TEST REPORT

KCTL Inc.
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Suwon-si, Gyeonggi-do, 16677, Korea
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1. Client

- Name : NEW OPTICS LTD.
- Address : 315, Hyuam-ro 392beon-gil, Nam-myeon, Yangju-si, Gyeonggi-do, Republic of Korea
- Date of Receipt : 2016-06-01

2. Use of Report : -

3. Name of Product and Model : Digital Canvas 265SQ / 265BXQ7W-UC

4. Manufacturer and Country of Origin : NEW OPTICS LTD. / Korea

5. FCC ID : 2AIWQ-265BXQ7W-UC

6. IC : 22127-265BXQ7W

7. Date of Test : 2016-10-21 to 2016-10-31

8. Test Standards : FCC Part 15 Subpart C, 15.247
ANSI C63.10-2013

9. Test Results : Refer to the test result in the test report

Affirmation	Tested by Name : Euijung Kim (Signature)	Technical Manager Name : Changmin Kim (Signature)

2017-02-09

KCTL Inc.

REPORT REVISION HISTORY

Date	Revision	Page No
2016-11-03	Originally issued	-
2017-02-09	Delete ID from IC ID and Test Standards revised.	1

[Contents]

1. Client information

Applicant:	NEW OPTICS LTD.
Address:	315, Hyuam-ro 392beon-gil, Nam-myeon, Yangju-si, Gyeonggi-do, Republic of Korea
Telephone number:	+82-31-860-7877
Facsimile number:	+82-31-860-7787
Contact person:	Guhoon Kim / kgh951us@newoptics.net

Manufacturer:	NEW OPTICS LTD.
Address:	315, Hyuam-ro 392beon-gil, Nam-myeon, Yangju-si, Gyeonggi-do, Republic of Korea

2. Laboratory information

Address

KCTL Inc.

65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea

Telephone Number: 82 70 5008 1021

Facsimile Number: 82 505 299 8311

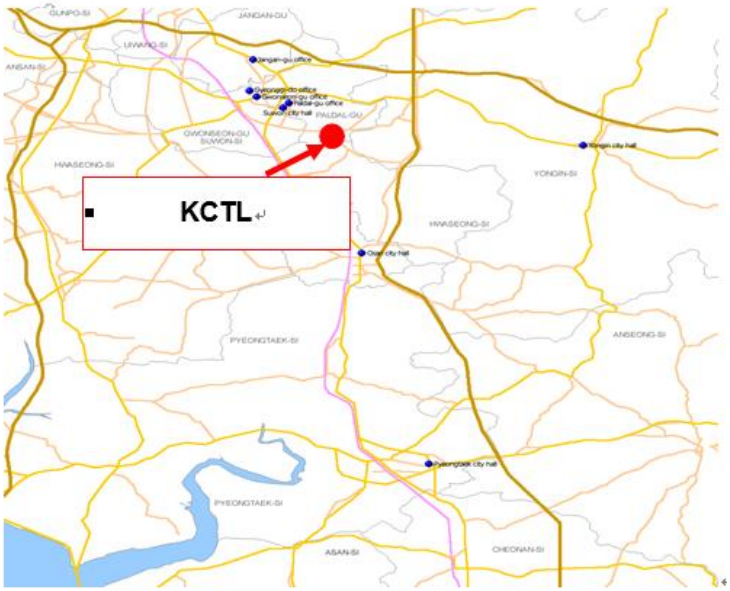
FCC Site Designation No: KR0040, FCC Site Registration No: 687132

VCCI Registration No. : R-3327, G-198, C-3706, T-1849

Industry Canada Registration No. : 8035A

KOLAS NO.: KT231

SITE MAP



3. Description of E.U.T.

3.1 Basic description

Applicant	NEW OPTICS LTD.
Address of Applicant	315, Hyuam-ro 392beon-gil, Nam-myeon, Yangju-si, Gyeonggi-do, Republic of Korea
Manufacturer	NEW OPTICS LTD.
Address of Manufacturer	315, Hyuam-ro 392beon-gil, Nam-myeon, Yangju-si, Gyeonggi-do, Republic of Korea
Type of equipment	Digital Canvas 265SQ
Basic Model	265BXQ7W-UC
Variant Model [1)]	265BXQ7W-US, 265BXQ7W-UW, 265BXQ7W-NC, 265BXQ7W-NS, 265BXQ7W-NW, 265BXQ4W-UC, 265BXQ4W-US, 265BXQ4W-UW, 265BXQ4W-NC, 265BXQ4W-NS, 265BXQ4W-NW, 265BXQ7W-KC, 265BXQ4W-KC, 265BSQ7W-KC, 265BSQ4W-KC
Serial number	N/A

1) Difference of Buyer or Buyer's Solution.

3.2 General description

Frequency Range	2 412 ㎒ ~ 2 462 ㎒ (802.11b/g/n_HT20), 2 402 ㎒ ~ 2 480 ㎒ (Bluetooth, Bluetooth Low Energy), 5 180 ㎒ ~ 5 240 ㎒ (802.11a), 5 260 ㎒ ~ 5 320 ㎒ (802.11a), 5 500 ㎒ ~ 5 700 ㎒ (802.11a), 5 745 ㎒ ~ 5 825 ㎒ (802.11a)
Type of Modulation	DSSS (802.11b), OFDM (802.11a/g/n_HT20), GFSK (Bluetooth, Bluetooth Low Energy), π/4DQPSK, 8DPSK (Bluetooth)
The number of channels	2.4 ㎓: 11 ch (802.11b/g/n_HT20), 79 ch (Bluetooth), 40 ch (Bluetooth Low Energy) 5 ㎓: 5 150 ㎒ Band: 4 (802.11a), 5 250 ㎒ Band: 4 (802.11a) 5 470 ㎒ Band: 11 (802.11a), 5 725 ㎒ Band: 4 (802.11a)
Type of Antenna	FPCB Cable Antenna
Antenna Gain	-4.50 ㏈i (2 400 ㎒ ~ 2 483.5 ㎒), -3.50 ㏈i (5 150 ㎒ ~ 5 850 ㎒)
Transmit Power	-0.66 ㏈m
Power supply	DC 24.00 V
Product SW/HW version	Android 4.4.4 or Above
Radio SW/HW version	5.90.195.89.13
Test SW Version	RF Test Tool V4.7
RF power setting in TEST SW	0 ㏈m

Note1) : The above EUT information was declared by the manufacturer.

3.3 Test frequency

	Frequency
Lowest frequency	2 402 ㎒
Middle frequency	2 441 ㎒
Highest frequency	2 480 ㎒

3.4 Test Voltage

Mode	Voltage
Nominal Voltage	DC 24.00 V

- 15.247 Requirements for Bluetooth transmitter

- This Bluetooth module has been tested by a Bluetooth Qualification Lab, and we confirm the following:
  1) This system is hopping pseudo-randomly.
  2) Each frequency is used equally on the average by each transmitter.
  3) The receiver input bandwidths that match the hopping channel bandwidths of their corresponding transmitters
  4) The receiver shifts frequencies in synchronization with the transmitted signals.

- 15.247(g): The system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this Section 15.247 should the transmitter be presented with a continuous data (or information) stream.
- 15.247(h): 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.

4. Summary of test results

4.1 Standards & results

FCC Rule	IC Rule	Parameter	Report Section	Test Result
15.203, 15.247(b)(4)	-	Antenna Requirement	5.1	C
15.247(b)(1), (4)	RSS-247, 5.4 (2)	Maximum Peak Output Power	5.2	C
15.247(a)(1)	RSS-247, 5.1 (2)	Carrier Frequency Separation	5.3	C
15.247(a)(1)	RSS-247, 5.1 (1)	20dB Channel Bandwidth	5.4	C
-	RSS-GEN, 6.6	Occupied Bandwidth	5.4	C
15.247(a)(iii) 15.247(b)(1)	RSS-247, 5.1	Number of Hopping Channel	5.5	C
15.247(a) (iii)	RSS-247, 5.1 (4)	Time of Occupancy(Dwell Time)	5.6	C
15.247(d), 15.205(a), 15.209(a)	RSS-247, 5.5 RSS-GEN, 8.9, 10	Spurious Emission, BandEdge, Restricted Band	5.7	C
15.207(a)	RSS-GEN, 8.8	Conducted Emissions	5.8	C
Note: C = complies, NC = Not complies, NT = Not tested, NA = Not Applicable				

- The general test methods used to test on this device are ANSI C63.10-2013

4.2 Uncertainty

Measurement Item	Expanded Uncertainty U = *k*Uc (*k* = 2)	
Conducted RF power	1.44 dB	
Conducted Spurious Emissions	1.52 dB	
Radiated Spurious Emissions	30 ㎒ ~ 300 ㎒:	+4.94 dB, -5.06 dB
		+4.93 dB, -5.05 dB
	300 ㎒ ~ 1 000 ㎒:	+4.97 dB, -5.08 dB
		+4.84 dB, -4.96 dB
	1 ㎓ ~ 25 ㎓:	+6.03 dB, -6.05 dB
Conducted Emissions	9 ㎑ ~ 150 ㎑:	3.75 dB
	150 ㎑ ~ 30 ㎒:	3.36 dB

5. Test results

5.1 Antenna Requirement

5.1.1 Regulation

5.1.1.1 Regulation for FCC

According to §15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

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

5.1.1.2 Regulation for IC

According to § RSS GEN Issue 4, 6.2, As per RSP-100, each applicant for equipment certification must provide a list of all antenna types that may be used with the transmitter, indicating the maximum permissible antenna gain (in dBi).
When a measurement at the antenna connector is used to determine RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer. The test report shall state the RF power, output power setting and spurious emission measurements, including the antenna type used.
In addition, applicants shall perform RF power and spurious emission measurements with each antenna type supplied or specified by the manufacturer for use with the transmitter.

5.1.2 Result

-Complied

The transmitter has permanently attached FPCB Cable antenna(internal antenna) on board.

5.2 Maximum Peak Output Power

5.2.1 Regulation

5.2.1.1 Regulation for FCC

According to §15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 ㎑ or the 20 ㏈ bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2 400-2 483.5 ㎒ band may have hopping channel carrier frequencies that are separated by 25 ㎑ or two-thirds of the 20 ㏈ bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 ㎽.

According to §15.247(b)(1), for frequency hopping systems operating in the 2 400-2 483.5 ㎒ band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725-5 850 ㎒ band: 1 watt. For all other frequency hopping systems in the 2 400-2 483.5 ㎒ band: 0.125 watts.

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

5.2.1.2 Regulation for IC

According to §RSS-247, 5.1(2), FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 ㎑ or the-20 ㏈ bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2 400-2 483.5 ㎒ have hopping channel carrier frequencies that are separated by 25 ㎑ or two thirds of the -20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W. 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.

According to §RSS-247, 5.4(2), For FHSs operating in the band 2 400-2 483.5 ㎒, 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; the maximum peak conducted output power shall not exceed 0.125 W and the e.i.r.p. shall not exceed 0.5 W if the hopset uses less than 75 hopping channels (see Section 5.4(5) for exceptions).

5.2.2 Measurement Procedure

The method of measurement used to test this FHSS device is ANSI C63.10-2013.

This is an RF-conducted test to evaluate maximum peak output power. Use a direct connection between the antenna port of the unlicensed wireless device and the spectrum analyzer, through suitable attenuation.

The hopping shall be disabled for this test:

a) Use the following spectrum analyzer settings:
   1) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel.
   2) RBW > 20 dB bandwidth of the emission being measured.
   3) VBW ≥ RBW.
   4) Sweep: Auto.
   5) Detector function: Peak.
   6) Trace: Max hold.

b) Allow trace to stabilize.
c) Use the marker-to-peak function to set the marker to the peak of the emission.
d) The indicated level is the peak output power, after any corrections for external attenuators and cables.
e) A plot of the test results and setup description shall be included in the test report.

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

5.2.3 Test Result

- Complied

- GFSK

Channel	Frequency [㎒]	Result [dBm]	Limit [dBm]	Margin [dB]	Avarage Power [dBm]
Lowest	2 402	-1.16	30.00	31.16	-2.01
Middle	2 441	-0.96	30.00	30.96	-1.82
Highest	2 480	-1.36	30.00	31.36	-2.24

- π/4DQPSK

Channel	Frequency [㎒]	Result [dBm]	Limit [dBm]	Margin [dB]	Avarage Power [dBm]
Lowest	2 402	-1.66	20.97	22.63	-4.71
Middle	2 441	-1.46	20.97	22.43	-4.52
Highest	2 480	-1.76	20.97	22.73	-5.02

- 8DPSK

Channel	Frequency [㎒]	Result [dBm]	Limit [dBm]	Margin [dB]	Avarage Power [dBm]
Lowest	2 402	-0.86	20.97	21.83	-4.32
Middle	2 441	-0.66	20.97	21.63	-4.16
Highest	2 480	-1.06	20.97	22.03	-4.59

NOTE:
1. We took the insertion loss of the cable loss into consideration within the measuring instrument.
2. It was measured by power sensor.

5.3 Carrier Frequency Separation

5.3.1 Regulation

5.3.1.1 Regulation for FCC

According to §15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 ㎑ or the 20 ㏈ bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2 400-2 483.5 ㎒ band may have hopping channel carrier frequencies that are separated by 25 ㎑ or two-thirds of the 20 ㏈ bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 ㎽.

5.3.1.2 Regulation for IC

According to §RSS-247, 5.1(2), FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 ㎑ or the -20 ㏈ bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2 400-2 483.5 ㎒ may have hopping channel carrier frequencies that are separated by 25 ㎑ or two thirds of the -20 ㏈ bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W. 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.

5.3.2 Measurement Procedure

The method of measurement used to test this FHSS device is ANSI C63.10-2013.

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

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

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

5.3.3 Test Result

- Complied

- GFSK

Channel	Frequency [㎒]	Carrier frequency separation [㎒]	Limit
Lowest	2 402	1.003	≥25 ㎑ or 20 ㏈ bandwidth
Middle	2 441	1.003	≥25 ㎑ or 20 ㏈ bandwidth
Highest	2 480	1.003	≥25 ㎑ or 20 ㏈ bandwidth

- 8DPSK

Channel	Frequency [㎒]	Carrier frequency separation [㎒]	Limit
Lowest	2 402	1.003	≥25 ㎑ or two-thirds of the 20 ㏈ bandwidth
Middle	2 441	1.003	≥25 ㎑ or two-thirds of the 20 ㏈ bandwidth
Highest	2 480	1.003	≥25 ㎑ or two-thirds of the 20 ㏈ bandwidth

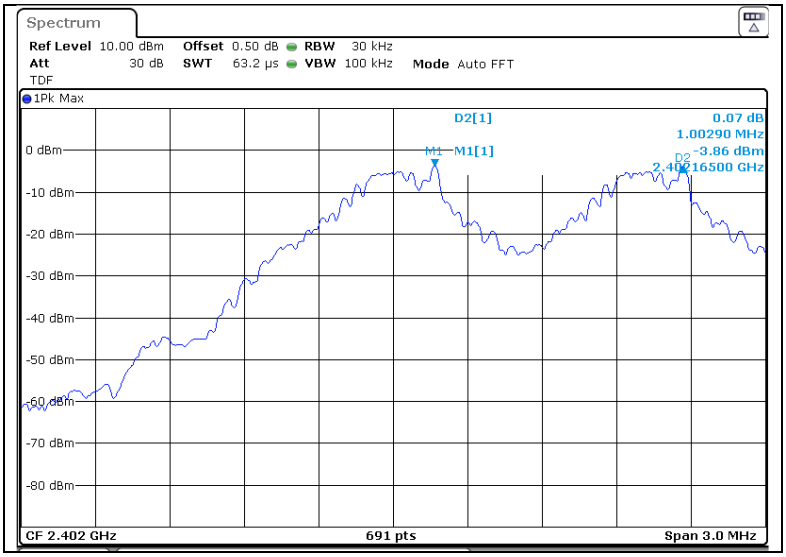
NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

5.3.4 Test Plot

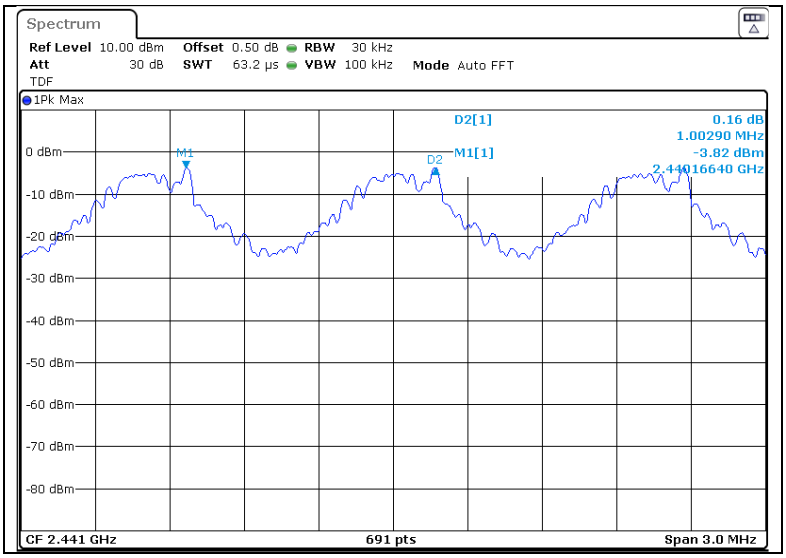
Figure 1. Plot of the Carrier Frequency Separation

- GFSK

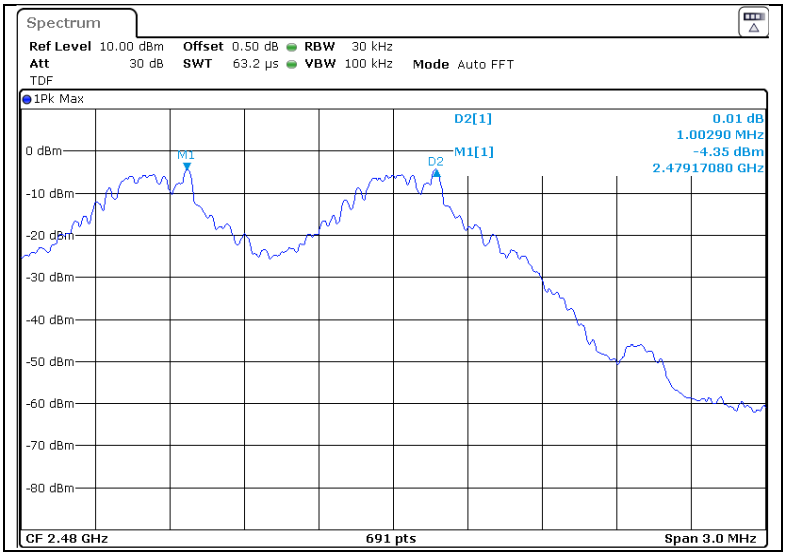
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

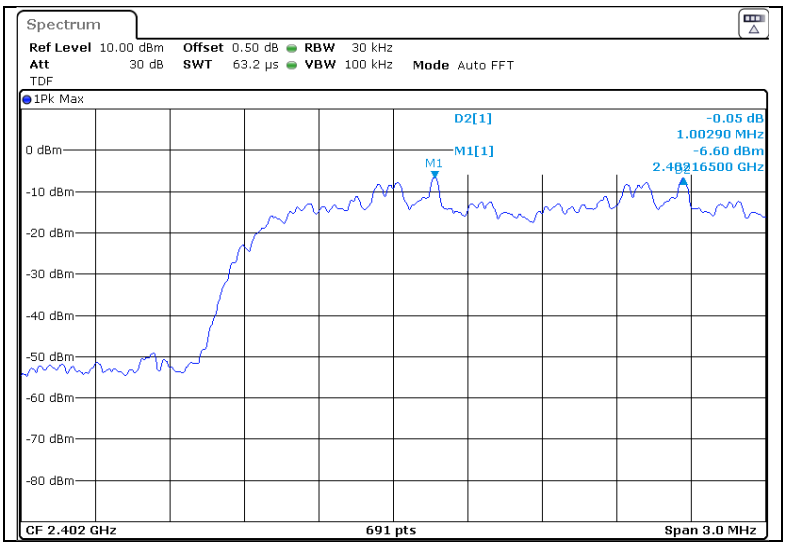


Highest Channel (2 480 ㎒)

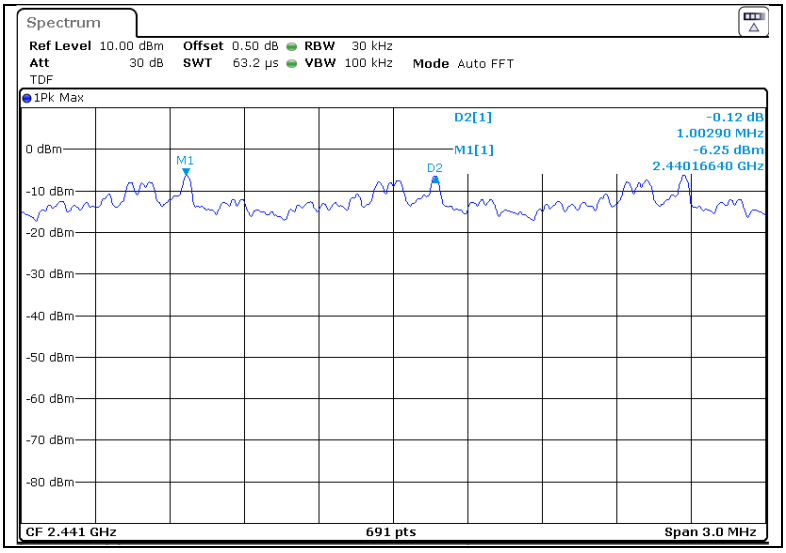


- 8DPSK

Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)



Highest Channel (2 480 ㎒)

5.4 20 dB Channel Bandwidth

5.4.1 Regulation

5.4.1.1 Regulation for FCC

According to §15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 ㎑ or the 20 ㏈ bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2 400-2 483.5 ㎒ band may have hopping channel carrier frequencies that are separated by 25 ㎑ or two-thirds of the 20 ㏈ bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 ㎽.

5.4.1.2 Regulation for IC

According to §RSS-247, 5.1(1), The bandwidth of a frequency hopping channel is the -20 dB emission bandwidth, measured with the hopping stopped. The system's radio frequency (RF) bandwidth is equal to the channel bandwidth multiplied by the number of channels in the hopset. The hopset shall be such that the near-term distribution of frequencies appears random, with sequential hops randomly distributed in both direction and magnitude of change in the hopset, whereas the long-term distribution appears evenly distributed.

- **Occupied Bandwidth**

According to § RSS GEN Issue 4, 6.6, The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth in the range of 1% to 5% of the anticipated emission bandwidth, and a video bandwidth at least 3x the resolution bandwidth. When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts.
- The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the occupied bandwidth (OBW) and video bandwidth (VBW) shall be approximately 3x RBW.

A peak, or peak hold, may be used in place of the sampling detector as this may produce a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold may be necessary to determine the occupied bandwidth if the device is not transmitting continuously.

The trace data points are recovered and are directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded.

5.4.2 Measurement Procedure

The method of measurement used to test this FHSS device is ANSI C63.10-2013.

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

a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The span range for the EMI receiver or spectrum analyzer shall be between two times and Five times the OBW.
b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1 % to 5 % of the OBW and video bandwidth (VBW) shall be approximately three times RBW, unless otherwise specified by the applicable requirement.
c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.
d) Steps a) through c) might require iteration to adjust within the specified tolerances.
e) The dynamic range of the instrument at the selected RBW shall be more than 10 dB below the target "−xx dB down" requirement; that is, if the requirement calls for measuring the −20 dB OBW, the instrument noise floor at the selected RBW shall be at least 30 dB below the reference value.
f) Set detection mode to peak and trace mode to max hold.

g) Determine the reference value: Set the EUT to transmit an unmodulated carrier or modulated signal, as applicable. Allow the trace to stabilize. Set the spectrum analyzer marker to the highest level of the displayed trace (this is the reference value).

h) Determine the "−xx dB down amplitude" using [(reference value) − xx]. Alternatively, this calculation may be made by using the marker-delta function of the instrument.

i) If the reference value is determined by an unmodulated carrier, then turn the EUT modulation ON, and either clear the existing trace or start a new trace on the spectrum analyzer and allow the new trace to stabilize. Otherwise, the trace from step g) shall be used for step j).

j) Place two markers, one at the lowest frequency and the other at the highest frequency of the envelope of the spectral display, such that each marker is at or slightly below the "−xx dB down amplitude" determined in step h). If a marker is below this "−xx dB down amplitude" value,then it shall be as close as possible to this value. The occupied bandwidth is the frequency difference between the two markers. Alternatively, set a marker at the lowest frequency of the envelope of the spectral display, such that the marker is at or slightly below the "−xx dB down amplitude" determined in step h). Reset the marker-delta function and move the marker to the other side of the emission until the delta marker amplitude is at the same level as the reference marker amplitude. The marker-delta frequency reading at this point is the specified emission bandwidth.

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

5.4.3 Test Result

- Complied

Mode	Channel	Frequency [㎒]	20 ㏈ Channel Bandwidth [㎒]	Occupied Bandwidth (99 % BW) [㎒]
GFSK	Lowest	2 402	0.875	0.884
	Middle	2 441	0.872	0.884
	Highest	2 480	0.872	0.887
8DPSK	Lowest	2 402	1.307	1.193
	Middle	2 441	1.304	1.190
	Highest	2 480	1.307	1.190

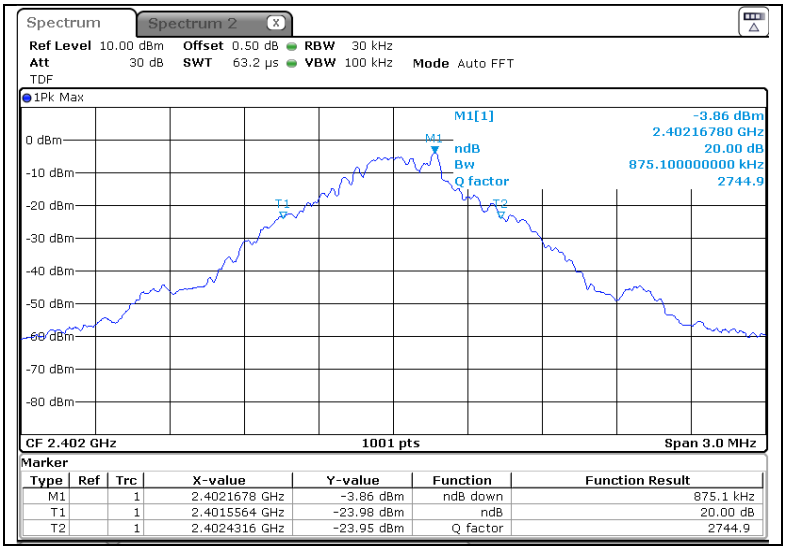
NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

5.4.4 Test Plot

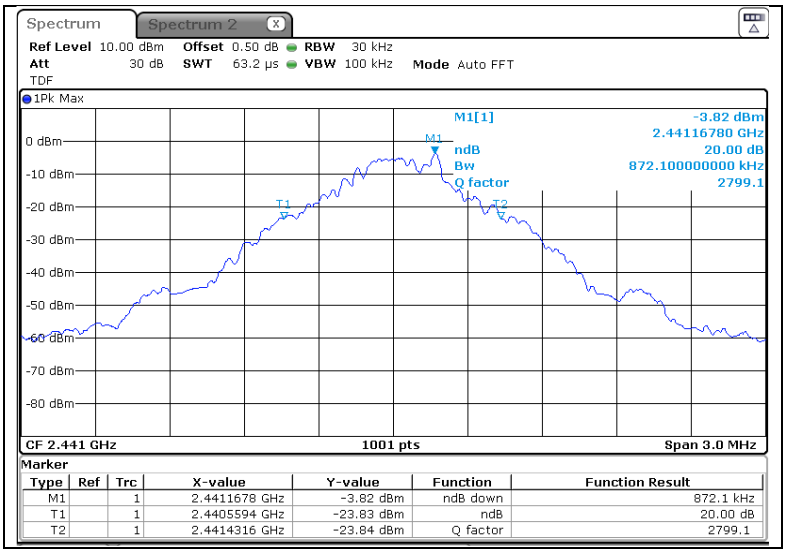
Figure 2. Plot of the 20 ㏈ Channel Bandwidth & Occupied Bandwidth (Conducted)

- GFSK_20 ㏈ Channel Bandwidth

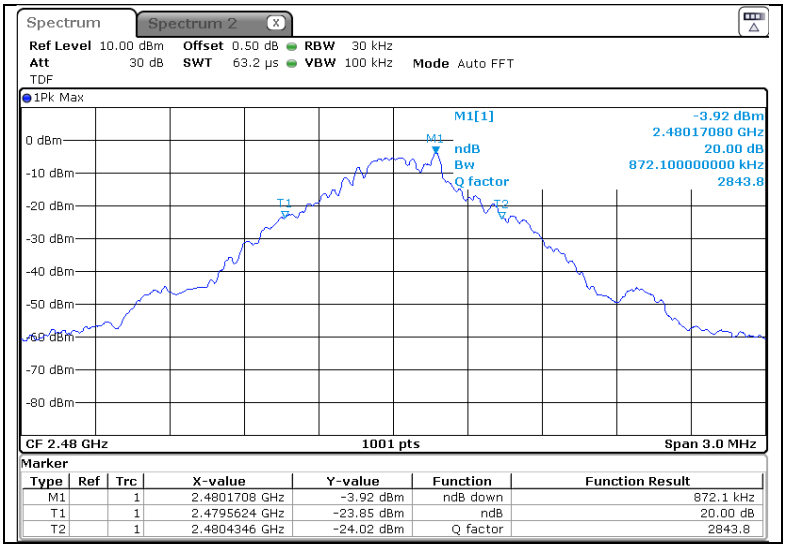
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

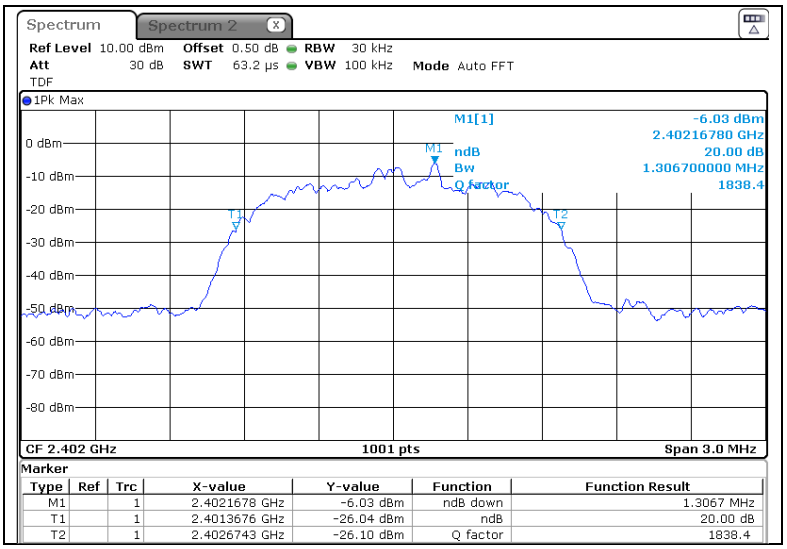


Highest Channel (2 480 ㎒)

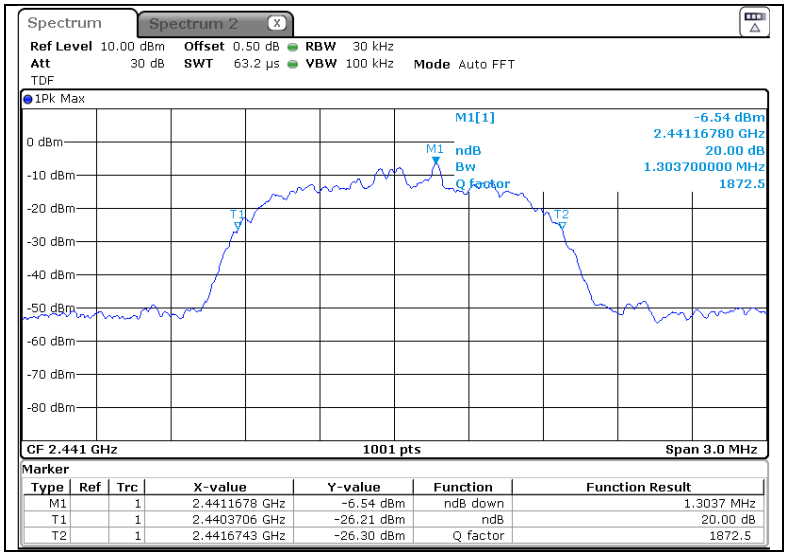


- 8DPSK_20 ㏈ Channel Bandwidth

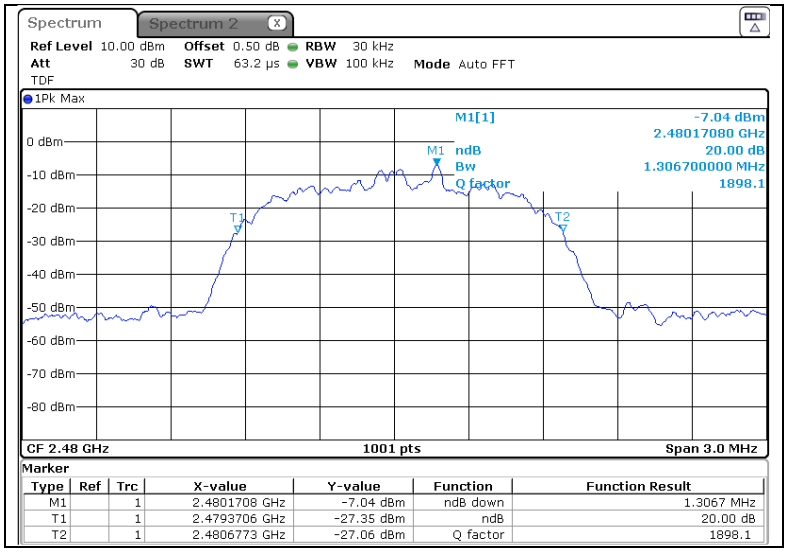
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

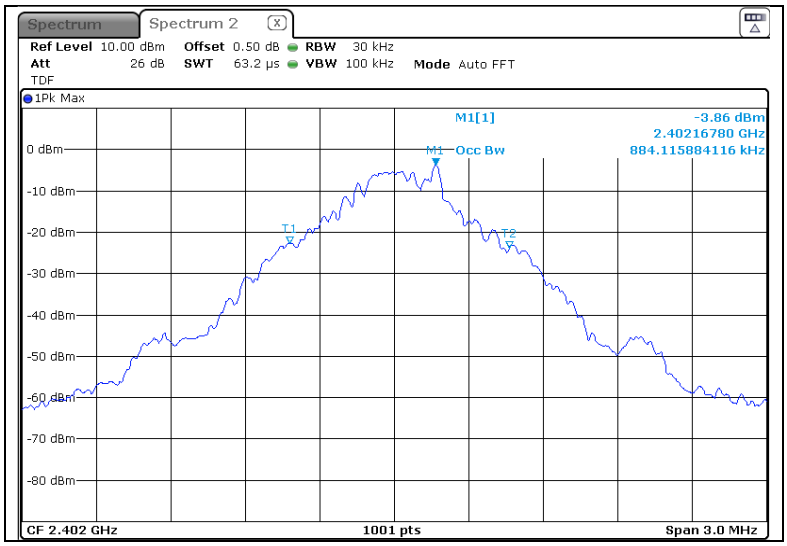


Highest Channel (2 480 ㎒)

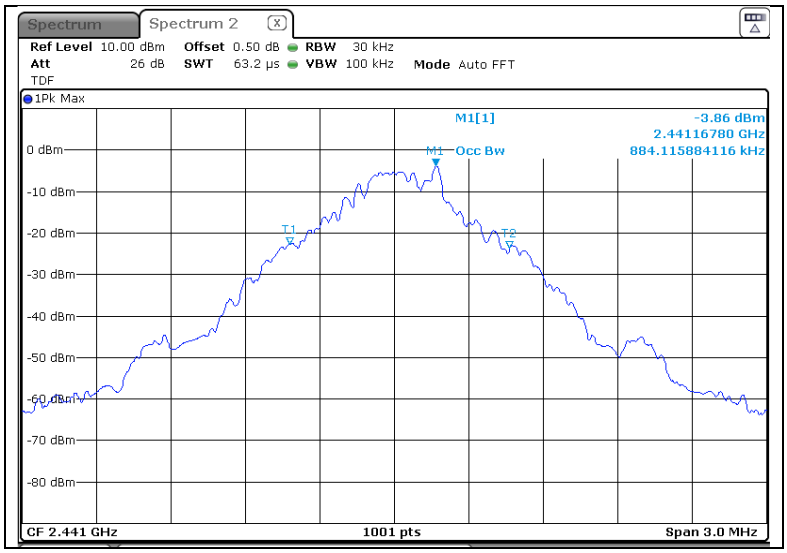


- GFSK_Occupied Bandwidth

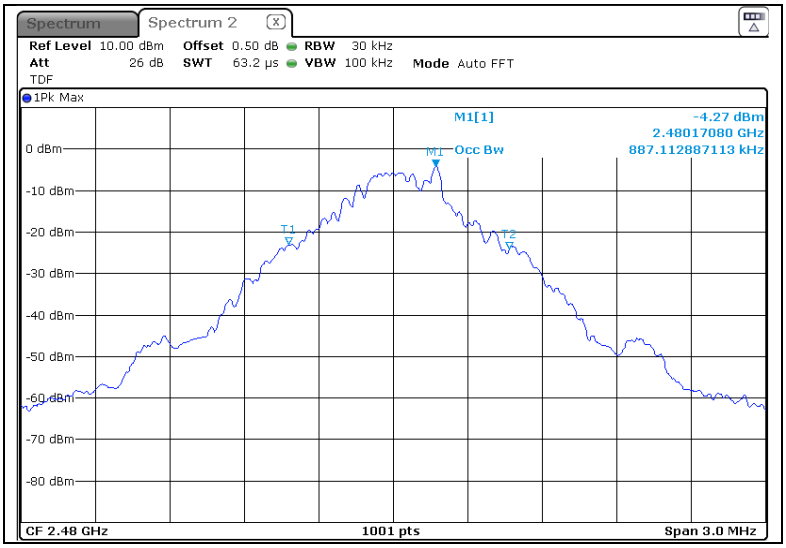
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

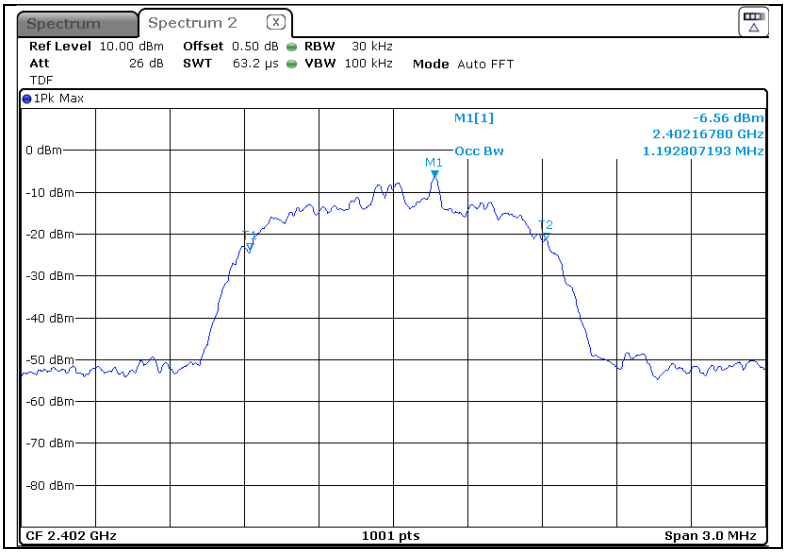


Highest Channel (2 480 ㎒)

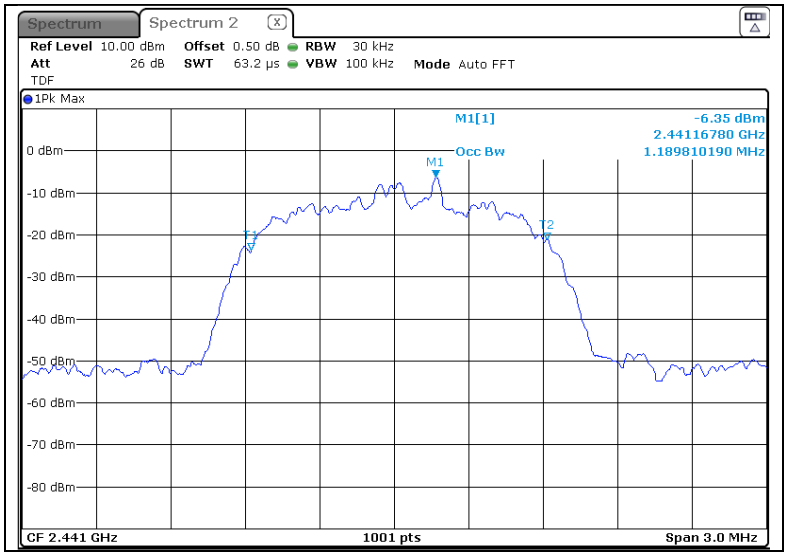


- 8DPSK_Occupied Bandwidth

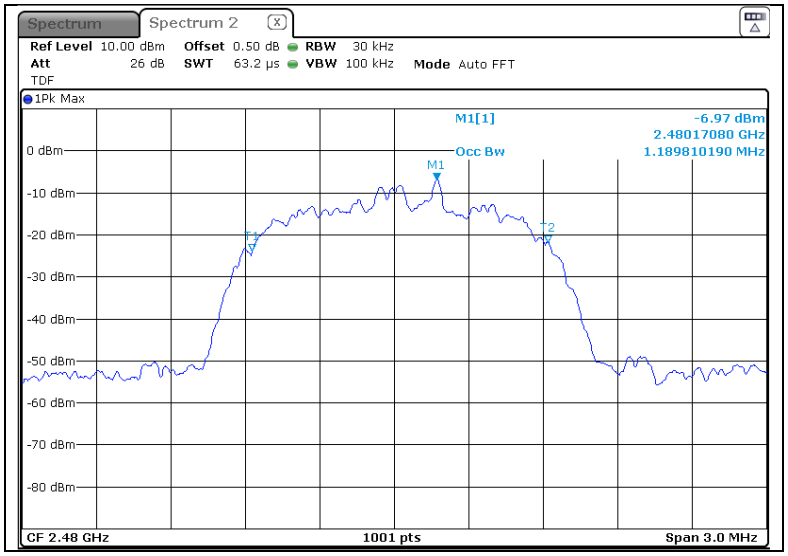
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)



Highest Channel (2 480 ㎒)



5.5 Number of Hopping Channels

5.5.1 Regulation

5.5.1.1 Regulation for FCC

According to §15.247(a)(1)(iii), Frequency hopping systems in the 2 400-2 483.5 ㎒ band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used. According to §15.247(b)(1), For frequency hopping systems operating in the 2 400-2 483.5 ㎒ band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725-5 850 ㎒ band: 1 watt. For all other frequency hopping systems in the 2 400-2 483.5 ㎒ band: 0.125 watts.

5.5.1.2 Regulation for IC

According to §RSS-247, 5.1(4), FHSs operating in the band 2 400-2 483.5 ㎒ shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

5.5.2 Measurement Procedure

The method of measurement used to test this FHSS device is ANSI C63.10-2013.

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

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

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

5.5.3 Test Result

- Complied

Mode	Frequency [㎒]	Number of hopping channel	Limit
GFSK	2 402 – 2 480	79	≥15
π/4DQPSK	2 402 – 2 480	79	≥15
8DPSK	2 402 – 2 480	79	≥15

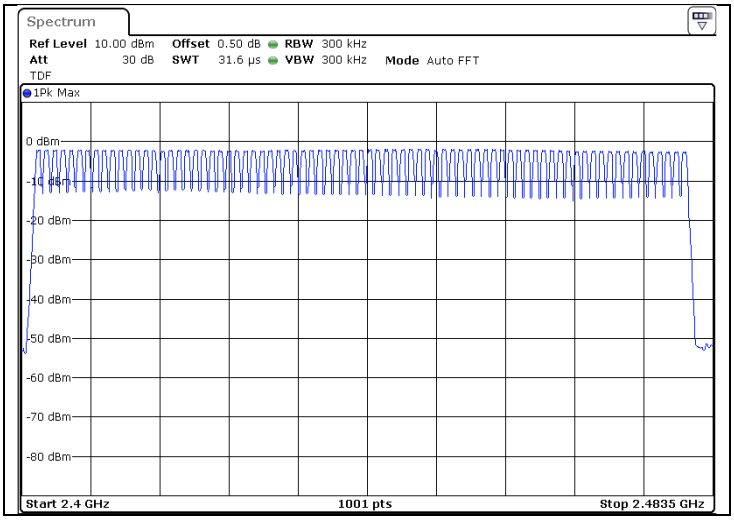
NOTE:

1. We took the insertion loss of the cable loss into consideration within the measuring instrument.
2. Measurement is made with EUT operating in hopping mode between 79 channels providing a worse case scenario as compared to AFH mode hopping between 20 channels.

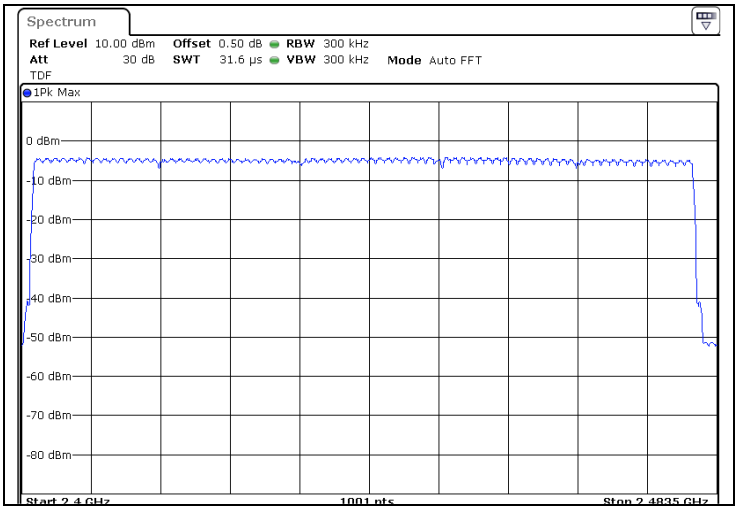
5.5.4 Test Plot

Figure 3. Plot of the Number of Hopping Channels (Conducted)

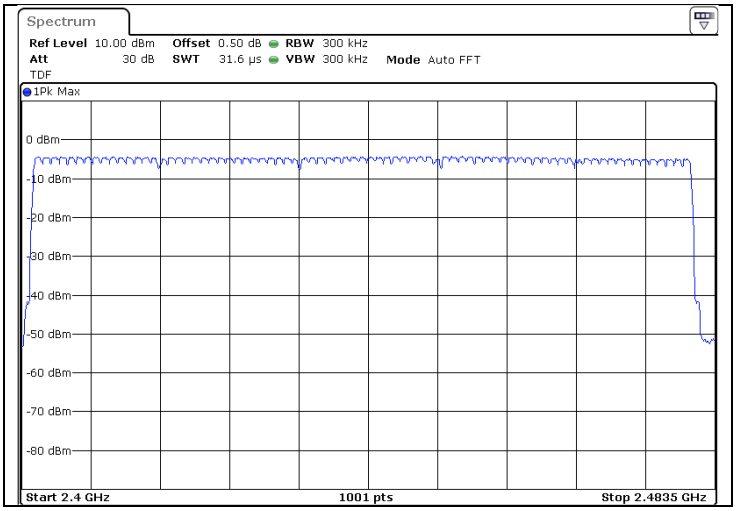
- GFSK



- π/4DQPSK



- 8DPSK


Spectrum
Ref Level 10.00 dBm Offset 0.50 dB RBW 300 kHz
Att 30 dB SWT 31.6 µs VBW 300 kHz Mode Auto FFT
TDF
1Pk Max
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
Start 2.4 GHz
1001 pts
Stop 2.4835 GHz

5.6 Time of Occupancy(Dwell Time)

5.6.1 Regulation

5.6.1.1 Regulation for FCC

According to §15.247(a)(1)(iii), frequency hopping systems in the 2 400-2 483.5 ㎒ band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

5.6.1.2 Regulation for IC

According to §RSS-247, 5.1(4), FHSs operating in the band 2 400-2 483.5 ㎒ shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

5.6.2 Measurement Procedure

The method of measurement used to test this FHSS device is ANSI C63.10-2013.

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

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

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.
Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

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

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

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

5.6.3 Test Result

- Complied

- Non-AFH

Modulation	Frequency [㎒]	Reading [㎳]	Hopping rate [hop/s]	Number of Channels	Result [s]	Limit [s]
DH1	2 441	0.382	800.000	79	0.122	0.40
DH3	2 441	1.639	400.000	79	0.262	0.40
DH5	2 441	2.888	266.667	79	0.308	0.40
2-DH1	2 441	0.388	800.000	79	0.124	0.40
2-DH3	2 441	1.642	400.000	79	0.263	0.40
2-DH5	2 441	2.892	266.667	79	0.308	0.40
3-DH1	2 441	0.388	800.000	79	0.124	0.40
3-DH3	2 441	1.641	400.000	79	0.263	0.40
3-DH5	2 441	2.895	266.667	79	0.309	0.40

- AFH

Modulation	Frequency [㎒]	Reading [㎳]	Hopping rate [hop/s]	Number of Channels	Result [s]	Limit [s]
DH1	2 441	0.382	400.000	20	0.061	0.40
DH3	2 441	1.639	200.000	20	0.131	0.40
DH5	2 441	2.888	133.333	20	0.154	0.40
2-DH1	2 441	0.388	400.000	20	0.062	0.40
2-DH3	2 441	1.642	200.000	20	0.131	0.40
2-DH5	2 441	2.892	133.333	20	0.154	0.40
3-DH1	2 441	0.388	400.000	20	0.062	0.40
3-DH3	2 441	1.641	200.000	20	0.131	0.40
3-DH5	2 441	2.895	133.333	20	0.154	0.40

NOTE 1. **Non AFH**
Result = Number of Transmission in 31.6s x Length of Trnasmission Test period
= 0.4 [seconds / channel] × 79 [channel] = 31.6 [seconds]

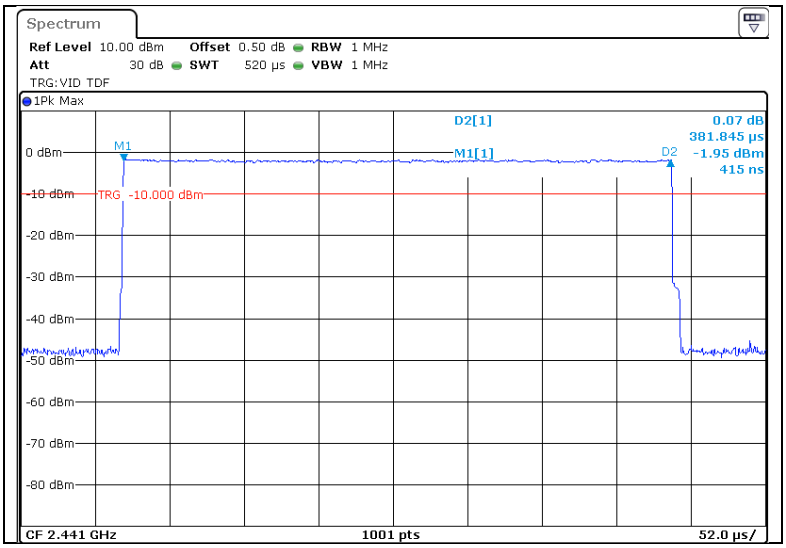
NOTE 2. **AFH**
Result = Number of Transmission in 8s x Length of Trnasmission Test period
= 0.4 [seconds / channel] × 20 [channel] = 8 [seconds]

5.6.4 Test Plot

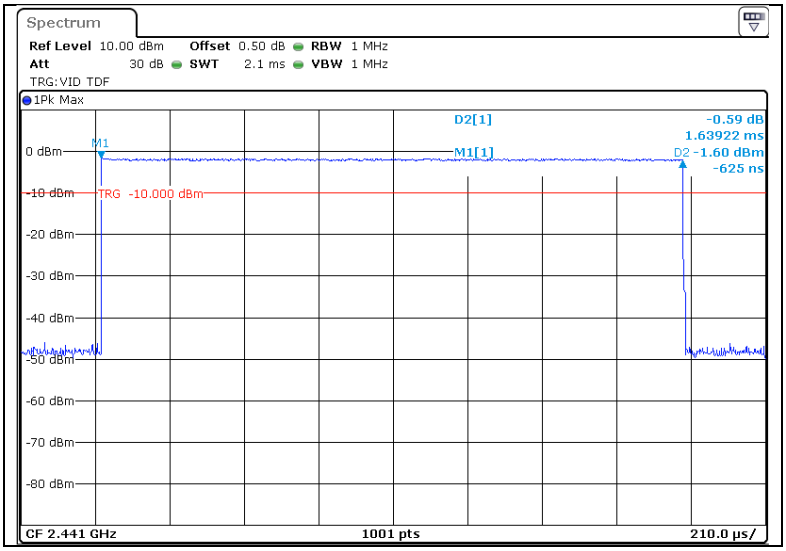
Figure 4. Plot of the Time of Occupancy (Conducted)

- GFSK_Non AFH mode

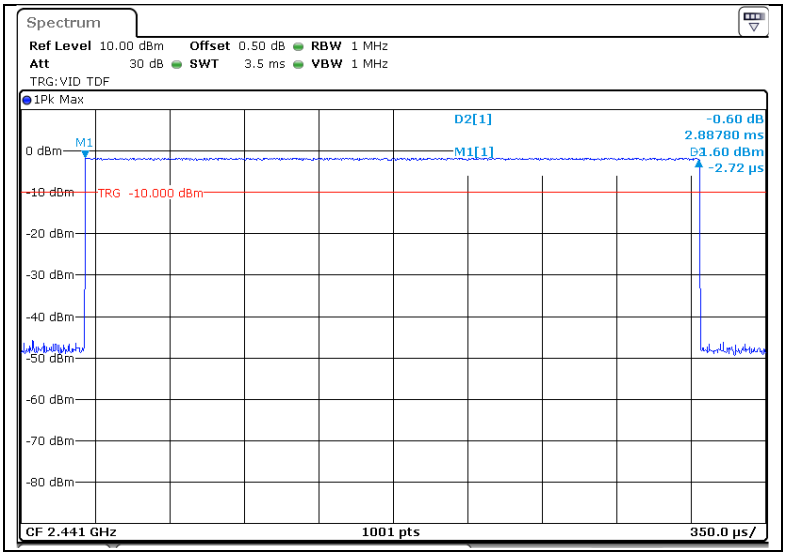
DH1 (2 441 ㎒)



DH3 (2 441 ㎒)

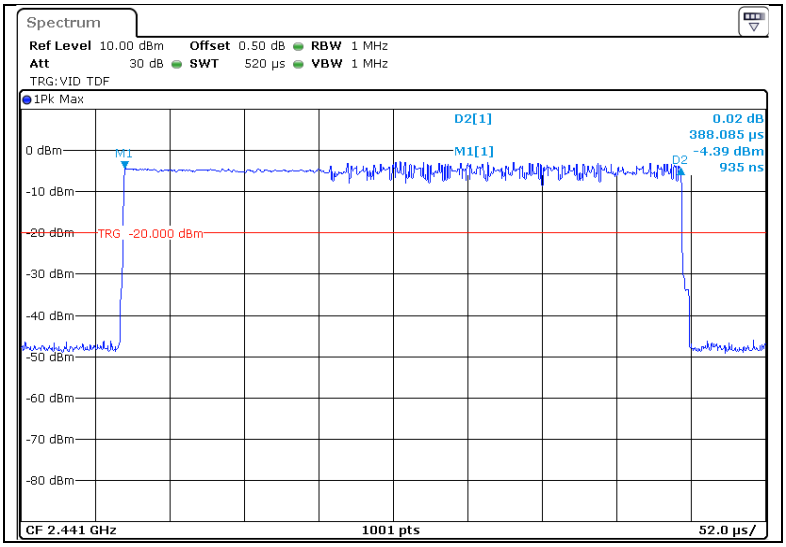


DH5 (2 441 ㎒)

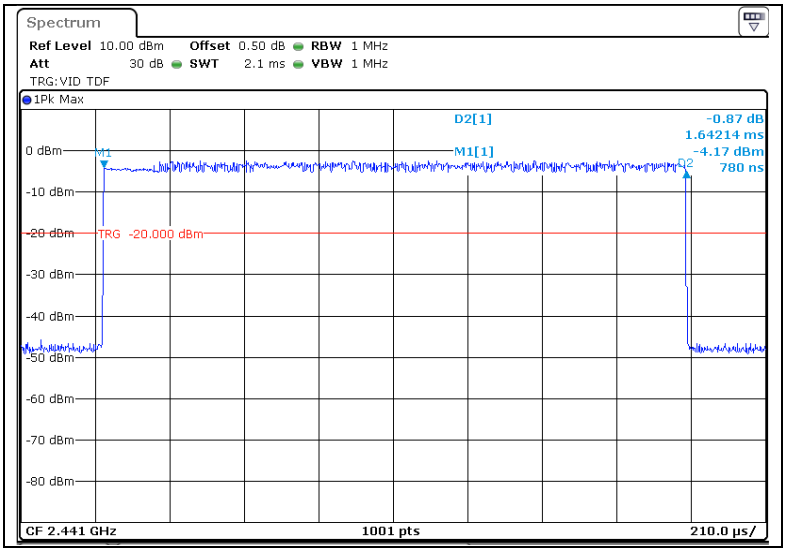


- π/4DQPSK_Non AFH mode

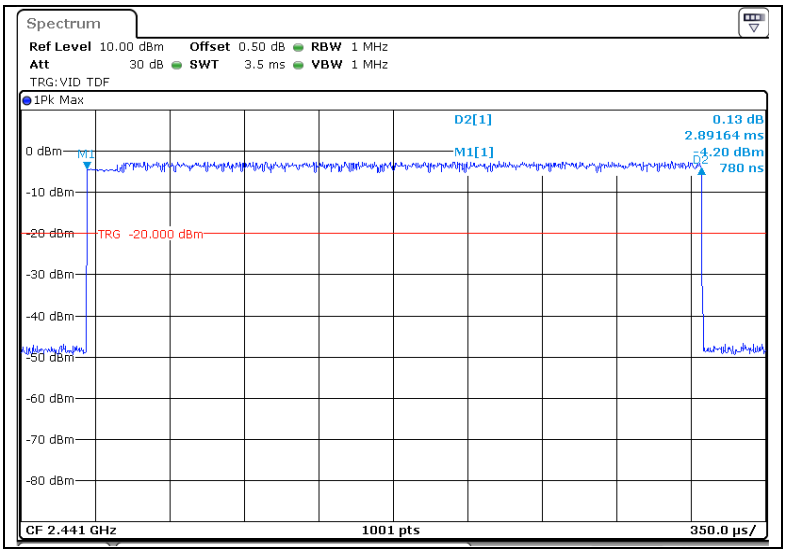
2-DH1 (2 441 ㎒)



2-DH3 (2 441 ㎒)

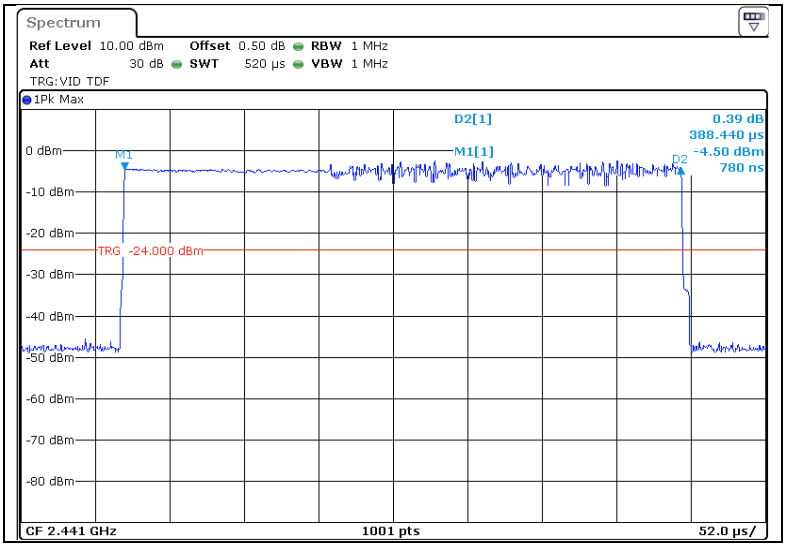


2-DH5 (2 441 ㎒)

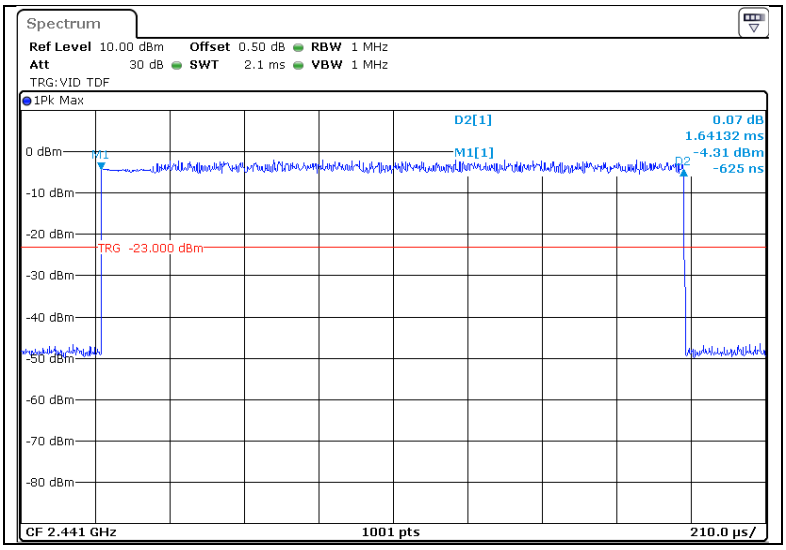


- 8DPSK_Non AFH mode

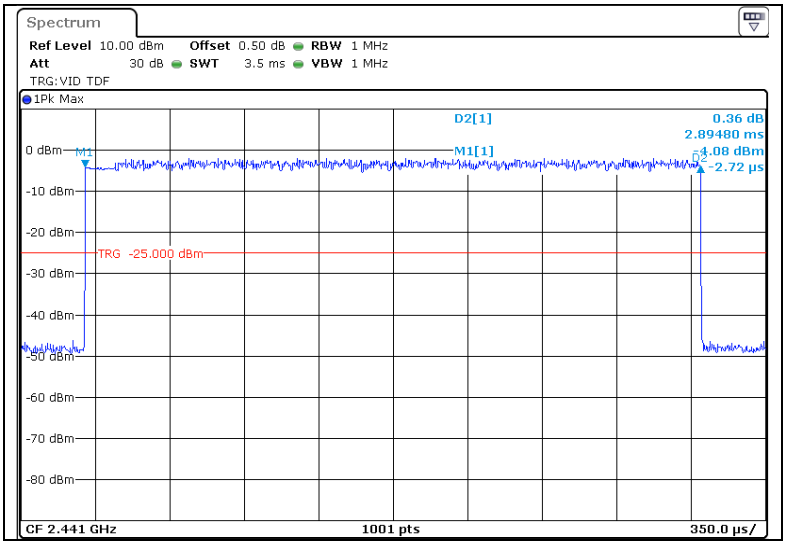
3-DH1 (2 441 ㎒)



3-DH3 (2 441 ㎒)



3-DH5 (2 441 ㎒)


Spectrum
Ref Level 10.00 dBm Offset 0.50 dB RBW 1 MHz
Att 30 dB SWT 3.5 ms VBW 1 MHz
TRG:VID TDF
1Pk Max
D2[1] 0.36 dB
2.89480 ms
M1[1] -4.08 dBm
-2.72 µs
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
TRG -25.000 dBm
CF 2.441 GHz
1001 pts
350.0 µs/

5.7 Spurious Emission, Band edge and Restricted bands

5.7.1 Regulation

5.7.1.1 Regulation for FCC

According to §15.247(d), in any 100 ㎑ bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 ㏈ below that in the 100 ㎑ bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 ㏈ instead of 20 ㏈. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

According to §15.209(a), Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall notexceed the field strength levels specified in the following table:

Frequency (㎒)	Field strength (㎶/m)	Measurement distance (m)
0.009 - 0.490	2 400/F(㎑)	300
0.490 -1.705	24 000/F(㎑)	30
1.705 – 30	30	30
30 - 88	100**	3
88 - 216	150**	3
216 - 960	200**	3
Above 960	500	3

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

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

㎒	㎒	㎒	㎓
0.009 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 -	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.52525	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	156.7 - 156.9	3260 - 3267	23.6 - 24.0
12.29 - 12.293	162.0125 - 167.17	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	167.72 - 173.2	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	240 - 285	3600 - 4400	Above 38.6
13.36 - 13.41	322 - 335.4		

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1 000 ㎒, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1 000 ㎒, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

5.7.1.2 Regulation for IC

According to §RSS-247, 5.5, In any 100 ㎑ 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 ㏈ below that in the 100 ㎑ bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided 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 ㏈ instead of 20 ㏈. Attenuation below the general field strength limits specified in RSS Gen is not required.

According to § RSS GEN Issue 4, 8.9, 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 4 and Table 5 below. Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

Table 4 – General Field Strength Limits for Licence-Exempt Transmitters at Frequencies Above 30 ㎒

Frequency (㎒)	Field Strength (㎶/m at 3 metres)
30-88	100
88-216	150
216-960	200
Above 960*	500

* Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 ㎒. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 ㏈ above the average limit.

Table 5 – General Field Strength Limits for Licence-Exempt Transmitters at Frequencies Below 30 MHz

Frequency	Electric Field Strength (μV/m)	Magnetic Field Strength (H-Field) (μA/m)	Measurement Distance (metres)
9-490 ㎑	2,400/F (F in ㎑)	2,400/377F (F in ㎑)	300
490-1,705 ㎑	24,000/F (F in ㎑)	24,000/377F (F in ㎑)	30
1,705-30 ㎒	30	N/A	30

According to § RSS GEN Issue 4, 8.10, Restricted bands, identified in Table 6, are designated primarily for safety-of-life services (distress calling and certain aeronautical bands), certain satellite downlinks, radio astronomy and some government uses. Except where otherwise indicated, the following restrictions apply:

(a) Fundamental components of modulation of licence-exempt radio apparatus shall not fall within the restricted bands of Table 6 except for apparatus complying under RSS-287;
(b) Unwanted emissions that fall into restricted bands of Table 6 shall comply with the limits specified in RSS-Gen; and
(c) Unwanted emissions that do not fall within the restricted frequency bands of Table 6 shall comply either with the limits specified in the applicable RSS or with those specified in this RSS-Gen.

Table 6 – Restricted Frequency Bands*

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

* Certain frequency bands listed in Table 6 and in bands 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.

5.7.2 Measurement Procedure

The method of measurement used to test this FHSS device is ANSI C63.10-2013.

1) Band-edge Compliance of RF Conducted Emissions

These procedures are applicable for determining compliance at authorized-band band-edges where the requirements are expressed as a value relative to the in-band signal level. Procedures for determining compliance with field strength limits at or close to the band-edges are given in 6.10.6 (see also Table A.2).
Band-edge tests are typically performed as a conducted test but may be performed as Radiated measurements on a test site meeting the specifications in 5.2, at the measurement distances specified in 5.3. The instrumentation shall meet the requirements in 4.1.1 using the bandwidths and detectors Specified in 4.1.4.2.
When performing radiated measurements, the measurement antenna(s) shall meet the specifications in 4.3. The EUT shall be connected to an antenna and operated at the highest power settings following procedures in 6.3.

For other than frequency-hopping devices, this test sequence shall be performed once. For devices that support frequency hopping, this test sequence shall be performed twice: once with the hopping function turned OFF and then repeated with the hopping function turned ON. The purpose of the test with the hopping function turned on is to confirm that the RF power remains OFF while the device is changing frequencies, and that the oscillator stabilizes at the new frequency before RF power is turned back ON.Overshoot of any oscillator, including phase-lock-loop stabilized oscillators, can cause the device to be temporarily tuned to frequencies outside the authorized band, and it is important that no transmissions occur during such temporary periods. Particular attention to the hopping sequence requirements specified below is needed in the case of adaptive frequency-hopping devices:

a) Connect the EMI receiver or spectrum analyzer to the EUT using an appropriate RF cable connected to the EUT output. Configure the spectrum analyzer settings as described in step e) (be sure to enter all losses between the unlicensed wireless device output and the spectrum analyzer).
b) Set the EUT to the lowest frequency channel (for the hopping on test, the hopping sequence shall include the lowest frequency channel).
c) Set the EUT to operate at maximum output power and 100 % duty cycle, or equivalent “normal mode of operation” as specified in 6.10.3.

d) If using the radiated method, then use the applicable procedure(s) of 6.4, 6.5, or 6.6, and orient the EUT and measurement antenna positions to produce the highest emission level.

e) Perform the test as follows:

1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.

2) Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.

3) Attenuation: Auto (at least 10 ㏈ preferred).

4) Sweep time: Coupled.

5) Resolution bandwidth: 100 ㎑.

6) Video bandwidth: 300 ㎑.

7) Detector: Peak.

8) Trace: Max hold.

f) Allow the trace to stabilize. For the test with the hopping function turned ON, this can take several minutes to achieve a reasonable probability of intercepting any emissions due to oscillator overshoot.

g) Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.

h) Repeat step c) through step e) for every applicable modulation.

i) Set the EUT to the highest frequency channel (for the hopping on test, the hopping sequence shall include the highest frequency channel) and repeat step c) through step d).

j) The band-edge measurement shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

2) Spurious RF Conducted Emissions:

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

3) Spurious Radiated Emissions:

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an semi-anechoic chamber at a distance of 3 meters.
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360°.
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 9 ㎑ to 30 ㎒ using the loop antenna, and from 30 to 1 000 ㎒ using the Bi-Log antenna, and from 1 000 ㎒ to 26 500 ㎒ using the horn antenna.
4. To obtain the final measurement data, the EUT was arranged on a turntable situated on a 4 × 4 meter in an semi-anechoic chamber. The EUT was tested at a distance 3 meters.
5. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.
6. The 0.8m height is for below 1 G testing, and 1.5m is for above 1G testing.

- **Procedure for unwanted emissions measurements below 1 000 ㎒**

The procedure for unwanted emissions measurements below 1 000 ㎒ is as follows:

a) Follow the requirements in 12.7.4.

b) Compliance shall be determined using CISPR quasi-peak detection; however, peak detection is permitted as an alternative to quasi-peak detection.

- **Procedure for peak unwanted emissions measurements above 1 000 ㎒**

The procedure for peak unwanted emissions measurements above 1 000 ㎒ is as follows:

a) Follow the requirements in 12.7.4.

b) Peak emission levels are measured by setting the instrument as follows:

1) RBW = 1 ㎒.

2) VBW ≥ [3 ㎒ RBW].

3) Detector = peak.

4) Sweep time = auto.

5) Trace mode = max hold.

6) Allow sweeps to continue until the trace stabilizes. Note that if the transmission is not continuous, then the time required for the trace to stabilize will increase by a factor of approximately 1 / D, where *D* is the duty cycle. For example, at 50 ㆍ duty cycle, the measurement time will increase by a factor of two, relative to measurement time for continuous transmission.

- **Procedures for average unwanted emissions measurements above 1 000 ㎒**

Method VB-A is averaging using reduced video bandwidth. The procedure for this method is as follows:

a) RBW = 1 ㎒.

b) Video bandwidth:

1) If the EUT is configured to transmit with D ≥ 98 ㆍ, then set VBW ≤ RBW / 100 (i.e., 10 ㎑), but not less than 10 ㎐.

2) If the EUT D is < 98%, then set VBW ≥ 1 / T, where T is defined in item a1) of 12.2.

c) Video bandwidth mode or display mode:

1) The instrument shall be set with video filtering applied in the power domain. Typically, this requires setting the detector mode to RMS (power averaging) and setting the average-VBW type to power (rms).

2) As an alternative, the instrument may be set to linear detector mode. Video filtering shall be applied in linear voltage domain (rather than in a log or ㏈ domain). Some instruments require linear display mode to accomplish this. Others have a setting for average-VBW type, which can be set to “voltage” regardless of the display mode.

d) Detector = peak.

e) Sweep time = auto.

f) Trace mode = max hold.

g) Allow max hold to run for at least 50 traces if the transmitted signal is continuous or has at least 98% duty cycle. For lower duty cycles, increase the minimum number of traces by a factor of 1/x, where D is the duty cycle. For example, use at least 200 traces if the duty cycle is 25%. (If a specific emission is demonstrated to be continuous—i.e., 100% duty cycle—then rather than turning ON and OFF with the transmit cycle, at least 50 traces should be averaged.)

5.7.3 Test Result

- Complied

1. Conducted Spurious Emissions was shown in figure 3.
   Note: We took the insertion loss of the cable into consideration within the measuring instrument.
2. Measured value of the Field strength of spurious Emissions (Radiated)
3. It tested x,y and z – 3 axis each, mentioned only worst case data at this report.

- Below 1 ㎓ data (Worst-case: GFSK)

Lowest Channel (2 402 ㎒)

Frequency [㎒]	Receiver Bandwidth [㎑]	Pol. [V/H]	Reading [dB(㎶)]	Cable Loss [dB]	Amp Gain [dB]	Antenna Factor [dB]	Factor [dB]	Result [dB(㎶/m)]	Limit [dB(㎶/m)]	Margin [dB]
Quasi-Peak DATA. Emissions below 30 ㎒										
5.10	9	H	35.90	0.59	-32.69	19.70	-12.40	23.50	69.50	46.00
16.31	9	V	38.60	1.02	-32.67	19.45	-12.20	26.40	69.50	43.10
Above 20.00	Not Detected	-	-	-	-	-	-	-	-	-
Quasi-Peak DATA. Emissions below 1 ㎓										
179.87	120	H	59.30	3.00	-32.49	9.59	-19.90	39.40	43.50	4.10
239.76	120	H	56.70	3.62	-32.49	12.47	-16.40	40.30	46.00	5.70
299.66	120	H	55.30	3.84	-32.53	13.59	-15.10	40.20	46.00	5.80
599.39	120	H	51.00	5.98	-32.87	19.29	-7.60	43.40	46.00	2.60
659.41	120	H	49.90	6.28	-32.86	19.48	-7.10	42.80	46.00	3.20
798.12	120	H	46.70	6.46	-32.64	20.78	-5.40	41.30	46.00	4.70
Above 800.00	Not Detected	-	-	-	-	-	-	-	-	-

NOTE 1. Factor = Cable loss + Amp gain + Antenna factor
NOTE 2. Although these tests were performed other than open field test site, adequate comparison measurements were confirmed against 30 m open field test site.
Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 937606.

- Above 1 ㎓ data

GFSK_Lowest channel (2 402 ㎒)

Frequency [㎒]	Receiver Bandwidth [㎑]	Pol. [V/H]	Reading [dB(㎶)]	Cable Loss [dB]	Amp Gain [dB]	Antenna Factor [dB]	Factor [dB]	Result [dB(㎶/m)]	Limit [dB(㎶/m)]	Margin [dB]
Peak DATA. Emissions above 1 ㎓										
1 995.00	1 000	V	82.60	4.49	-62.71	30.92	-27.30	55.30	74.00	18.70
2 323.75 [1)]	1 000	H	65.20	4.75	-61.19	31.44	-25.00	40.20	74.00	33.80
2 793.44	1 000	H	73.50	5.10	-61.99	32.19	-24.70	48.80	74.00	25.20
3 989.38	1 000	H	74.70	5.91	-62.04	32.63	-23.50	51.20	74.00	22.80
5 586.19	1 000	H	71.60	6.88	-62.60	35.32	-20.40	51.20	74.00	22.80
19 302.62	1 000	H	48.00	12.80	-52.10	44.60	5.30	53.30	74.00	20.70
24 921.12	1 000	V	47.20	15.00	-52.60	45.40	7.80	55.00	74.00	19.00
Above 25 000.00	Not Detected	-	-	-	-	-	-	-	-	-
Average DATA. Emissions above 1 ㎓										
1 995.00	1 000	V	67.90	4.49	-62.71	30.92	-27.30	40.60	54.00	13.40
2 323.75 [1)]	1 000	H	54.80	4.75	-61.19	31.44	-25.00	29.80	54.00	24.20
2 793.44	1 000	H	61.20	5.10	-61.99	32.19	-24.70	36.50	54.00	17.50
3 989.38	1 000	H	66.90	5.91	-62.04	32.63	-23.50	43.40	54.00	10.60
5 586.19	1 000	H	64.70	6.88	-62.60	35.32	-20.40	44.30	54.00	9.70
19 302.62	1 000	H	36.80	12.80	-52.10	44.60	5.30	42.10	54.00	11.90
24 921.12	1 000	V	35.50	15.00	-52.60	45.40	7.80	43.30	54.00	10.70
Above 25 000.00	Not Detected	-	-	-	-	-	-	-	-	-

[1)] Restricted band.

GFSK_Middle channel (2 441 ㎒)

Frequency [㎒]	Receiver Bandwidth [㎑]	Pol. [V/H]	Reading [dB(㎶)]	Cable Loss [dB]	Amp Gain [dB]	Antenna Factor [dB]	Factor [dB]	Result [dB(㎶/m)]	Limit [dB(㎶/m)]	Margin [dB]
Peak DATA. Emissions above 1 ㎓										
1 678.44	1 000	V	77.90	4.07	-63.69	30.12	-29.50	48.40	74.00	25.60
1 995.31	1 000	V	81.80	4.49	-62.71	30.92	-27.30	54.50	74.00	19.50
2 793.75	1 000	H	72.90	5.10	-61.99	32.19	-24.70	48.20	74.00	25.80
3 989.38	1 000	H	75.50	5.91	-62.04	32.63	-23.50	52.00	74.00	22.00
5 586.19	1 000	H	73.30	6.88	-62.60	35.32	-20.40	52.90	74.00	21.10
18 921.19	1 000	V	47.80	12.70	-51.90	44.40	5.20	53.00	74.00	21.00
25 264.31	1 000	H	46.50	15.00	-52.60	45.70	8.10	54.60	74.00	19.40
Above 26 000.00	Not Detected	-	-	-	-	-	-	-	-	-
Average DATA. Emissions above 1 ㎓										
1 678.44	1 000	V	72.00	4.07	-63.69	30.12	-29.50	42.50	54.00	11.50
1 995.31	1 000	V	68.50	4.49	-62.71	30.92	-27.30	41.20	54.00	12.80
2 793.75	1 000	H	62.20	5.10	-61.99	32.19	-24.70	37.50	54.00	16.50
3 989.38	1 000	H	66.70	5.91	-62.04	32.63	-23.50	43.20	54.00	10.80
5 586.19	1 000	H	64.30	6.88	-62.60	35.32	-20.40	43.90	54.00	10.10
18 921.19	1 000	V	36.70	12.70	-51.90	44.40	5.20	41.90	54.00	12.10
25 264.31	1 000	H	35.00	15.00	-52.60	45.70	8.10	43.10	54.00	10.90
Above 26 000.00	Not Detected	-	-	-	-	-	-	-	-	-

GFSK_Highest channel (2 480 ㎒)

Frequency [㎒]	Receiver Bandwidth [㎑]	Pol. [V/H]	Reading [dB(㎶)]	Cable Loss [dB]	Amp Gain [dB]	Antenna Factor [dB]	Factor [dB]	Result [dB(㎶/m)]	Limit [dB(㎶/m)]	Margin [dB]
Peak DATA. Emissions above 1 ㎓										
1 678.44	1 000	V	77.60	4.07	-63.69	30.12	-29.50	48.10	74.00	25.90
1 995.31	1 000	V	82.40	4.49	-62.71	30.92	-27.30	55.10	74.00	18.90
2 491.25 [1)]	1 000	H	64.50	4.87	-61.08	31.71	-24.50	40.00	74.00	34.00
3 989.38	1 000	H	76.10	5.91	-62.04	32.63	-23.50	52.60	74.00	21.40
5 586.19	1 000	H	71.80	6.88	-62.60	35.32	-20.40	51.40	74.00	22.60
18 327.25	1 000	H	47.70	12.50	-51.60	44.10	5.00	52.70	74.00	21.30
25 401.37	1 000	V	45.70	15.00	-52.50	45.80	8.30	54.00	74.00	20.00
Above 26 000.00	Not Detected	-	-	-	-	-	-	-	-	-
Average DATA. Emissions above 1 ㎓										
1 678.44	1 000	V	71.50	4.07	-63.69	30.12	-29.50	42.00	54.00	12.00
1 995.31	1 000	V	68.90	4.49	-62.71	30.92	-27.30	41.60	54.00	12.40
2 491.25 [1)]	1 000	H	54.50	4.87	-61.08	31.71	-24.50	30.00	54.00	24.00
3 989.38	1 000	H	66.30	5.91	-62.04	32.63	-23.50	42.80	54.00	11.20
5 586.19	1 000	H	64.80	6.88	-62.60	35.32	-20.40	44.40	54.00	9.60
18 327.25	1 000	H	37.00	12.50	-51.60	44.10	5.00	42.00	54.00	12.00
25 401.37	1 000	V	35.30	15.00	-52.50	45.80	8.30	43.60	54.00	10.40
Above 26 000.00	Not Detected	-	-	-	-	-	-	-	-	-

[1)] Restricted band.

8DPSK_Lowest channel (2 402 ㎒)

Frequency [㎒]	Receiver Bandwidth [㎑]	Pol. [V/H]	Reading [dB(㎶)]	Cable Loss [dB]	Amp Gain [dB]	Antenna Factor [dB]	Factor [dB]	Result [dB(㎶/m)]	Limit [dB(㎶/m)]	Margin [dB]
Peak DATA. Emissions above 1 ㎓										
1 995.00	1 000	V	81.90	4.49	-62.71	30.92	-27.30	54.60	74.00	19.40
2 331.56 [1)]	1 000	H	65.20	4.75	-61.11	31.46	-24.90	40.30	74.00	33.70
2 793.13	1 000	H	73.10	5.10	-61.99	32.19	-24.70	48.40	74.00	25.60
3 989.38	1 000	H	75.30	5.91	-62.04	32.63	-23.50	51.80	74.00	22.20
5 586.19	1 000	H	71.80	6.88	-62.60	35.32	-20.40	51.40	74.00	22.60
19 196.37	1 000	V	48.10	12.80	-52.10	44.60	5.30	53.40	74.00	20.60
24 469.56	1 000	H	46.60	14.70	-52.40	45.20	7.50	54.10	74.00	19.90
Above 25 000.00	Not Detected	-	-	-	-	-	-	-	-	-
Average DATA. Emissions above 1 ㎓										
1 995.00	1 000	V	68.10	4.49	-62.71	30.92	-27.30	40.80	54.00	13.20
2 331.56 [1)]	1 000	H	54.70	4.75	-61.11	31.46	-24.90	29.80	54.00	24.20
2 793.13	1 000	H	59.80	5.10	-61.99	32.19	-24.70	35.10	54.00	18.90
3 989.38	1 000	H	66.90	5.91	-62.04	32.63	-23.50	43.40	54.00	10.60
5 586.19	1 000	H	64.50	6.88	-62.60	35.32	-20.40	44.10	54.00	9.90
19 196.37	1 000	V	36.60	12.80	-52.10	44.60	5.30	41.90	54.00	12.10
24 469.56	1 000	H	35.80	14.70	-52.40	45.20	7.50	43.30	54.00	10.70
Above 25 000.00	Not Detected	-	-	-	-	-	-	-	-	-

[1)] Restricted band.

8DPSK_Middle channel (2 441 ㎒)

Frequency [㎒]	Receiver Bandwidth [㎑]	Pol. [V/H]	Reading [dB(㎶)]	Cable Loss [dB]	Amp Gain [dB]	Antenna Factor [dB]	Factor [dB]	Result [dB(㎶/m)]	Limit [dB(㎶/m)]	Margin [dB]
Peak DATA. Emissions above 1 ㎓										
1 678.44	1 000	V	78.10	4.07	-63.69	30.12	-29.50	48.60	74.00	25.40
1 995.00	1 000	V	83.50	4.49	-62.71	30.92	-27.30	56.20	74.00	17.80
2 793.44	1 000	H	73.10	5.10	-61.99	32.19	-24.70	48.40	74.00	25.60
3 989.38	1 000	H	74.70	5.91	-62.04	32.63	-23.50	51.20	74.00	22.80
5 586.19	1 000	H	70.80	6.88	-62.60	35.32	-20.40	50.40	74.00	23.60
18 904.19	1 000	H	47.70	12.70	-51.90	44.40	5.20	52.90	74.00	21.10
24 375.00	1 000	V	46.40	14.60	-52.40	45.10	7.30	53.70	74.00	20.30
Above 25 000.00	Not Detected	-	-	-	-	-	-	-	-	-
Average DATA. Emissions above 1 ㎓										
1 678.44	1 000	V	73.00	4.07	-63.69	30.12	-29.50	43.50	54.00	10.50
1 995.00	1 000	V	69.80	4.49	-62.71	30.92	-27.30	42.50	54.00	11.50
2 793.44	1 000	H	60.10	5.10	-61.99	32.19	-24.70	35.40	54.00	18.60
3 989.38	1 000	H	67.30	5.91	-62.04	32.63	-23.50	43.80	54.00	10.20
5 586.19	1 000	H	64.60	6.88	-62.60	35.32	-20.40	44.20	54.00	9.80
18 904.19	1 000	H	36.70	12.70	-51.90	44.40	5.20	41.90	54.00	12.10
24 375.00	1 000	V	36.10	14.60	-52.40	45.10	7.30	43.40	54.00	10.60
Above 25 000.00	Not Detected	-	-	-	-	-	-	-	-	-

8DPSK_Highest channel (2 480 ㎒)

Frequency [㎒]	Receiver Bandwidth [㎑]	Pol. [V/H]	Reading [dB(㎶)]	Cable Loss [dB]	Amp Gain [dB]	Antenna Factor [dB]	Factor [dB]	Result [dB(㎶/m)]	Limit [dB(㎶/m)]	Margin [dB]
Peak DATA. Emissions above 1 ㎓										
1 995.31	1 000	V	83.00	4.49	-62.71	30.92	-27.30	55.70	74.00	18.30
2 491.25 [1)]	1 000	H	65.30	4.87	-61.08	31.71	-24.50	40.80	74.00	33.20
2 793.13	1 000	H	74.00	5.10	-61.99	32.19	-24.70	49.30	74.00	24.70
3 989.38	1 000	H	76.50	5.91	-62.04	32.63	-23.50	53.00	74.00	21.00
5 586.19	1 000	H	72.00	6.88	-62.60	35.32	-20.40	51.60	74.00	22.40
18 340.00	1 000	V	48.40	12.50	-51.60	44.10	5.00	53.40	74.00	20.60
24 355.87	1 000	H	47.30	14.60	-52.40	45.10	7.30	54.60	74.00	19.40
Above 25 000.00	Not Detected	-	-	-	-	-	-	-	-	-
Average DATA. Emissions above 1 ㎓										
1 995.31	1 000	V	71.70	4.49	-62.71	30.92	-27.30	44.40	54.00	9.60
2 491.25 [1)]	1 000	H	54.60	4.87	-61.08	31.71	-24.50	30.10	54.00	23.90
2 793.13	1 000	H	63.10	5.10	-61.99	32.19	-24.70	38.40	54.00	15.60
3 989.38	1 000	H	67.30	5.91	-62.04	32.63	-23.50	43.80	54.00	10.20
5 586.19	1 000	H	64.90	6.88	-62.60	35.32	-20.40	44.50	54.00	9.50
18 340.00	1 000	V	37.00	12.50	-51.60	44.10	5.00	42.00	54.00	12.00
24 355.87	1 000	H	36.10	14.60	-52.40	45.10	7.30	43.40	54.00	10.60
Above 25 000.00	Not Detected	-	-	-	-	-	-	-	-	-

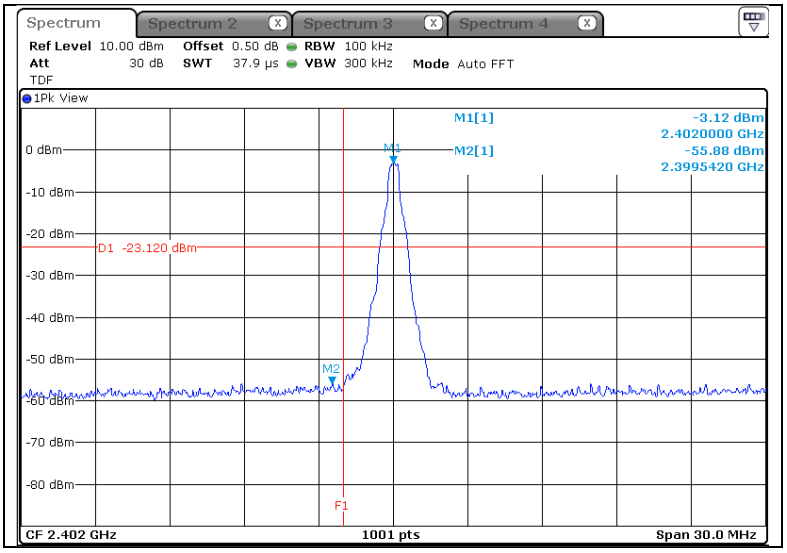
[1)] Restricted band.

5.7.4 Test Plot

Figure 5. Plot of the Band Edge (Conducted)

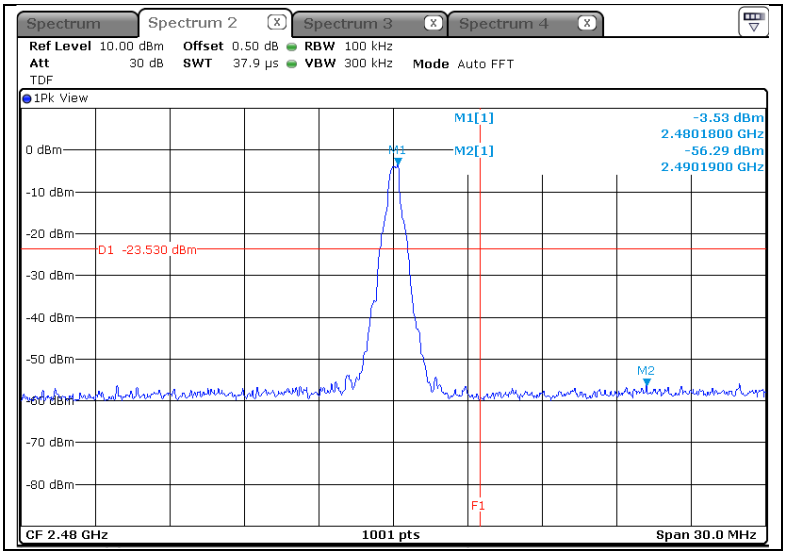
- GFSK (Without hopping)

Lowest Channel (2 402 ㎒)



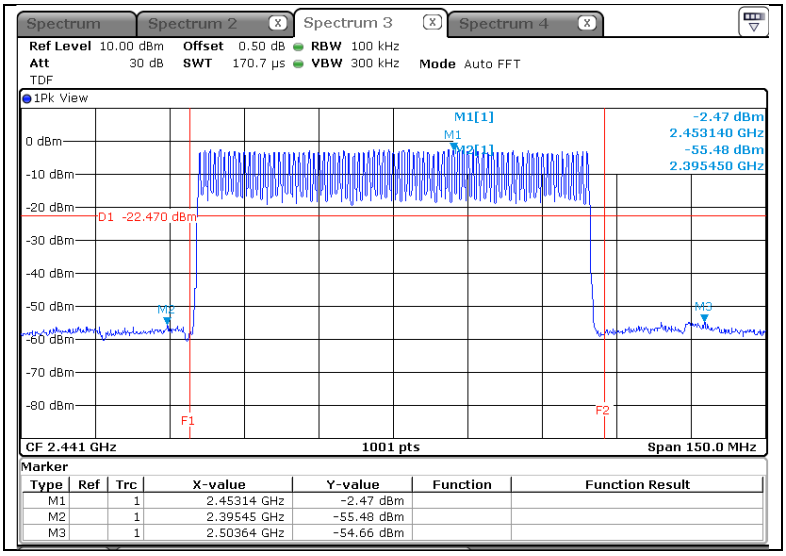
- Result of 2 400.0 ㎒

Highest Channel (2 480 ㎒)



- Result of 2 483.5 ㎒

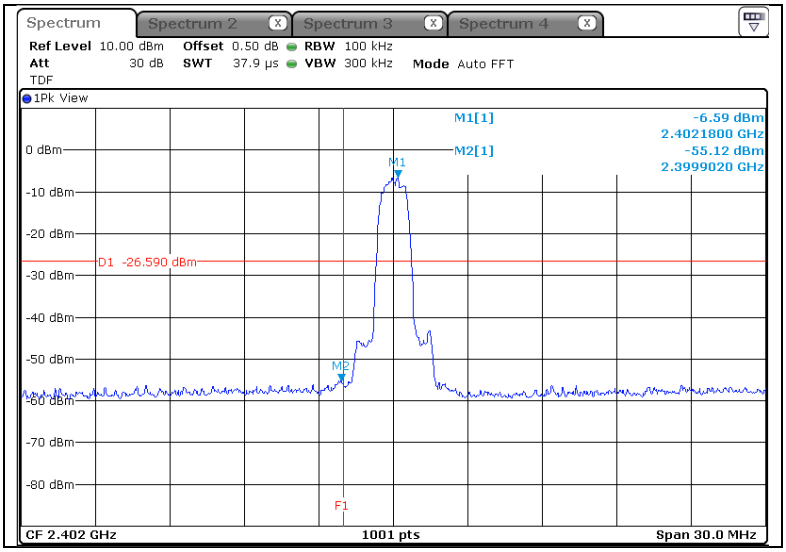
- GFSK (With hopping)



- Result of 2 400.0 ㎒ - 2 483.5 ㎒

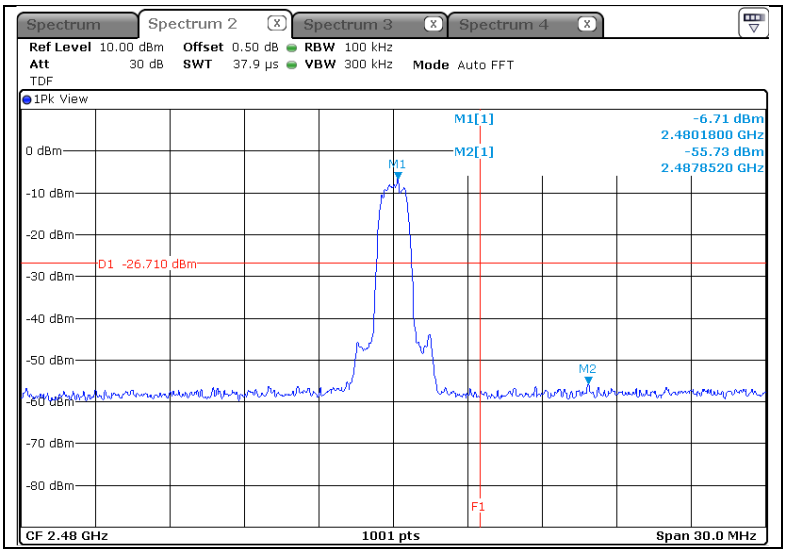
- 8DPSK (Without hopping)

Lowest Channel (2 402 ㎒)



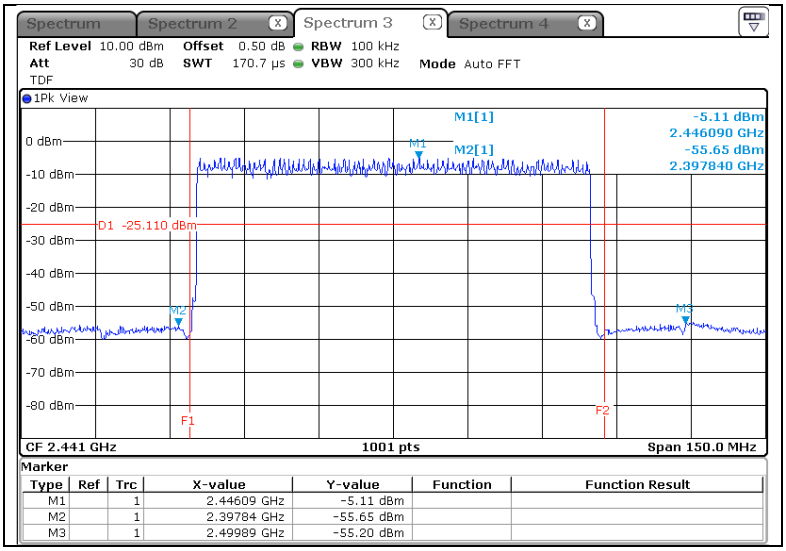
- Result of 2 400.0 ㎒

Highest Channel (2 480 ㎒)



- Result of 2 483.5 ㎒

- 8DPSK (With hopping)

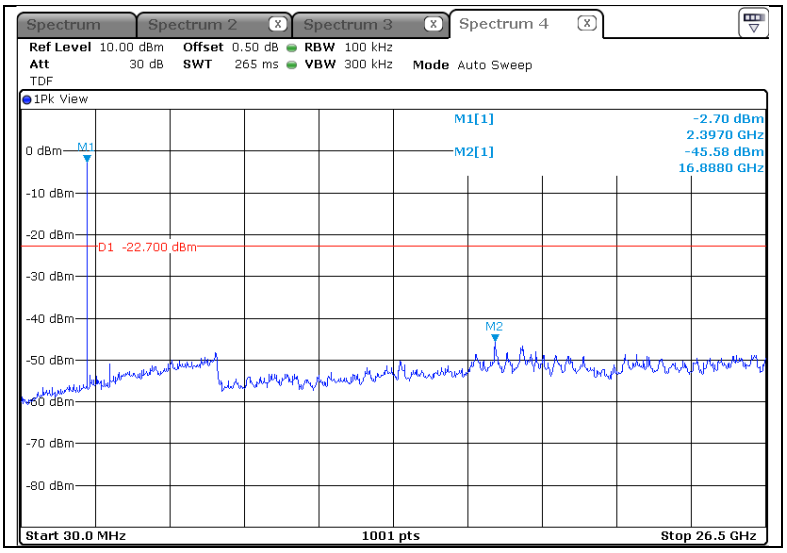


- Result of 2 400.0 ㎒ - 2 483.5 ㎒

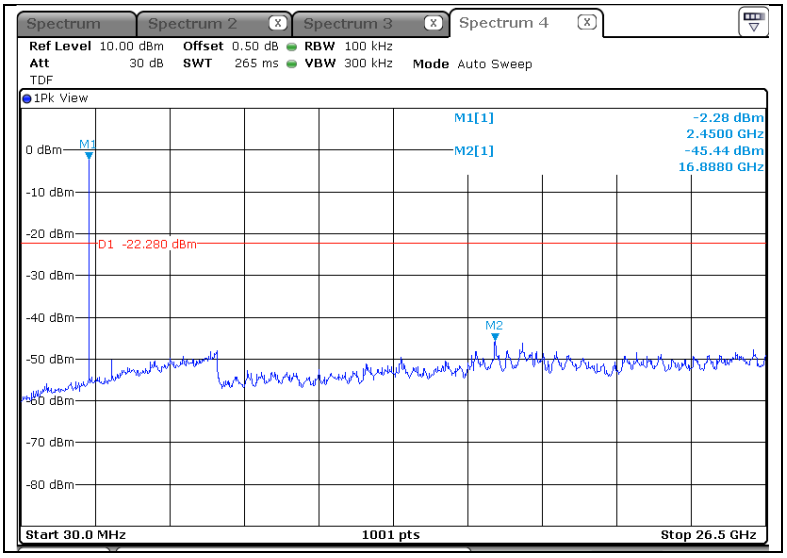
Figure 6. Plot of the Spurious RF conducted emissions

- GFSK

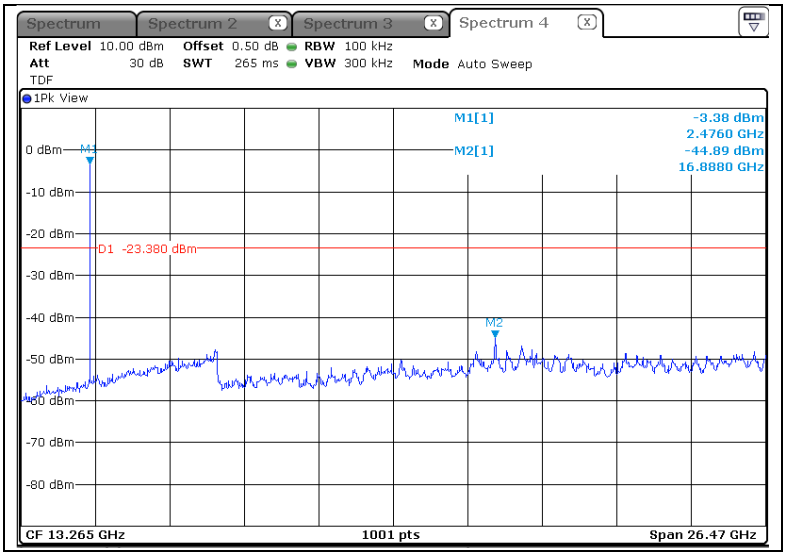
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

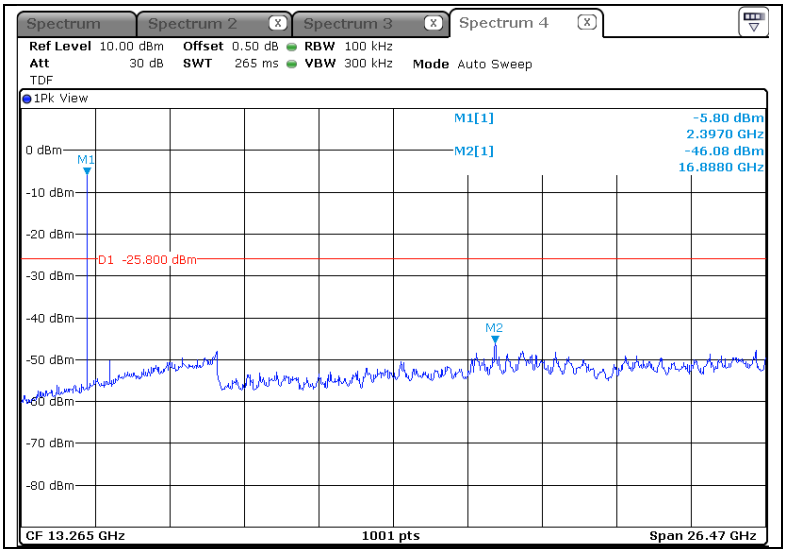


Highest Channel (2 480 ㎒)

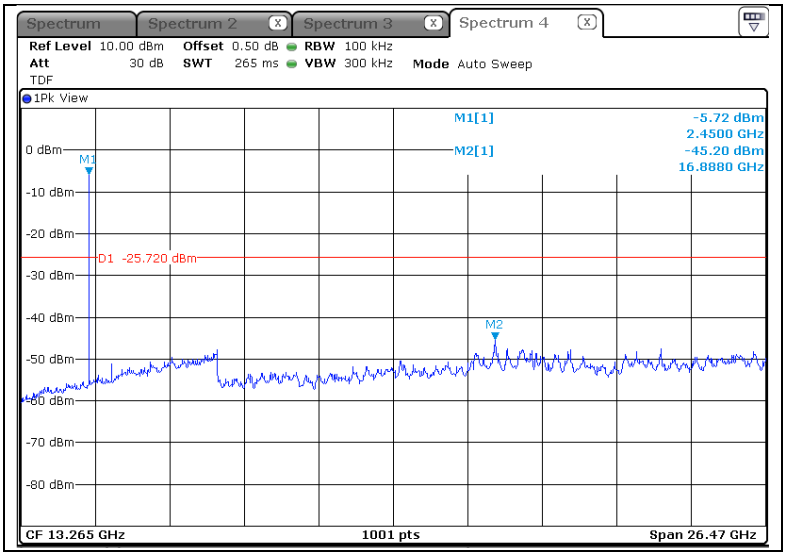


- 8DPSK

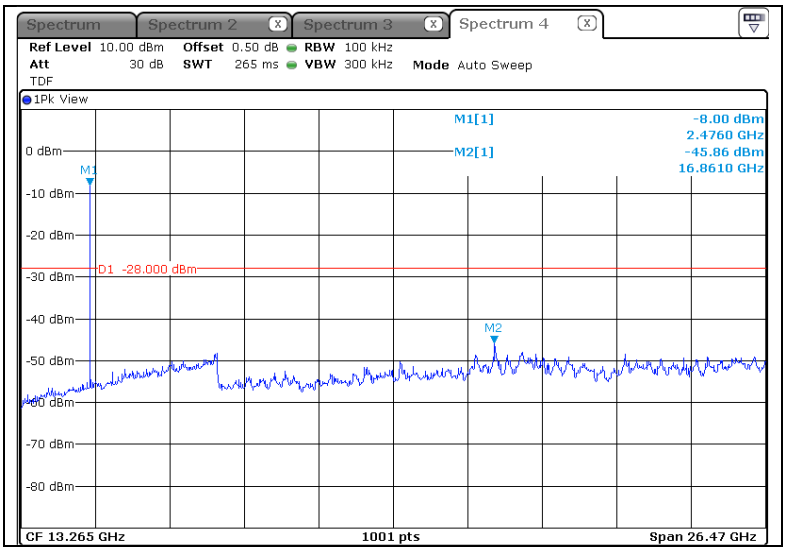
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)



Highest Channel (2 480 ㎒)



5.8 Conducted Emission

5.8.1 Regulation

5.8.1.1 Regulation for FCC

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

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

* Decreases with the logarithm of the frequency.

According to §15.107(a), for unintentional device, except for Class A digital devices, line conducted emission limits are the same as the above table.

5.8.1.2 Regulation for IC

According to § RSS GEN Issue 4, 8.8, 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 ㎑ -30 ㎒, shall not exceed the limits in Table 3.

Unless the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply either directly or indirectly (such as with a battery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 ㎒ to 30 ㎒ shall not exceed the limits shown in Table 3 below. The more stringent limit applies at the frequency range boundaries.

The conducted emissions shall be measured in accordance with the reference publication mentioned in Section 3.

Frequency (㎒)	Conducted limit (㏈㎶)	
	Qausi-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.

5.8.2 Measurement Procedure

1) The EUT was placed on a wooden table of size, 1 m by 1.5 m, raised 80 ㎝ in which is located 40 ㎝ away from the vertical wall and 1.5m away from the side wall of the shielded room.

2) Each current-carrying conductor of the EUT power cord was individually connected through a 50Ω/50μH LISN, which is an input transducer to a Spectrum Analyzer or an EMI/Field Intensity Meter, to the input power source.

3) Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.

4) The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment is the system) was then performed over the frequency range of 0.15 ㎒ to 30 ㎒.

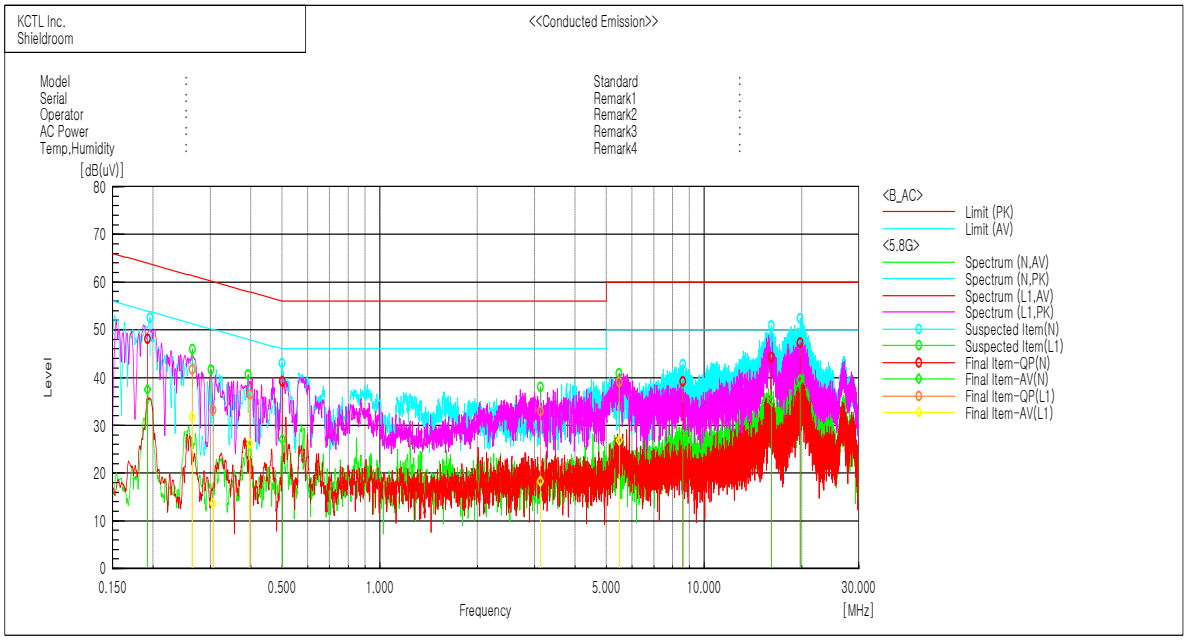
5) The measurements were made with the detector set to PEAK amplitude within a bandwidth of 10 ㎑ or to QUASI-PEAK and AVERAGE within a bandwidth of 9 ㎑. The EUT was in transmitting mode during the measurements.

5.8.3 Test Result

- Complied

Figure 6. plot of Conducted Emission

- Conducted worst-case data : 8DPSK_Middle channel (2 441 ㎒)



Final Result

--- N Phase ---

No.	Frequency [MHz]	Reading QP [dB(uV)]	Reading CAV [dB(uV)]	c.f [dB]	Result QP [dB(uV)]	Result CAV [dB(uV)]	Limit QP [dB(uV)]	Limit AV [dB(uV)]	Margin QP [dB]	Margin CAV [dB]
1	0.19214	38.1	27.4	10.0	48.1	37.4	63.9	53.9	15.8	16.5
2	0.50061	29.4	17.3	9.8	39.2	27.1	56.0	46.0	16.8	18.9
3	8.59265	29.2	18.0	9.9	39.1	27.9	60.0	50.0	20.9	22.1
4	16.11409	34.3	25.1	10.0	44.3	35.1	60.0	50.0	15.7	14.9
5	19.78459	37.2	29.4	10.1	47.3	39.5	60.0	50.0	12.7	10.5

--- L1 Phase ---

No.	Frequency [MHz]	Reading QP [dB(uV)]	Reading CAV [dB(uV)]	c.f [dB]	Result QP [dB(uV)]	Result CAV [dB(uV)]	Limit QP [dB(uV)]	Limit AV [dB(uV)]	Margin QP [dB]	Margin CAV [dB]
1	0.26395	32.0	21.9	9.7	41.7	31.6	61.3	51.3	19.6	19.7
2	0.30625	23.4	3.8	9.7	33.1	13.5	60.1	50.1	27.0	36.6
3	0.39751	26.5	16.2	9.9	36.4	26.1	57.9	47.9	21.5	21.8
4	3.1278	23.2	8.4	9.8	33.0	18.2	56.0	46.0	23.0	27.8
5	5.47496	29.1	16.9	9.9	39.0	26.8	60.0	50.0	21.0	23.2

6. Test equipment used for test

	Equipment Name	Manufacturer	Model No.	Serial No.	Next Cal. Date
■	Spectrum Analyzer	R & S	FSV40	100989	17.01.07
■	DC Power Supply	Agilent	E3632A	KR75304571	17.07.07
■	Signal Generator	R & S	SMR40	100007	17.06.02
■	Wideband Power Sensor	R & S	NRP-Z81	102398	17.02.11
■	ATTENUATOR	HP	8491A	29738	17.01.07
■	EMI TEST RECEIVER	R & S	ESCI	100732	17.08.25
■	TWO-LINE V-NETWORK	R & S	ENV216	101352	17.08.26
■	Bi-Log Antenna	SCHWARZBECK	VULB 9163	552	18.06.27
■	Amplifier	SONOMA INSTRUMENT	310N	186280	17.04.07
■	Attenuator	SCHWARZBECK	DGA9552N	BU2404	17.04.08
■	Horn antenna	ETS.lindgren	3116	00086635	17.05.03
■	Horn antenna	ETS.lindgren	3117	161225	17.05.03
■	AMPLIFIER	L-3 Narda-MITEQ	AMF-7D-01001800-22-10P	2003683	17.08.26
■	AMPLIFIER	L-3 Narda-MITEQ	JS44-18004000-33-8P	2000996	17.08.26
■	LOOP Antenna	R & S	HFH2-Z2	100355	18.03.03
■	Antenna Mast	MATURO	AM4.0	079/3440509	-
■	Turn Table	MATURO	CO2000-SOFT	-	-
■	Highpass Filter	WT	WT-A1698-HS	WT160411001	17.07.08
■	Vector Signal Generator	R & S	SMBV100A	257566	17.01.07
■	Cable Assembly	HUER+SUHNER	SUCOFLEX 102	MY3571/2	-