TEST REPORT

CTK Co., Ltd.
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Report No.: CTK-2019-04073

1. Client

◦ Name : HANKOOK Technology inc.

◦ Address : 1F, 30, Sowol-ro 2-gil, Jung-gu, Seoul, Republic of Korea

◦ Date of Receipt : 2019-09-21

2. Manufacturer

◦ Name : HANKOOK Technology inc.

◦ Address : 1F, 30, Sowol-ro 2-gil, Jung-gu, Seoul, Republic of Korea

3. Use of Report : For FCC Certification

4. Test Sample / Model: AVN / HTAVNC-100HCVN

5. Date of Test : 2019-10-18 to 2019-10-22

6. Test Standard(method) used : FCC 47 CFR part 15 subpart C 15.247

7. Testing Environment: Temp.: (24 ± 1) ℃, Humidity: (50 ± 3) % 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 Ji-Hye, Kim: (Signature)	Technical Manager Won-Jae, Hwang: (Signature)

2019-10-23

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

REPORT REVISION HISTORY

Date	Revision	Page No
2019-10-23	Issued (CTK-2019-04073)	all

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1. General Product Description

1.1 Client Information

Company	HANKOOK Technology inc.
Contact Point	1F, 30, Sowol-ro 2-gil, Jung-gu, Seoul, Republic of Korea
Contact Person	Name : Kim Sang Jin E-mail : sjkim@myht.co.kr Tel : +82-2-2106-7500 Fax : +82-2-2136-1379

1.2 Product Information

FCC ID	2AUVO-HTAVNC100HCVN
Product Description	AVN
Model name	HTAVNC-100HCVN
Operating Frequency	2 402 MHz - 2 480 MHz
RF Output Power	GFSK : 5.569 dBm (3.605 mW) 8-DPSK : 4.207 dBm (2.635 mW)
Antenna Specification	Antenna type : Chip Antenna Peak Gain : 0.0 dBi
Number of channels	79
Channel Spacing	1 MHz
Type of Modulation	GFSK(1Mbps), π/4 DQPSK(2Mbps), 8DPSK(3Mbps)
Power Source	DC 12 V
Hardware Rev	V302
Software Rev	V1030

1.3 Peripheral Devices

Device	Manufacturer	Model No.	Serial No.
Note Computer	HP	15-bs563TU	CND7253QPR
AC/DC Adapter	HP	HSTNN-LA40	-

2. Facility and Accreditations

2.1 Test Facility

The measurement facility is located at (Ho-dong), 113, Yejik-ro, Cheoin-gu, Yong-in-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.

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3. Test Specifications

3.1 Standards

Section in FCC	Requirement(s)	Status (Note 1)	Test Condition
15.247(a)	Carrier Frequency Separation	C	Conducted
15.247(a)	Number of Hopping Frequencies	C	
15.247(a)	20 dB Bandwidth	C	
15.247(a)	Time of occupancy (Dwell Time)	C	
15.247(b)	Maximum peak conducted output power	C	
15.247(d)	Unwanted emission	C	
15.209	Transmitter emission	C	Radiated
15.207(a)	AC Conducted Emission	NA	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.			

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
GFSK	DH5	1 Mbps	77.3 %
8-DPSK	3-DH5	3 Mbps	77.6 %

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
Occupied Bandwidth	0.1 MHz
Unwanted Emission(conducted)	3.0 dB
Radiated Emissions (f ≤ 1 GHz)	4.0 dB
Radiated Emissions (f > 1 GHz)	5.0 dB

3.4 Test Software

Conducted Test	Ics Pro Ver. 6.0.3
Radiated Test	TOYO EMI software EP5RE Ver. 6.0.1.0
Line Conducted Test	-

4. Technical Characteristic Test

4.1 Carrier Frequency Separation

Test Procedures

ANSI C63.10-2013 - Section 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

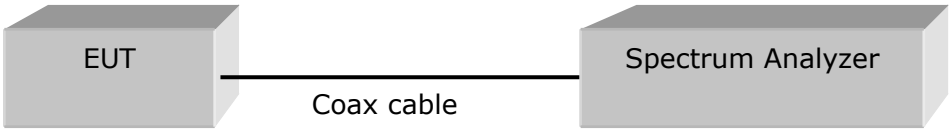


Figure 1 : Measurement setup for the carrier frequency separation

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

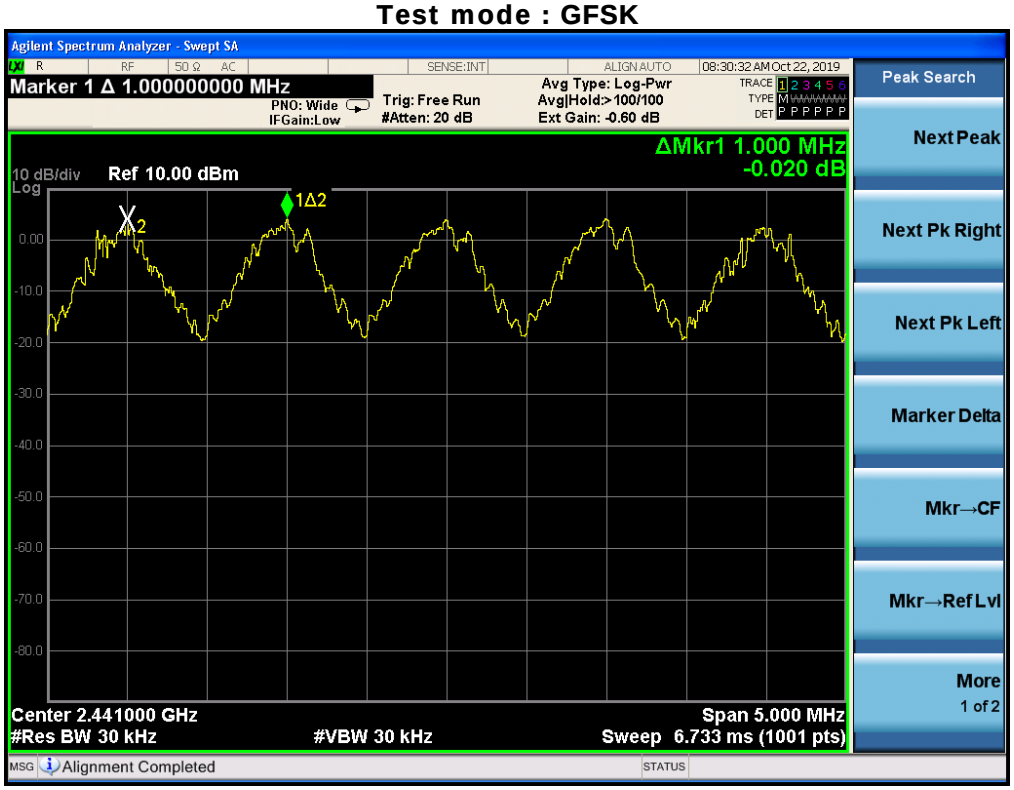
Channel	Adjacent Hopping Channel Separation [kHz]	Two-third of 20dB bandwidth [kHz]	Minimum Bandwidth [kHz]	Result
Middle	1 000	628.3	25	Complies

Test mode : 8-DPSK

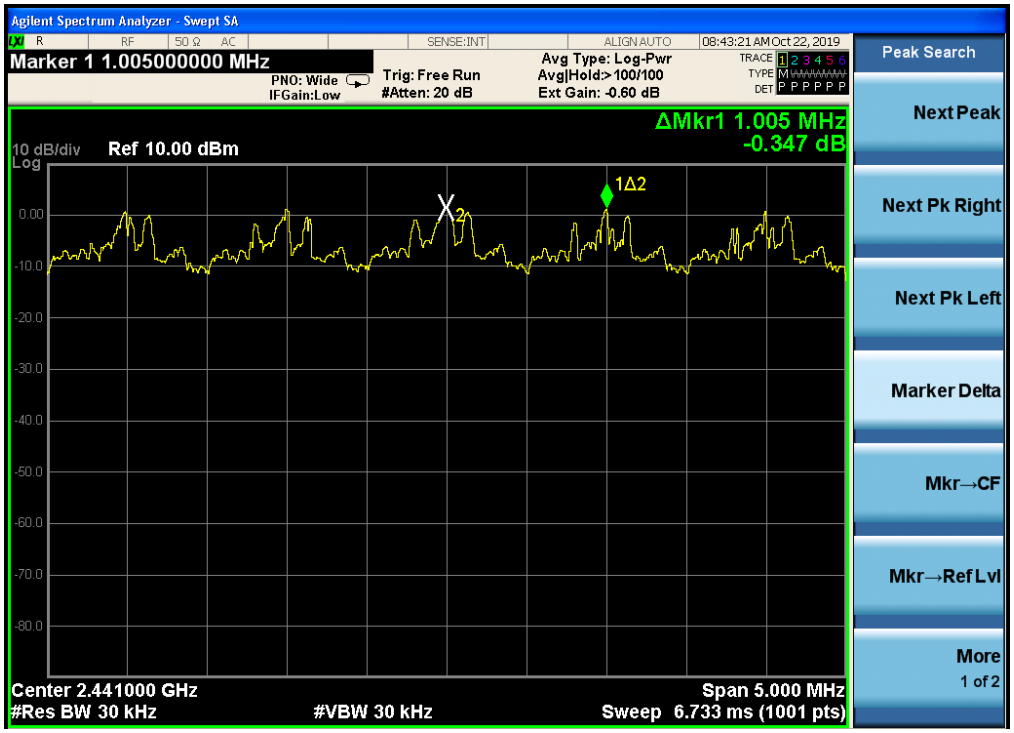
Channel	Adjacent Hopping Channel Separation [kHz]	Two-third of 20dB bandwidth [kHz]	Minimum Bandwidth [kHz]	Result
Middle	1 005	847.3	25	Complies

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 - Section 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 = 2389.5 MHz, Stop = 2439.5 MHz
2: Start = 2439.5 MHz, Stop = 2489.5 MHz

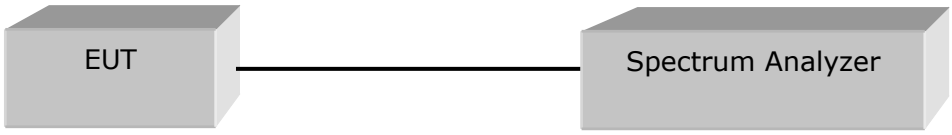
b) RBW = 300 kHz (To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller)

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

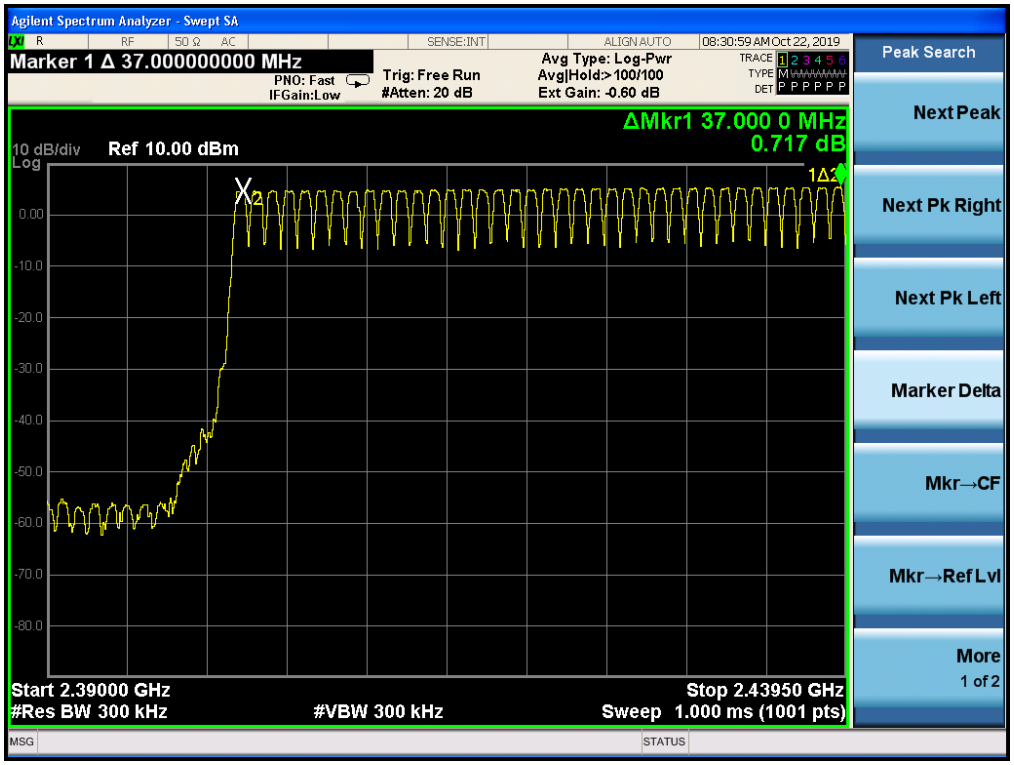
Total number of Hopping Channels	Result
79	Complies

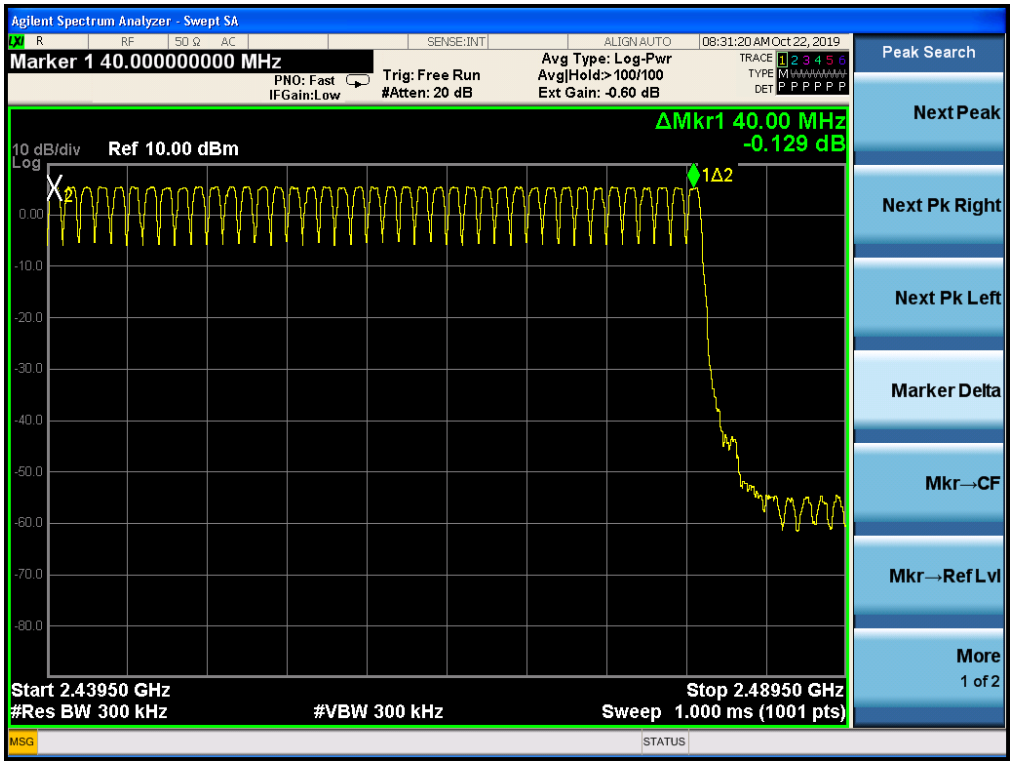
Test mode : 8-DPSK

Total number of Hopping Channels	Result
79	Complies

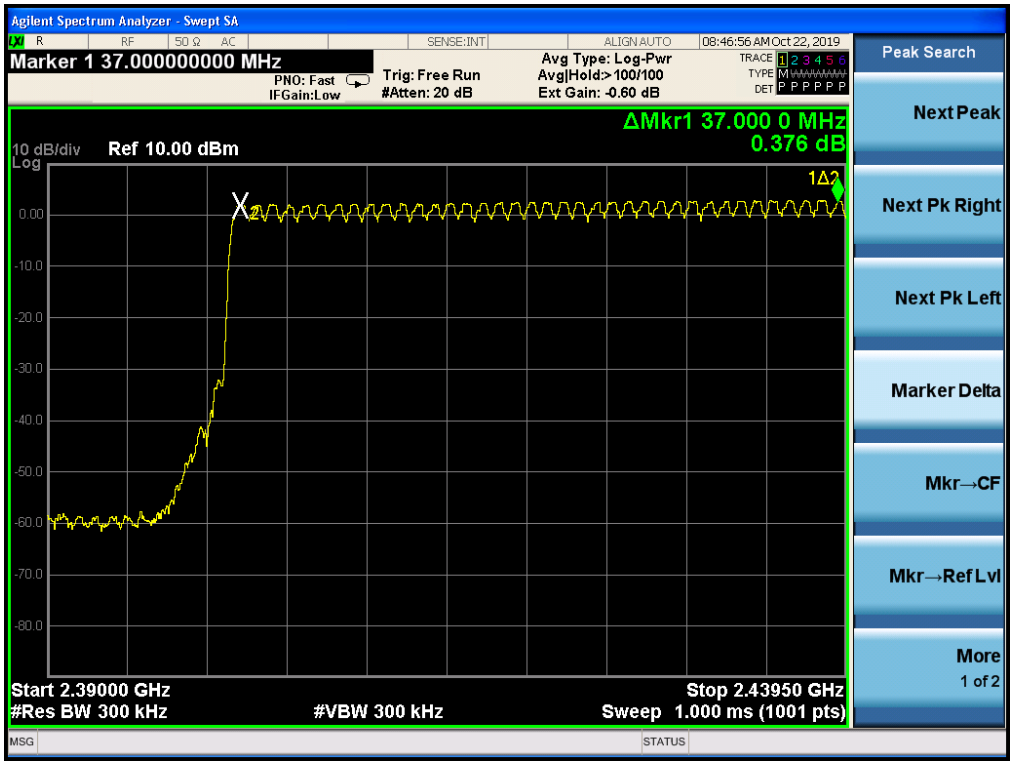
See next pages for actual measured spectrum plots.

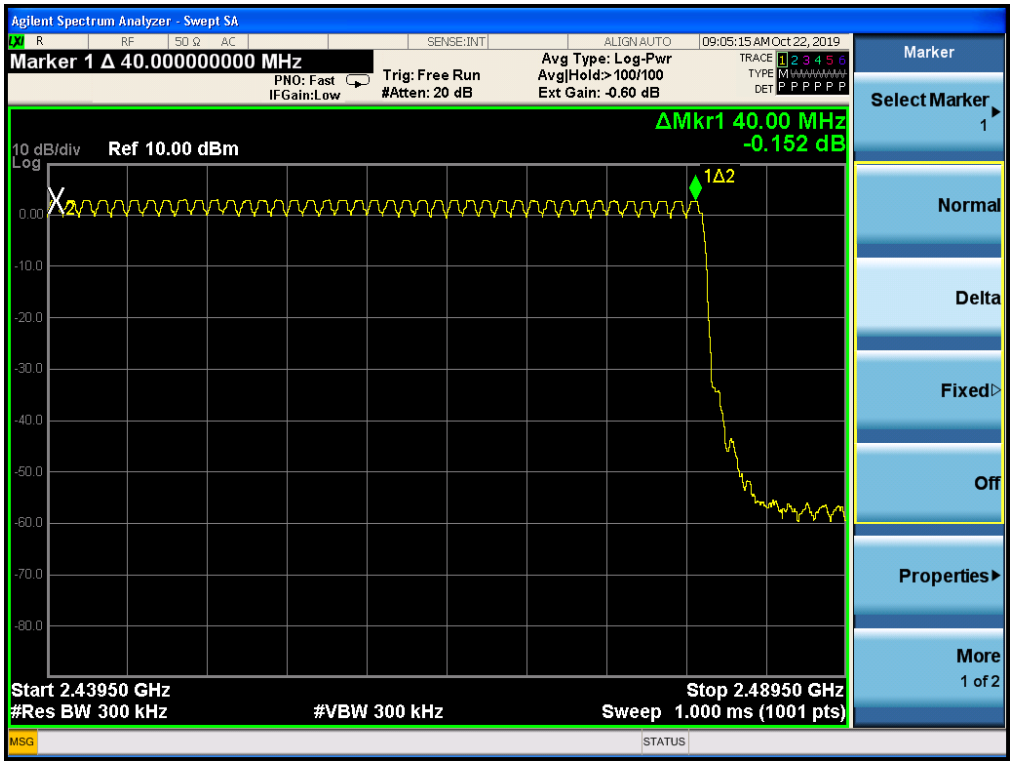
Test Mode : GFSK





Test Mode : 8-DPSK





4.3 20 dB bandwidth & 99% Bandwidth

Test Procedures

ANSI C63.10-2013 - Section 6.9.2

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.

Test Procedures

ANSI C63.10-2013 - Section 6.9.3

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)

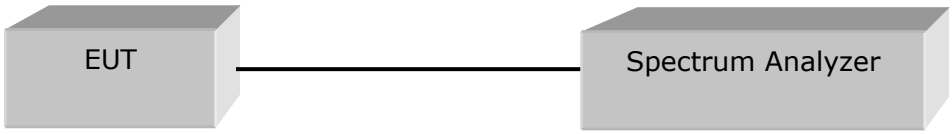
b) RBW = 30 kHz (1% to 5% of the OBW)

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
Low	2 402	0.933	0.851	Complies
Middle	2 441	0.938	0.850	Complies
High	2 480	0.942	0.854	Complies

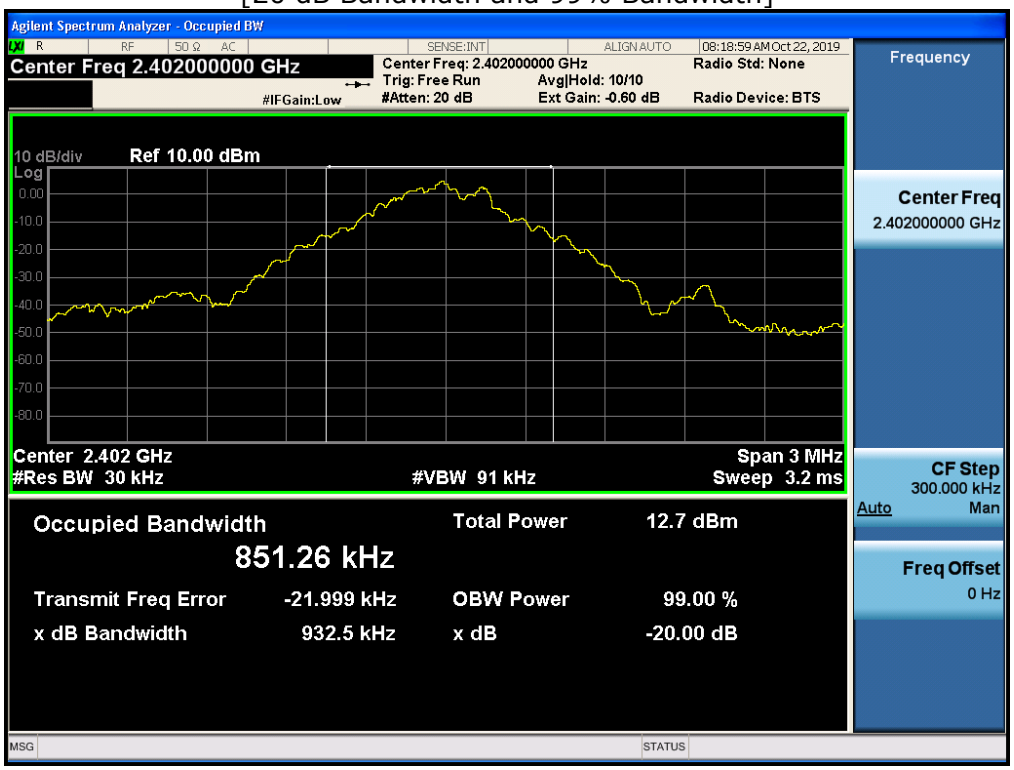
Test mode : 8-DPSK

Channel	Frequency [MHz]	20 dB Bandwidth [MHz]	99% Bandwidth [MHz]	Result
Low	2 402	1.265	1.153	Complies
Middle	2 441	1.262	1.153	Complies
High	2 480	1.271	1.159	Complies

See next pages for actual measured spectrum plots.

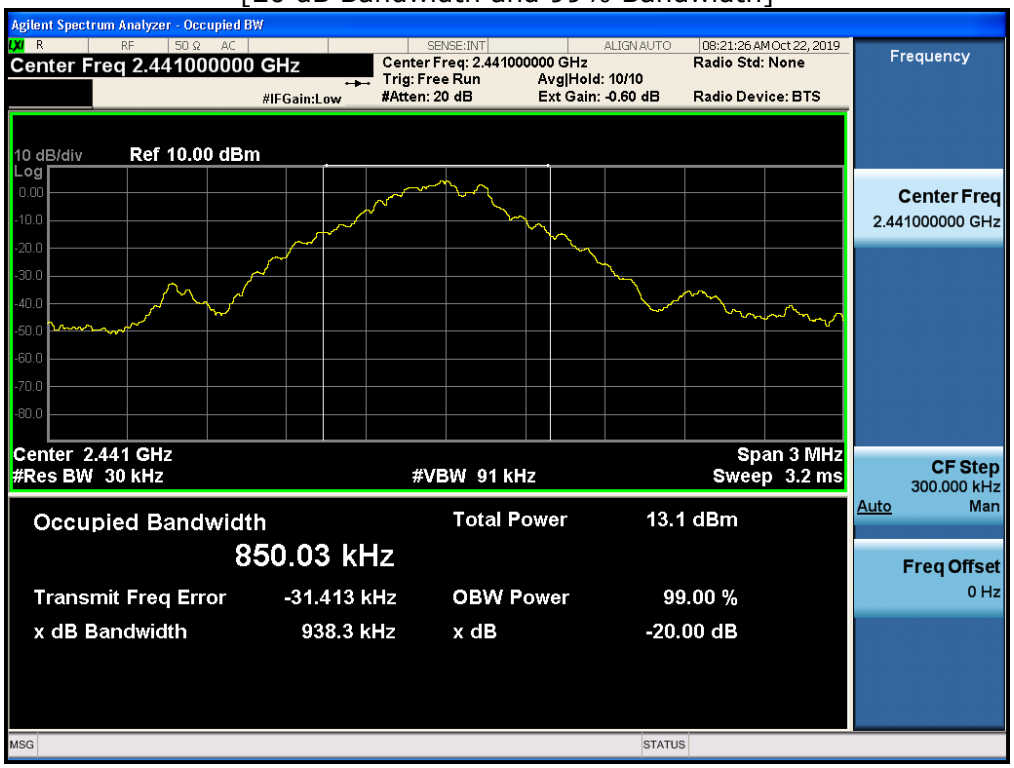
GFSK - Lowest Frequency (2 402 MHz)

[20 dB Bandwidth and 99% Bandwidth]



GFSK - Middle Frequency (2 441 MHz)

[20 dB Bandwidth and 99% Bandwidth]

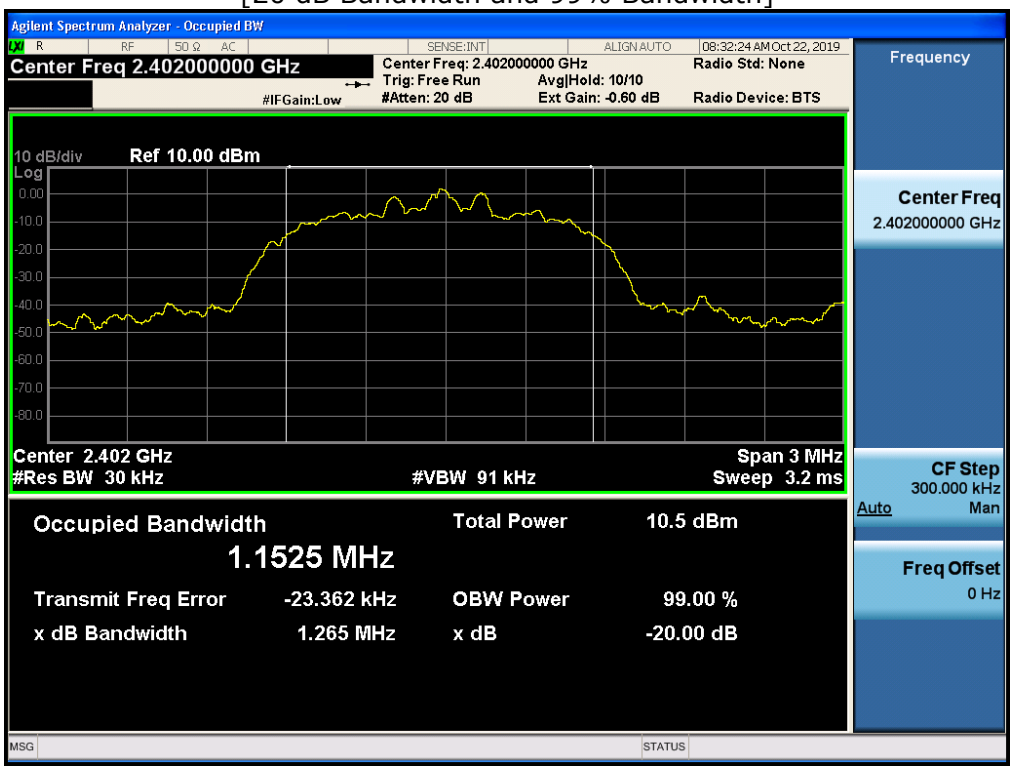


GFSK - Highest Frequency (2 480 MHz)

[20 dB Bandwidth and 99% Bandwidth]

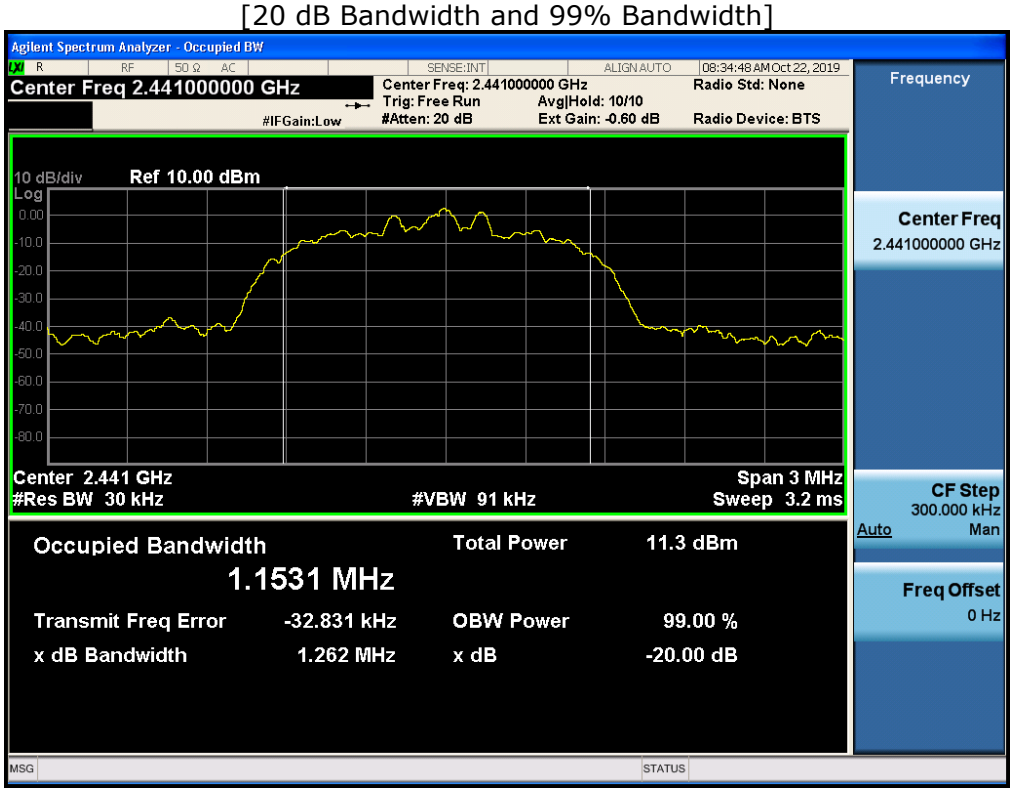
8-DPSK - Lowest Frequency (2 402 MHz)

[20 dB Bandwidth and 99% Bandwidth]



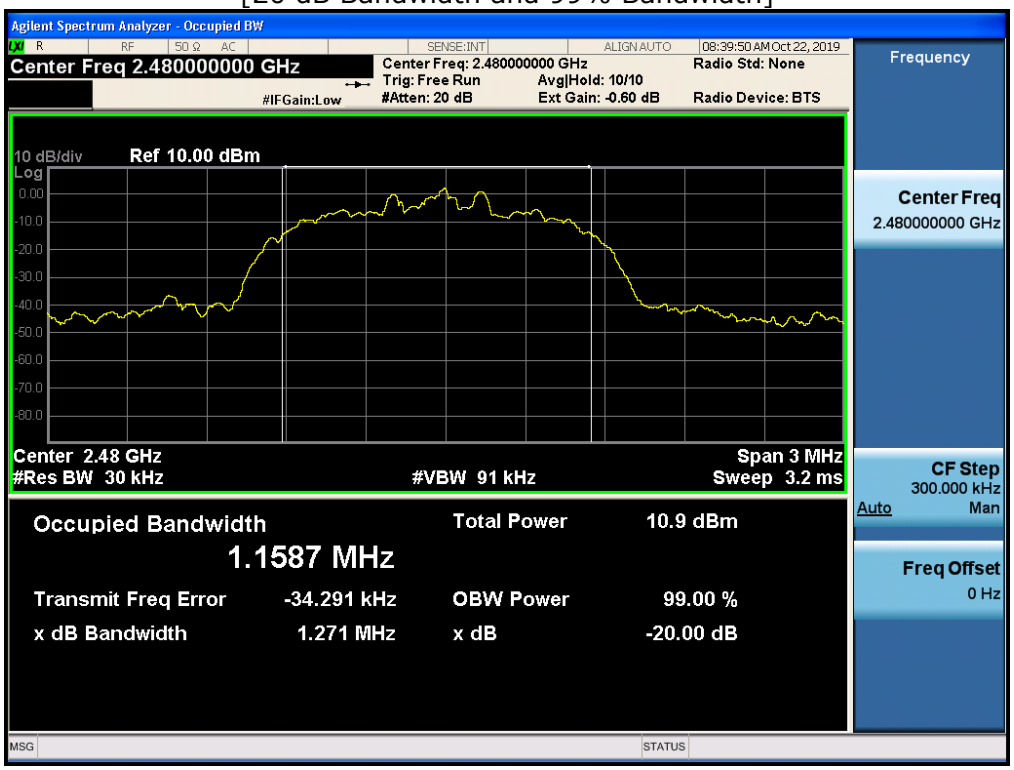
8-DPSK - Middle Frequency (2 441 MHz)

[20 dB Bandwidth and 99% Bandwidth]



8-DPSK - Highest Frequency (2 480 MHz)

[20 dB Bandwidth and 99% Bandwidth]



4.4 Time of Occupancy

Test Procedures

ANSI C63.10-2013 - Section 7.8.4

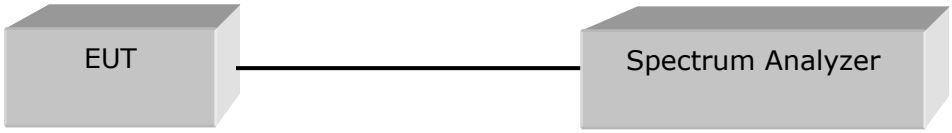
The dwell time was measured with a spectrum analyzer connected to the antenna terminal, while EUT has its hopping function enabled.

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)



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

Test mode : GFSK

Mode	Number of hops Channels	Transmit time per hop(msec)	Result (msec)	Limit (msec)
DH1	79	0.395	**126.40**	400
DH3	79	1.655	**264.80**	400
DH5	79	2.900	**309.33**	400

Test mode : 8-DPSK

Mode	Number of hops Channels	Transmit time per hop(msec)	Result (msec)	Limit (msec)
3-DH1	79	0.415	**132.80**	400
3-DH3	79	1.660	**265.60**	400
3-DH5	79	2.910	**310.40**	400

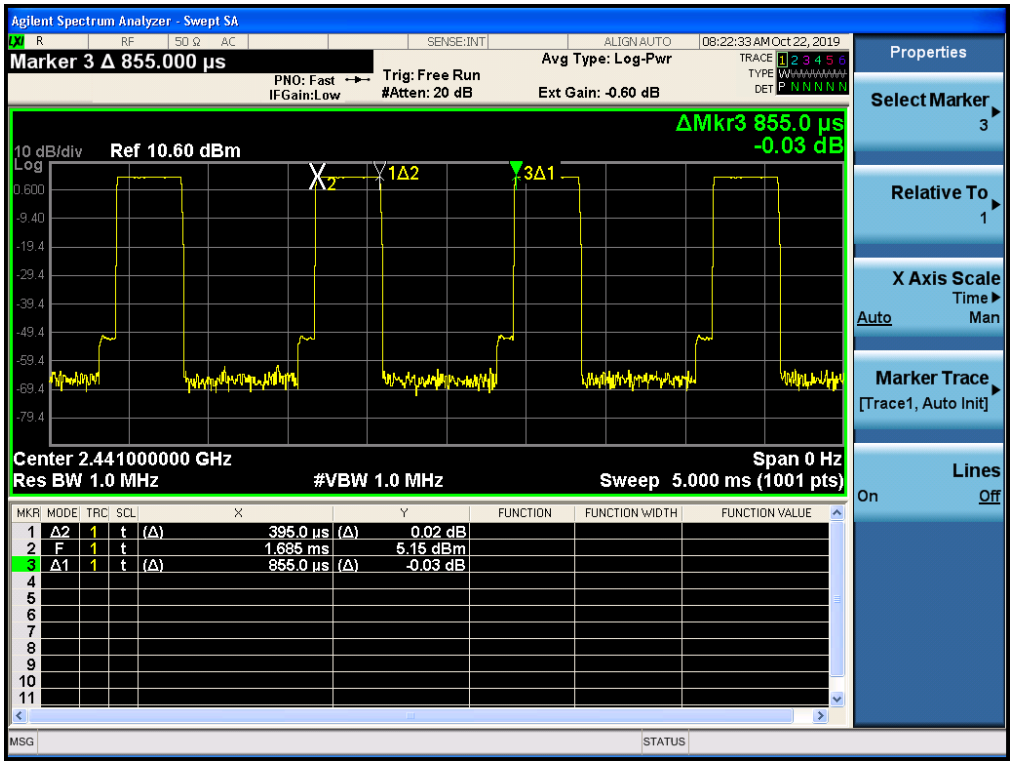
※ Remark:

Average time of occupancy = Transmit time per hop * Number of hopping channels in 31.6s

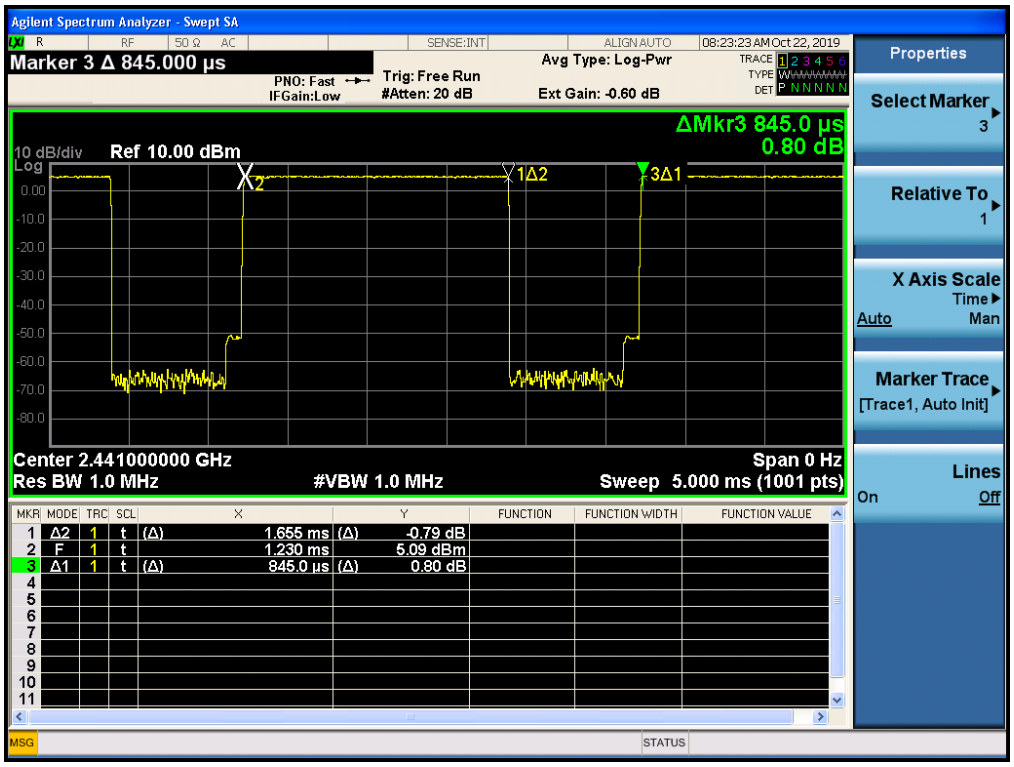
According the BLUETOOTH STANDARD SPECIFICATION, the nominal hop rate is 1600 hop/s. All bluetooth units participating in the piconet are time and hop synchronized to the channel.
- The maximum number of hopping channels in 31.6s for DH1 = 1600 / 2 / 79 * 31.6 = 320
- The maximum number of hopping channels in 31.6s for DH3 = 1600 / 4 / 79 * 31.6 = 160
- The maximum number of hopping channels in 31.6s for DH5 = 1600 / 6 / 79 * 31.6 = 107

See next pages for actual measured spectrum plots.

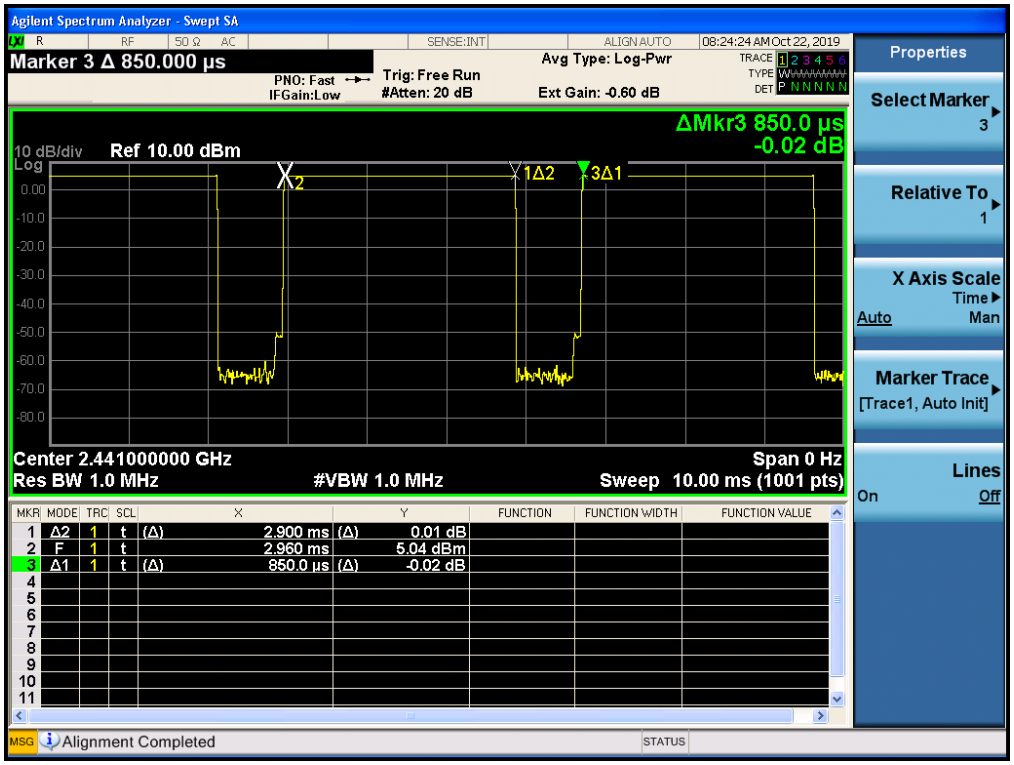
Transmit time for PACKET Type DH1(GFSK)



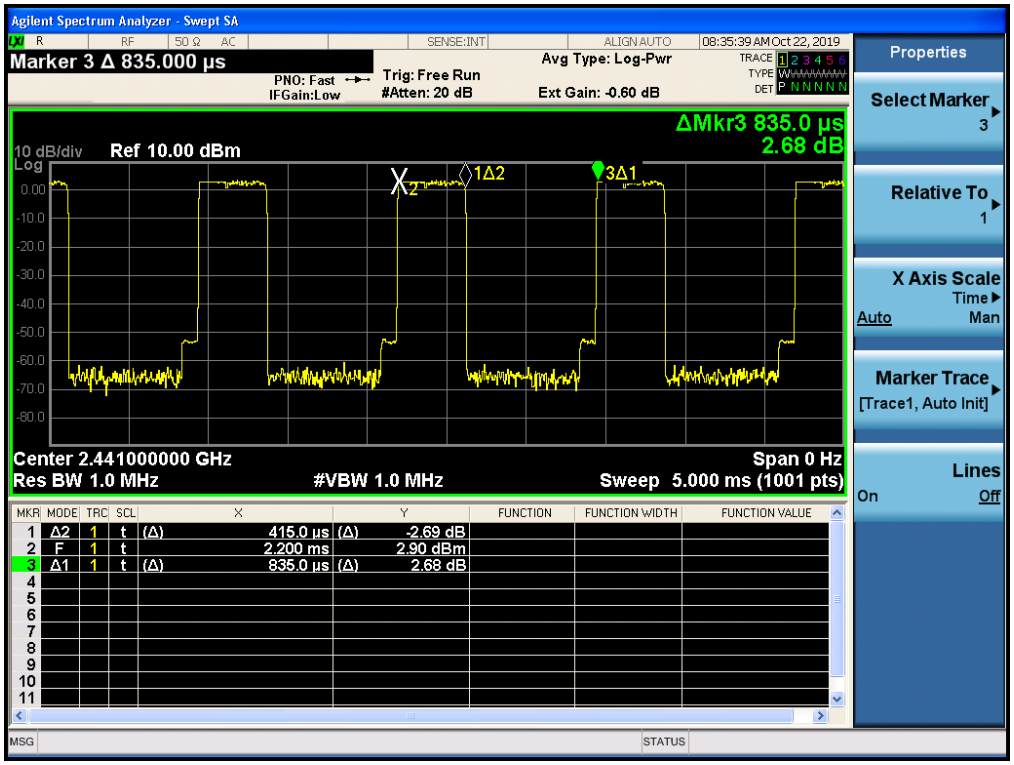
Transmit time for PACKET Type DH3(GFSK)



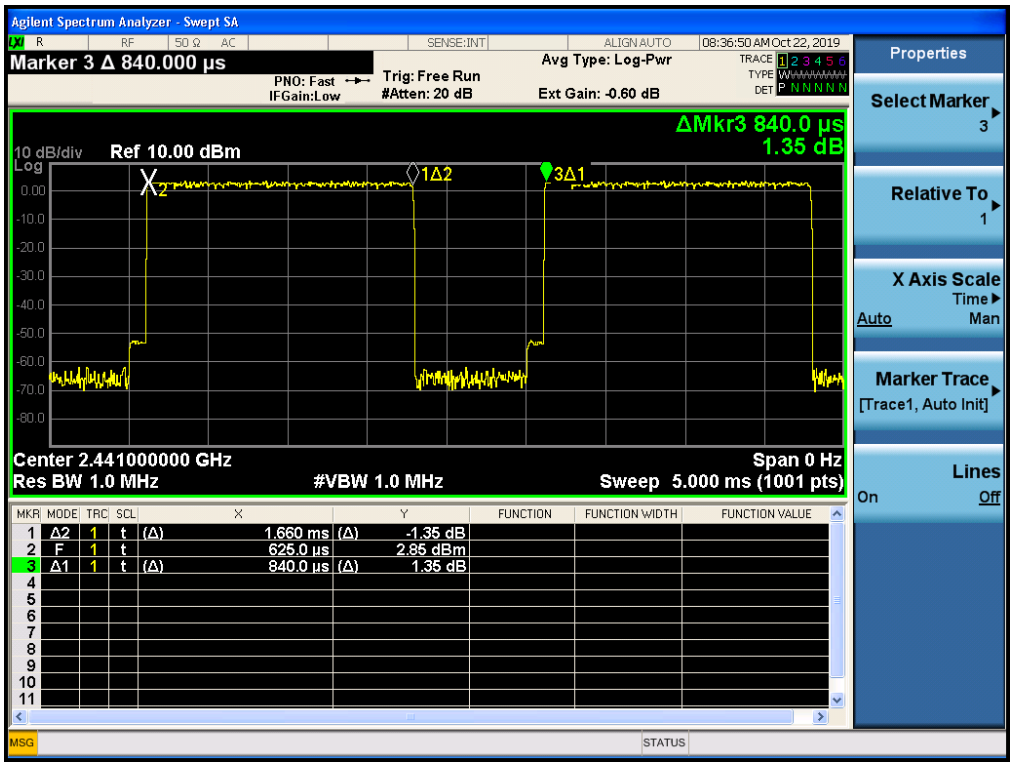
Transmit time for PACKET Type DH5(GFSK)



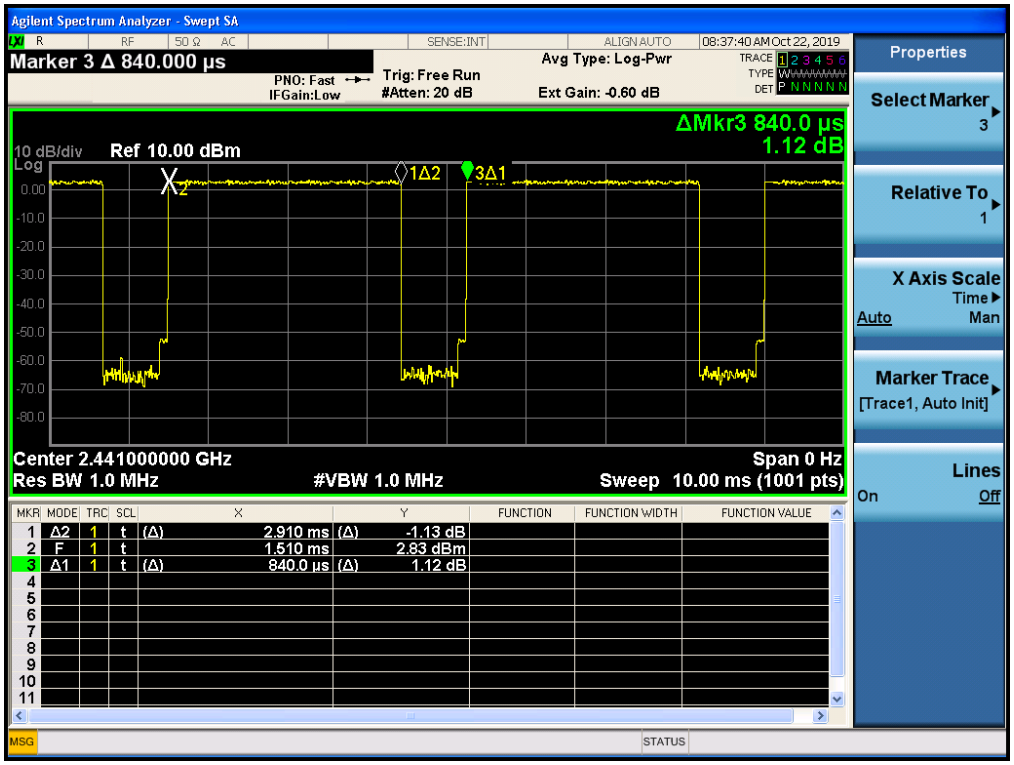
Transmit time for PACKET Type 3-DH1(8-DPSK)



Transmit time for PACKET Type 3-DH3(8-DPSK)



Transmit time for PACKET Type 3-DH5(8-DPSK)



4.5 Maximum peak Conducted Output Power

Test Procedures

ANSI C63.10-2013 - Section 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)

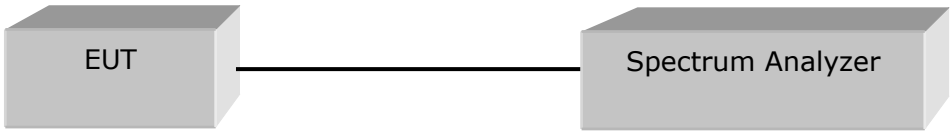
b) RBW = 3 MHz (greater than the 20 dB bandwidth of the emission being measured)

c) VBW = 3 MHz (≥ RBW)

d) Detector = peak

e) Trace = max hold

f) Sweep = auto



Limit

For FHSs operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W and the e.i.r.p. shall not exceed 4 W if the hopset uses 75 or more hopping channels.

Test Results

Test mode : GFSK

Frequency [MHz]	Channel No.	Output Power [dBm]	Output power [mW]	Result
2 402	0	4.961	3.134	Complies
2 441	39	5.433	3.494	Complies
2 480	78	5.569	3.605	Complies

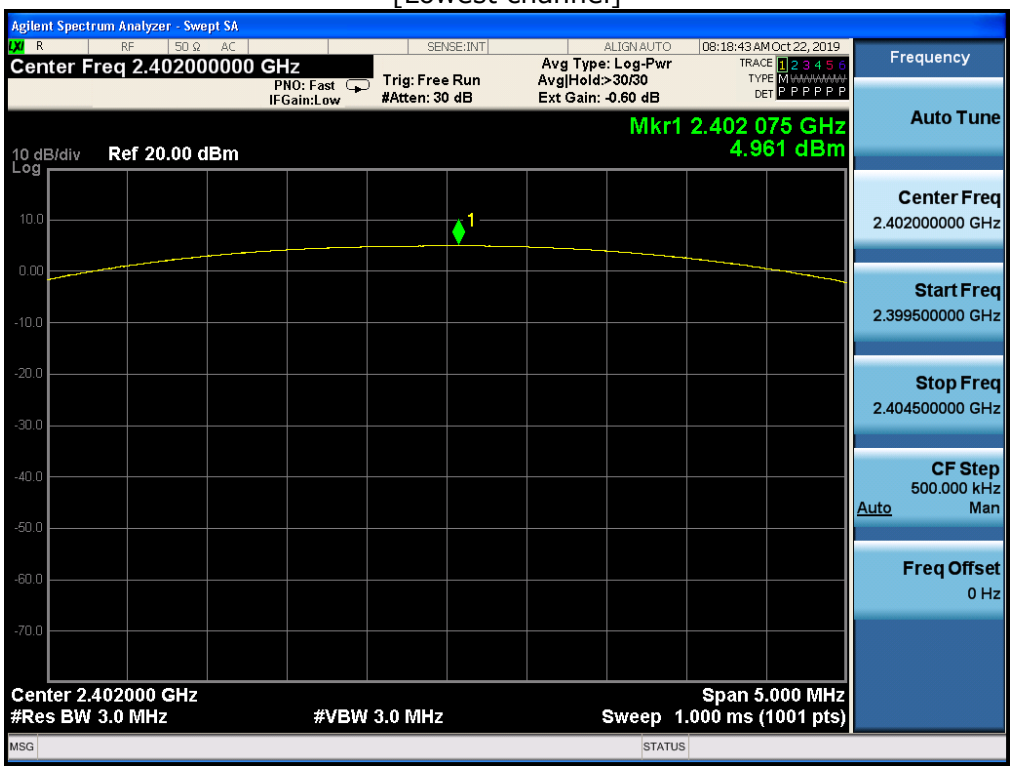
Test mode : 8-DPSK

Frequency [MHz]	Channel No.	Output Power [dBm]	Output power [mW]	Result
2 402	0	3.424	2.200	Complies
2 441	39	4.207	2.635	Complies
2 480	78	4.030	2.529	Complies

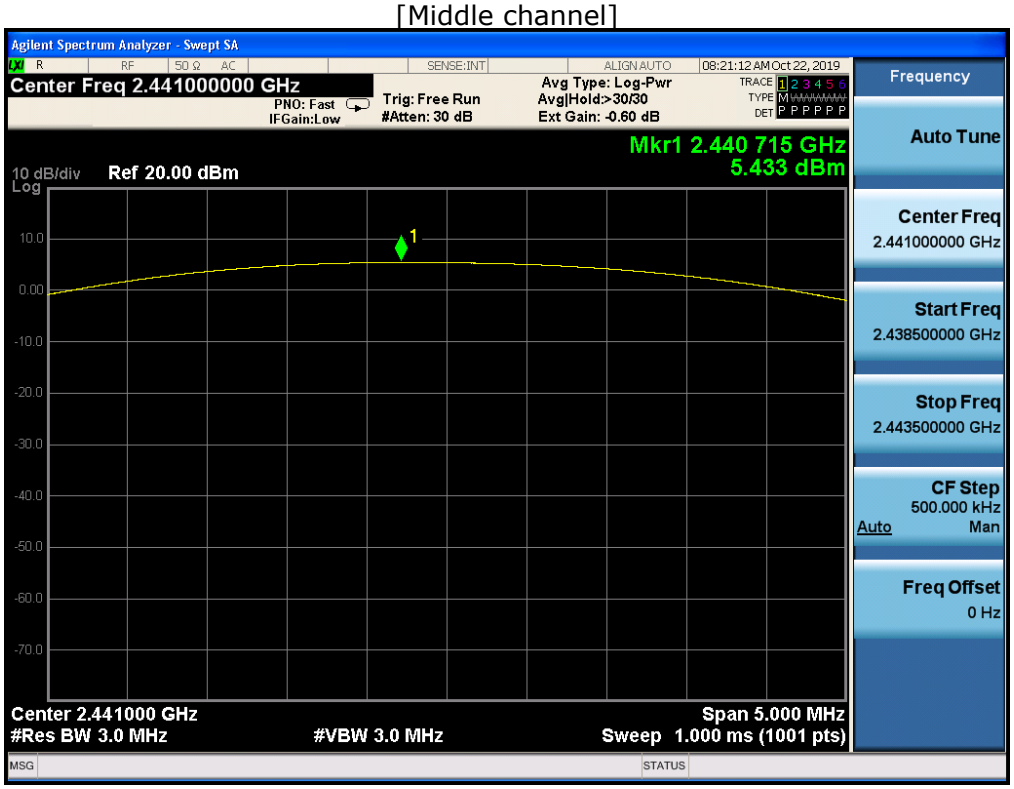
See next pages for actual measured spectrum plots.

Test Mode : GFSK

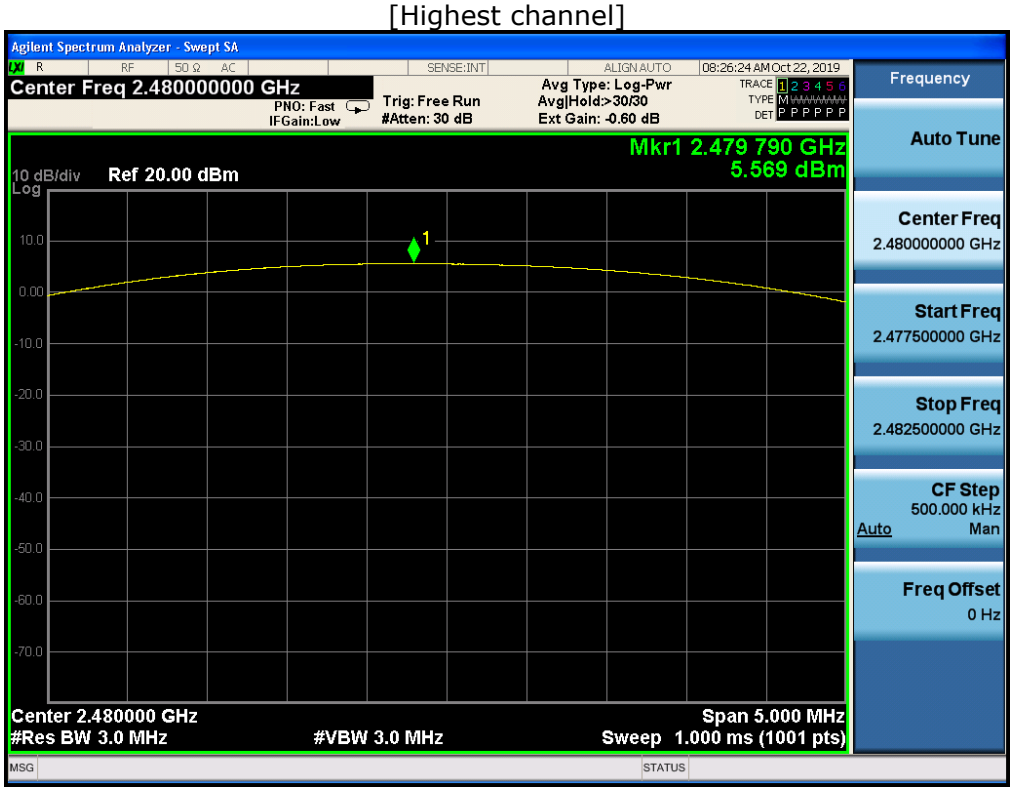
[Lowest channel]



[Middle channel]

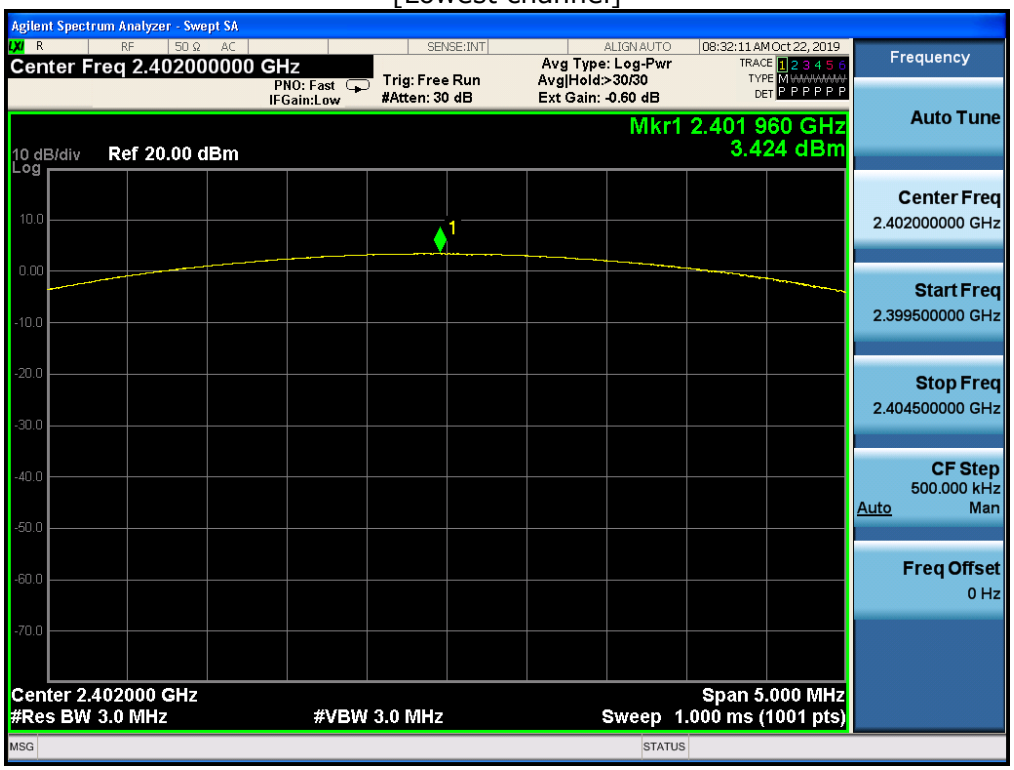


[Highest channel]

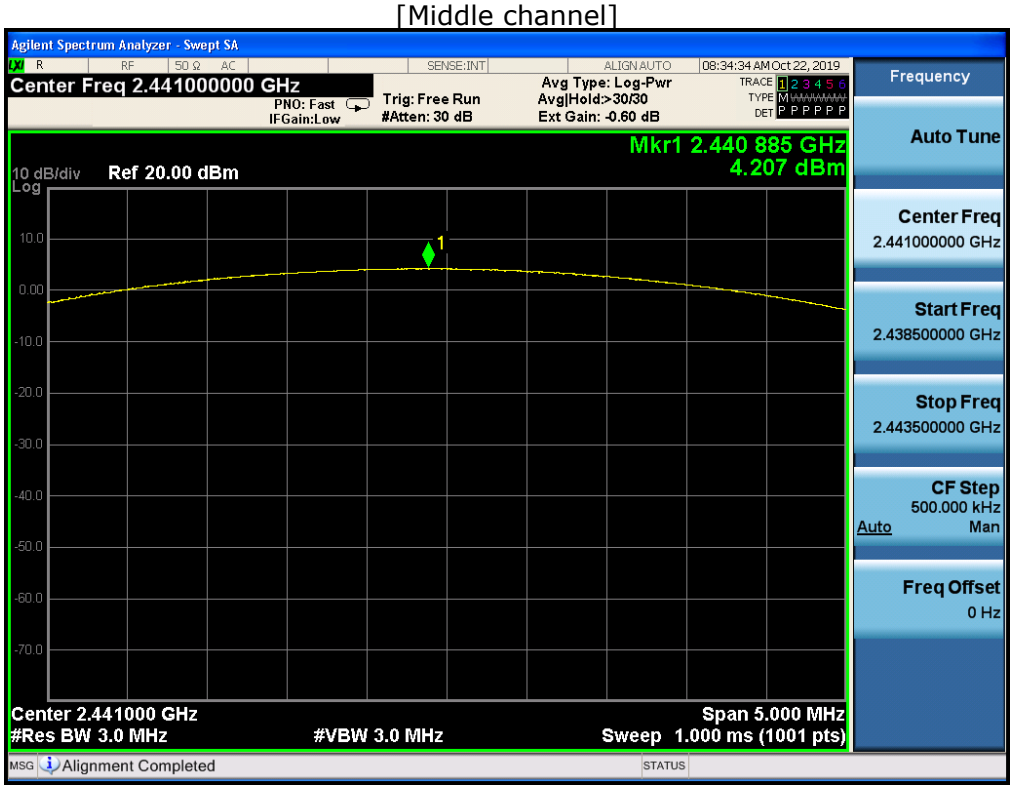


Test Mode : 8-DPSK

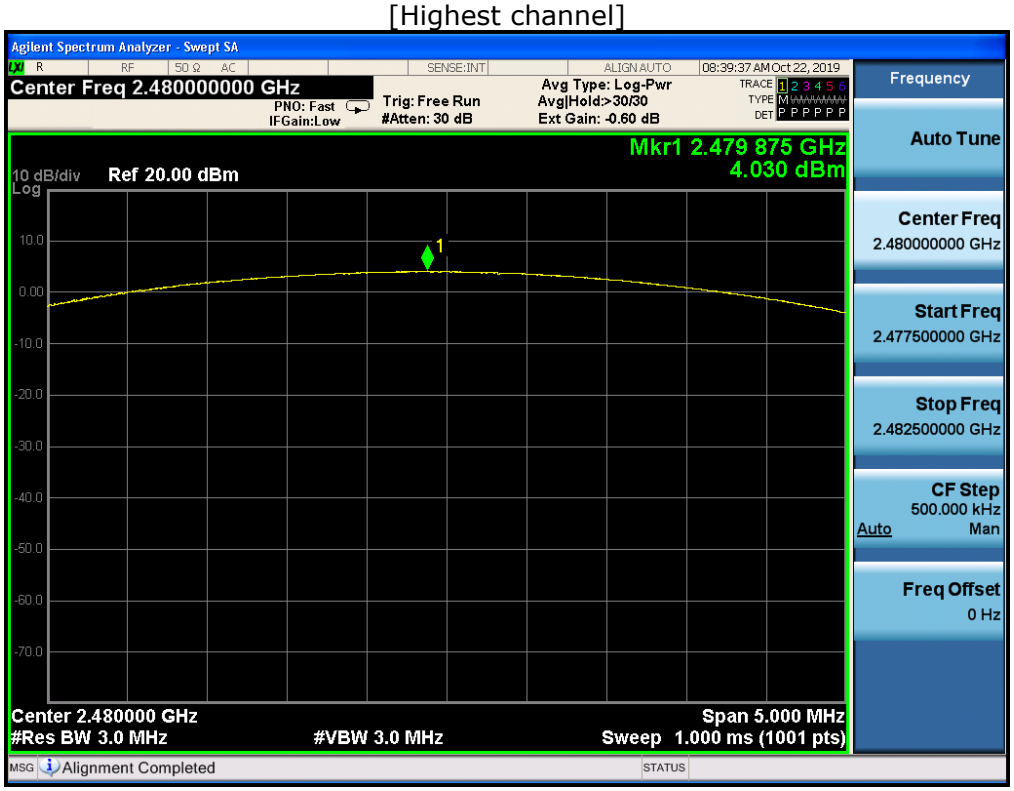
[Lowest channel]



[Middle channel]



[Highest channel]



4.6 Unwanted Emissions (Conducted)

Test Procedures

ANSI C63.10-2013 - Section 7.8.6, 7.8.8

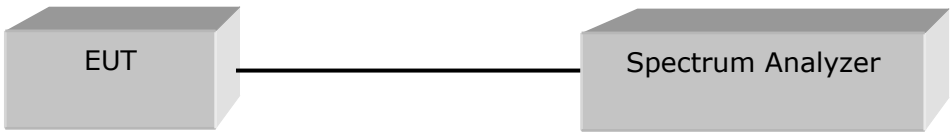
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either 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(4), 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 = 10 MHz
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.

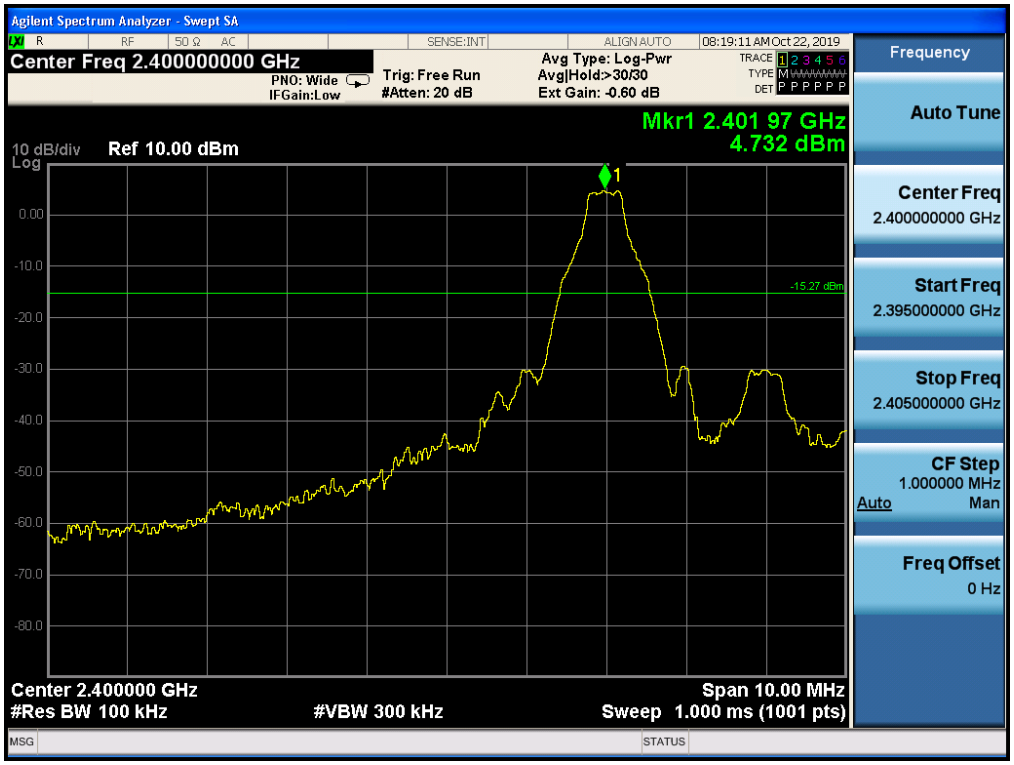
See next pages for actual measured spectrum plots.

Band Edge

Test Mode : Hopping mode, GFSK

Test Mode : Hopping mode, 8-DPSK

Test Mode : Non-Hopping mode, GFSK

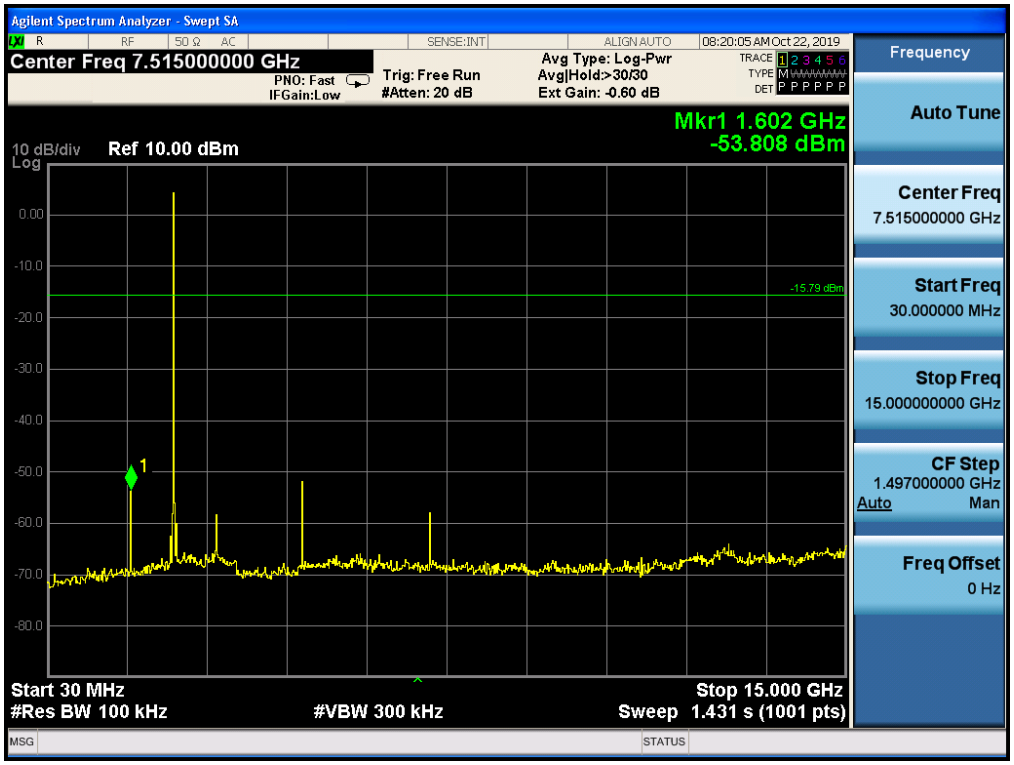


Test Mode : Non-Hopping mode, 8-DPSK

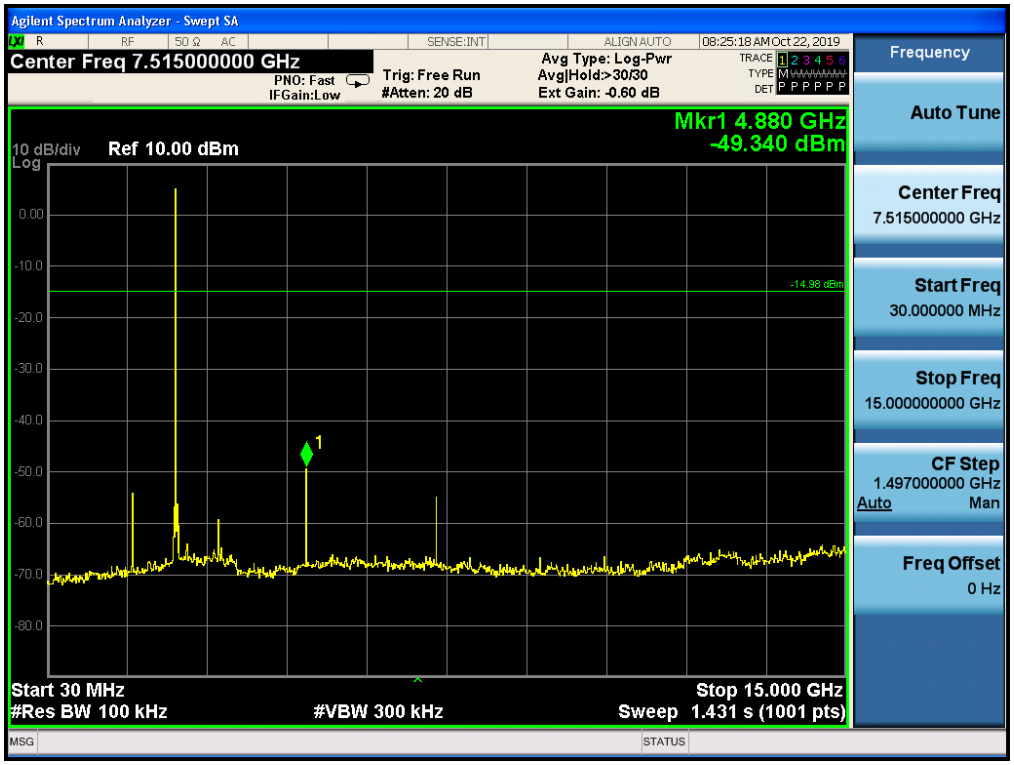
Spurious Emission

Test Mode : GFSK

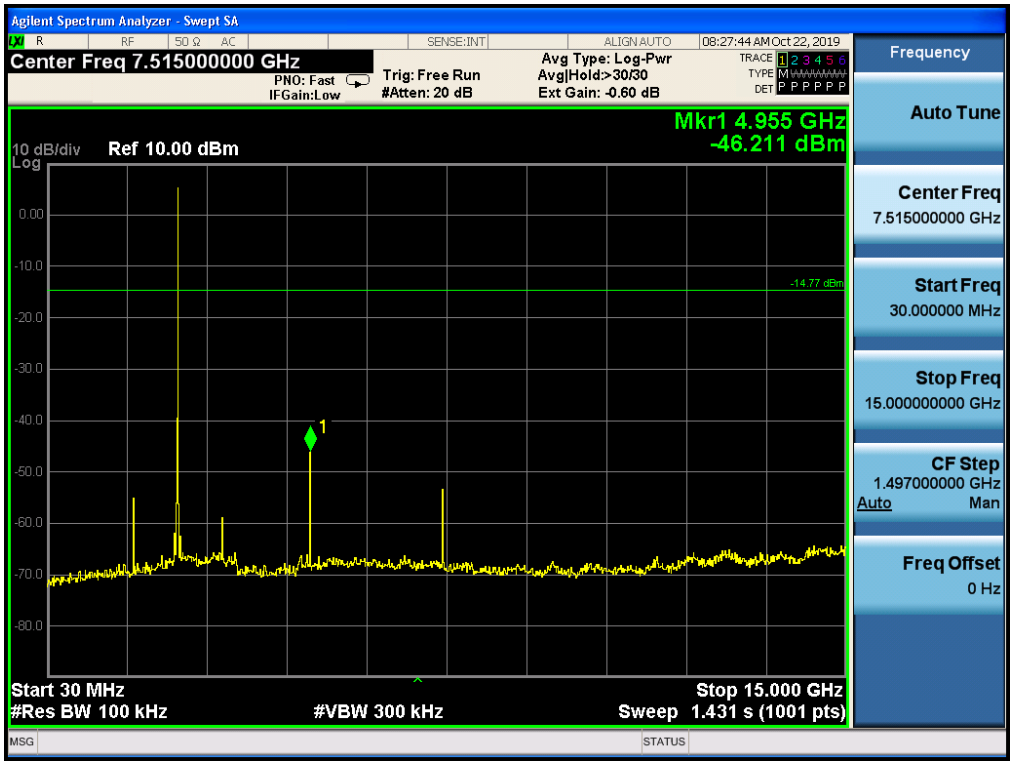
[Lowest channel]



[Middle Channel]

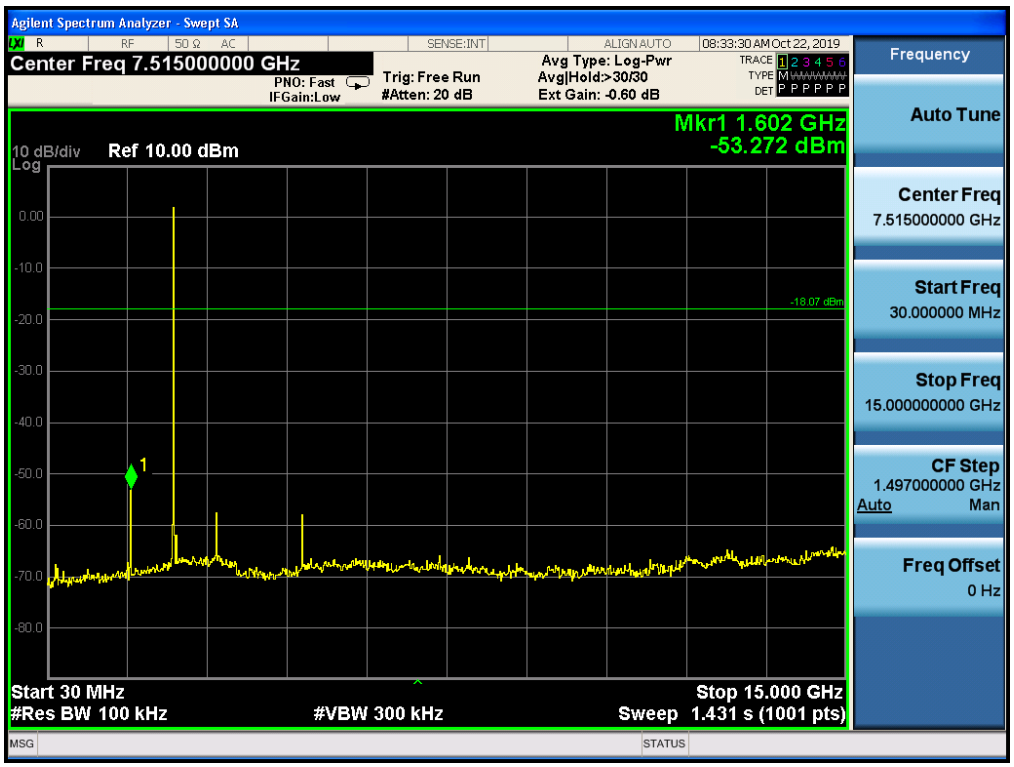


[Highest Channel]

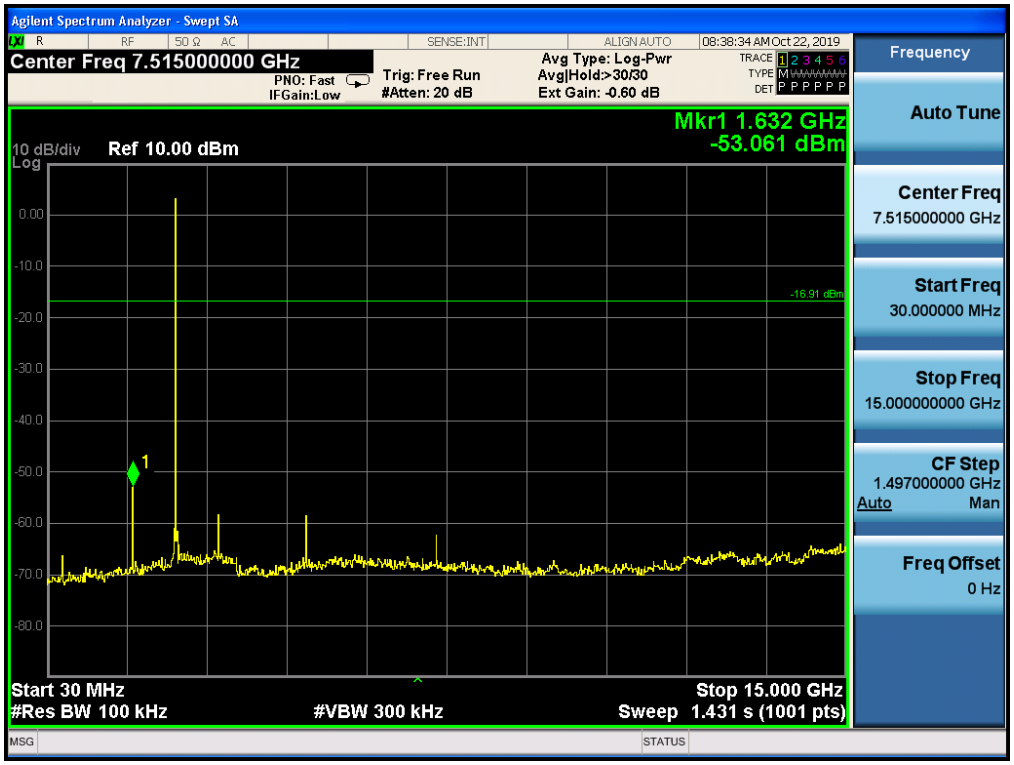


Test Mode : 8-DPSK

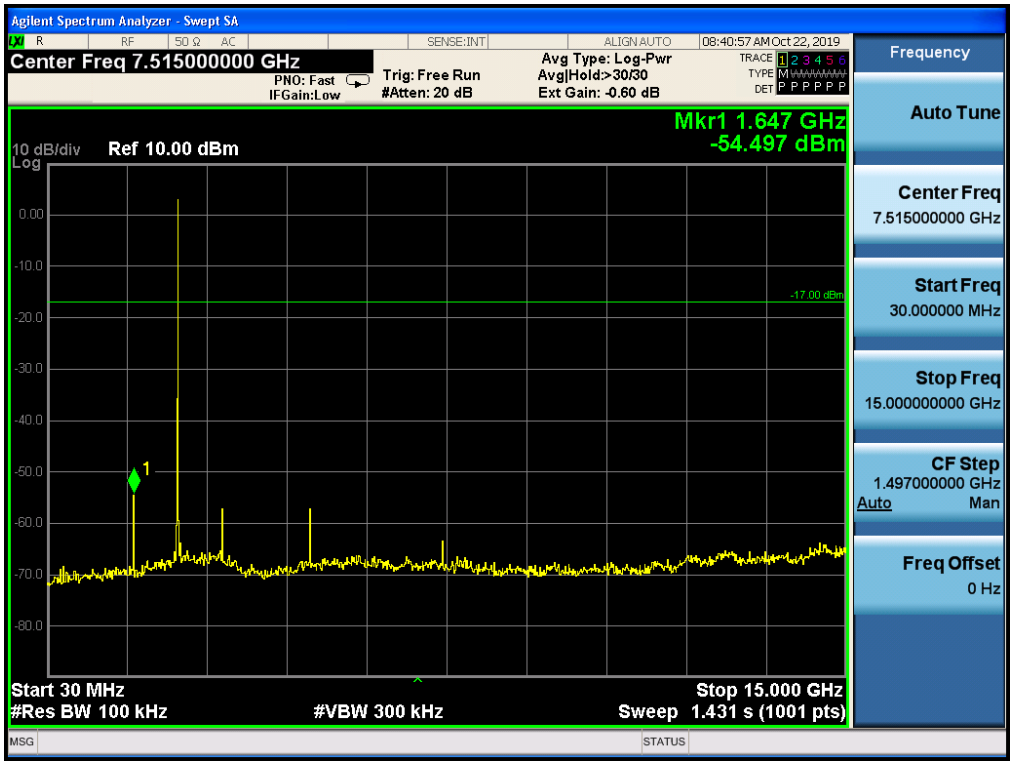
[Lowest channel]



[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

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 ~ 25 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

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.

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 :

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@3m	Field Strength dBuV/m@3m	Measurement Distance (meters)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705-30	30	-	30
30-88	100**	40	3
88-216	150**	43.5	3
216-960	200**	46	3
Above 960	500	54	3

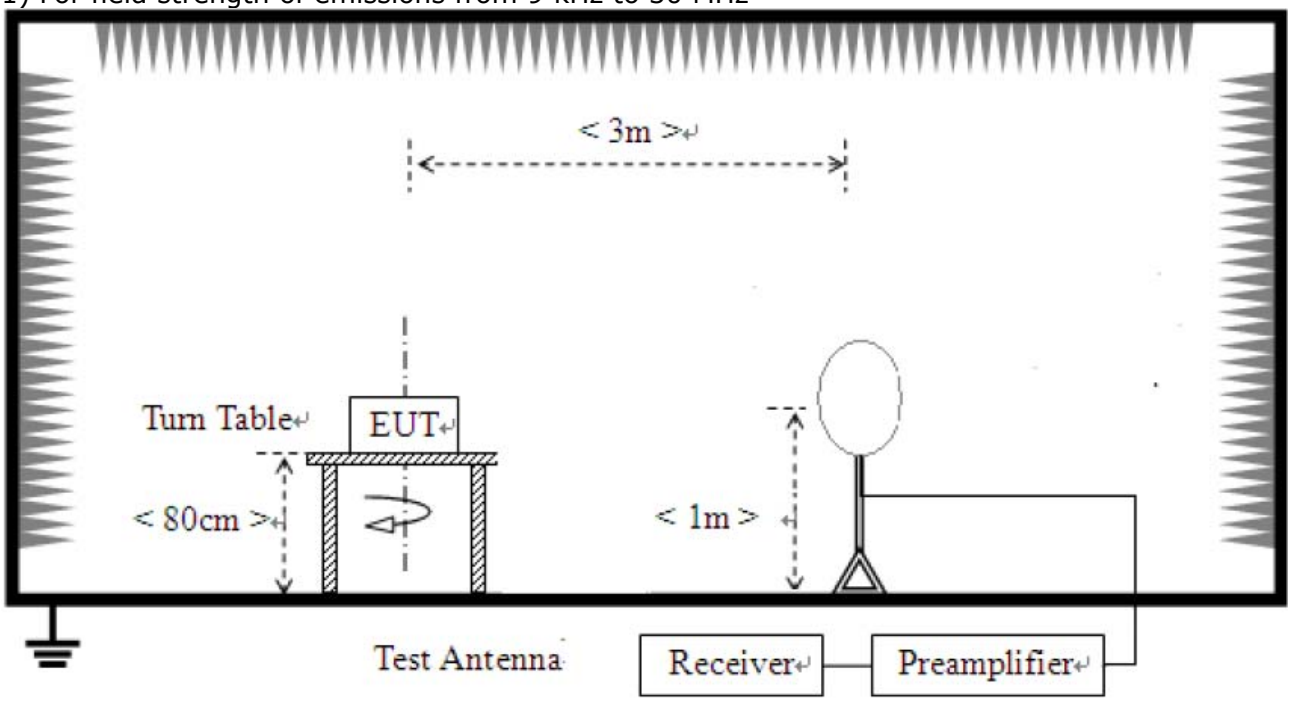
** Except as provided in 15.209(g).fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72MHz, 76-88MHz, 174-216MHz, 470-806MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g.15.231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

Note :

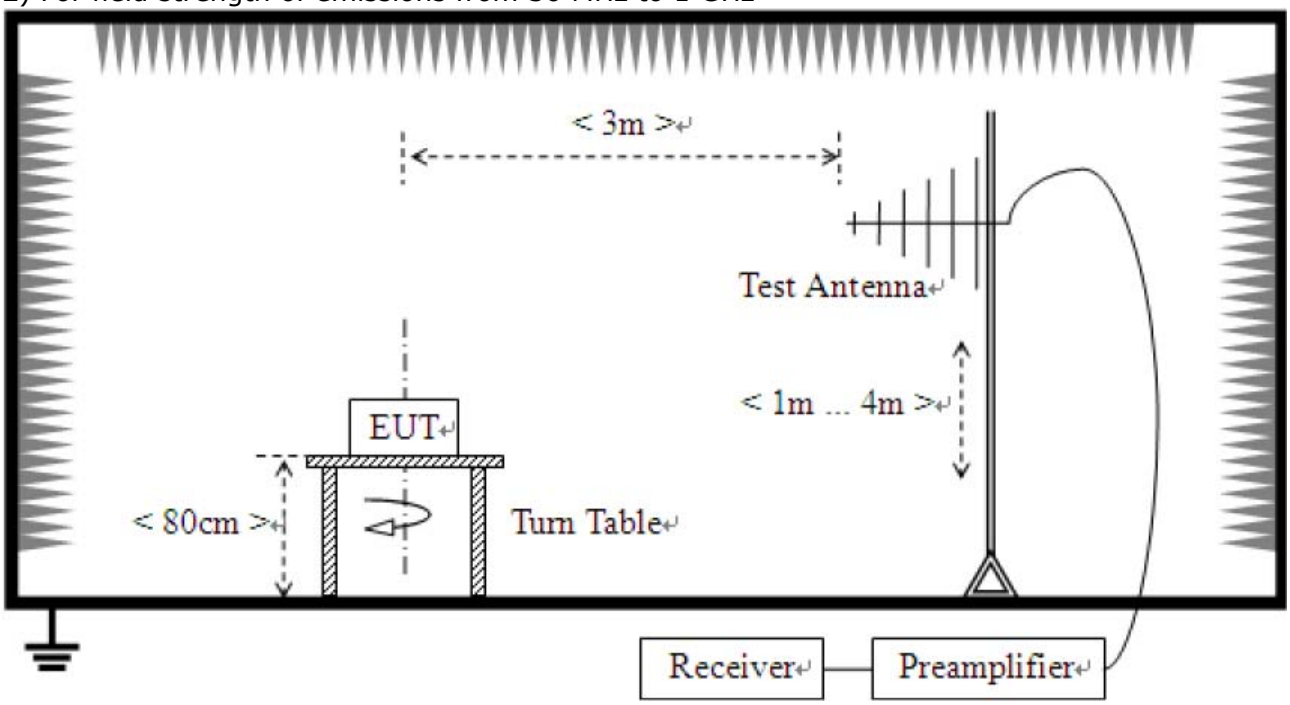
1) For above 1 GHz, the emission limit in this paragraph is based on measurement instrumentation employing an average detector, measurement using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit.
2) For above 1 GHz, limit field strength of 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 1 MHz for peak measurement and 10 Hz for average measurement.(Duty Cycle is > 98%,)
4) Duty Cycle is < 98%, VBW setting will need to > 1/T.
5) DCCF = Duty Cycle Correction Factor
   DCCF = 20*Log(T_{on}/100 ms)
   T_{on} = 2.901 ms(GFSK) / 2.912 ms(8-DPSK)
   DCCF = -30.75 dB(GFSK) / -30.72 dB(8-DPSK)
   Result Average = Result Peak + DCCF

Test Setup:

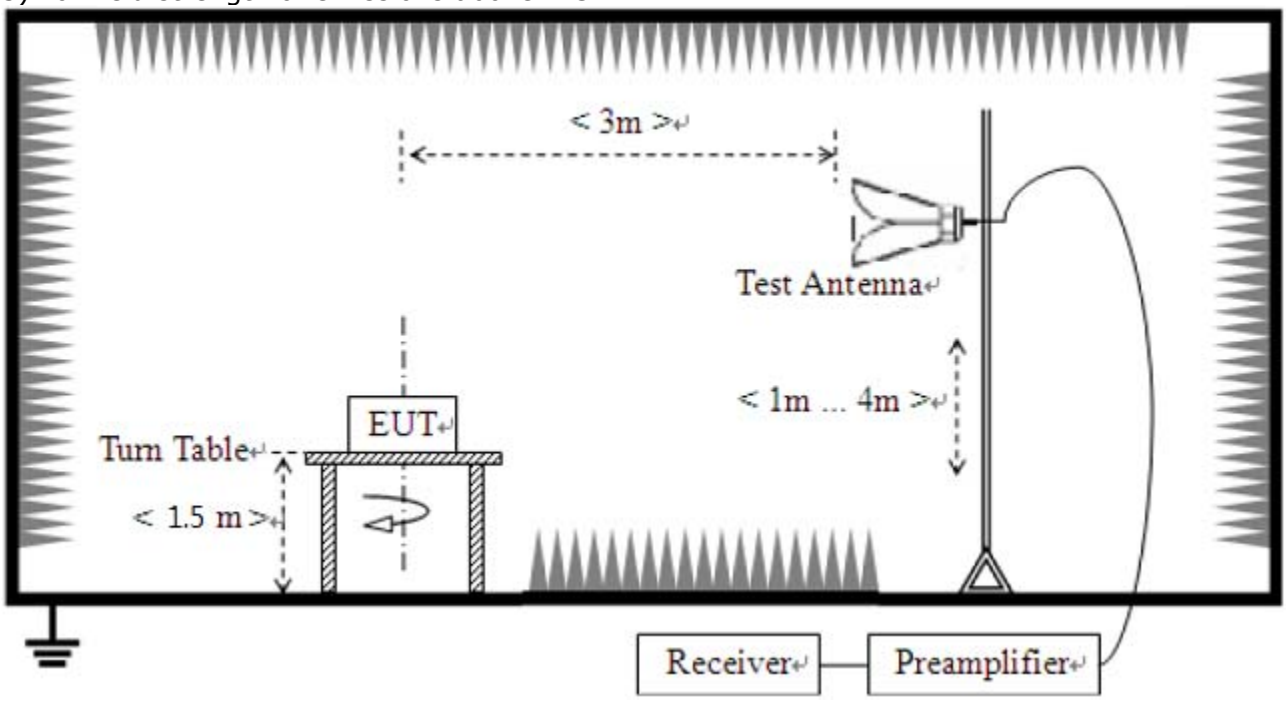
1) For field strength of emissions from 9 kHz to 30 MHz



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



3) For field strength of emissions above 1 GHz



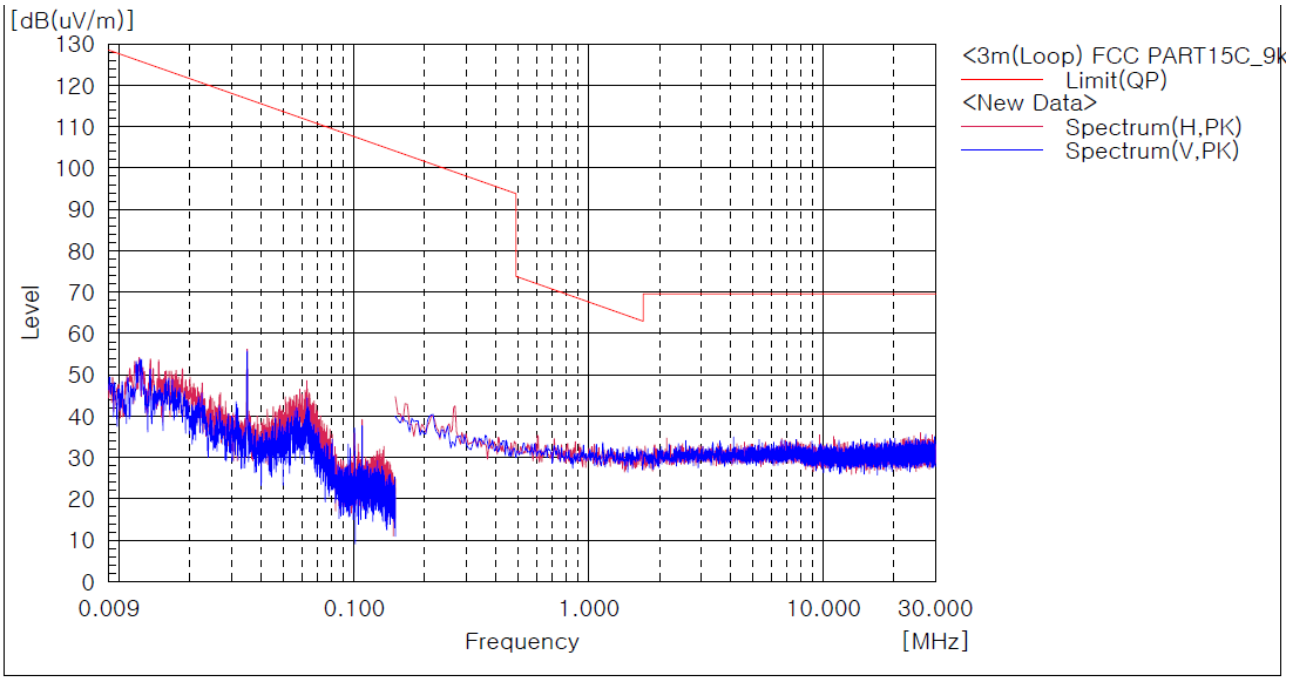
Test results

1) 9 kHz to 30 MHz

Test mode : Transmitter (Worst Case)

The requirements are:
☒ Complies

Test Data



Frequency (MHz)	Measured Data (dBuV/m)	Margin (dB)	Remark
The emissions 9 kHz to 30 MHz were 20 dB lower than the limit.			

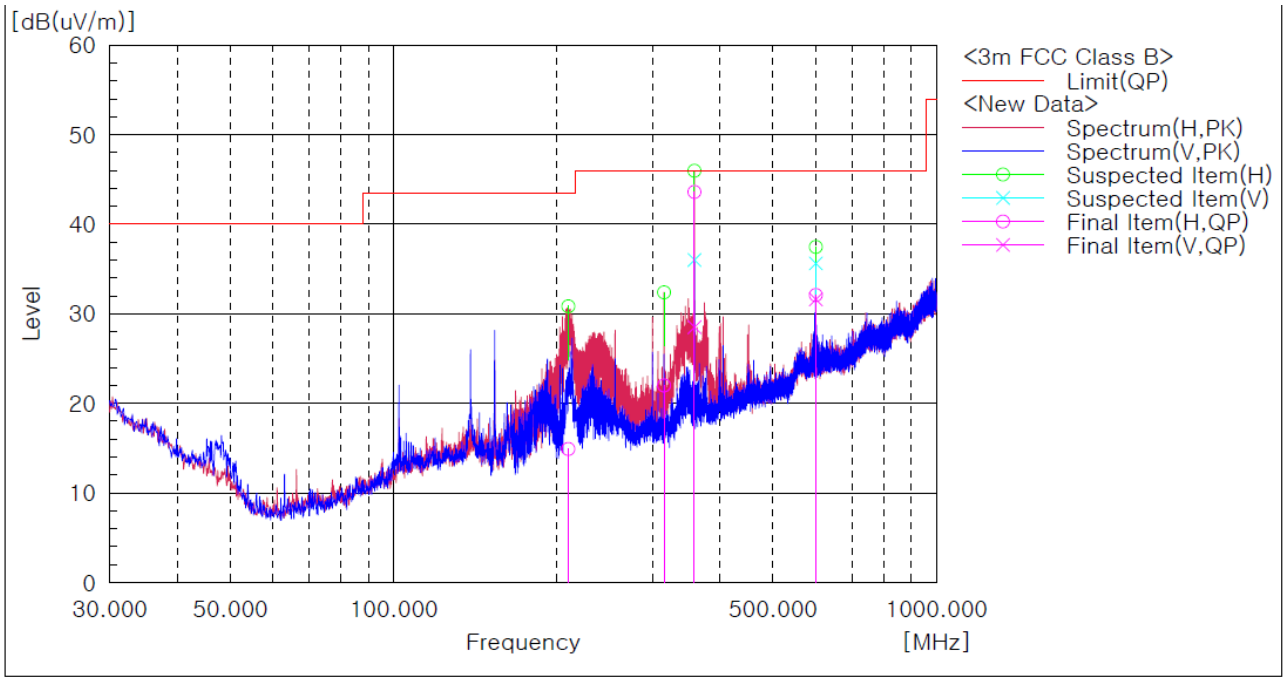
Remark :
1. The unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down positon(X,Y axis). The worst emission was found in lie-down position(X axis) and the worst case was recorded.
2. Result = Reading + c.f(Correction factor)
3. Correction factor = Antenna factor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

2) 30 MHz to 1 GHz

Test mode : Transmitter (Worst Case)

The requirements are:
☒ Complies

Test Data



Final Result

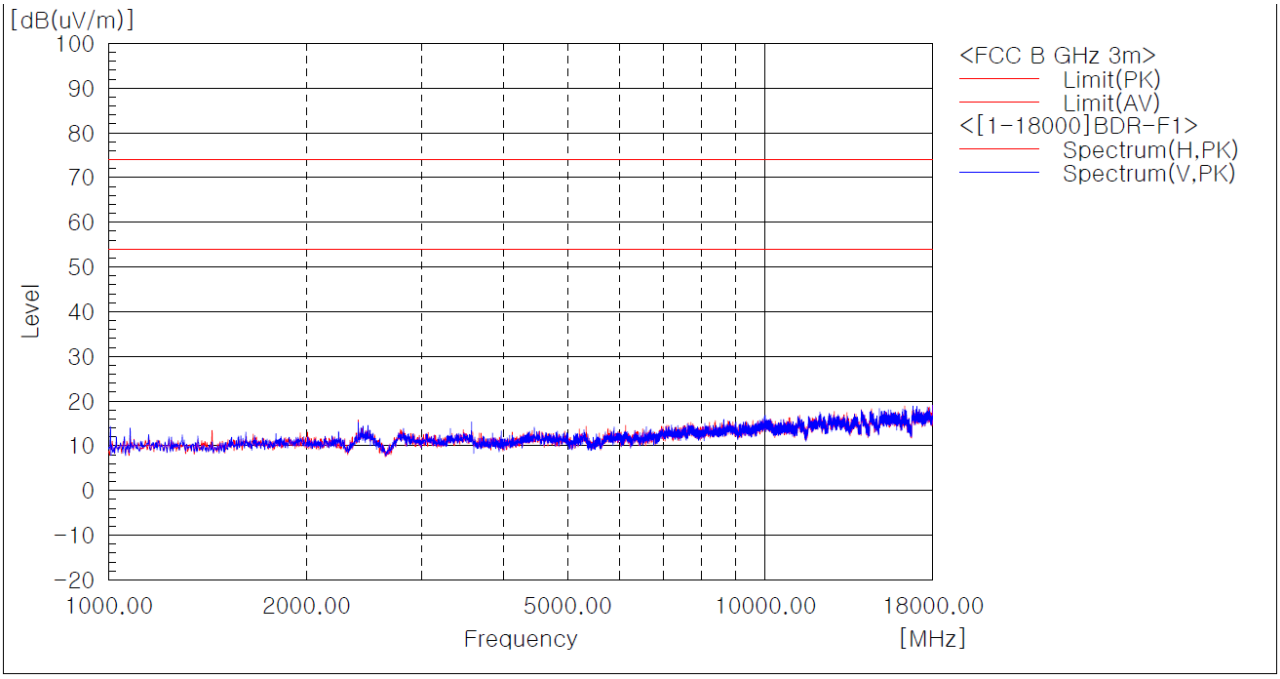
No.	Frequency [MHz]	(P)	Reading QP [dB(uV)]	c.f [dB(1/m)]	Result QP [dB(uV/m)]	Limit QP [dB(uV/m)]	Margin QP [dB]	Height [cm]	Angle [deg]
1	209.935	H	28.2	-13.3	14.9	43.5	28.6	101.0	71.0
2	315.059	H	30.1	-8.1	22.0	46.0	24.0	101.0	71.0
3	358.345	H	50.2	-6.6	43.6	46.0	2.4	101.0	71.0
4	358.345	V	35.1	-6.6	28.5	46.0	17.5	101.0	289.0
5	599.996	H	32.5	-0.4	32.1	46.0	13.9	309.0	265.0
6	599.996	V	32.0	-0.4	31.6	46.0	14.4	101.0	3.0

Remark :
1. 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

3) above 1 GHz

The requirements are:
☒ Complies

Test Data



Test mode : GFSK

Lowest frequency(2 402 MHz)

Frequency [MHz]	(P)	Limit AV [dBuV/m]	Limit PK [dBuV/m]	Result AV [dBuV/m]	Result PK [dBuV/m]	Margin AV [dB]	Margin PK [dB]
The emissions above 1 GHz were 20 dB lower than the limit.							

Middle frequency(2 441 MHz)

Frequency [MHz]	(P)	Limit AV [dBuV/m]	Limit PK [dBuV/m]	Result AV [dBuV/m]	Result PK [dBuV/m]	Margin AV [dB]	Margin PK [dB]
The emissions above 1 GHz were 20 dB lower than the limit.							

Highest frequency(2 480 MHz)

Frequency [MHz]	(P)	Limit AV [dBuV/m]	Limit PK [dBuV/m]	Result AV [dBuV/m]	Result PK [dBuV/m]	Margin AV [dB]	Margin PK [dB]
The emissions above 1 GHz were 20 dB lower than the limit.							

Remarks

1. 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) + Duty cycle c.f
3. Correction factor = Antenna factor + Cable loss - Amp Gain
4. Result Average = Result Peak + DCCF

Test mode : 8-DPSK

Lowest frequency(2 402 MHz)

Frequency [MHz]	(P)	Limit AV [dBuV/m]	Limit PK [dBuV/m]	Result AV [dBuV/m]	Result PK [dBuV/m]	Margin AV [dB]	Margin PK [dB]
The emissions above 1 GHz were 20 dB lower than the limit.							

Middle frequency(2 441 MHz)

Frequency [MHz]	(P)	Limit AV [dBuV/m]	Limit PK [dBuV/m]	Result AV [dBuV/m]	Result PK [dBuV/m]	Margin AV [dB]	Margin PK [dB]
The emissions above 1 GHz were 20 dB lower than the limit.							

Highest frequency(2 480 MHz)

Frequency [MHz]	(P)	Limit AV [dBuV/m]	Limit PK [dBuV/m]	Result AV [dBuV/m]	Result PK [dBuV/m]	Margin AV [dB]	Margin PK [dB]
The emissions above 1 GHz were 20 dB lower than the limit.							

Remarks

1. 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) + Duty cycle c.f
3. Correction factor = Antenna factor + Cable loss + 6 dB attenuator - Amp Gain
4. Result Average = Result Peak + DCCF

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

The EUT was placed on a non-metallic table 0.8m above the metallic, grounded floor and 0.4m from the reference ground plane wall. The distance to other metallic surfaces was at least 0.8m.
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:
☒ Not Applicable

Test Data

[LINE]

NA

[NEUTRAL]

NA

4.9 Frequency Hopping System Requirements

Standard Applicable

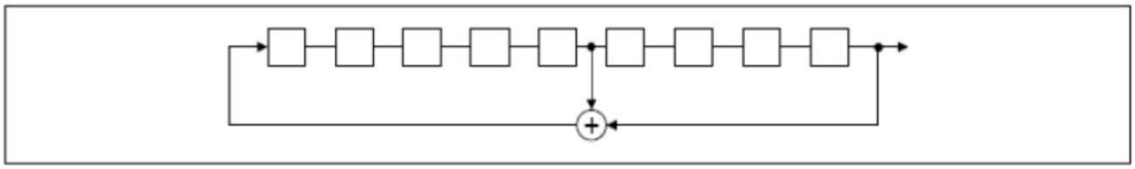
According to FCC Part 15.247(a)(1), The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(g) Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

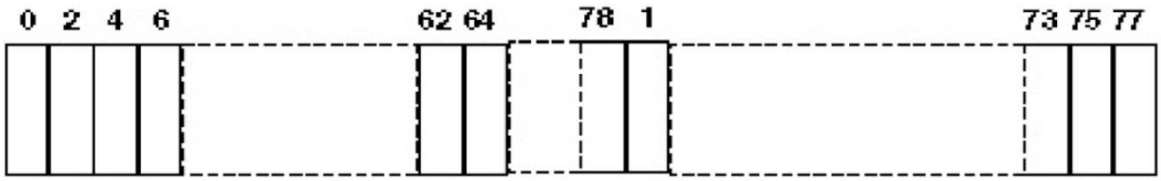
(h) The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

EUT Pseudorandom Frequency Hopping Sequence

The pseudo random sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage, and the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONEs; i.e. the shift register is initialized with nine ones. Number of shift register stages: 9 Length of pseudo-random sequence: 2^9-1 = 511 bits Longest sequence of zeros: 8 (non-inverted signal)



Linear Feedback Shift Register for Generation of the PRBS sequence



Each frequency used equally on the average by each transmitter. The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

Frequency Hopping System

This transmitter device is frequency hopping device, and complies with FCC part 15.247 rule. This device uses Bluetooth radio which operates in 2400-2483.5 MHz band. Bluetooth uses a radio technology called frequency-hopping spread spectrum, which chops up the data being sent and transmits chunks of it on up to 79 bands (1 MHz each; centred from 2402 to 2480 MHz) in the range 2,400-2,483.5 MHz. The transmitter switches hop frequencies 1,600 times per second to assure a high degree of data security. All Bluetooth devices participating in a given piconet are synchronized to the frequency-hopping channel for the piconet. The frequency hopping sequence is determined by the master's device address and the phase of the hopping sequence (the frequency to hop at a specific time) is determined by the master's internal clock. Therefore, all slaves in a piconet must know the master's device address and must synchronize their clocks with the master's clock.

Adaptive Frequency Hopping (AFH) was introduced in the Bluetooth specification to provide an effective way for a Bluetooth radio to counteract normal interference. AFH identifies "bad" channels, where either other wireless devices are interfering with the Bluetooth signal or the Bluetooth signal is interfering with another device. The AFH-enabled Bluetooth device will then communicate with other devices within its piconet to share details of any identified bad channels. The devices will then switch to alternative available "good" channels, away from the areas of interference, thus having no impact on the bandwidth used.

*Example for a Bluetooth device using channel numbers would be :
Ch 44, 35, 78, 03, 15, 21, 76, 40, 56, 13, 02, 19, 67, 39, 78, 20, 21, 64, 75 etc.

APPENDIX A – Test Equipment Used For Tests

	Name of Equipment	Manufacturer	Model No.	Serial No.	Date of Calibration	Due Date
1	Signal Analyzer	Agilent	N9020A	MY48011598	2019-10-16	2020-10-16
2	Spectrum Analyzer	Rohde & Schwarz	FSV40	101574	2019-01-28	2020-01-28
3	Signal Generator	Rohde & Schwarz	SMB100A	175528	2019-10-16	2020-10-16
4	EMI Test Receiver	Rohde & Schwarz	ESCI7	100814	2019-10-22	2020-10-22
5	Bilog Antenna	Schaffner	CBL6111C	2551	2018-05-10	2020-05-10
6	Active Loop Antenna	SCHWARZBECK	FMZB 1513	1513-126	2018-05-27	2020-05-27
7	6dB Attenuator	R&S	DNF	272.4110.50-2	2018-10-25	2019-10-25
8	AMPLIFIER	SONOMA	310	291721	2019-01-28	2020-01-28
9	EMI Test Receiver	Rohde & Schwarz	ESU40	100336	2019-01-29	2020-01-29
10	Preamplifier	Agilent	8449B	3008A02011	2018-12-03	2019-12-03
11	Horn Antenna	ETS-Lindgren	3115	00078894	2017-12-04	2019-12-04
12	Horn Antenna	ETS-Lindgren	3116	00062916	2017-12-04	2019-12-04
13	Band Reject Filter	Micro Tronics	BRM50702	G233	2019-01-28	2020-01-28
14	LISN	Rohde & Schwarz	ENV216	101235	2019-01-29	2020-01-29
15	Combiner/Divider	Weinschel	1580	SQ369	2019-10-18	2020-10-18
16	DC Power Supply	HP	E3632A	KR94907541	2019-10-15	2020-10-15
17	Dual-Tracking DC Power Supply	Topward Electric Instruments Co.,Ltd.	6303D	711196	2019-01-21	2020-01-21

	Cable	Manufacturer	Model No.	Serial No.	Check Date
1	RF Cable	Canare Corporation	L-5D2W	N/A	2018-12-19
2	RF Cable	Junkosha Inc.	MWX221	1512S149	2019-10-19
3	RF Cable	HUBER+SUHNER	SUCOFLEX 102	MY073/2	2018-12-19
4	RF Cable	HUBER+SUHNER	SUCOFLEX 102	MY4728/2	2018-12-19
5	RF Cable	HUBER+SUHNER	SUCOFLEX 104	MY27558/4	2018-12-19
6	RF Cable	HUBER+SUHNER	SUCOFLEX 104	N/A	2018-12-19
7	RF Cable	HUBER+SUHNER	SUCOFLEX 104	MY27573/4	2018-12-19
8	RF Cable	HUBER+SUHNER	SUCOFLEX 106	N/A	2018-12-19