Certificate of Test

NCT CO., LTD.
211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, 18511, Republic of Korea
(Tel: +82-31-323-6070 / Fax: +82-31-323-6071)

Report No.: NW2103-F001

Your business' success starts with NCT

1. **Client**
   - ○ Name : SENA TECHNOLOGIES.Inc
   - ○ Address : 19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, Korea
   - ○ Date of Receipt : 2021-01-11

2. **Use of Report :** FCC & IC Approval

3. **Test Sample**
   - ○ Description / Model Name : SPIDER ST1 / SP88
   - ○ FCC ID : S7A-SP88 / IC : 8154A-SP88

4. **Place of Test :** ■ Fixed test □ Field test
   (Address:211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, 18511, Republic of Korea)

5. **Date of Test :** 2021-01-18 ~ 2021-02-16

6. **Test method used :** FCC Part 15 Subpart C 15.247
   RSS-247 Issue 2(2017-02), RSS-GEN Issue 5(2019-03)

7. **Testing Environment :**
   - ○ Temperature: (25 ± 5) °C, Humidity: Less than 75 % R.H.

   * Unless specified otherwise in the individual methods, the tests were conducted on ambient conditions.

8. **Test Results :** Refer to the test results

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.
This Test Report cannot be reproduced, except in full
This test report is not related to KOLAS recognition and RRA designation.

Affirmation	**Tested by** Jong-Myoung, Shin (signature)	**Technical Manager** Changmin, Kim (signature)

Mar 03, 2021

NCT CO., LTD. (seal)

Contact us at report@nct.re.kr to confirm the authenticity of this report

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1. General Information's

1.1 Test Performed

Laboratory	:	NCT Co., Ltd.
Address	:	211-71, Geumgok-ro, Hwaseong-si, Gyeonggi-do, 18511, Korea
Telephone	:	+82-31-323-6070
Facsimile	:	+82-31-323-6071
FCC Designation No.	:	KR0166
FCC Registration No.	:	409631
IC Site Registration No.	:	25897

2. Information's about Test Item

2.1 Applicant Information

Company name	:	SENA TECHNOLOGIES.Inc
Address	:	19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, Korea
Telephone / Facsimile	:	+82-2-571-8283 / +82-2-573-7710

2.2 Equipment Under Test (EUT) description

Test item particulars	:	SPIDER ST1
Model and/or type reference	:	SP88
Additional model name	:	-
Serial number	:	Prototype
Antenna type and gain	:	Chip Antenna(M/N: SENA_009) with Max gain: 0.93 dBi
Date (s) of performance of tests:	:	2021-01-18 ~ 2021-02-16
Date of receipt of test item	:	2021-01-11
EUT condition	:	Pre-production, not damaged
Number of channel	:	79
EUT Power Source	:	DC 3.7 V
Type of Modulation	:	BDR Mode(GFSK), EDR Mode(Pi/4 DQPSK, 8DPSK)
Firmware version	:	1.0
Hardware version	:	1.0
Test software name(version)	:	Qualcomm BlueSuite_BlueTest3(3.3.5)

2.3 Tested Frequency

Test Mode	Test frequency (㎒)		
	Low frequency	Middle frequency	High frequency
GFSK	2 402	2 441	2 480
Pi/4 DQPSK	2 402	2 441	2 480
8DPSK	2 402	2 441	2 480

2.4 Used Test Software Setting Value

Test Mode	Setting Item		
	Atn	Mag	Exp
GFSK	0	7	0
Pi/4 DQPSK	0	4	0
8DPSK	0	4	0

2.5 Worst-Case

BDR	GFSK(DH5)
EDR	8DPSK(3-DH5)

Note: The power measurement has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates.

3. Test Report

3.1 Test Summary

Applied	FCC Rule	IC Rule	Test Items	Test Condition	Result
☒	15.203	-	Antenna Requirement	Conducted	C
☒	15.247(a)	-	20 ㏈ Bandwidth		C
☒	-	RSS GEN (6.7)	Occupied Bandwidth (99%)		C
☒	15.247(a)	RSS-247 (5.1)	Number of Hopping Frequencies		C
☒	15.247(a)	RSS-247 (5.1)	Time of Occupancy (Dwell Time)		C
☒	15.247(a)	RSS-247 (5.1)	Carrier Frequencies Separation		C
☒	15.247(b)	RSS-247 (5.4)	Peak Output Power		C
☒	15.247(d)	RSS-247 (5.5)	Conducted Spurious Emission		C
☒	15.247(d) 15.205 & 15.209	RSS-247 (5.5) RSS-GEN (8.9 & 8.10)	Radiated Spurious Emission	Radiated	C
☒	15.207	RSS-GEN (8.8)	Conducted Emissions	AC Line Conducted	C

Note 1: C=Complies NC=Not Complies NT=Not Tested NA=Not Applicable

The sample was tested according to the following specification: ANSI C63.10:2013.

Compliance was determined by specification limits of the applicable standard according to customer requirements.

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3.2 Test Report Version

Test Report No.	Date	Description
NW2103-F001	2021-03-03	Initial issue

3.3 Transmitter Requirements

3.3.1 Antenna Requirement

Accoding to §15.203 An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall 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. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

Accoding to §15.247(b)(4) e conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

3.3.1.1 Result

Complies
(The transmitter has a Chip Antenna. The directional peak gain of the antenna is 0.93 dBi.)

3.3.2 20 ㏈ Bandwidth & Occupied Bandwidth (99%)

3.3.2.1 Test Setup

Refer to the APPENDIX I.

3.3.2.2 Limit

Limit : Not Applicable

3.3.2.3 Test Procedure

1. The 20 ㏈ bandwidth & Occupied bandwidth were measured with a spectrum analyzer connected to RF antenna Connector (conducted measurement) while EUT was operating in transmit mode. The analyzer center frequency was set to the EUT carrier frequency, using the analyzer.

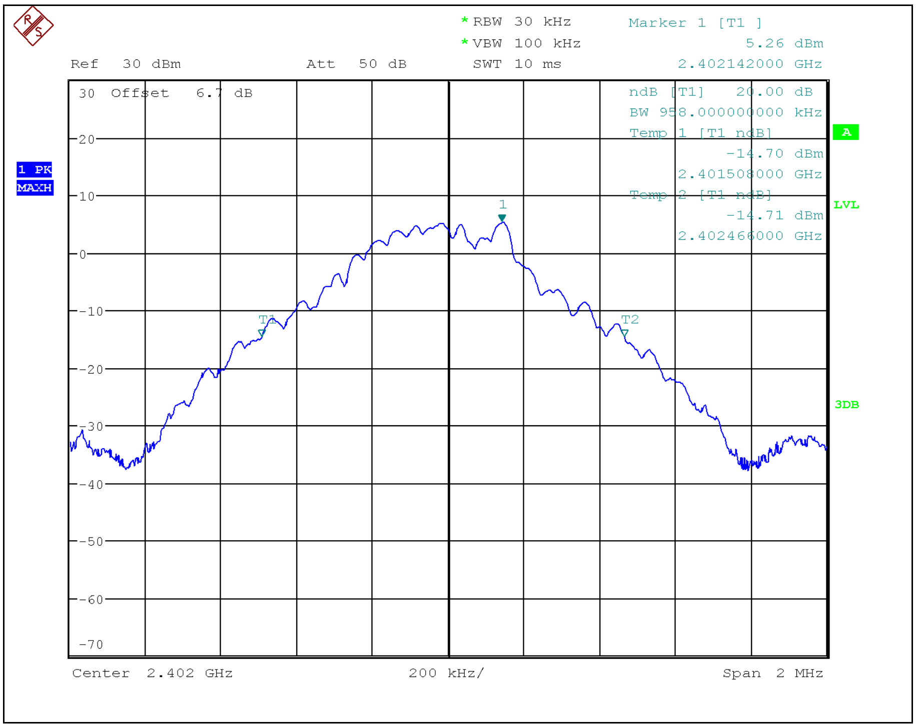
2. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using below setting:
   RBW = 1% to 5% of the 20 ㏈ Bandwidth & Occupied Bandwidth
   VBW ≥ 3 × RBW
   Span = between two times and five times the 20 ㏈ Bandwidth & Occupied Bandwidth
   Sweep = Auto
   Detector function = Peak
   Trace = Max Hold

3.3.2.4 Test Result

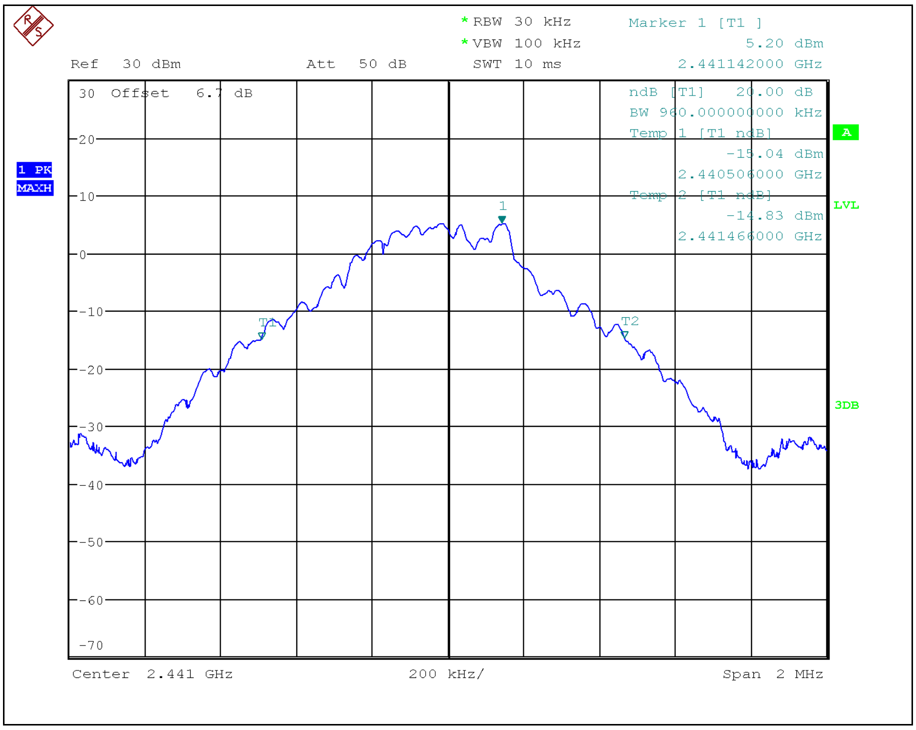
Test Mode	Test Frequency	20 ㏈ Bandwidth (㎒)	Occupied Bandwidth (㎒)
GFSK	Low	0.958	0.870
	Middle	0.960	0.870
	High	0.956	0.866
8DPSK	Low	1.306	1.180
	Middle	1.306	1.182
	High	1.310	1.182

3.3.2.5 Test Plot

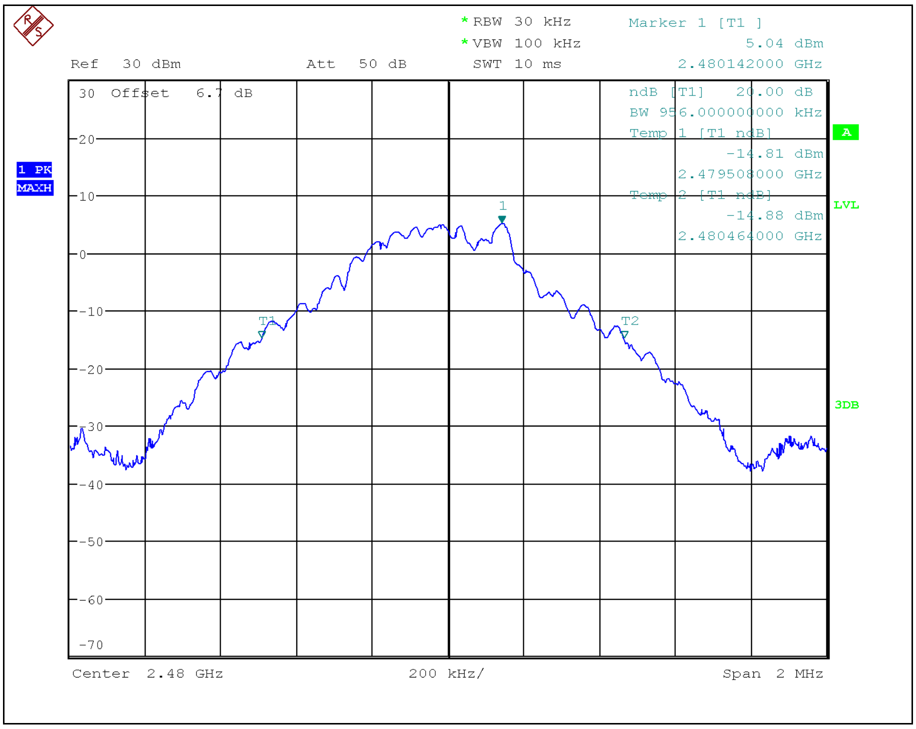
GFSK _ Low frequency **20 dB Bandwidth**



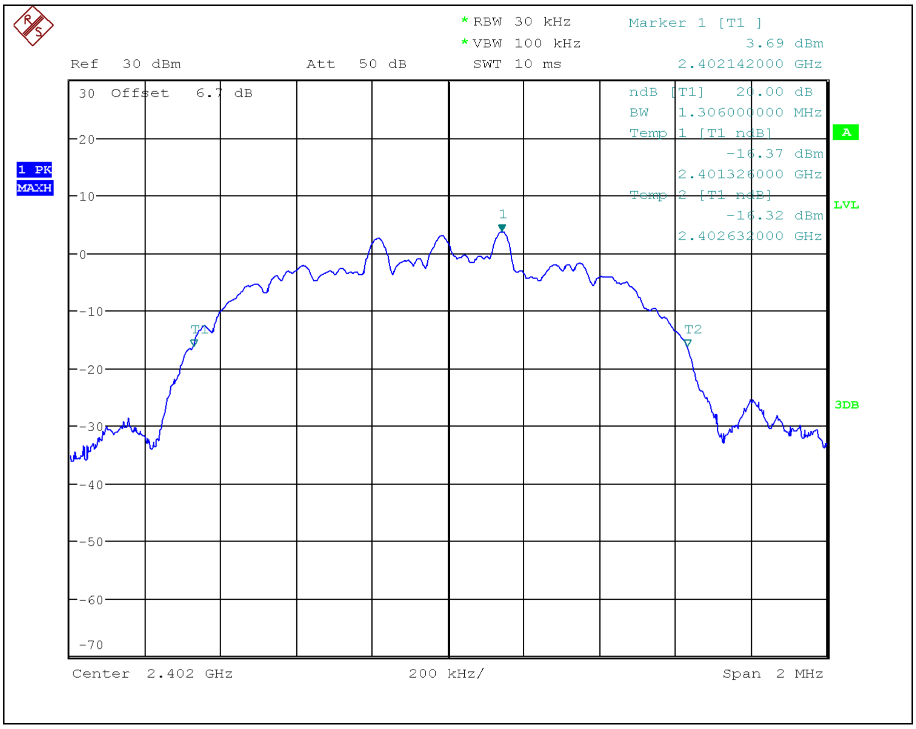
GFSK _ Middle frequency **20 dB Bandwidth**



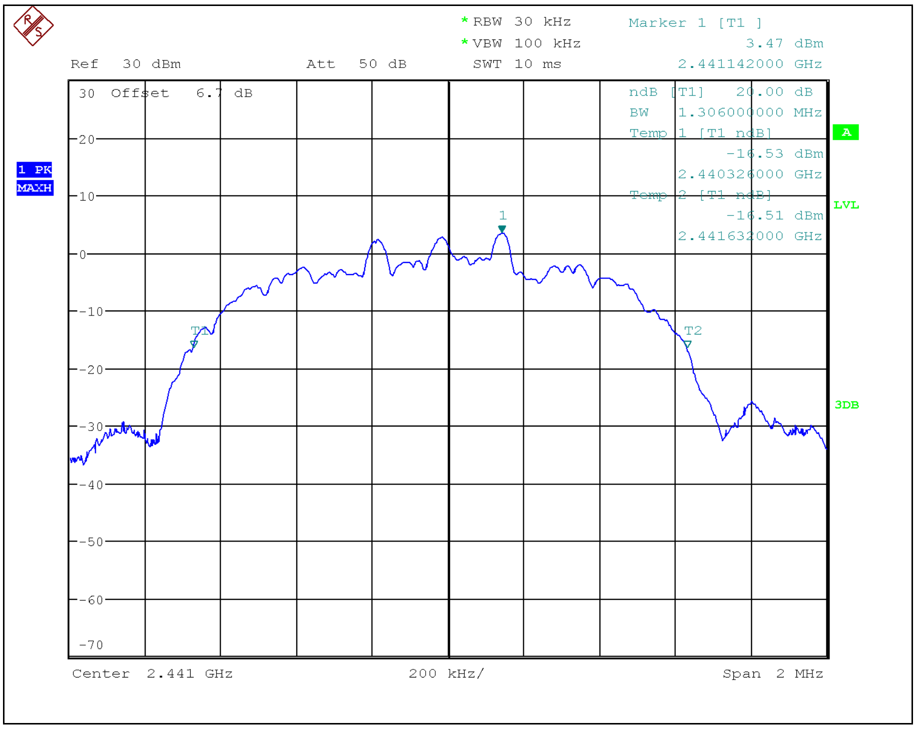
GFSK _ High frequency 20 ㏈ Bandwidth



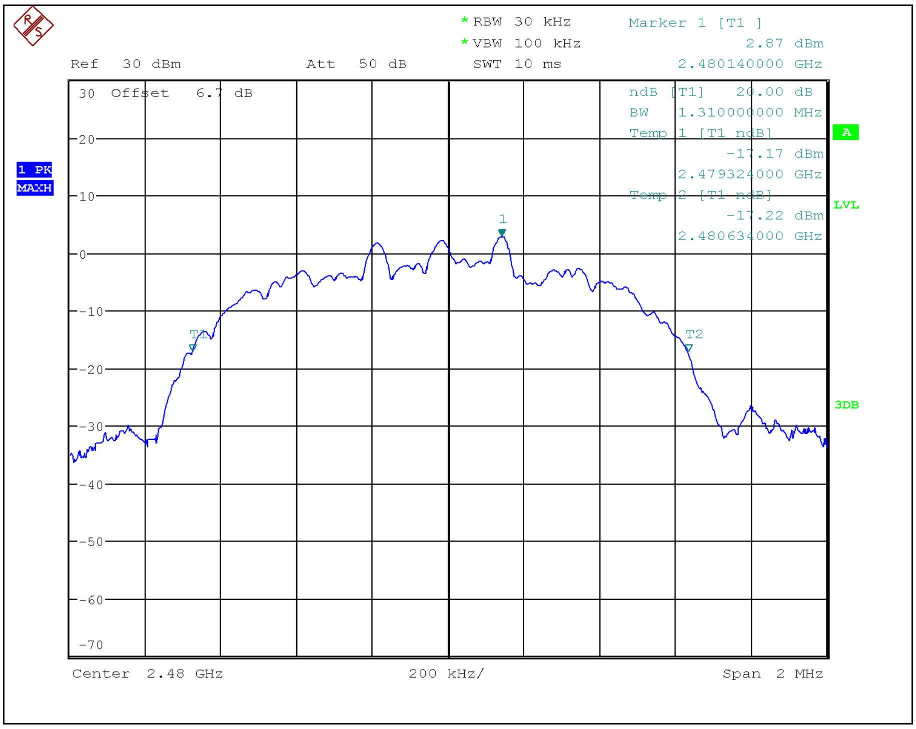
8DPSK _ Low frequency 20 ㏈ Bandwidth



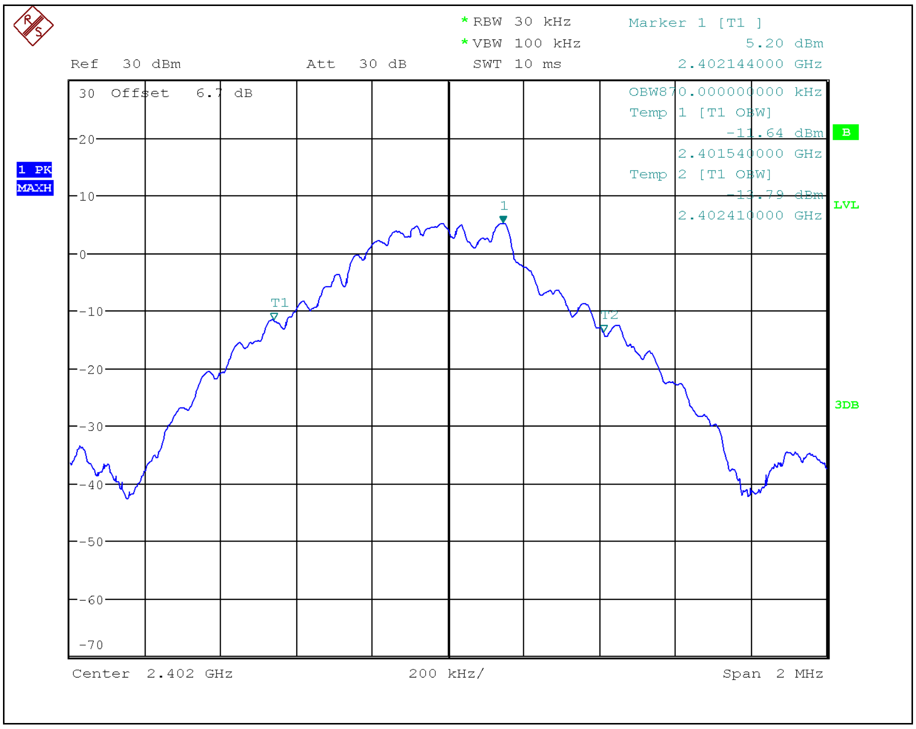
8DPSK _ Middle frequency 20 dB Bandwidth



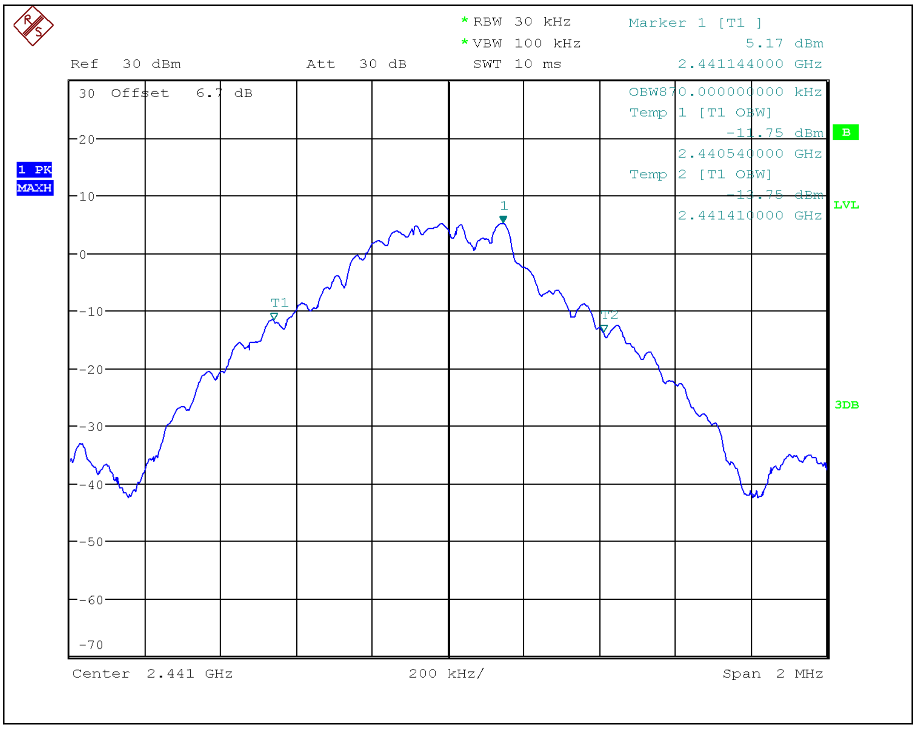
8DPSK _ High frequency 20 dB Bandwidth



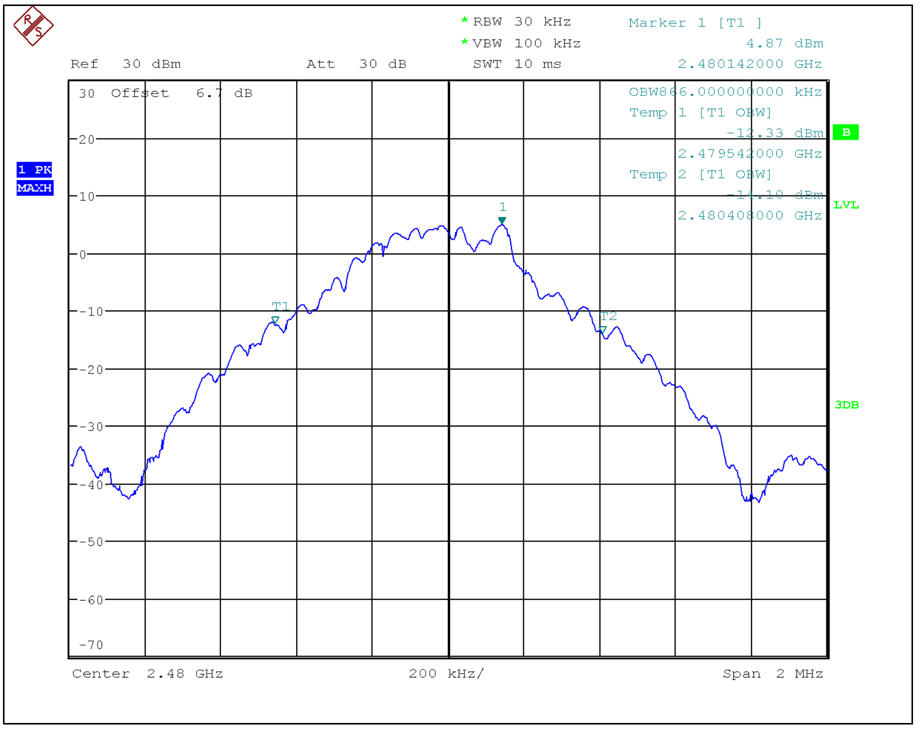
GFSK _ Low frequency **Occupied Bandwidth**



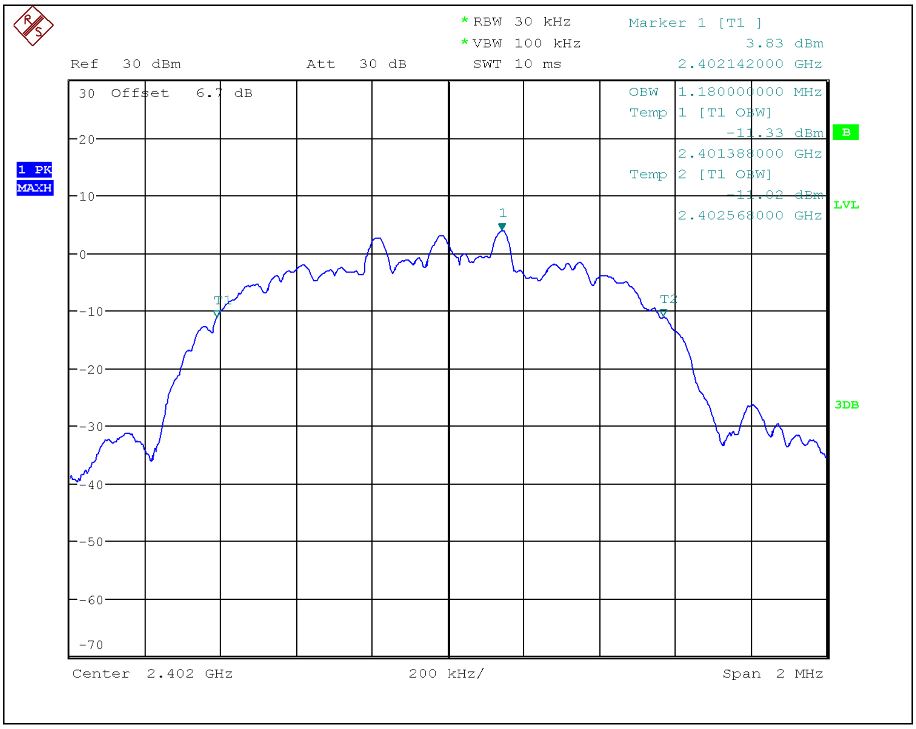
GFSK _ Middle frequency **Occupied Bandwidth**



GFSK _ High frequency **Occupied Bandwidth**



8DPSK _ Low frequency **Occupied Bandwidth**



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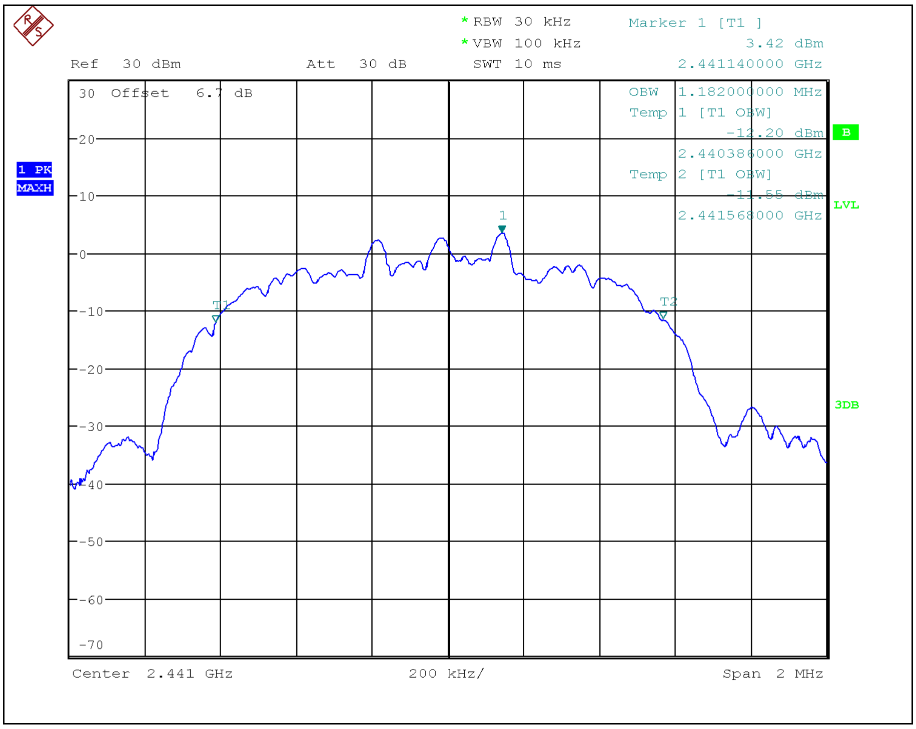
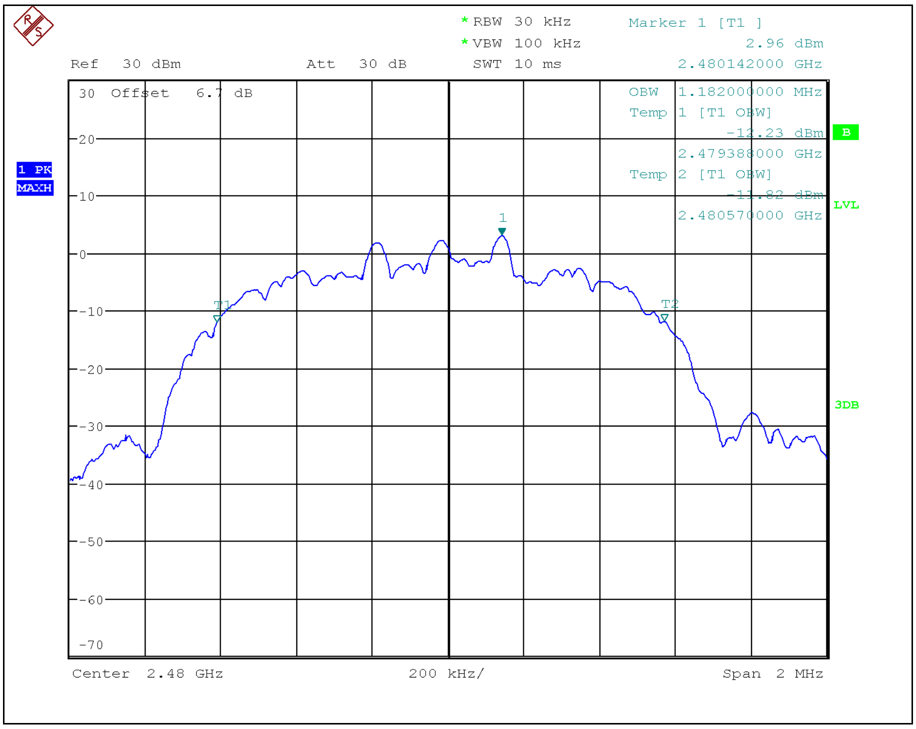
8DPSK _ Middle frequency Occupied Bandwidth



8DPSK _ High frequency Occupied Bandwidth



3.3.3 Number of Hopping Frequencies

3.3.3.1 Test Setup

Refer to the APPENDIX I.

3.3.3.2 Limit

Limit : >= 15 hops

3.3.3.3 Test Procedure

The number of hopping frequencies was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled.
To get higher resolution, two frequency ranges for FH mode within the 2400 ~ 2483.5 ㎒ were examined.

The spectrum analyzer is set to:

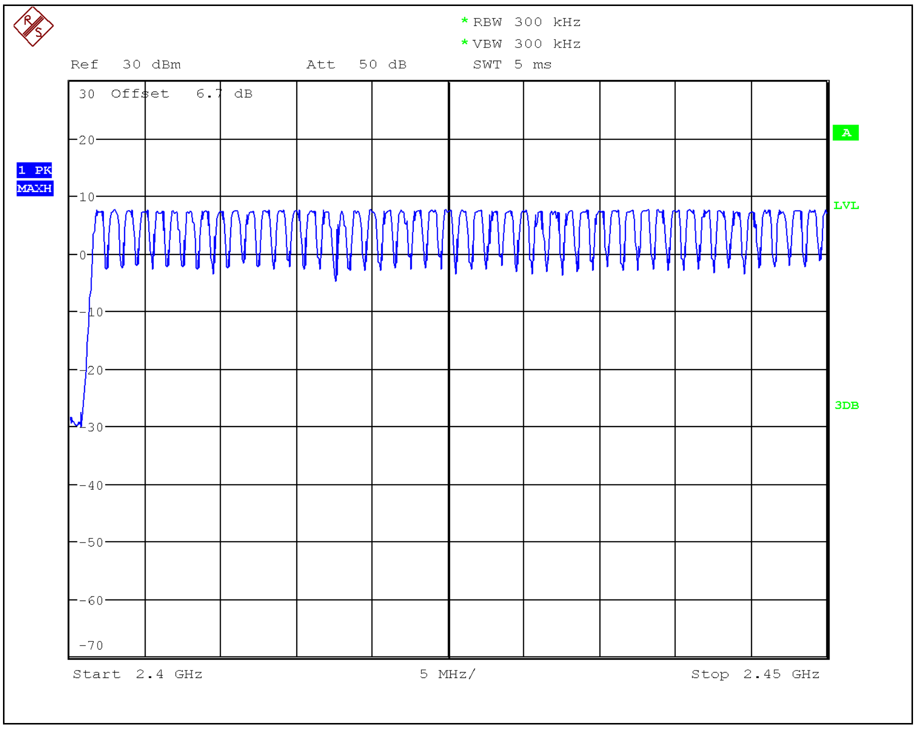
Span = 50 ㎒
RBW = To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 ㏈ bandwidth, whichever is smaller.
VBW ≥ RBW Sweep = Auto
Detector = Peak Trace = Max hold

3.3.3.4 Test Result

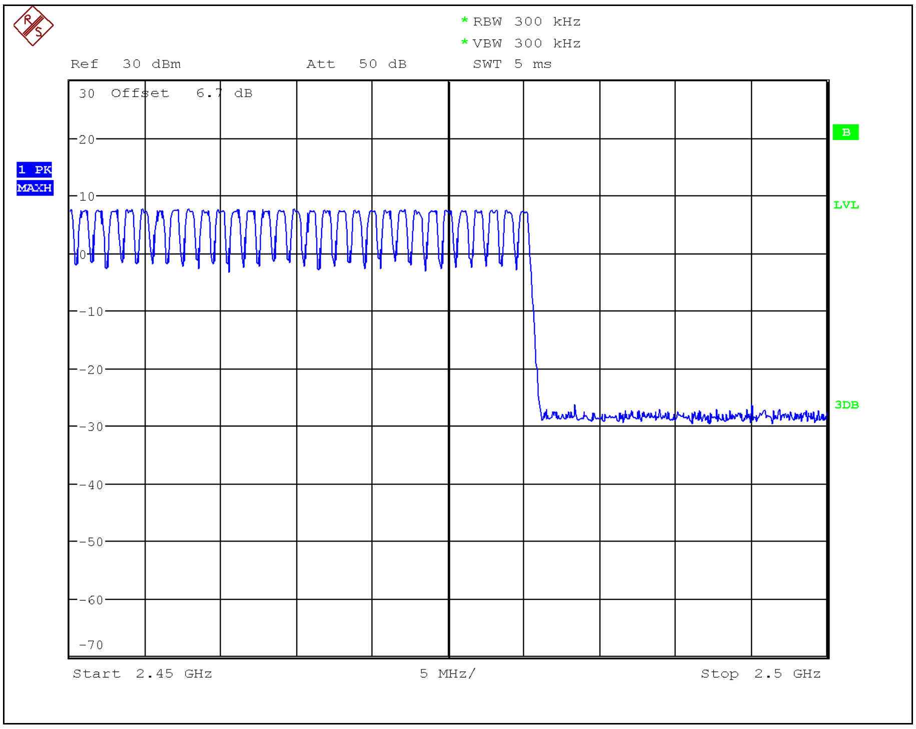
Test Mode	Number of Hopping Channels
GFSK	79
8DPSK	79

3.3.3.5 Test Plot

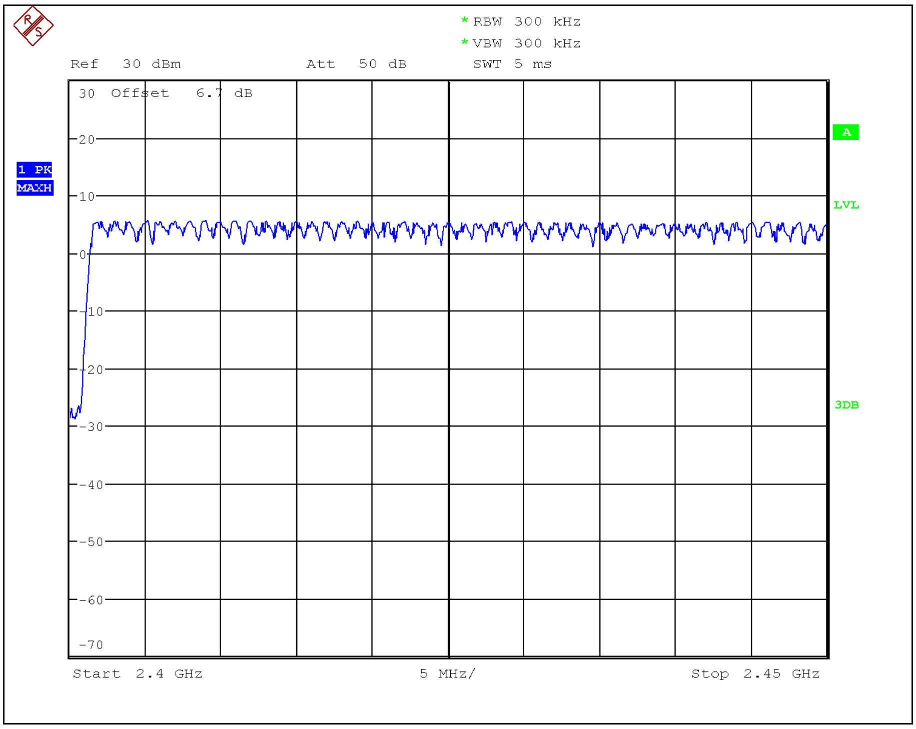
GFSK _ Hopping Mode Number of Hopping Frequencies



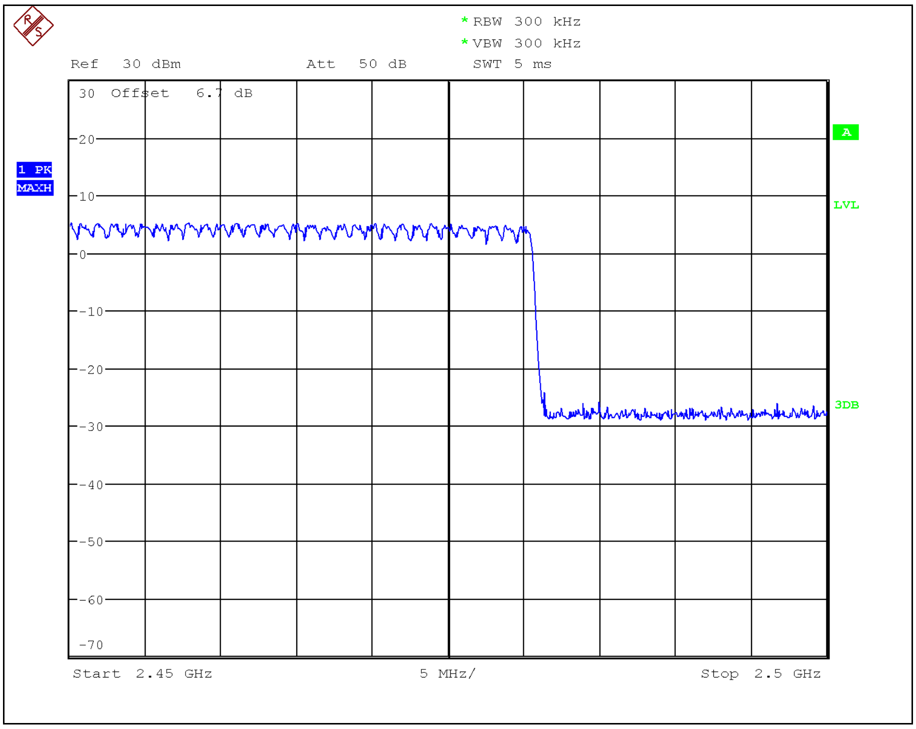
GFSK _ Hopping Mode Number of Hopping Frequencies



8DPSK _ Hopping Mode Number of Hopping Frequencies



8DPSK _ Hopping Mode Number of Hopping Frequencies



3.3.4 Time of Occupancy (Dwell Time)

3.3.4.1 Test Setup

Refer to the APPENDIX I.

3.3.4.2 Limit

The maximum permissible time of occupancy is 400 ms within a period of 400 ms multiplied by the number of hopping channels employed.

3.3.4.3 Test Procedure

The dwell time was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled.

The spectrum analyzer is set to:
Center frequency = 2442 ㎒ Span = Zero
RBW = 1 ㎒ (RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel)
VBW ≥ RBW Detector = Peak
Trace = Max hold

3.3.4.4 Test Result

Test Mode	Number of Hopping Channels	Burst On Time (ms)	Result (sec)	Limit (sec)
GFSK (non-AFH)	79	2.883	0.31	0.40
GFSK (AFH)	20	2.883	0.15	0.40
8DPSK (non-AFH)	79	2.883	0.31	0.40
8DPSK (AFH)	20	2.883	0.00	0.40

Note: Dwell Time = 0.4 x Hopping channel x Burst On Time x ((Hopping rate / Time slots) / Hopping channel)
- Time slots for DH5 = 6 slots (TX = 5 slot / RX = 1 slot)
- Hopping Rate = 1600 for FH mode & 800 for AFH mode

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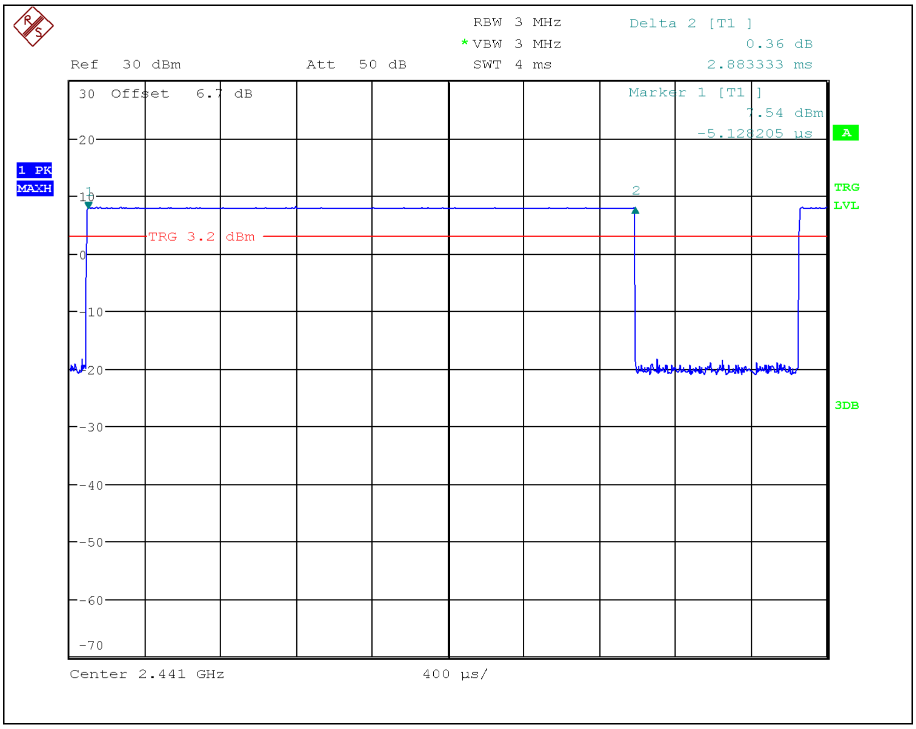
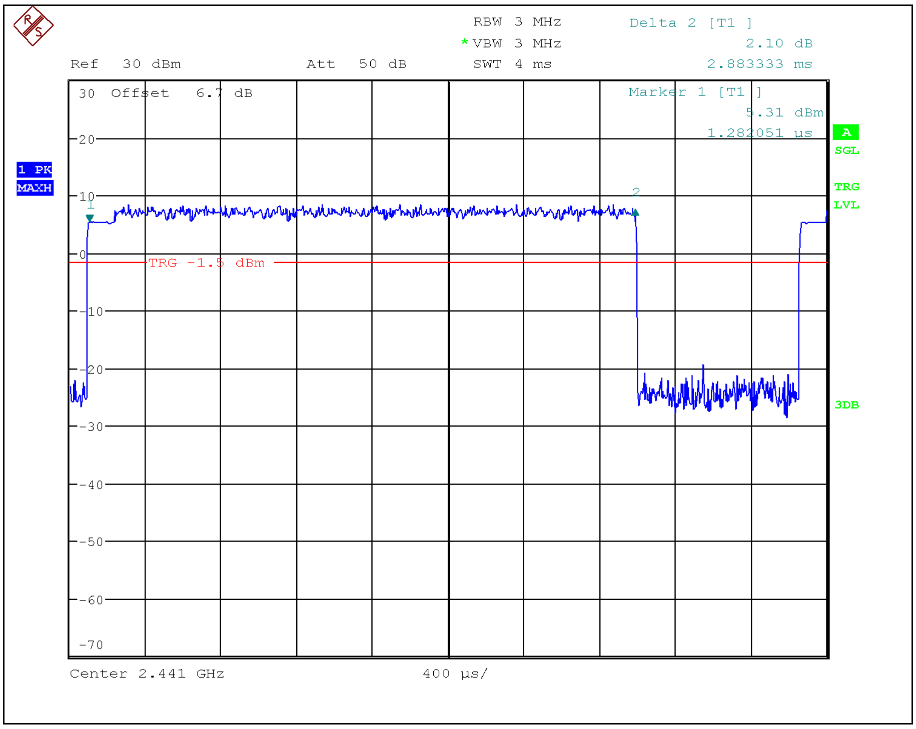
3.3.4.5 Test Plot

GFSK **Time of Occupancy**



8DPSK **Time of Occupancy**



3.3.5 Carrier Frequencies Separation

3.3.5.1 Test Setup

Refer to the APPENDIX I.

3.3.5.2 Limit

Limit : ≥ 25 ㎑ or ≥ Two-Thirds of the 20 ㏈ Bandwidth whichever is greater.

3.3.5.3 Test Procedure

The carrier frequency separation was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled.
After the trace being stable, the reading value between the peaks of the adjacent channels using the marker delta function was recorded as the measurement results.

The spectrum analyzer is set to:
Span = wide enough to capture the peaks of two adjacent channels
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.
VBW ≥ RBW Sweep = Auto
Detector = Peak Trace = Max hold

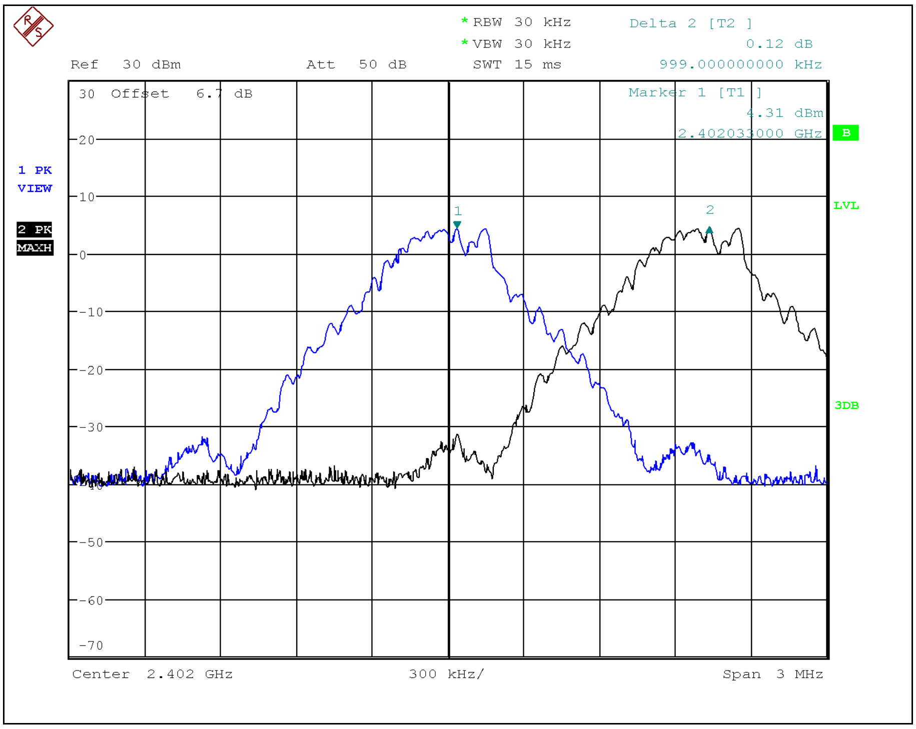
3.3.5.4 Test Result

Test Mode	Test Frequency	Carrier Frequencies Separation (㎑)	Min. Limit (㎑)
GFSK	Low	0.999	0.639
	Middle	0.999	0.640
	High	1.002	0.637
8DPSK	Low	1.002	0.871
	Middle	1.002	0.871
	High	0.999	0.873

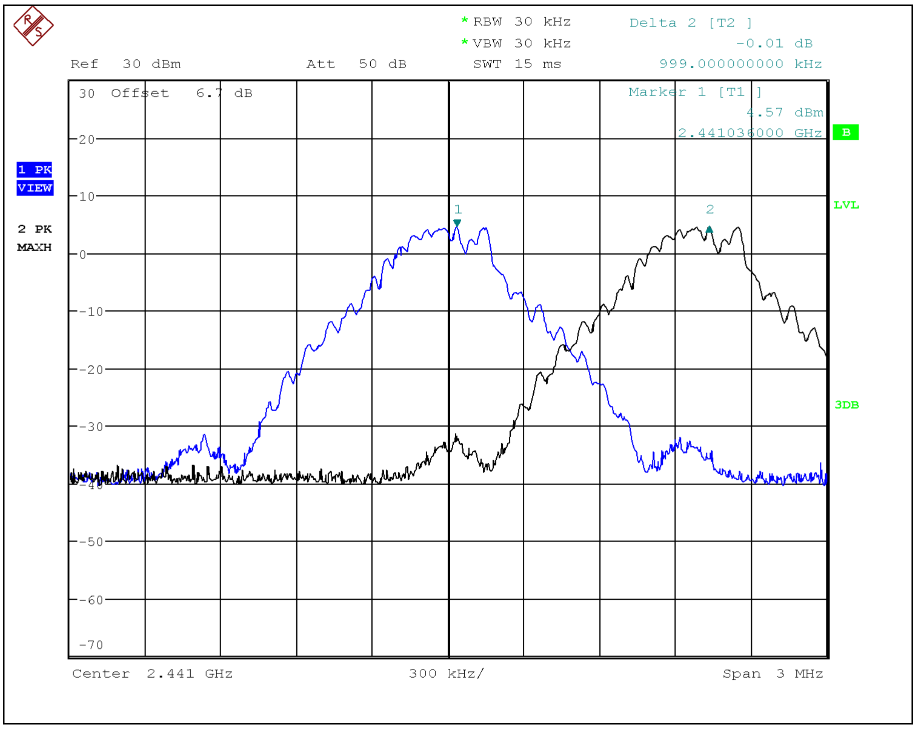
Note: Limit(㎑) = Test Result of 20 ㏈ BW * 2/3

3.3.5.5 Test Plot

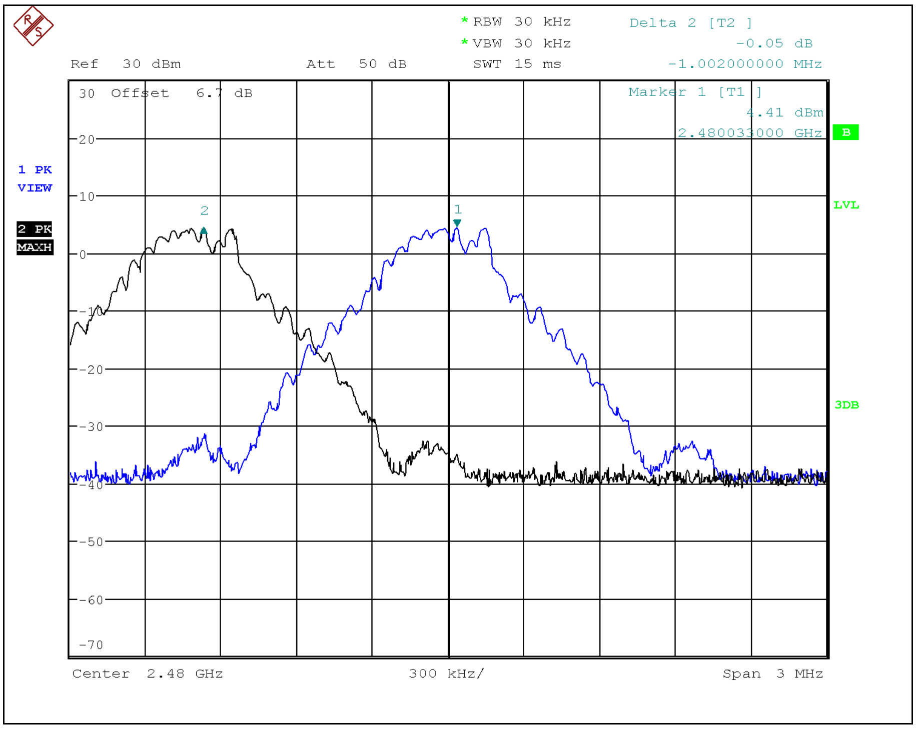
GFSK _ Low frequency Carrier Frequency Separation



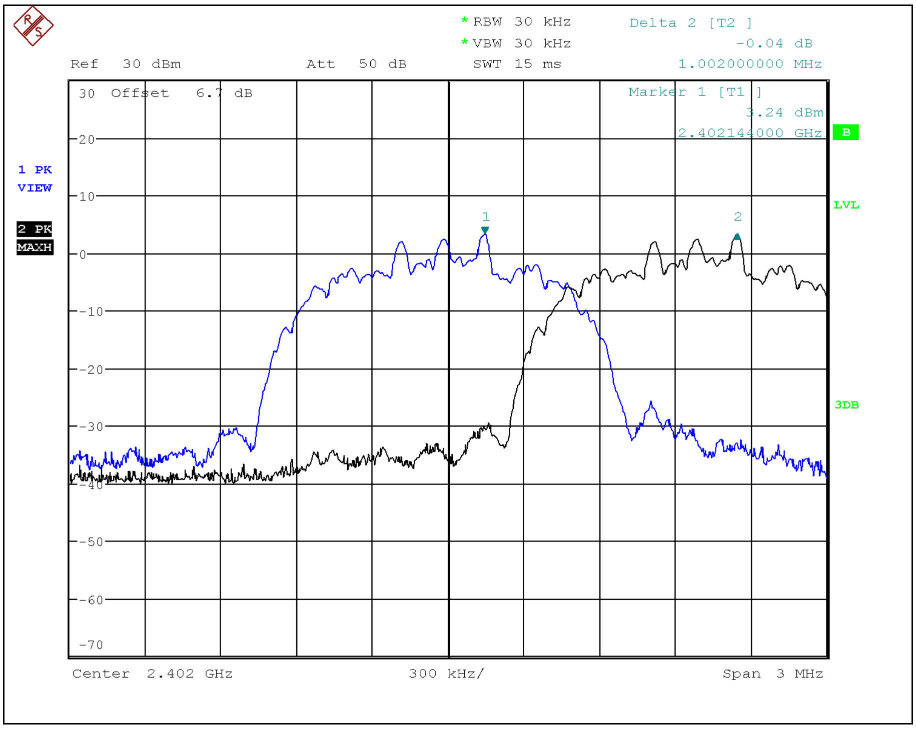
GFSK _ Middle frequency Carrier Frequency Separation



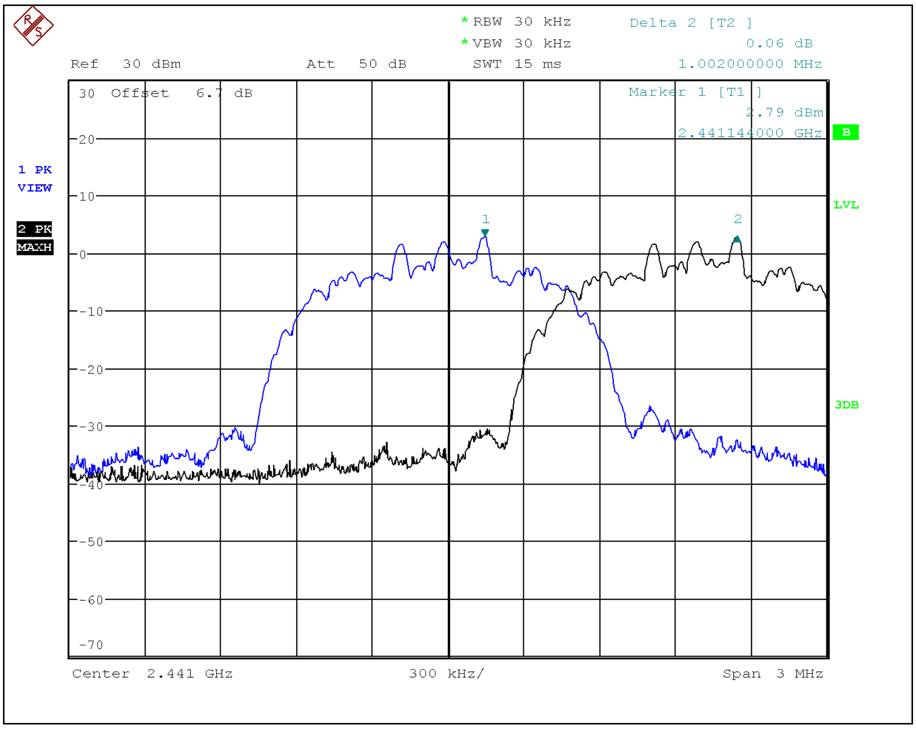
GFSK _ High frequency Carrier Frequency Separation



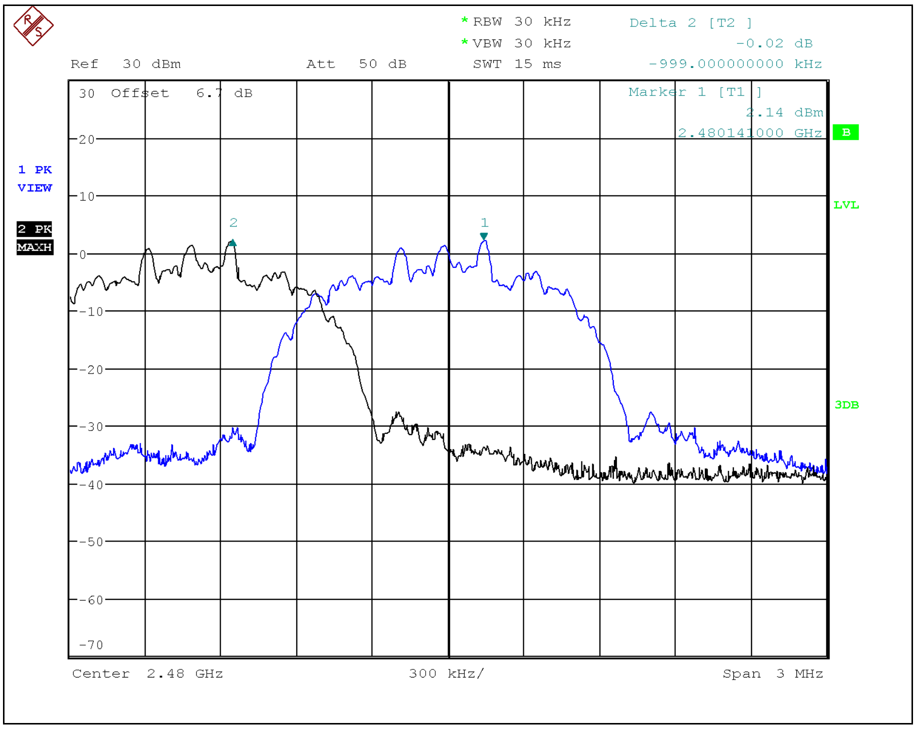
8DPSK _ Low frequency Carrier Frequency Separation



8DPSK _ Middle frequency   Carrier Frequency Separation



8DPSK _ High frequency   Carrier Frequency Separation



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3.3.6 Peak Output Power

3.3.6.1 Test Setup

Refer to the APPENDIX I.

3.3.6.2 Limit

■ **FCC Requirements**

The maximum peak output power of the intentional radiator shall not exceed the following:

1. §15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 ㎑ or the 20 ㏈ bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 ㎒ band may have hopping channel carrier frequencies that are separated by 25 ㎑ or two-thirds of the 20 ㏈ bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 ㎽.
2. §15.247(b)(1), For frequency hopping systems operating in the 2400 – 2483.5 ㎒ employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725 – 5805 ㎒ band: 1 Watt. For all other frequency hopping systems in the 2400-2483.5 ㎒ band: 0.125 watts.

■ **IC Requirements**

1. 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)

3.3.6.3 Test Procedure

1. The RF output power was measured with a spectrum analyzer connected to the RF Antenna connector (conducted measurement) while EUT was operating in transmit mode at the appropriate center frequency, a spectrum analyzer was used to record the shape of the transmit signal.
2. The peak output power of the fundamental frequency was measured with the spectrum analyzer using;
   Span = approximately 5 times of the 20 ㏈ bandwidth, centered on a hopping channel
   RBW ≥ 20 ㏈ Bandwidth
   VBW ≥ RBW
   Sweep = Auto
   Detector function = Peak
   Trace = Max Hold

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3.3.6.4 Test Result

Test Mode	Test Frequency	Peak Output Power		Frame Average Power	
		dBm	mW	dBm	mW
GFSK	Low	7.96	6.25	7.78	6.00
	Middle	7.95	6.24	7.63	5.79
	High	7.81	6.04	7.25	5.31
Pi/4 DQPSK	Low	8.42	6.95	6.43	4.40
	Middle	7.98	6.28	6.36	4.33
	High	7.28	5.35	6.03	4.01
8DPSK	Low	9.12	8.17	6.66	4.63
	Middle	8.79	7.57	6.59	4.56
	High	7.95	6.24	6.37	4.34

Note1: Frame Average Power was tested using an average power meter for reference only.

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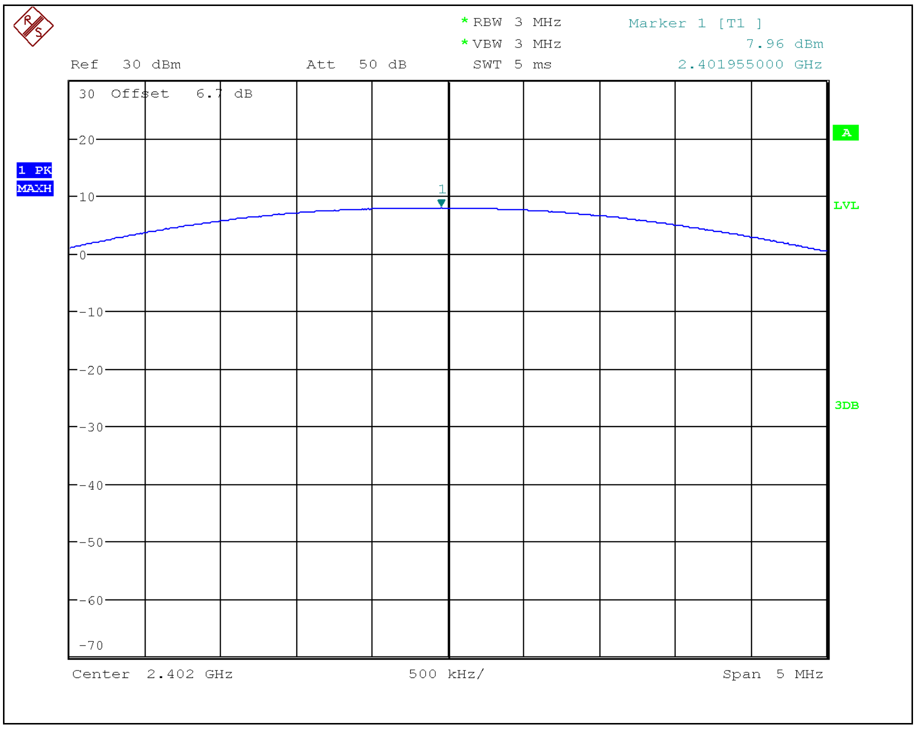
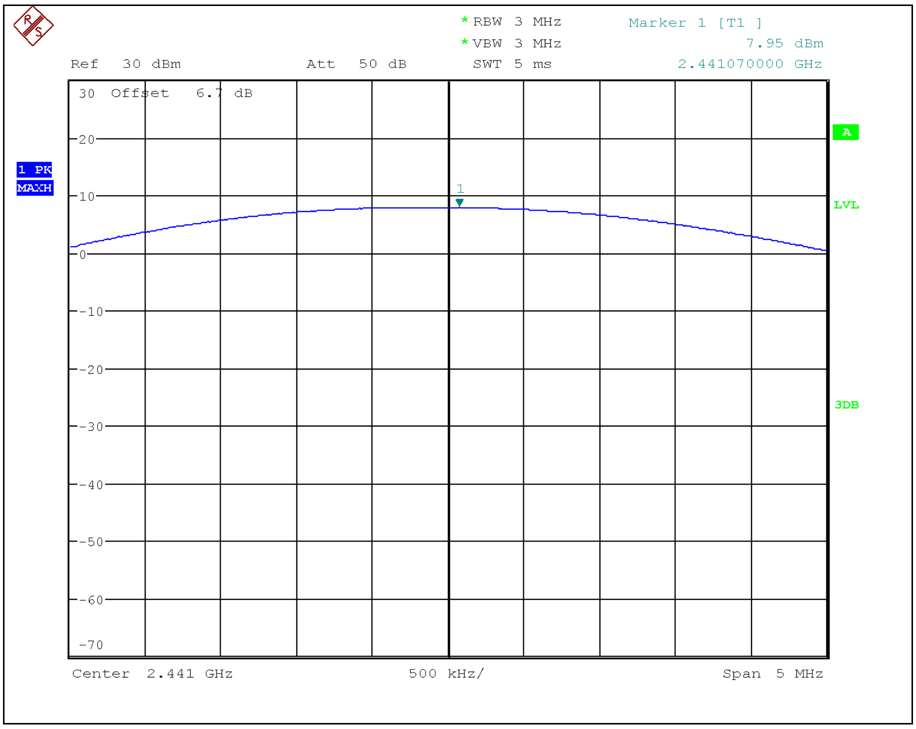
3.3.6.5 Test Plot

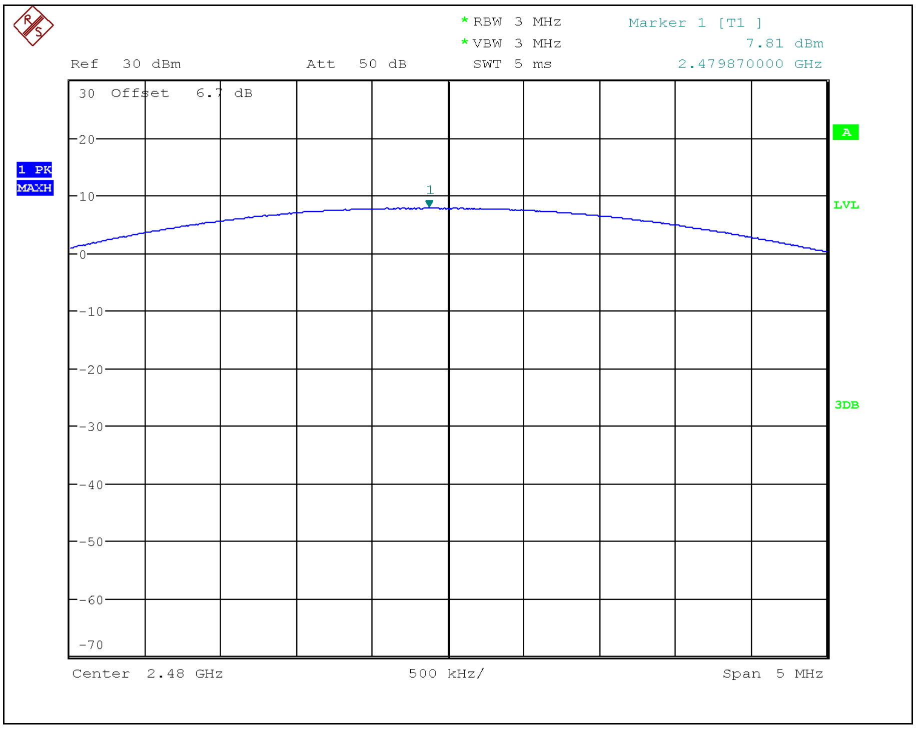
GFSK _ Low frequency **Peak Output Power**



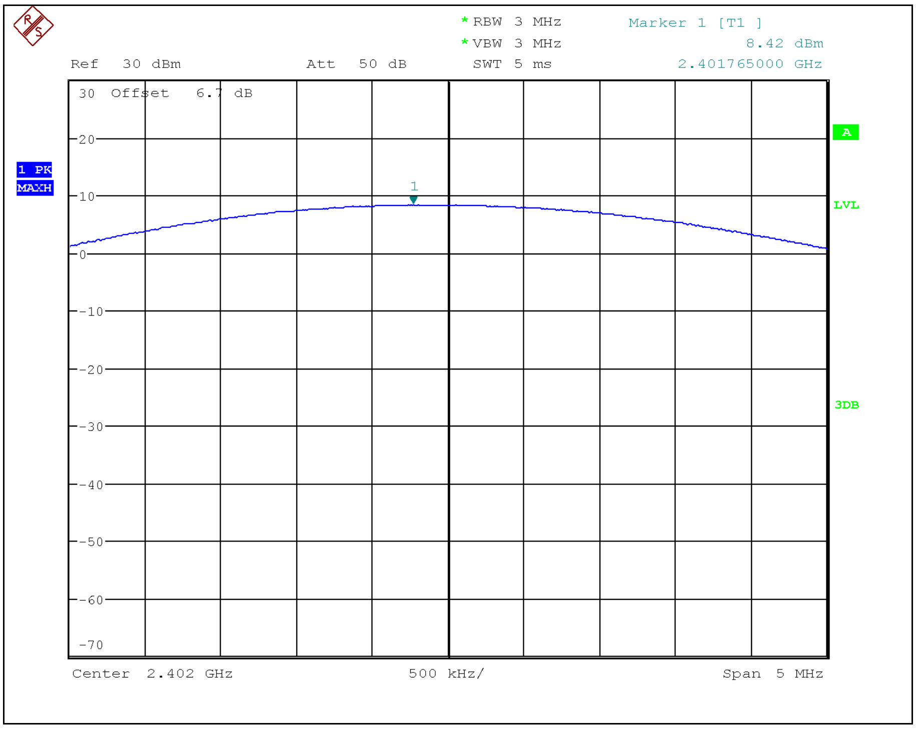
GFSK _ Middle frequency **Peak Output Power**



GFSK _ High frequency **Peak Output Power**

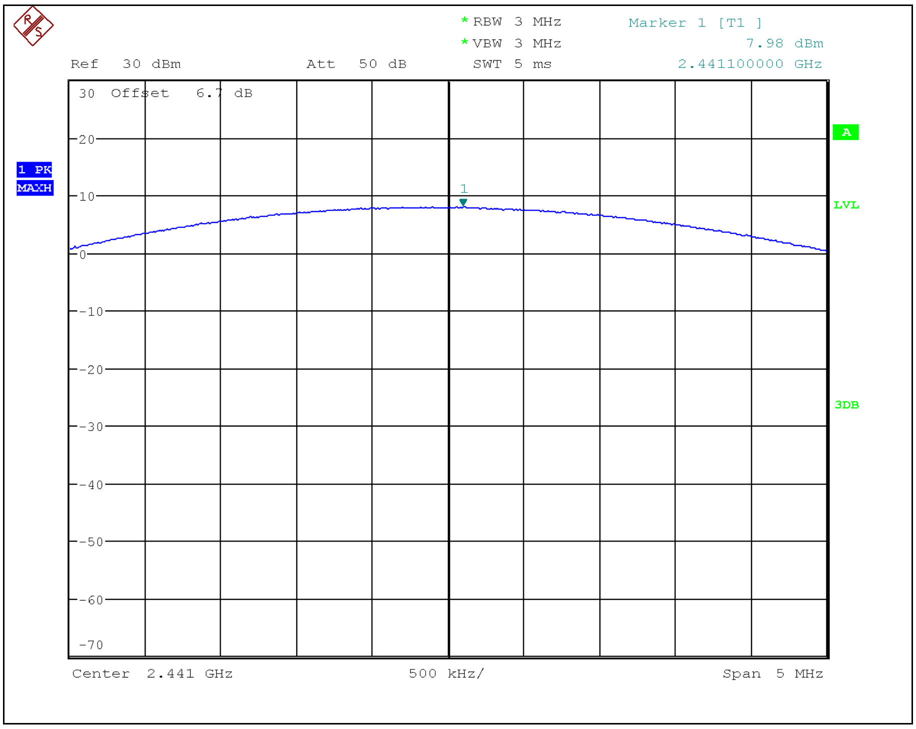


Pi/4 DQPSK _ Low frequency **Peak Output Power**



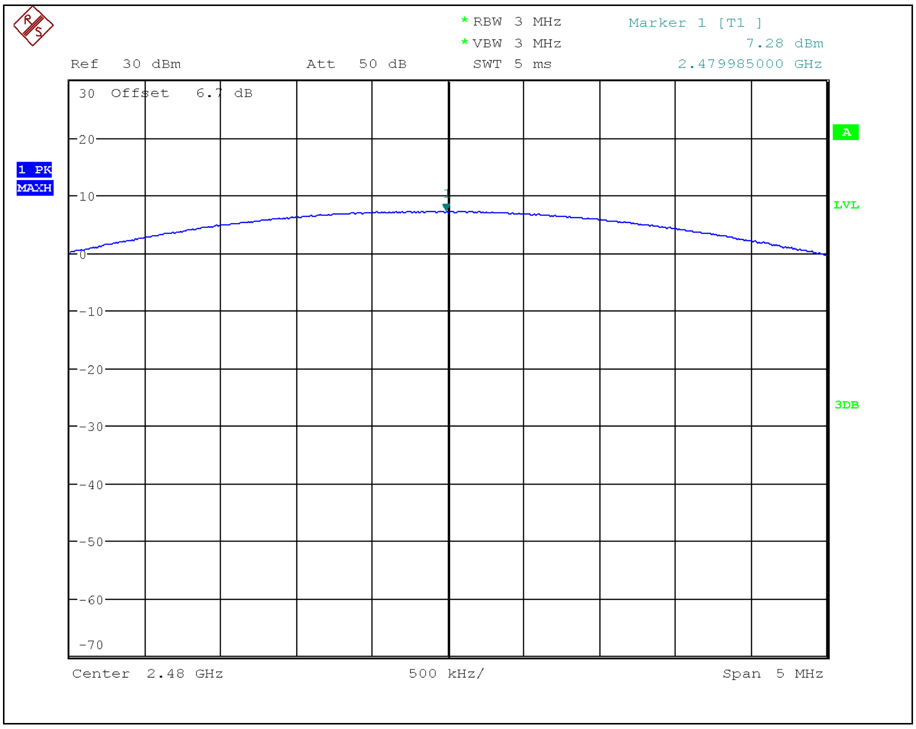
Pi/4 DQPSK _ Middle frequency

Peak Output Power



Pi/4 DQPSK _ High frequency

Peak Output Power



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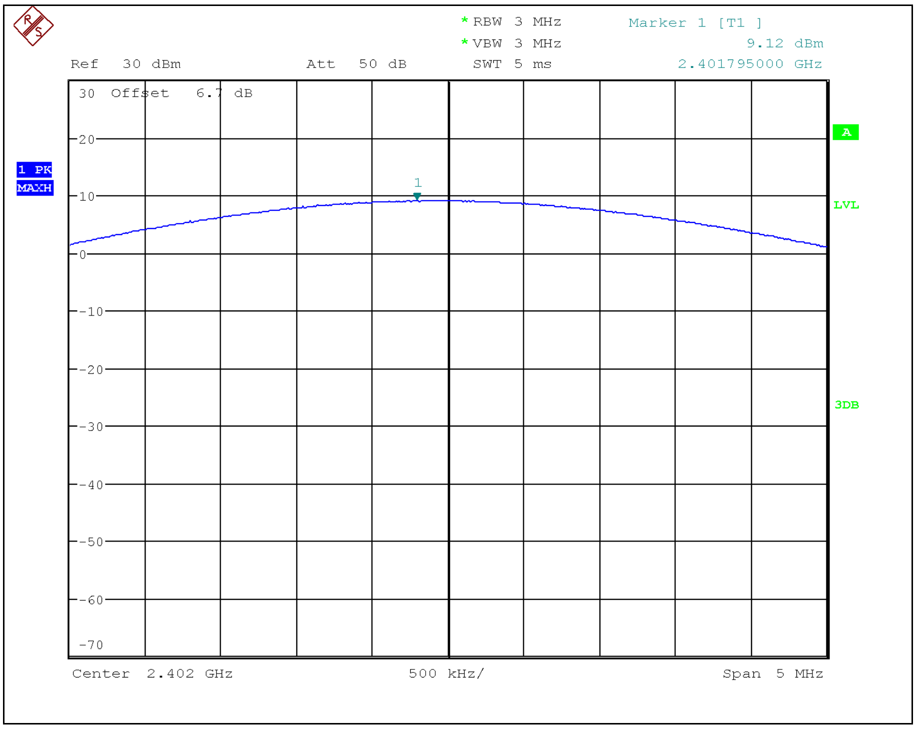
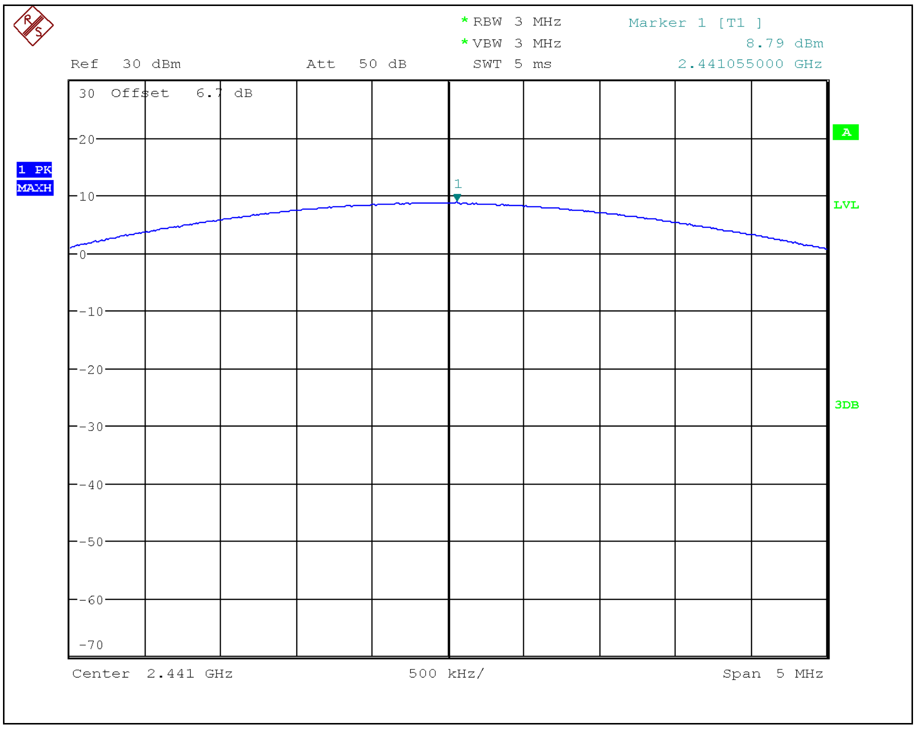
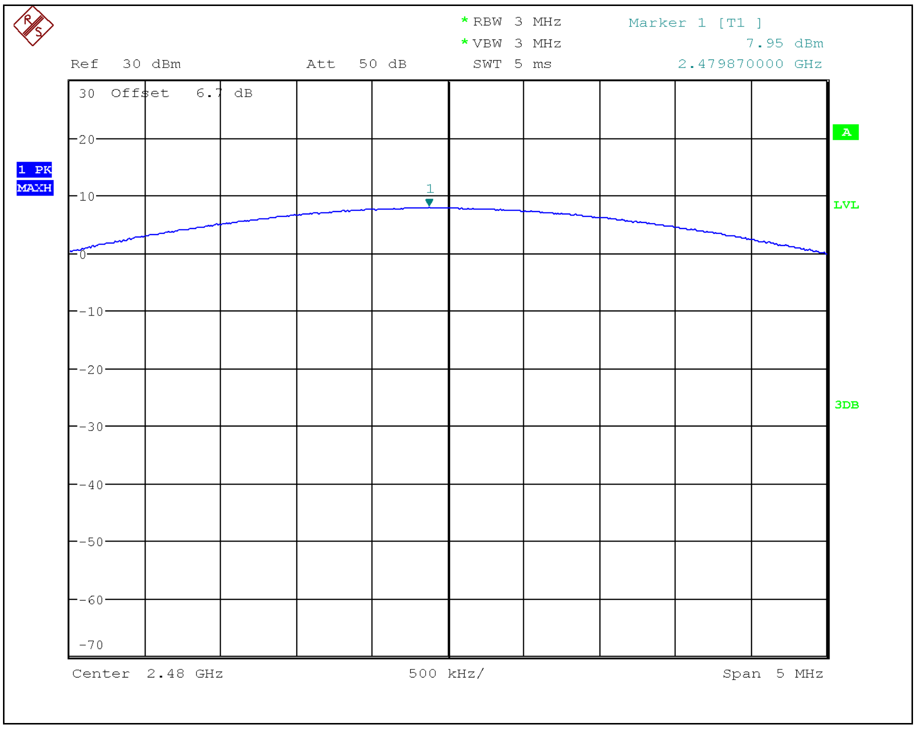
8DPSK _ Low frequency   Peak Output Power



8DPSK _ Middle frequency   Peak Output Power



8DPSK _ High frequency **Peak Output Power**



3.3.7 TX Radiated Spurious Emission and Conducted Spurious Emission

3.3.7.1 Test Setup

Refer to the APPENDIX I.

3.3.7.2 Limit

According to §15.247(d), in any 100 ㎑ 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 ㏈ below that in the 100 ㎑ 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 ㏈ instead of 20 ㏈. Attenuation below the general limits specified in section §15.209(a) is not required. In addition, radiated emission which in the restricted band, as define in section §15.205(a), must also comply the radiated emission limits specified in section §15.209(a) (see section §15.205(c))

According to § 15.209(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 (㎒)	Limit (uV/m)	Measurement Distance (meter)
0.009 ~ 0.490	2400/F (㎑)	300
0.490 ~ 1705	24000/F (㎑)	30
1705 ~ 30.0	30	30
30 ~ 88	100 **	3
88 ~ 216	150 **	3
216 ~ 960	200 **	3
Above 960	500	3

** Except as provided in 15.209(g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54 - 72 ㎒, 76 - 88 ㎒, 174 - 216 ㎒ or 470 – 806 ㎒. However, operation within these frequency bands is permitted under other sections of this Part, e.g. 15.231 and 15.241.

According to § 15.205(a) and (b), only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.009 ~ 0.110	16.42 ~ 16.423	399.90 ~ 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.	1435 ~ 1626.5	9.0 ~ 9.2
4.20725 ~ 4.20775	25 73 ~ 74.6	1645.5 ~ 1646.5	9.3 ~ 9.5
4.17725 ~ 4.17775	74.8 ~ 75.2	1660 ~ 1710	10.6 ~ 12.7
6.215 ~ 6.218	108 ~ 121.94	1718.8 ~ 1722.2	13.25 ~ 13.4
6.26775 ~ 6.26825	149.9 ~ 150.05	2200 ~ 2300	14.47 ~ 14.5
6.31175 ~ 6.31225	156.52475 ~ 156.52525	2310 ~ 2390	15.35 ~ 16.2
8.291 ~ 8.294	156.7 ~ 156.9	2483.5 ~ 2500	17.7 ~ 21.4
8.362 ~ 8.366	162.0125 ~ 167.17	2690 ~ 2900	22.01 ~ 23.12
8.37625 ~ 8.38675	3345.8 ~ 3358	3260 ~ 3267	23.6 ~ 24.0
8.41425 ~ 8.41475	3600 ~ 4400	3332 ~ 3339	31.2 ~ 31.8
12.51975 ~ 12.52025	3345.8 ~ 3358	240 ~ 285	36.43 ~ 36.5
12.57675 ~ 12.57725	3600 ~ 4400	322 ~ 335.4	Above 38.6
13.36 ~ 13.41			

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 ㎒, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 ㎒, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

3.3.7.3 Test Procedure for Radiated Spurious Emission

1. The EUT is placed on a non-conductive table. For emission measurements at or below 1 ㎓, the table height is 80 cm. For emission measurements above 1 ㎓, the table height is 1.5 m. The table was rotated 360 degrees to determine the position of the highest radiation.

2. During performing radiated emission below 1 ㎓, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 ㎓, the EUT was set 1 or 3 meter away from the interference-receiving antenna.

3. For measurements above 1㎓ absorbers are placed on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections. For measurements below 1 ㎓, the absorbers are removed.

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

5. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the table was turned from 0 degrees to 360 degrees to find the maximum reading.
   (The EUT was pre-tested with three axes (X, Y, Z) and the final test was performed at the worst case.)

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

7. If the emission level of the EUT in peak mode was 10 ㏈ lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 ㏈ margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

Measurement Instrument Setting

1. Frequency Range: Below 1 ㎓
   RBW = 100 or 120 ㎑, VBW = 3 x RBW, Detector = Peak or Quasi Peak

2. Frequency Range: Above 1 ㎓
   Peak Measurement
      RBW = 1 ㎒, VBW = 3 ㎒, Detector = Peak, Sweep time = Auto,
      Trace mode = Max Hold until the trace stabilizes

   Average Measurement
      RBW = 1㎒, VBW ≥ 1/T, Detector = Peak, Sweep Time = Auto,
      Trace Mode = Max Hold until the trace stabilizes

3.3.7.4 Test Procedure for Conducted Spurious Emission

1. The transmitter output was connected to the spectrum analyzer.

2. The reference level of the fundamental frequency was measured with the spectrum analyzer using RBW = 100 ㎑, VBW = 300 ㎑.

3. The conducted spurious emission was tested each ranges were set as below.
   Frequency range: 30 ㎒ ~ 26.5 ㎓
      RBW = 100 ㎑, VBW = 300 ㎑, Sweep Time = Auto, Detector = Peak,
      Trace = Max Hold

   LIMIT LINE = 20 ㏈ below of the reference level of above measurement procedure Step 2. (RBW = 100 ㎑, VBW = 300 ㎑)

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3.3.7.5 Test Result

9 ㎑ ~ 25 ㎓ Data (Modulation: GFSK)

- Low frequency

Frequency	Reading (㏈ uV/m)		Pol.	Factor (㏈)	DCCF (㏈)	Limits (㏈ uV/m)		Result (㏈ uV/m)		Margin (㏈)	
(㎒)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
4 804.00	N/A	66.77	V	-9.38	-24.78	54.0	74.0	32.6	57.4	21.4	16.6
7 206.00	N/A	50.16	V	-0.37	-24.78	54.0	74.0	25.0	49.8	29.0	24.2
9 608.00	N/A	51.18	H	0.63	-24.78	54.0	74.0	27.0	51.8	27.0	22.2

- Middle frequency

Frequency	Reading (㏈ uV/m)		Pol.	Factor (㏈)	DCCF (㏈)	Limits (㏈ uV/m)		Result (㏈ uV/m)		Margin (㏈)	
(㎒)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
4 882.00	N/A	64.94	V	-9.28	-24.78	54.0	74.0	30.9	55.7	23.1	18.3
7 323.00	N/A	49.60	V	-0.18	-24.78	54.0	74.0	24.6	49.4	29.4	24.6
9 764.00	N/A	48.98	H	1.03	-24.78	54.0	74.0	25.2	50.0	28.8	24.0

- High frequency

Frequency	Reading (㏈ uV/m)		Pol.	Factor (㏈)	DCCF (㏈)	Limits (㏈ uV/m)		Result (㏈ uV/m)		Margin (㏈)	
(㎒)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
2 483.50	N/A	40.47	V	13.29	-24.78	54.0	74.0	29.0	53.8	25.0	20.2
4 960.00	N/A	62.67	V	-9.18	-24.78	54.0	74.0	28.7	53.5	25.3	20.5
7 440.00	N/A	48.47	V	-0.04	-24.78	54.0	74.0	23.6	48.4	30.4	25.6
9 920.00	N/A	48.66	H	1.32	-24.78	54.0	74.0	25.2	50.0	28.8	24.0

Note 1: The radiated emissions were inverstigated 9 ㎑ to 25 ㎓. And no other spurious and harmonic emissions were found above listed frequencies.
Note 2: DCCF(Duty Cycle Correction Factor)
- Time to cycle through all channels = ∆t = T [ms] X 20 minimum hopping channels, where T = pulse width = 2.883 ms
- 100 ms / ∆t [ms] = H -> Round up to next highest integer, to account for worst case, H' = 100 / (2.883 X 20) = 1.73 ≒ 2
- The Worst Case Dwell Time = T [ms] x H' = 2.883 ms X 2 = 5.77 ms
- DCCF = 20 x log(The Worst Case Dwell Time / 100 ms) ㏈ = 20 x log(5.77 / 100) = -24.78 ㏈

Note 3: Sample Calculation.
Margin = Limit – Result / Peak Result = Peak Reading + TF / Average Result = Peak Reading + TF + DCCF
TF = Ant factor + Cable Loss + Filter Loss – Amp Gain

9 ㎑ ~ 25 ㎓ Data (Modulation: 8DPSK)

- Low frequency

Frequency	Reading		Pol.	Factor	DCCF	Limits		Result		Margin	
	(㏈ uV/m)			(㏈)	(㏈)	(㏈ uV/m)		(㏈ uV/m)		(㏈)	
(㎒)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
4 804.00	N/A	68.22	V	-9.38	-24.78	54.0	74.0	34.1	58.8	19.9	15.2
7 206.00	N/A	49.97	V	-0.37	-24.78	54.0	74.0	24.8	49.6	29.2	24.4
9 608.00	N/A	50.64	H	0.63	-24.78	54.0	74.0	26.5	51.3	27.5	22.7

- Middle frequency

Frequency	Reading		Pol.	Factor	DCCF	Limits		Result		Margin	
	(㏈ uV/m)			(㏈)	(㏈)	(㏈ uV/m)		(㏈ uV/m)		(㏈)	
(㎒)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
4 882.00	N/A	66.79	V	-9.28	-24.78	54.0	74.0	32.7	57.5	21.3	16.5
7 323.00	N/A	49.40	V	-0.18	-24.78	54.0	74.0	24.4	49.2	29.6	24.8
9 764.00	N/A	48.53	H	1.03	-24.78	54.0	74.0	24.8	49.6	29.2	24.4

- High frequency

Frequency	Reading		Pol.	Factor	DCCF	Limits		Result		Margin	
	(㏈ uV/m)			(㏈)	(㏈)	(㏈ uV/m)		(㏈ uV/m)		(㏈)	
(㎒)	AV / Peak					AV / Peak		AV / Peak		AV / Peak	
2 483.50	N/A	43.49	V	13.29	-24.78	54.0	74.0	32.0	56.8	22.0	17.2
4 960.00	N/A	64.07	V	-9.18	-24.78	54.0	74.0	30.1	54.9	23.9	19.1
7 440.00	N/A	48.47	V	-0.04	-24.78	54.0	74.0	23.6	48.4	30.4	25.6
9 920.00	N/A	48.06	H	1.32	-24.78	54.0	74.0	24.6	49.4	29.4	24.6

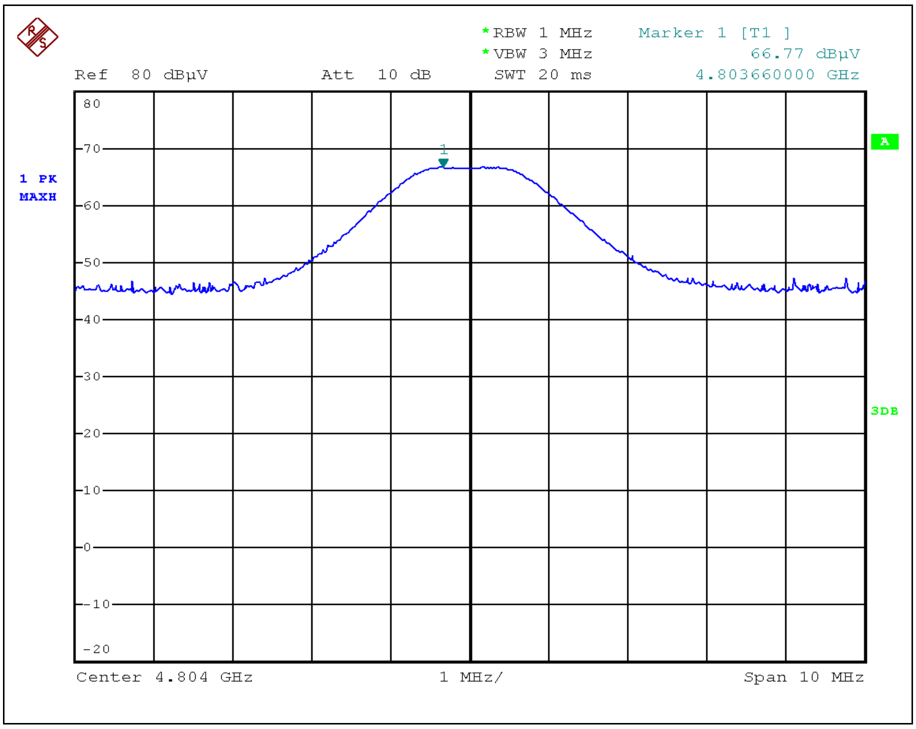
Note 1: The radiated emissions were inverstigated 9 ㎑ to 25 ㎓. And no other spurious and harmonic emissions were found above listed frequencies.
Note 2: DCCF(Duty Cycle Correction Factor)
- Time to cycle through all channels = ∆t = T [ms] X 20 minimum hopping channels, where T = pulse width = 2.883 ms
- 100 ms / ∆t [ms] = H -> Round up to next highest integer, to account for worst case, H' = 100 / (2.883 X 20) = 1.73 ≒ 2
- The Worst Case Dwell Time = T [ms] x H' = 2.883 ms X 2 = 5.77 ms
- DCCF = 20 x log(The Worst Case Dwell Time / 100 ms) ㏈ = 20 x log(5.77 / 100) = -24.78 ㏈

Note 3: Sample Calculation.
Margin = Limit – Result / Peak Result = Peak Reading + TF / Average Result = Peak Reading + TF + DCCF
TF = Ant factor + Cable Loss + Filter Loss – Amp Gain

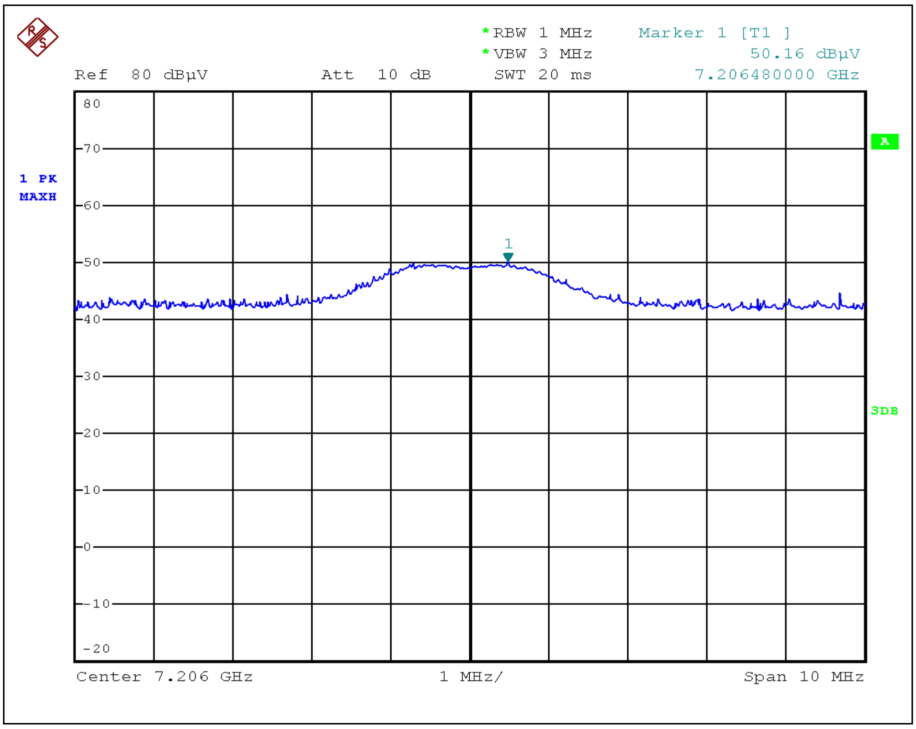
3.3.7.6 Test Plot for Radiated Spurious Emission

- **GFSK _ Low frequency**

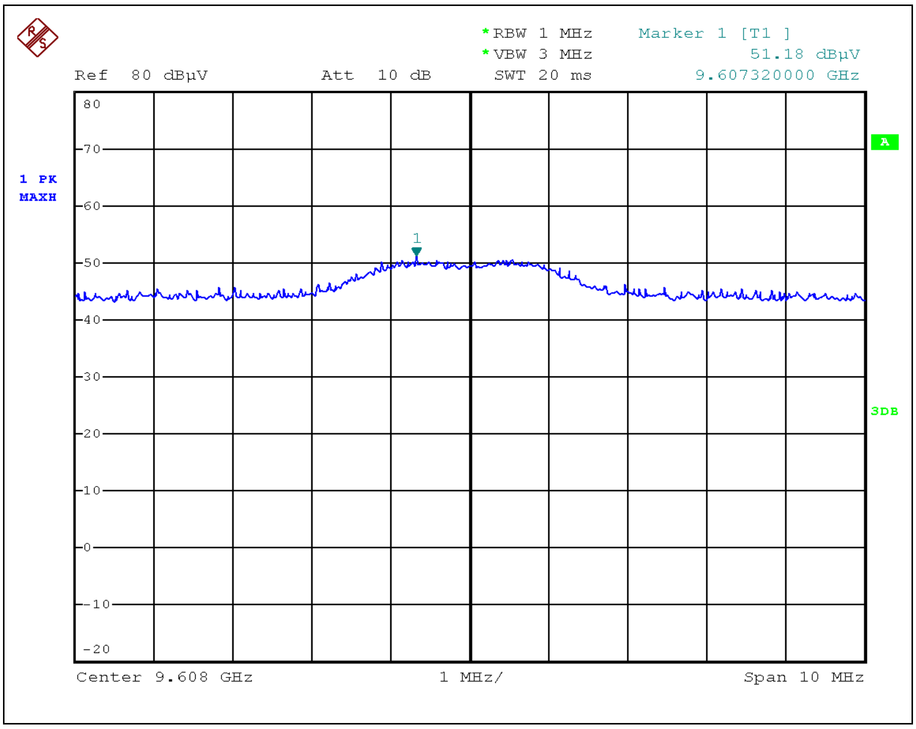
Spurious – Peak



Spurious – Peak

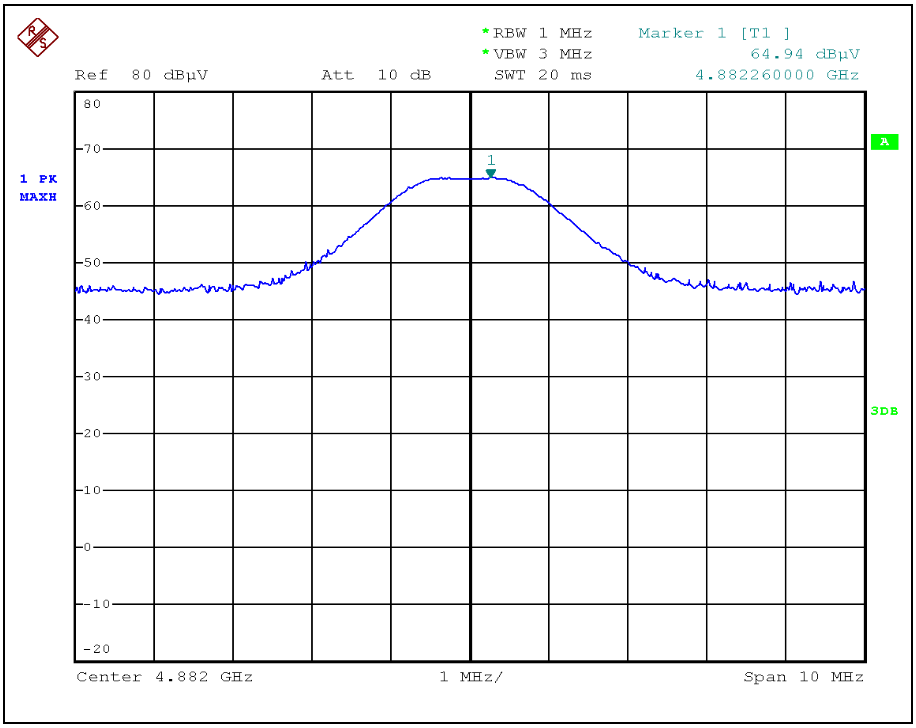


Spurious – Peak

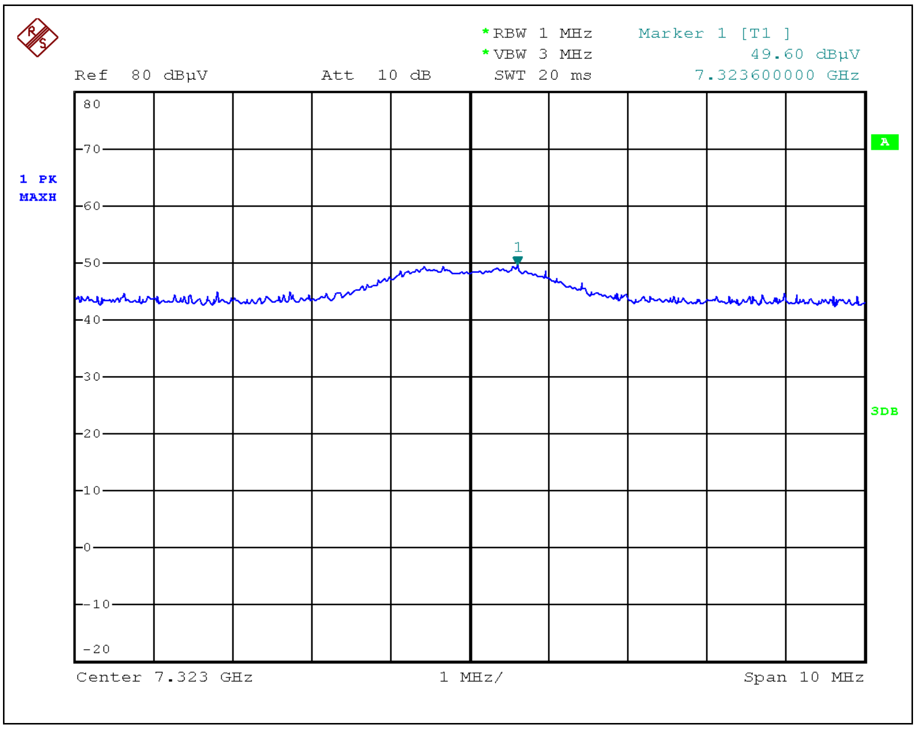


- **GFSK _ Middle frequency**

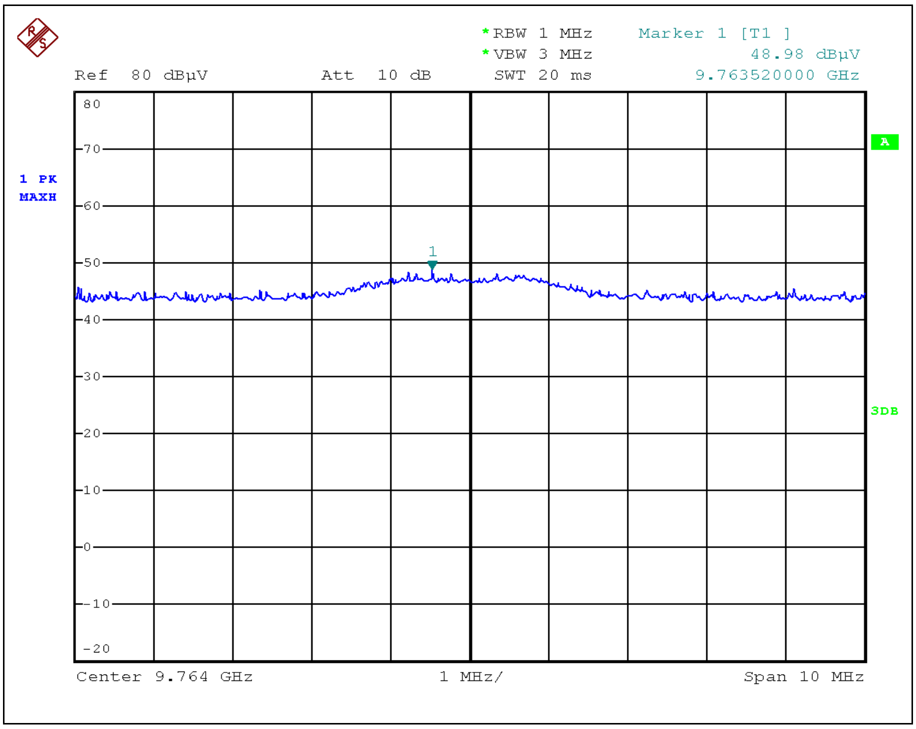
Spurious – Peak



Spurious – Peak

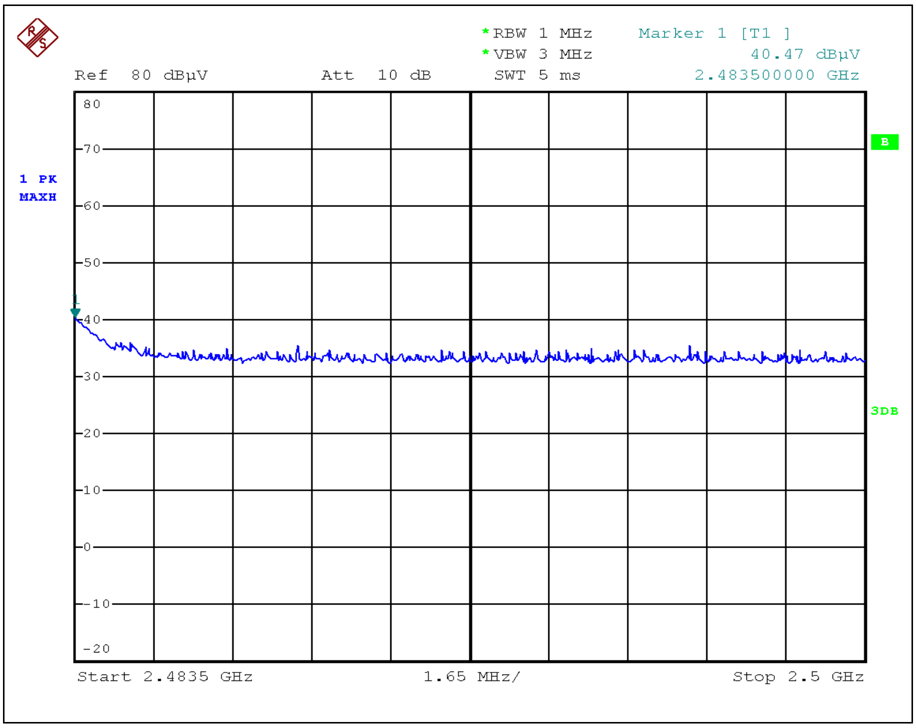


Spurious – Peak

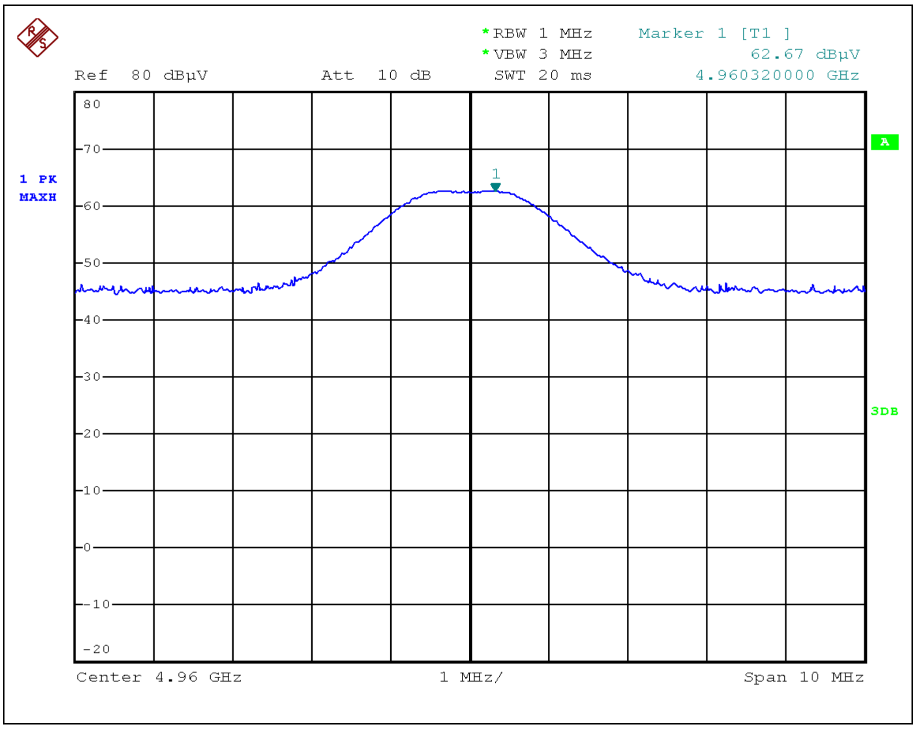


- **GFSK _ High frequency**

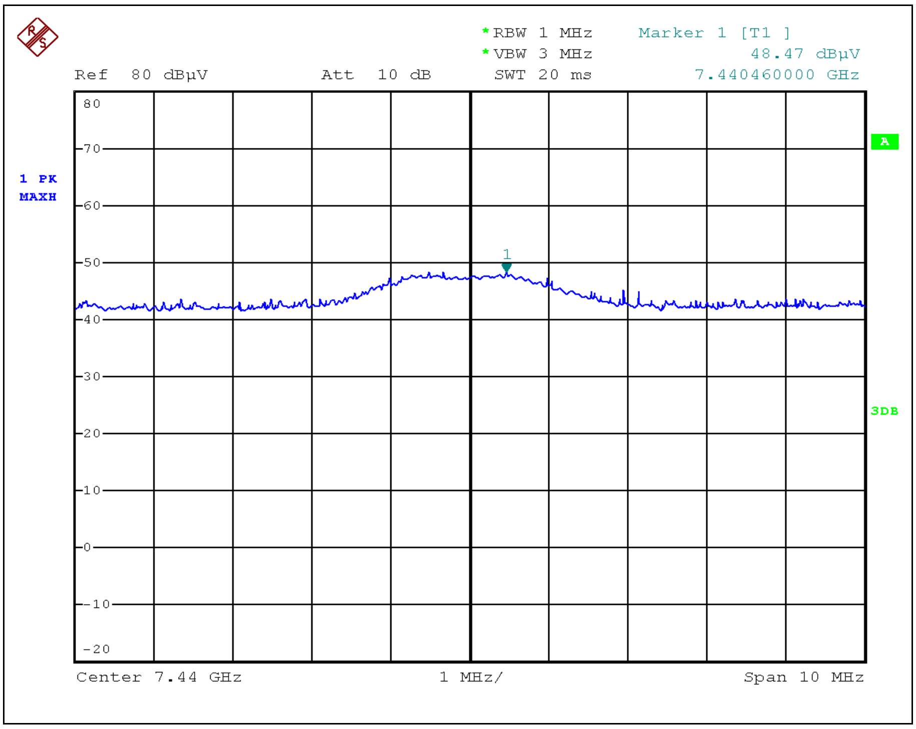
Restricted Band - Peak



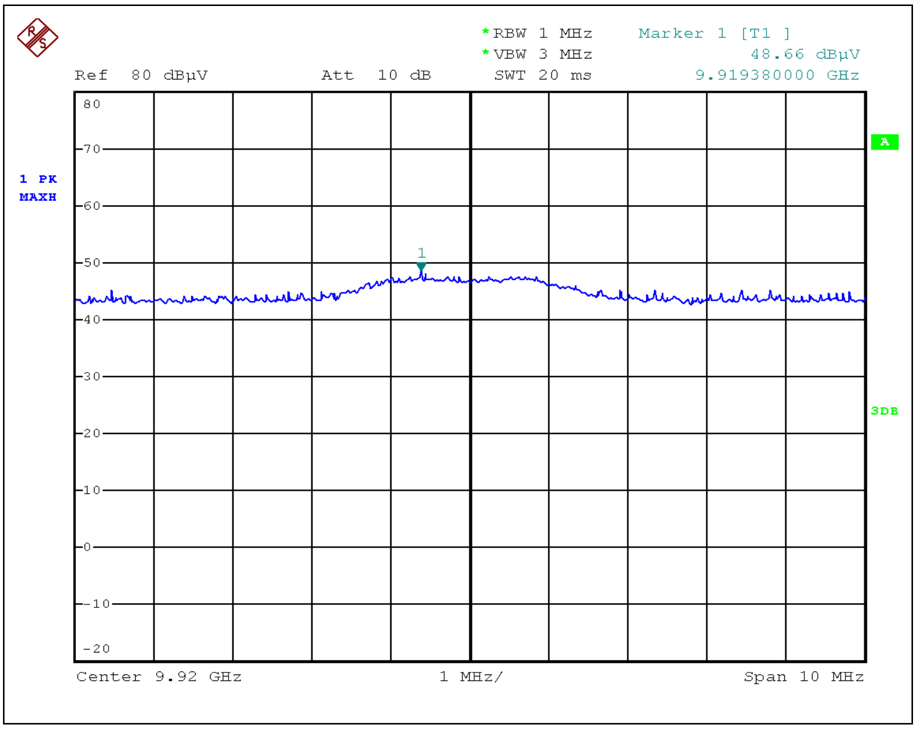
Spurious – Peak



Spurious – Peak

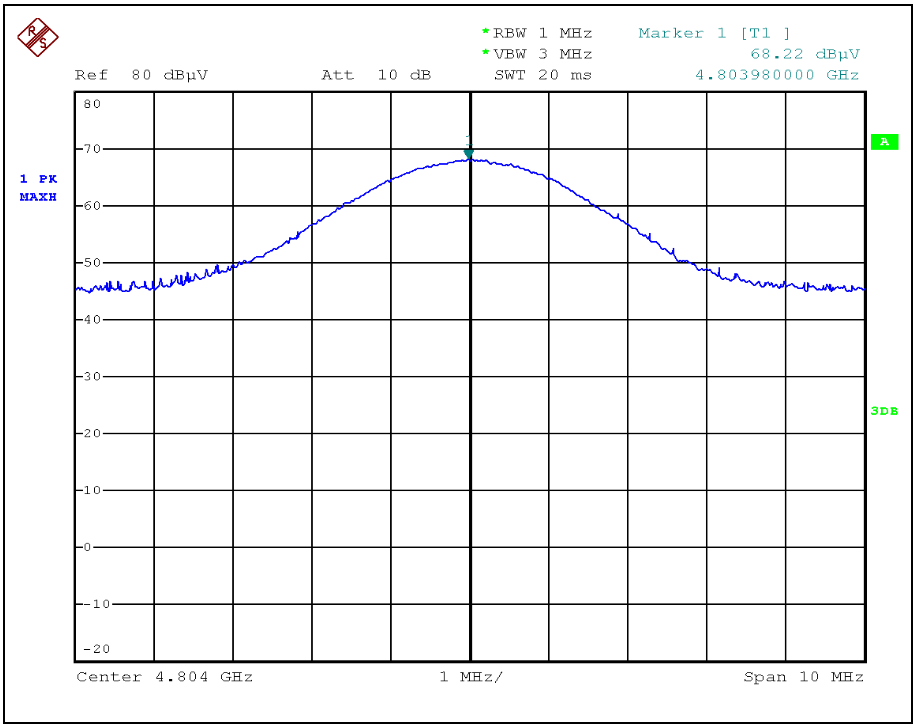


Spurious – Peak

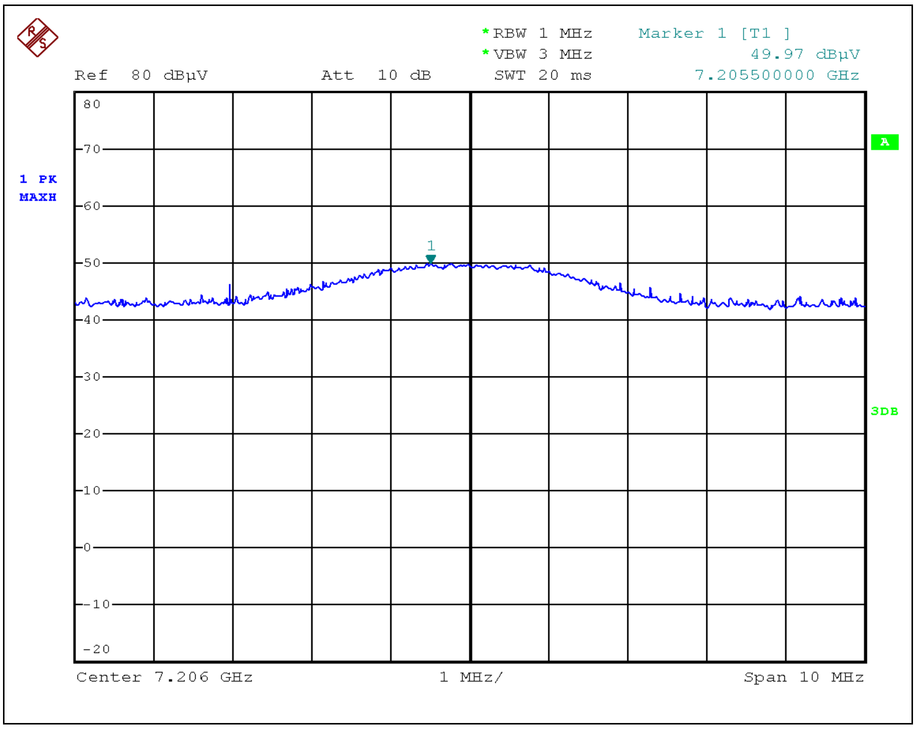


● 8DPSK _ Low frequency

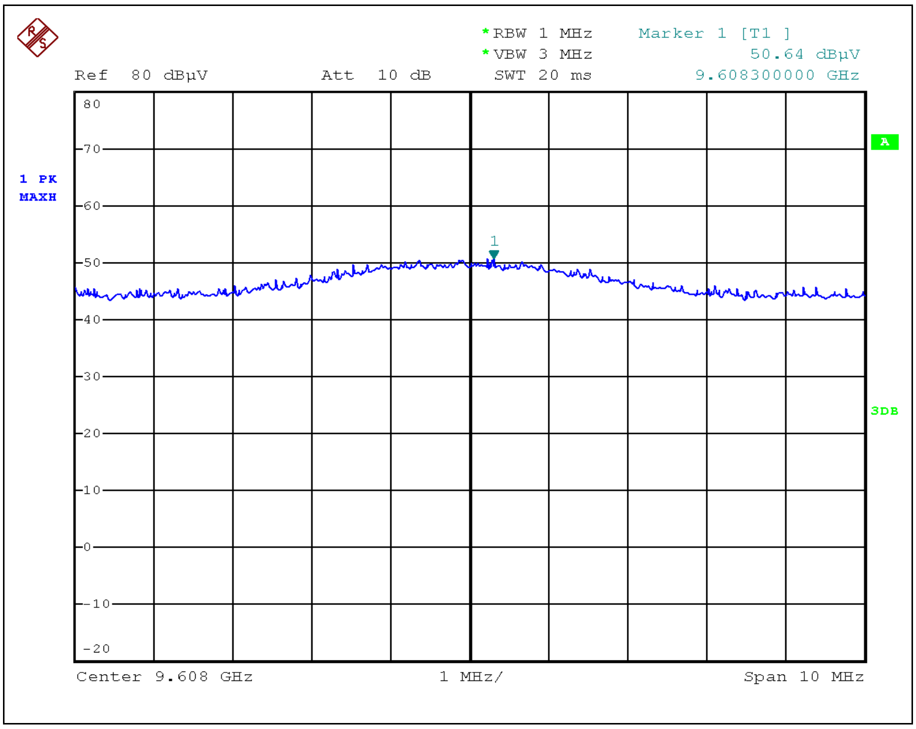
Spurious – Peak



Spurious – Peak

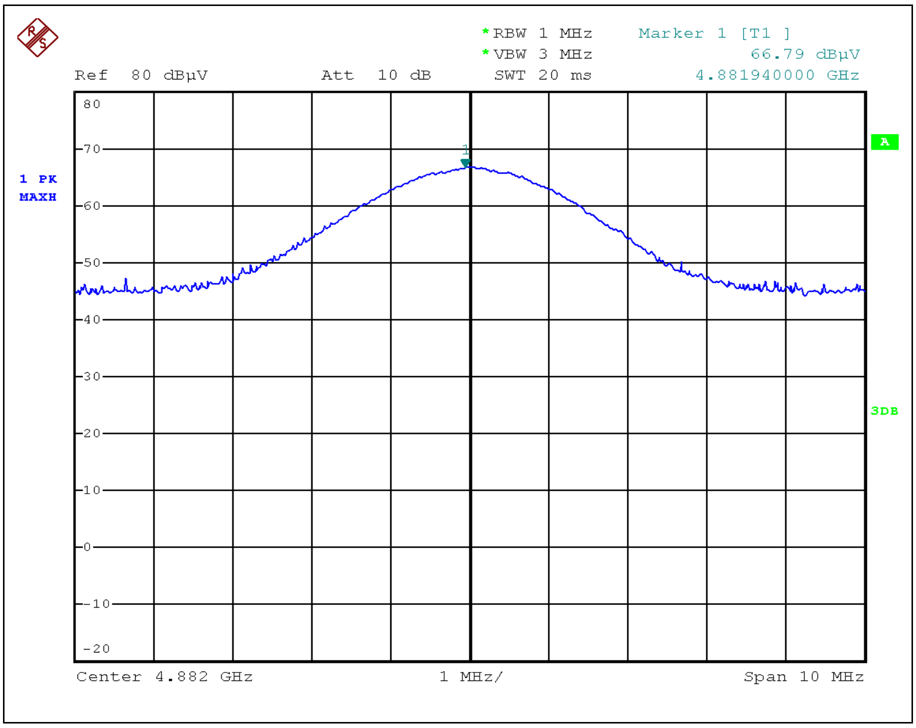


Spurious – Peak

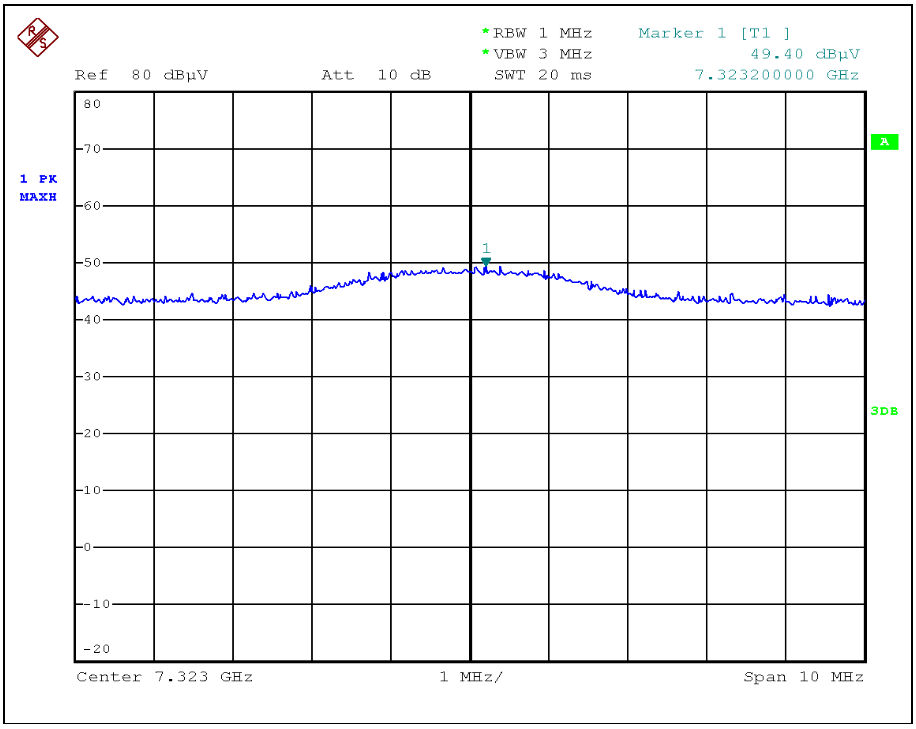


- **8DPSK _ Middle frequency**

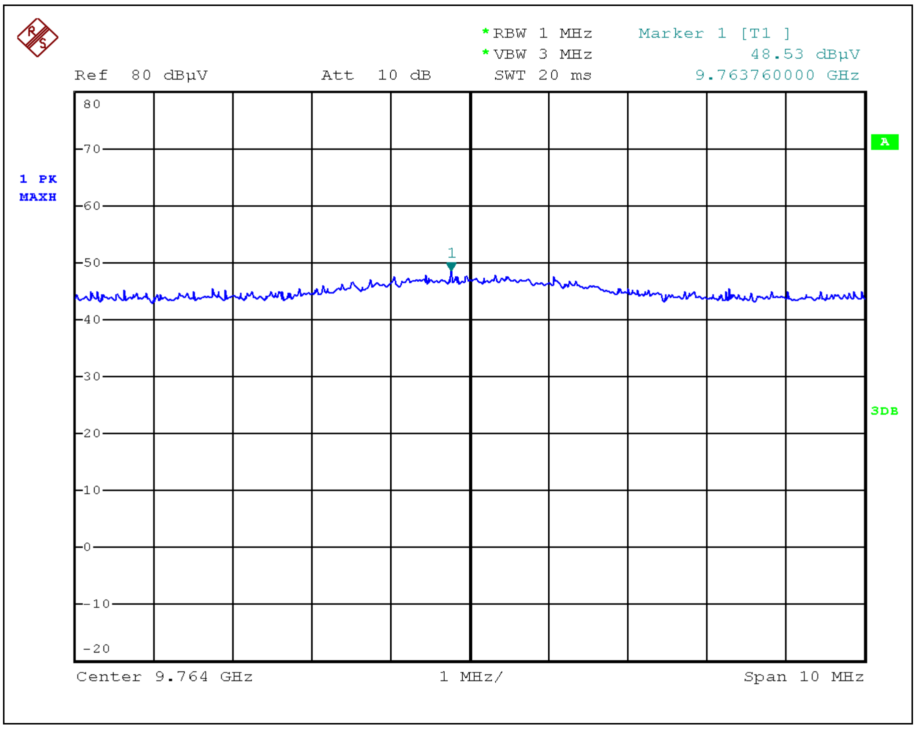
Spurious – Peak



Spurious – Peak

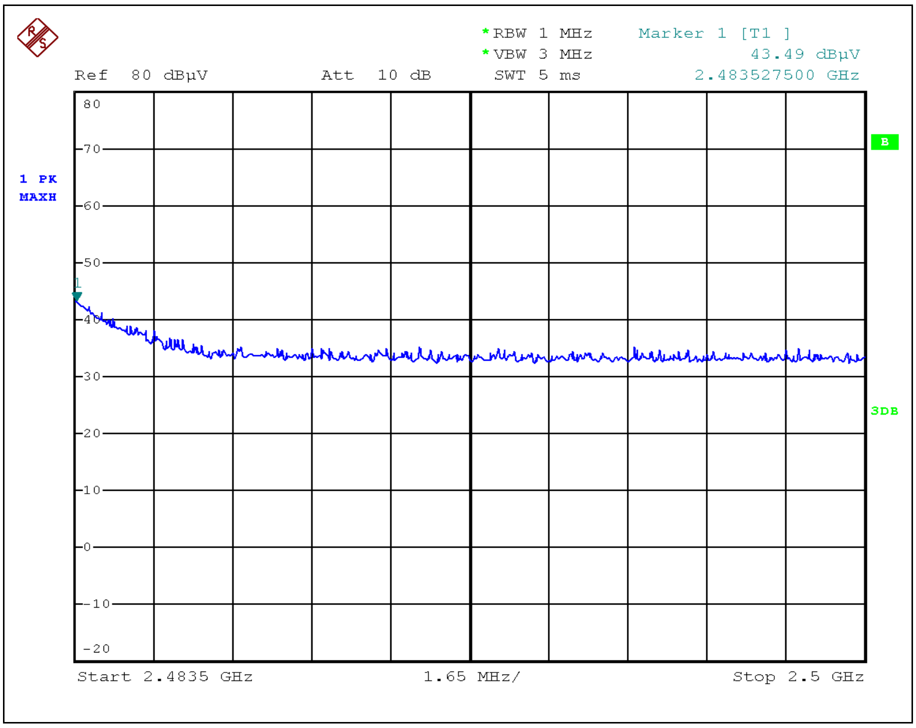


Spurious – Peak

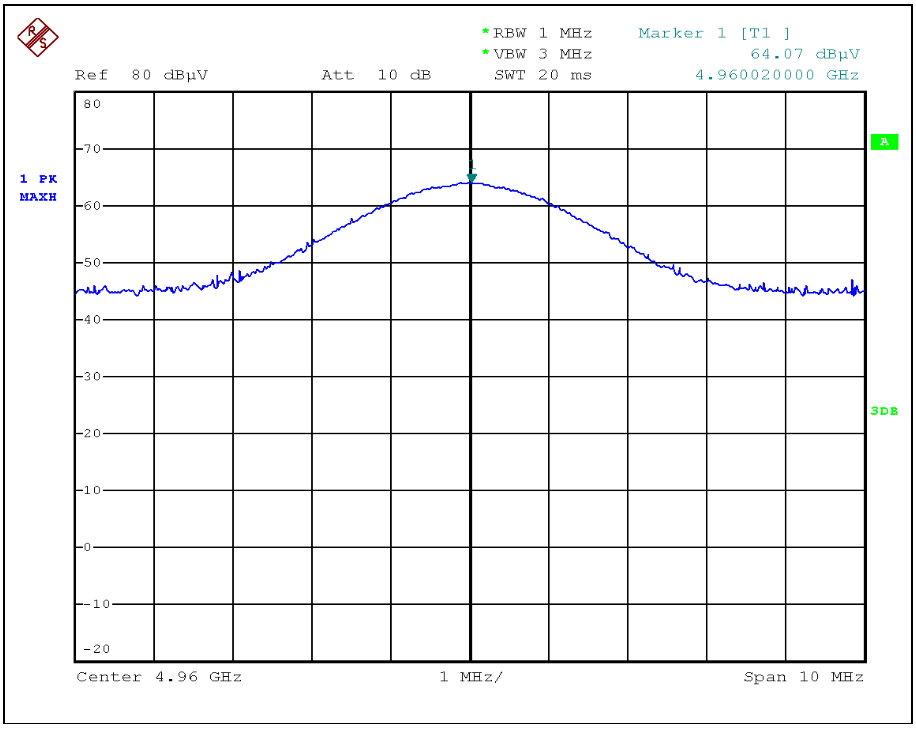


- **8DPSK _ High frequency**

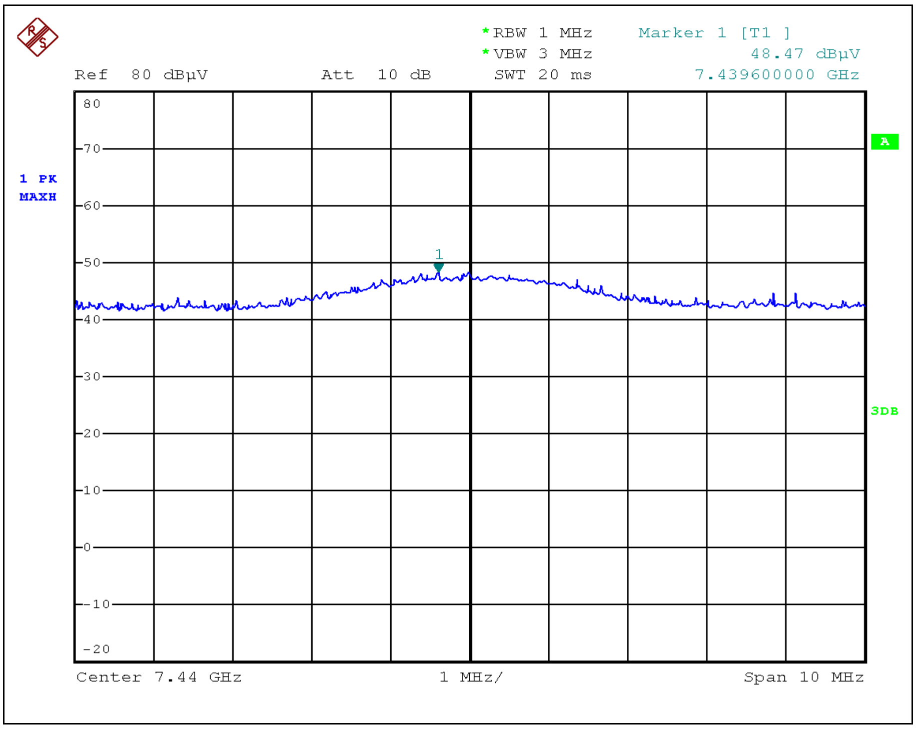
Restricted Band - Peak



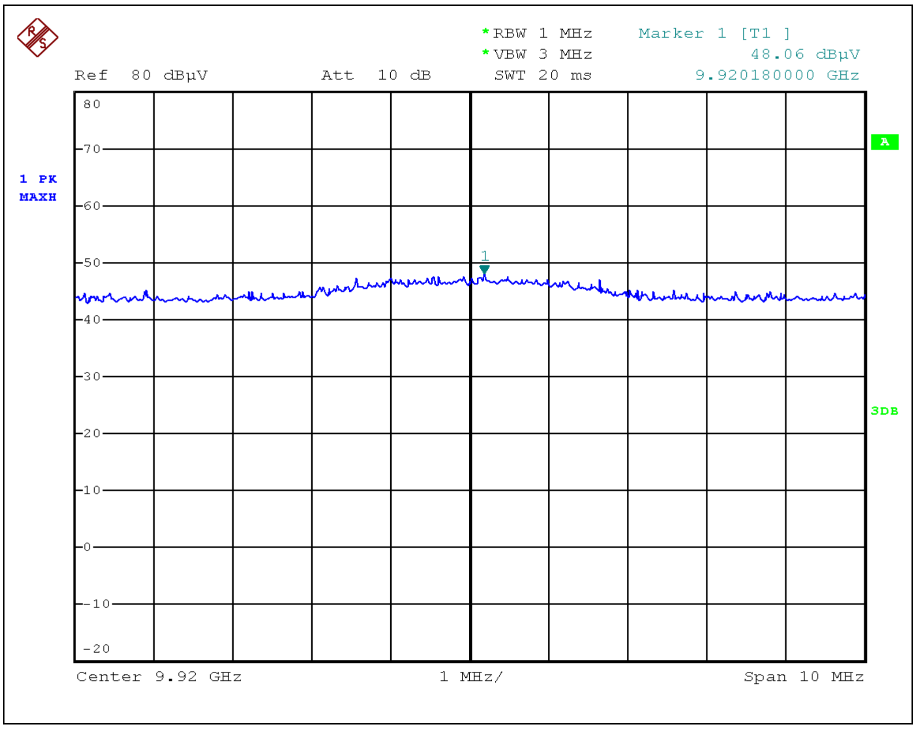
Spurious – Peak



Spurious – Peak



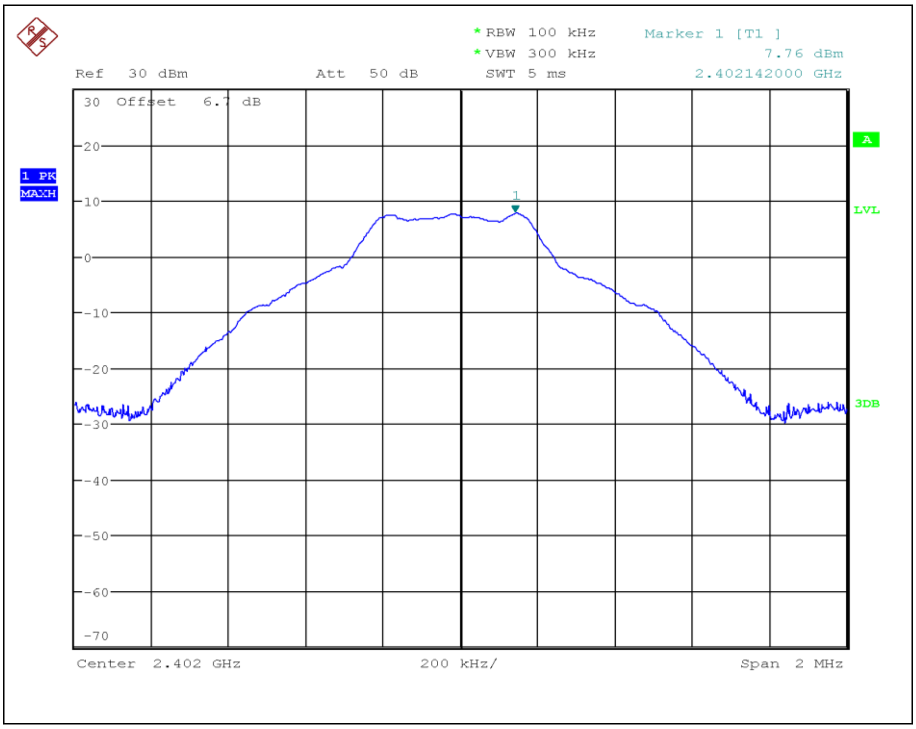
Spurious – Peak



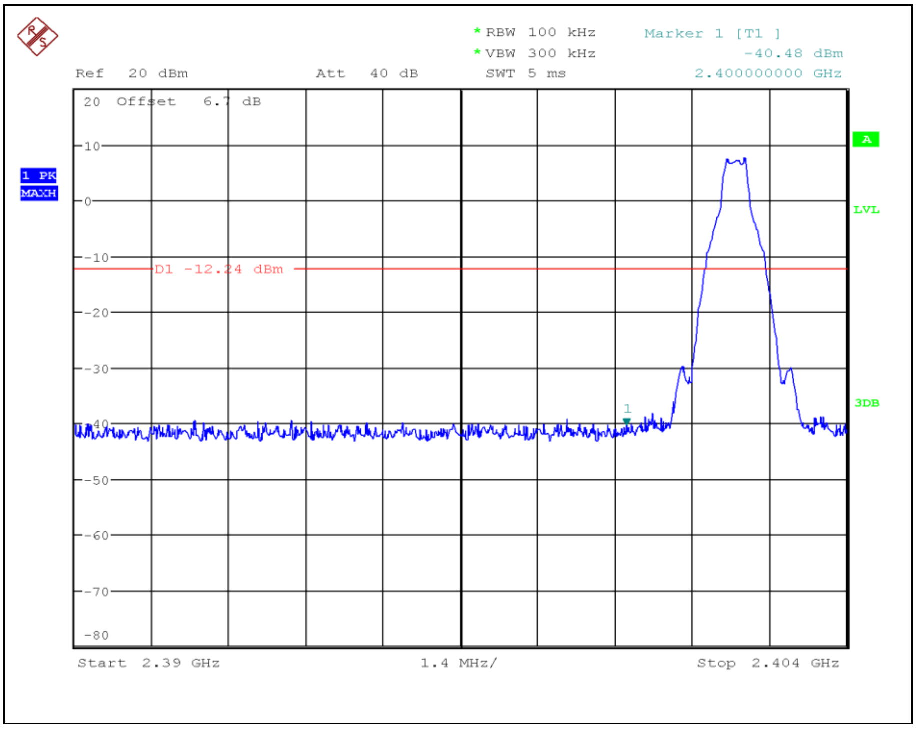
3.3.7.7 Test Plot for Conducted Spurious Emission

- GFSK _ Low frequency

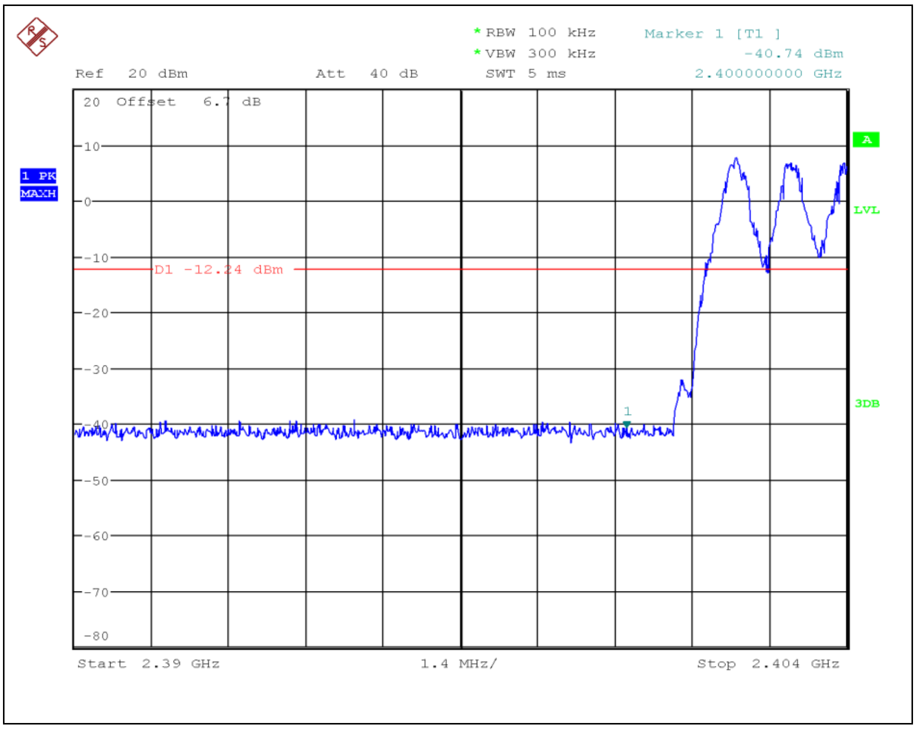
Reference



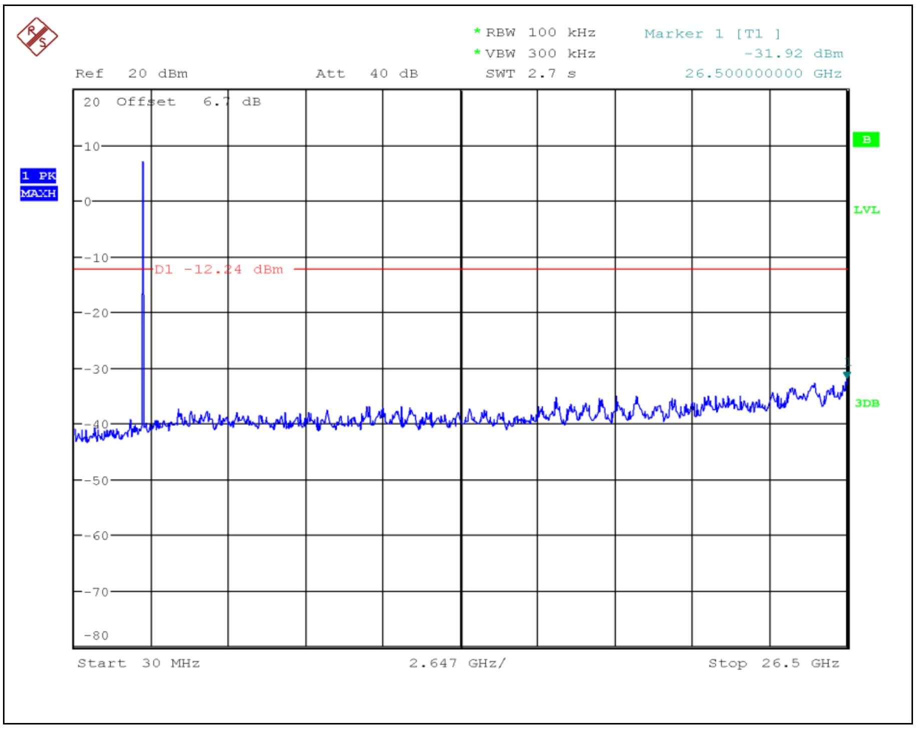
Bandedge _ Single



Bandedge _ Hopping

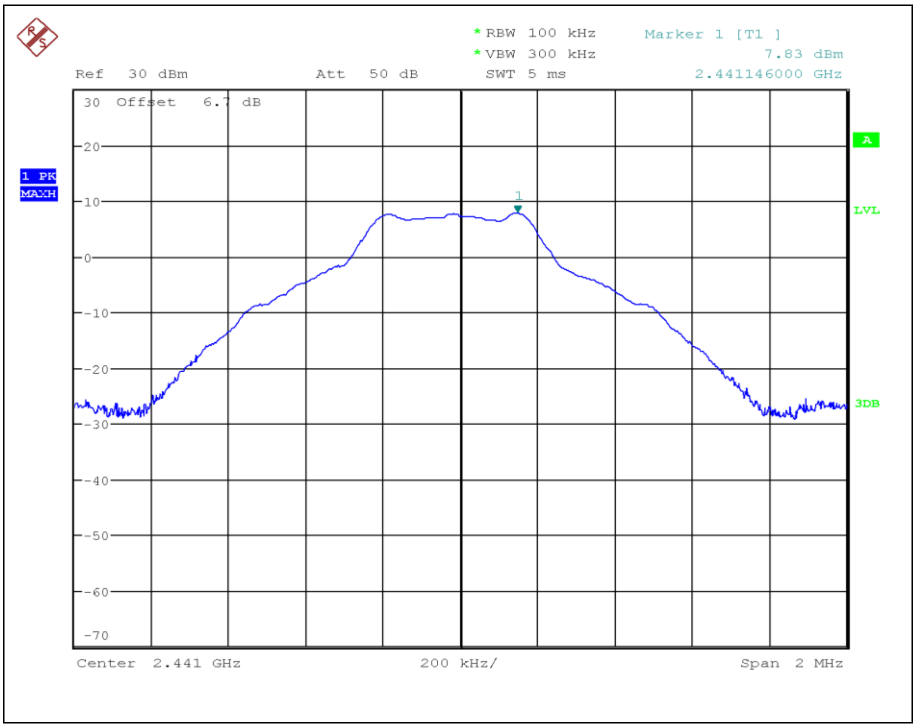


Spurious

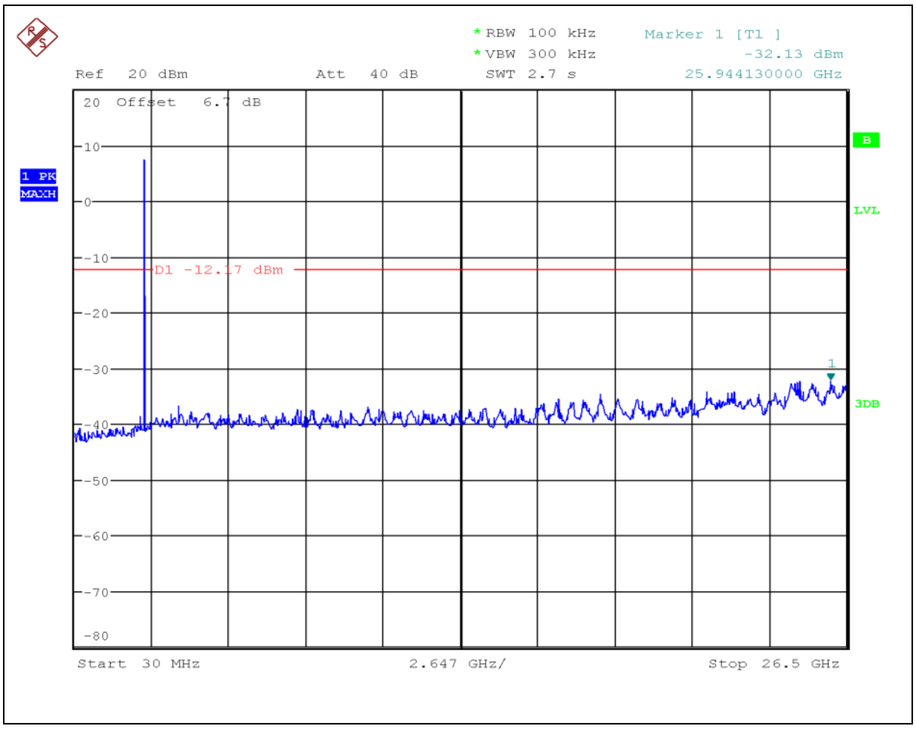


● **GFSK _ Middle frequency**

Reference

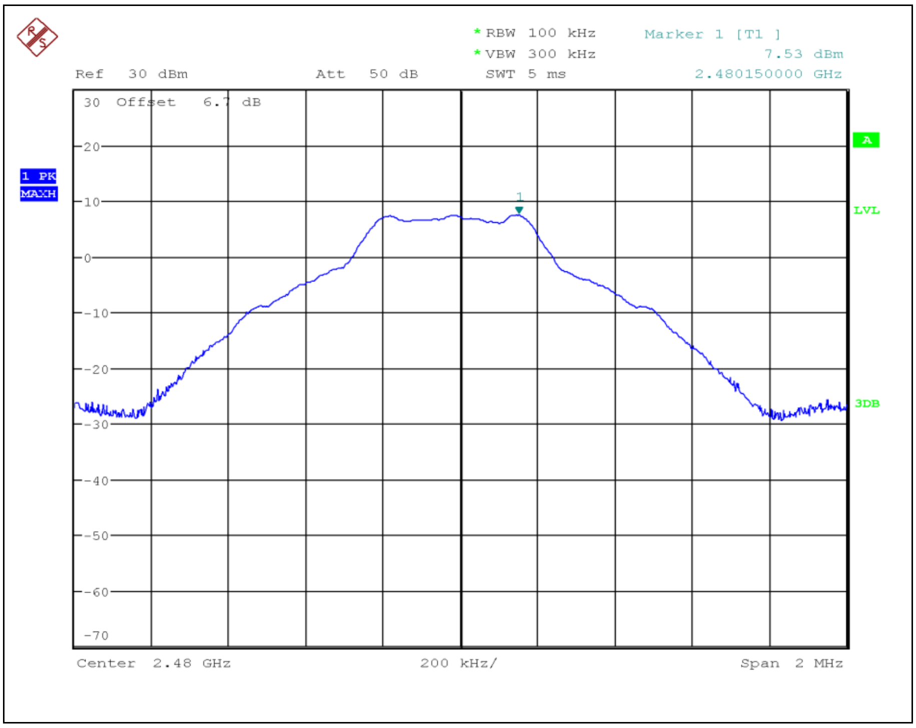


Spurious

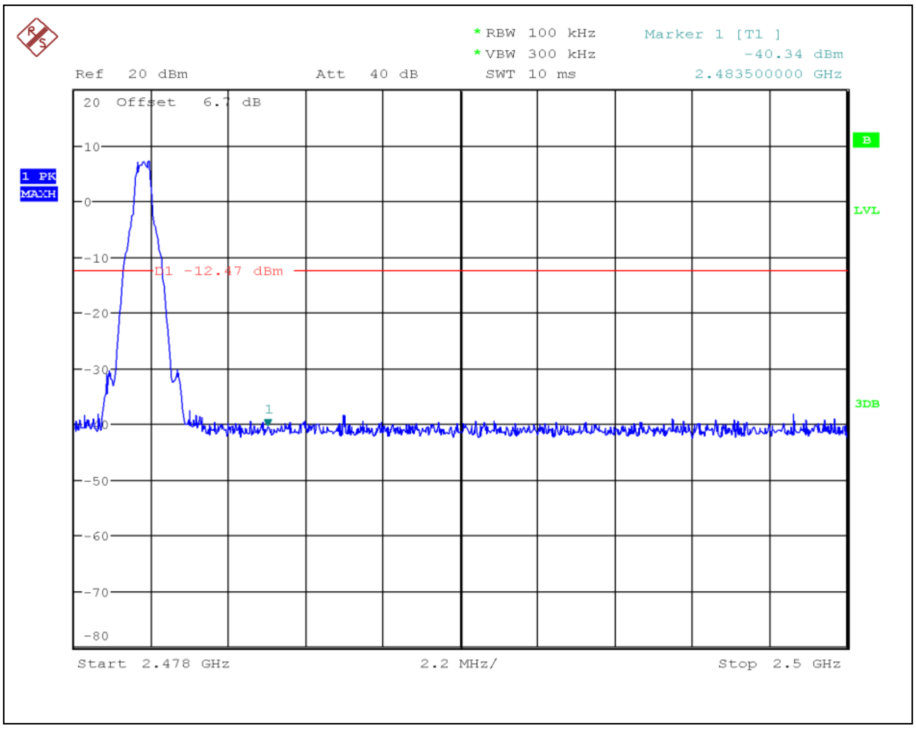


- **GFSK _ High frequency**

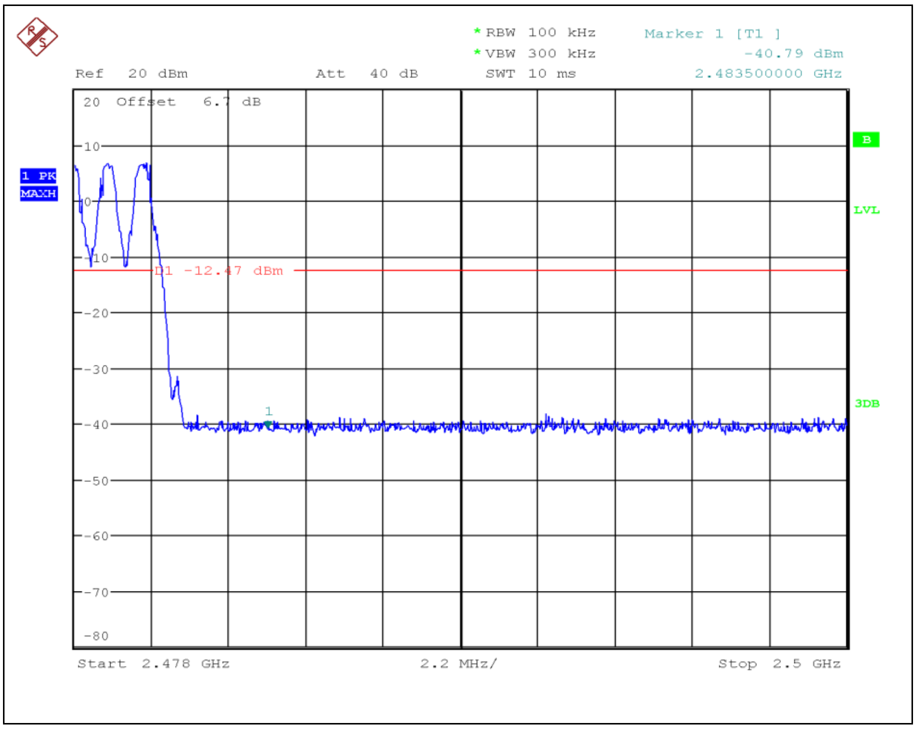
Reference



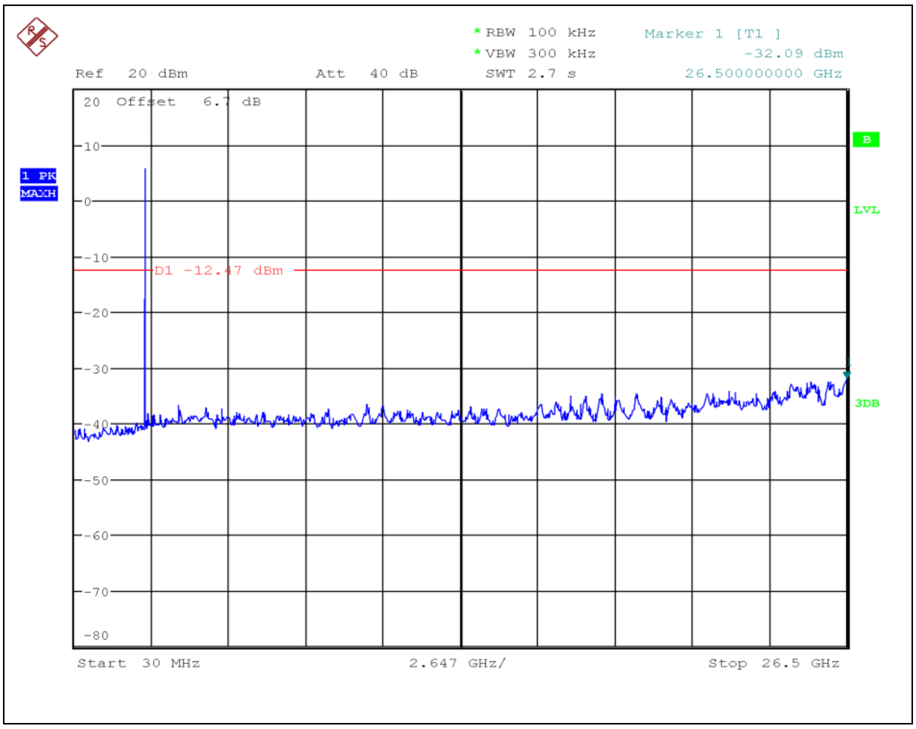
Bandedge _ Single



Bandedge _ Hopping

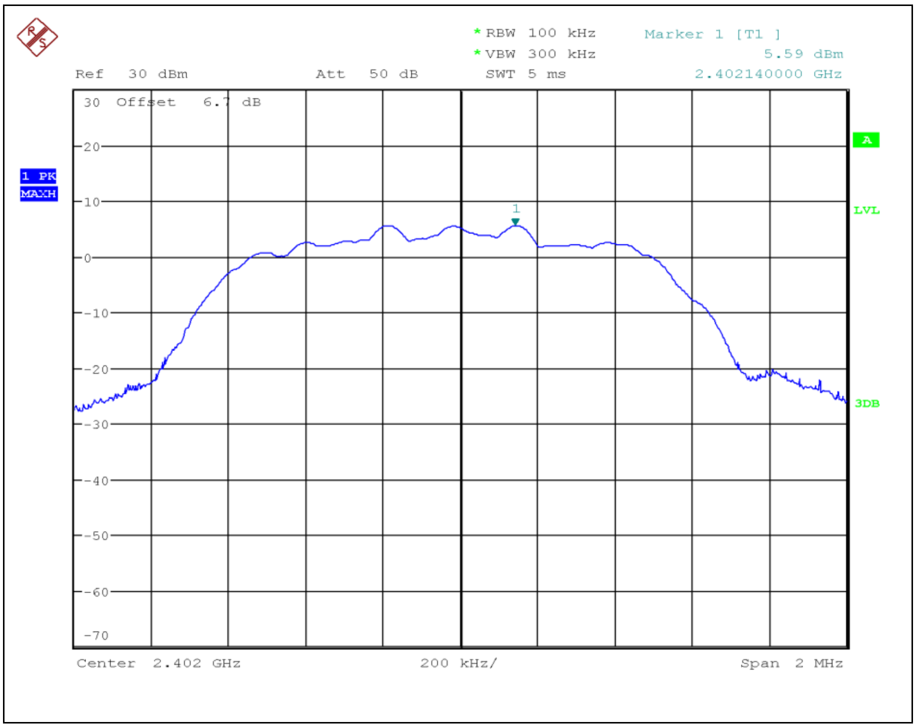


Spurious



- 8DPSK _ Low frequency

Reference



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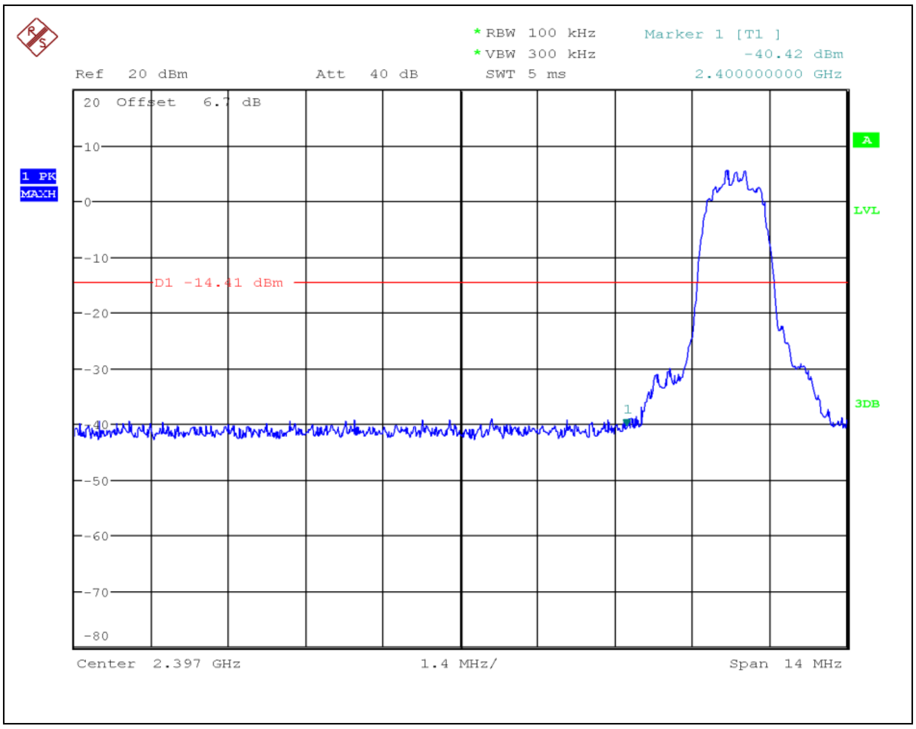

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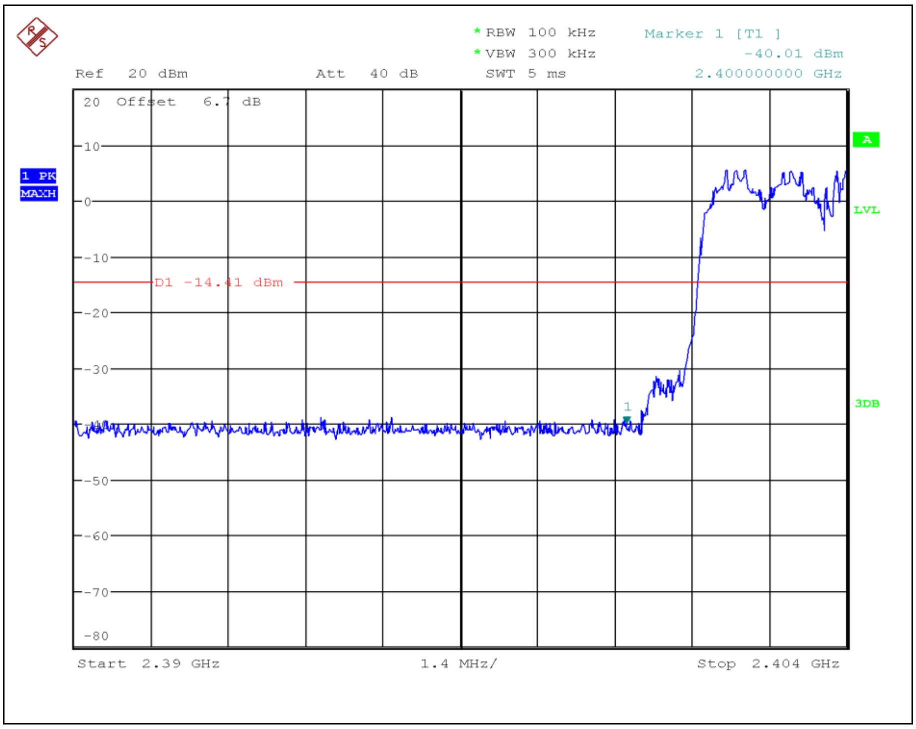
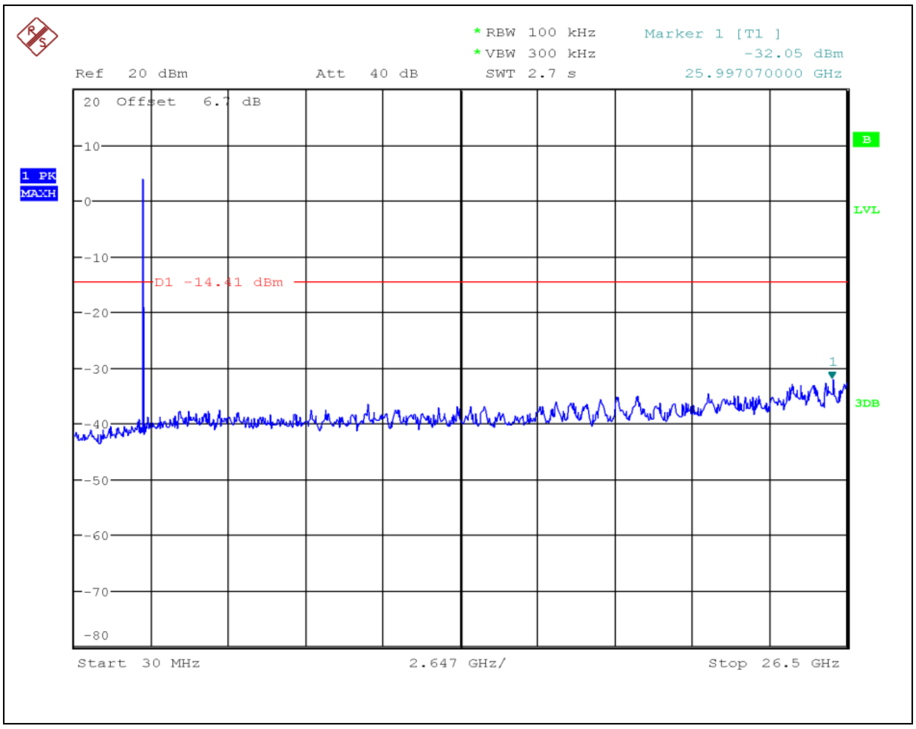
Bandedge _ Hopping



Spurious



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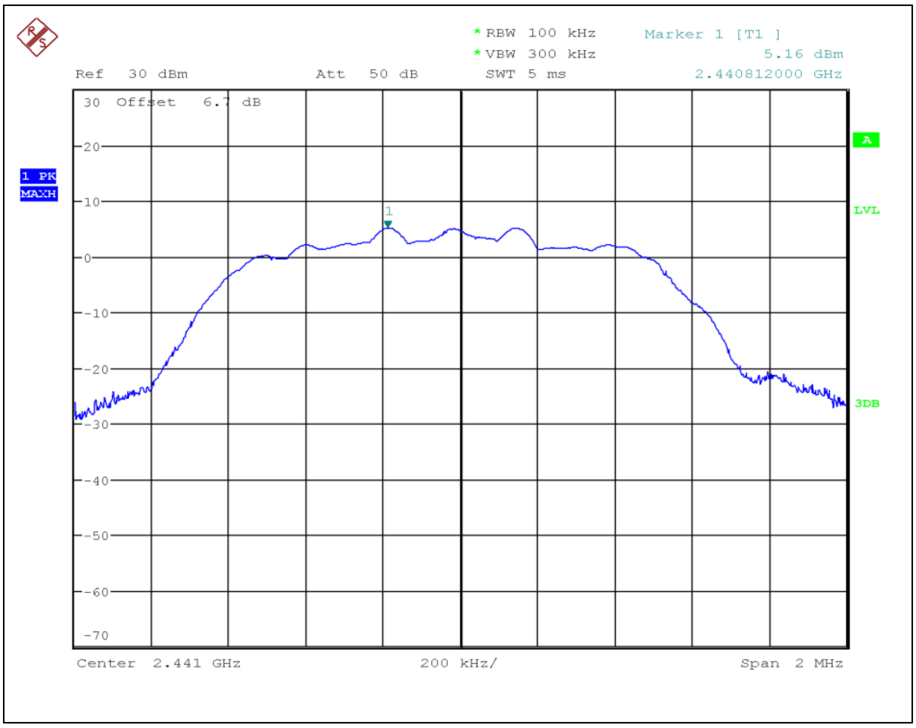
- **8DPSK _ Middle frequency**

Reference



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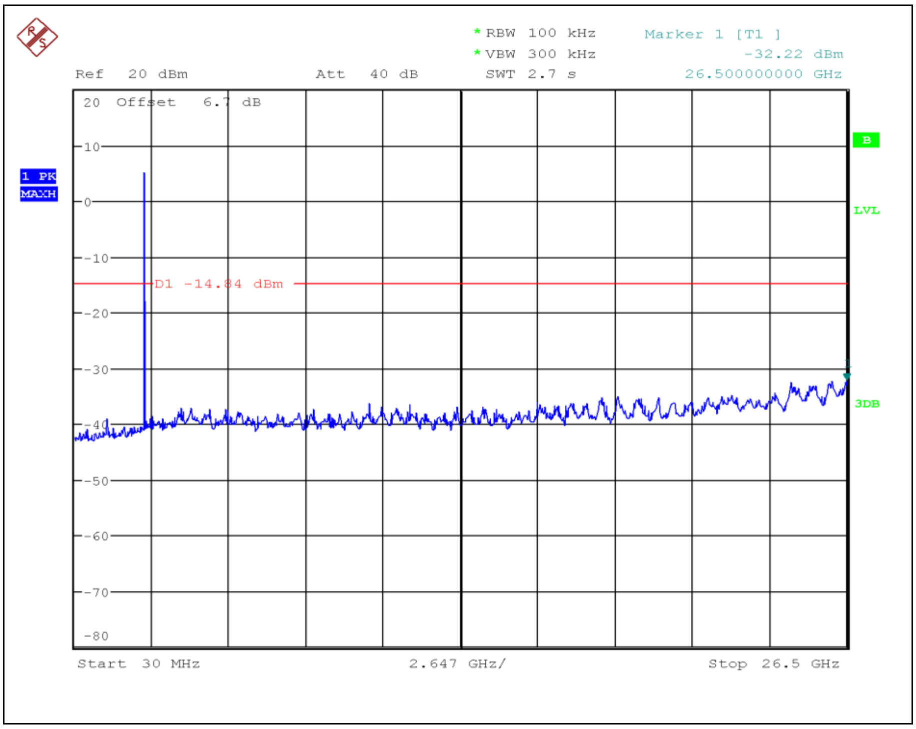
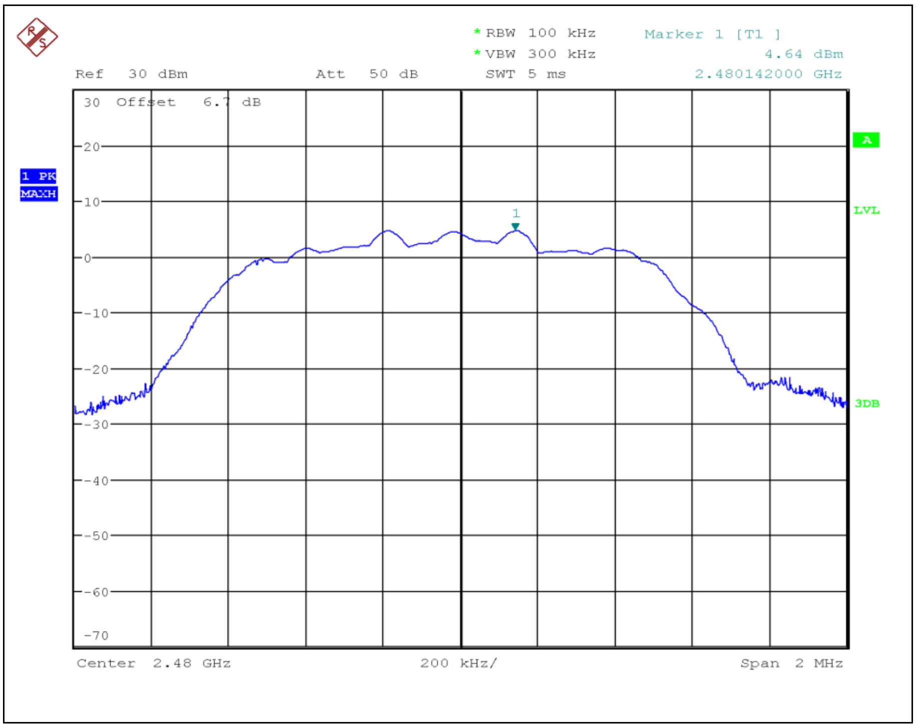
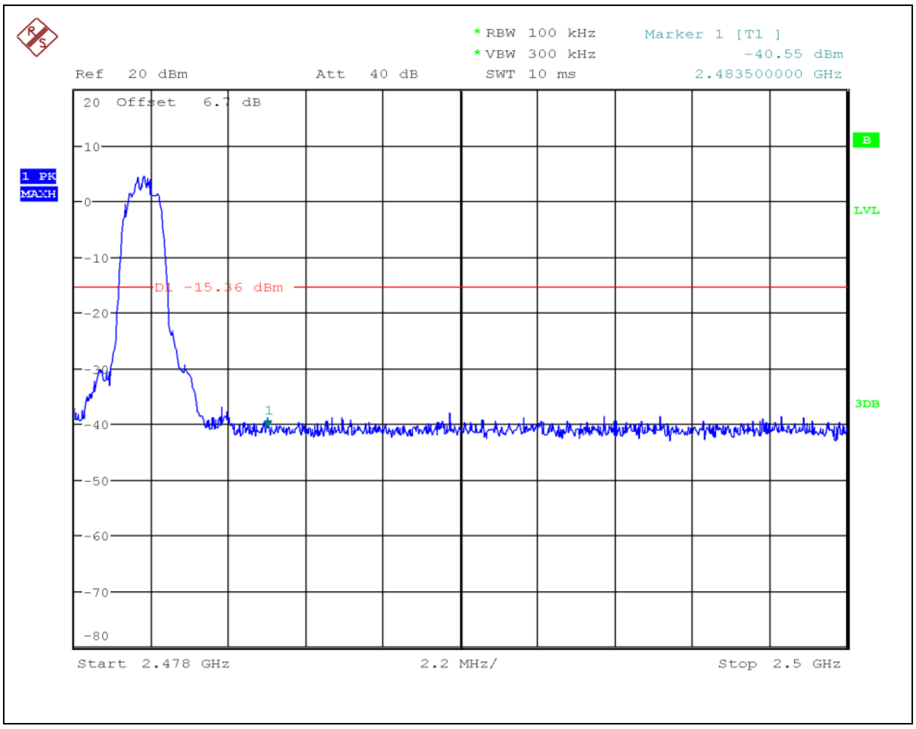


- **8DPSK _ High frequency**

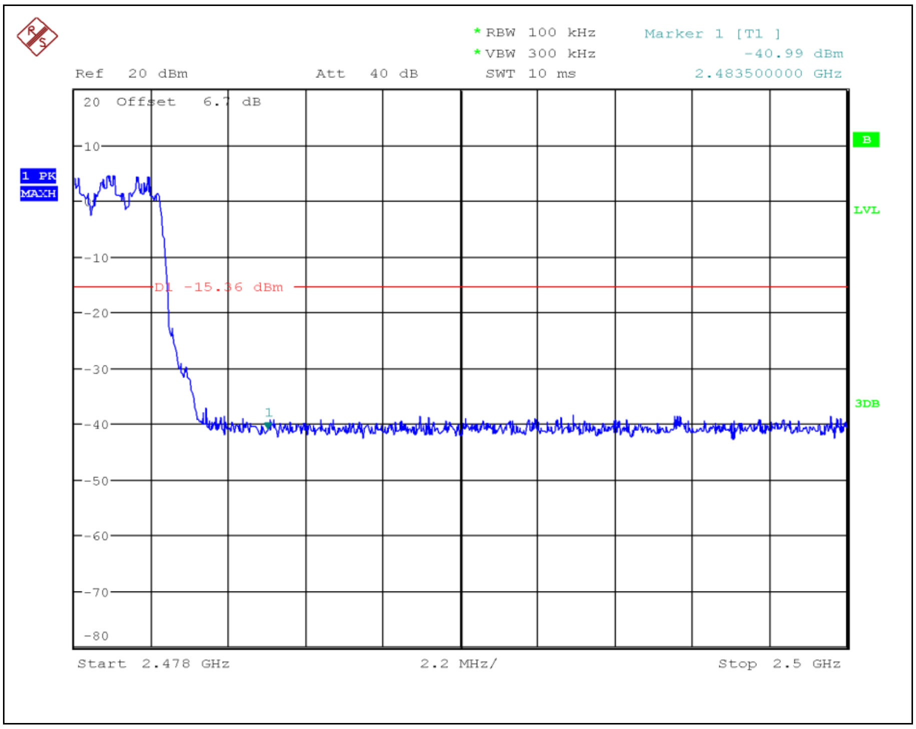
Reference



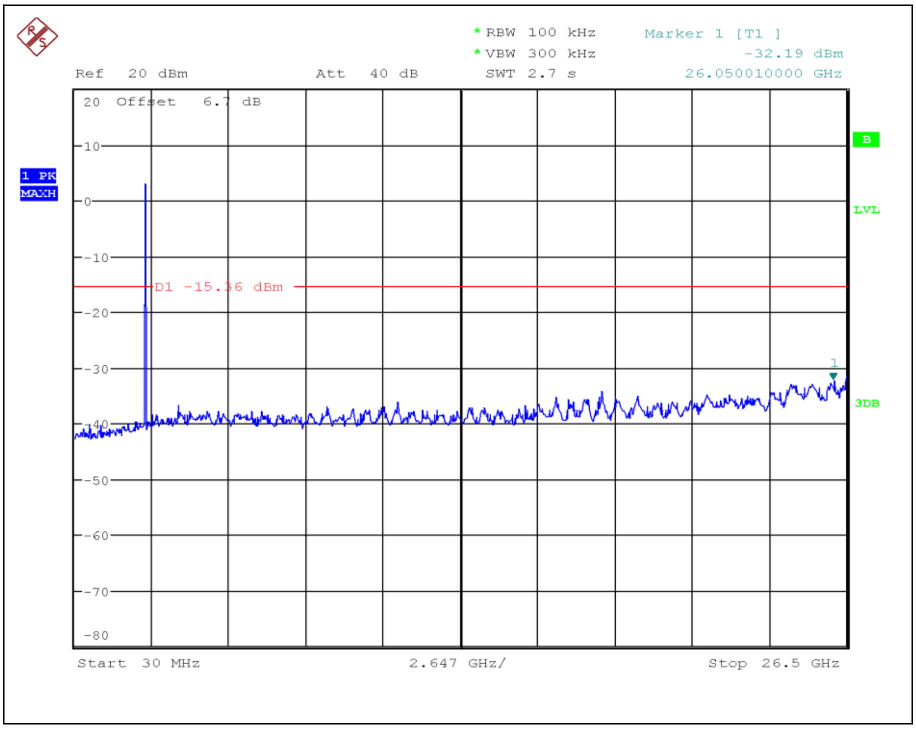
Bandedge _ Single



Bandedge _ Hopping



Spurious



3.3.8 Conducted Emission

3.3.8.1 Test Setup

See test photographs for the actual connections between EUT and support equipment.

3.3.8.2 Limit

According to §15.207(a) for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 ㎑ to 30 ㎒, shall not exceed the limits in the following table, as measured using a 50 uH/50 ohm line impedance stabilization network (LISN).
Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequency ranges.

Frequency Range (㎒)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15 ~ 0.5	66 to 56 *	56 to 46 *
0.5 ~ 5	56	46
5 ~ 30	60	50

* Decreases with the logarithm of the frequency

3.3.8.3 Test Procedure

Conducted emissions from the EUT were measured according to the ANSI C63.10.
1. The test procedure is performed in a 6.5 m × 3.5 m × 3.5 m (L × W × H) shielded room. The EUT along with its peripherals were placed on a 1.0 m (W) × 1.5 m (L) and 0.8 m in height wooden table and the EUT was adjusted to maintain a 0.4 meter space from a vertical reference plane.
2. The EUT was connected to power mains through a line impedance stabilization network (LISN) which provides 50 ohm coupling impedance for measuring instrument and the chassis ground was bounded to the horizontal ground plane of shielded room.
3. All peripherals were connected to the second LISN and the chassis ground also bounded to the horizontal ground plane of shielded room.
4. The excess power cable between the EUT and the LISN was bundled. The power cables of peripherals were unbundled. All connecting cables of EUT and peripherals were moved to find the maximum emission.

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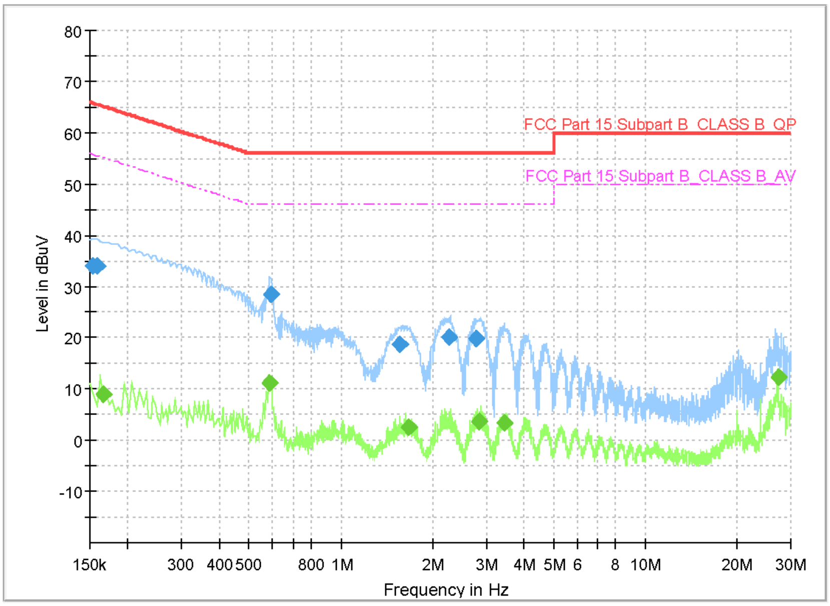
3.3.8.4 Test Result

- **AC Line Conducted Emission (Graph)**

Test Report

Common Information

Test Model:	SP88
Test Standard:	FCC Part 15 Subpart B
Test Mode:	Bluetooth
Test Conditions:	AC 120 V, 60 Hz / 20.3 'C, 43.3 % R. H.
Operator Name:	JongMyoung, Shin
Comment:	LINE
Order Number:	-



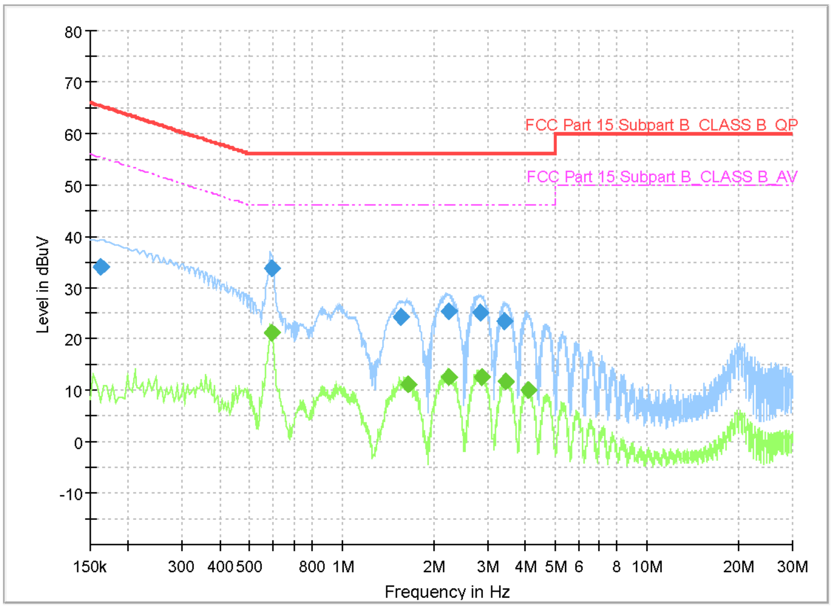
Final Result

Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.154000	34.11	---	65.78	31.68	1000.0	9.000	L1	10.5
0.158000	34.03	---	65.57	31.54	1000.0	9.000	L1	10.5
0.166000	---	8.88	55.16	46.28	1000.0	9.000	L1	10.5
0.584000	---	11.27	46.00	34.73	1000.0	9.000	L1	10.5
0.588000	28.38	---	56.00	27.62	1000.0	9.000	L1	10.5
1.568000	18.59	---	56.00	37.41	1000.0	9.000	L1	10.6
1.664000	---	2.68	46.00	43.32	1000.0	9.000	L1	10.6
2.260000	19.98	---	56.00	36.02	1000.0	9.000	L1	10.6
2.792000	19.81	---	56.00	36.19	1000.0	9.000	L1	10.6
2.860000	---	3.77	46.00	42.23	1000.0	9.000	L1	10.6
3.452000	---	3.49	46.00	42.51	1000.0	9.000	L1	10.6
27.380000	---	12.41	50.00	37.59	1000.0	9.000	L1	11.4

Test Report

Common Information

Test Model:	SP88
Test Standard:	FCC Part 15 Subpart B
Test Mode:	Bluetooth
Test Conditions:	AC 120 V, 60 Hz / 20.3 'C, 43.3 % R. H.
Operator Name:	JongMyoung, Shin
Comment:	NEUTRAL
Order Number:	-



Final Result

Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.162000	34.13	---	65.36	31.23	1000.0	9.000	N	10.5
0.588000	33.75	---	56.00	22.25	1000.0	9.000	N	10.5
0.588000	---	21.36	46.00	24.64	1000.0	9.000	N	10.5
1.568000	24.18	---	56.00	31.82	1000.0	9.000	N	10.6
1.652000	---	11.30	46.00	34.70	1000.0	9.000	N	10.6
2.236000	25.42	---	56.00	30.58	1000.0	9.000	N	10.6
2.240000	---	12.68	46.00	33.32	1000.0	9.000	N	10.6
2.836000	25.14	---	56.00	30.86	1000.0	9.000	N	10.6
2.892000	---	12.70	46.00	33.30	1000.0	9.000	N	10.6
3.424000	23.44	---	56.00	32.56	1000.0	9.000	N	10.6
3.452000	---	11.89	46.00	34.11	1000.0	9.000	N	10.6
4.108000	---	10.18	46.00	35.82	1000.0	9.000	N	10.6

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APPENDIX I

TEST SETUP

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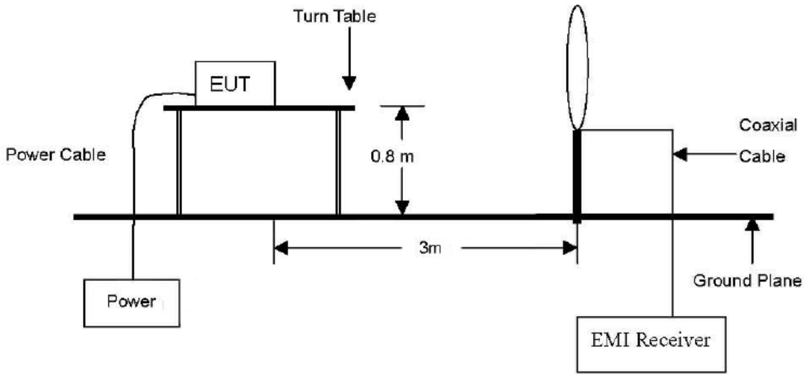
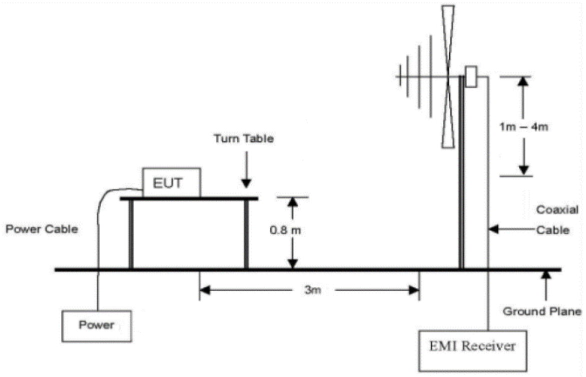
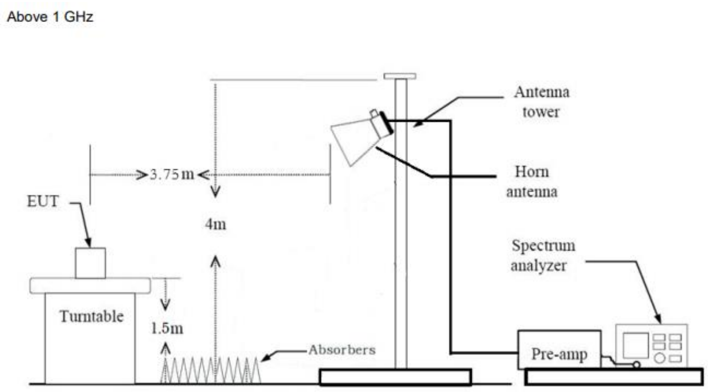
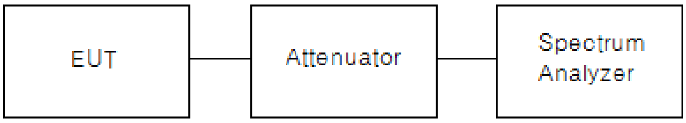
- Radiated Measurement

below 30 ㎒	
below 1 ㎓	
above 1 ㎓	

- Conducted Measurement

Conducted	

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APPENDIX II

TEST EQUIPMENT USED FOR TESTS

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	Description	Manufacturer	Serial No.	Model No.	Cal. Date	Next Cal. Date
1	SPECTRUM ANALYZER	R&S	100617	FSP40	2020-03-10	2021-03-10
2	SPECTRUM ANALYZER	R&S	100250	FSU26	2020-09-22	2021-09-22
3	Triple Output DC Power Supply	Agilent	MY40038816	E3631A	2020-03-10	2021-03-10
4	Power supply	GWInstek	EH120798	PST-3202	2020-03-10	2021-03-10
5	Humi./Baro/Temp. data recorder	Lutron	38420	MHB-382SD	2020-11-13	2021-11-13
6	8360B SERIES SWEPT SIGNAL GENERATOR	HP	3614A00312	83640B	2020-12-30	2021-12-30
7	LOOP-ANTENNA	Schwarzbeck	00124	FMZB1519 B	2019-06-27	2021-06-27
8	TRILOG Broadband Antenna	Schwarzbeck	01027	VULB 9168	2019-06-17	2021-06-17
9	Double Ridged Broadband Horn Antenna	Schwarzbeck	02087	BBHA 9120D	2020-06-05	2021-06-05
10	Broadband Horn Antenna	Schwarzbeck	00938	BBHA 9170	2020-05-29	2021-05-29
11	Amplifier	TESTEK	190007-L	TK-PA18H	2020-05-28	2021-05-28
12	Amplifier	TESTEK	190008-L	TK-PA1840H	2020-05-29	2021-05-29
13	ATTENUATOR	INMET	279465	40AH2W	2020-07-28	2021-07-28
14	ATTENUATOR	Weinschel	none	WA41/12-30-12	2020-03-10	2021-03-10
15	High Pass Filter	Mini-Circuits	1741	VHF-3100+	2020-03-10	2021-03-10
16	High Pass Filter	Mini-Circuits	1732	VHF-8400+	2020-03-10	2021-03-10
17	LISN	Schwarzbeck	00984	NSLK 8127	2020-05-28	2021-05-28
18	EMI Test Receiver	R&S	102116	ESRP3	2020-05-28	2021-05-28