TEST REPORT

KCTL Inc.
65, Sinwon-ro, Yeongtong-gu,
Suwon-si, Gyeonggi-do, 16677, Korea
TEL: 82-31-285-0894 FAX: 82-505-299-8311
www.kctl.co.kr

1. Client

- Name : SELVAS Healthcare,Inc.
- Address : 155, Sinseong-ro, Yuseong-gu, Daejeon, Republic of Korea
- Date of Receipt : 2018-06-08

2. Use of Report : -

3. Name of Product and Model : QBraille XL / B240H

4. Manufacturer and Country of Origin : SELVAS Healthcare,Inc. / Korea

5. FCC ID : 2AL4DB240H

6. Date of Test : 2018-08-10 to 2018-08-16

7. Test Standards : FCC Part 15 Subpart C, 15.247

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

Affirmation	Tested by Name : Jaehyoung Lee (Signature)	Technical Manager Name : Seungyong Kim (Signature)

2018-08-20

KCTL Inc.

REPORT REVISION HISTORY

Date	Revision	Page No
2018-06-28	Originally issued	-
2018-08-16	Fully Re-tested	all
2018-08-20	Added note for cable loss offset and revised plot	6,12, 13, 90, 93, 103

[Contents]

1. Client information

Applicant:	SELVAS Healthcare,Inc.
Address:	155, Sinseong-ro, Yuseong-gu, Daejeon, Republic of Korea
Telephone number:	+82 42 864 4460
Contact person:	Yunse Lee / aiden.y.lee@selvas.com

Manufacturer:	SELVAS Healthcare,Inc.
Address:	155, Sinseong-ro, Yuseong-gu, Daejeon, Republic of Korea

2. Laboratory information

Address

KCTL Inc.

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

Telephone Number: +82 31 285 0894

Facsimile Number: +82 505 299 8311

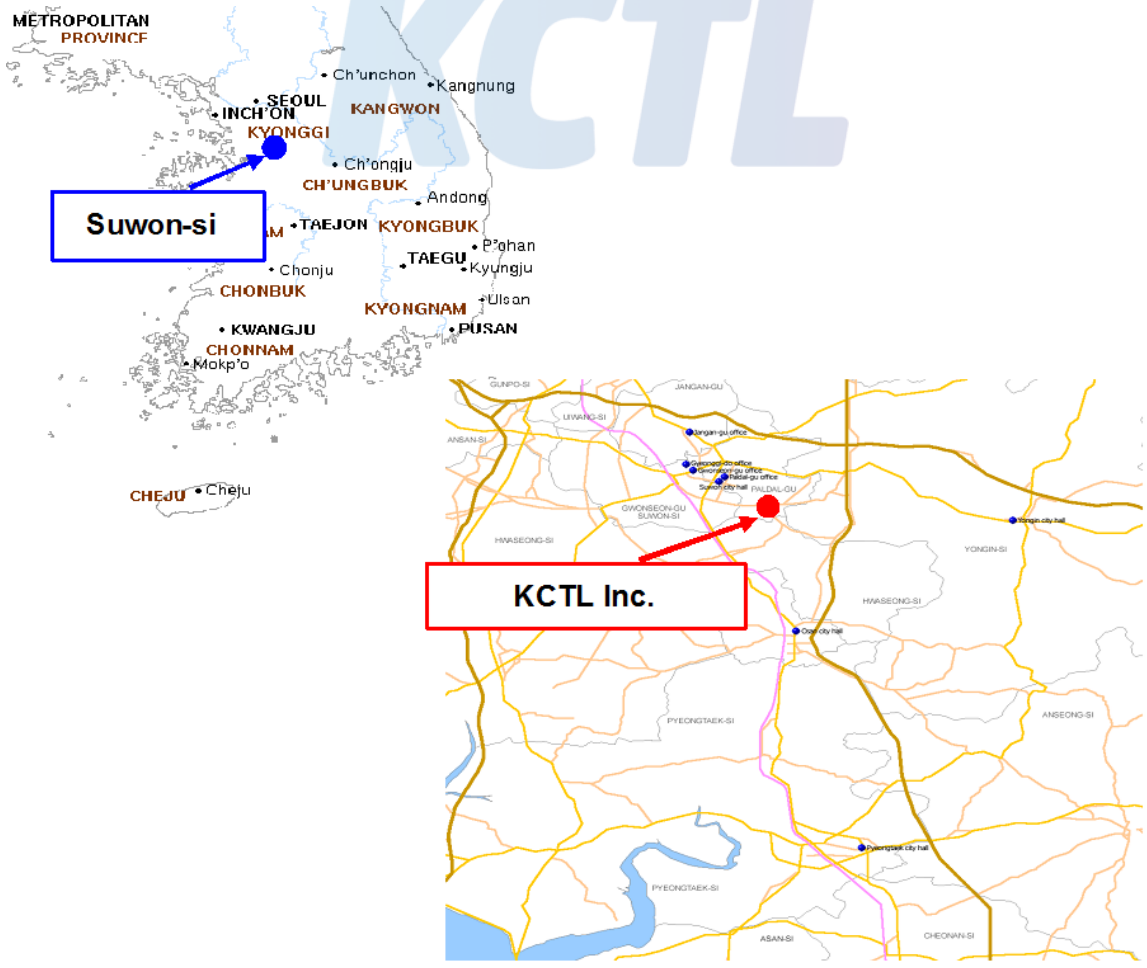
FCC Site Designation No: KR0040, FCC Site Registration No: 687132

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	SELVAS Healthcare,Inc.
Address of Applicant	155, Sinseong-ro, Yuseong-gu, Daejeon, Republic of Korea
Manufacturer	SELVAS Healthcare,Inc.
Address of Manufacturer	155, Sinseong-ro, Yuseong-gu, Daejeon, Republic of Korea
Type of equipment	QBraille XL
Basic Model	B240H
Serial number	N/A

3.2 General description

Frequency Range	2 402 ㎒ ~ 2 480 ㎒
Type of Modulation	GFSK, π/4DQPSK, 8DPSK
The number of channels	79 ch
Type of Antenna	Chip Antenna
Antenna Gain	0.5 ㏈i
Transmit Power	4.35 ㏈m (Module 1), 2.54 ㏈m (Module 2)
Operation temperature	21 ℃
Power supply	DC 5 V
Product SW/HW version	1.0 / 2.40.3.26556
Radio SW/HW version	1.0 / 2.40.3.26556
Test SW Version	CSR Bluesuite 2.5.0
RF power setting in TEST SW	Referred the measuring instrument from manufacturer

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 5 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	Parameter	Report Section	Test Result
15.203, 15.247(b)(4)	Antenna Requirement	5.1	C
15.247(b)(1), (4)	Maximum Peak Output Power	5.2	C
15.247(a)(1)	Carrier Frequency Separation	5.3	C
15.247(a)(1)	20dB Channel Bandwidth	5.4	C
-	Occupied Bandwidth	5.4	C
15.247(a)(iii) 15.247(b)(1)	Number of Hopping Channel	5.5	C
15.247(a) (iii)	Time of Occupancy(Dwell Time)	5.6	C
15.247(d),15.205(a),15.209(a)	Spurious Emission, BandEdge, Restricted Band	5.7	C
15.207(a)	Conducted Emissions	5.8	C
Note1) : C = Complies, NC = Not Complies, NT = Not Tested, NA = Not Applicable Note2) : This device is consisted of two bluetooth modules which are same type. Note3) : Two bluetooth modules do not support transmission at the same time.			

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

4.2 Measurement Uncertainty

Measurement Item	Expanded Uncertainty U = *k*Uc (*k* = 2)	
Conducted RF power	1.42 dB	
Conducted Spurious Emissions	1.58 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

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.

5.1.2 Result

-Complied

The transmitter has permanently attached Chip Antenna (internal antenna) on board.

5.2 Maximum Peak Output Power

5.2.1 Regulation

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.

5.2.2 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

- Module 1

- GFSK

Channel	Frequency [㎒]	Result [dBm]	Limit [dBm]	Margin [dB]	Average Power [dBm]
Lowest	2 402	3.34	30.00	26.66	1.87
Middle	2 441	3.65	30.00	26.35	2.23
Highest	2 480	4.35	30.00	25.65	2.89

- π/4DQPSK

Channel	Frequency [㎒]	Result [dBm]	Limit [dBm]	Margin [dB]	Average Power [dBm]
Lowest	2 402	1.34	20.97	19.63	-2.47
Middle	2 441	1.44	20.97	19.53	-2.41
Highest	2 480	2.04	20.97	18.93	-1.71

- 8DPSK

Channel	Frequency [㎒]	Result [dBm]	Limit [dBm]	Margin [dB]	Average Power [dBm]
Lowest	2 402	1.44	20.97	19.53	-2.50
Middle	2 441	1.54	20.97	19.43	-2.39
Highest	2 480	2.14	20.97	18.83	-1.75

NOTE:
1. We took the insertion loss of the cable loss into consideration within the measuring instrument.
   Cable loss: 0.5 dB
2. It was measured by power sensor.

- Module 2

- GFSK

Channel	Frequency [㎒]	Result [dBm]	Limit [dBm]	Margin [dB]	Average Power [dBm]
Lowest	2 402	1.74	30.00	28.26	0.25
Middle	2 441	1.84	30.00	28.16	0.30
Highest	2 480	2.54	30.00	27.46	1.01

- π/4DQPSK

Channel	Frequency [㎒]	Result [dBm]	Limit [dBm]	Margin [dB]	Average Power [dBm]
Lowest	2 402	-0.66	20.97	21.63	-4.67
Middle	2 441	-0.56	20.97	21.53	-4.61
Highest	2 480	0.14	20.97	20.83	-3.99

- 8DPSK

Channel	Frequency [㎒]	Result [dBm]	Limit [dBm]	Margin [dB]	Average Power [dBm]
Lowest	2 402	-0.46	20.97	21.43	-4.66
Middle	2 441	-0.46	20.97	21.43	-4.64
Highest	2 480	0.14	20.97	20.83	-3.97

NOTE:
1. We took the insertion loss of the cable loss into consideration within the measuring instrument.
   Cable loss: 0.5 dB
2. It was measured by power sensor.

5.3 Carrier Frequency Separation

5.3.1 Regulation

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 ㎽.

5.3.2 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

- Module 1

- GFSK

Channel	Frequency [㎒]	Carrier frequency separation [㎒]	Limit [㎒]
Lowest	2 402	1.000	0.972
Middle	2 441	1.000	0.919
Highest	2 480	1.000	0.991

- π/4DQPSK

Channel	Frequency [㎒]	Carrier frequency separation [㎒]	Limit [㎒]
Lowest	2 402	1.000	0.887
Middle	2 441	1.000	0.887
Highest	2 480	1.000	0.887

- 8DPSK

Channel	Frequency [㎒]	Carrier frequency separation [㎒]	Limit [㎒]
Lowest	2 402	1.000	0.887
Middle	2 441	1.000	0.887
Highest	2 480	1.000	0.887

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

- Module 2

- GFSK

Channel	Frequency [㎒]	Carrier frequency separation [㎒]	Limit [㎒]
Lowest	2 402	1.000	0.973
Middle	2 441	1.000	0.990
Highest	2 480	1.000	0.993

- π/4DQPSK

Channel	Frequency [㎒]	Carrier frequency separation [㎒]	Limit [㎒]
Lowest	2 402	1.000	0.893
Middle	2 441	1.000	0.887
Highest	2 480	1.000	0.887

- 8DPSK

Channel	Frequency [㎒]	Carrier frequency separation [㎒]	Limit [㎒]
Lowest	2 402	1.000	0.893
Middle	2 441	1.000	0.887
Highest	2 480	1.000	0.887

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

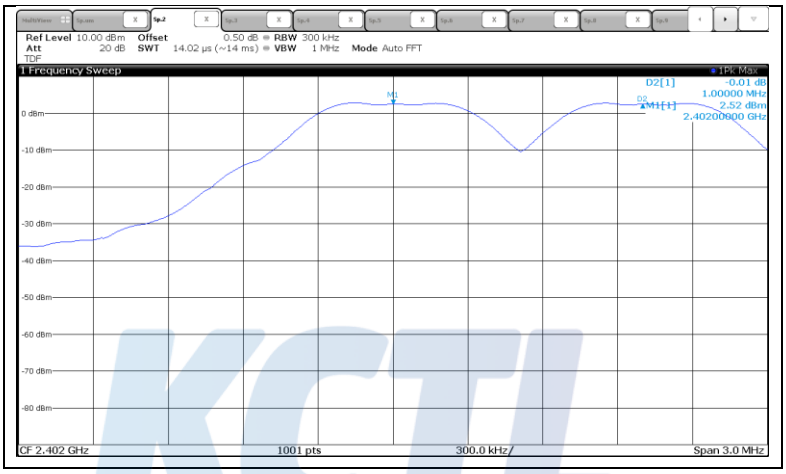
5.3.4 Test Plot

Figure 1. Plot of the Carrier Frequency Separation

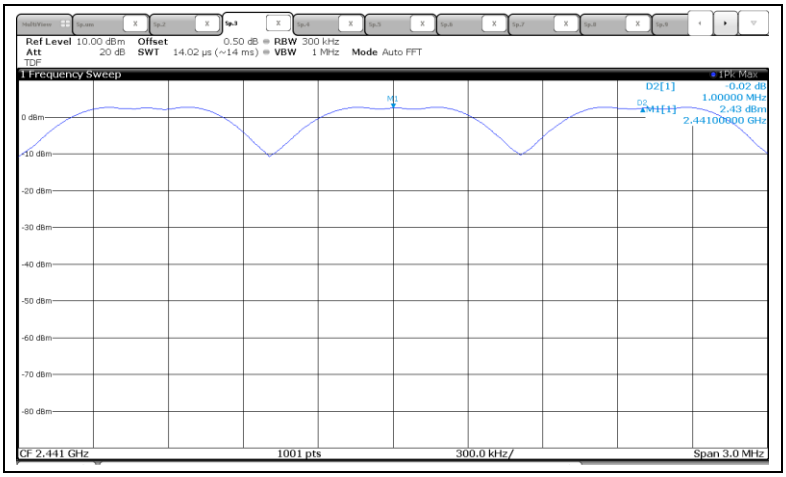
- Module 1

- GFSK

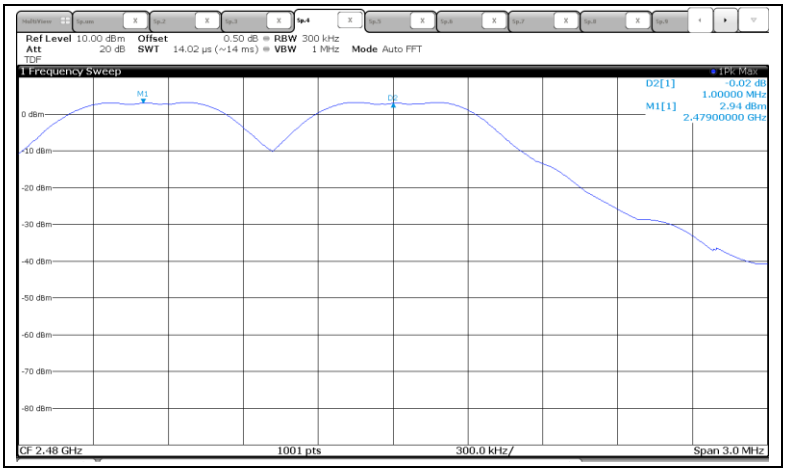
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

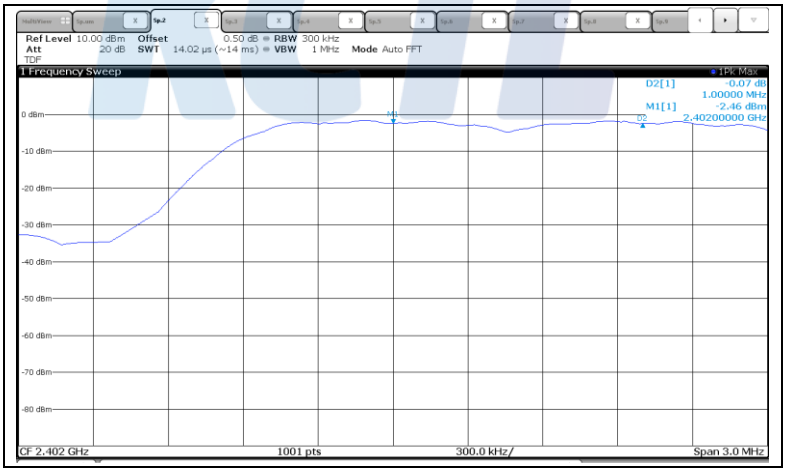


Highest Channel (2 480 ㎒)

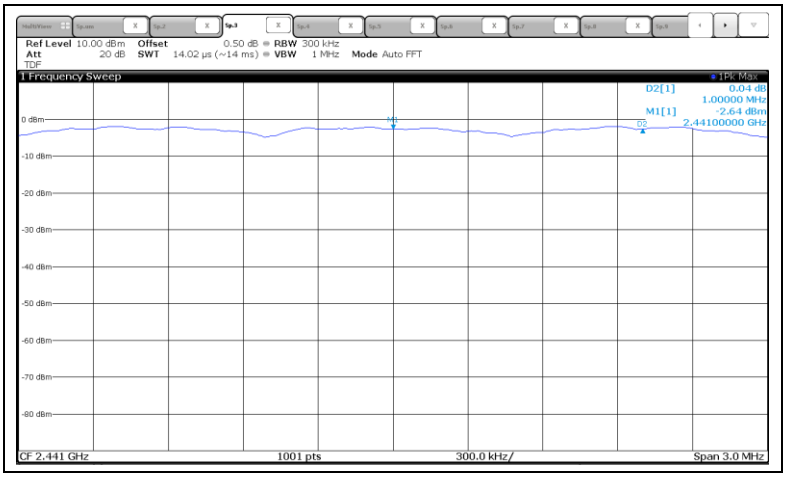


- π/4DQPSK

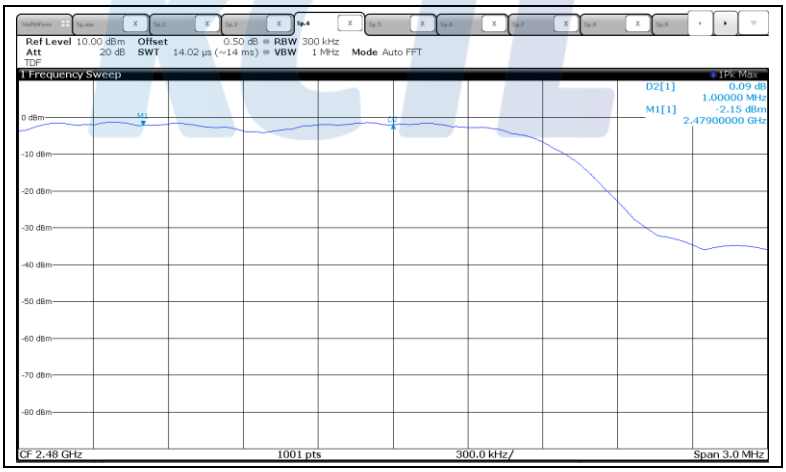
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

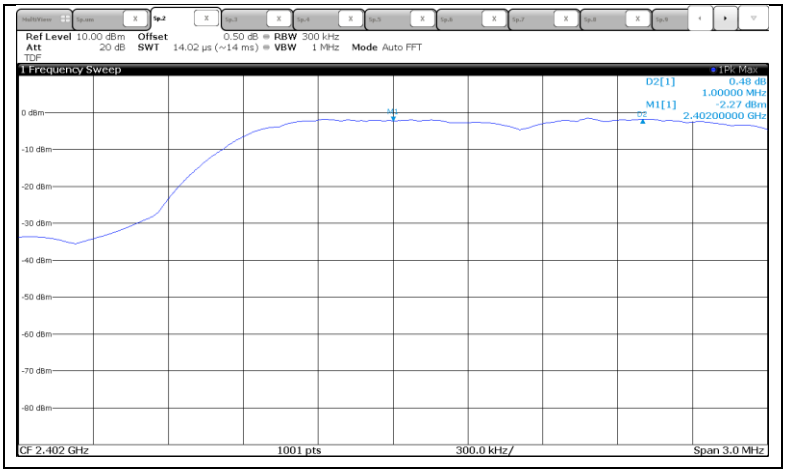


Highest Channel (2 480 ㎒)

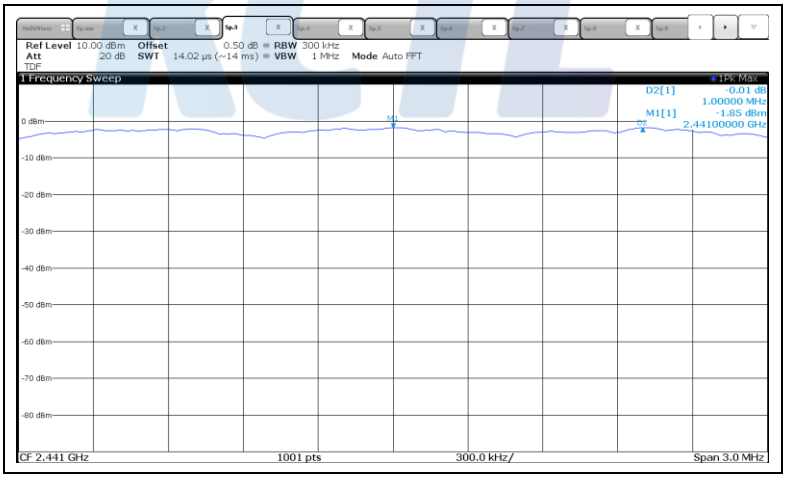


- 8DPSK

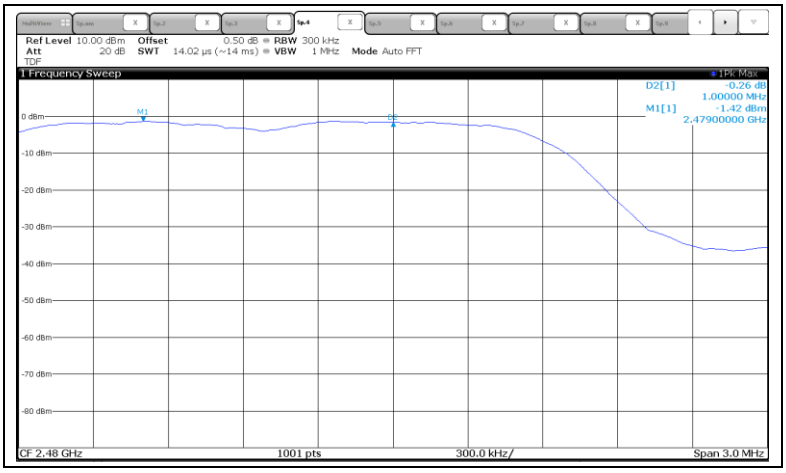
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)



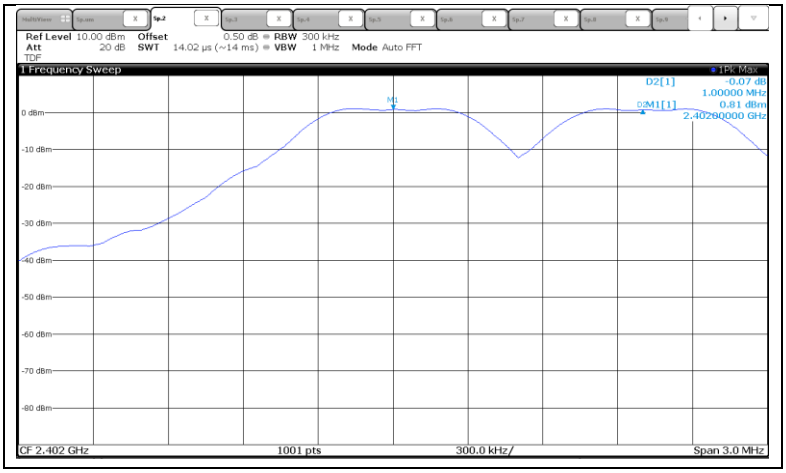
Highest Channel (2 480 ㎒)



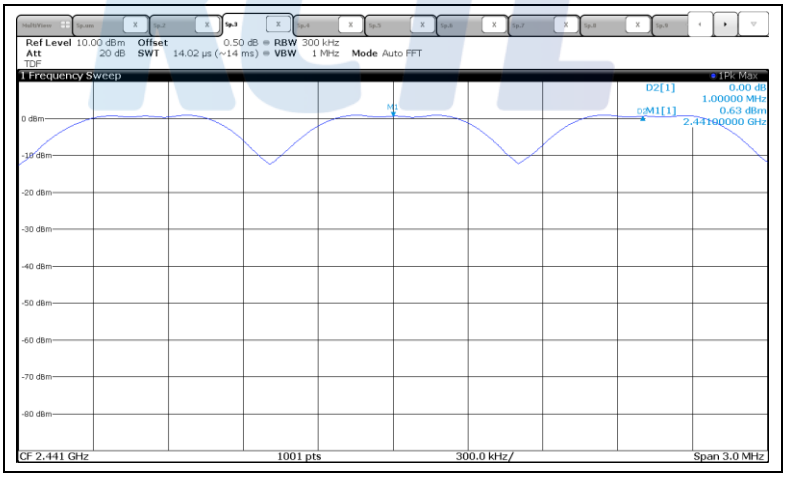
- Module 2

- GFSK

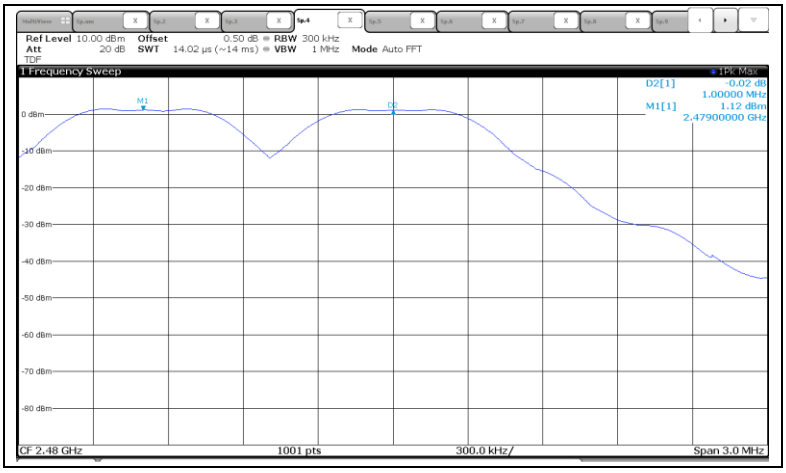
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

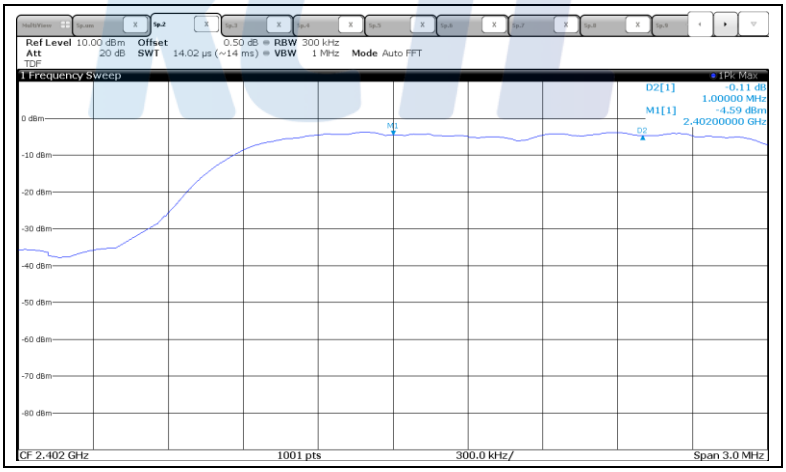


Highest Channel (2 480 ㎒)

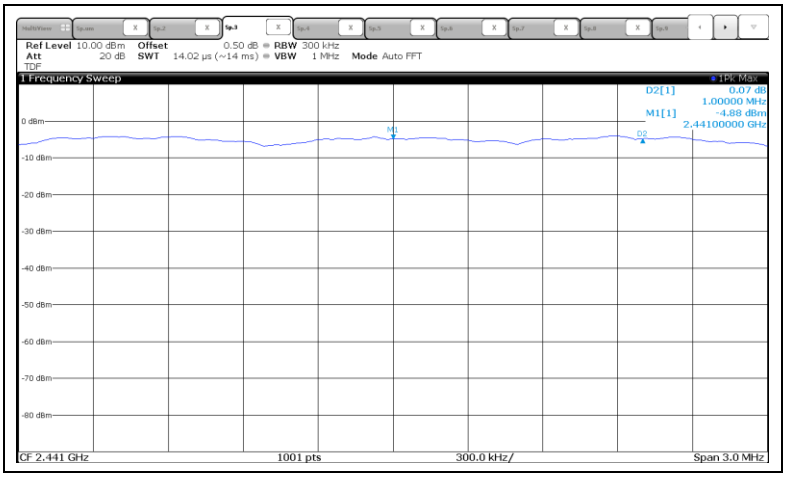


- π/4DQPSK

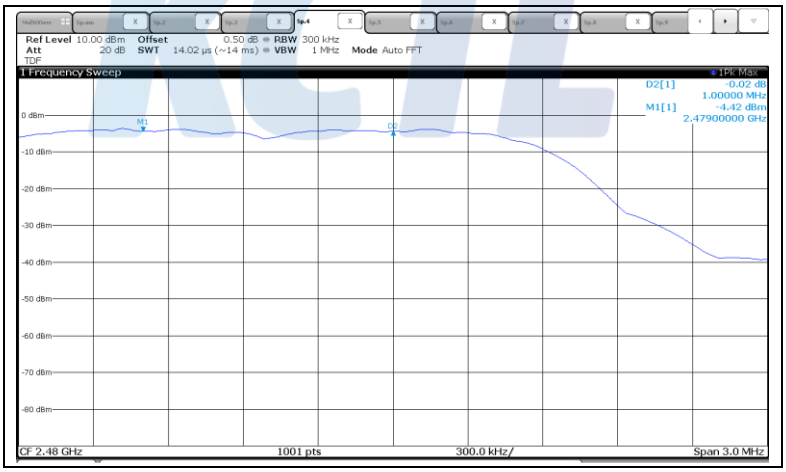
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

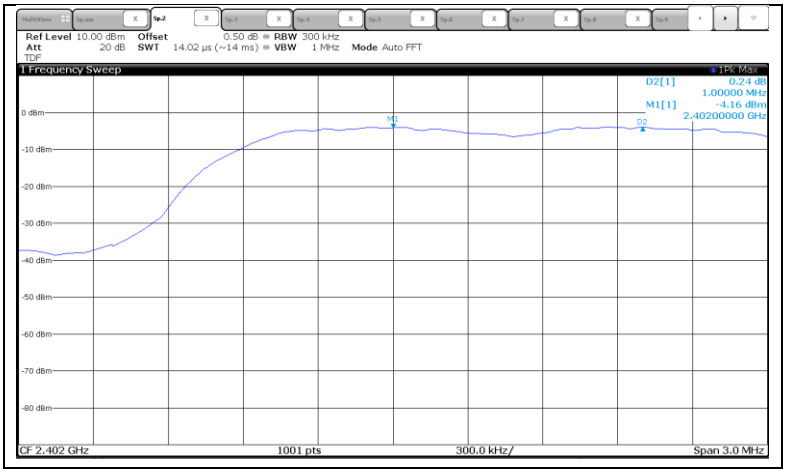


Highest Channel (2 480 ㎒)

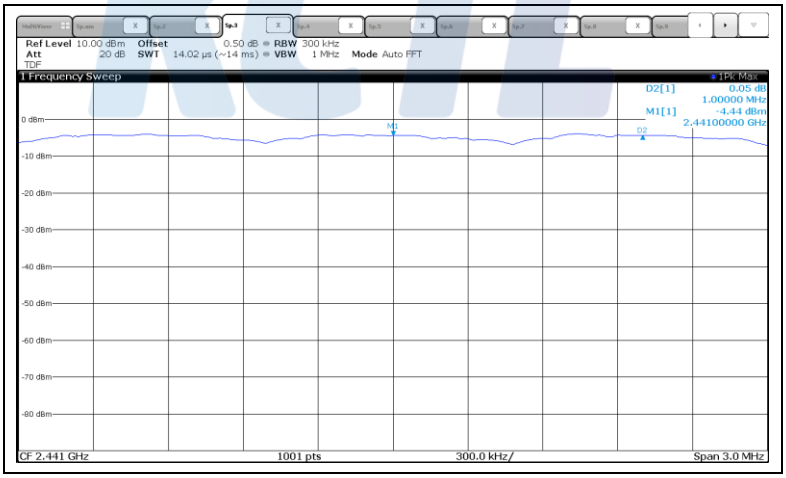


- 8DPSK

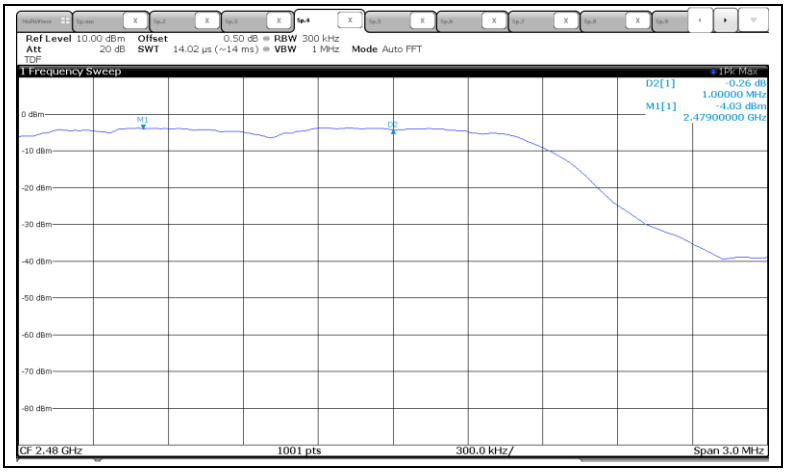
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)



Highest Channel (2 480 ㎒)



5.4 20 dB Channel Bandwidth

5.4.1 Regulation

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 ㎽.

5.4.2 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 ㏈ down from the reference value). Typical ratios, expressed in dB, are −6 ㏈, −20 ㏈, and −26 ㏈,corresponding to 6 ㏈ BW, 20 ㏈ BW, and 26 ㏈ BW, respectively. In this subclause, the ratio is designated by “−xx ㏈.” 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 ㏈” bandwidth; other requirements might specify that the “−xx ㏈” 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 ㏈ 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 ㏈ below the target “−xx ㏈ down” requirement; that is, if the requirement calls for measuring the −20 ㏈ OBW, the instrument noise floor at the selected RBW shall be at least 30 ㏈ 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

- Module 1

Mode	Channel	Frequency [㎒]	20 ㏈ Channel Bandwidth [㎒]	Occupied Bandwidth (99 % BW) [㎒]
GFSK	Lowest	2 402	0.972	0.907
	Middle	2 441	0.919	0.907
	Highest	2 480	0.991	0.907
π/4DQPSK	Lowest	2 402	1.330	1.189
	Middle	2 441	1.330	1.180
	Highest	2 480	1.330	1.185
8DPSK	Lowest	2 402	1.330	1.208
	Middle	2 441	1.330	1.206
	Highest	2 480	1.330	1.206

- Module 2

Mode	Channel	Frequency [㎒]	20 ㏈ Channel Bandwidth [㎒]	Occupied Bandwidth (99 % BW) [㎒]
GFSK	Lowest	2 402	0.973	0.901
	Middle	2 441	0.990	0.908
	Highest	2 480	0.993	0.906
π/4DQPSK	Lowest	2 402	1.340	1.183
	Middle	2 441	1.330	1.184
	Highest	2 480	1.330	1.182
8DPSK	Lowest	2 402	1.340	1.197
	Middle	2 441	1.330	1.195
	Highest	2 480	1.330	1.195

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

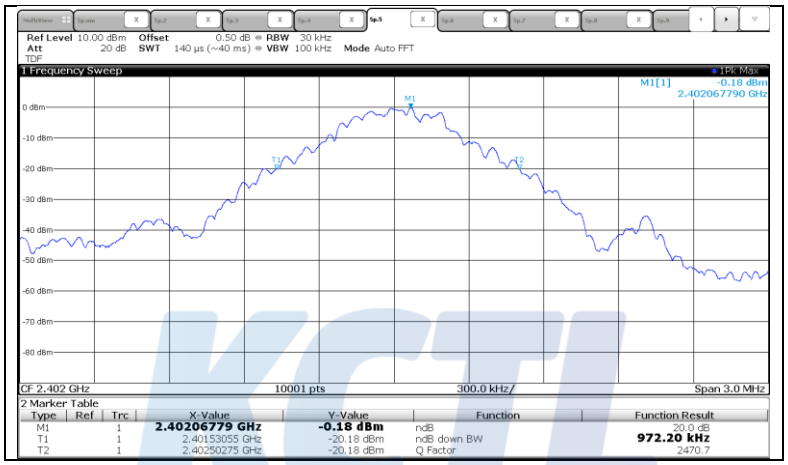
5.4.4 Test Plot

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

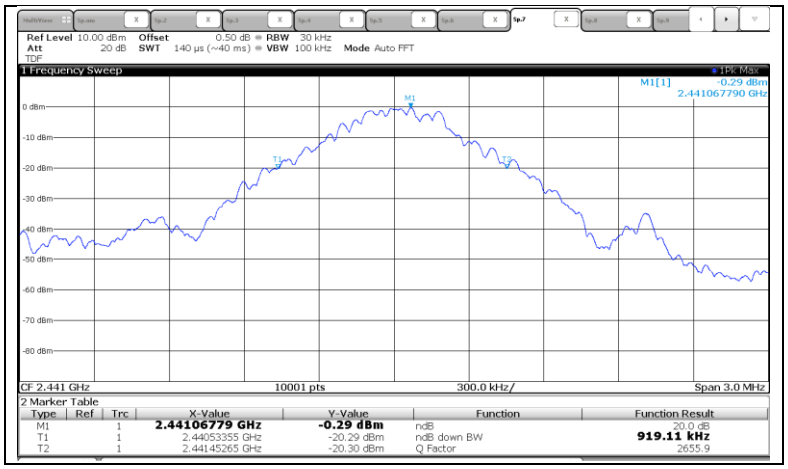
- Module 1

- GFSK_20 ㏈ Channel Bandwidth

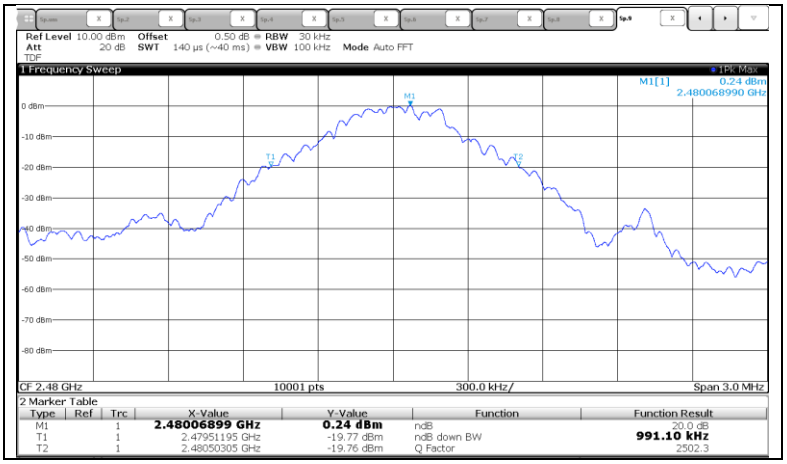
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

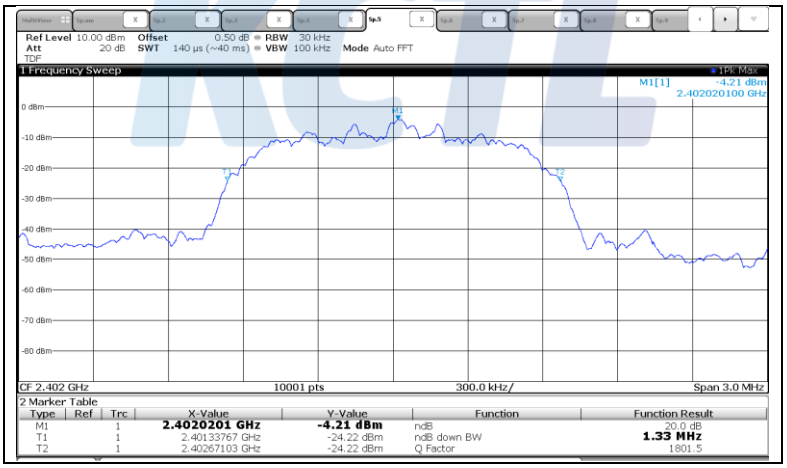


Highest Channel (2 480 ㎒)

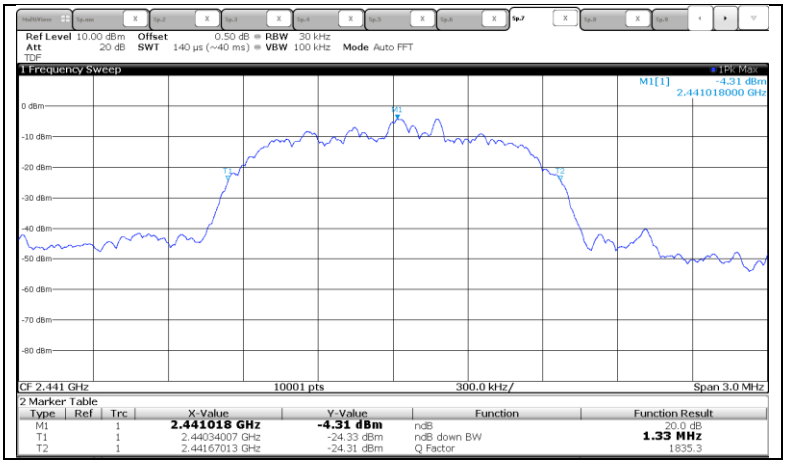


- π/4DQPSK_20 ㏈ Channel Bandwidth

Lowest Channel (2 402 ㎒)



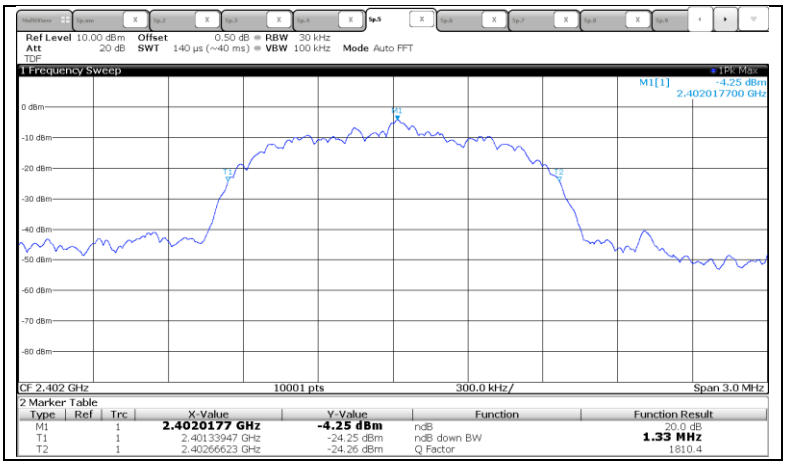
Middle Channel (2 441 ㎒)



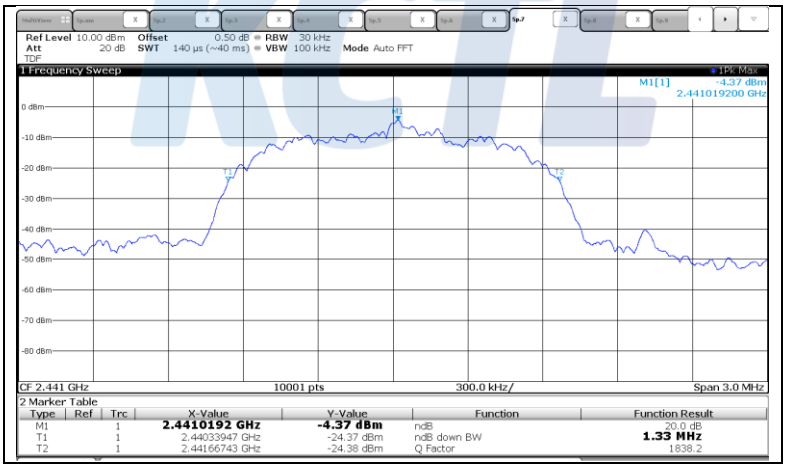
Highest Channel (2 480 ㎒)

- 8DPSK_20 dB Channel Bandwidth

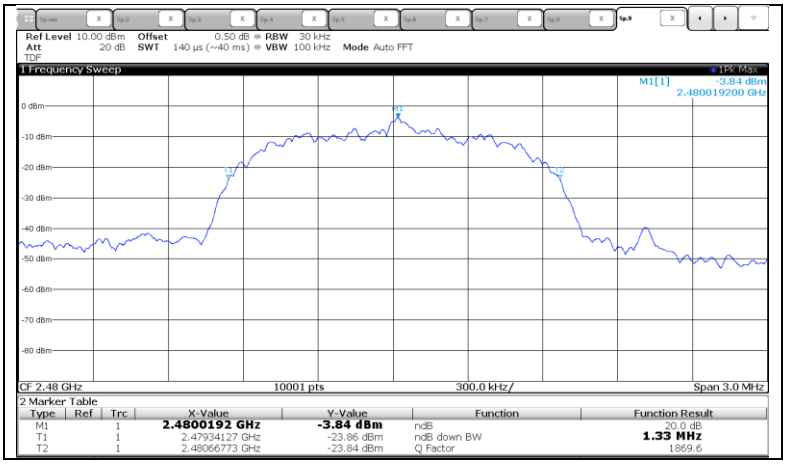
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)



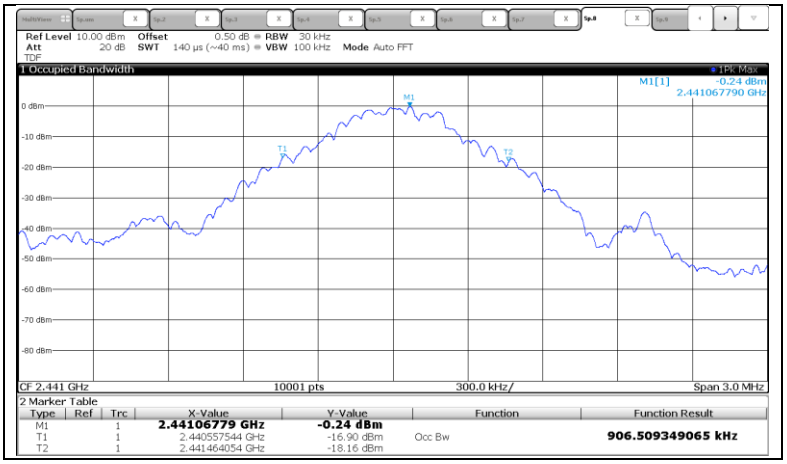
Highest Channel (2 480 ㎒)



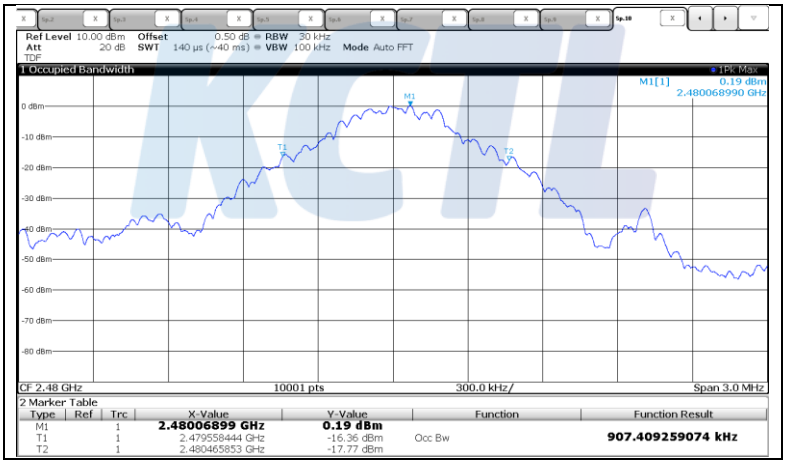
- GFSK_Occupied Bandwidth

Lowest Channel (2 402 ㎒)

Middle Channel (2 441 ㎒)

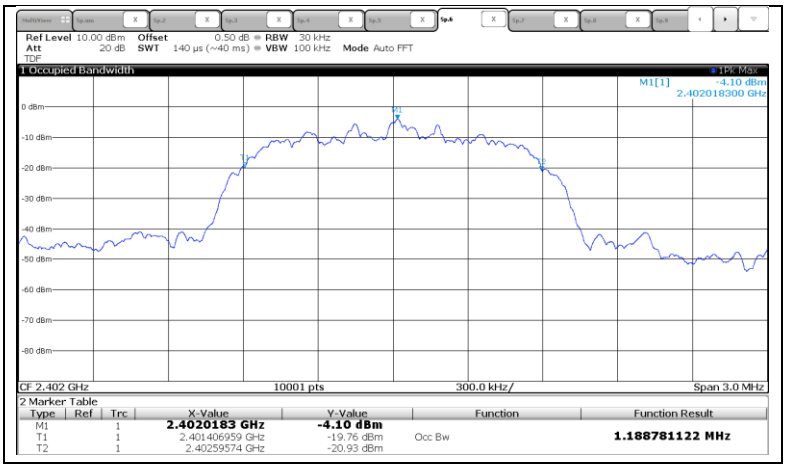


Highest Channel (2 480 ㎒)

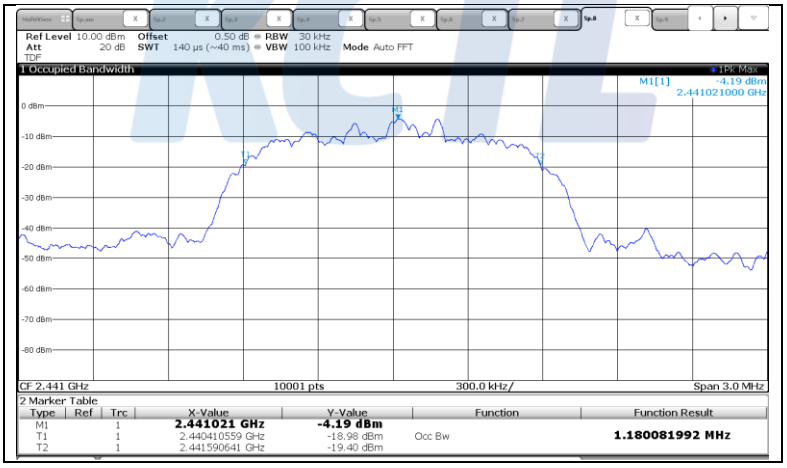


- π/4DQPSK_Occupied Bandwidth

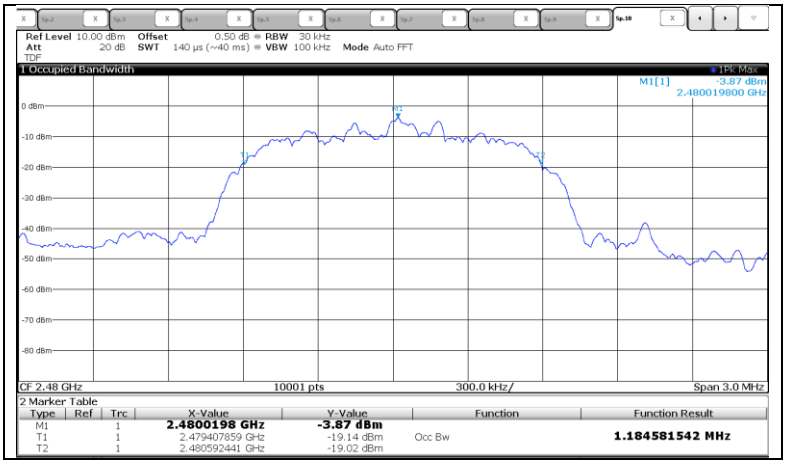
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

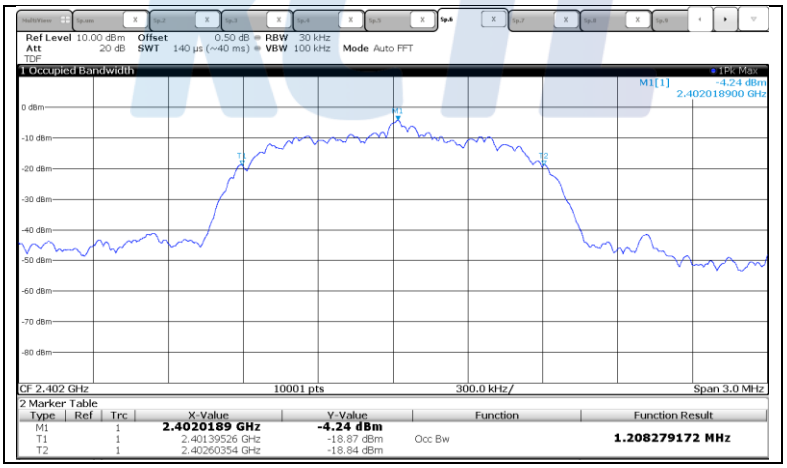


Highest Channel (2 480 ㎒)

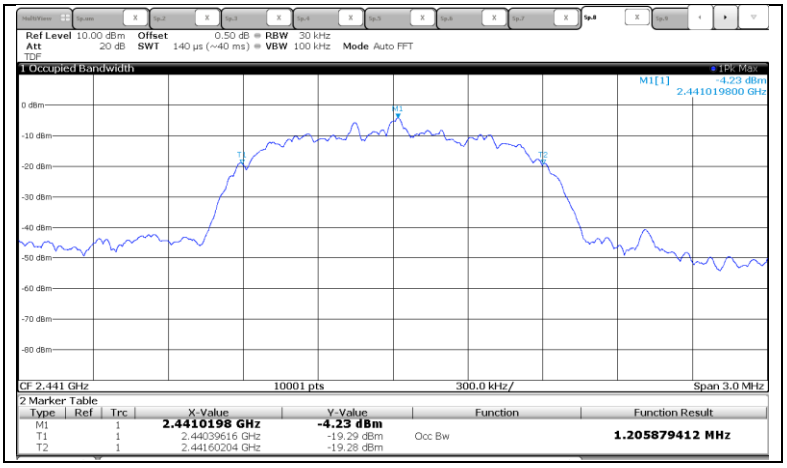


- 8DPSK_Occupied Bandwidth

Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

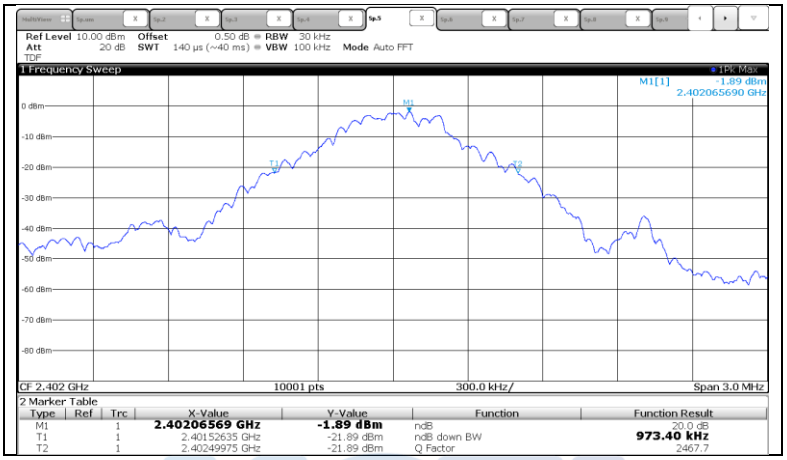


Highest Channel (2 480 ㎒)

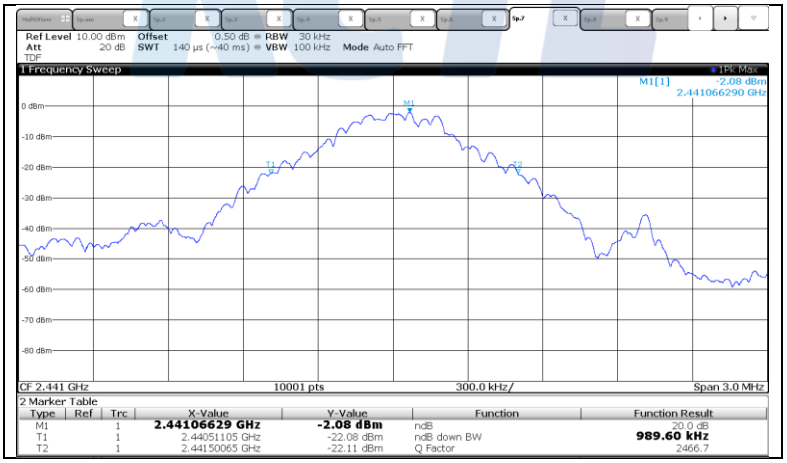
- Module 2

- GFSK_20 dB Channel Bandwidth

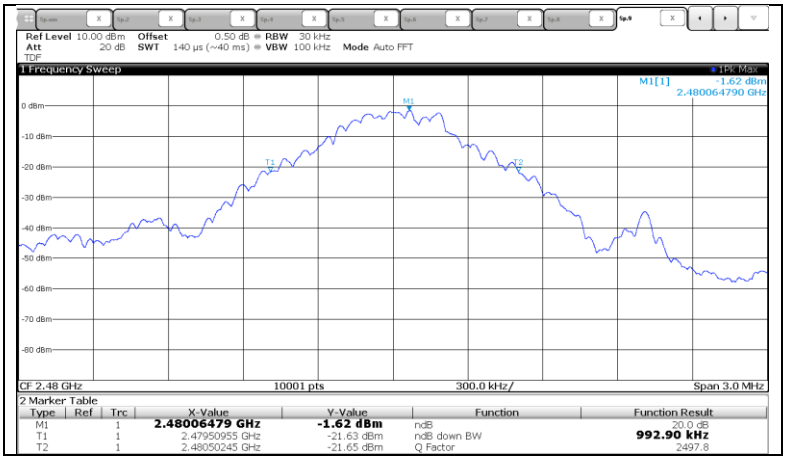
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

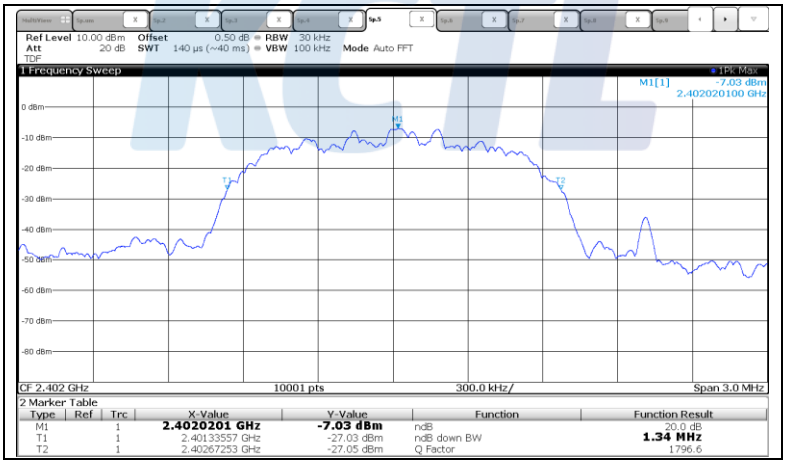


Highest Channel (2 480 ㎒)

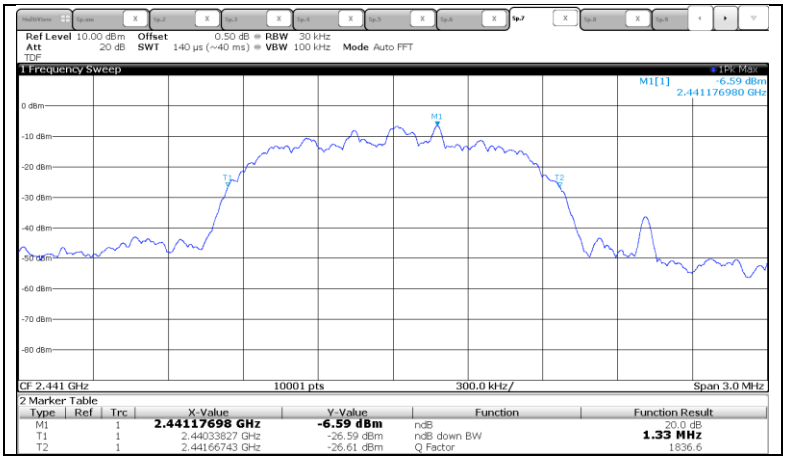


- π/4DQPSK_20 ㏈ Channel Bandwidth

Lowest Channel (2 402 ㎒)



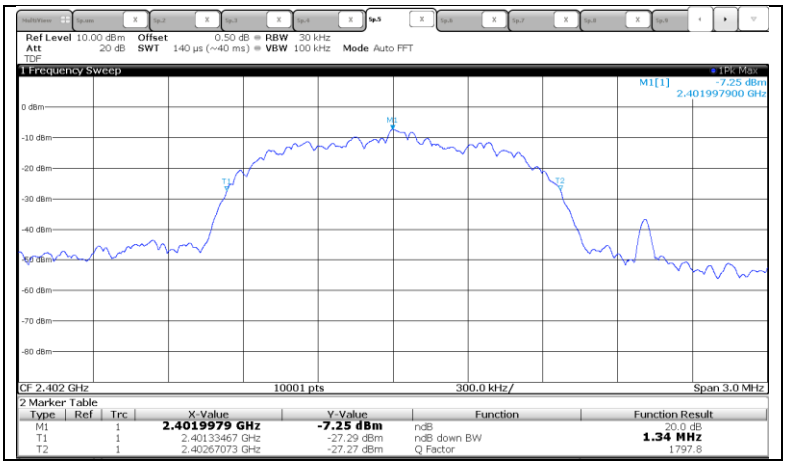
Middle Channel (2 441 ㎒)



Highest Channel (2 480 ㎒)

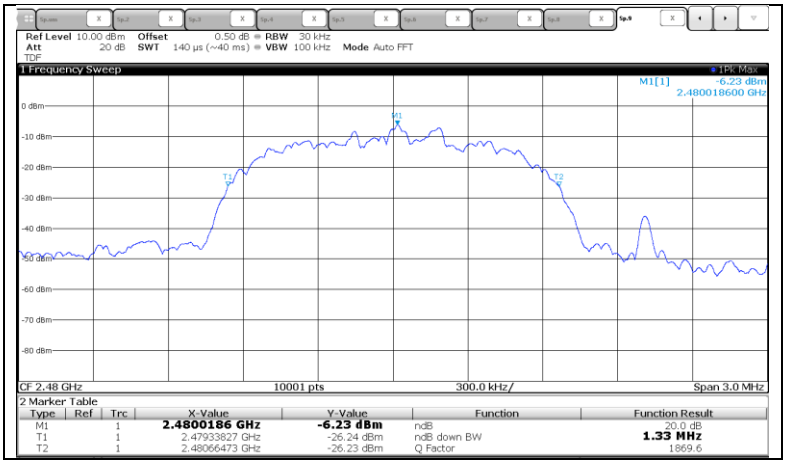
- 8DPSK_20 dB Channel Bandwidth

Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

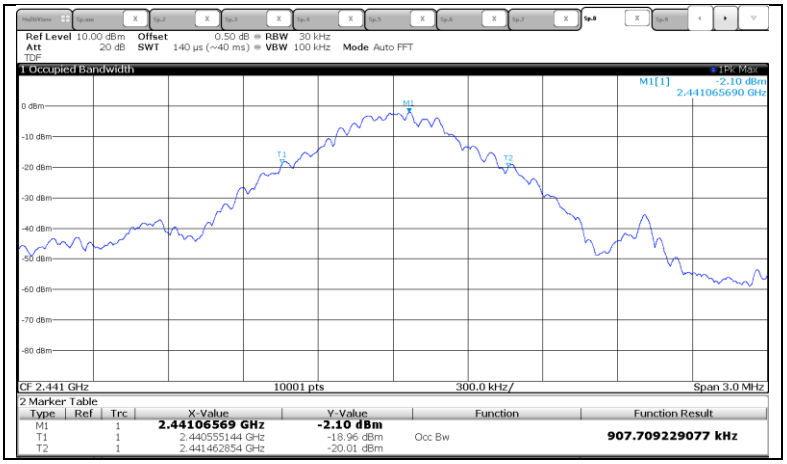
Highest Channel (2 480 ㎒)



- GFSK_Occupied Bandwidth

Lowest Channel (2 402 ㎒)

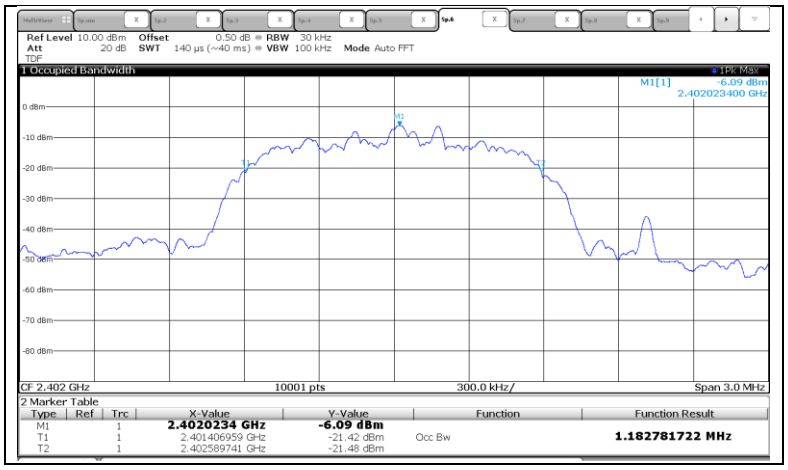
Middle Channel (2 441 ㎒)



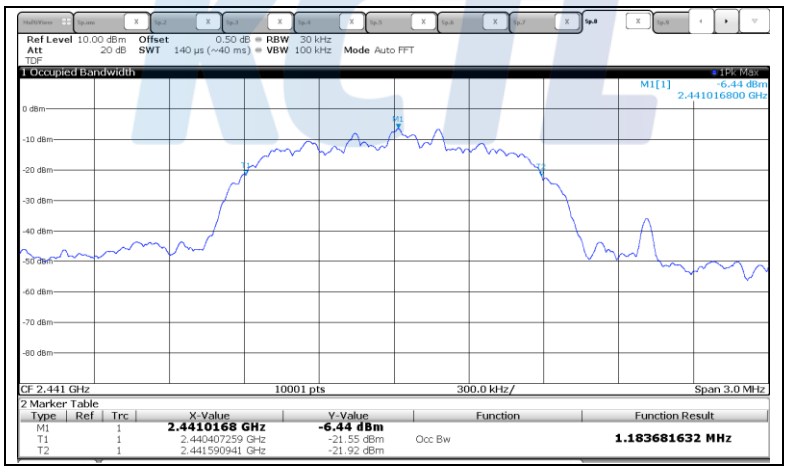
Highest Channel (2 480 ㎒)

- π/4DQPSK_Occupied Bandwidth

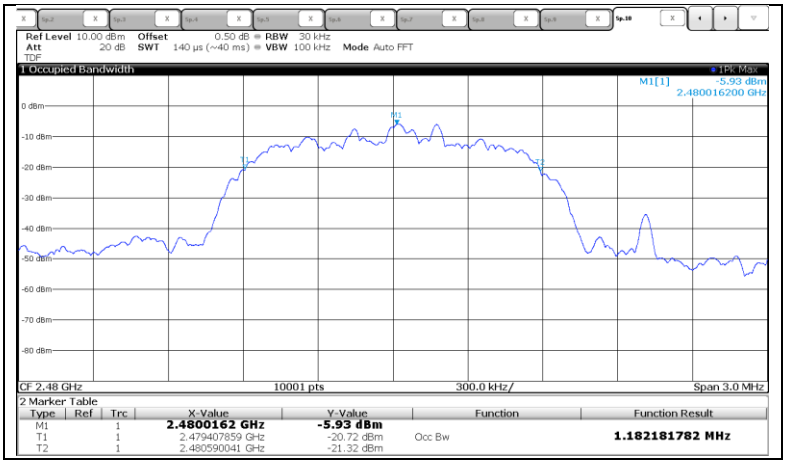
Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)

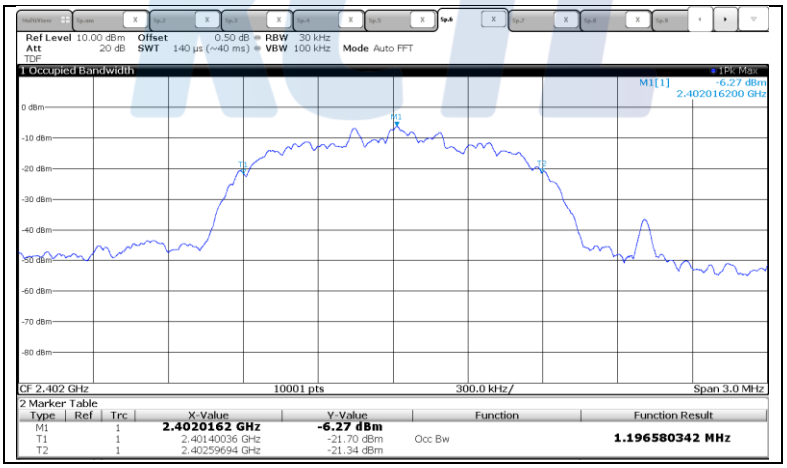


Highest Channel (2 480 ㎒)

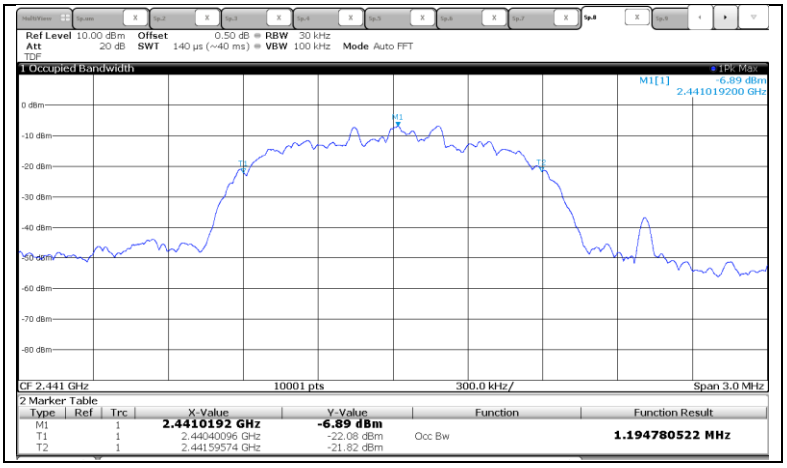


- 8DPSK_Occupied Bandwidth

Lowest Channel (2 402 ㎒)



Middle Channel (2 441 ㎒)



Highest Channel (2 480 ㎒)

5.5 Number of Hopping Channels

5.5.1 Regulation

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.

5.5.2 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 ㏈ 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

- Module 1

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

- Module 2

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.

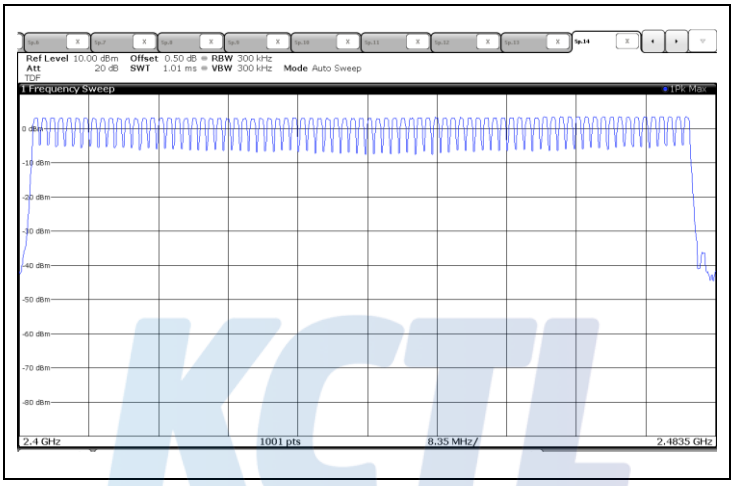
5.5.4 Test Plot

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

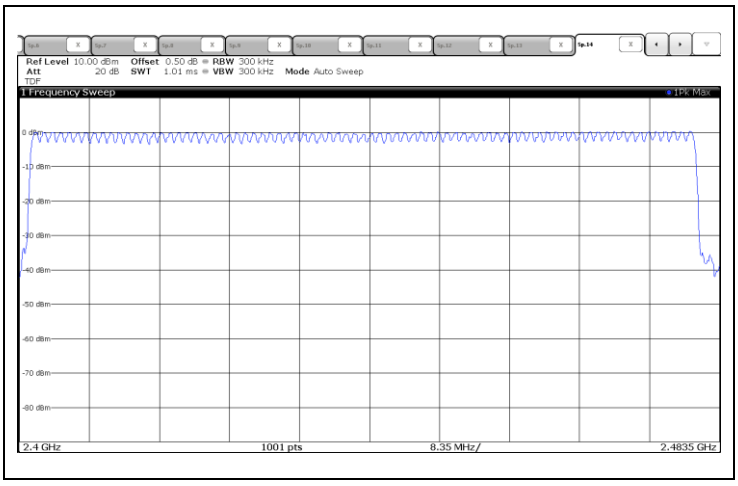
- Module 1

Non-AFH Mode

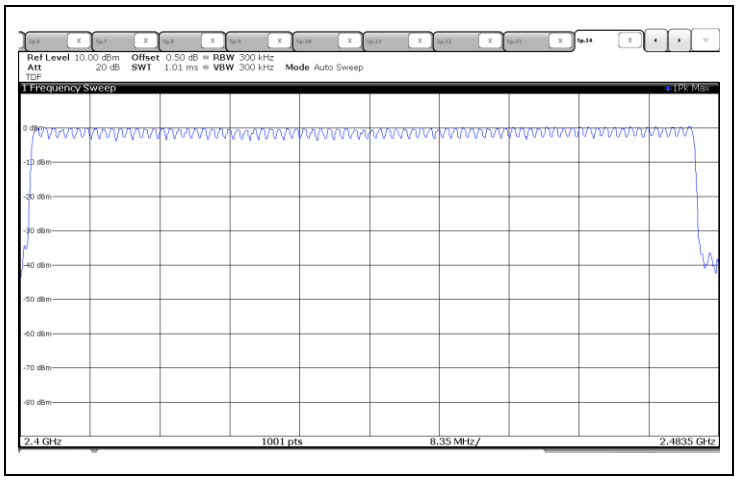
- GFSK



- π/4DQPSK

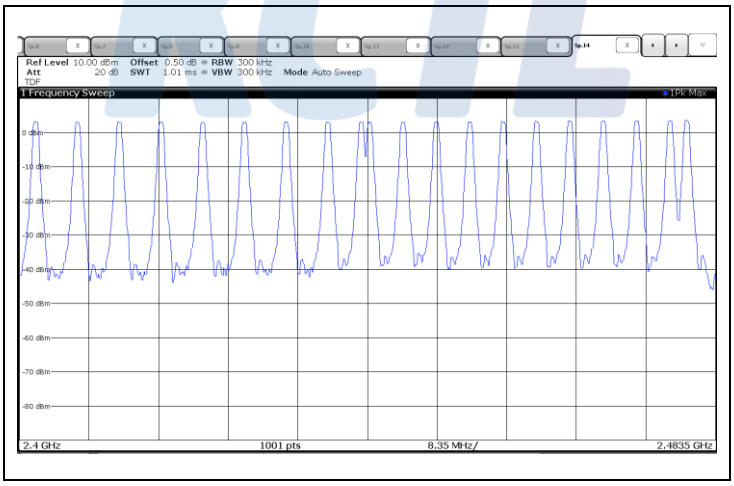


- 8DPSK

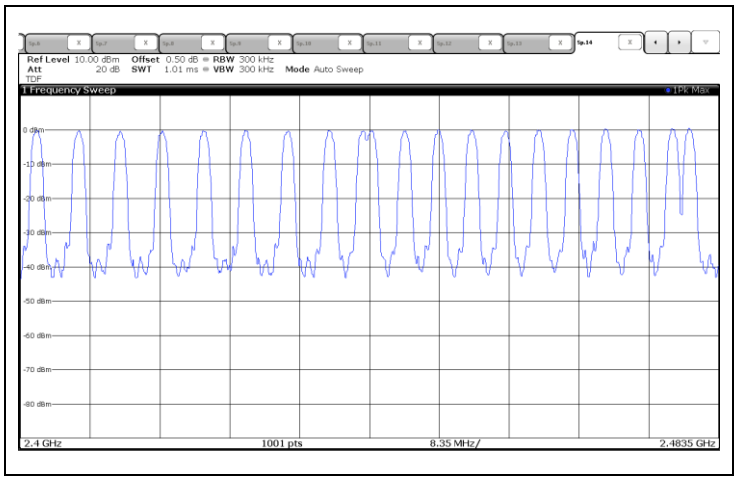


AFH Mode

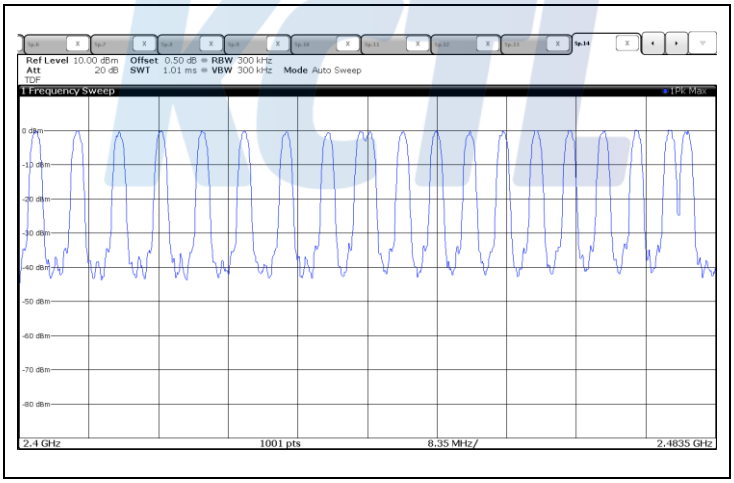
- GFSK



- π/4DQPSK



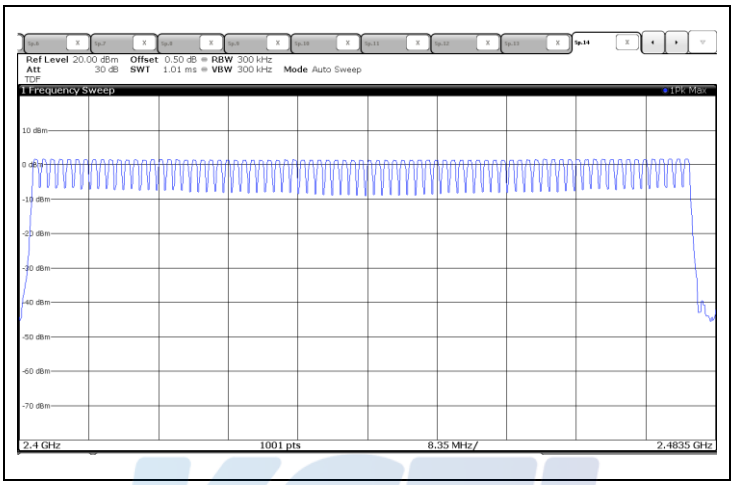
- 8DPSK



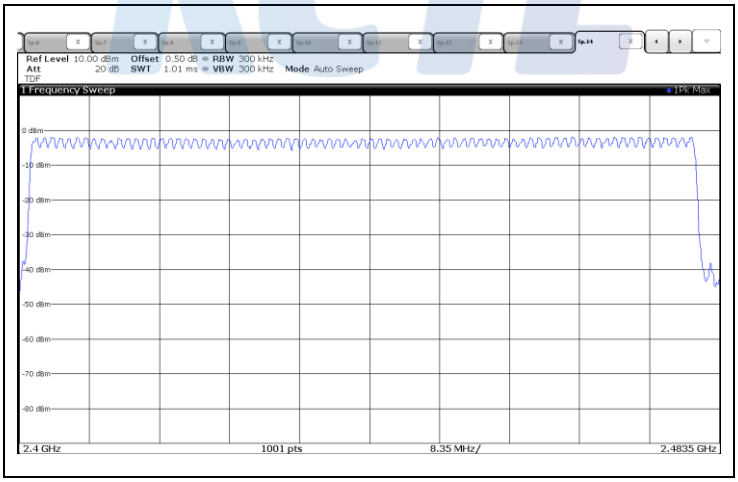
- Module 2

Non-AFH Mode

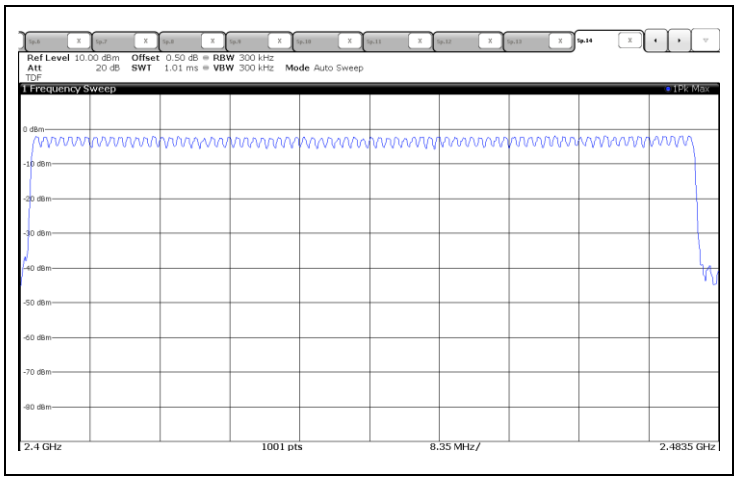
- GFSK



- π/4DQPSK

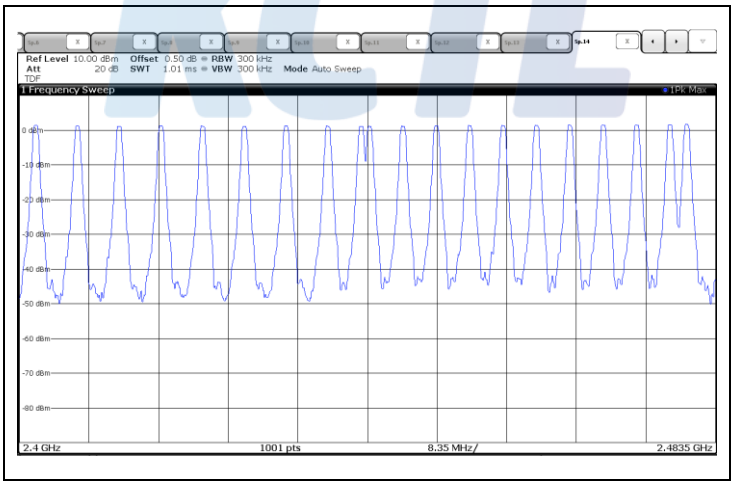


- 8DPSK

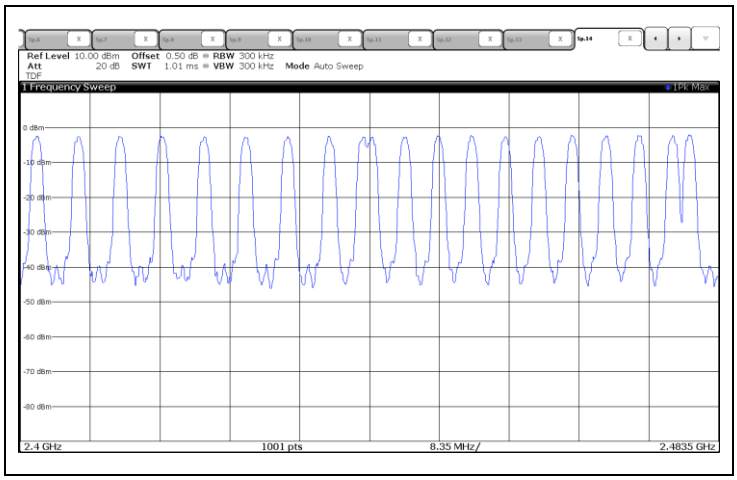


AFH Mode

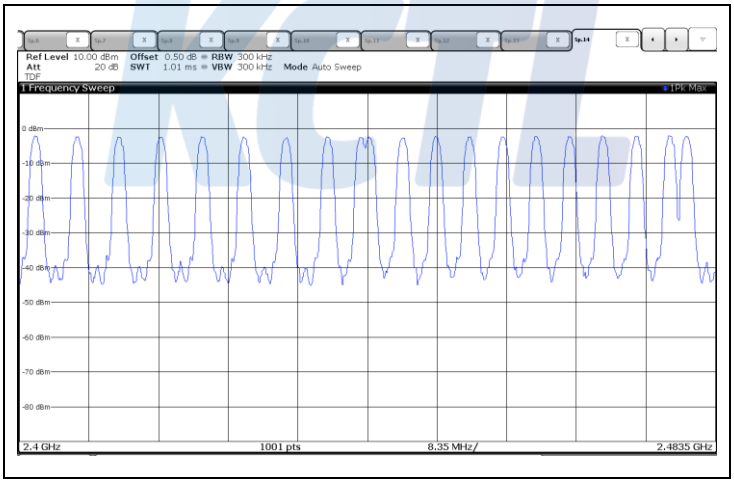
- GFSK



- π/4DQPSK



- 8DPSK



5.6 Time of Occupancy(Dwell Time)

5.6.1 Regulation

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.

5.6.2 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

- Module 1

- Non-AFH

Packet type	Frequency [㎒]	Reading [㎳]	Hopping rate [hop/s]	Number of Channels	Result [s]	Limit [s]
DH1	2 441	0.396	800.000	79	0.127	0.400
DH3	2 441	1.652	400.000	79	0.264	0.400
DH5	2 441	2.902	266.667	79	0.310	0.400
2-DH1	2 441	0.408	800.000	79	0.131	0.400
2-DH3	2 441	1.661	400.000	79	0.266	0.400
2-DH5	2 441	2.912	266.667	79	0.311	0.400
3-DH1	2 441	0.407	800.000	79	0.130	0.400
3-DH3	2 441	1.660	400.000	79	0.266	0.400
3-DH5	2 441	2.912	266.667	79	0.311	0.400

- AFH

Packet type	Frequency [㎒]	Reading [㎳]	Hopping rate [hop/s]	Number of Channels	Result [s]	Limit [s]
DH1	2 441	0.396	400.000	20	0.063	0.400
DH3	2 441	1.651	200.000	20	0.132	0.400
DH5	2 441	2.902	133.333	20	0.155	0.400
2-DH1	2 441	0.407	400.000	20	0.065	0.400
2-DH3	2 441	1.661	200.000	20	0.133	0.400
2-DH5	2 441	2.909	133.333	20	0.155	0.400
3-DH1	2 441	0.408	400.000	20	0.065	0.400
3-DH3	2 441	1.658	200.000	20	0.133	0.400
3-DH5	2 441	2.912	133.333	20	0.155	0.400

NOTE 1. **Non AFH**
Result = Reading x (Hopping rate / Number of channels) x Test Period
Hopping rate = 1600/time slot
Test period = 0.4 [seconds / channel] × 79 [channel] = 31.6 [seconds]

NOTE 2. **AFH**
Result = Reading x (Hopping rate / Number of channels) x Test Period
Hopping rate = 800/time slot
Test period = 0.4 [seconds / channel] × 20 [channel] = 8 [seconds]

- Module 2

- Non-AFH

Packet type	Frequency [㎒]	Reading [㎳]	Hopping rate [hop/s]	Number of Channels	Result [s]	Limit [s]
DH1	2 441	0.394	800.000	79	0.126	0.400
DH3	2 441	1.651	400.000	79	0.264	0.400
DH5	2 441	2.899	266.667	79	0.309	0.400
2-DH1	2 441	0.407	800.000	79	0.130	0.400
2-DH3	2 441	1.661	400.000	79	0.266	0.400
2-DH5	2 441	2.902	266.667	79	0.310	0.400
3-DH1	2 441	0.407	800.000	79	0.130	0.400
3-DH3	2 441	1.660	400.000	79	0.266	0.400
3-DH5	2 441	2.902	266.667	79	0.310	0.400

- AFH

Packet type	Frequency [㎒]	Reading [㎳]	Hopping rate [hop/s]	Number of Channels	Result [s]	Limit [s]
DH1	2 441	0.394	400.000	20	0.063	0.400
DH3	2 441	1.652	200.000	20	0.132	0.400
DH5	2 441	2.902	133.333	20	0.155	0.400
2-DH1	2 441	0.408	400.000	20	0.065	0.400
2-DH3	2 441	1.660	200.000	20	0.133	0.400
2-DH5	2 441	2.902	133.333	20	0.155	0.400
3-DH1	2 441	0.406	400.000	20	0.065	0.400
3-DH3	2 441	1.660	200.000	20	0.133	0.400
3-DH5	2 441	2.906	133.333	20	0.155	0.400

NOTE 1. **Non AFH**
Result = Reading x (Hopping rate / Number of channels) x Test Period
Hopping rate = 1600/time slot
Test period = 0.4 [seconds / channel] × 79 [channel] = 31.6 [seconds]

NOTE 2. **AFH**
Result = Reading x (Hopping rate / Number of channels) x Test Period
Hopping rate = 800/time slot
Test period = 0.4 [seconds / channel] × 20 [channel] = 8 [seconds]

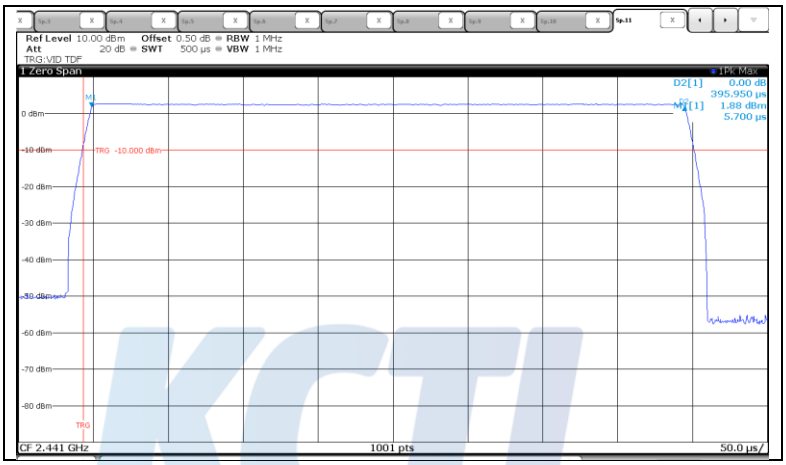
5.6.4 Test Plot

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

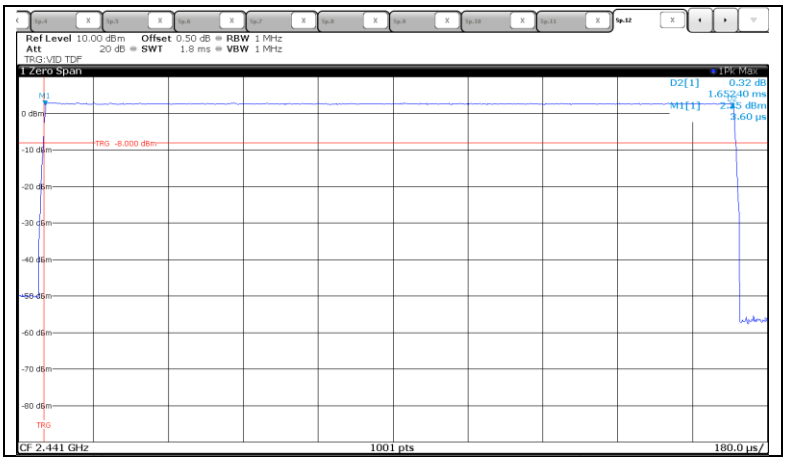
- Module 1

- GFSK_Non AFH mode

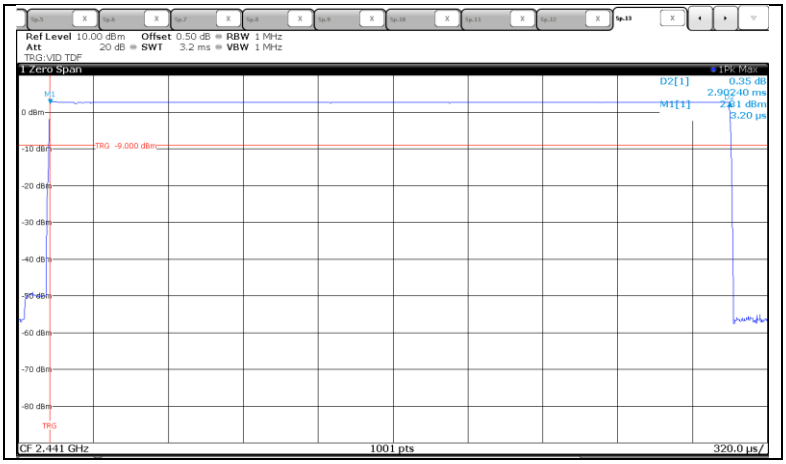
DH1 (2 441 ㎒)



DH3 (2 441 ㎒)

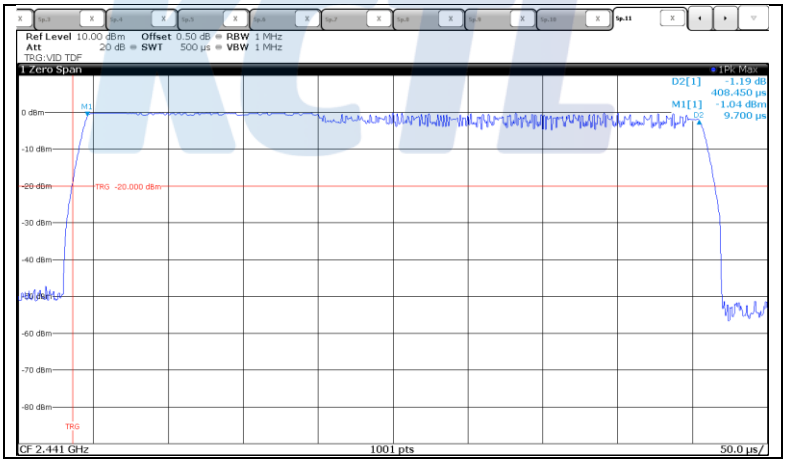


DH5 (2 441 ㎒)

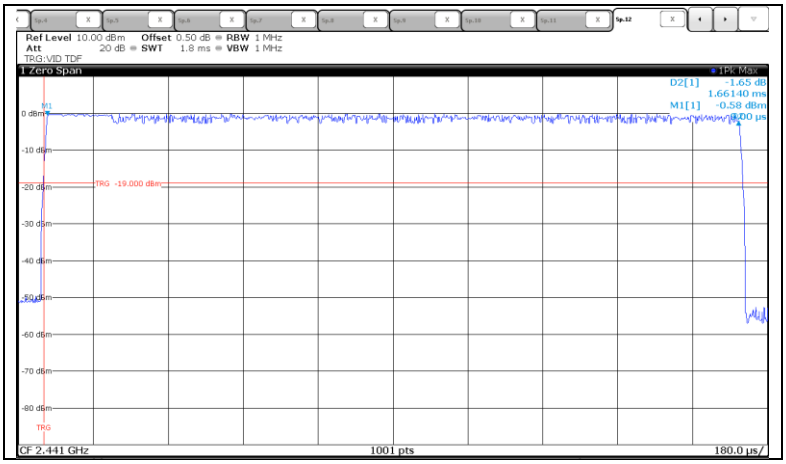


- π/4DQPSK_Non AFH mode

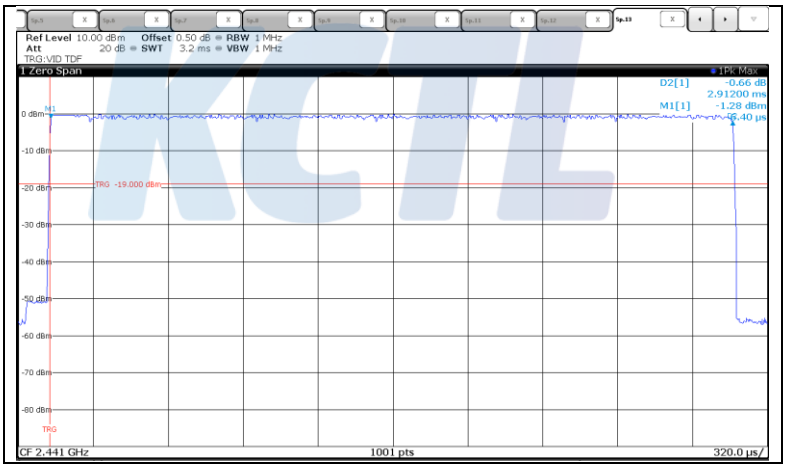
2-DH1 (2 441 ㎒)



2-DH3 (2 441 ㎒)

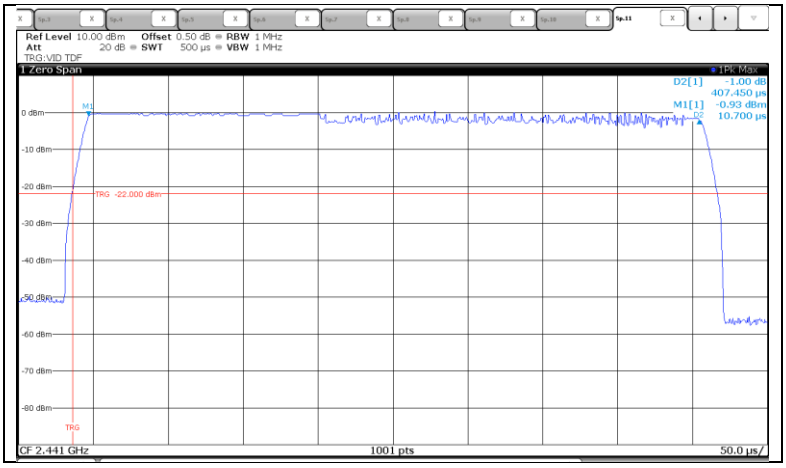


2-DH5 (2 441 ㎒)

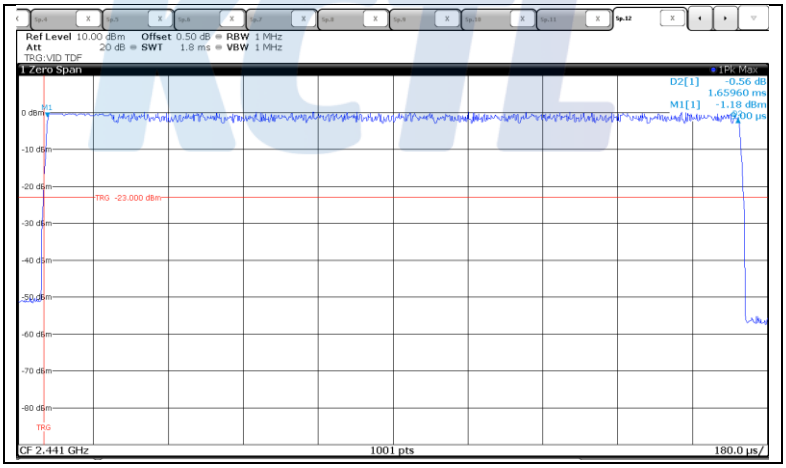


- 8DPSK_Non AFH mode

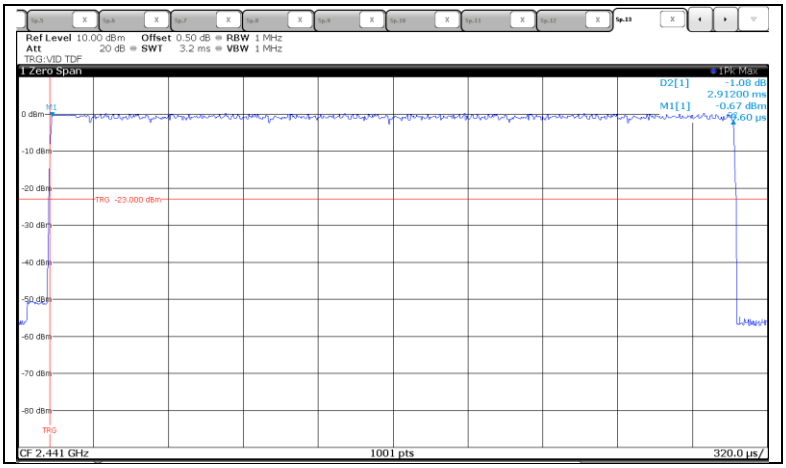
3-DH1 (2 441 ㎒)



3-DH3 (2 441 ㎒)

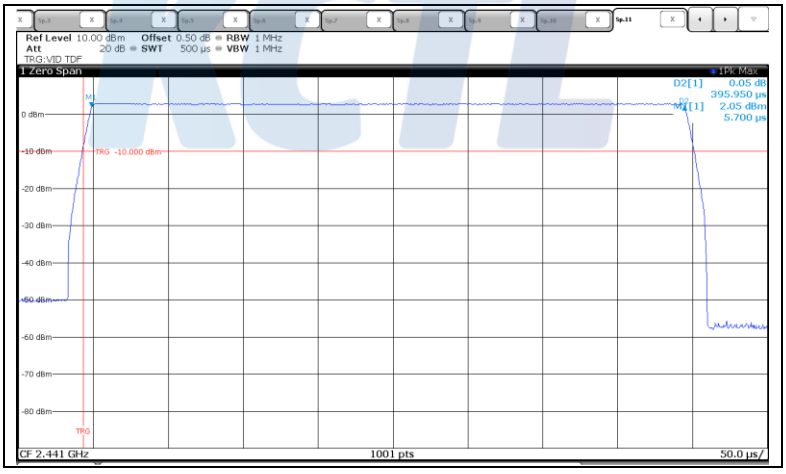


3-DH5 (2 441 ㎒)

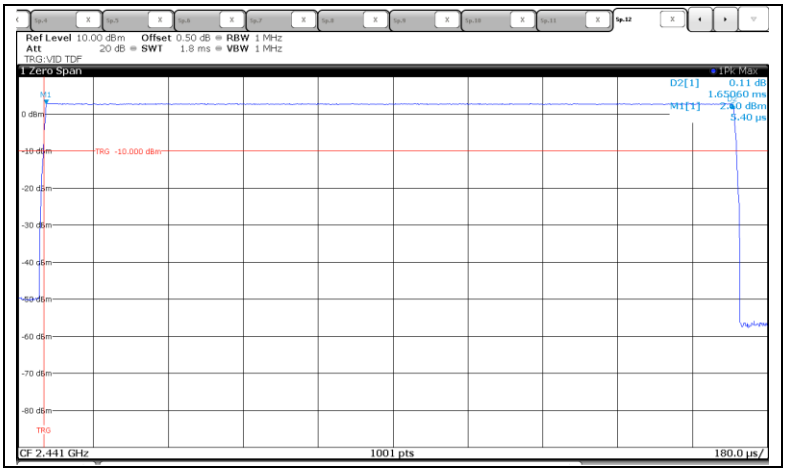


- GFSK_AFH mode

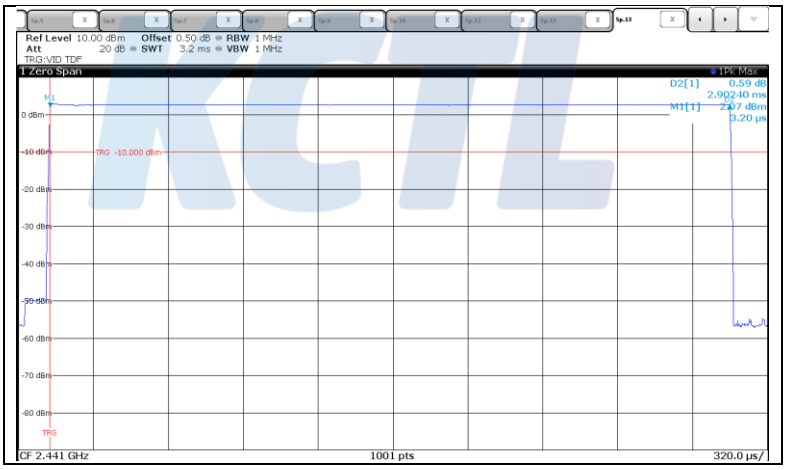
DH1 (2 441 ㎒)



DH3 (2 441 ㎒)

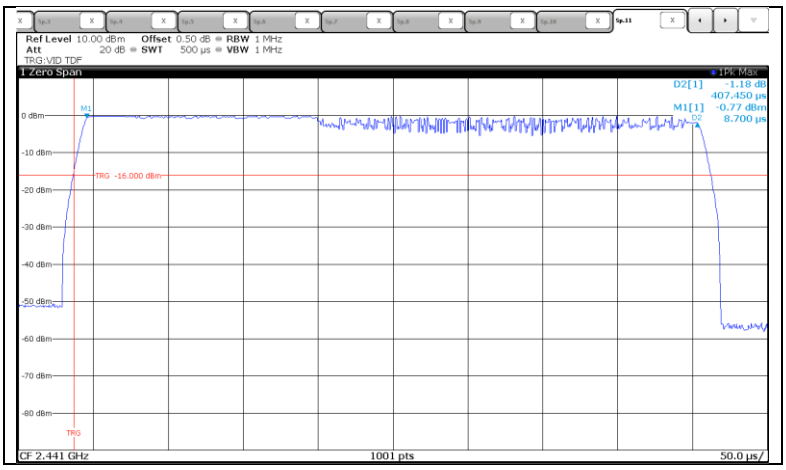


DH5 (2 441 ㎒)

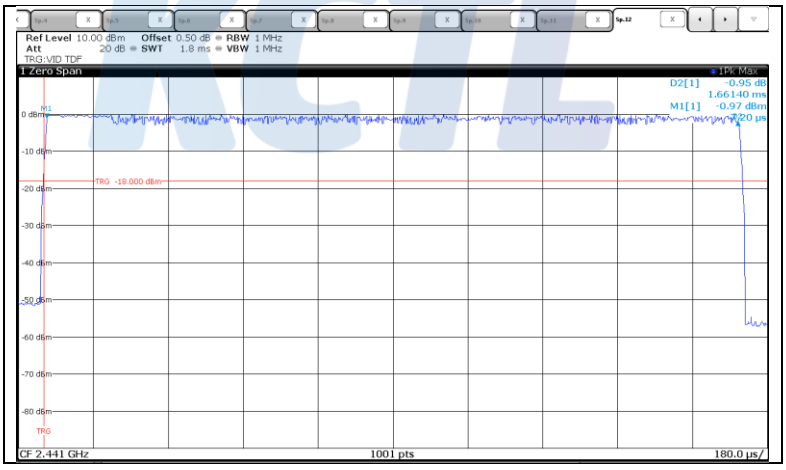


- π/4DQPSK_AFH mode

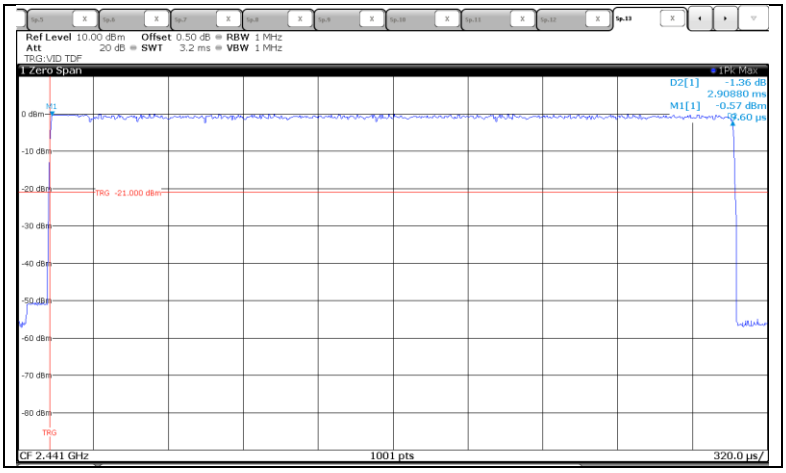
2-DH1 (2 441 ㎒)



2-DH3 (2 441 ㎒)

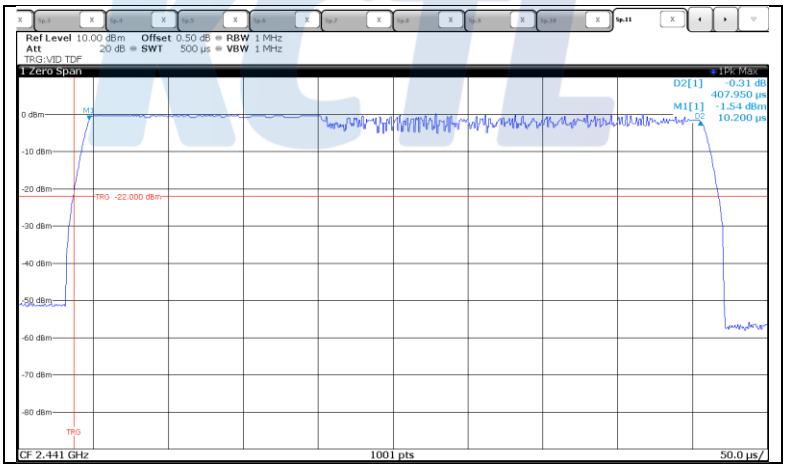


2-DH5 (2 441 ㎒)

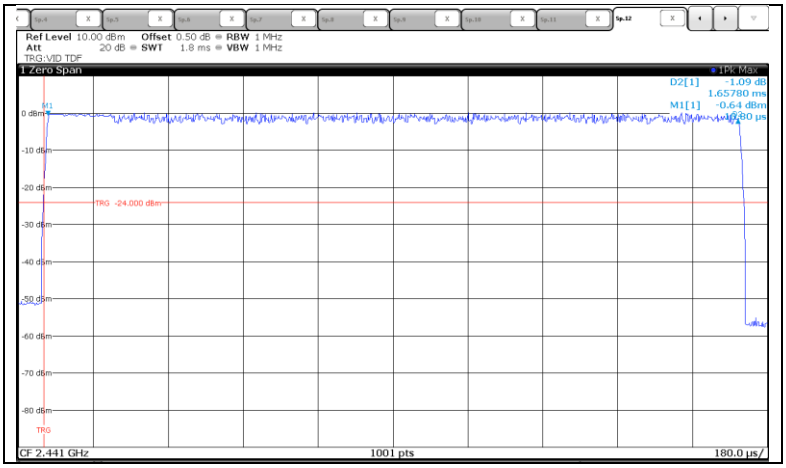


- 8DPSK_AFH mode

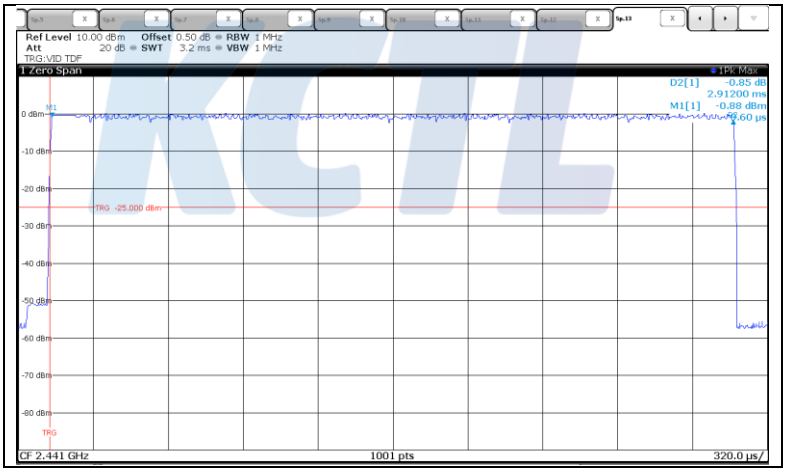
3-DH1 (2 441 ㎒)



3-DH3 (2 441 ㎒)



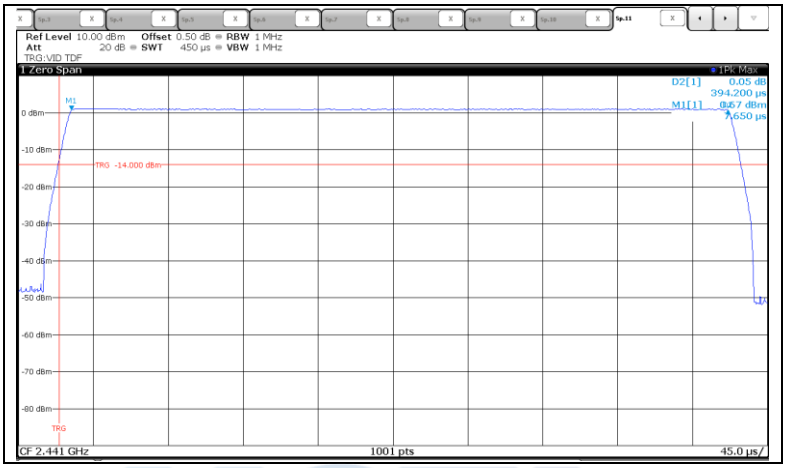
3-DH5 (2 441 ㎒)



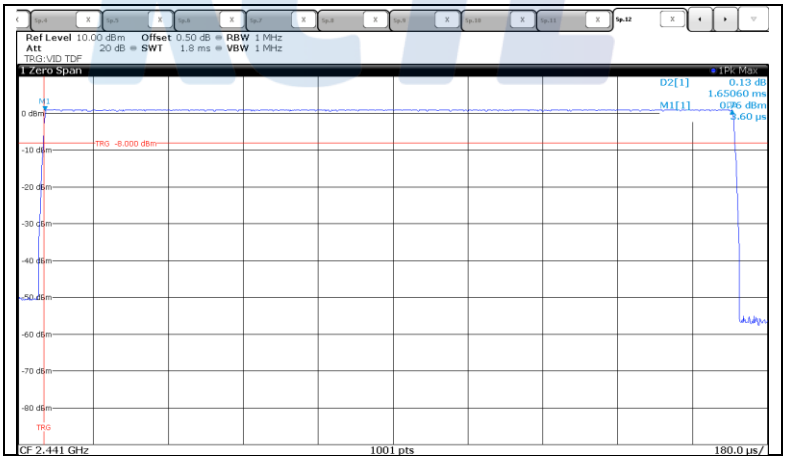
- Module 2

- GFSK_Non AFH mode

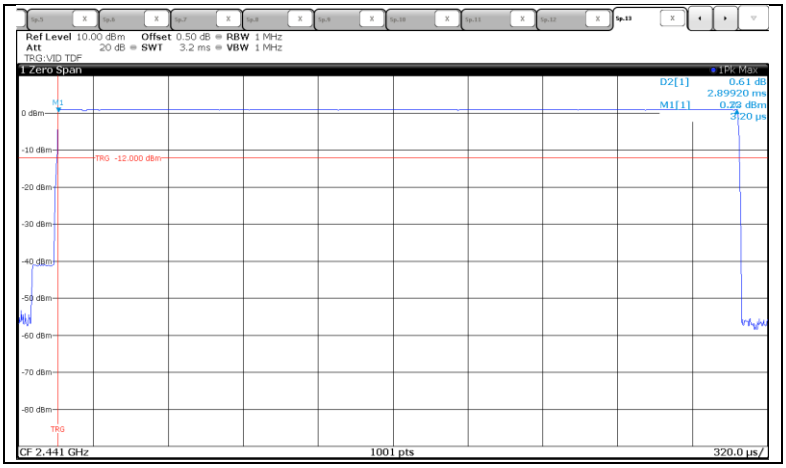
DH1 (2 441 ㎒)



DH3 (2 441 ㎒)



DH5 (2 441 ㎒)



- π/4DQPSK_Non AFH mode

2-DH1 (2 441 ㎒)