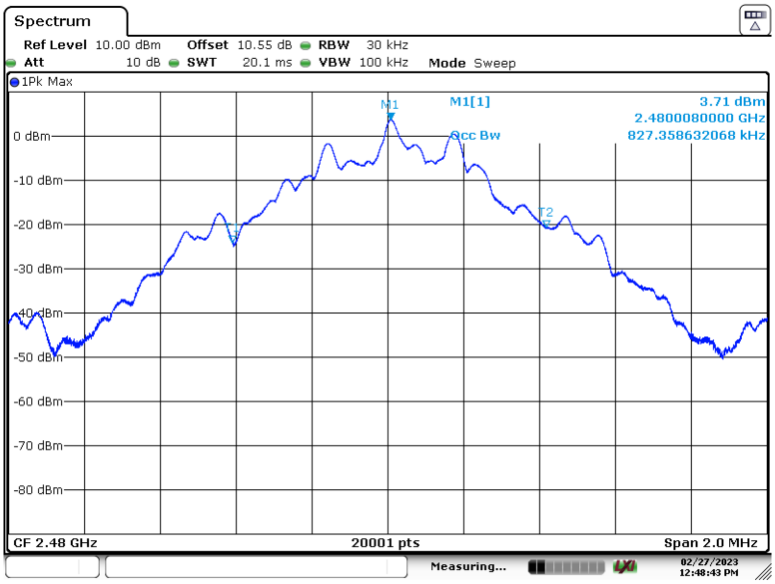
π/4DQPSK

High



Date: 27.FEB.2023 12:48:43

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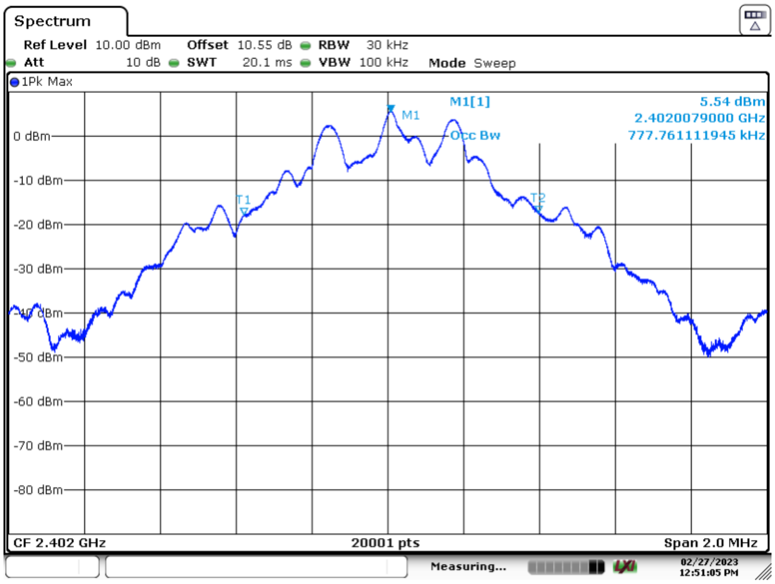
8DPSK

Low



Date: 27.FEB.2023 12:51:06

Mid

Date: 27.FEB.2023 12:53:43

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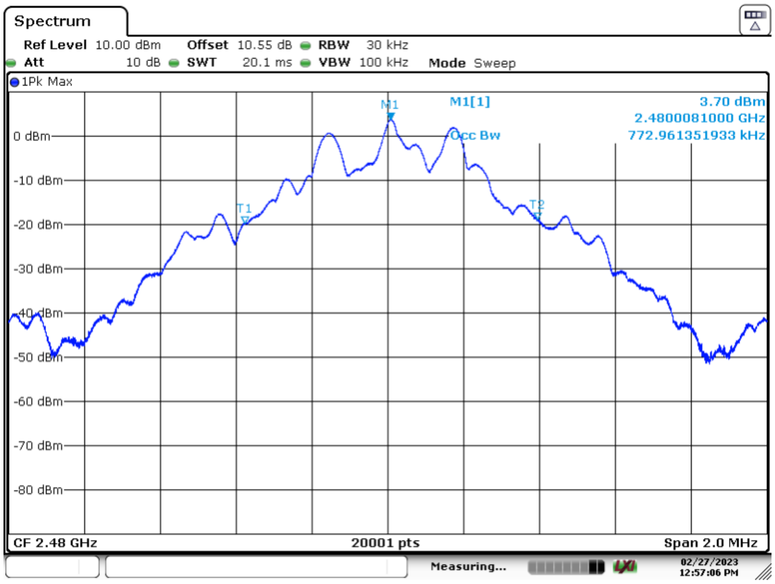
8DPSK

High



Date: 27.FEB.2023 12:57:07

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Frequency Stability

§15.215 Additional provisions to the general radiated emission limitations. (c)

The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

FCC §15.31(e)

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

RSS-Gen 8.11 Frequency Stability

If the frequency stability of the licence-exempt radio apparatus is not specified in the applicable RSS, the fundamental emissions of the radio apparatus should be kept within at least the central 80% of its permitted operating frequency band in order to minimize the possibility of out-of-band operation. In addition, its occupied bandwidth shall be entirely outside the restricted bands and the prohibited TV bands of 54-72 MHz, 76-88 MHz, 174-216 MHz, and 470-602 MHz, unless otherwise indicated.

RSS-Gen 6.11 Transmitter Frequency Stability

Frequency stability is a measure of frequency drift due to temperature and supply voltage variations, with reference to the frequency measured at an appropriate reference temperature and the rated supply voltage.

When the measurement method of transmitter frequency stability is not stated in the applicable RSS or reference standards, the following conditions apply:

(a)The reference temperature for radio transmitters is +20°C (+68°F).

(b)A hand-held device that is only capable of operating using internal batteries shall be tested at the battery's nominal voltage, and again at the battery's operating end-point voltage, which shall be specified by the equipment manufacturer. For this test, either a battery or an external power supply can be used.

(c)The operating carrier frequency shall be set up in accordance with the manufacturer's published operation and instruction manual prior to the commencement of these tests. No adjustment of any frequency-determining circuit element shall be made subsequent to this initial set-up.

With the transmitter installed in an environmental test chamber, the unmodulated carrier frequency and frequency stability shall be measured under the conditions specified below for licensed and licence-exempt devices, unless specified otherwise in the applicable RSS. A sufficient stabilization period at each temperature shall be used prior to each frequency measurement.

For licensed devices, the following measurement conditions apply:

(a) at the temperatures of -30°C (-22°F), +20°C (+68°F) and +50°C (+122°F), and at the manufacturer's rated supply voltage

(b) at the temperature of +20°C (+68°F) and at ±15% of the manufacturer's rated supply voltage

For licence-exempt devices, the following conditions apply:

(a) at the temperatures of -20°C (-4°F), +20°C (+68°F) and +50°C (+122°F), and at the manufacturer's rated supply voltage

(b) at the temperature of +20°C (+68°F) and at ±15% of the manufacturer's rated supply voltage

If the frequency stability limits are only met within a temperature range that is smaller than the range specified in (a) for licensed or licence-exempt devices, the frequency stability requirement will be deemed to be met if the transmitter is automatically prevented from operating outside this smaller temperature range and if the published operating characteristics for the equipment are revised to reflect this restricted temperature range.

If the device contains both licence and licence-exempt transmitter modules, the device's frequency stability shall be measured under the most stringent condition specified in the applicable RSS of the transmitter module.

In addition, if an unmodulated carrier is not available, the method used to measure frequency stability shall be described in the test report.

ANSI C63.10 6.8 Frequency stability tests

Some unlicensed wireless device requirements specify frequency stability tests with variation of supply voltage and temperature; the requirements can be found in the regulatory specifications for each type of unlicensed wireless device. The procedures listed in 6.8.1 and 6.8.2 shall be used for frequency stability tests.

ANSI C63.10 6.8.1 Frequency stability with respect to ambient temperature

a) Supply the EUT with a nominal ac voltage or install a new or fully charged battery in the EUT. If possible, a dummy load shall be connected to the EUT because an antenna near the metallic walls of an environmental test chamber could affect the output frequency of the EUT. If the EUT is equipped with a permanently attached, adjustable-length antenna, then the EUT shall be placed in the center of the chamber with the antenna adjusted to the shortest length possible. Turn ON the EUT and tune it to one of the number of frequencies shown in 5.6.

b) Couple the unlicensed wireless device output to the measuring instrument by connecting an antenna to the measuring instrument with a suitable length of coaxial cable and placing the measuring antenna near the EUT (e.g., 15 cm away), or by connecting a dummy load to the measuring instrument, through an attenuator if necessary.

c) Adjust the location of the measurement antenna and the controls on the measurement instrument to obtain a suitable signal level (i.e., a level that will not overload the measurement instrument but is strong enough to allow measurement of the operating or fundamental frequency of the EUT).

d) Turn the EUT OFF and place it inside the environmental temperature chamber. For devices that have oscillator heaters, energize only the heater circuit.

e) Set the temperature control on the chamber to the highest specified in the regulatory requirements for the type of device and allow the oscillator heater and the chamber temperature to stabilize.

f) While maintaining a constant temperature inside the environmental chamber, turn the EUT ON and record the operating frequency at startup, and at 2 minutes, 5 minutes, and 10 minutes after the EUT is energized. Four measurements in total are made.

g) Measure the frequency at each of frequencies specified in 5.6.

h) Switch OFF the EUT but do not switch OFF the oscillator heater.

i) Lower the chamber temperature by not more than 10 °C, and allow the temperature inside the chamber to stabilize.

j) Repeat step f) through step i) down to the lowest specified temperature.

ANSI C63.10 6.8.2 Frequency stability when varying supply voltage

Unless otherwise specified, these tests shall be made at ambient room temperature (+15 °C to +25 °C). An antenna shall be connected to the antenna output terminals of the EUT if possible. If the EUT is equipped with or uses an adjustable-length antenna, then it shall be fully extended.

a) Supply the EUT with nominal voltage or install a new or fully charged battery in the EUT. Turn ON the EUT and couple its output to a frequency counter or other frequency-measuring instrument.

NOTE—An instrument that has an adequate level of accuracy as specified by the procuring or regulatory agency is the recommended measuring instrument.

b) Tune the EUT to one of the number of frequencies required in 5.6. Adjust the location of the measurement antenna and the controls on the measurement instrument to obtain a suitable signal level (i.e., a level that will not overload the measurement instrument but is strong enough to allow measurement of the operating or fundamental frequency of the EUT).

c) Measure the frequency at each of the frequencies specified in 5.6.

d) Repeat the above procedure at 85% and 115% of the nominal supply voltage as described in 5.13.

Table 18 – Frequency stability with temperature

Channel Frequency kHz	Time	+50 C kHz	+20 C kHz	-20 C kHz		Change kHz	
2402000	0 min	2401991.0	2402003.3	2402014.8	Min	24.8	Pass
	2 min	2401990.5	2402007.3	2402012.8	2401990.0		
	5 min	2401990.3	2402008.8	2402001.5	Max		
	10 min	2401990.0	2402009.5	2402011.3	2402014.8		
2441000	0 min	2440990.8	2441005.5	2441011.5	Min	22.0	Pass
	2 min	2440990.5	2441007.8	2441011.5	2440990.0		
	5 min	2440990.0	2441008.3	2441011.8	Max		
	10 min	2440990.3	2441009.0	2441012.0	2441012.0		
2480000	0 min	2479990.8	2480002.5	2480012.3	Min	23.0	Pass
	2 min	2479990.0	2480005.8	2480013.0	2479990.0		
	5 min	2479990.0	2480008.5	2480012.5	Max		
	10 min	2479990.0	2480009.8	2480012.5	2480013.0		

Table 19 – Frequency stability with varying voltage supply

No change in radiated signal level was observed with the battery's nominal voltage, and again at the battery's fully charged operating end-point voltage.	Pass

END OF TEST REPORT