TEST REPORT

CTK Co., Ltd.
(Ho-dong), 113, Yejik-ro, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea
Tel: +82-31-339-9970
Fax: +82-31-624-9501

1. Client

◦ Name : ANOTO KOREA Corp.

◦ Address : 501, IRUM building, 225-18, Pangyoyeok-ro, Bundang-gu, Seongnam-si, Gyeonggi-do, Republic of Korea

◦ Date of Receipt : 2021-04-29

2. Manufacturer

◦ Name : ANOTO KOREA Corp.

◦ Address : 501, IRUM building, 225-18, Pangyoyeok-ro, Bundang-gu, Seongnam-si, Gyeonggi-do, Republic of Korea

3. Use of Report : For FCC & ISED Certification

4. Test Sample / Model: Digital Pen / echoII

5. Date of Test : 2021-06-02 to 2021-06-03

6. Test Standard(method) used : FCC 47 CFR part 15 subpart C 15.247
ANSI C63.10-2013, RSS-247, RSS-Gen

7. Testing Environment: Temp.: (23 ± 1) ℃, Humidity: (48 ± 5) % R.H.

8. Test Results : Compliance

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.

Affirmation	Tested by Gwanyong Kim: (Signature)	Technical Manager Young-taek Lee: (Signature)

2021-06-03

Republic of KOREA **CTK Co., Ltd.**

REPORT REVISION HISTORY

Date	Revision	Page No
2021-06-03	Issued (CTK-2021-02042)	all

This report shall not be reproduced except in full, without the written approval of CTK Co., Ltd. This document may be altered or revised by CTK Co., Ltd. personnel only, and shall be noted in the revision section of the document. Any alteration of this document not carried out by CTK Co., Ltd. will constitute fraud and shall nullify the document.

CONTENTS

1. General Product Description 4
1.1 Client Information 4
1.2 Product Information 4
1.3 Peripheral Devices 4
2. Facility and Accreditations 5
2.1 Test Facility 5
2.2 Laboratory Accreditations and Listings 5
2.3 Calibration Details of Equipment Used for Measurement 5
3. Test Specifications 6
3.1 Standards 6
3.2 Mode of operation during the test 6
3.3 Maximum Measurement Uncertainty 7
4. Technical Characteristic Test 8
4.1 Carrier Frequency Separation 8
4.2 Number of Hopping Frequencies 10
4.3 20 dB bandwidth & 99 % Bandwidth 13
4.4 Time of Occupancy (Dwell Time) 19
4.5 Maximum peak Conducted Output Power 30
4.6 Unwanted Emissions (Conducted) 38
4.7 Radiated Emission 49
4.8 AC Power Line Conducted Emissions 66
5. APPENDIX A – Test Equipment Used For Tests 71

1. General Product Description

1.1 Client Information

Company	ANOTO KOREA Corp.
Contact Point	501, IRUM building, 225-18, Pangyoyeok-ro, Bundang-gu, Seongnam-si, Gyeonggi-do, Republic of Korea
Contact Person	Name : Changhoon Shin E-mail : changhoon.shin@anoto.com Tel : +82-10-8009-3880 Fax : +82-31-600-0801

1.2 Product Information

FCC ID	ADM-ECHOII
Certification Number ISED	23775-ECHOII
Product Description	Digital Pen
Basic model (HVIN)	echoII
Variant Model name	-
Operating Frequency	2 402 MHz – 2 480 MHz
RF Output Power	GKSK : 4.57 dBm (2.864 mW) - Peak Conducted π/4 DQPSK : 4.22 dBm (2.642 mW) - Peak Conducted 8-DPSK : 4.44 dBm (2.780 mW) - Peak Conducted
Antenna type	Chip Antenna
Antenna gain	3.4 dBi
Number of channels	79
Channel Spacing	1 MHz
Type of Modulation	GFSK(1 Mbps), π/4 DQPSK(2 Mbps), 8-DPSK(3 Mbps)
Power Source	DC 3.7 V (Battery)
FVIN	3.1.2.4
Test Software(Version)	Tera term (Version 4.8.5) MediTek BT Tool (Version W1537)
RF Power setting in Test SW	Power Setting "7"

1.3 Peripheral Devices

Device	Manufacturer	Model No.	Serial No.
Note Computer	Samsung Electronics	550XDA	NT-21022303
AC/DC Adapter	LITE-ON TECHNOLOGY CHANGZHOU CO., LTD	PA-1400-96	AC-4019A

2. Facility and Accreditations

2.1 Test Facility

The measurement facility is located at (Ho-dong), 113, Yejik-ro, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea.

2.2 Laboratory Accreditations and Listings

Country	Agency	Registration Number
USA	FCC	805871
CANADA	ISED	8737A-2
KOREA	NRRA	KR0025

2.3 Calibration Details of Equipment Used for Measurement

Test equipment and test accessories are calibrated on regular basis. The maximum time between calibrations is one year or what is recommended by the manufacturer, whichever is less. All test equipment calibrations are traceable to the Korea Research Institute of Standards and Science (KRISS), therefore, all test data recorded in this report is traceable to KRISS.

3. Test Specifications

3.1 Standards

Section in FCC	Section in RSS	Requirement(s)	Status (Note 1)	Test Condition
15.247(a)	RSS-247 5.1(b)	Carrier Frequency Separation	C	Conducted
15.247(a)	RSS-247 5.1(d)	Number of Hopping Frequencies	C	
15.247(a)	RSS-247 5.1(a)	20 dB Bandwidth	C	
15.247(a)	RSS-247 5.1(d)	Time of occupancy (Dwell Time)	C	
15.247(b)	RSS-247 5.4(b)	Maximum peak conducted output power	C	
15.247(d)	RSS-247 5.5	Unwanted emission	C	
15.209	RSS-Gen 6.13	Transmitter emission	C	Radiated
15.207(a)	RSS-Gen 8.8	AC Conducted Emission	C	Line Conducted

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

Note 2: The data in this test report are traceable to the national or international standards.

Note 3: The sample was tested according to the following specification: FCC Part 15.247, ANSI C63.10-2013, RSS-247 Issue 2, RSS-Gen Issue 5

Note 4: The tests were performed according to the method of measurements prescribed in KDB No.558074, ANSI C63.10-2013

Note 5: This device is frequency hopping system(FHS), and complies frequency hopping system requirement.

3.2 Mode of operation during the test

The EUT is operated in a manner representative of the typical of the equipments.
During at testing, system components were manipulated within the confines of typical usage to maximize each emission. All modulation modes were tests.
The results are only attached worst cases.

Test Frequency

Lowest channel	Middle channel	Highest channel
2 402 MHz	2 441 MHz	2 480 MHz

Test mode

Modulation	Packet type	Data rate	Duty Cycle	Duty Cycle Factor
GFSK	DH5	1 Mbps	57.20 %	2.43 dB
π/4 DQPSK	2-DH5	2 Mbps	57.60 %	2.40 dB
8-DPSK	3-DH5	3 Mbps	57.60 %	2.40 dB

3.3 Maximum Measurement Uncertainty

The value of the measurement uncertainty for the measurement of each parameter.
Coverage factor k = 2, Confidence levels of 95 %

Description	Uncertainty
Conducted RF Output Power	1.5 dB (C.L. : Approx. 95 %, k = 2)
Occupied Bandwidth	0.1 MHz (C.L. : Approx. 95 %, k = 2)
Unwanted Emission(conducted)	3.0 dB (C.L. : Approx. 95 %, k = 2)
Radiated Emissions (f ≤ 30 MHz)	1.5 dB (C.L. : Approx. 95 %, k = 2)
Radiated Emissions (f ≤ 1 GHz)	4.66 dB (C.L. : Approx. 95 %, k = 2)
Radiated Emissions (f > 1 GHz)	4.76 dB (C.L. : Approx. 95 %, k = 2)
AC Conducted Emission	1.96 dBμV (C.L. : Approx. 95 %, k = 2)

4. Technical Characteristic Test

4.1 Carrier Frequency Separation

Test Procedures

ANSI C63.10-2013 7.8.2

The carrier frequency separation was measured with a spectrum analyzer connected to the antenna terminal, while EUT has 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 :

a) Span = 5 MHz (wide enough to capture the peaks of two adjacent channels)
b) RBW = 30 kHz (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) VBW = 30 kHz (≥ RBW)
d) Sweep = auto
e) Detector function = peak
f) Trace = max hold

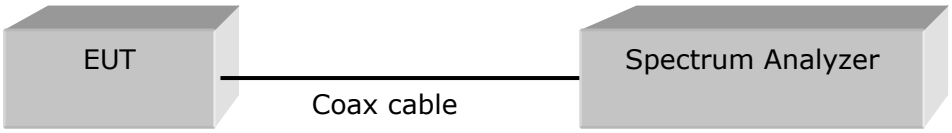


Figure 1 : Measurement setup for the carrier frequency separation

Limit
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.

Test Results

Test mode : GFSK

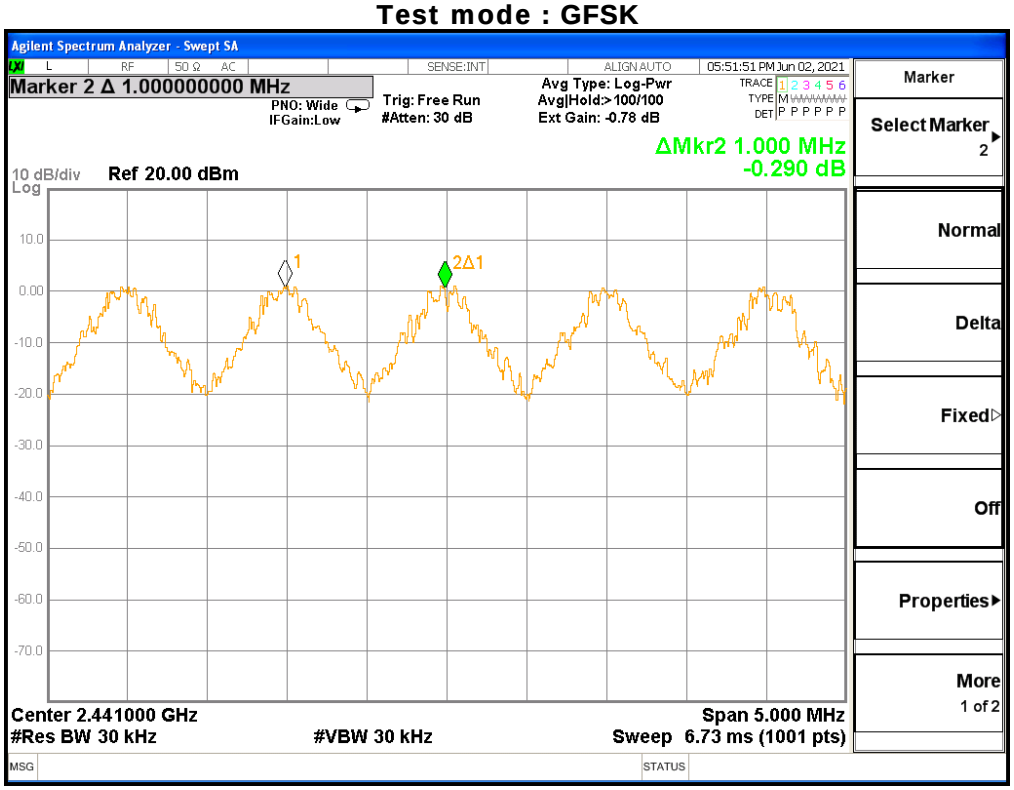
Channel	Adjacent Hopping Channel Separation [kHz]	Two-third of 20dB bandwidth [kHz]	Minimum Bandwidth [kHz]	Result
Middle	1000	693	25	Complies

Test mode : 8-DPSK

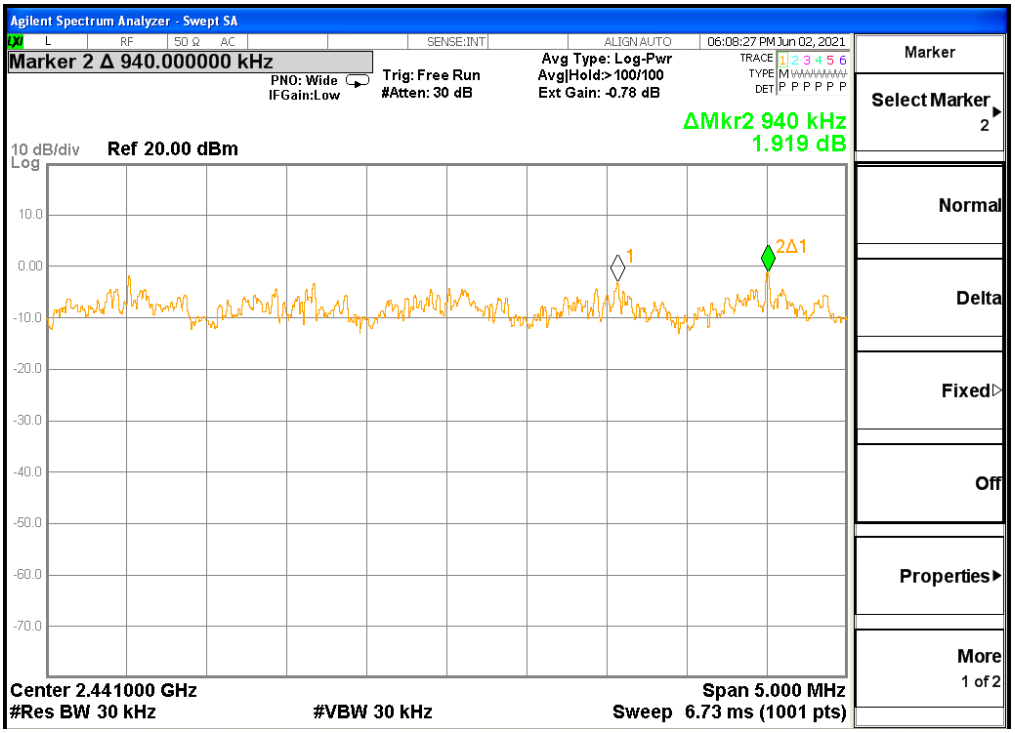
Channel	Adjacent Hopping Channel Separation [kHz]	Two-third of 20dB bandwidth [kHz]	Minimum Bandwidth [kHz]	Result
Middle	940	865	25	Complies

See next pages for actual measured spectrum plots.

Test mode : GFSK



Test mode : 8-DPSK



4.2 Number of Hopping Frequencies

Test Procedures

ANSI C63.10-2013 7.8.3

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

The spectrum analyzer is set to :

a) Frequency range 1: Start = 2 390.0 MHz, Stop = 2 439.5 MHz
2: Start = 2 439.5 MHz, Stop = 2 489.5 MHz

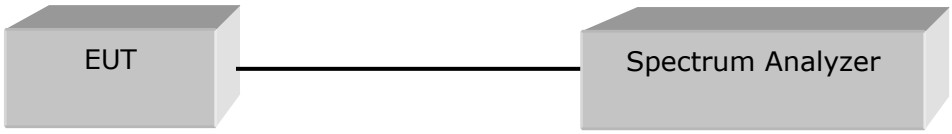
b) RBW = 300 kHz (To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller)

c) VBW = 300 kHz (≥ RBW)

d) Sweep = auto

e) Detector function = peak

f) Trace = max hold



Limit

FHSs operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels.

Test Results

Test mode : GFSK

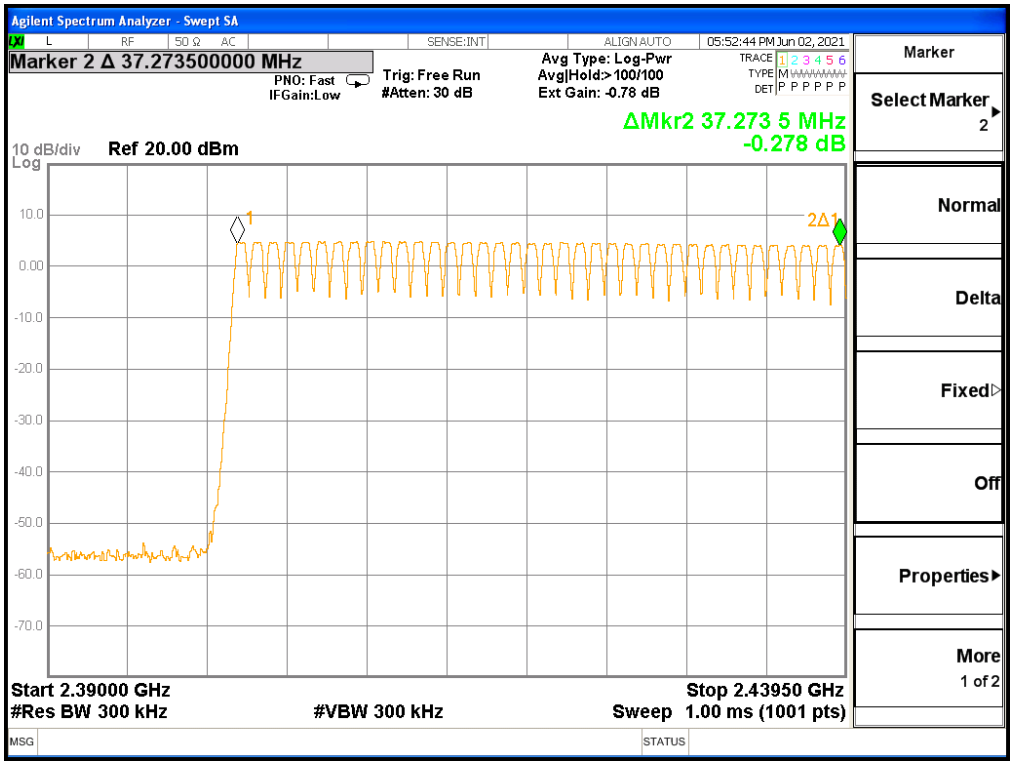
Total number of Hopping Channels	Result
79	Complies

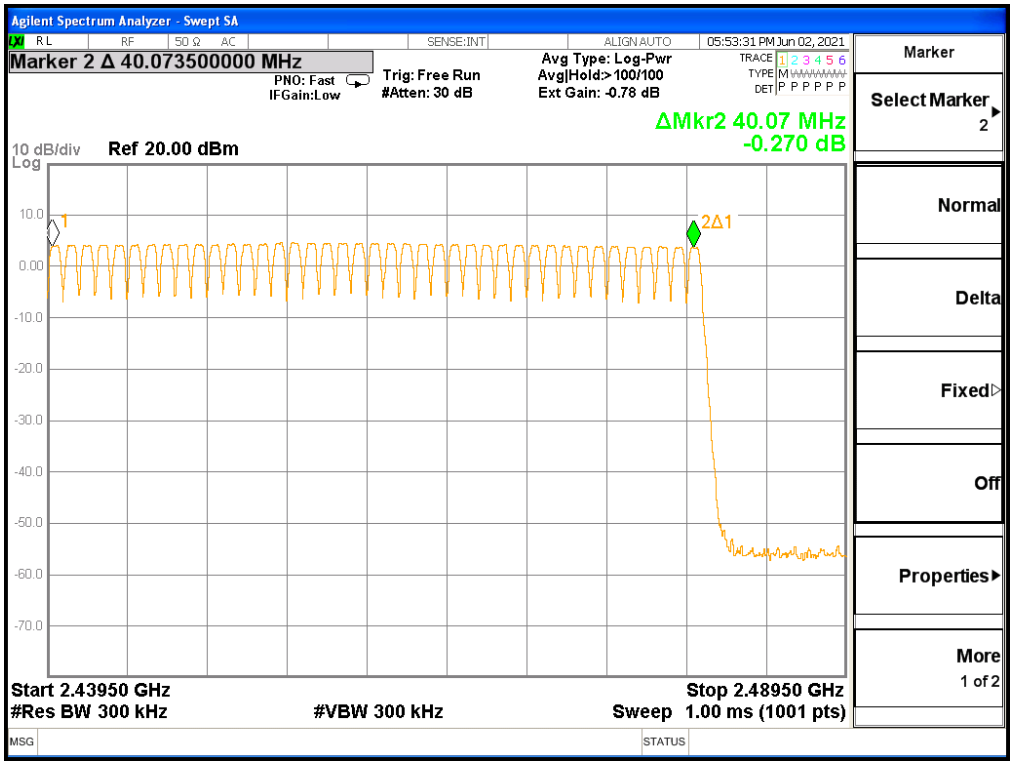
Test mode : 8-DPSK

Total number of Hopping Channels	Result
79	Complies

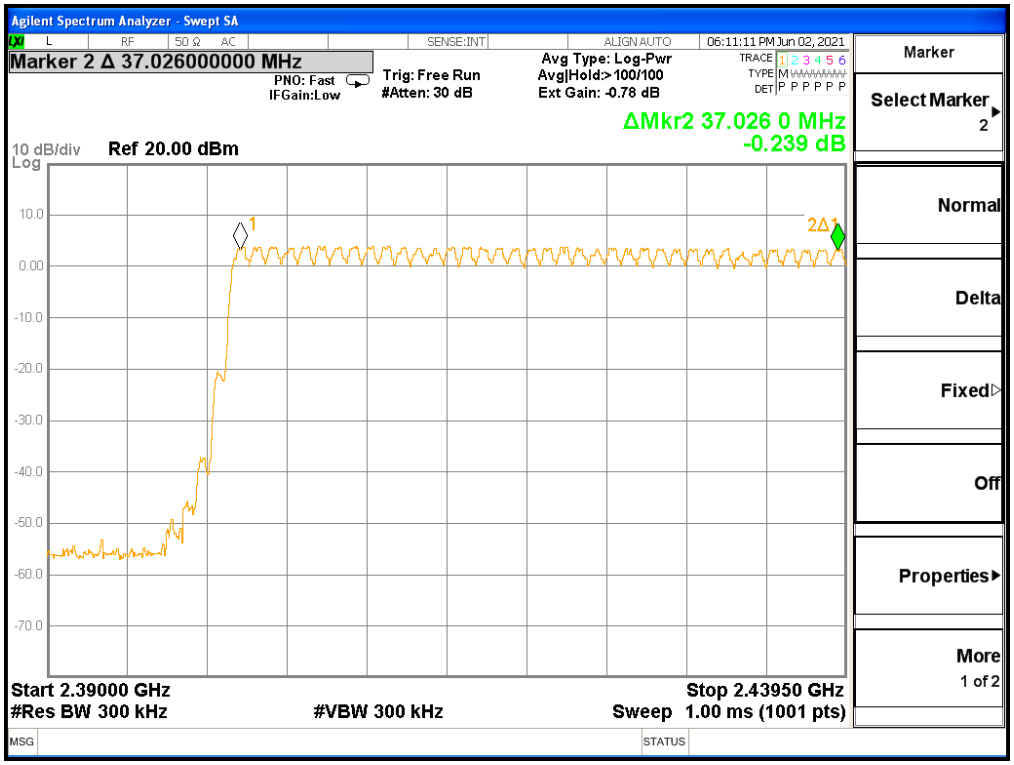
See next pages for actual measured spectrum plots.

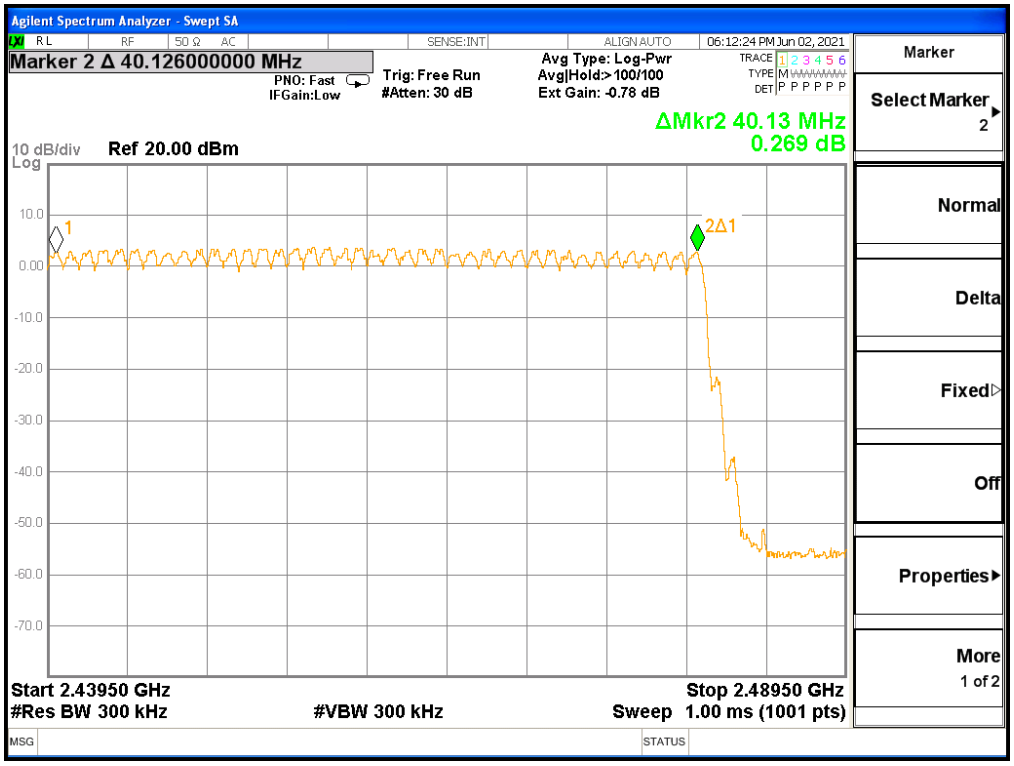
Test Mode : GFSK





Test Mode : 8-DPSK





4.3 20 dB bandwidth & 99 % Bandwidth

Test Procedures

ANSI C63.10-2013 6.9.2
RSS-GEN Issue 5 - Section 6.7

Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 20 dB relative to the maximum level measured in the fundamental emission.

ANSI C63.10-2013 6.9.3
RSS-GEN Issue 5 - Section 6.7

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5 % of the total mean power of the given emission.
Use the 99 % power bandwidth function of the instrument and report the measured bandwidth.

The spectrum analyzer is set to :

Center frequency = the highest, middle and the lowest channels

a) Span = 3 MHz (between 2 times and 5 times the OBW)

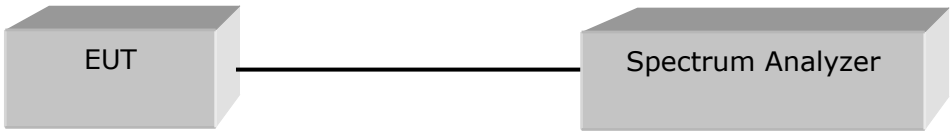
b) RBW = 30 kHz (1 % to 5 % of the OBW)

c) VBW = 100 kHz (approximately 3 times RBW)

d) Sweep = auto

e) Detector function = peak

f) Trace = max hold



Limit

Limit : N/A

Test Results

Test mode : GFSK

Channel	Frequency [MHz]	20 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
Lowest	2 402	1.033	0.902	Complies
Middle	2 441	1.039	0.903	Complies
Highest	2 480	1.028	0.893	Complies

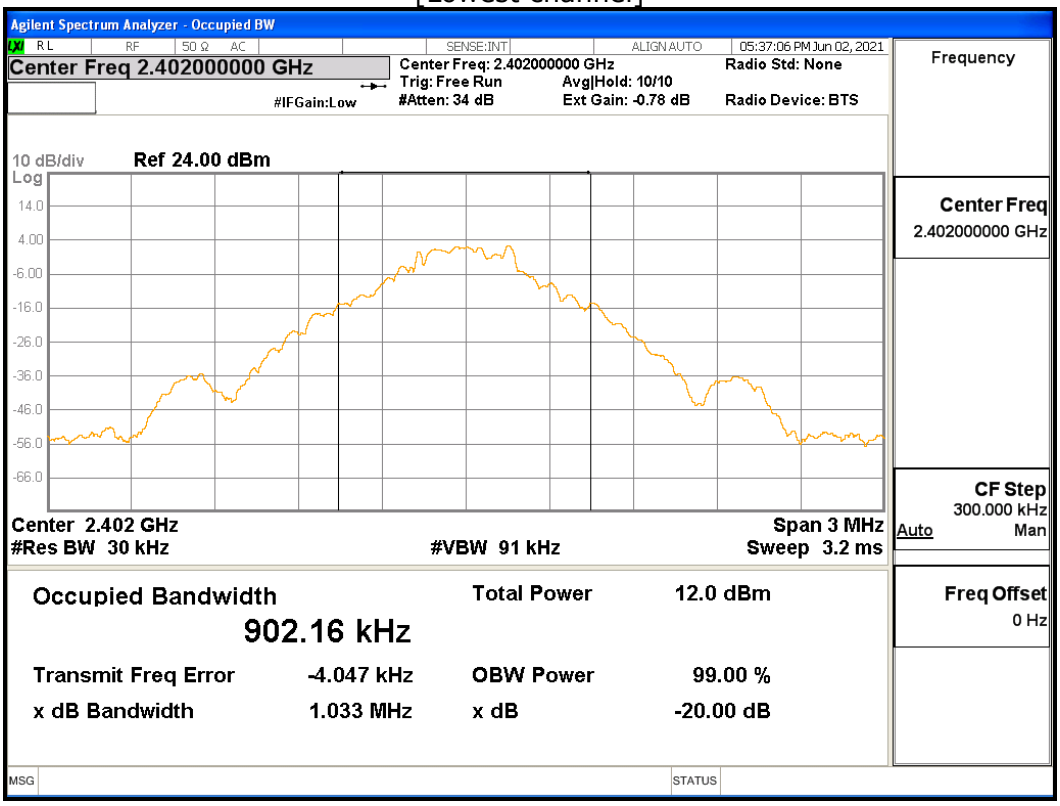
Test mode : 8-DPSK

Channel	Frequency [MHz]	20 dB Bandwidth [MHz]	99 % Bandwidth [MHz]	Result
Lowest	2 402	1.289	1.221	Complies
Middle	2 441	1.298	1.225	Complies
Highest	2 480	1.300	1.221	Complies

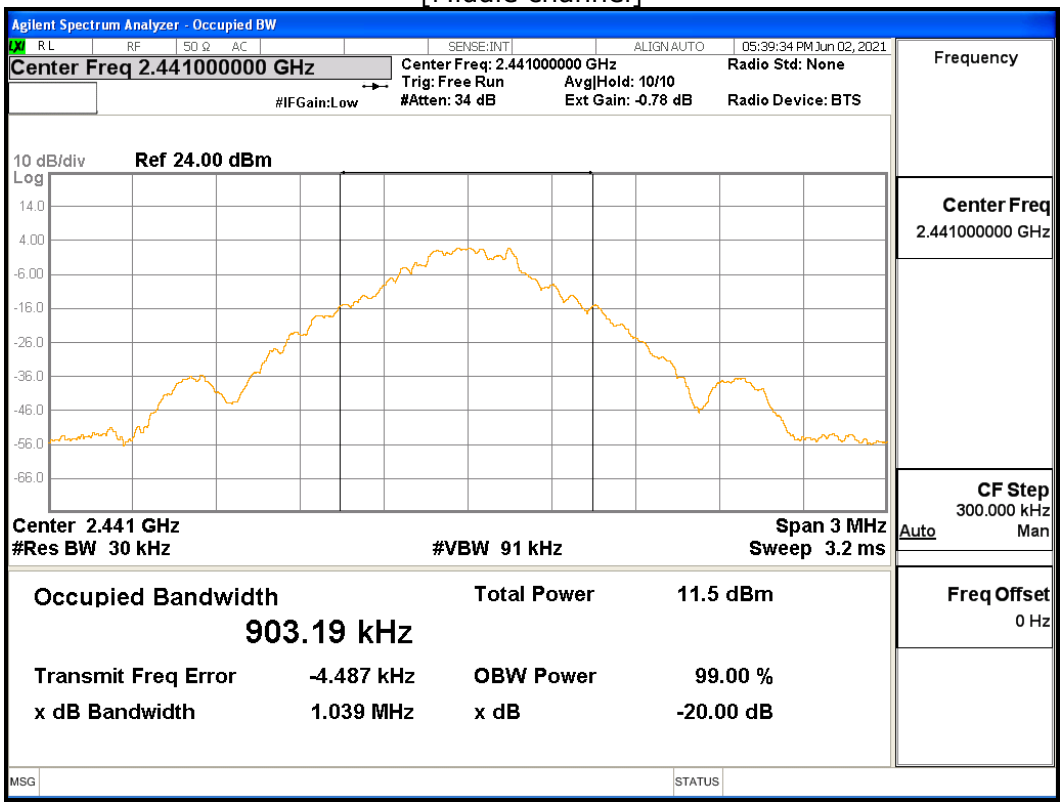
See next pages for actual measured spectrum plots.

20 dB bandwidth & 99 % Bandwidth - GFSK

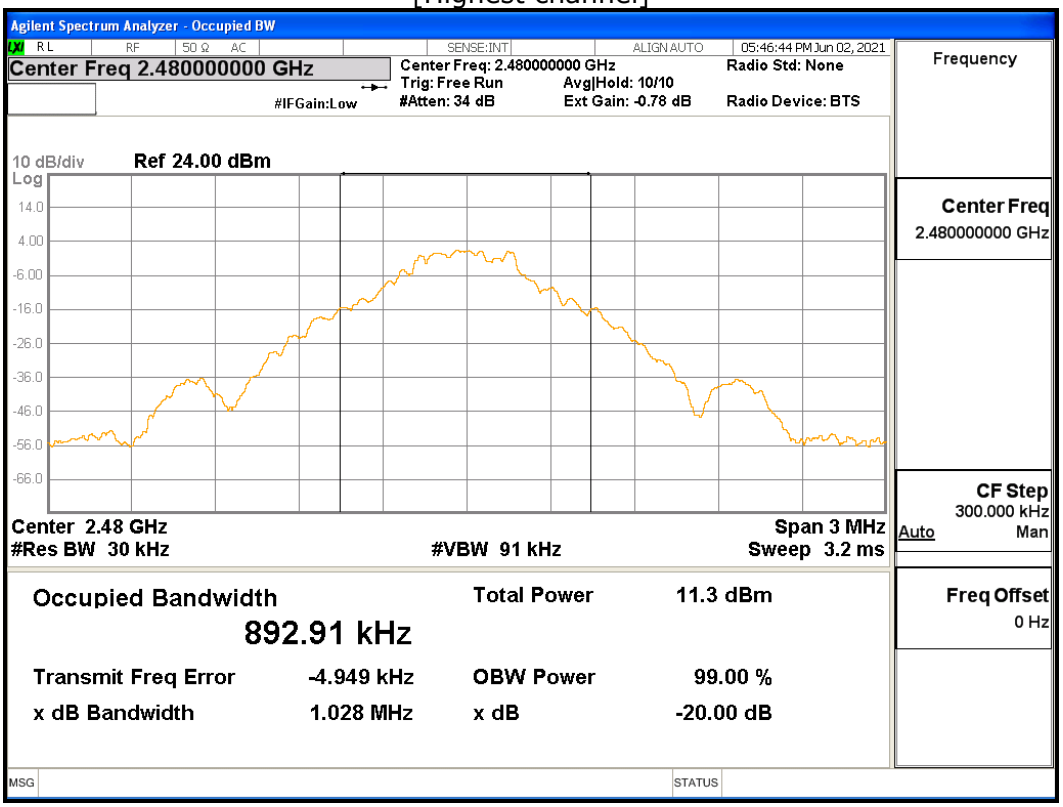
[Lowest channel]



[Middle channel]

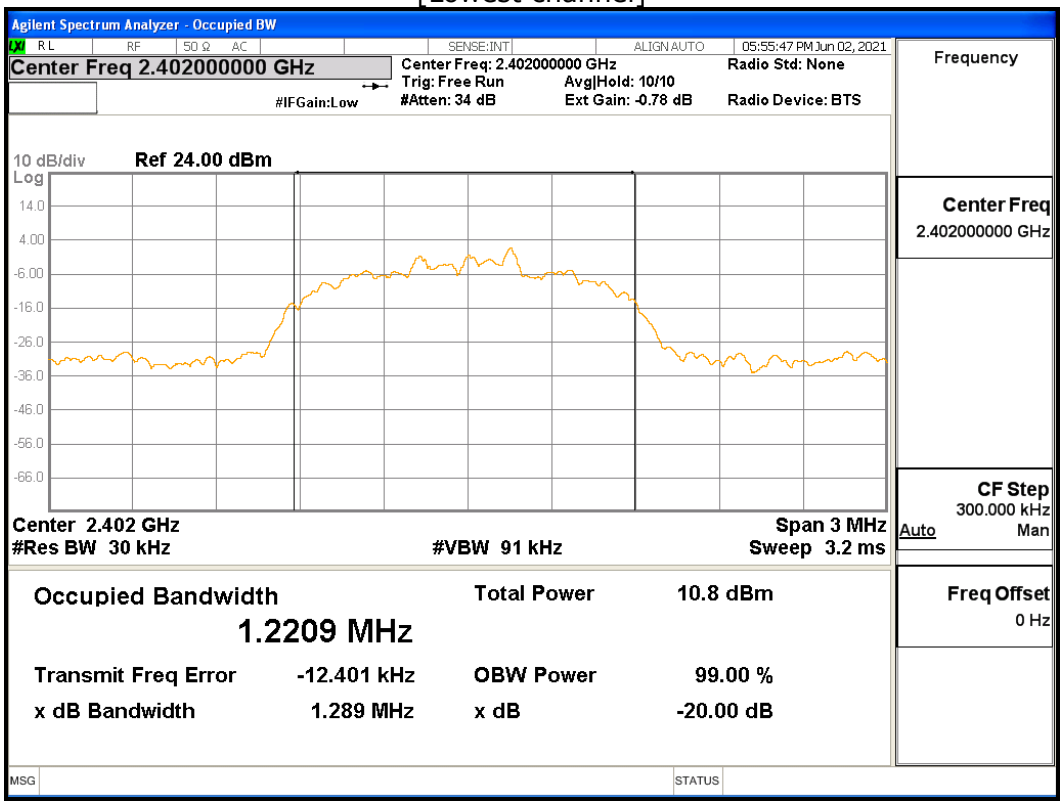


[Highest channel]

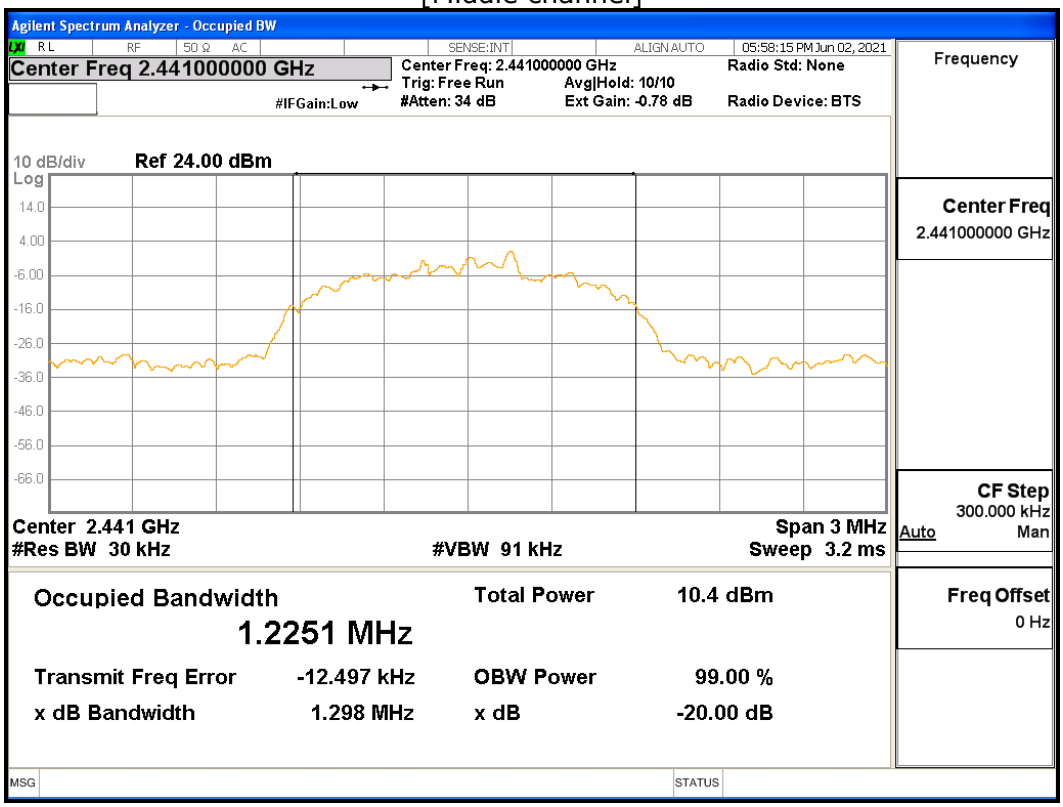


20 dB bandwidth & 99 % Bandwidth - 8-DPSK

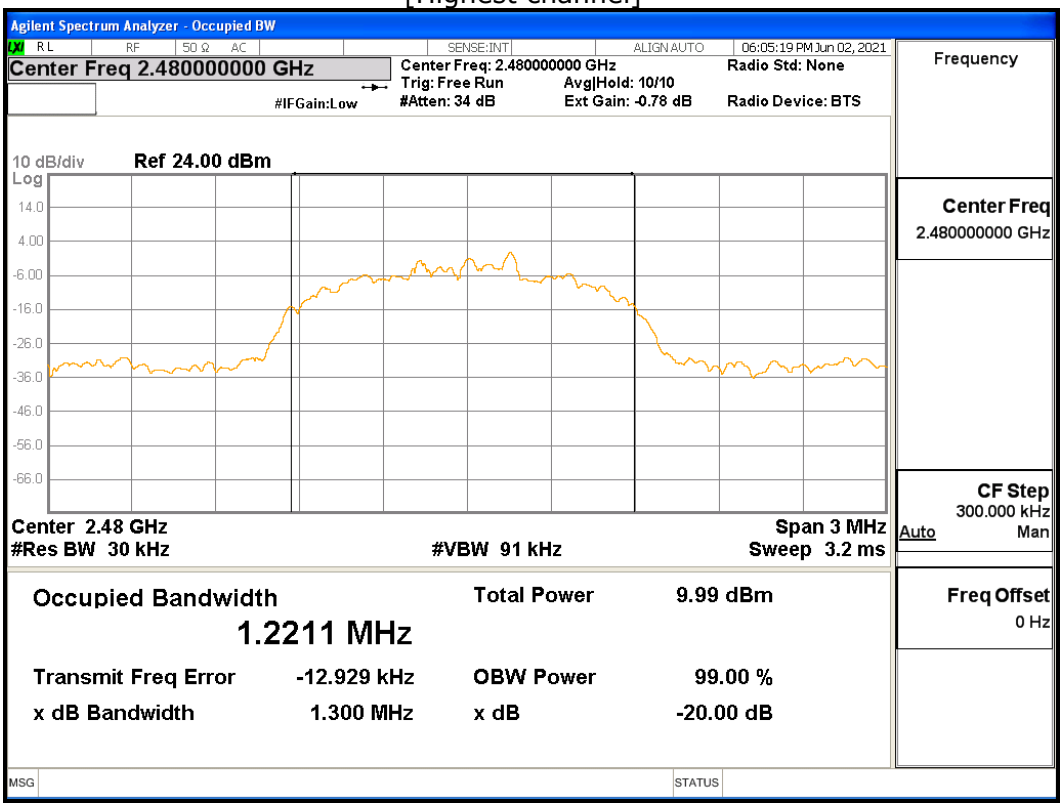
[Lowest channel]



[Middle channel]



[Highest channel]



4.4 Time of Occupancy (Dwell Time)

Test Procedures

ANSI C63.10-2013 7.8.4

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

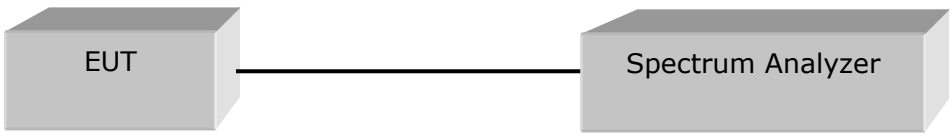
a) Span: Zero span, centered on a hopping channel.
b) RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
c) Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger 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.



Limit

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.

Test Results

The requirements are:
☒ Complies

Test Data

Test mode : GFSK

Mode	Number of hops on spectrum analyzer	period specified in the requirement (sec)	analyzer sweep time (sec)	Number of transmission in a period (channel number*0.4 sec)	Transmission time per hop (msec)	average time of occupancy (msec)	Limit (msec)
1-DH1	24	31.6	5.0	151.68	**0.365**	**55.363**	**400**
1-DH3	24	31.6	5.0	151.68	**1.620**	**245.722**	**400**
1-DH5	15	31.6	5.0	94.80	**2.860**	**271.128**	**400**

Test mode : π/4 DQPSK

Mode	Number of hops on spectrum analyzer	period specified in the requirement (sec)	analyzer sweep time (sec)	Number of transmission in a period (channel number*0.4 sec)	Transmission time per hop (msec)	average time of occupancy (msec)	Limit (msec)
2-DH1	24	31.6	5.0	151.68	**0.374**	**56.728**	**400**
2-DH3	30	31.6	5.0	189.60	**1.629**	**308.858**	**400**
2-DH5	16	31.6	5.0	101.12	**2.879**	**291.124**	**400**

Test mode : 8-DPSK

Mode	Number of hops on spectrum analyzer	period specified in the requirement (sec)	analyzer sweep time (sec)	Number of transmission in a period (channel number*0.4 sec)	Transmission time per hop (msec)	average time of occupancy (msec)	Limit (msec)
3-DH1	22	31.6	5.0	139.04	**0.370**	**51.445**	**400**
3-DH3	21	31.6	5.0	132.72	**1.620**	**215.006**	**400**
3-DH5	10	31.6	5.0	63.20	**2.880**	**182.016**	**400**

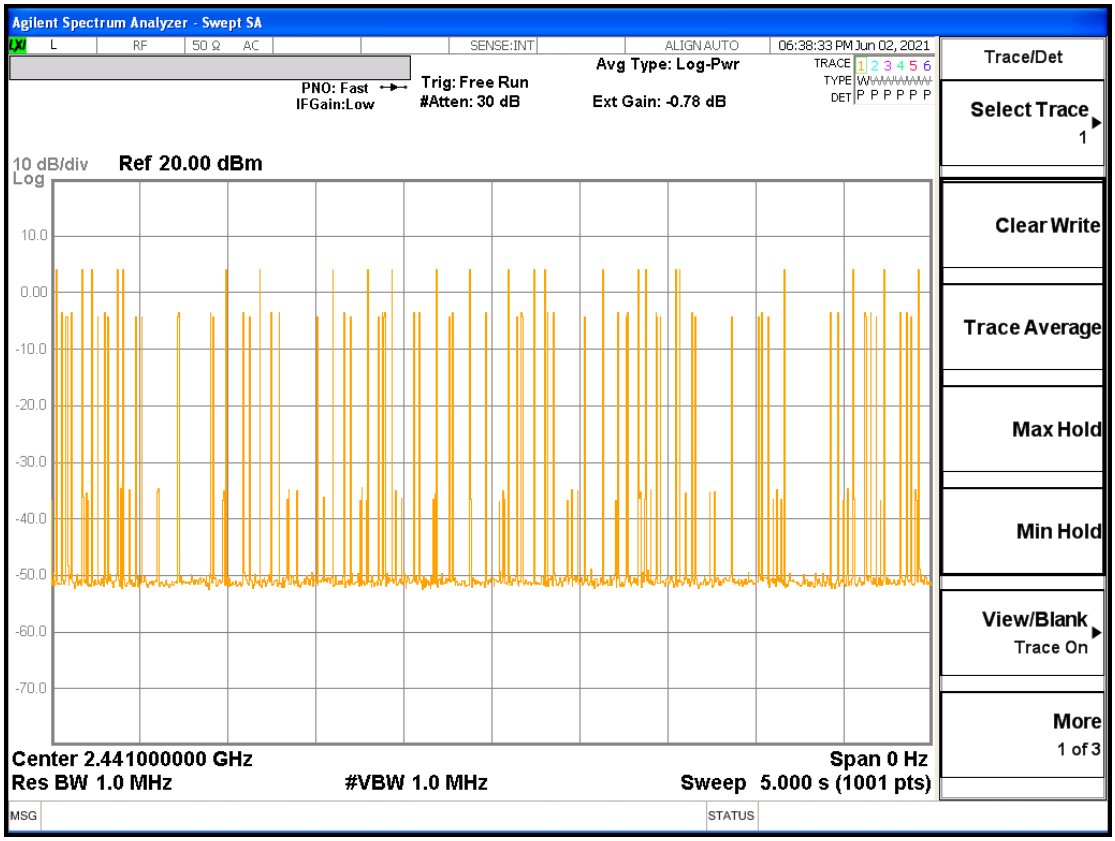
Remark:

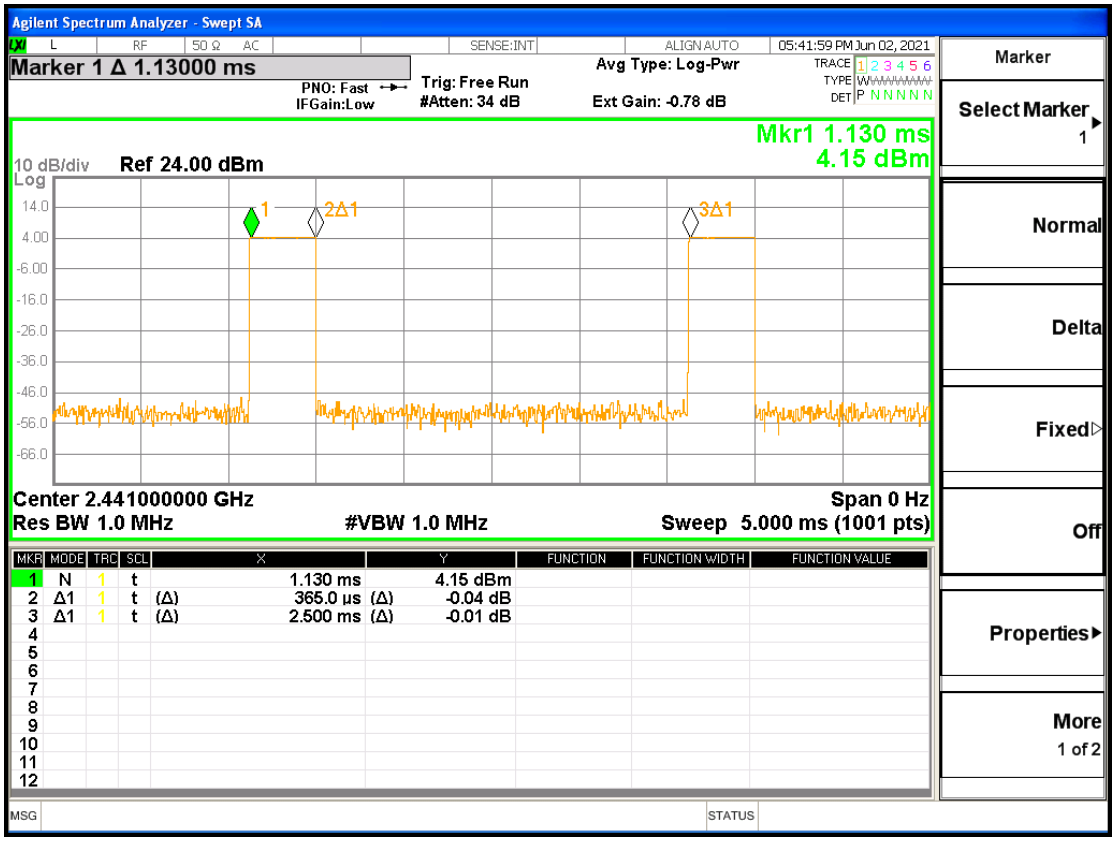
Number of transmission in a period(Channel number * 0.4)
= Number of hops on spectrum analyzer × (period specified in the requirement / analyzer sweep time)

Average time of occupancy = Number of transmission in a period × Transmission time per hop

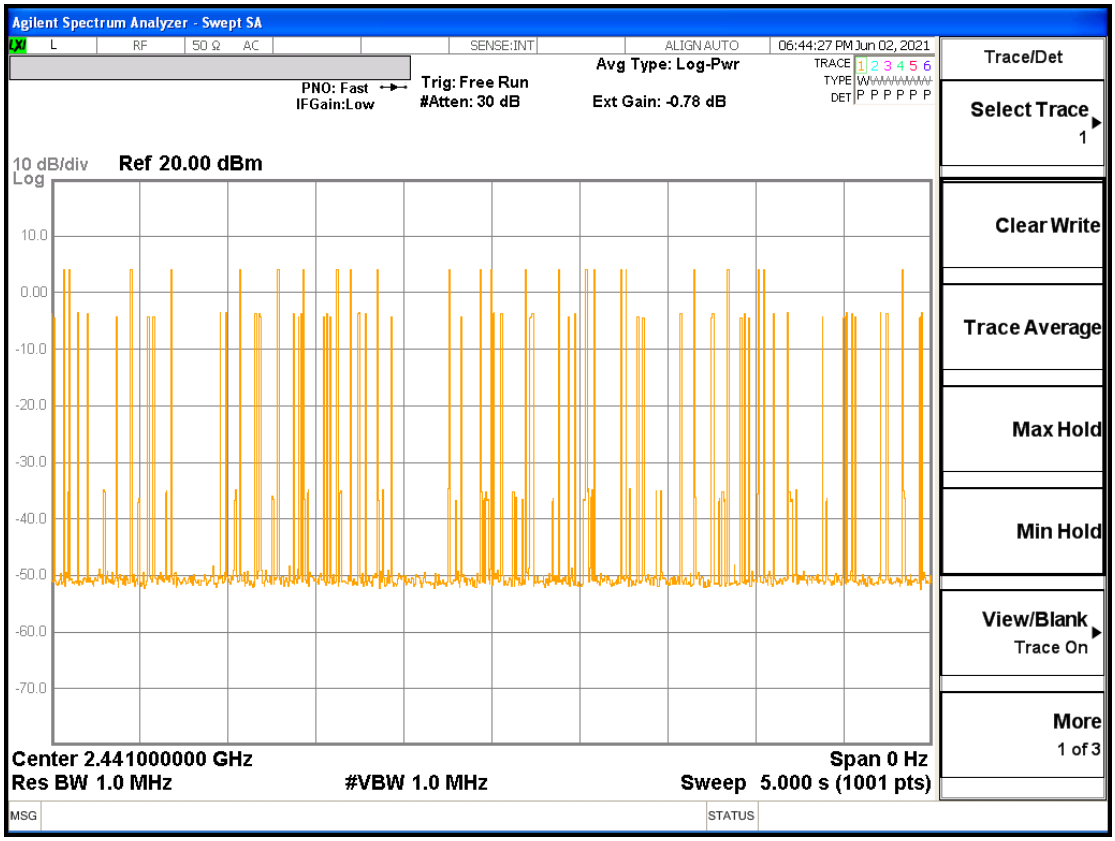
See next pages for actual measured spectrum plots.

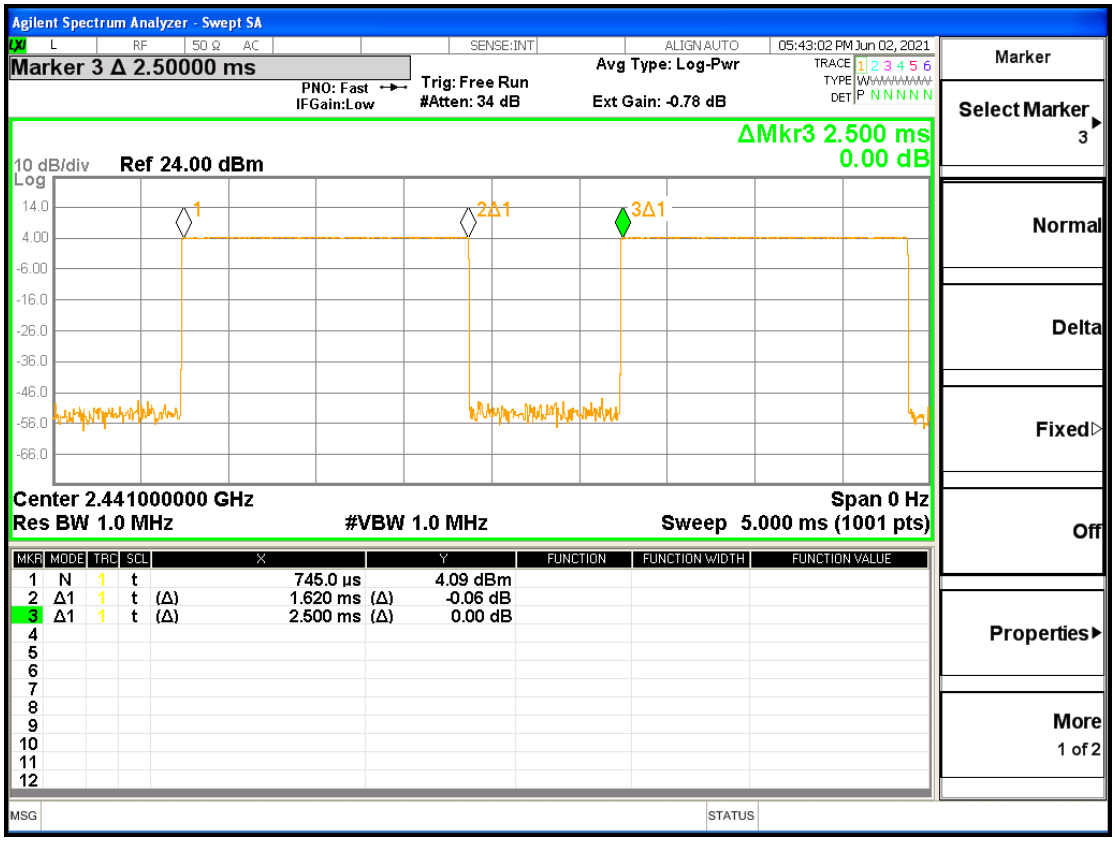
Time of Occupancy for Packet Type 1-DH1(GFSK)



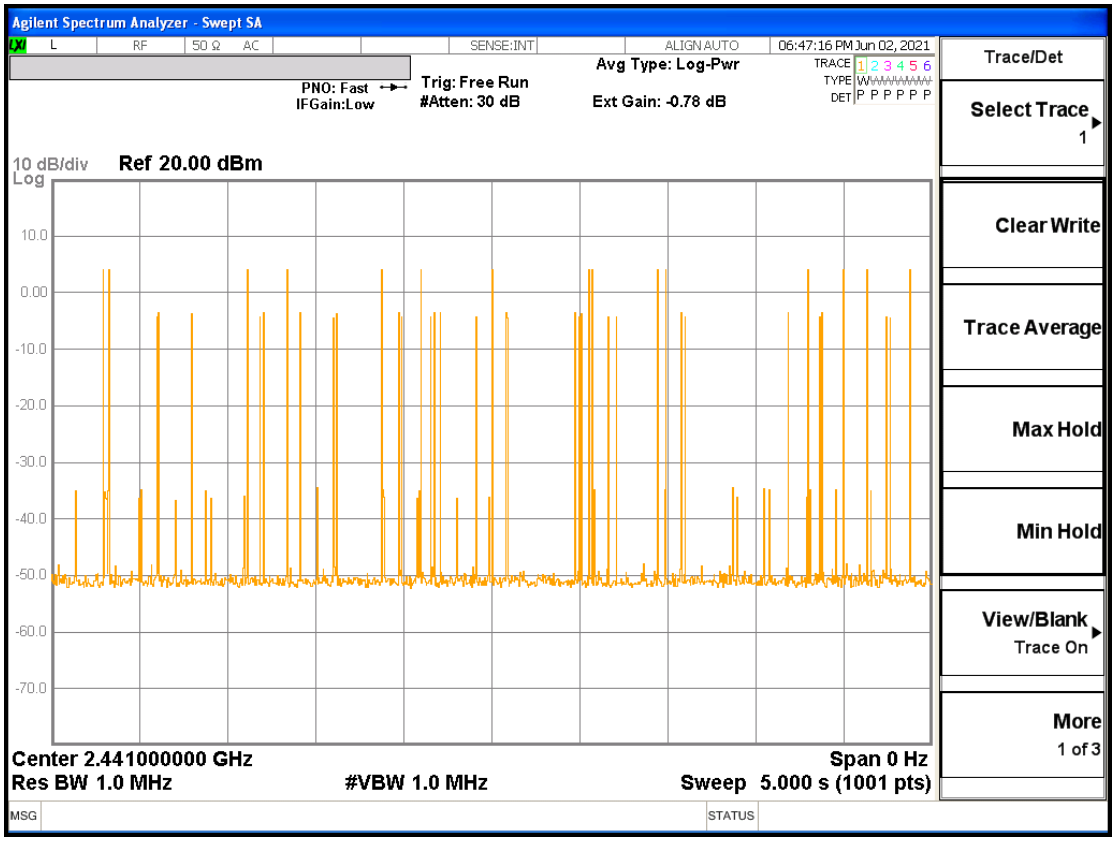


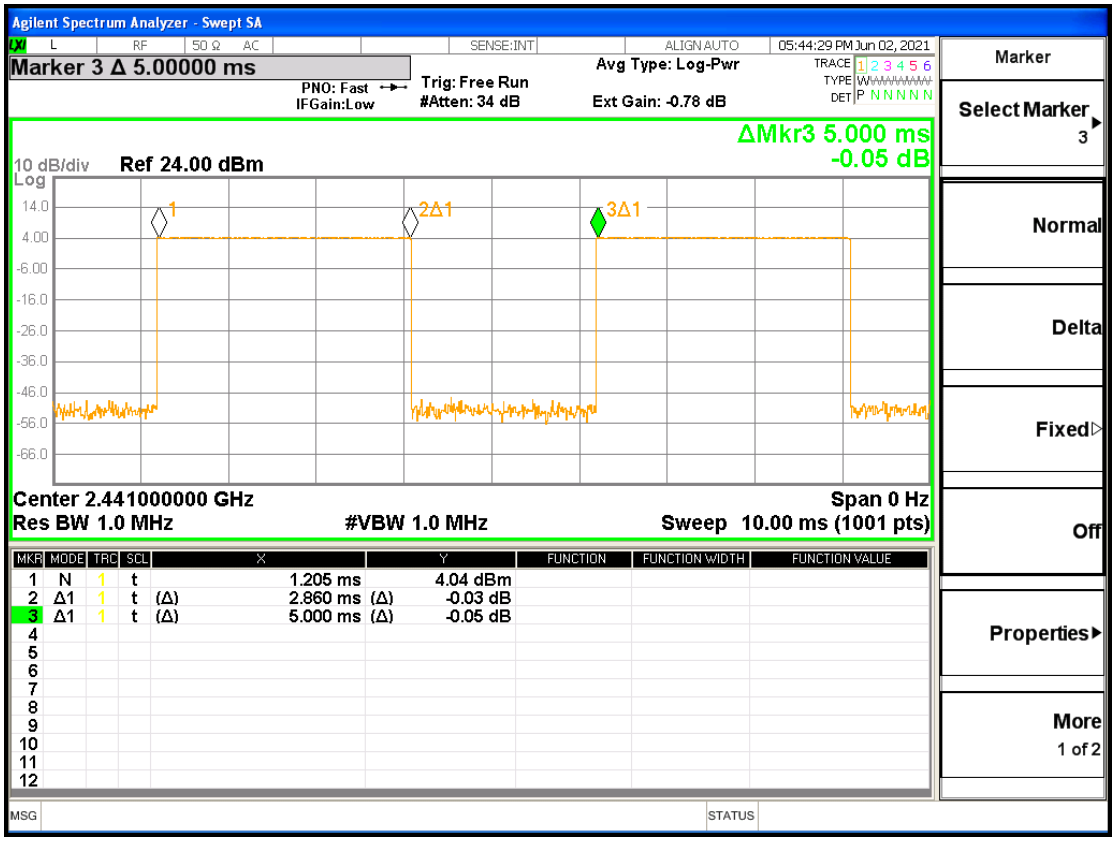
Time of Occupancy for Packet Type 1-DH3(GFSK)



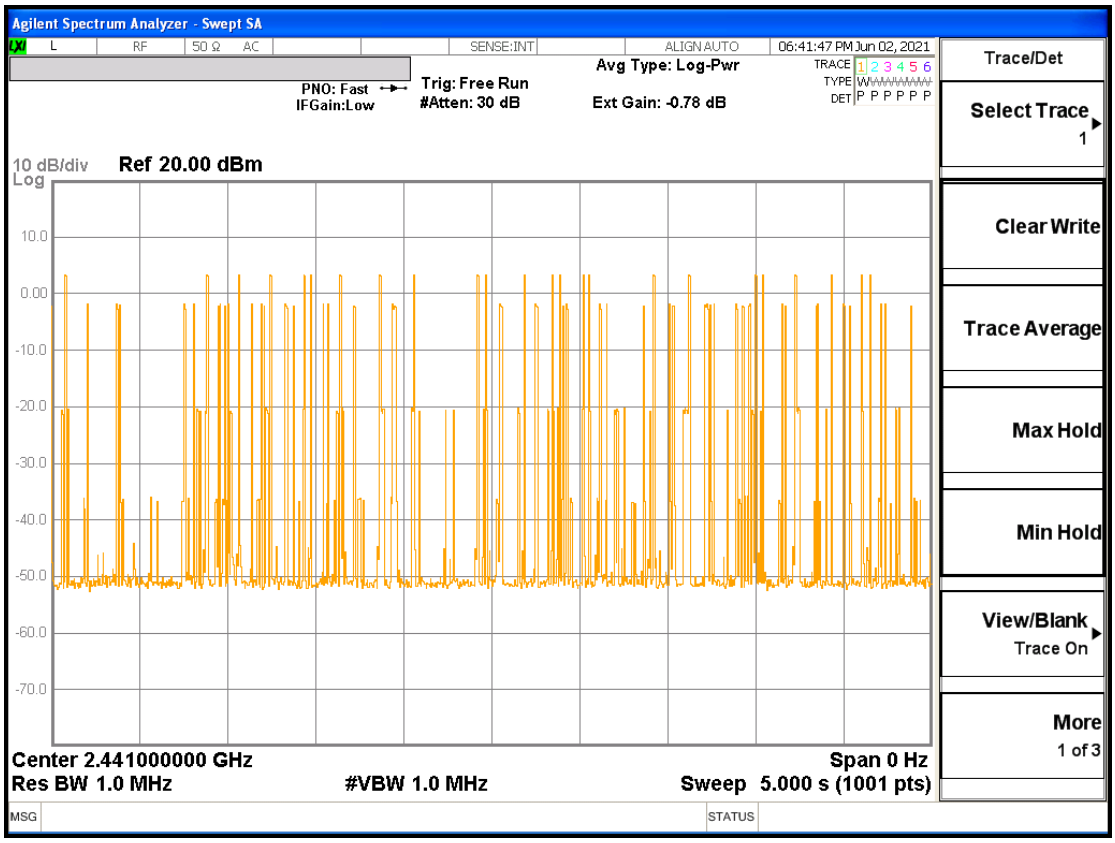


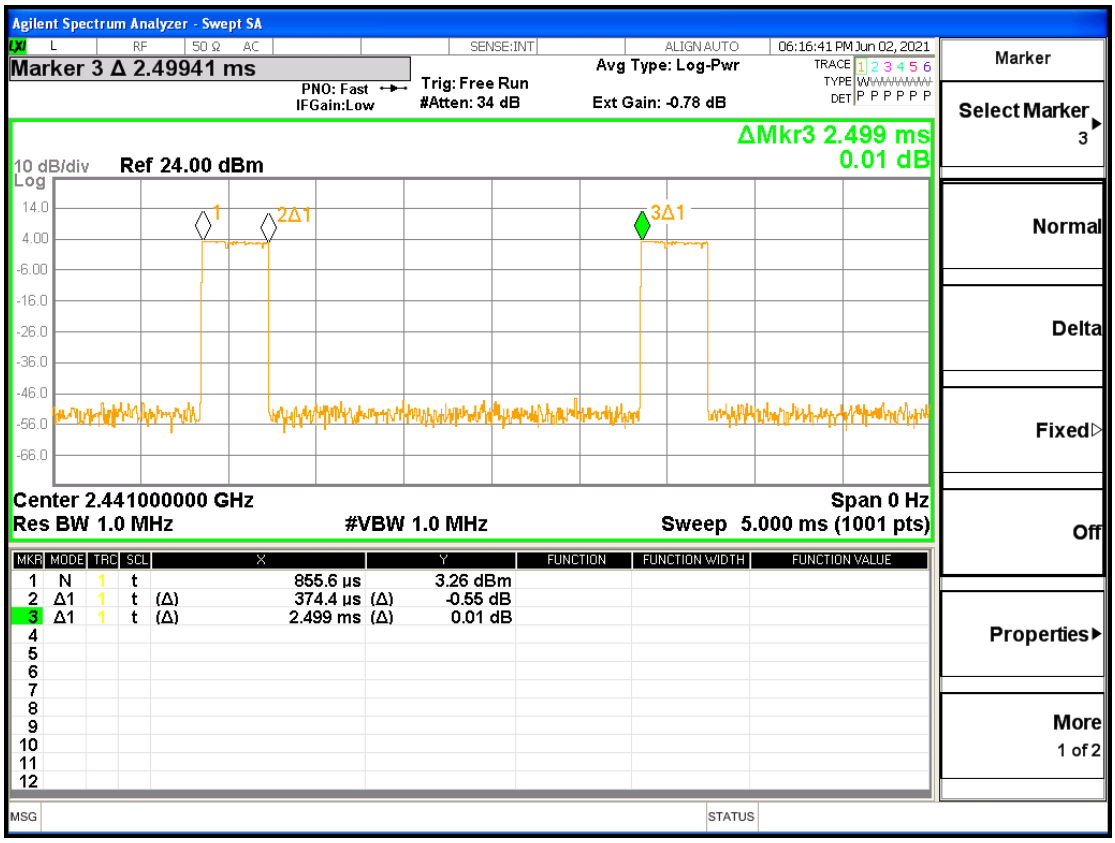
Time of Occupancy for Packet Type 1-DH5(GFSK)



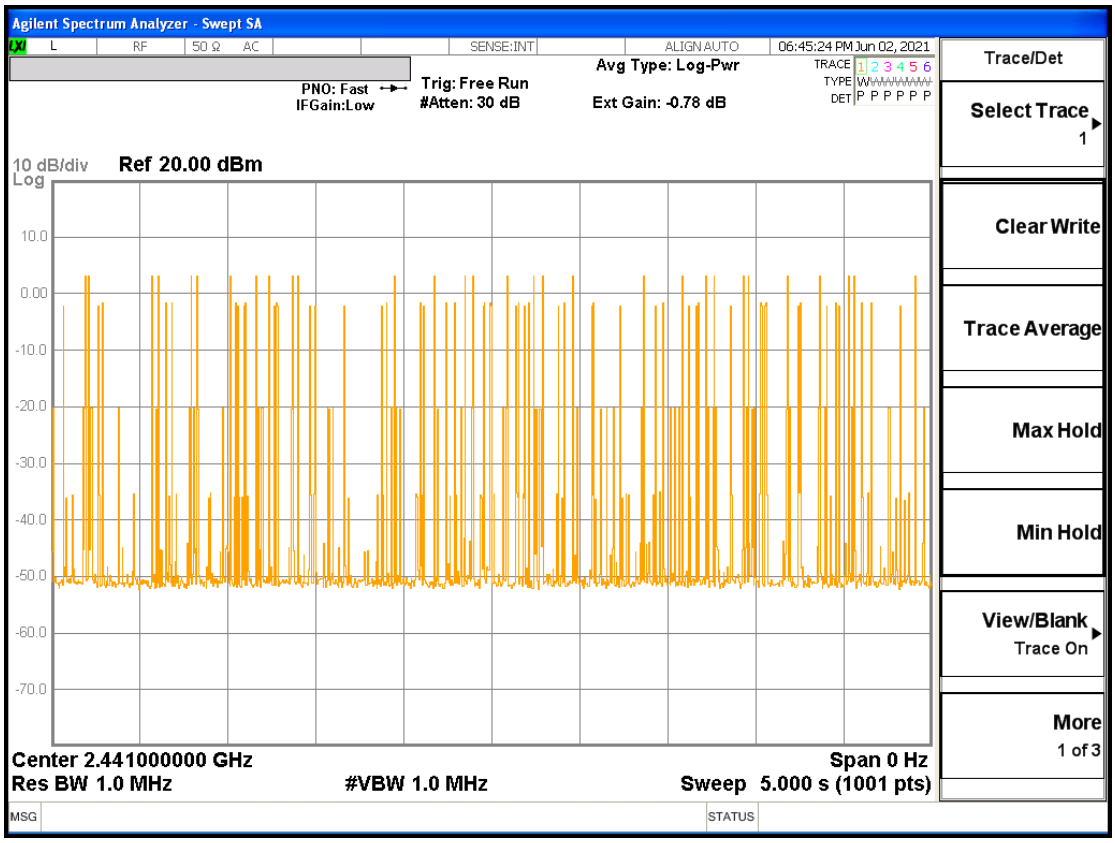


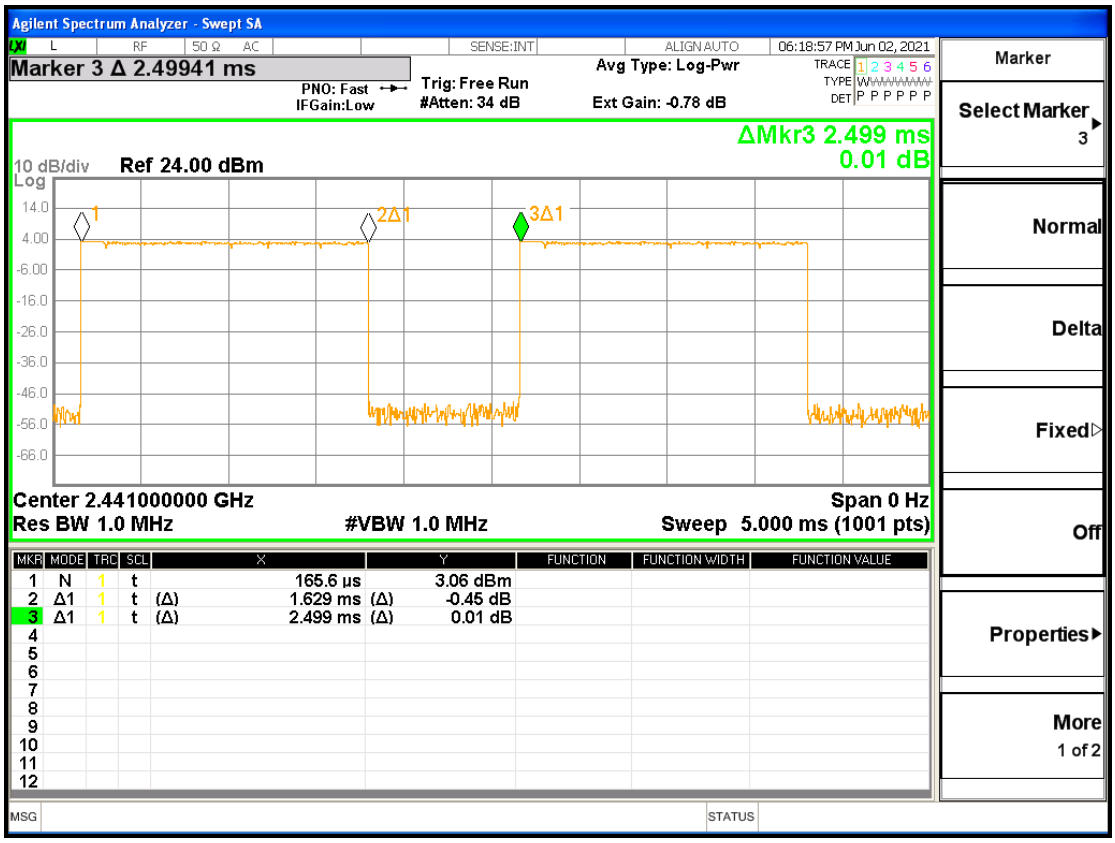
Time of Occupancy for Packet Type 2-DH1(π/4 DQPSK)



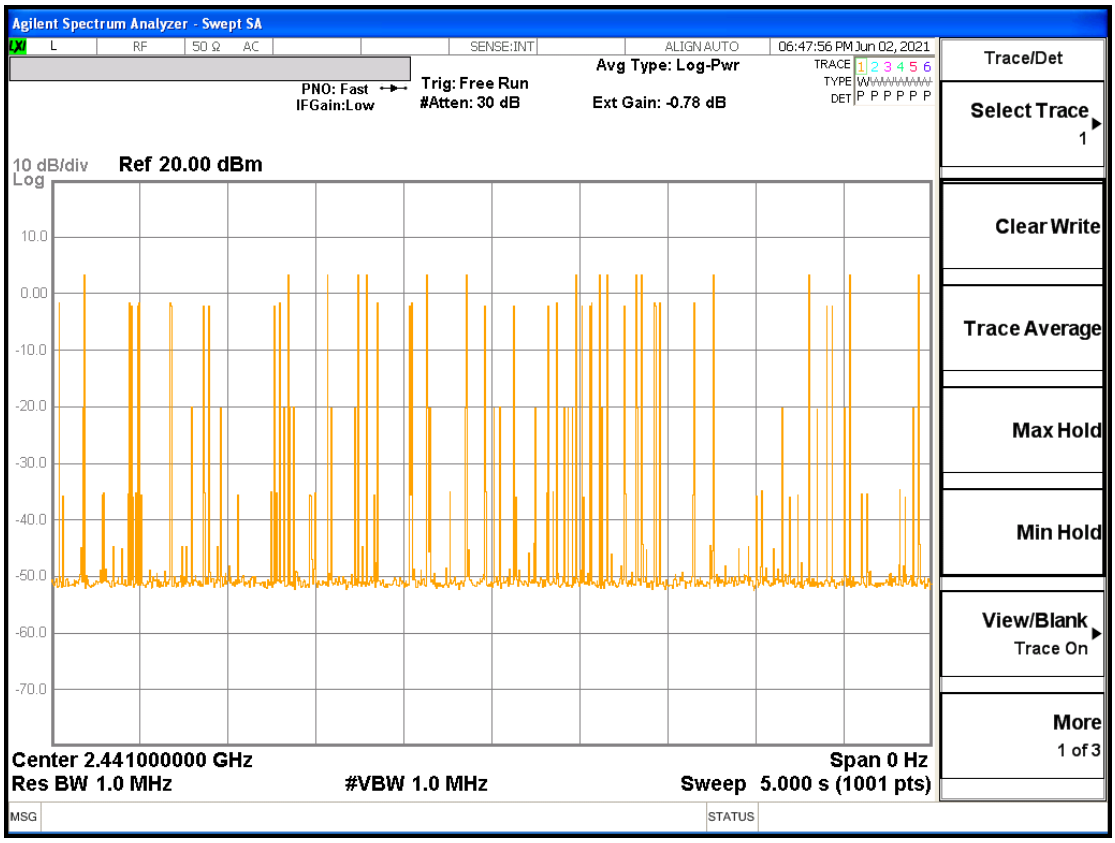


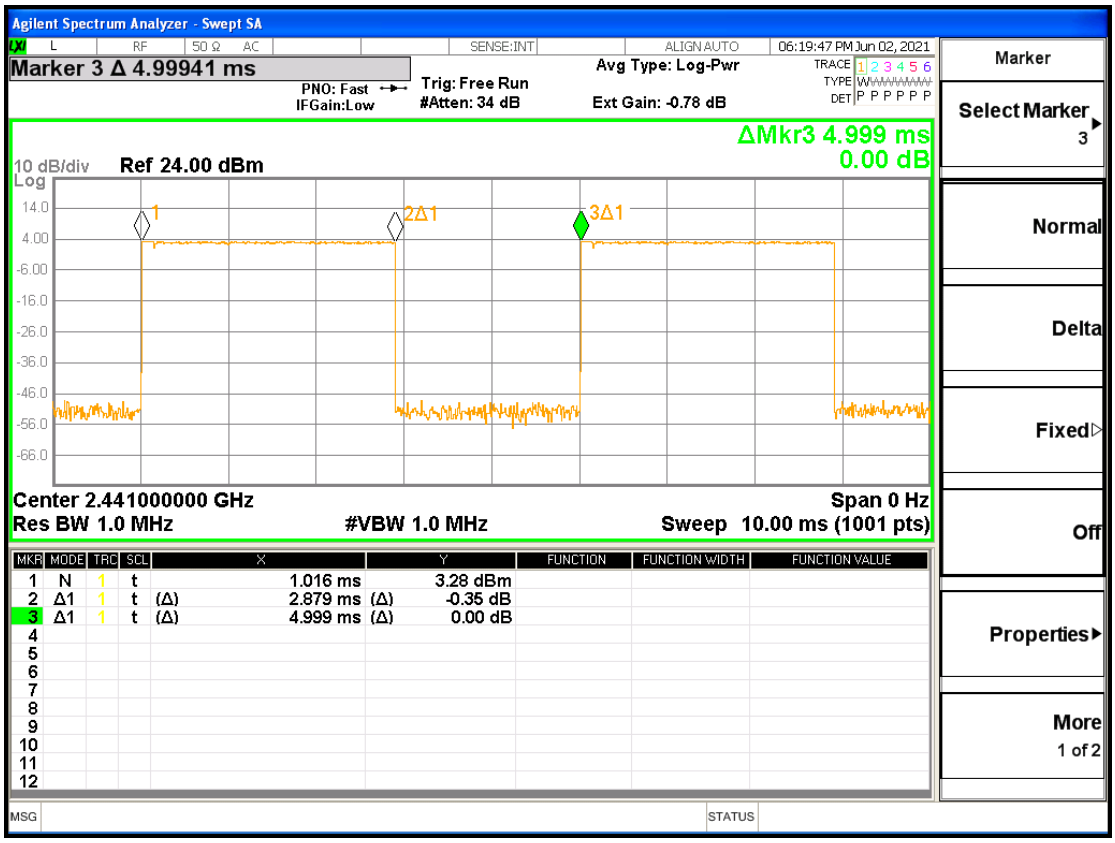
Time of Occupancy for Packet Type 2-DH3(π/4 DQPSK)



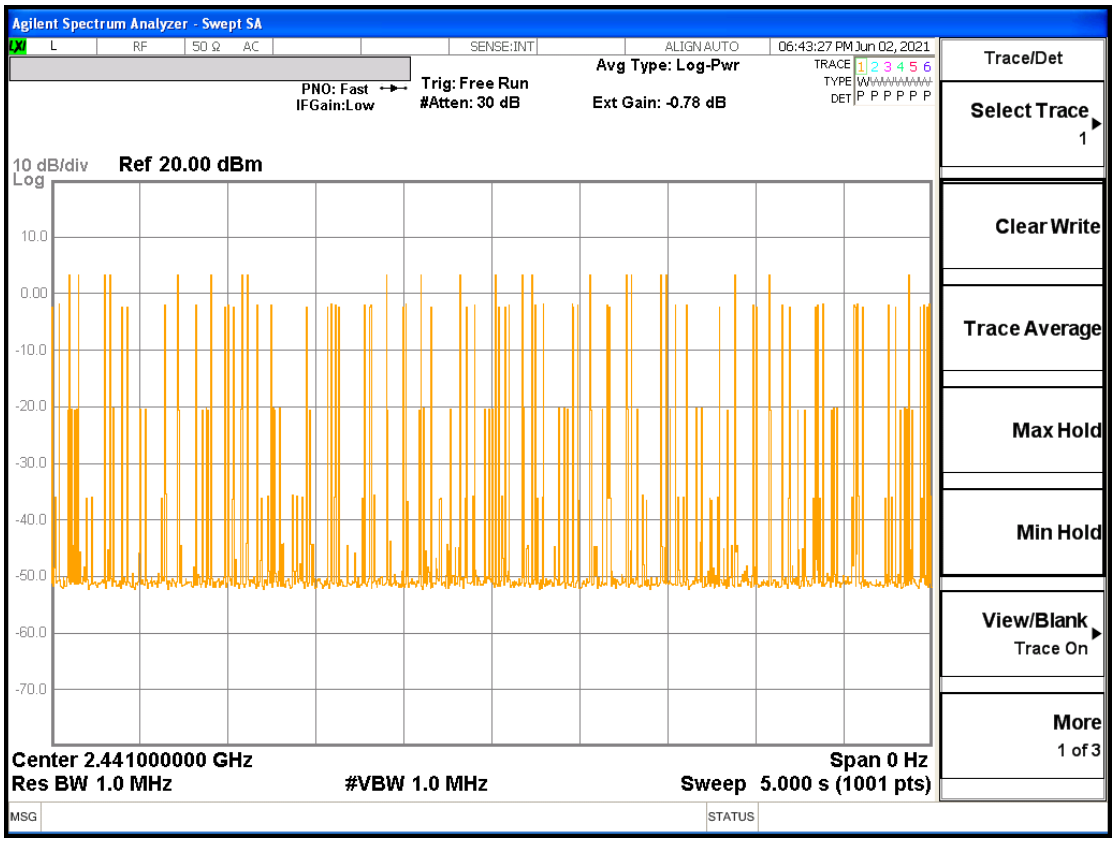


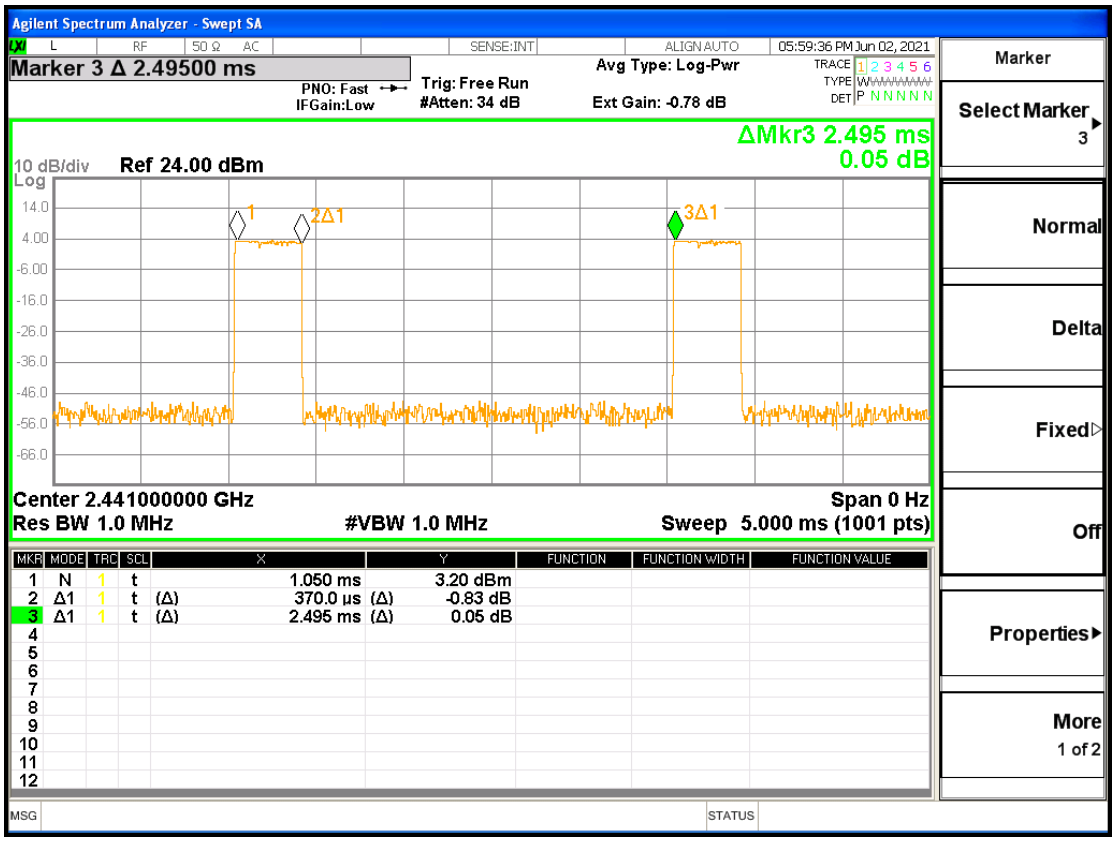
Time of Occupancy for Packet Type 2-DH5(π/4 DQPSK)



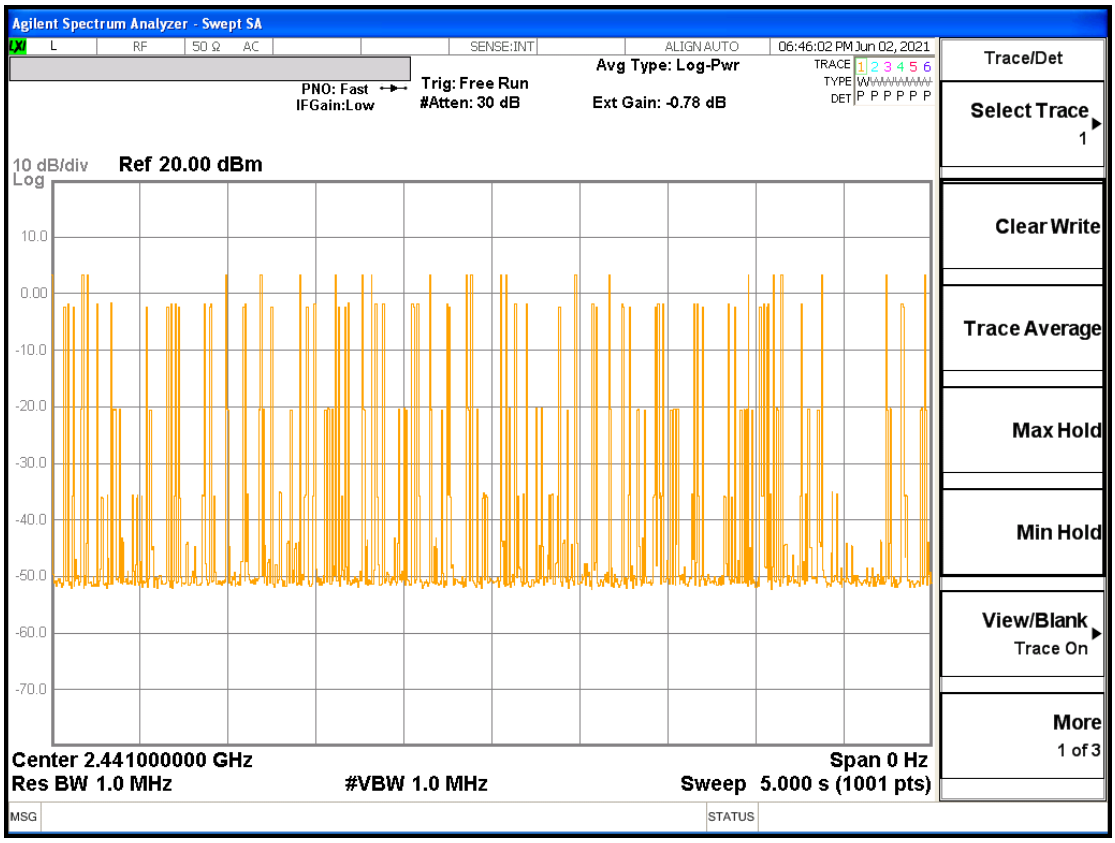


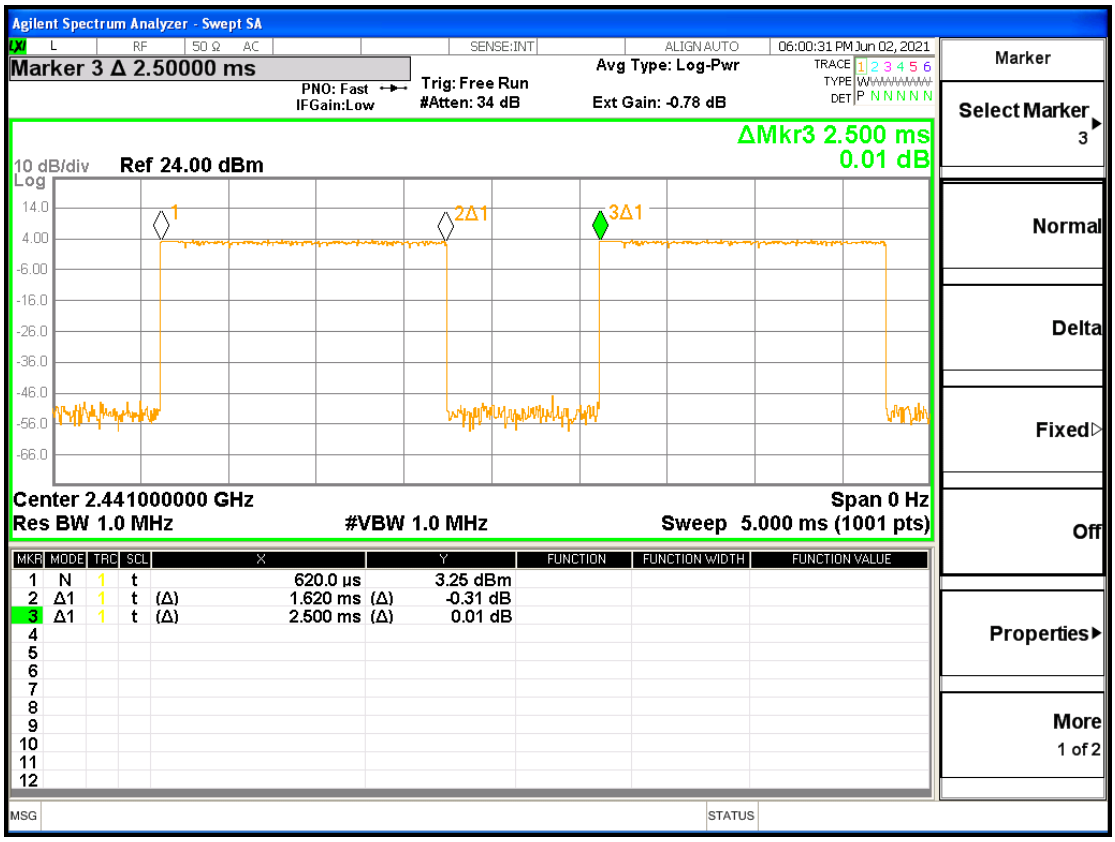
Time of Occupancy for Packet Type 3-DH1(8-DPSK)



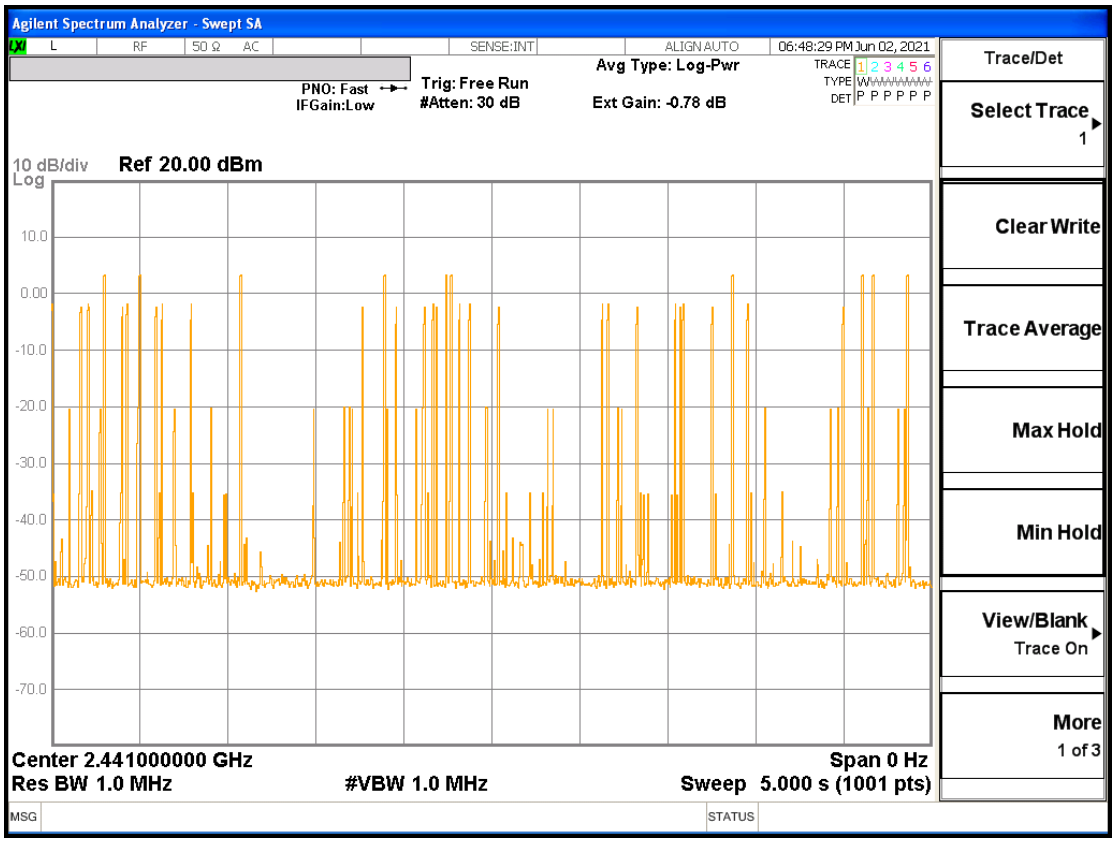


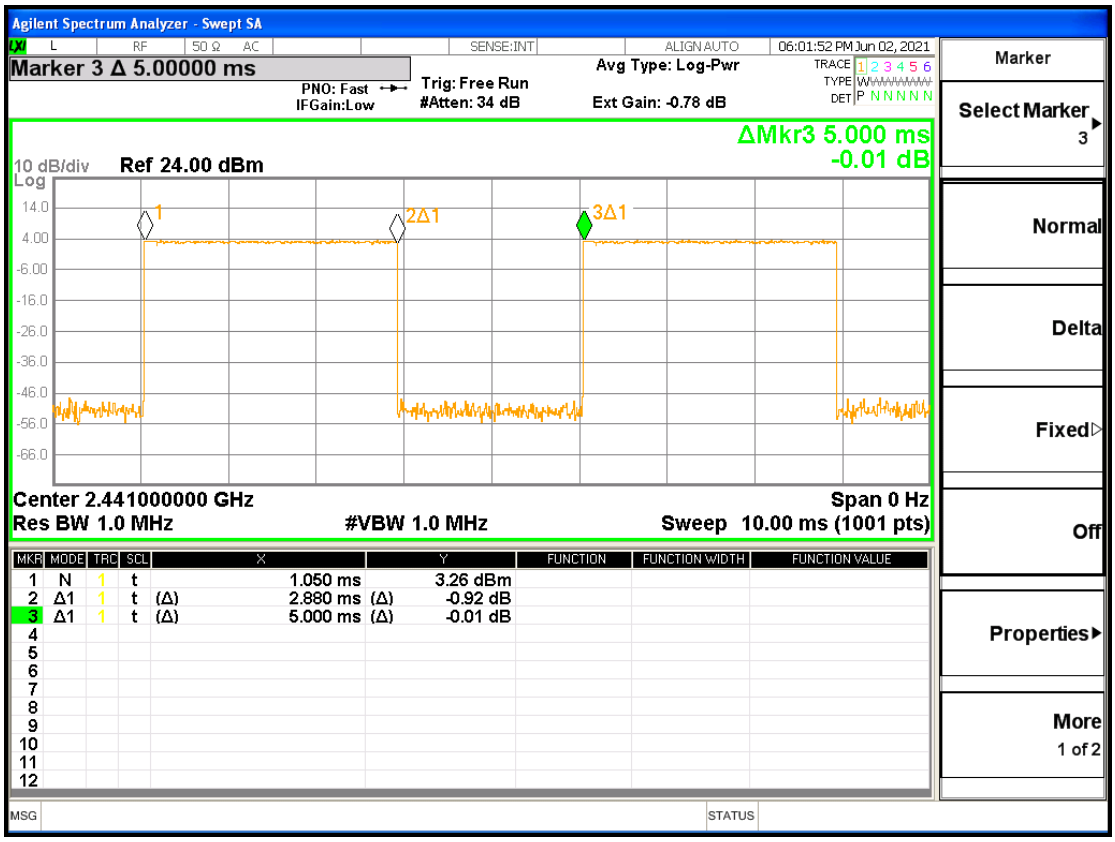
Time of Occupancy for Packet Type 3-DH3(8-DPSK)





Time of Occupancy for Packet Type 3-DH5(8-DPSK)





4.5 Maximum peak Conducted Output Power

Test Procedures

ANSI C63.10-2013 7.8.5

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.

The spectrum analyzer is set to :

Center frequency = the highest, middle and the lowest channels

a) Span = 5 MHz (approximately 5 times of the 20 dB bandwidth)

b) RBW = 3 MHz (greater than the 20 dB bandwidth of the emission being measured)

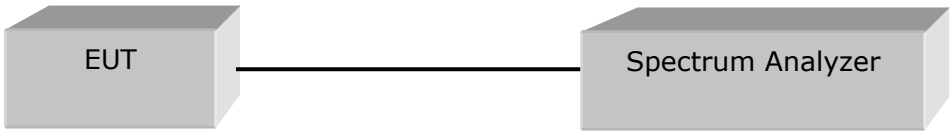
c) VBW = 3 MHz (≥ RBW)

d) Detector = peak

e) Trace = max hold

f) Sweep = auto

Allow trace to stabilize.
Use the marker-to-peak function to set the marker to the peak of the emission.



Limit

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

Test Results

Test mode : GFSK

Frequency [MHz]	Conducted Power [dBm]	Conducted power [mW]	e.i.r.p. [dBm]	e.i.r.p. [W]	Result
2 402	4.57	2.864	7.97	0.006 3	Complies
2 441	4.22	2.642	7.62	0.005 8	Complies
2 480	3.75	2.371	7.15	0.005 2	Complies

Test mode : π/4 DQPSK

Frequency [MHz]	Conducted Power [dBm]	Conducted power [mW]	e.i.r.p. [dBm]	e.i.r.p. [W]	Result
2 402	4.22	2.642	7.62	0.005 8	Complies
2 441	3.81	2.404	7.21	0.005 3	Complies
2 480	3.33	2.153	6.73	0.004 7	Complies

Test mode : 8-DPSK

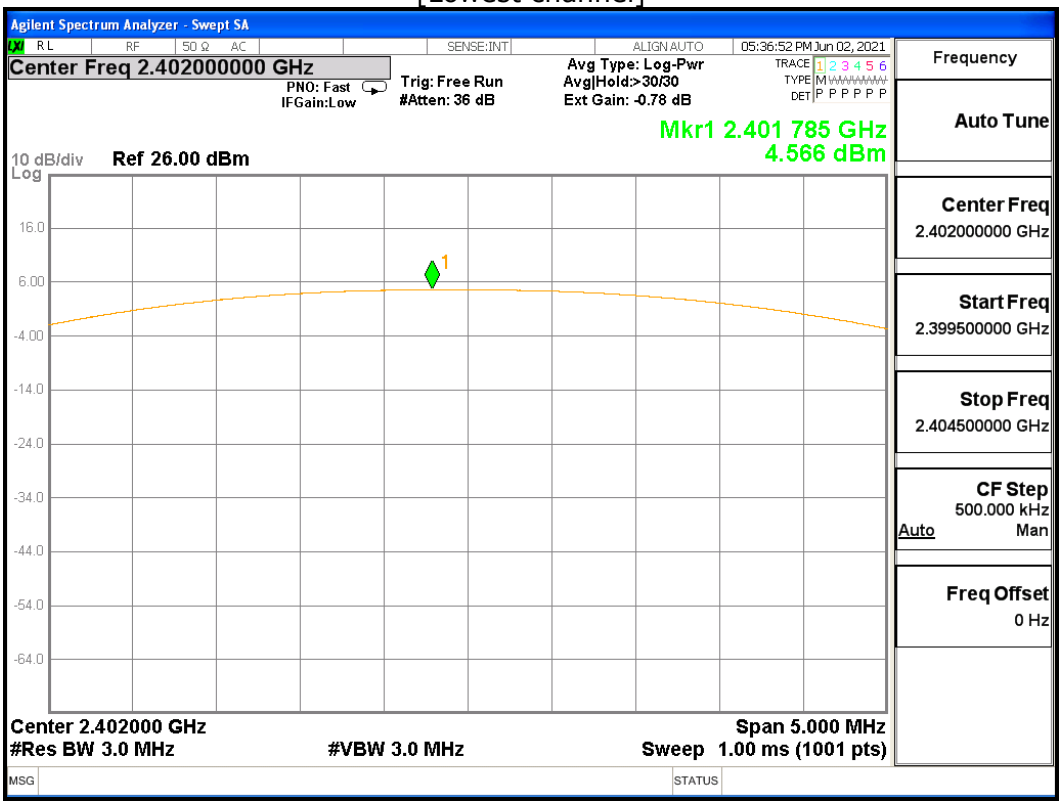
Frequency [MHz]	Conducted Power [dBm]	Conducted power [mW]	e.i.r.p. [dBm]	e.i.r.p. [W]	Result
2 402	4.44	2.780	7.84	0.006 1	Complies
2 441	3.90	2.455	7.30	0.005 4	Complies
2 480	3.43	2.203	6.83	0.004 8	Complies

Remark
1. e.i.r.p.[dBm] = Conducted Power[dBm] + Antenna Gain[dBi]
2. Antenna Gain [dBi] = 3.4

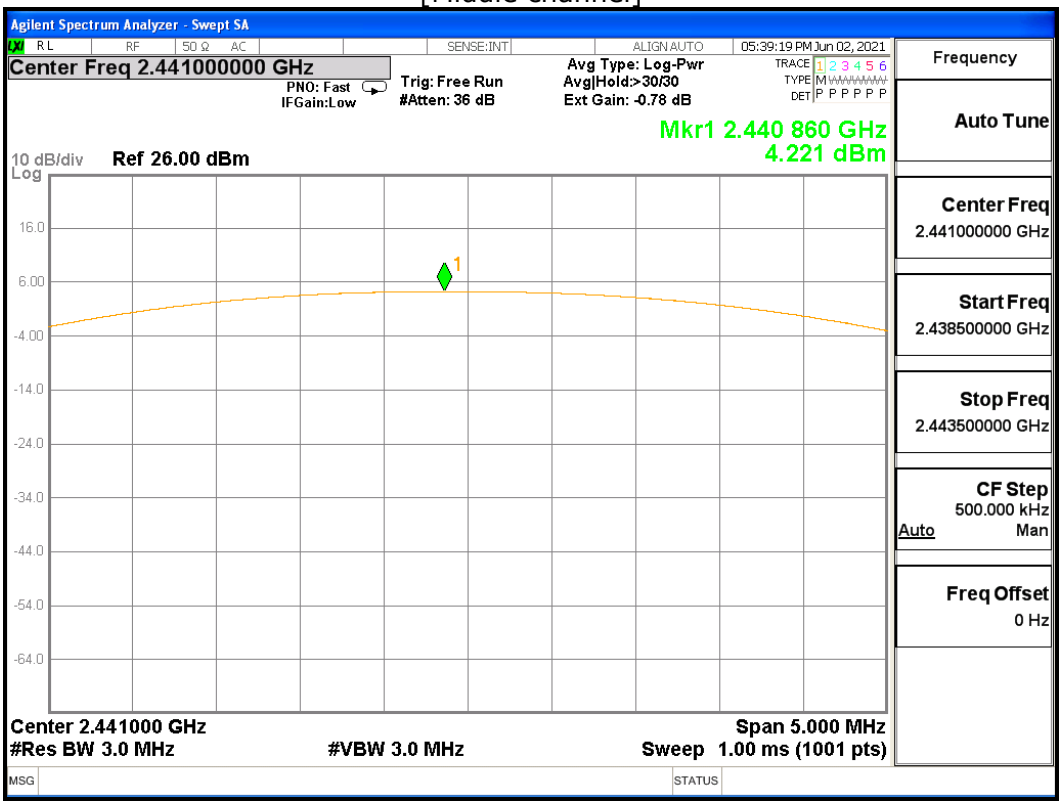
See next pages for actual measured spectrum plots.

Test Mode : GFSK

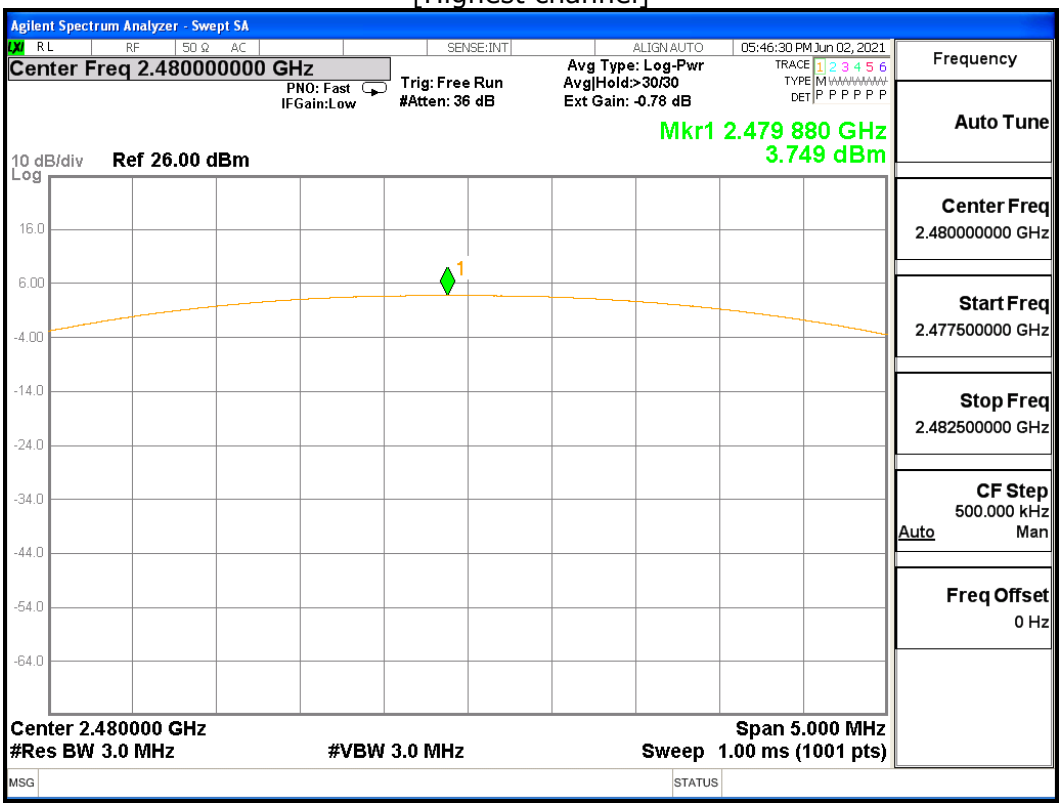
[Lowest channel]



[Middle channel]

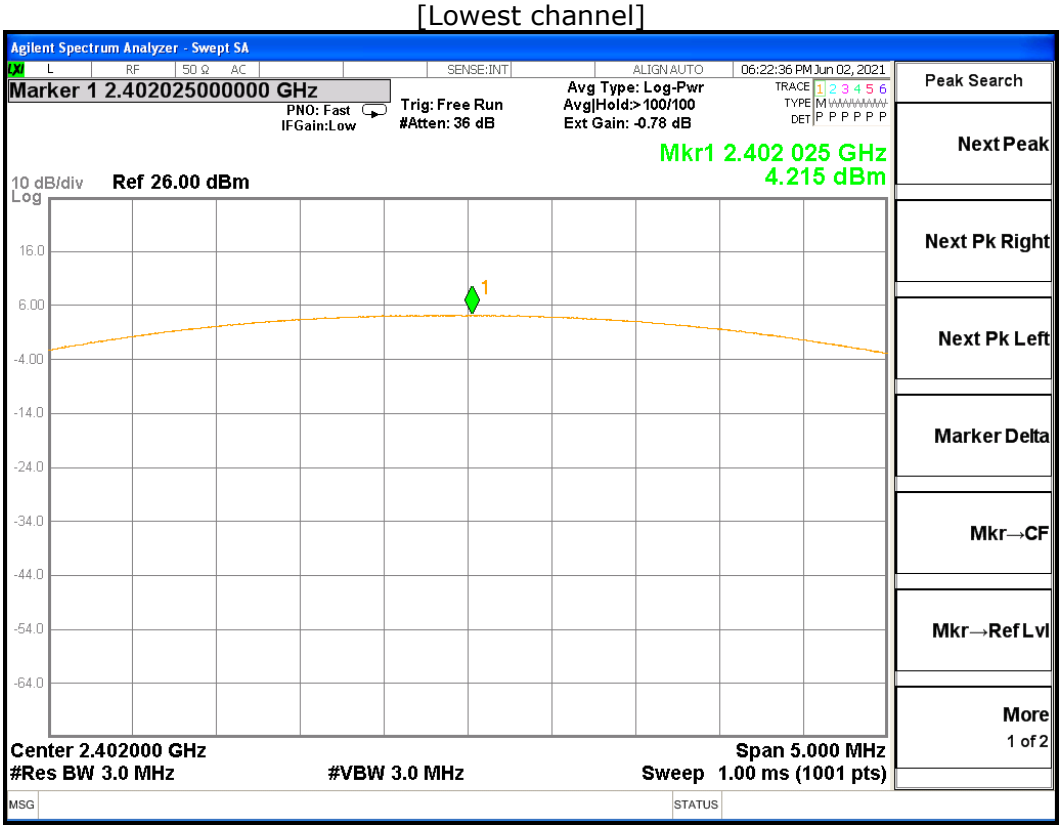


[Highest channel]

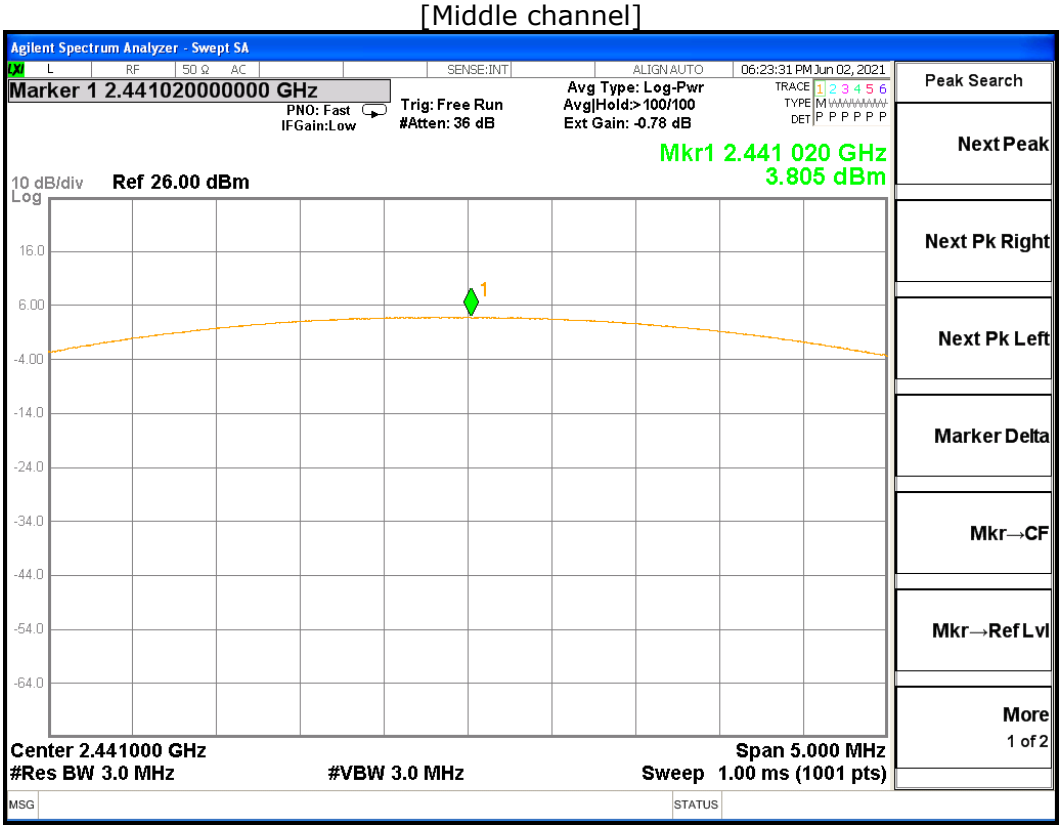


Test Mode : π/4 DQPSK

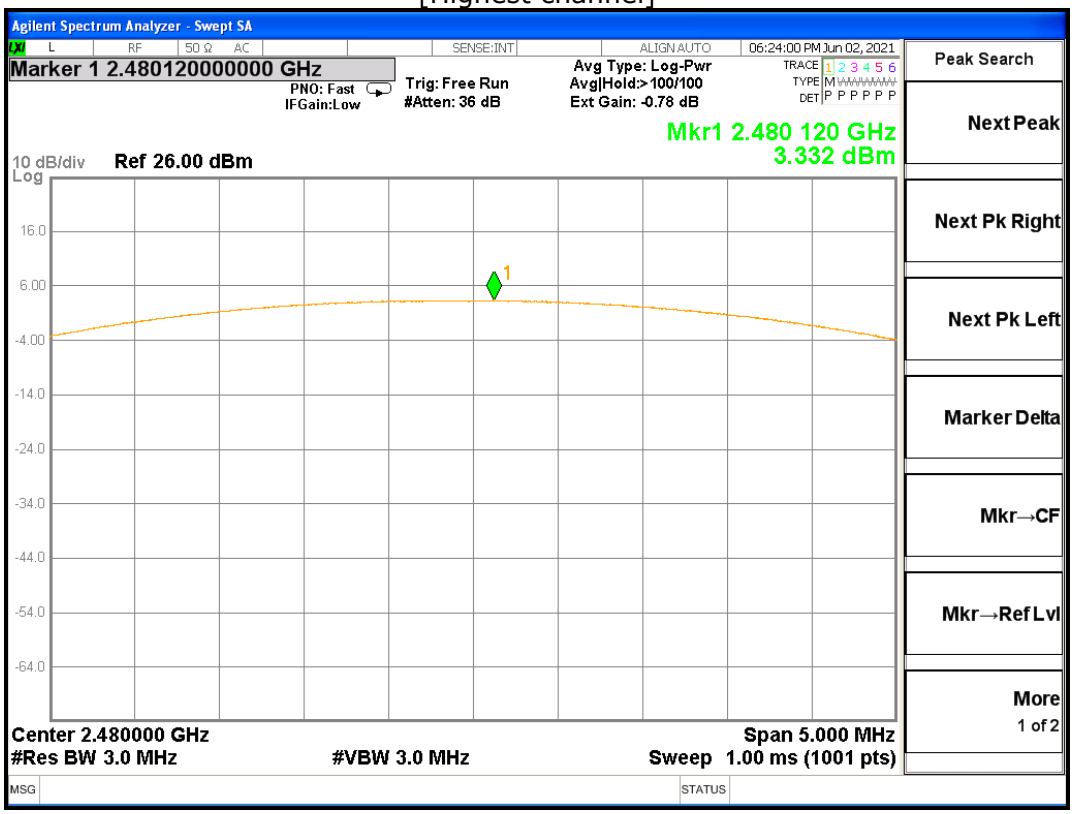
[Lowest channel]



[Middle channel]

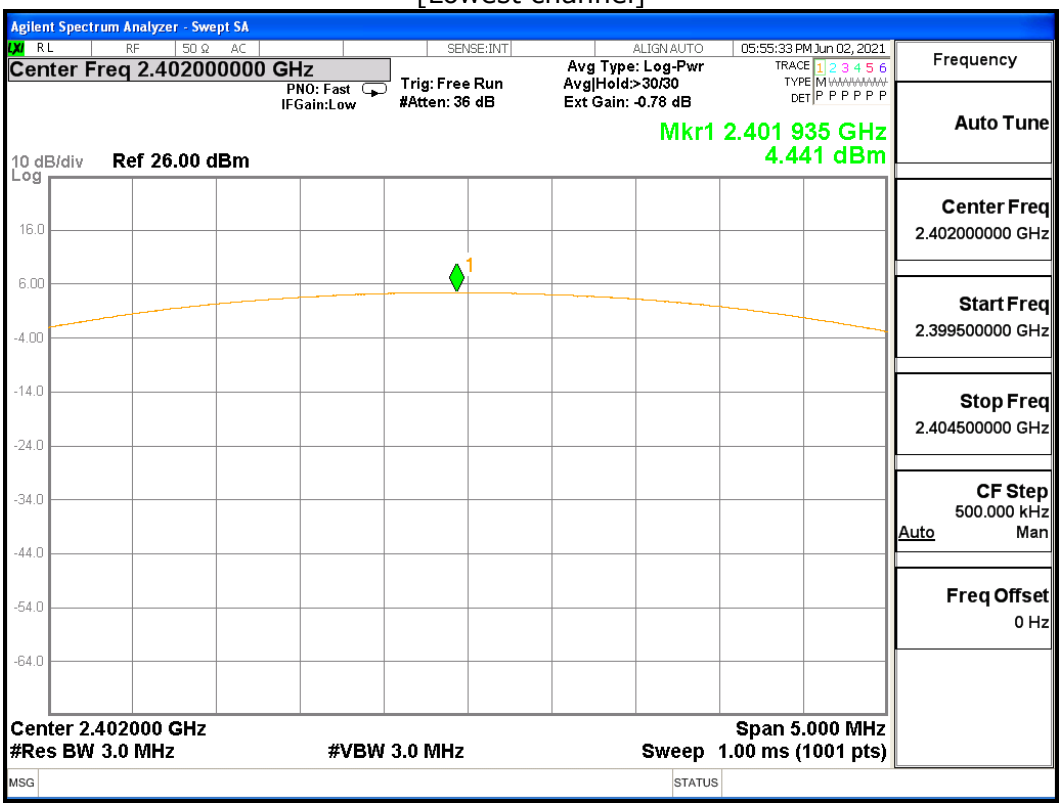


[Highest channel]

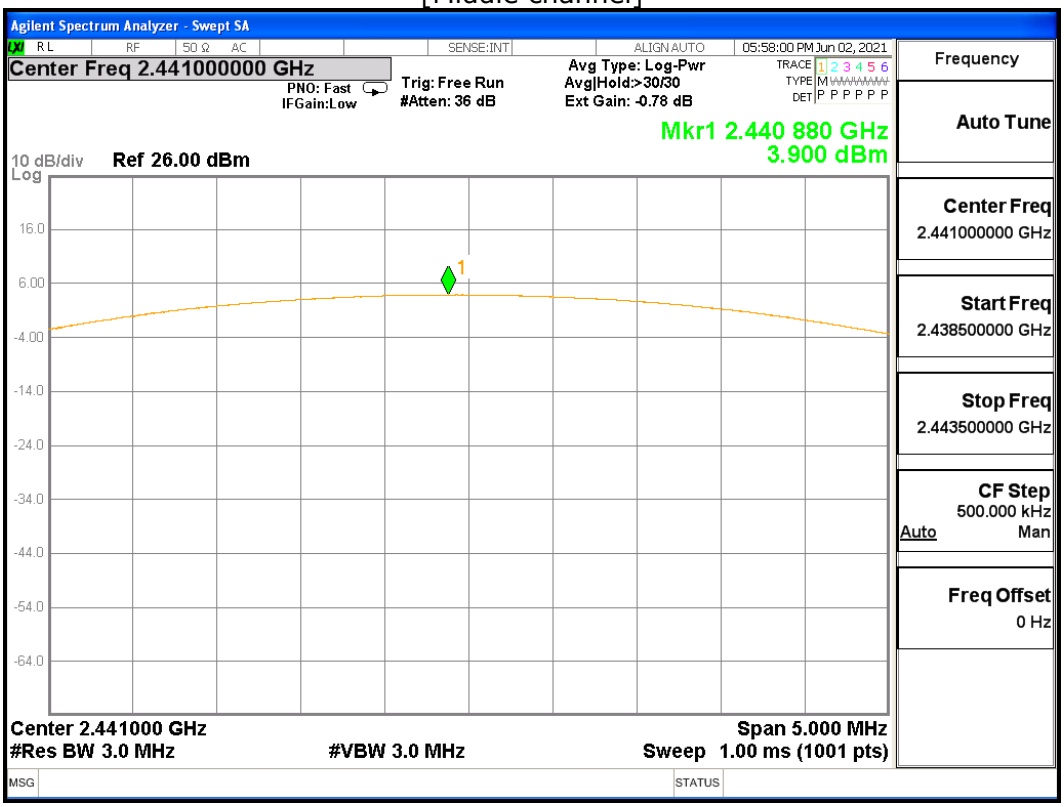


Test Mode : 8-DPSK

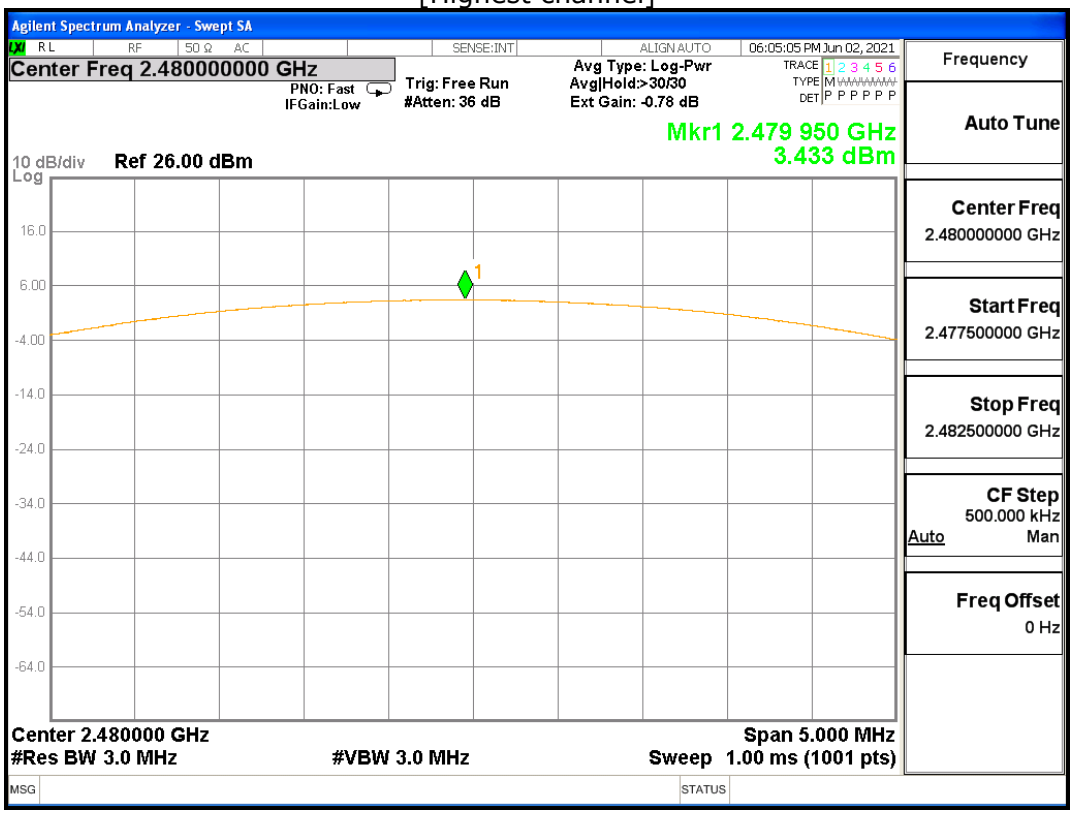
[Lowest channel]



[Middle channel]



[Highest channel]



4.6 Unwanted Emissions (Conducted)

Test Procedures

ANSI C63.10-2013 7.8.6 / ANSI C63.10-2013 7.8.8

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.

The bandwidth at 20 dB down from the highest inband spectral density was measured with a spectrum analyzer connected to the antenna terminal, while EUT has its hopping function disabled at the highest, middle and the lowest available channels.

The spectrum analyzer is set to :

Center frequency = the highest, middle and the lowest channels

a) RBW = 100 kHz

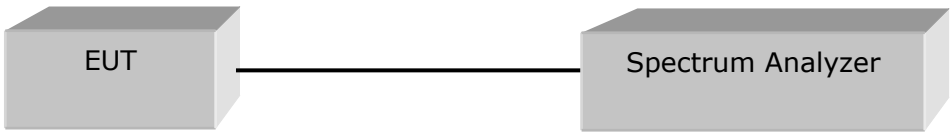
b) VBW = 300 kHz (≥ RBW)

c) Span = 30 MHz to 10 times the operating frequency in GHz

d) Detector = peak

e) Trace = max hold

f) Sweep = auto



Limit

> 20 dBc

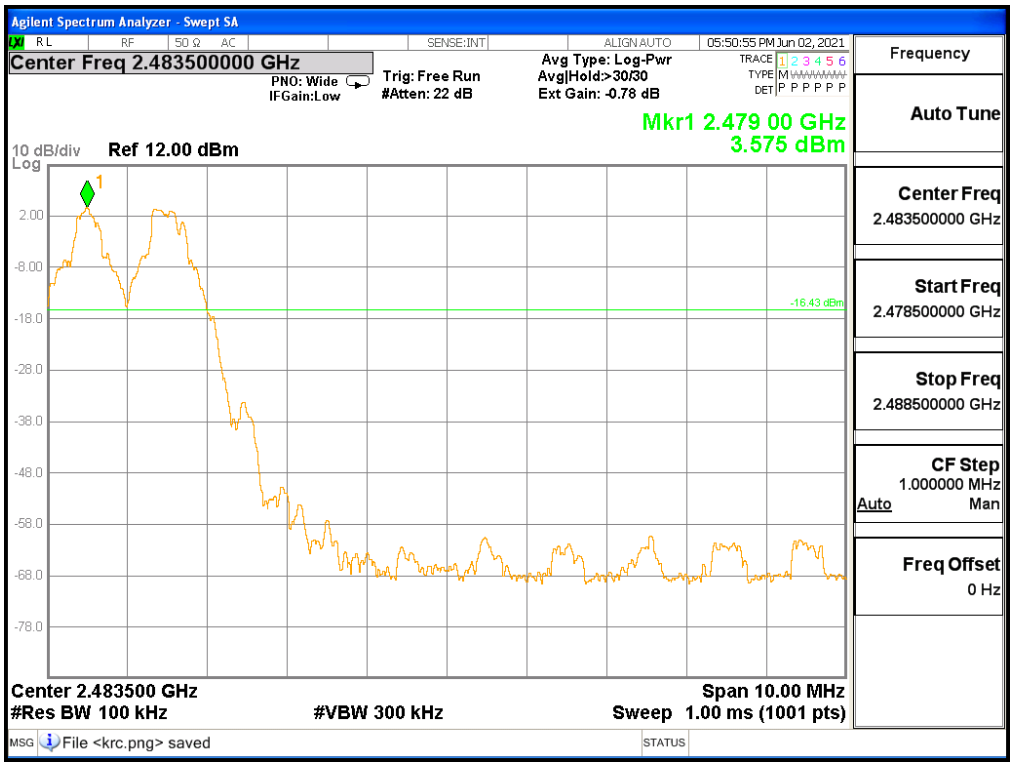
Test Results

All conducted emission in any 100 kHz bandwidth outside of the spectrum band was at least 20 dB lower than the highest level of the in-band spectral density.
Therefore the applying equipment meets the requirement.

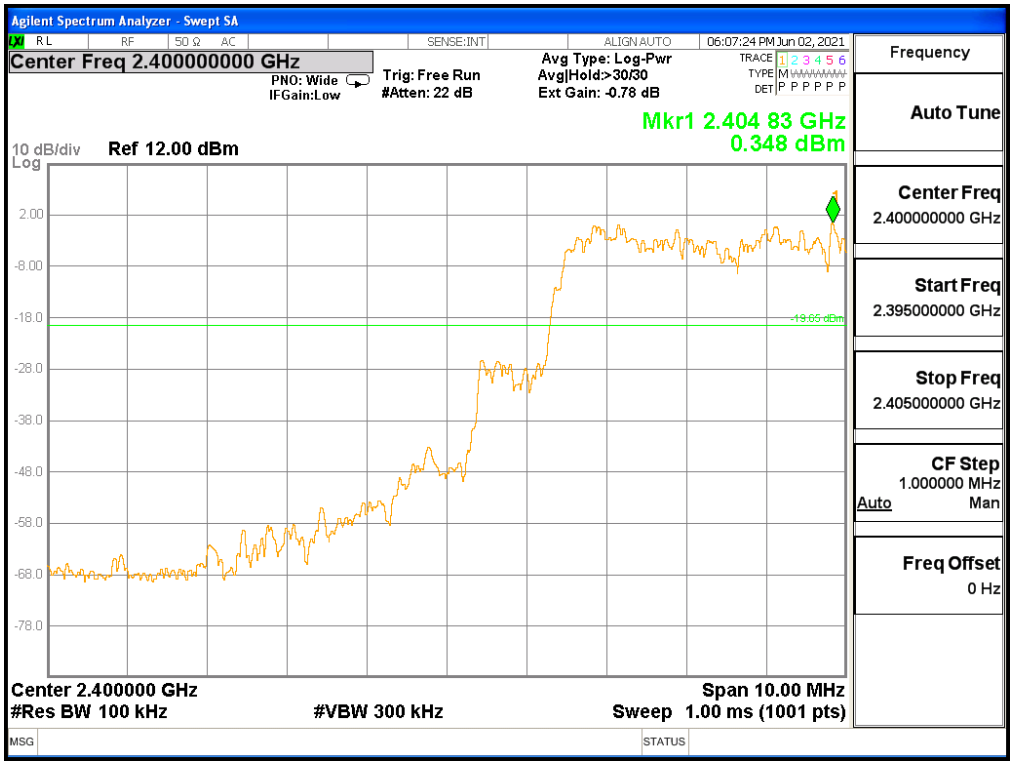
See next pages for actual measured spectrum plots.

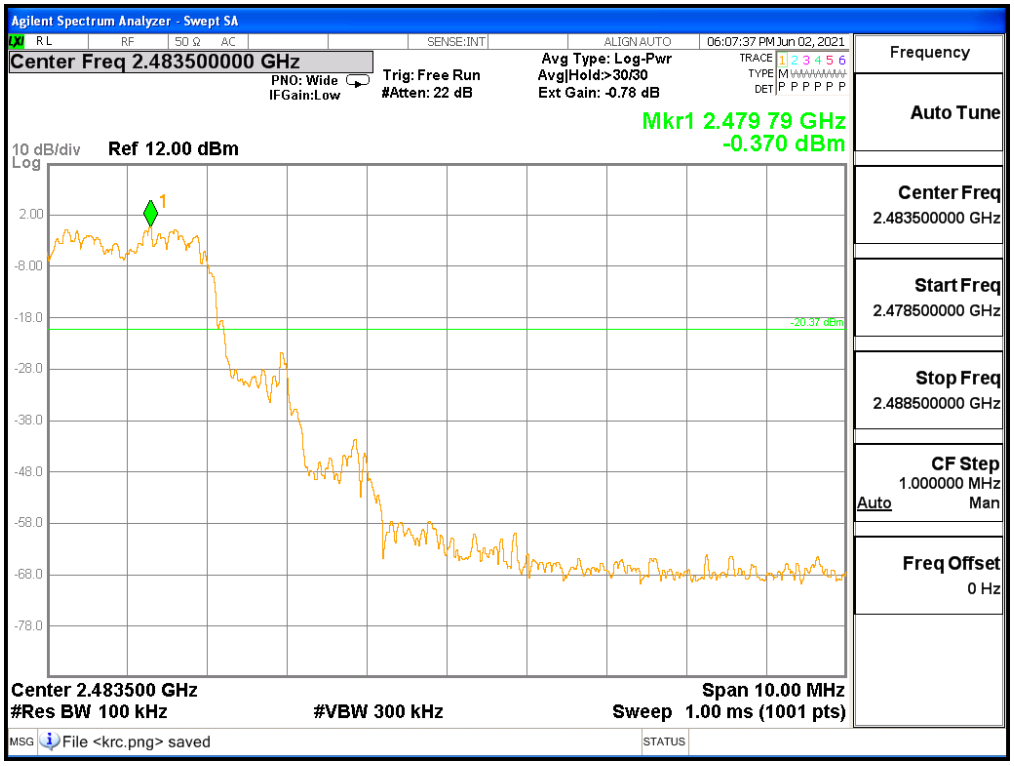
Band Edge

Test Mode : Hopping mode, GFSK

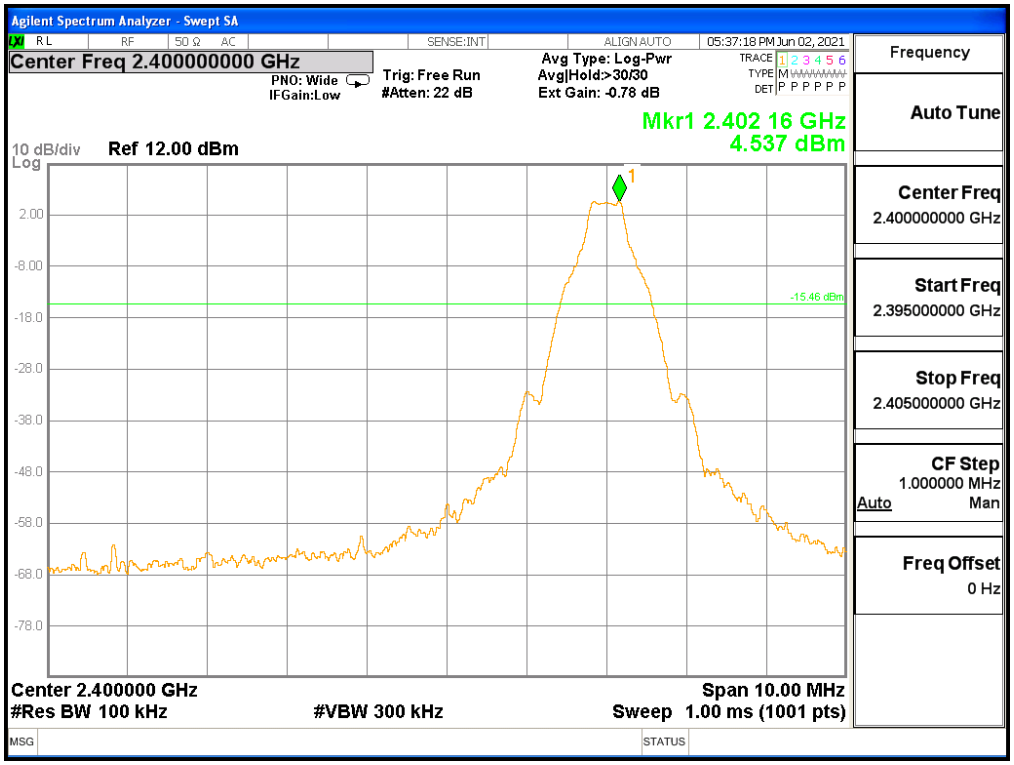


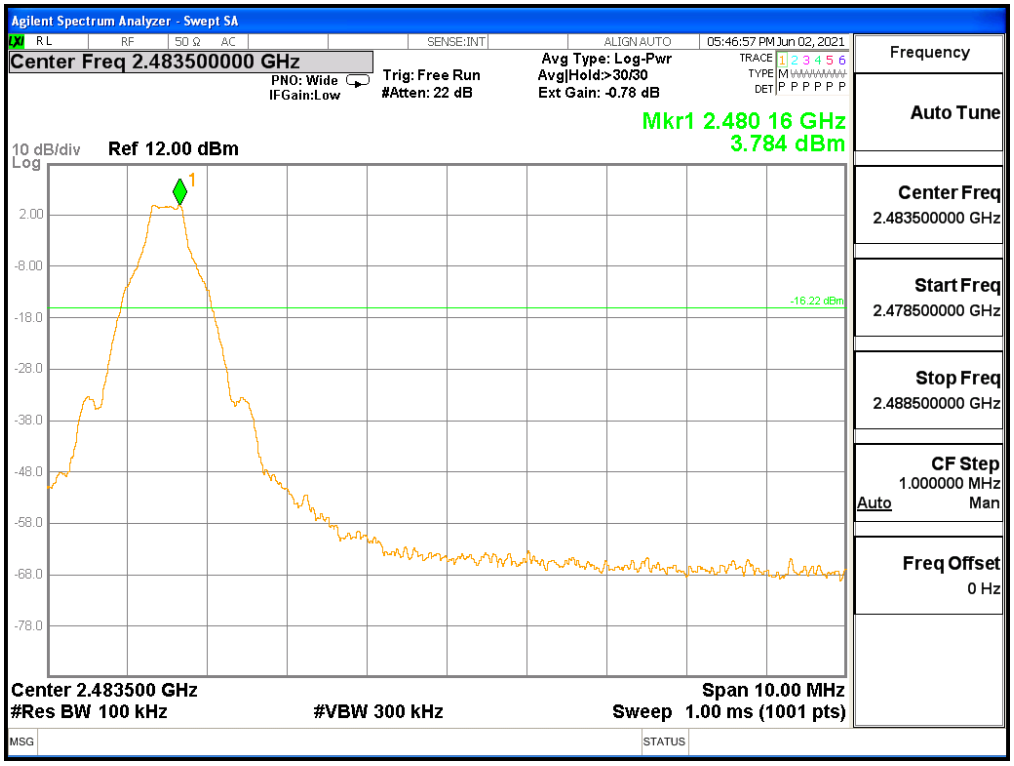
Test Mode : Hopping mode, 8-DPSK



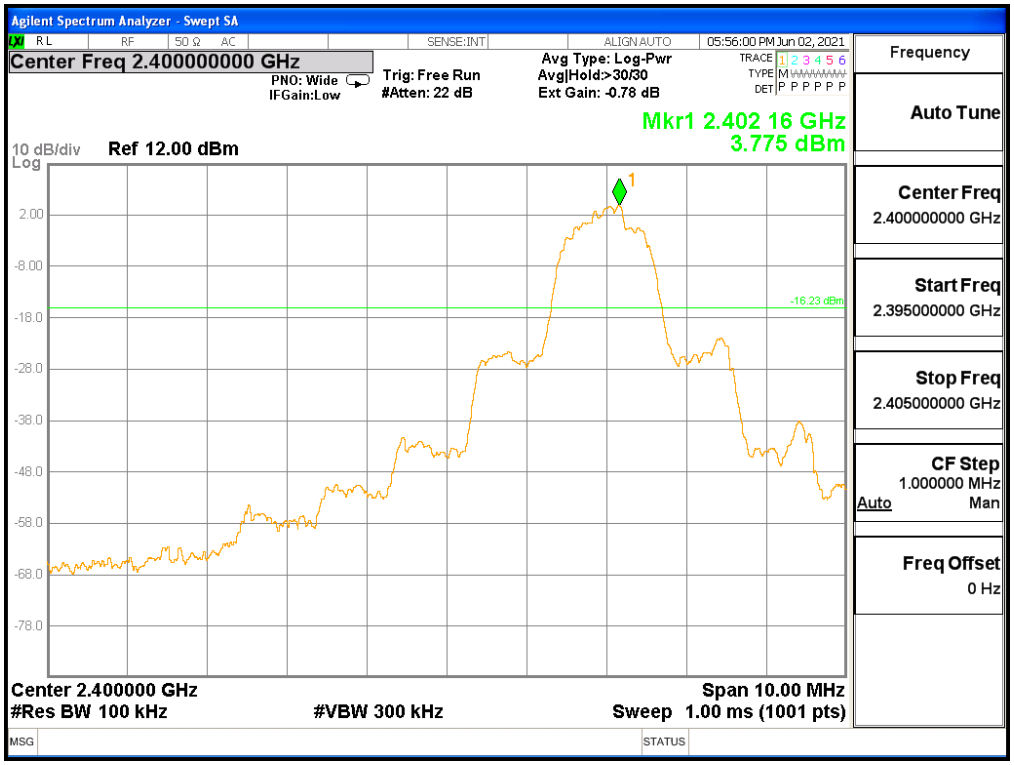


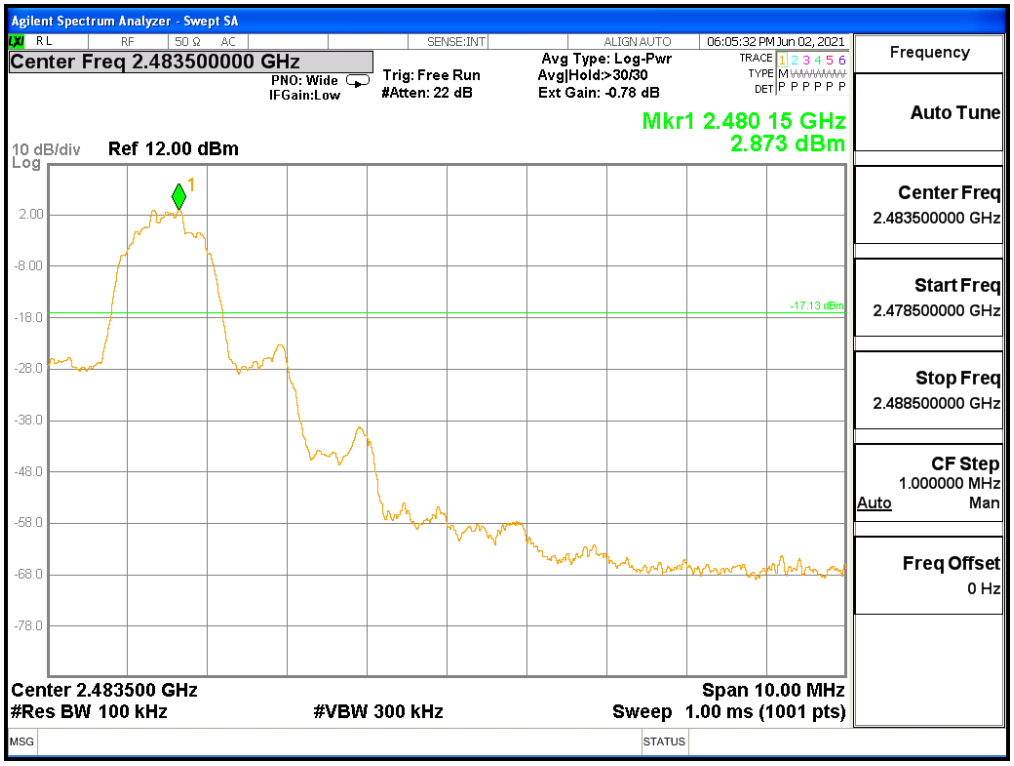
Test Mode : Non-Hopping mode, GFSK





Test Mode : Non-Hopping mode, 8-DPSK

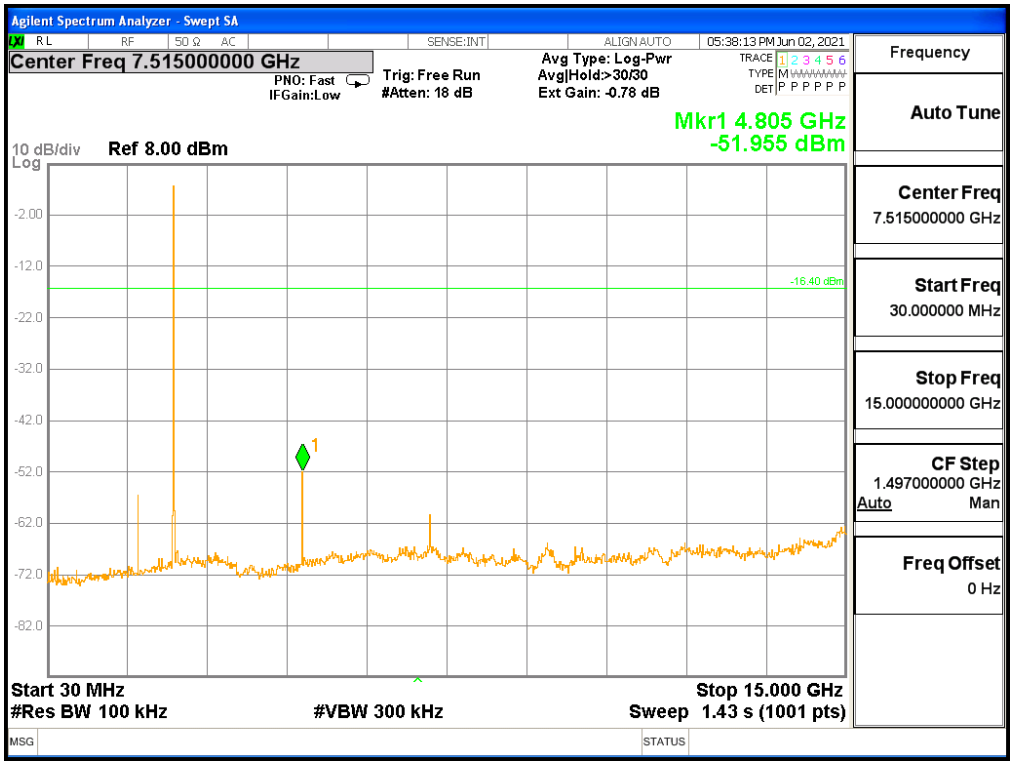


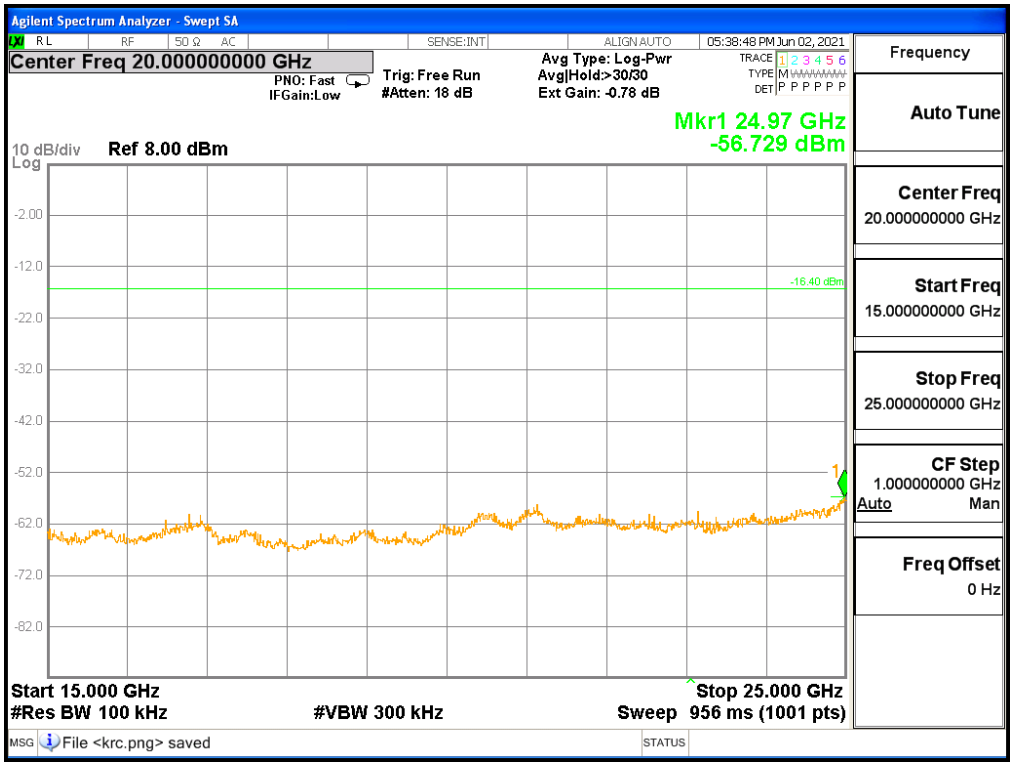


Spurious Emission

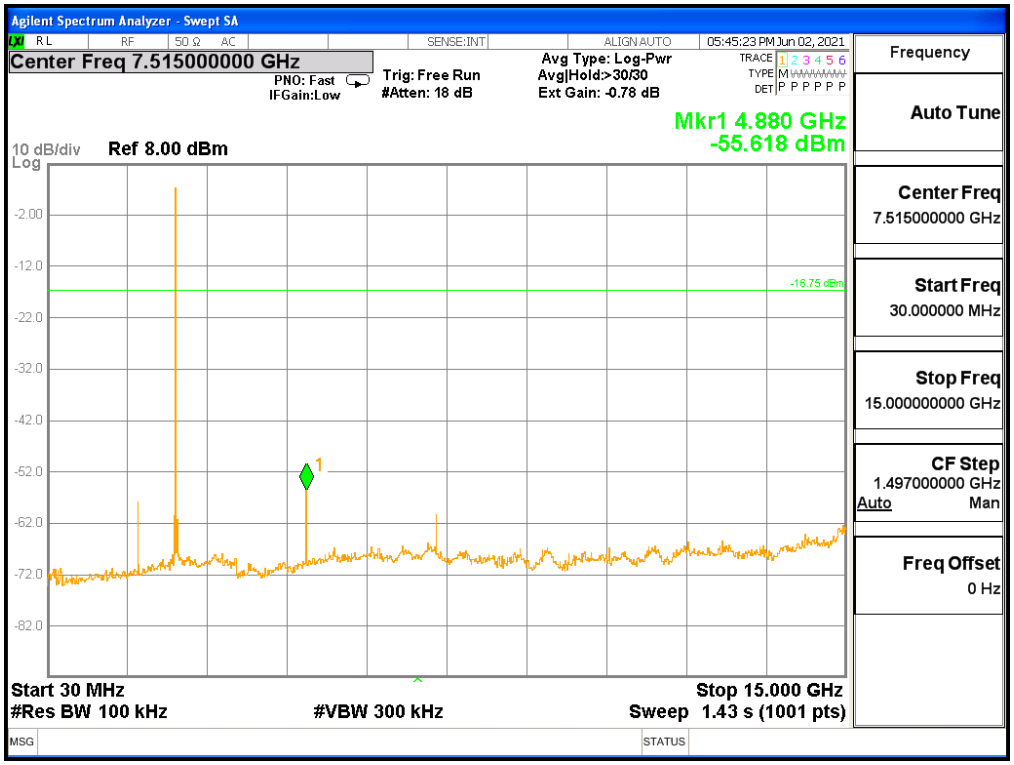
Test Mode : GFSK

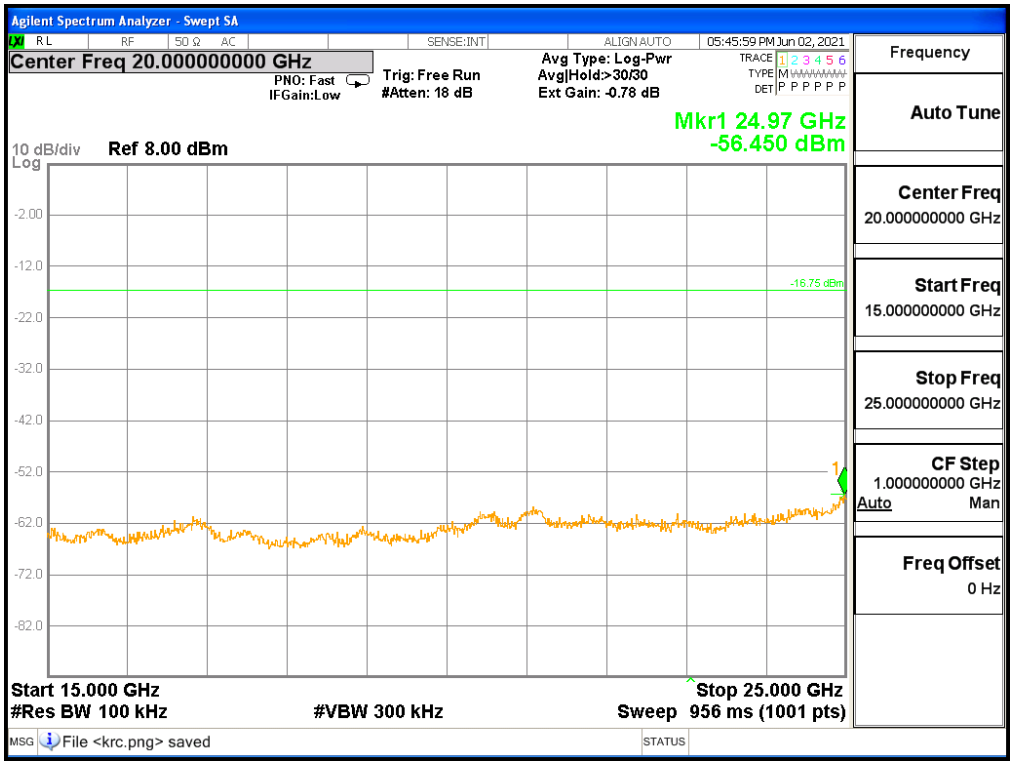
[Lowest Channel]



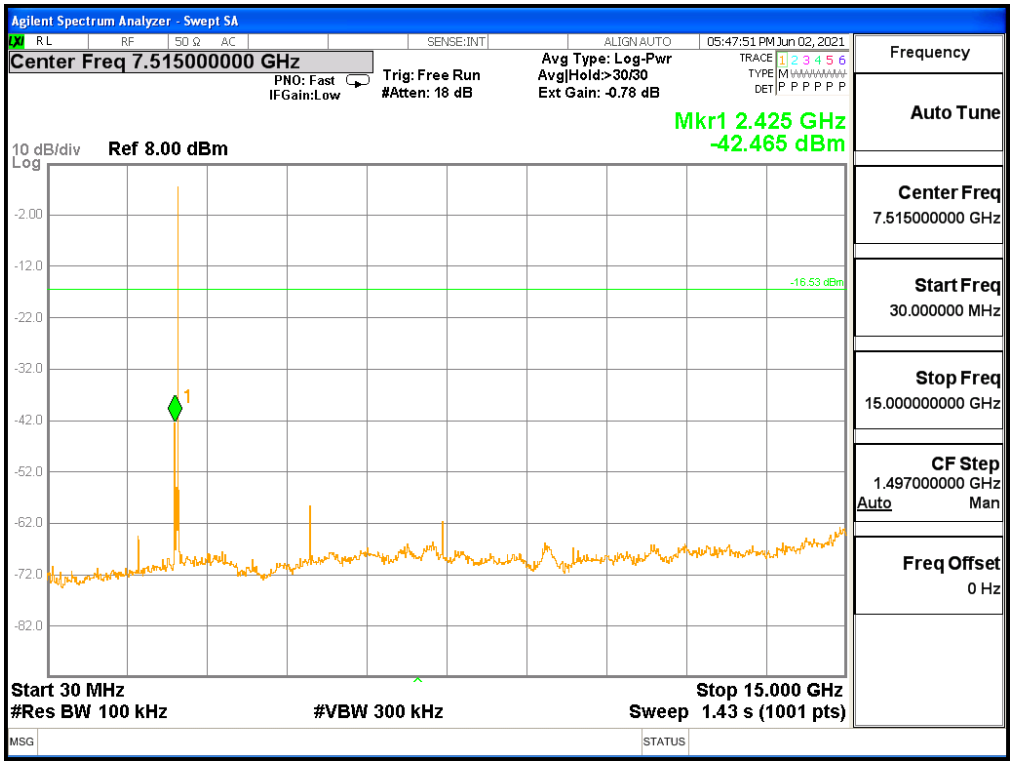


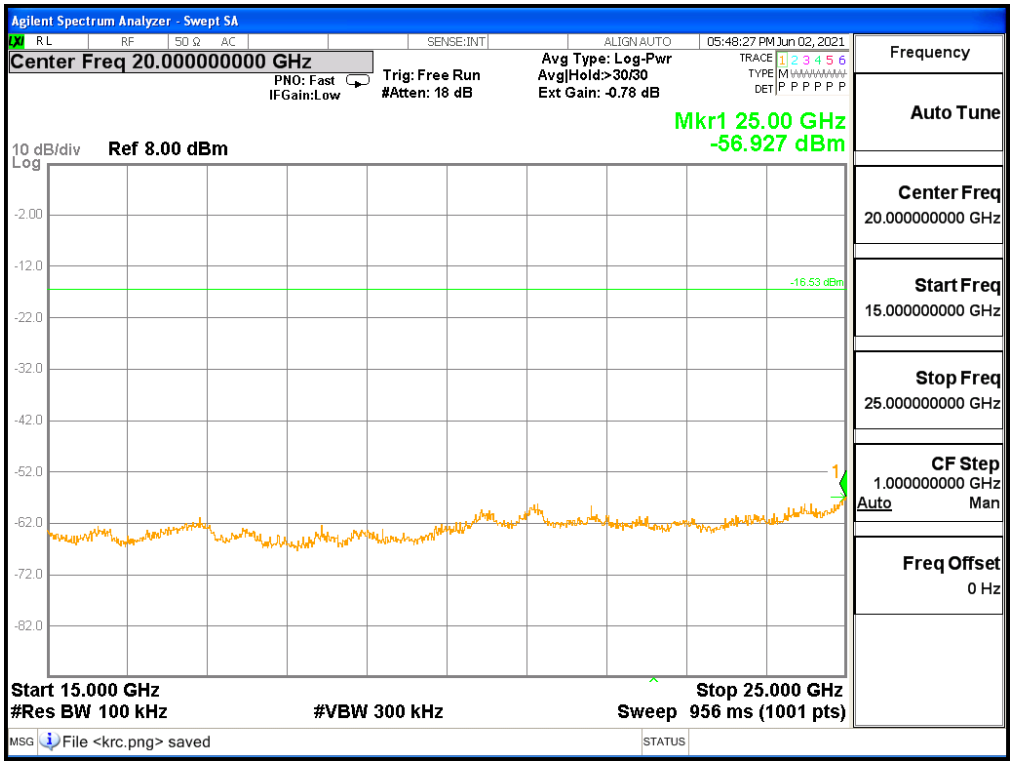
[Middle Channel]





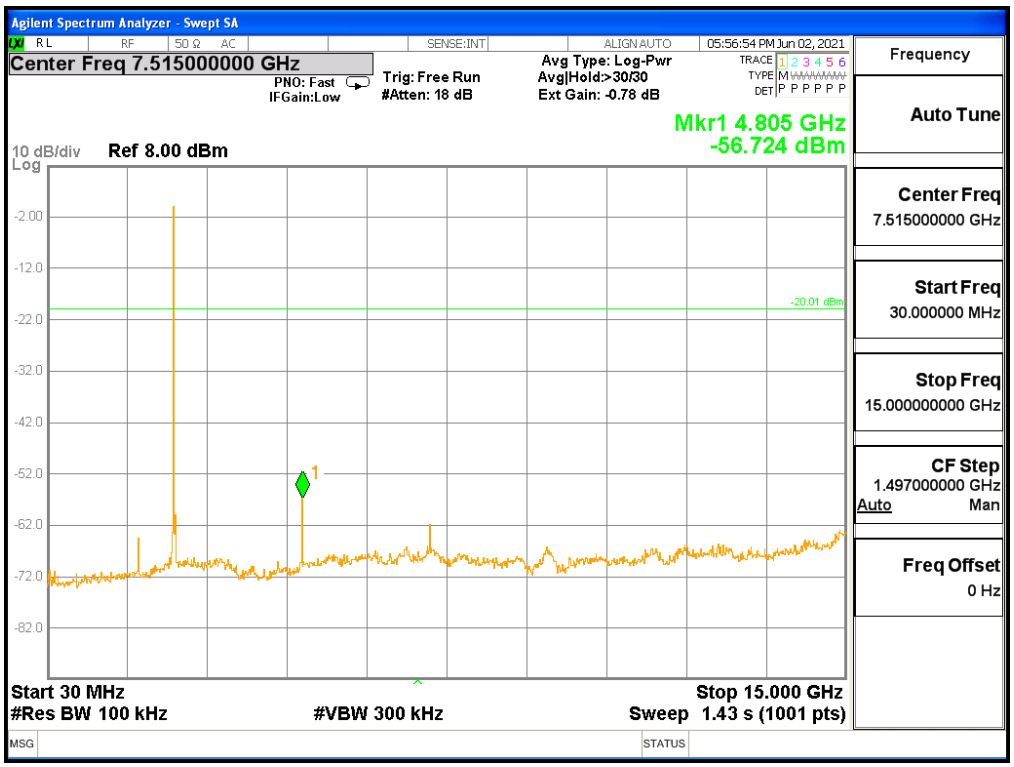
[Highest Channel]

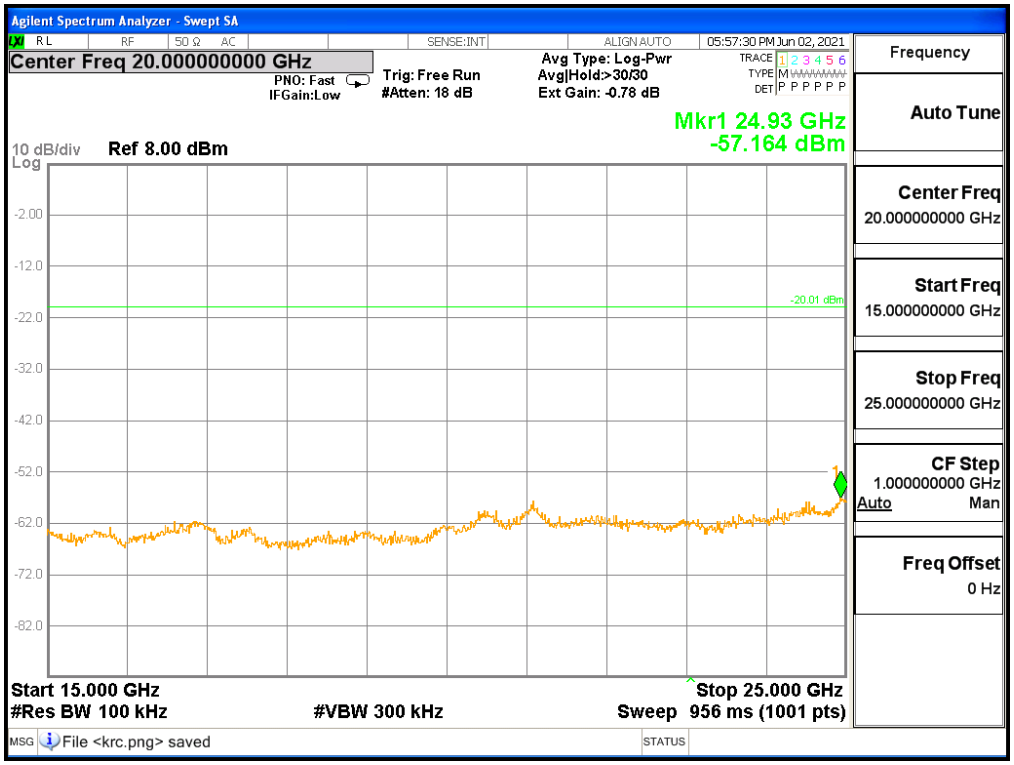




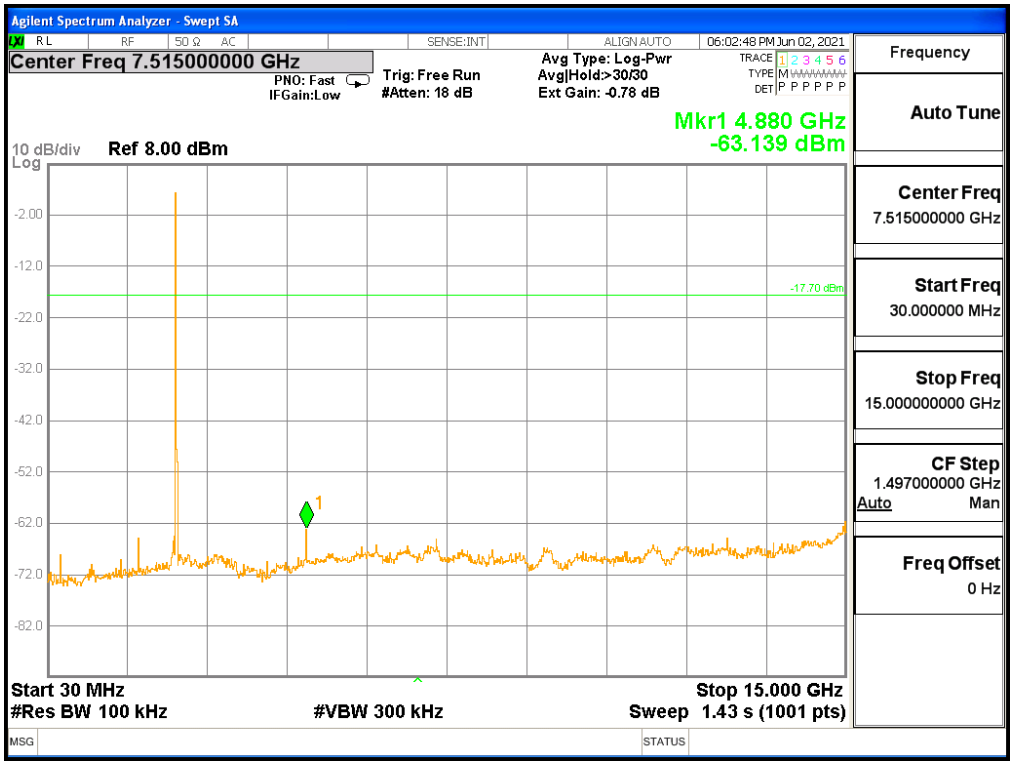
Test Mode : 8-DPSK

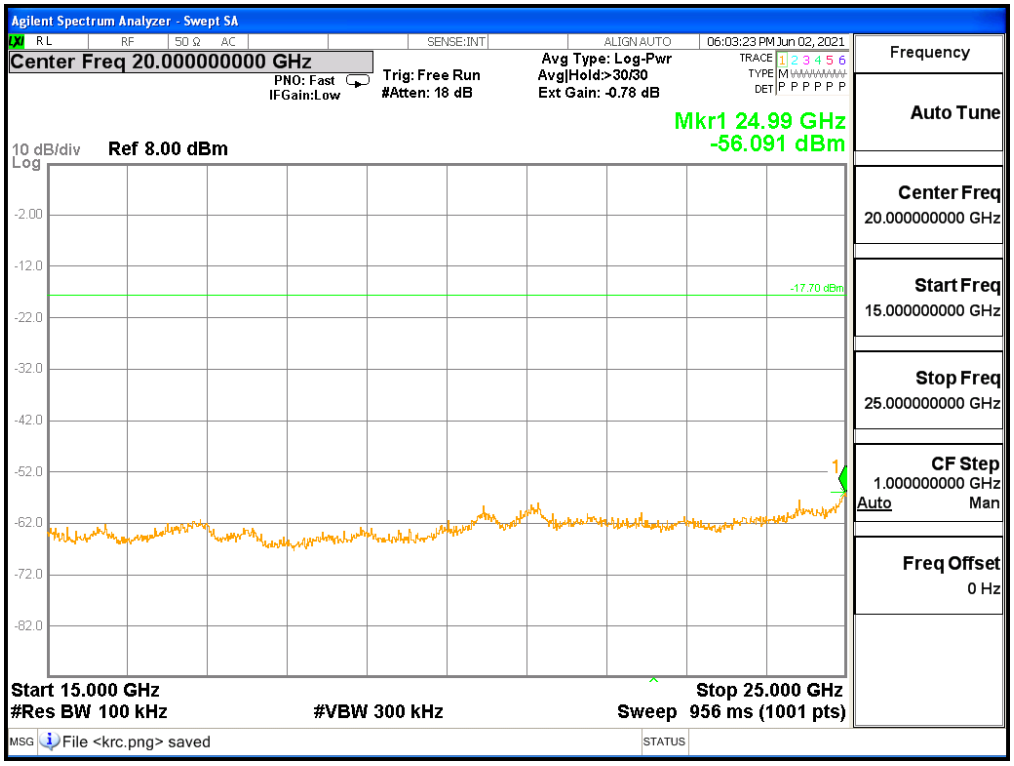
[Lowest Channel]



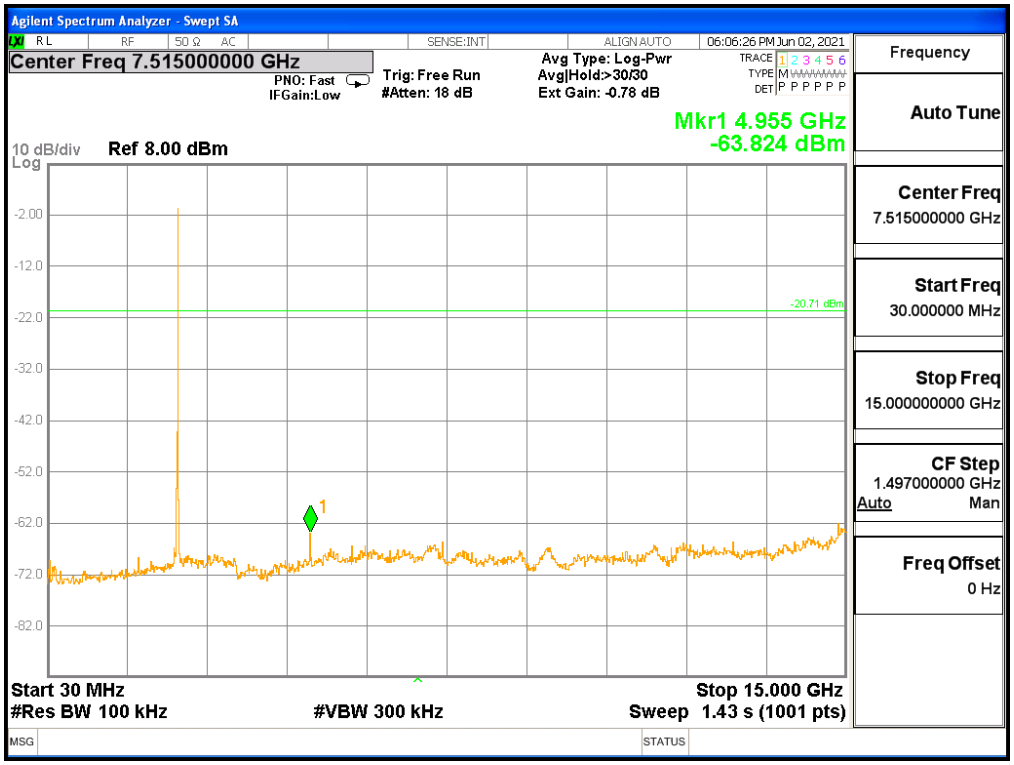


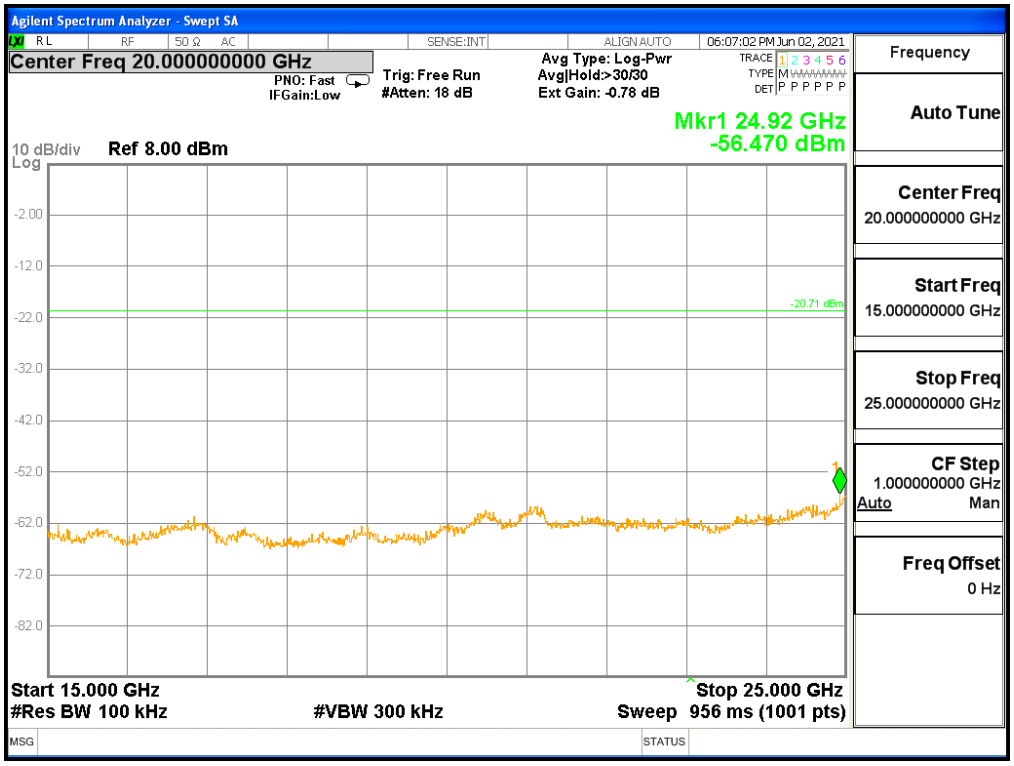
[Middle Channel]





[Highest Channel]





4.7 Radiated Emission

Test Location

☒ 10 m SAC (test distance : ☐ 10 m, ☒ 3 m)
☒ 3 m SAC (test distance : 3 m)

Test Procedures

ANSI C63.10-2013 - Section 6.5, 6.6
RSS-Gen - Section 6.13

1) In the frequency range of 9 kHz to 30 MHz, magnetic field is measured with Loop Antenna. The center of the Loop Test Antenna is 1m above the ground. During the measurement the Loop Test Antenna rotates about its vertical axis for maximum response at each azimuth about the EUT.
2) In the frequency rage above 30 MHz, Bi-Log Test Antenna(30 MHz to 1 GHz) and Horn Test Antenna(above 1 GHz) are used. Test Antenna is 3m away from the EUT. Test Antenna height is carried from 1m to 4m above the ground to determine the maximum value of the field strength. The emissions levels at both horizontal and vertical polarizations should be tested.

Instrument Settings

Frequency Range = 9 kHz ~ 26.5 GHz (2.4 GHz 10th harmonic)

a) RBW = 1 MHz for f ≥ 1 GHz, 100 kHz for f < 1 GHz, 9 kHz for f < 30 MHz
200 Hz for f < 150 kHz

b) VBW ≥ RBW

c) Sweep time = auto couple

Limit :

Unwanted emissions that do not fall within the restricted frequency bands of Table 1 shall comply either with the limits specified in the applicable RSS or with those specified in this RSS-Gen.

FCC Part 15 § 15.205 (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

Table 1. Restricted Frequency Bands

MHz	MHz	MHz	MHz	MHz	GHz
0.09-0.11	8.37626-8.38675	73-74.6	399.9-410	2690-2900	10.6-12.7
[1]0.495-0.505	8.41425-8.41475	74.8-75.2	608-614	3260-3267	13.25-13.4
2.1735-2.1905	12.29-12.293	108-121.94	960-1240	3332-3339	14.47-14.5
4.125-4.128	12.51975-12.52025	123-138	1300-1427	3345.8-3358	15.35-16.2
4.17725-4.17775	12.57675-12.57725	149.9-150.05	1435-1626.5	3600-4400	17.7-21.4
4.20725-4.20775	13.36-13.41	156.52475-156.52525	1645.5-1646.5	4500-5150	22.01-23.12
6.215-6.218	16.42-16.423	156.7-156.9	1660-1710	5350-5460	23.6-24
6.26775-6.26825	16.69475-16.69525	162.0125-167.17	1718.8-1722.2	7250-7750	31.2-31.8
6.31175-6.31225	16.80425-16.80475	167.72-173.2	2200-2300	8025-8500	36.43-36.5
8.291-8.294	25.5-25.67	240-285	2310-2390	9000-9200	[2]Above 38.6
8.362-8.366	37.5-38.25	322-335.4	2483.5-2500	9300-9500	

[1] Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.

[2] Above 38.6

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

*Certain frequency bands listed in Table 1 and in band above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in the 200- and 300-series of RSSs, such as RSS-210 and RSS-310, which contain the requirements that apply to licence-exempt radio apparatus

FCC Part 15 § 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 2 :

Except when the requirements applicable to a given device state otherwise, emissions from licence-exempt transmitters shall comply with the field strength limits shown in table 2 Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

Table 2. General Field Strength Limits for Licence-Exempt Transmitters

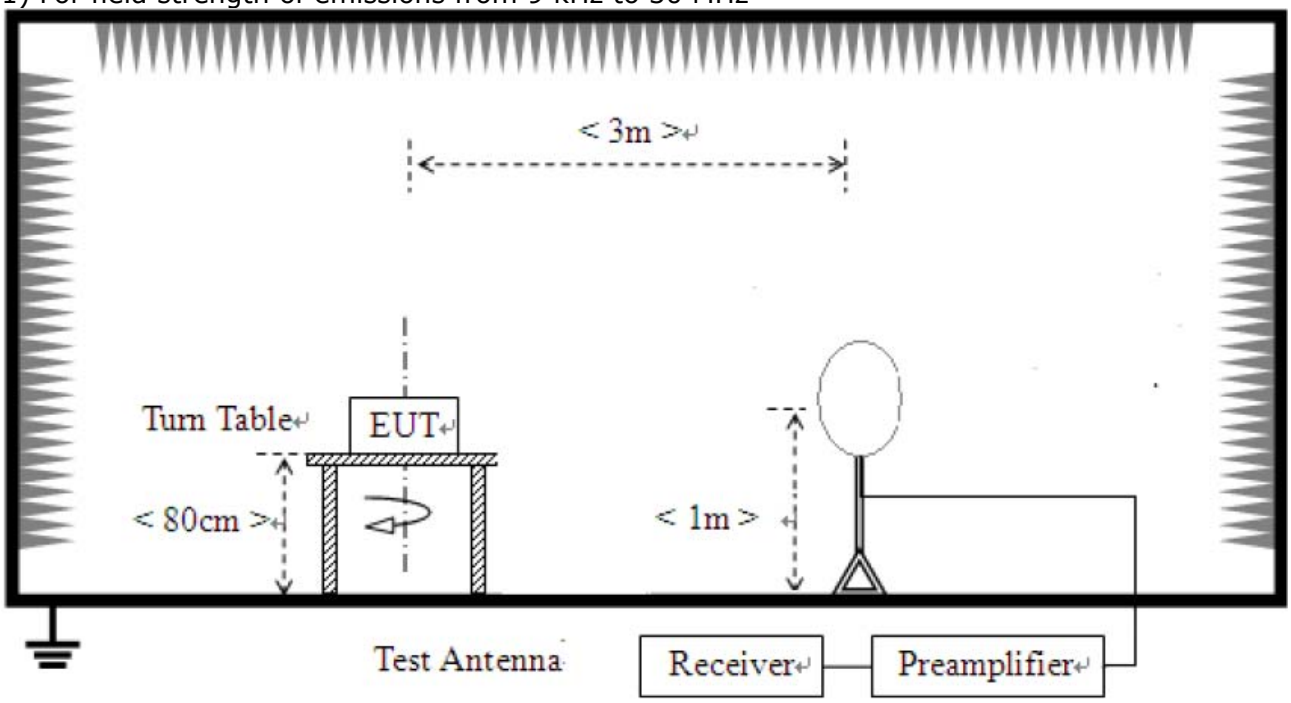
Frequency(MHz)	Field Strength (uV/m)	Field Strength (dBuV/m)	Deasurement Distance (meters)
0.009-0.490	2400/F(kHz)	48.5 – 13.8	300
0.490-1.705	24000/F(kHz)	33.8 – 23	30
1.705-30	30	29.5	30
30-88	100**	40	3
88-216	150**	43.5	3
216-960	200**	46	3
Above 960	500	54	3

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

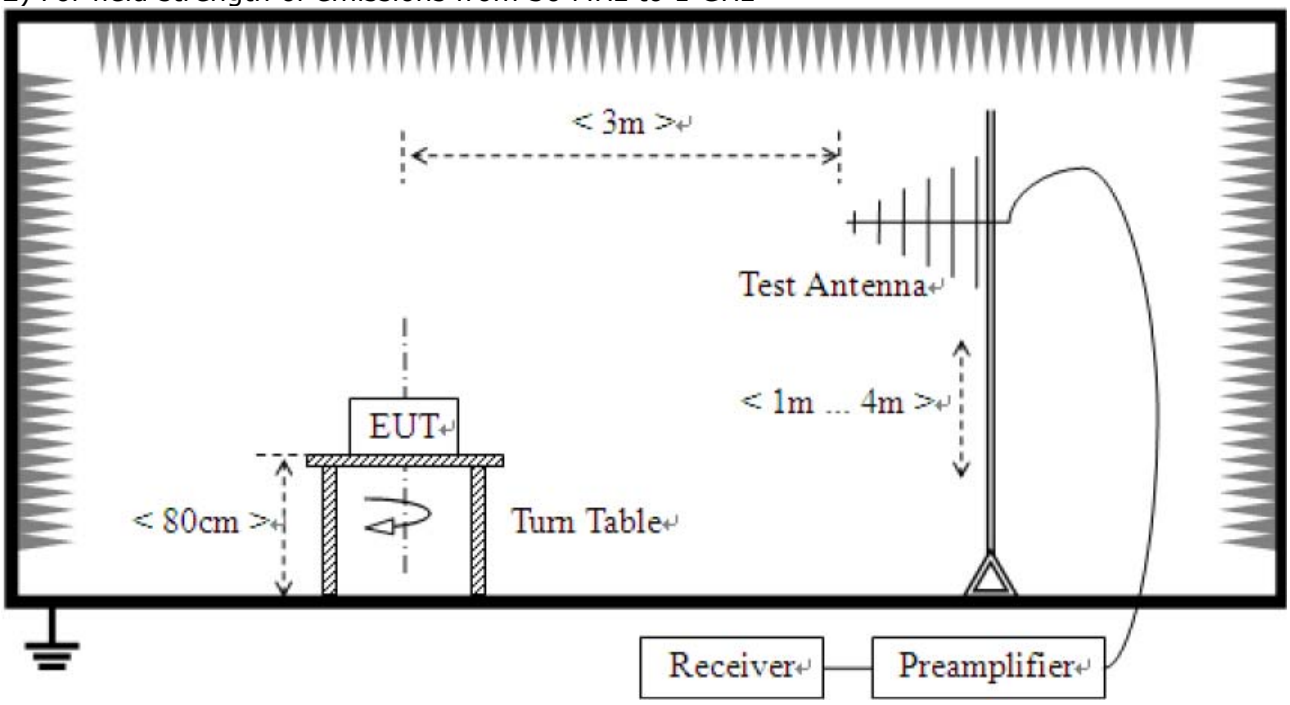
Note :
1) For above 1 GHz, the emission limit in this paragraph is based on measurement instrumentation employing an average detector, measurement using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit.
2) For above 1 GHz, limit field strength of harmonics : 54 dBuV/m@3m (AV) and 74 dBuV/m@3m (PK)
3) For measurement above 1GHz, the resolution bandwidth is set to 1 MHz and video bandwidth is set to 3 MHz for peak measurement.

Test Setup:

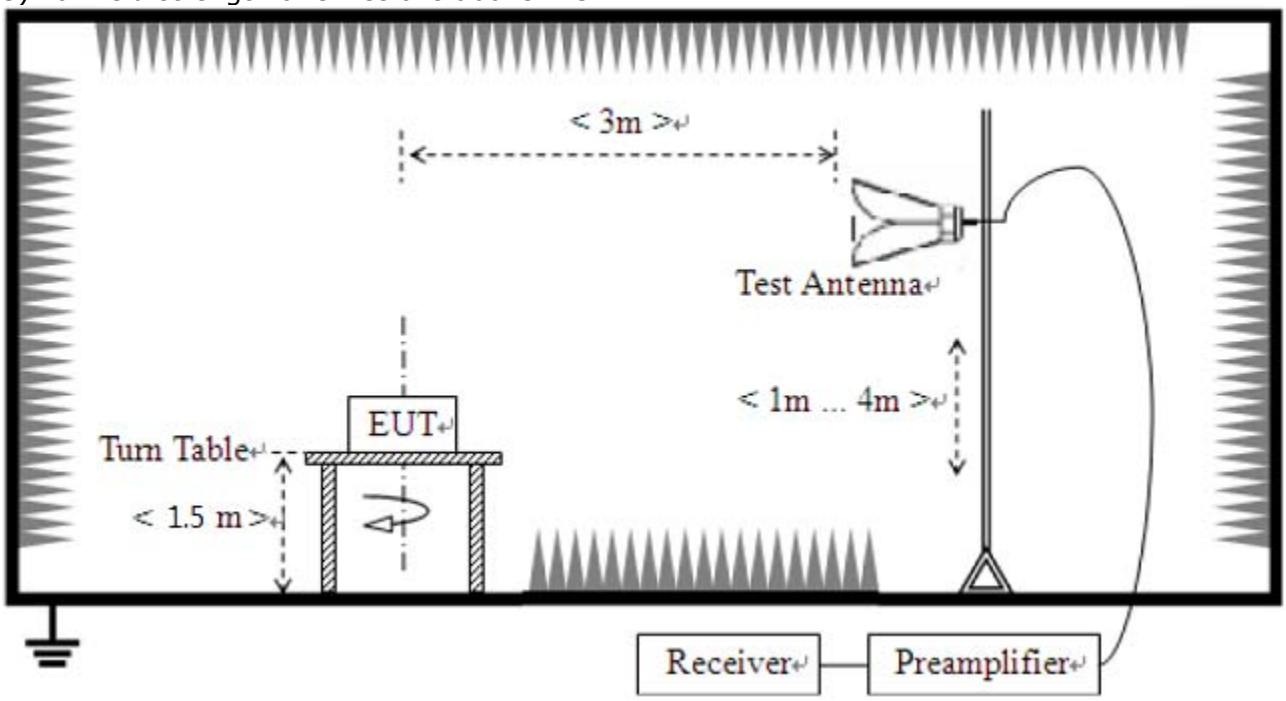
1) For field strength of emissions from 9 kHz to 30 MHz



2) For field strength of emissions from 30 MHz to 1 GHz



3) For field strength of emissions above 1 GHz



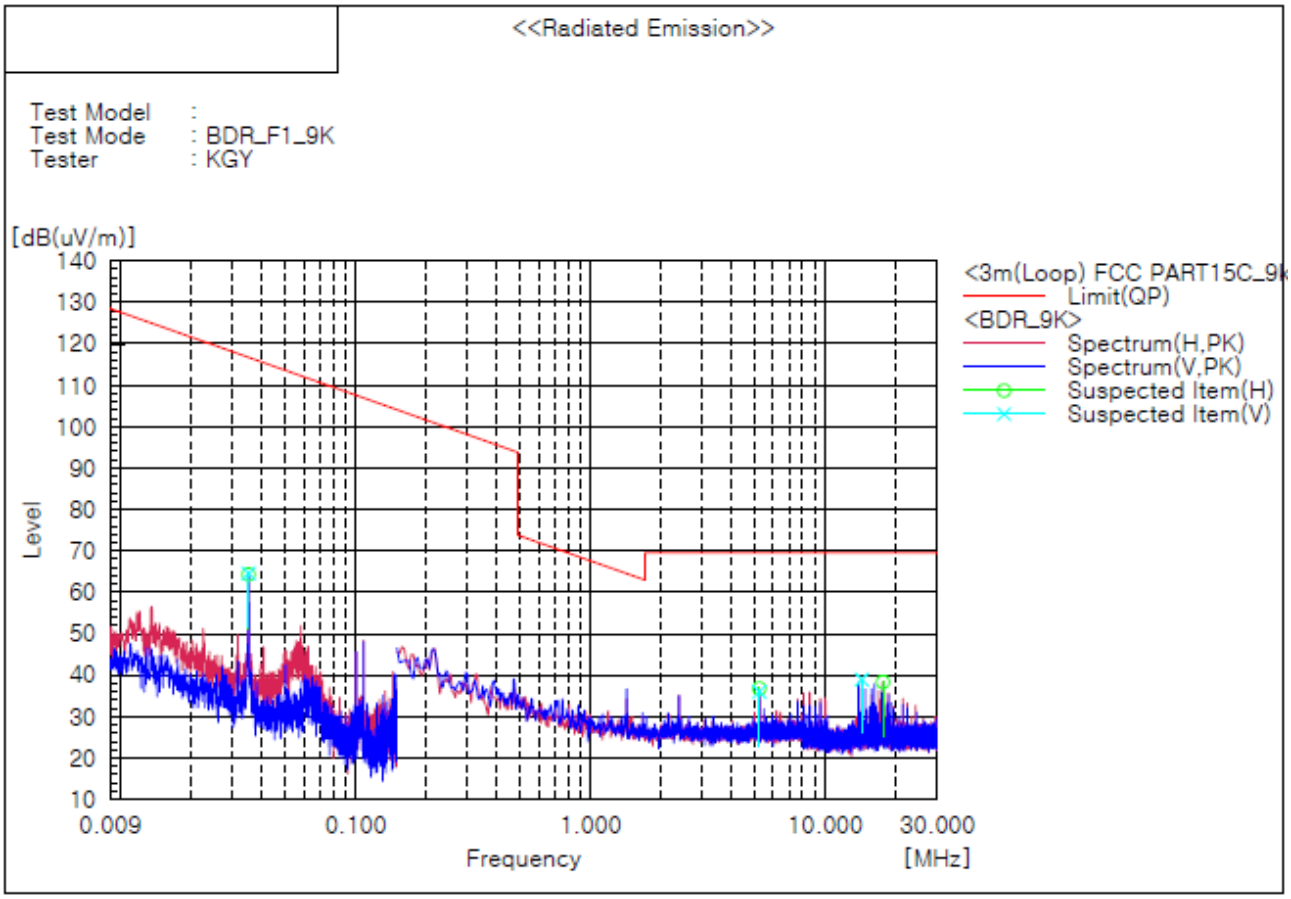
Test results

1) 9 kHz to 30 MHz

Test mode : Transmission status GFSK Lowest channel(Worst case)

The requirements are:
☒ Complies

Test Data



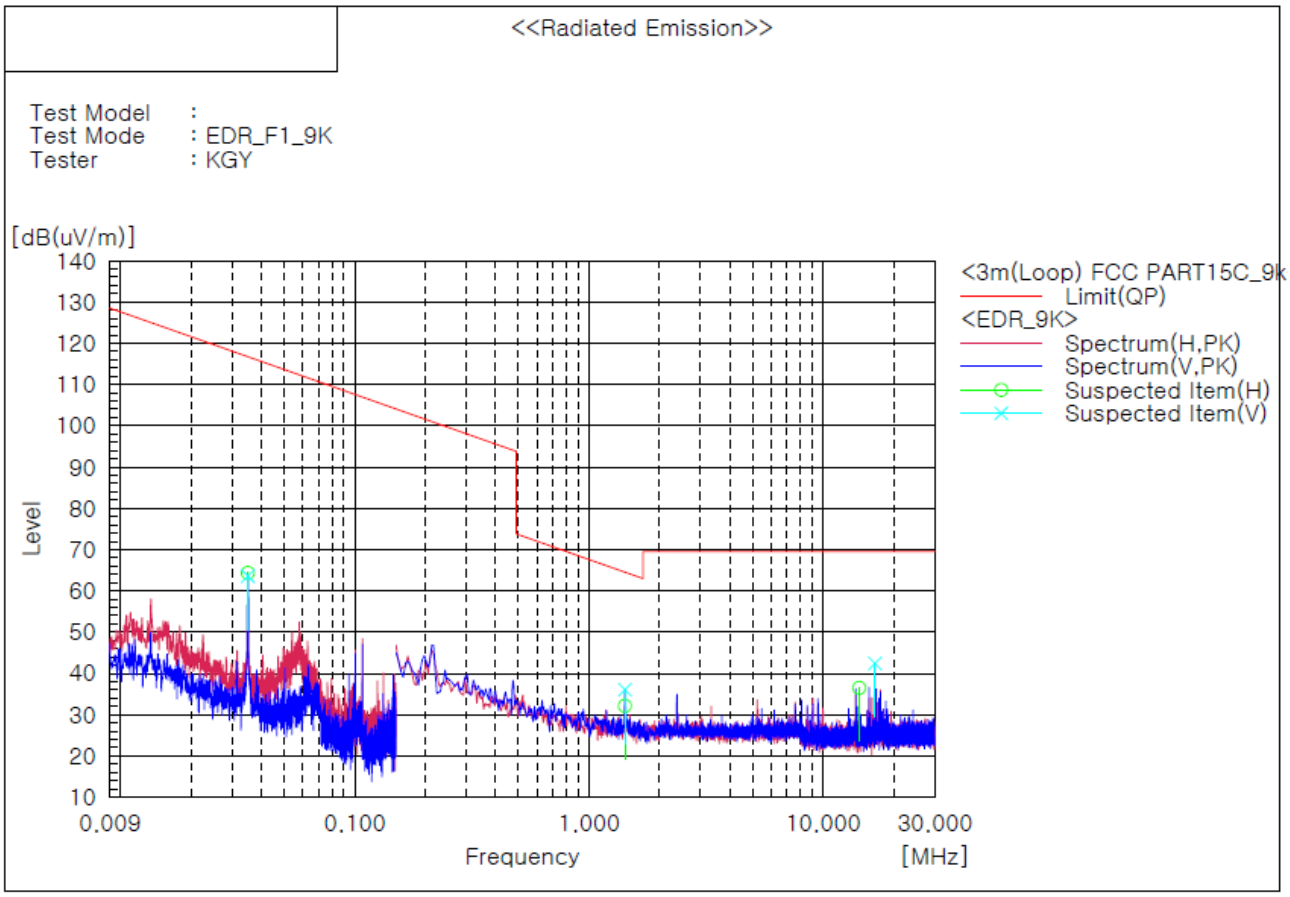
Result : There are more than 20 dB of margin compared to the reference value.

Remark :
1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor)
3. Correction factor = Antenna factor + Cable loss + 6 dB attenuator
4. Distance extrapolation factor = 40 log (specific distance / test distance) (dB)
5. This data is the Peak(PK) value.

Test mode : Transmission status 8-DPSK Lowest channel(Worst case)

The requirements are:
☒ Complies

Test Data



Result : There are more than 20 dB of margin compared to the reference value.

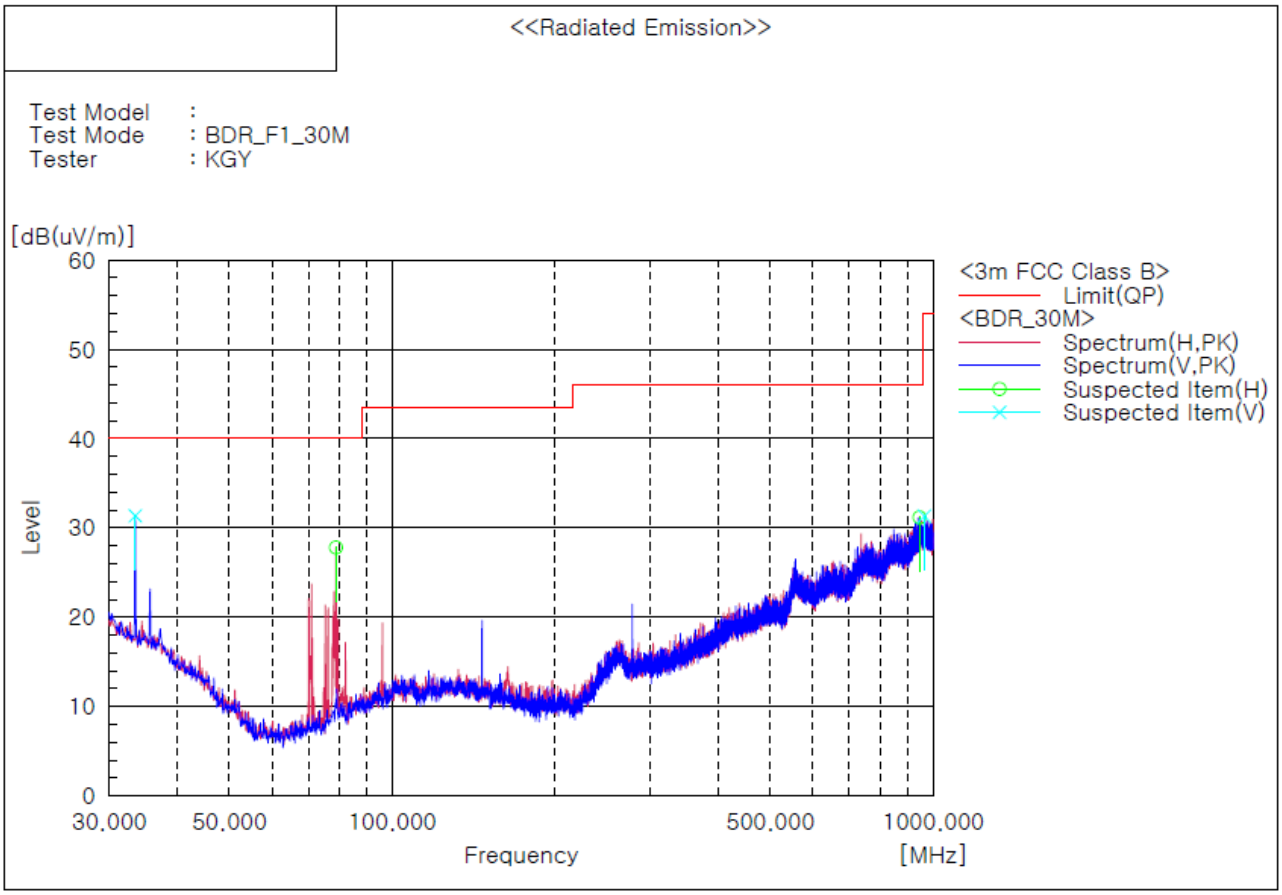
Remark :
1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor)
3. Correction factor = Antenna factor + Cable loss + 6 dB attenuator
4. Distance extrapolation factor = 40 log (specific distance / test distance) (dB)
5. This data is the Peak(PK) value.

2) 30 MHz to 1 GHz

Test mode : Transmission status GFSK Lowest channel(Worst case)

The requirements are:
☒ Complies

Test Data



Spectrum Selection

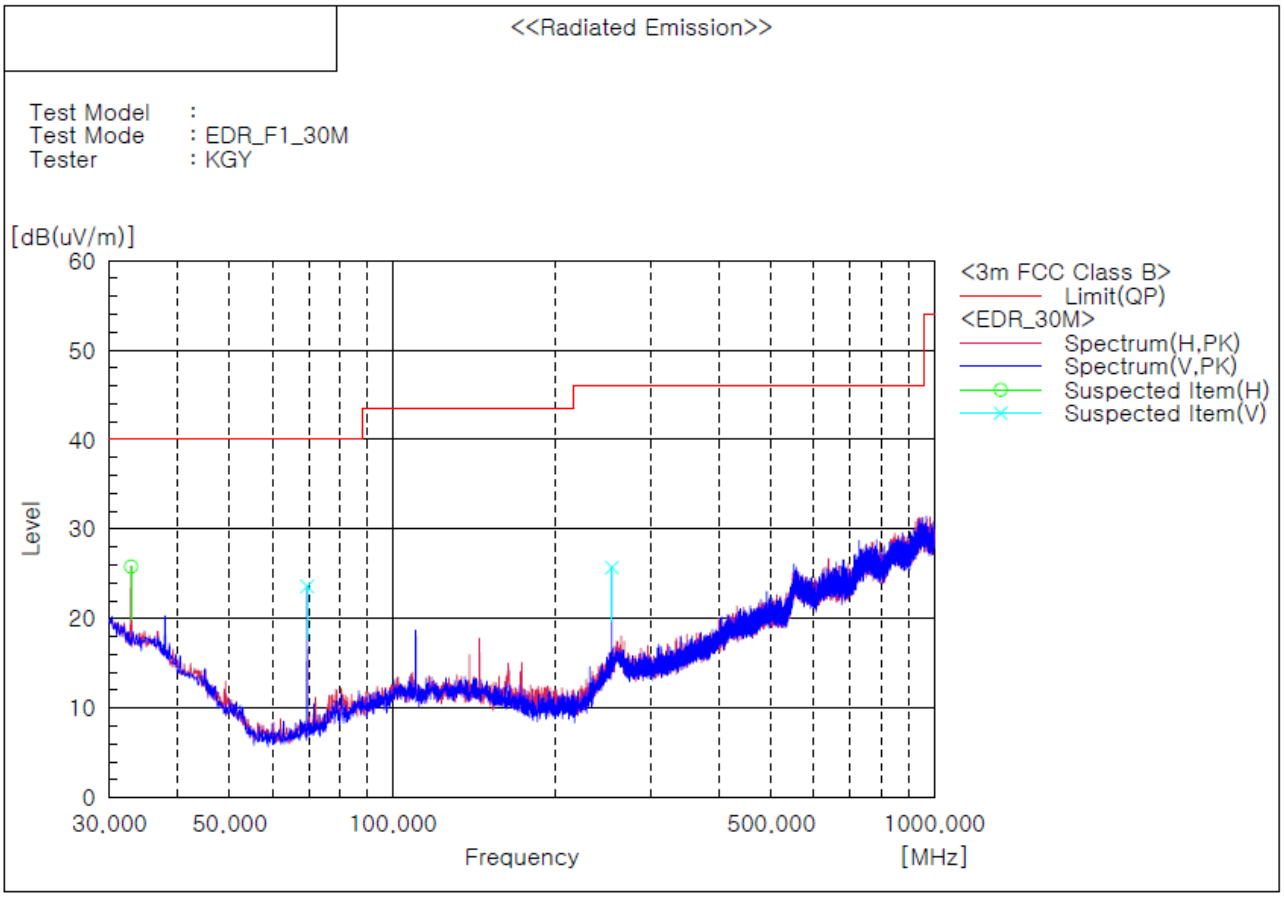
No.	Frequency [MHz]	(P)	Reading [dB(uV)]	c.f [dB(1/m)]	Result PK [dB(uV/m)]	Limit QP [dB(uV/m)]	Margin QP [dB]	Height [cm]	Angle [deg]
1	33.516	V	38.5	-7.1	31.4	40.0	8.6	101.0	339.0
2	943.983	H	23.0	8.2	31.2	46.0	14.8	306.0	301.0
3	963.746	V	22.7	8.6	31.3	54.0	22.7	101.0	200.0
4	78.743	H	44.0	-16.2	27.8	40.0	12.2	209.0	339.0

Remark :
1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(Correction factor)
3. Correction factor = Antenna factor + Cable loss + 6 dB attenuator - Amp Gain
4. This data is the Peak(PK) value.

Test mode : Transmission status 8-DPSK Lowest channel(Worst case)

The requirements are:
☒ Complies

Test Data



Spectrum Selection

No.	Frequency [MHz]	(P)	Reading [dB(uV)]	c.f [dB(1/m)]	Result PK [dB(uV/m)]	Limit QP [dB(uV/m)]	Margin QP [dB]	Height [cm]	Angle [deg]
1	32.910	H	32.6	-6.8	25.8	40.0	14.2	210.0	339.0
2	69.528	V	41.4	-17.8	23.6	40.0	16.4	291.0	339.0
3	253.949	V	34.4	-8.7	25.7	46.0	20.3	101.0	339.0

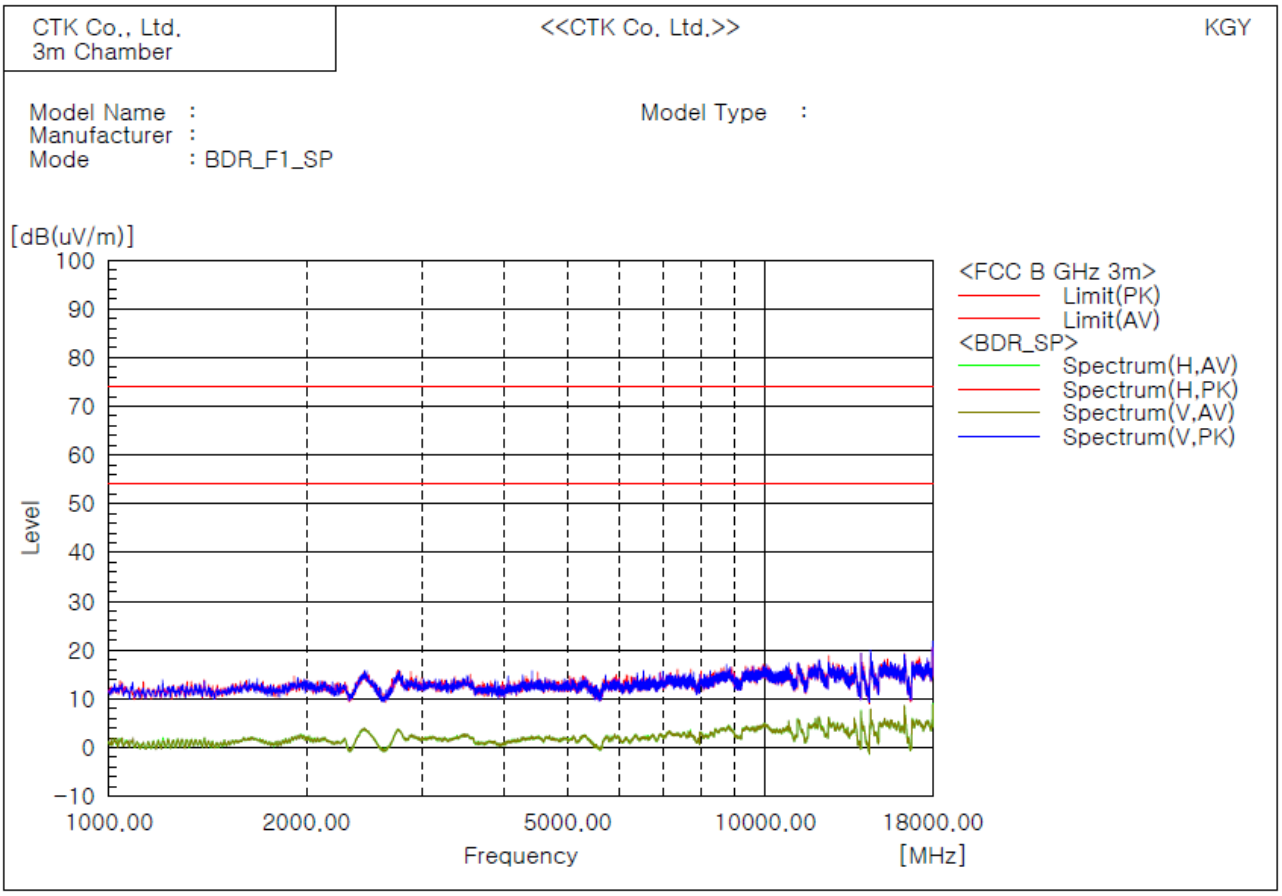
Remark :
1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(Correction factor)
3. Correction factor = Antenna factor + Cable loss + 6 dB attenuator - Amp Gain
4. This data is the Peak(PK) value.

3) 1 GHz to 18 GHz

Test mode : Transmission status GFSK Lowest channel(Worst case)

The requirements are:
☒ Complies

Test Data



Result : There are more than 20 dB of margin compared to the reference value.

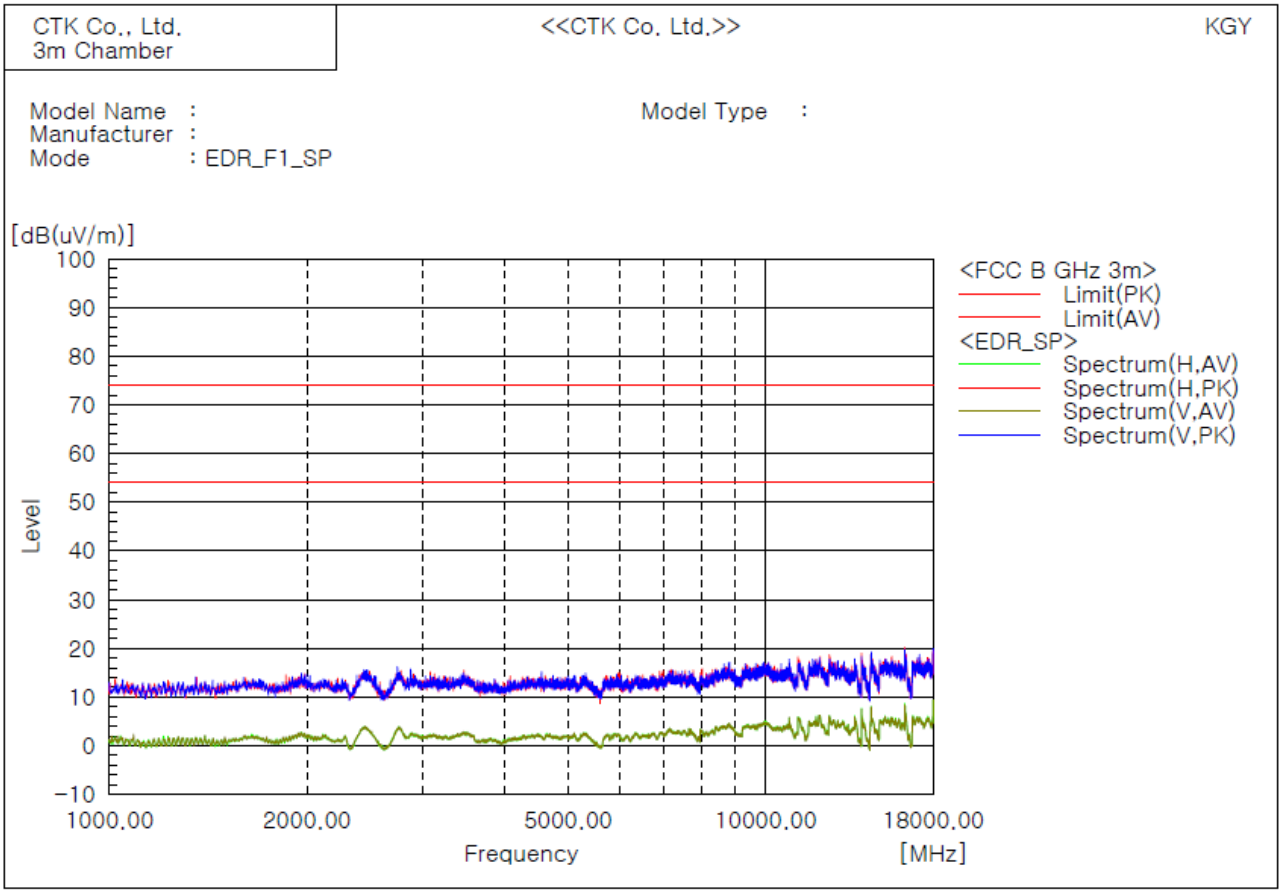
Remarks

1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor)
3. Correction factor = Antenna factor + Cable loss - Amp Gain
4. Band reject filter was used from 1 GHz to 18 GHz

Test mode : Transmission status 8-DPSK Lowest channel(Worst case)

The requirements are:
☒ Complies

Test Data



Result : There are more than 20 dB of margin compared to the reference value.

Remarks

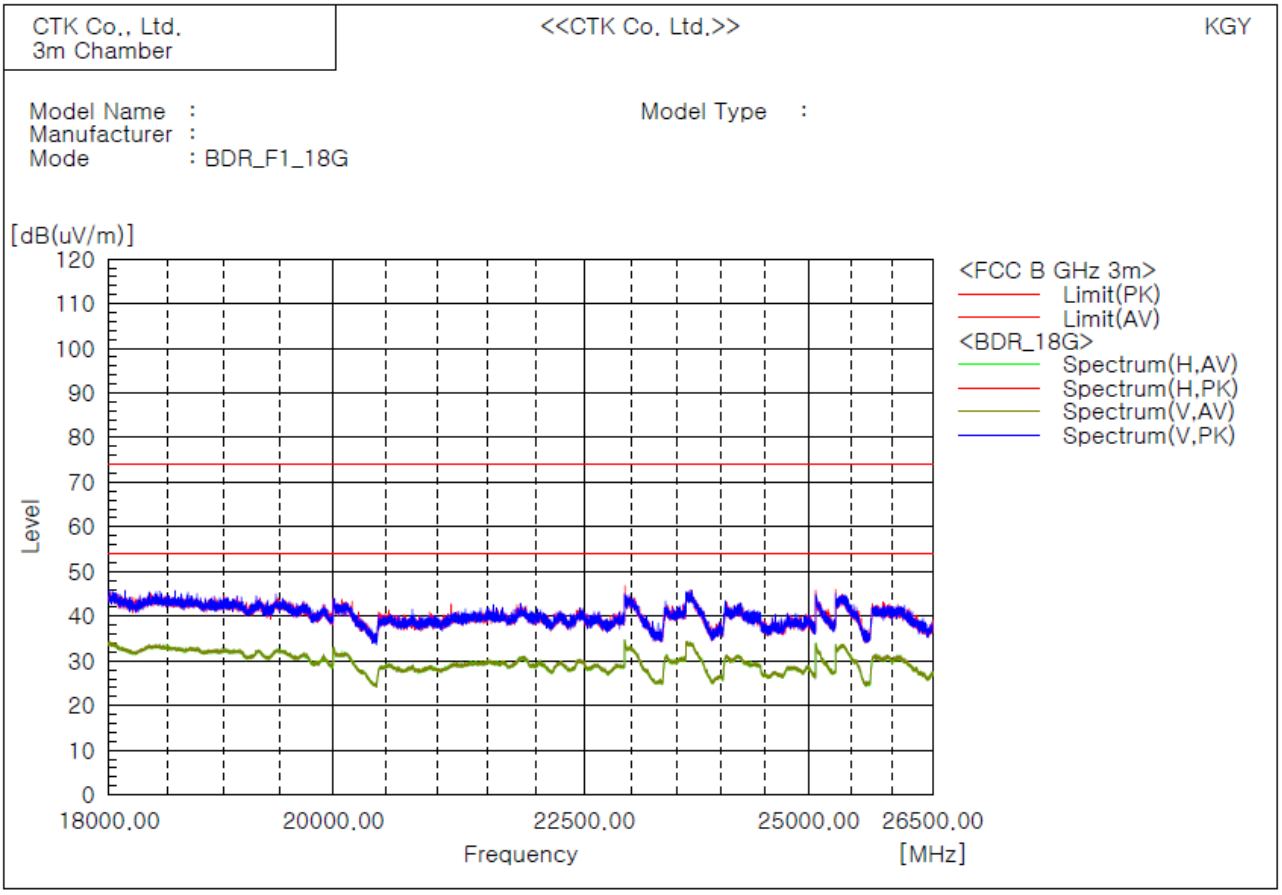
1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor)
3. Correction factor = Antenna factor + Cable loss - Amp Gain
4. Band reject filter was used from 1 GHz to 18 GHz

4) 18 GHz to 26.5 GHz

Test mode : Transmission status GFSK Lowest channel(Worst case)

The requirements are:
☒ Complies

Test Data



Result : There are more than 20 dB of margin compared to the reference value.

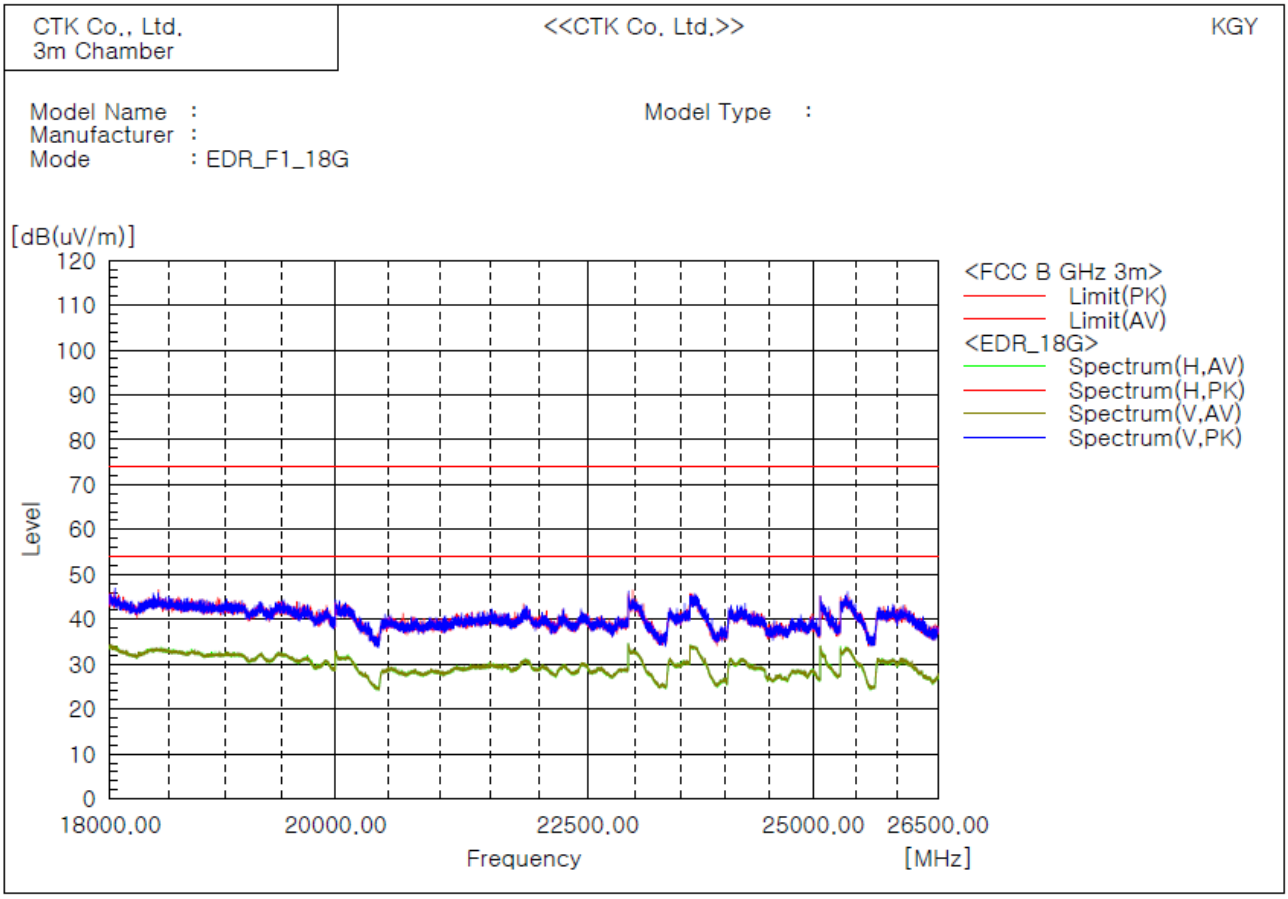
Remarks

1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor)
3. Correction factor = Antenna factor + Cable loss - Amp Gain

Test mode : Transmission status 8-DPSK Lowest channel(Worst case)

The requirements are:
☒ Complies

Test Data



Result : There are more than 20 dB of margin compared to the reference value.

Remarks

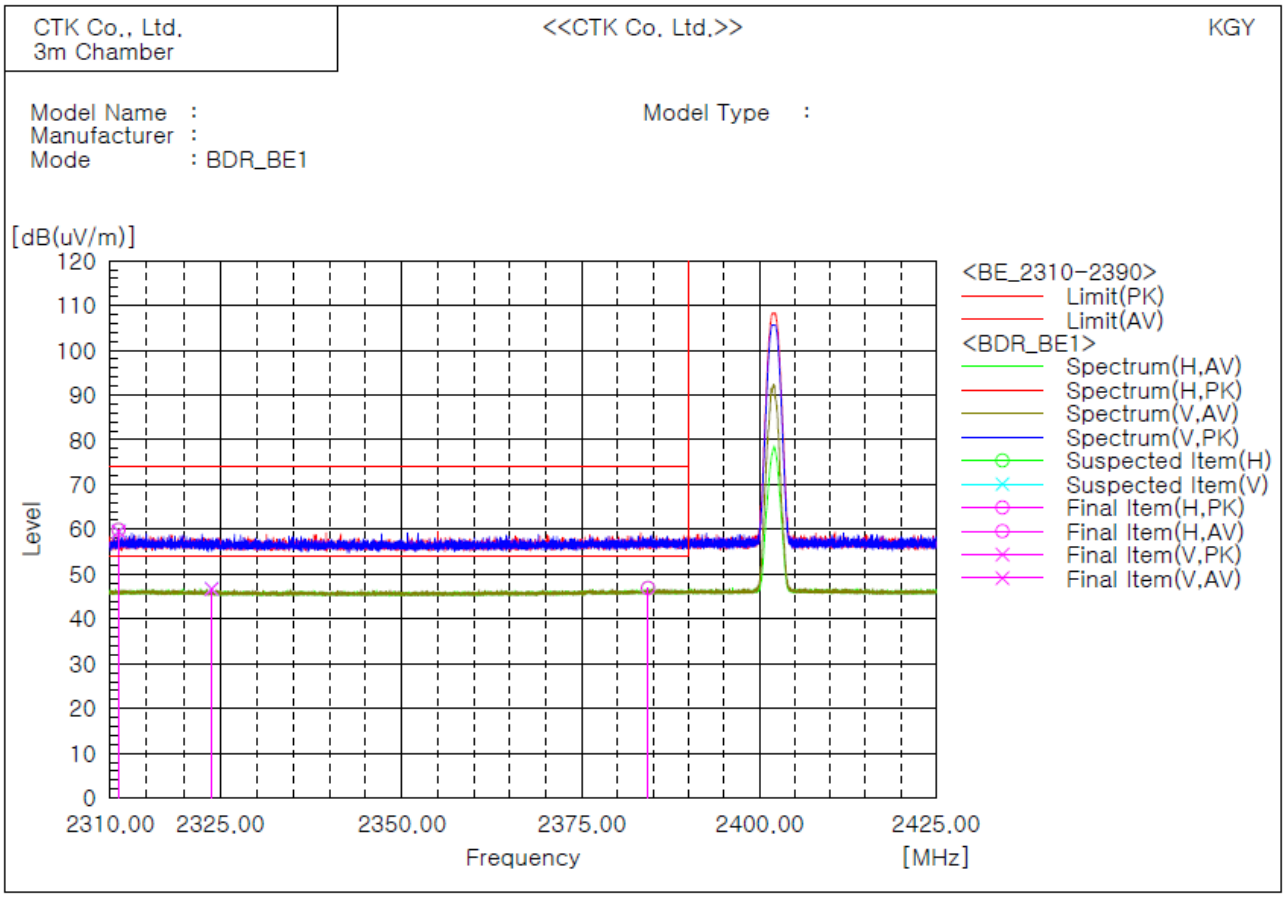
1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor)
3. Correction factor = Antenna factor + Cable loss - Amp Gain

5) Restricted Frequency Bands

Test mode : Transmission status GFSK Lowest channel
(Test frequency range : 2 310 MHz – 2 390 MHz)

The requirements are:
☒ Complies

Test Data



Final Result

No.	Frequency [MHz]	(P)	Reading PK [dB(uV)]	Reading AV [dB(uV)]	c.f [dB(1/m)]	Result PK [dB(uV/m)]	Result AV [dB(uV/m)]	Limit PK [dB(uV/m)]	Limit AV [dB(uV/m)]	Margin PK [dB]	Margin AV [dB]	Height [cm]	Angle [deg]
1	2311.165	H	53.7	--------	6.2	59.9	--------	74.0	54.0	14.1	--------	235.8	26.0
2	2311.179	V	53.3	--------	6.2	59.5	--------	74.0	54.0	14.5	--------	464.0	5.0
3	2323.858	V	--------	40.7	6.0	--------	46.7	74.0	54.0	--------	7.3	222.3	0.1
4	2384.290	H	--------	40.7	6.2	--------	46.9	74.0	54.0	--------	7.1	99.8	0.1

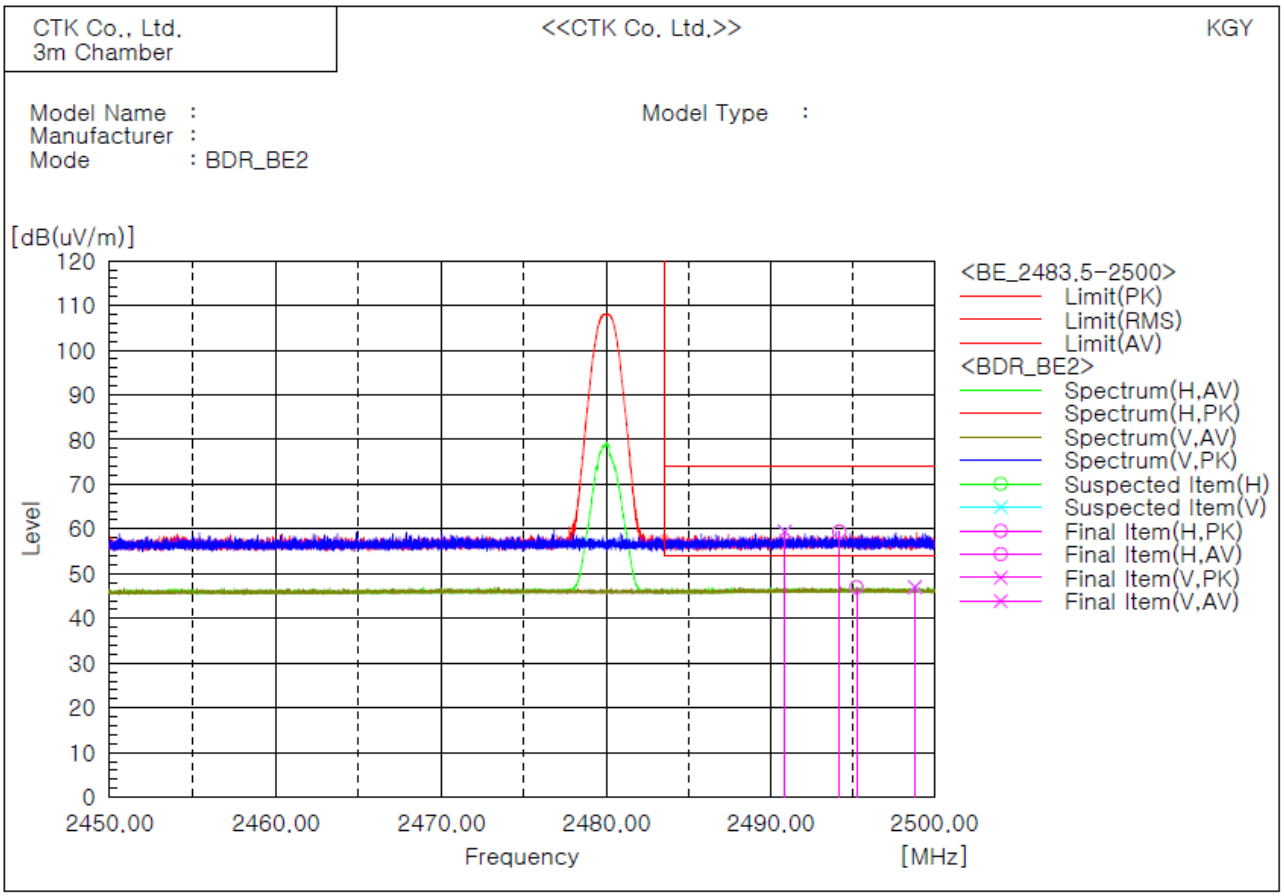
Remarks

1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor)
3. Correction factor = Antenna factor + Cable loss - Amp Gain

Test mode : Transmission status GFSK Highest channel
(Test frequency range : 2 483.5 MHz – 2 500 MHz)

The requirements are:
☒ Complies

Test Data



Final Result

No.	Frequency [MHz]	(P)	Reading PK [dB(uV)]	Reading AV [dB(uV)]	c.f [dB(1/m)]	Result PK [dB(uV/m)]	Result AV [dB(uV/m)]	Limit PK [dB(uV/m)]	Limit AV [dB(uV/m)]	Margin PK [dB]	Margin AV [dB]	Height [cm]	Angle [deg]
1	2490.863	V	53.1	--------	6.3	59.4	--------	74.0	54.0	14.6	--------	99.8	255.9
2	2494.200	H	53.1	--------	6.3	59.4	--------	74.0	54.0	14.6	--------	99.8	62.3
3	2495.250	H	--------	40.7	6.3	--------	47.0	74.0	54.0	--------	7.0	354.5	359.9
4	2498.819	V	--------	40.7	6.3	--------	47.0	74.0	54.0	--------	7.0	344.1	0.1

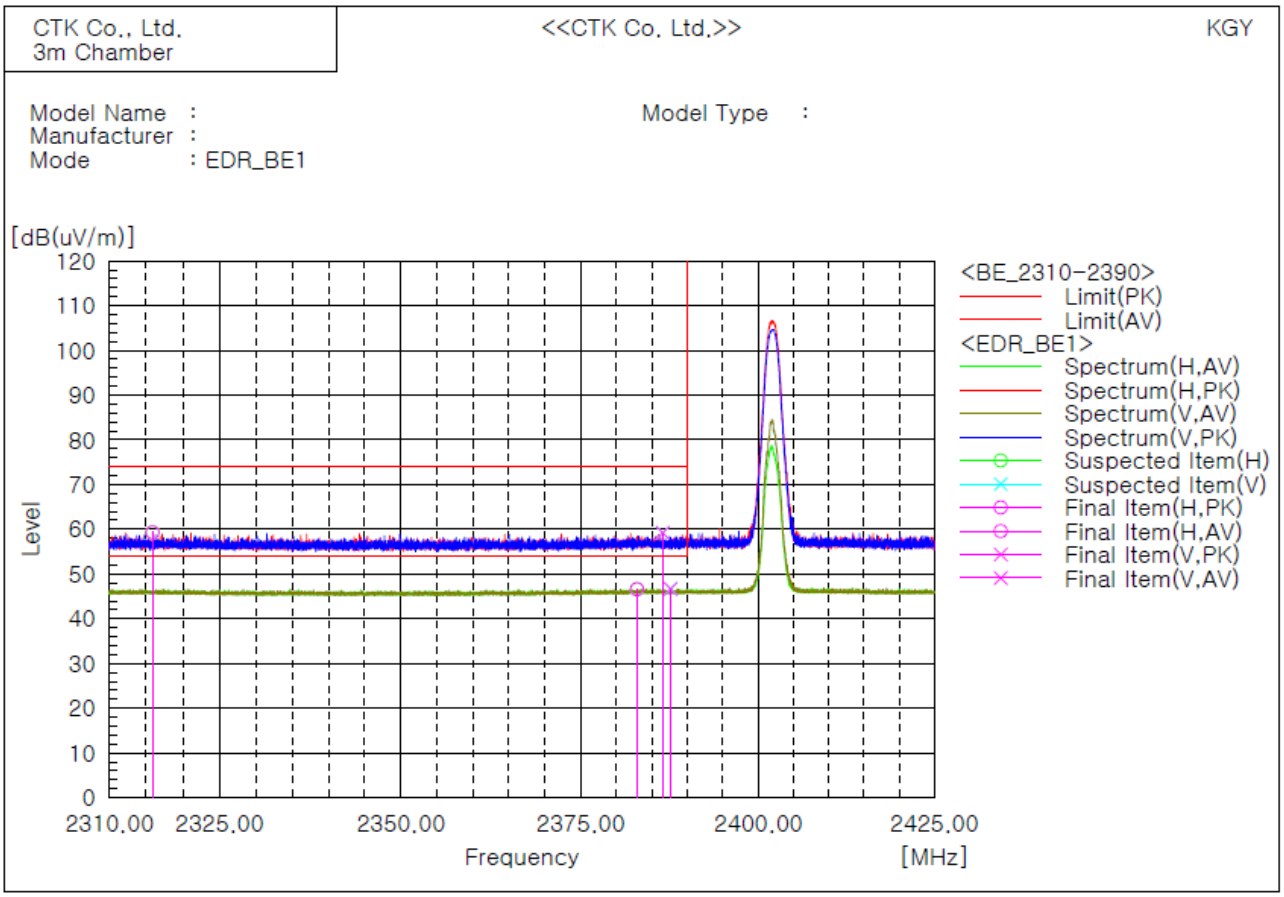
Remarks

1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor)
3. Correction factor = Antenna factor + Cable loss - Amp Gain

Test mode : Transmission status 8-DPSK Lowest channel
(Test frequency range : 2 310 MHz – 2 390 MHz)

The requirements are:
☒ Complies

Test Data



Final Result

No.	Frequency [MHz]	(P)	Reading PK [dB(uV)]	Reading AV [dB(uV)]	c.f [dB(1/m)]	Result PK [dB(uV/m)]	Result AV [dB(uV/m)]	Limit PK [dB(uV/m)]	Limit AV [dB(uV/m)]	Margin PK [dB]	Margin AV [dB]	Height [cm]	Angle [deg]
1	2315.894	H	53.1	--------	6.2	59.3	--------	74.0	54.0	14.7	--------	235.8	355.3
2	2382.925	H	--------	40.4	6.2	--------	46.6	74.0	54.0	--------	7.4	464.3	359.9
3	2386.518	V	53.0	--------	6.2	59.2	--------	74.0	54.0	14.8	--------	100.0	349.8
4	2387.639	V	--------	40.5	6.2	--------	46.7	74.0	54.0	--------	7.3	464.3	0.0

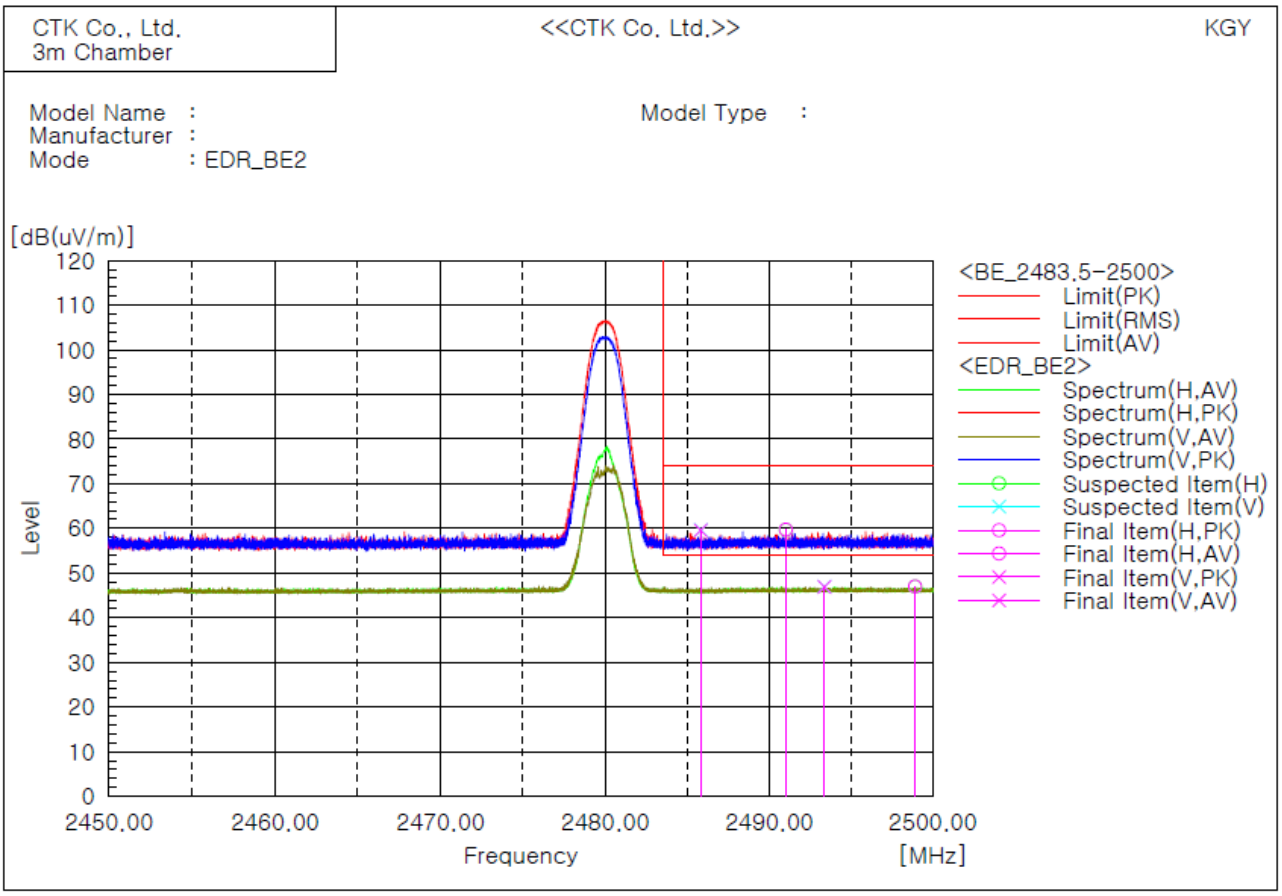
Remarks

1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor)
3. Correction factor = Antenna factor + Cable loss - Amp Gain

Test mode : Transmission status 8-DPSK Highest channel
(Test frequency range : 2 483.5 MHz – 2 500 MHz)

The requirements are:
☒ Complies

Test Data



Final Result

No.	Frequency [MHz]	(P)	Reading PK [dB(uV)]	Reading AV [dB(uV)]	c.f [dB(1/m)]	Result PK [dB(uV/m)]	Result AV [dB(uV/m)]	Limit PK [dB(uV/m)]	Limit AV [dB(uV/m)]	Margin PK [dB]	Margin AV [dB]	Height [cm]	Angle [deg]
1	2485.831	V	53.4	--------	6.2	59.6	--------	74.0	54.0	14.4	--------	343.6	4.9
2	2491.019	H	53.4	--------	6.3	59.7	--------	74.0	54.0	14.3	--------	355.3	354.8
3	2493.375	V	--------	40.6	6.3	--------	46.9	74.0	54.0	--------	7.1	99.8	359.9
4	2498.925	H	--------	40.7	6.3	--------	47.0	74.0	54.0	--------	7.0	355.3	359.9

Remarks

1. Measuring position : The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in lie-down position(Y axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor)
3. Correction factor = Antenna factor + Cable loss - Amp Gain

4.8 AC Power Line Conducted Emissions

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz-30 MHz, shall not exceed the limits.

Instrument Settings

IF Band Width: 9 kHz

Test Procedures

ANSI C63.10-2013 - Section 6.2.2
RSS-Gen - Section 8.8

The EUT was placed on a non-metallic table 0.8 m above the metallic, grounded floor and 0.4 m from the reference ground plane wall. The distance to other metallic surfaces was at least 0.8 m.
Amplitude measurements were performed with a quasi-peak detector and an average detector.

Limit

Frequency (MHz)	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

* The level decreases linearly with the logarithm of the frequency.
** A linear average detector is required.

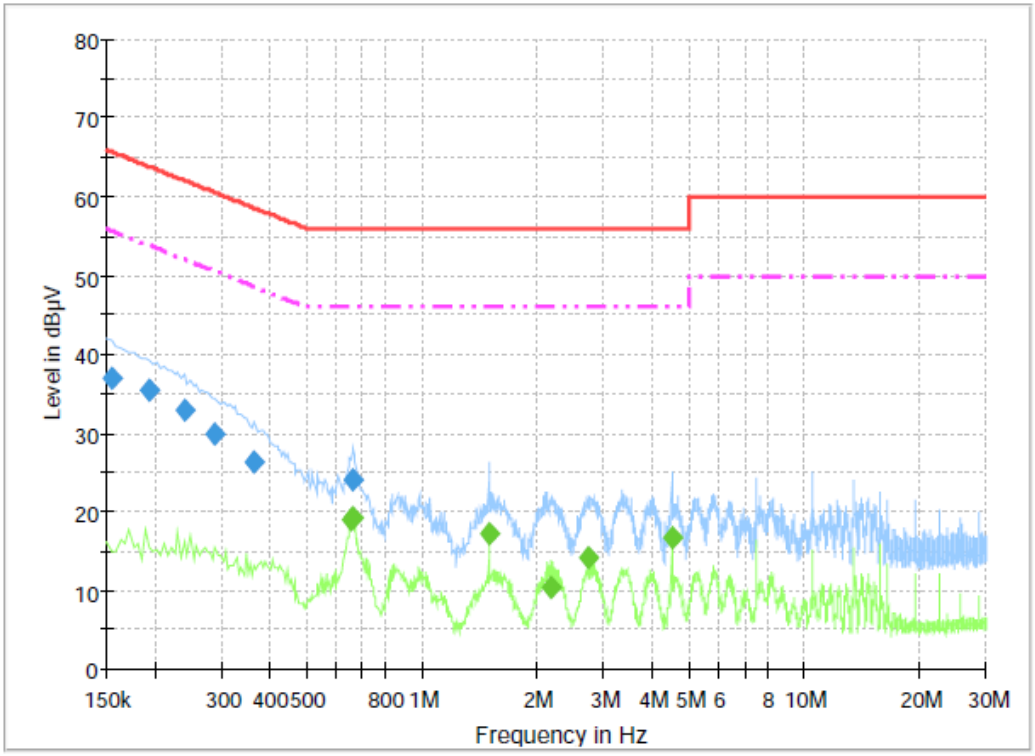
Test Results

The requirements are:
☒ Complies

Test Data

Test mode : GFSK lowest channel(Worst case)

[LINE]



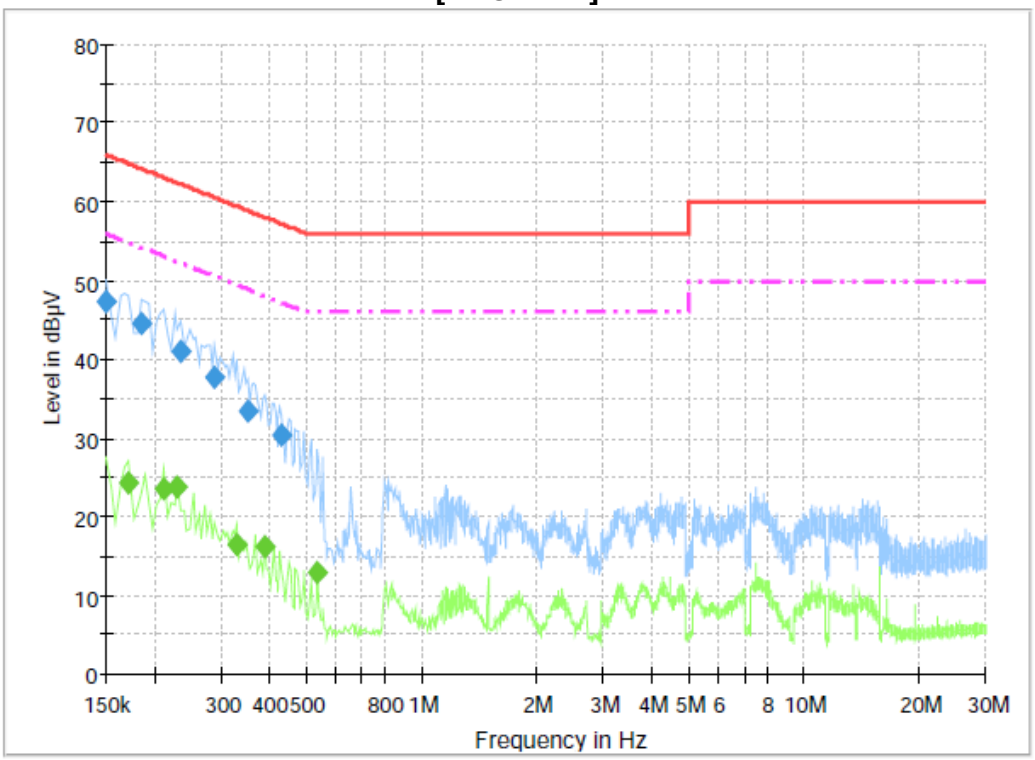
Final Result 1

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.154500	37.0	1000.0	9.000	On	L1	9.7	28.8	65.8
0.195000	35.5	1000.0	9.000	On	L1	9.7	28.3	63.8
0.240000	32.9	1000.0	9.000	On	L1	9.7	29.2	62.1
0.289500	29.8	1000.0	9.000	On	L1	9.7	30.7	60.5
0.366000	26.3	1000.0	9.000	On	L1	9.7	32.3	58.6
0.663000	23.9	1000.0	9.000	On	L1	9.7	32.1	56.0

Final Result 2

Frequency (MHz)	CAverage (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.654000	18.9	1000.0	9.000	On	L1	9.7	27.1	46.0
0.663000	19.2	1000.0	9.000	On	L1	9.7	26.8	46.0
1.504500	17.3	1000.0	9.000	On	L1	9.8	28.7	46.0
2.188500	10.4	1000.0	9.000	On	L1	9.8	35.6	46.0
2.742000	14.2	1000.0	9.000	On	L1	9.8	31.8	46.0
4.510500	16.8	1000.0	9.000	On	L1	9.9	29.2	46.0

[NEUTRAL]



Final Result 1

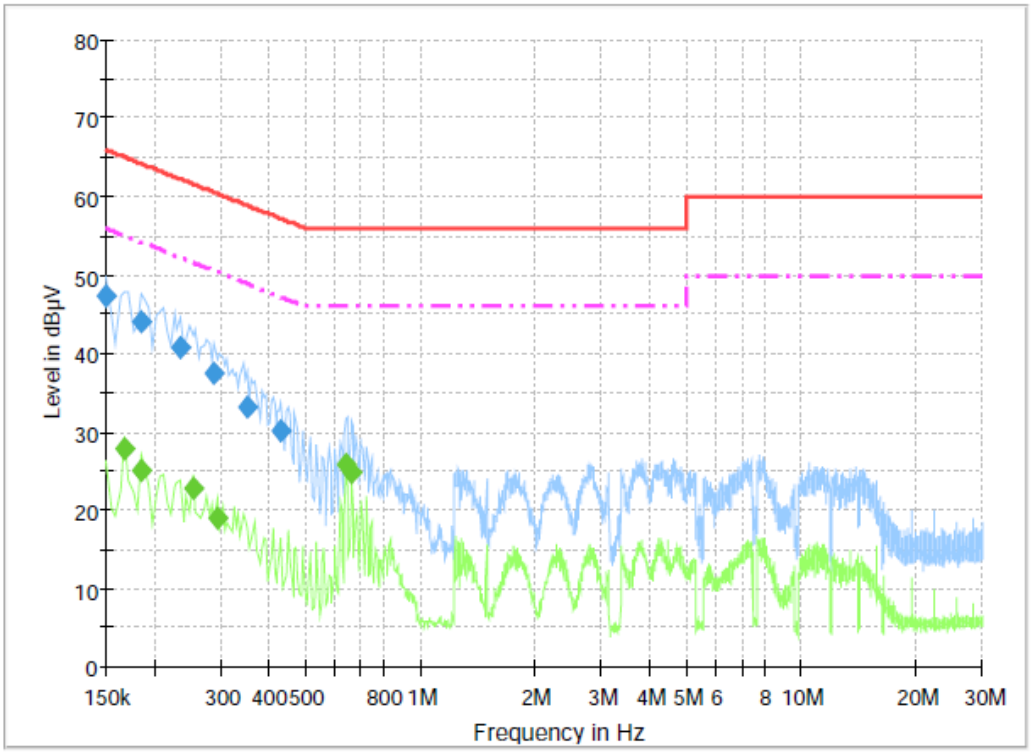
Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	47.5	1000.0	9.000	On	N	9.7	18.5	66.0
0.186000	44.6	1000.0	9.000	On	N	9.7	19.6	64.2
0.235500	41.1	1000.0	9.000	On	N	9.7	21.1	62.3
0.289500	37.8	1000.0	9.000	On	N	9.7	22.8	60.5
0.352500	33.5	1000.0	9.000	On	N	9.7	25.4	58.9
0.433500	30.4	1000.0	9.000	On	N	9.7	26.8	57.2

Final Result 2

Frequency (MHz)	CAverage (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.172500	24.3	1000.0	9.000	On	N	9.7	30.6	54.8
0.213000	23.6	1000.0	9.000	On	N	9.7	29.5	53.1
0.231000	23.8	1000.0	9.000	On	N	9.7	28.6	52.4
0.330000	16.6	1000.0	9.000	On	N	9.7	32.9	49.5
0.388500	16.1	1000.0	9.000	On	N	9.7	32.0	48.1
0.537000	13.0	1000.0	9.000	On	N	9.7	33.0	46.0

Test mode : 8-DPSK lowest channel(Worst case)

[LINE]



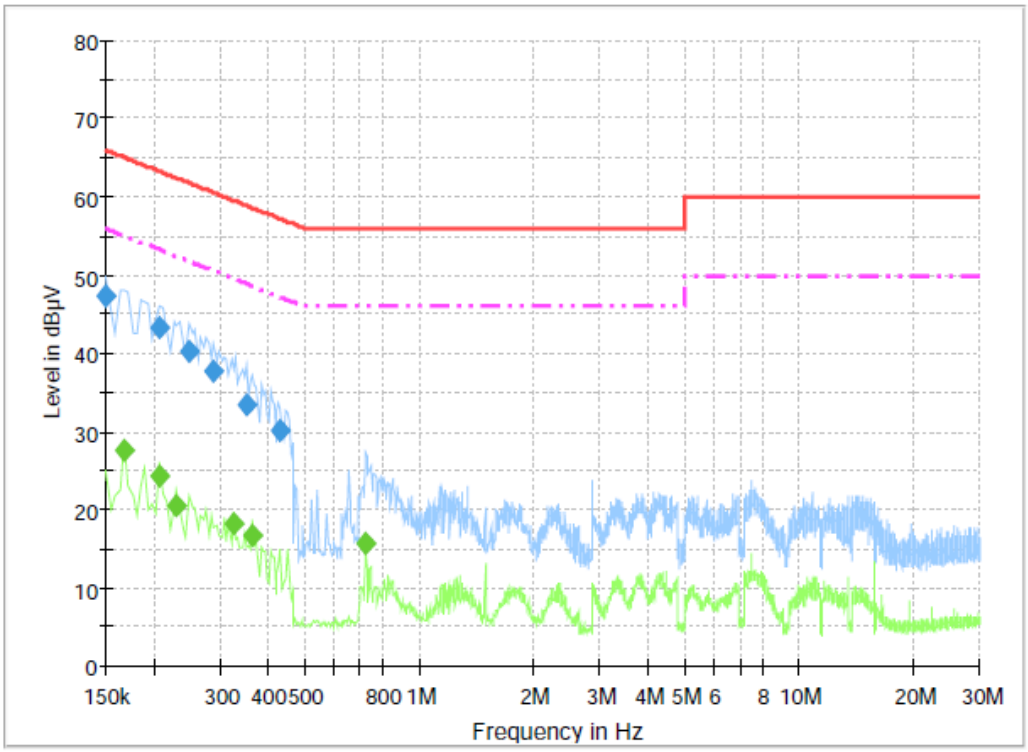
Final Result 1

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	47.3	1000.0	9.000	On	L1	9.7	18.7	66.0
0.186000	44.1	1000.0	9.000	On	L1	9.7	20.1	64.2
0.235500	40.8	1000.0	9.000	On	L1	9.7	21.4	62.3
0.289500	37.5	1000.0	9.000	On	L1	9.7	23.0	60.5
0.352500	33.2	1000.0	9.000	On	L1	9.7	25.7	58.9
0.433500	30.2	1000.0	9.000	On	L1	9.7	27.0	57.2

Final Result 2

Frequency (MHz)	CAverage (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.168000	28.0	1000.0	9.000	On	L1	9.7	27.1	55.1
0.186000	25.0	1000.0	9.000	On	L1	9.7	29.2	54.2
0.253500	22.7	1000.0	9.000	On	L1	9.7	28.9	51.6
0.294000	19.1	1000.0	9.000	On	L1	9.7	31.3	50.4
0.640500	25.9	1000.0	9.000	On	L1	9.7	20.1	46.0
0.663000	24.8	1000.0	9.000	On	L1	9.7	21.2	46.0

[NEUTRAL]



Final Result 1

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	47.3	1000.0	9.000	On	N	9.7	18.7	66.0
0.208500	43.3	1000.0	9.000	On	N	9.7	20.0	63.3
0.249000	40.1	1000.0	9.000	On	N	9.7	21.7	61.8
0.289500	37.6	1000.0	9.000	On	N	9.7	22.9	60.5
0.352500	33.5	1000.0	9.000	On	N	9.7	25.4	58.9
0.433500	30.3	1000.0	9.000	On	N	9.7	26.9	57.2

Final Result 2

Frequency (MHz)	CAverage (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.168000	27.5	1000.0	9.000	On	N	9.7	27.6	55.1
0.208500	24.3	1000.0	9.000	On	N	9.7	29.0	53.3
0.231000	20.6	1000.0	9.000	On	N	9.7	31.8	52.4
0.325500	18.1	1000.0	9.000	On	N	9.7	31.4	49.6
0.366000	16.7	1000.0	9.000	On	N	9.7	31.8	48.6
0.726000	15.6	1000.0	9.000	On	N	9.7	30.4	46.0

5. APPENDIX A – Test Equipment Used For Tests

	Name of Equipment	Manufacturer	Model No.	Serial No.	Cal Date	Due Date
1	Signal Analyzer	Agilent	N9020A	US46470483	2021-02-16	2022-02-16
2	Signal Generator	Rohde & Schwarz	SMB100A	175528	2021-04-12	2022-04-12
3	EMI Test Receiver	Rohde & Schwarz	ESCI7	100814	2020-10-20	2021-10-20
4	Bilog Antenna	SCHAFFNER	CBL6111C	2551	2021-03-22	2023-03-22
5	Active Loop Antenna	SCHWARZBECK	FMZB 1513	1513-126	2020-05-20	2022-05-20
6	6dB Attenuator	BIRD	5W 6dB	1744	2020-12-16	2021-12-16
7	6dB Attenuator	Rohde & Schwarz	DNF	272.4110.50-2	2020-10-23	2021-10-23
8	AMPLIFIER	SONOMA	310	291721	2021-01-22	2022-01-22
9	EMI Test Receiver	Rohde & Schwarz	ESU40	100336	2021-01-12	2022-01-12
10	Preamplifier	Agilent	8449B	3008A02011	2020-11-30	2021-11-30
11	Double Ridged Guide Antenna	ETS-Lindgren	3117	00154525	2019-10-14	2021-10-14
12	Horn Antenna	SCHWARZBECK	BBHA9170	00967	2020-05-25	2022-05-25
13	Band Reject Filter	Micro Tronics	BRM50702	G444	2020-10-14	2021-10-14
14	DC Power Supply	HP	E3632A	KR75301278	2020-07-23	2021-07-23
15	Dual-Tracking DC Power Supply	Topward Electric Instruments Co.,Ltd.	6303D	711196	2021-01-14	2022-01-14
16	Low Noise Amplifier	TESTEK	TK-PA1840H	200115-L	2021-05-21	2022-05-21
17	LISN	Rohde & Schwarz	ENV216	101236	2020-10-20	2021-10-20
18	EMI Test Receiver	Rohde & Schwarz	ESCI3	100032	2021-01-15	2022-01-15

	Cable	Manufacturer	Model No.	Serial No.	Check Date
1	RF Cable	Canare Corporation	L-5D2W	N/A	2020-10-20
2	RF Cable	Junkosha Inc.	MWX221	2005S321	2021-06-02
3	RF Cable	HUBER+SUHNER	SUCOFLEX 102	MY073/2	2021-02-20
4	RF Cable	HUBER+SUHNER	SUCOFLEX 102	MY4728/2	2021-02-20
5	RF Cable	HUBER+SUHNER	SUCOFLEX 104	MY27558/4	2021-02-20
6	RF Cable	HUBER+SUHNER	SUCOFLEX 104	N/A	2021-02-20
7	RF Cable	HUBER+SUHNER	SUCOFLEX 104	MY27573/4	2021-02-20
8	RF Cable	HUBER+SUHNER	SUCOFLEX 106	N/A	2021-02-20
9	RF Cable	HUBER+SUHNER	SUCOFLEX 102	803010/2	2021-02-20
10	RF Cable	HUBER+SUHNER	SUCOFLEX 102	803742/2	2021-02-20
11	RF Cable	HUBER+SUHNER	SUCOFLEX 102	MY4728/2	2021-02-20
12	Extension cord	-	-	-	2020-10-20