TEST REPORT

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1. Client

- Name : HYUNDAI MOBIS CO., LTD.
- Address : 203, Teheran-ro, Gangnam-gu, Seoul, 06141, Korea
- Date of Receipt : 2019-09-20

2. Use of Report : Certification

3. Name of Product and Model : WIDE AVN / ATC32HYAN

4. Manufacturer and Country of Origin : Hyundai Mobis., Ltd. / Korea

5. FCC ID : TQ8-ATC32HYAN

6. Date of Test : 2019-10-01 to 2019-10-31

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

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

	Tested by	Technical Manager
Affirmation	Name : MyeongJun Kwon (Signature)	Name : Heesu Ahn (Signature)

2020-02-09

KCTL Inc.

Report revision history

Date	Revision	Page No
2020-02-09	Initial report	-

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1. General information

Client	:	HYUNDAI MOBIS CO., LTD.
Address	:	203, Teheran-ro, Gangnam-gu, Seoul, 06141, Korea
Manufacturer	:	Hyundai Mobis., Ltd
Address	:	95, Sayang 2-Gil, Munbaek-Myeon, Jincheon-Gun, Chungcheongbuk-Do 27862 Korea
Laboratory	:	KCTL Inc.
Address	:	65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea
Accreditations	:	FCC Site Designation No: KR0040, FCC Site Registration No: 687132 VCCI Registration No. : R-20080, G-20078, C-20059, T-20056 Industry Canada Registration No. : 8035A KOLAS No.: KT231

2. Device information

Equipment under test	:	WIDE AVN
Model	:	ATC32HYAN
Derivative model	:	ATC32HCAN, ATC35HCAN
Frequency range	:	2 402 ㎒ ~ 2 480 ㎒ (Bluetooth(BDR/EDR)) 2 412 ㎒ ~ 2 462 ㎒ (802.11b/g/n_HT20) UNII-1: 5 180 ㎒ ~ 5 240 ㎒ (802.11a/n_HT20/ac_VHT20) UNII-1: 5 190 ㎒ ~ 5 230 ㎒ (802.11n_HT40/ac_VHT40) UNII-1: 5 210 ㎒ (802.11ac_VHT80) UNII-2A: 5 260 ㎒ ~ 5 320 ㎒ (802.11a/n_HT20/ac_VHT20) UNII-2A: 5 270 ㎒ ~ 5 310 ㎒ (802.11n_HT40/ac_VHT40) UNII-2A: 5 290 ㎒ (802.11ac_VHT80) UNII-2C: 5 500 ㎒ ~ 5 720 ㎒ (802.11a/n_HT20/ac_VHT20) UNII-2C: 5 510 ㎒ ~ 5 710 ㎒ (802.11n_HT40/ac_VHT40) UNII-2C: 5 530 ㎒ ~ 5 690 ㎒ (802.11ac_VHT80) UNII-3: 5 745 ㎒ ~ 5 825 ㎒ (802.11a/n_HT20/ac_VHT20) UNII-3: 5 755 ㎒ ~ 5 795 ㎒ (802.11n_HT40/ac_VHT40) UNII-3: 5 775 ㎒ (802.11ac_VHT80)
Modulation technique	:	Bluetooth(BDR/EDR)_ GFSK, π/4DQPSK, 8DPSK WIFI(802.11a/b/g/n20/n40/ac20/ac40/ac80)_DSSS, OFDM
Number of channels	:	Bluetooth(BDR/EDR)_79ch 2.4㎓ WIFI (802.11b/g/n_HT20)_11ch UNII-1: 4 ch (20 ㎒), 2 ch (40 ㎒), 1 ch (80 ㎒) UNII-2A: 4 ch (20 ㎒), 2 ch (40 ㎒), 1 ch (80 ㎒) UNII-2C: 9 ch (20 ㎒), 5 ch (40 ㎒), 2 ch (80 ㎒) UNII-3: 5 ch (20 ㎒), 2 ch (40 ㎒), 1 ch (80 ㎒)
Power source	:	DC 14.4 V

Antenna specification	:	WIFI/Bluetooth(BDR/EDR)_Pattern Antenna
Antenna gain	:	2.4㎓ WIFI (802.11b/g/n_HT20) : -0.70 dBi
		Bluetooth(BDR/EDR) : 0.29 dBi
		UNII-1 :3.51 dBi, UNII-2A : 3.12 dBi
		UNII-2C : 2.28 dBi, UNII-3 : -0.84 dBi
Software version	:	MQ4.USA.0000.V028.001.190821
Hardware version	:	MQ4.USA.STD_AVN_G5_WIDE.004.001
Test device serial No.	:	N/A
Operation temperature	:	-20 ℃ ~ 70 ℃

2.1. Simultaneously transmission condition

Technology	Modulation	Test mode	Frequency (㎒)
WLAN 2.4 ㎓	OFDM	802.11g	2 412
WLAN 5 ㎓	OFDM	802.11a / UNII-2C	5 500
Bluetooth	GFSK	BDR	2 441

2.2. Information about derivative model

The difference between basic model and derivative models is:

The derivative models have a different product identification number.

ATC32HCAN(96560 P4720), ATC35HCAN(96560 P4920)

2.3. Frequency/channel operations

This device contains the following capabilities:
WIFI(2.4㎓ band 802.11b/g/n(HT20), 5㎓ band 802.11a/n(HT20/HT40)/ac(VHT/20/40/80)), Bluetooth(BDR/EDR)

Ch.	Frequency (㎒)
00	2 402
. .	. .
39	2 441
. .	. .
78	2 480

Table 2.3.1. Bluetooth(BDR/EDR) mode

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 tocomply 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.

3. Antenna requirement

Requirement of FCC part section 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 transmitter has permanently attached Pattern Antenna (internal antenna) on board.
- The E.U.T Complies with the requirement of §15.203, §15.247.

4. Summary of tests

FCC Part section(s)	Parameter	Test results
15.247(b)(1),(4)	Maximum peak output power	Pass
15.247(a)(1)	Carrier frequency separation	Pass
15.247(a)(1)	20dB channel bandwidth	Pass
-	Occupied Bandwidth	Pass
15.247(a)(iii) 15.247(b)(1)	Number of hopping channel	Pass
15.247(a)(iii)	Time of occupancy(dwell time)	Pass
15.205(a), 15.209(a), 15.247(d)	Spurious emission	Pass
	Band-edge, restricted band	Pass
15.207(a)	Conducted Emissions	N/A(Note2)

Notes:

1. All modes of operation and data rates were investigated. The test results shown in the following sections represent the worst case emissions.
2. This test is not applicable because the EUT falls into the automotive device and it's not to be connected to the public utility(AC) power line.
3. According to exploratory test no any obvious emission were detected from 9 ㎑ to 30 ㎒. Although these tests were performed other than open field site, adequate comparison measurements were confirmed against 30 m open field 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 414788.
4. The fundamental of the EUT was investigated in three orthogonal orientations X, Y and Z. It was determined that X orientation was worst-case orientation. Therefore, all final radiated testing was performed with the EUT in X orientation
5. The test procedure(s) in this report were performed in accordance as following.
   - ANSI C63.10-2013
   - KDB 558074 D01 v05r02

5. Measurement uncertainty

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of k=2 to indicated a 95 % level of confidence. The measurement data shown herein meets of exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded uncertainty (±)	
Conducted RF power	1.76 dB	
Conducted spurious emissions	4.03 dB	
Radiated spurious emissions	9 kHz ~ 30 MHz	2.28 dB
	30 MHz ~ 300 MHz	4.98 dB
	300 MHz ~ 1 000 MHz	5.14 dB
	1 GHz ~ 6 GHz	6.70 dB
	Above 6 GHz	6.60 dB
Conducted emissions	9 kHz ~ 150 kHz	3.66 dB
	150 kHz ~ 30 MHz	3.26 dB

6. Measurement results explanation example

The offset level is set in the spectrum analyzer to compensate the RF cable loss factor between EUT conducted output port and spectrum analyzer.
With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

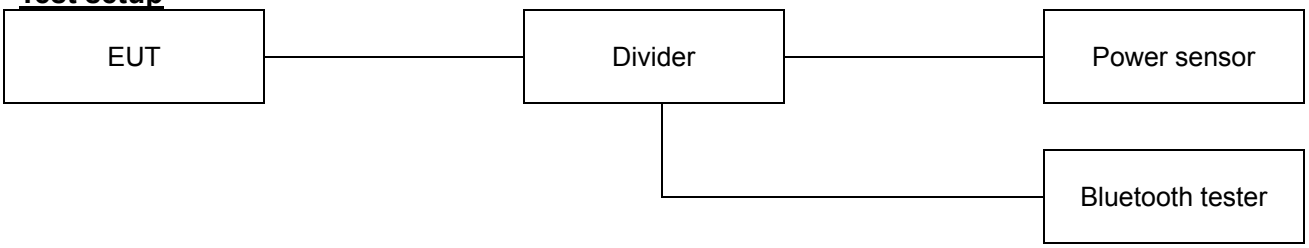
Frequency (㎒)	Factor(㏈)	Frequency (㎒)	Factor(㏈)
30	6.15	9 000	8.23
50	6.18	10 000	8.61
100	6.23	11 000	8.47
200	6.35	12 000	8.54
300	6.44	13 000	9.15
400	6.53	14 000	9.86
500	6.61	15 000	9.51
600	6.69	16 000	9.71
700	6.75	17 000	9.89
800	6.83	18 000	10.17
900	6.92	19 000	9.94
1 000	6.90	20 000	10.04
2 000	7.79	21 000	10.17
3 000	7.90	22 000	10.70
4 000	8.01	23 000	11.58
5 000	8.05	24 000	10.64
6 000	8.16	25 000	11.48
7 000	8.30	26 000	10.66
8 000	8.37	26 500	10.58

Note.
Offset(㏈) = RF cable loss(㏈) + Power Divider(㏈)

7 Test results

7.1. Maximum peak output power

Test setup



Limit

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.

Test procedure

ANSI C63.10-2013 - Section 7.8.5

Test settings

The test follows ANSI C63.10-2013 – Section 7.8.5. Using the power sensor instead of a spectrum analyzer.

Notes:

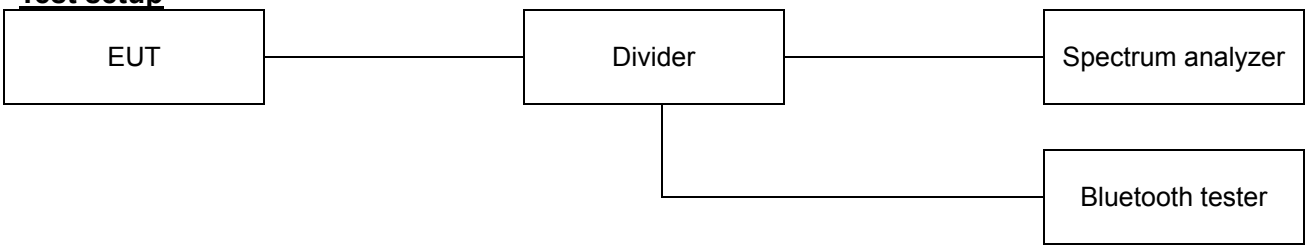
A peak responding power sensor is used, where the power sensor system video bandwidth is greater than the occupied bandwidth of the EUT.

Test results

Frequency(㎒)	Data rate(Mbps)	Measured output power(dBm)		Limit(dBm)
		Peak	Average	
2 402	1	3.13	2.35	30.00
2 441	1	3.70	3.11	
2 480	1	3.60	2.96	
2 402	2	0.91	-2.50	30.00
2 441	2	1.74	-1.52	
2 480	2	1.82	-1.52	
2 402	3	1.11	-2.44	30.00
2 441	3	1.81	-1.52	
2 480	3	1.85	-1.50	

7.2. Carrier frequency separation

Test setup



Limit

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 ㎽.

Test procedure

ANSI C63.10-2013 - Section 7.8.2

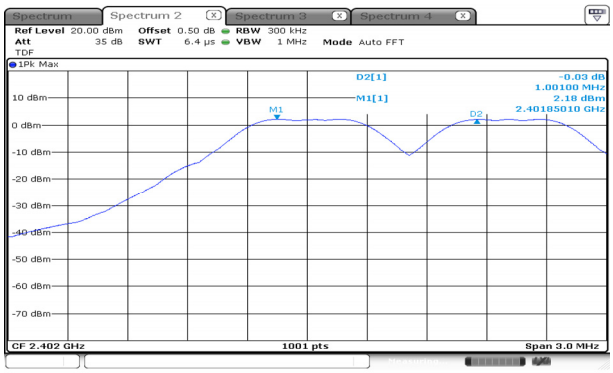
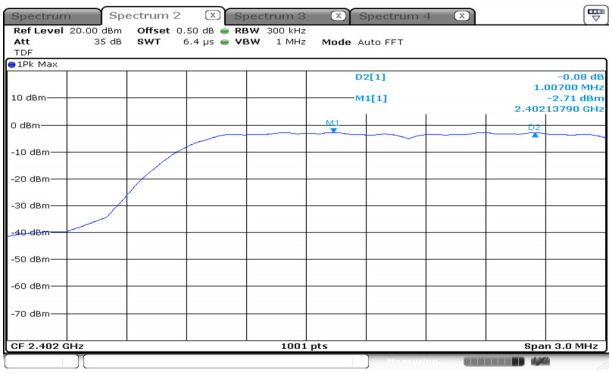
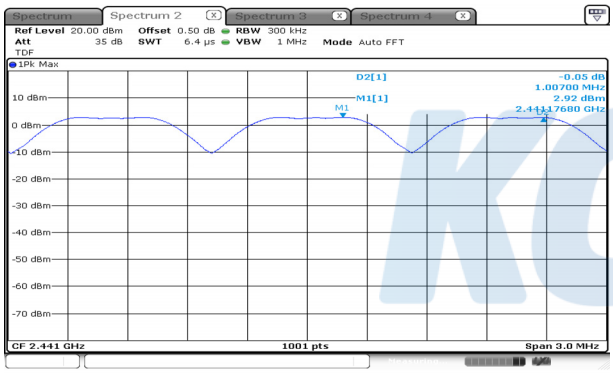
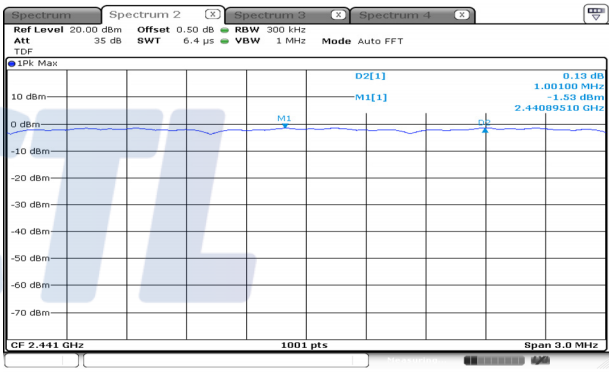
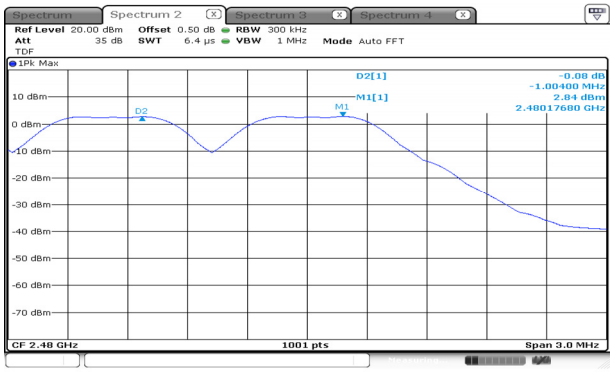
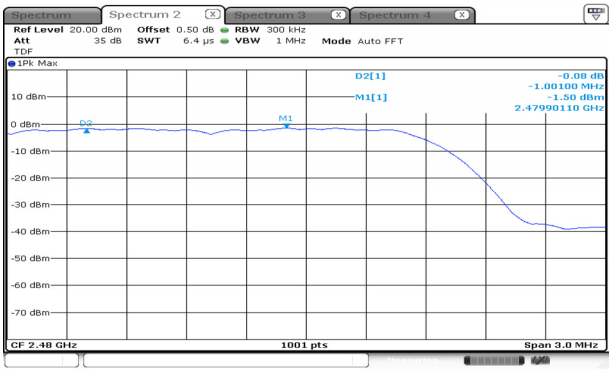
Test settings

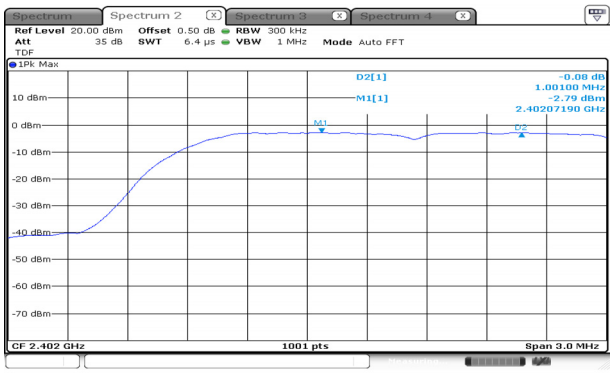
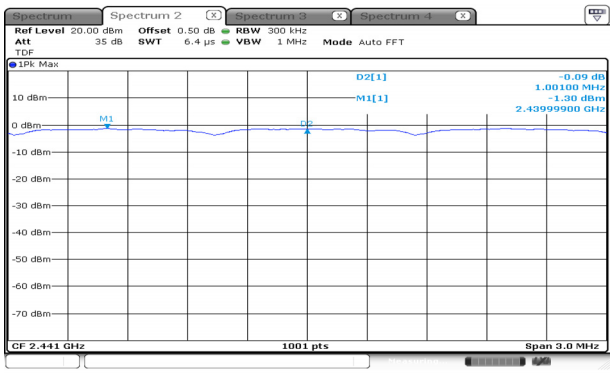
a) Span: Wide enough to capture the peaks of two adjacent channels.
b) RBW: Start with the RBW set to approximately 30 % of the channel spacing; adjust as necessary to best identify the center of each individual channel.
c) Video (or average) bandwidth (VBW) ≥ RBW.
d) Sweep: Auto.
e) Detector function: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

Test results

Frequency(㎒)	Data rate(Mbps)	Carrier frequency separation(㎒)
2 402	1	1.001
2 441	1	1.007
2 480	1	1.004
2 402	2	1.007
2 441	2	1.001
2 480	2	1.001
2 402	3	1.001
2 441	3	1.001
2 480	3	1.001

GFSK / Low ch.	π/4DQPSK / Low ch.
	
GFSK / Mid ch.	**π/4DQPSK / Mid ch.**
	
GFSK / High ch.	**π/4DQPSK / High ch.**
	

8DPSK / Low ch.	8DPSK / Mid ch.
	
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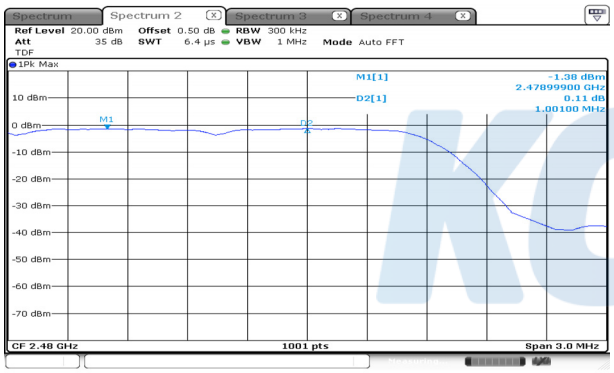
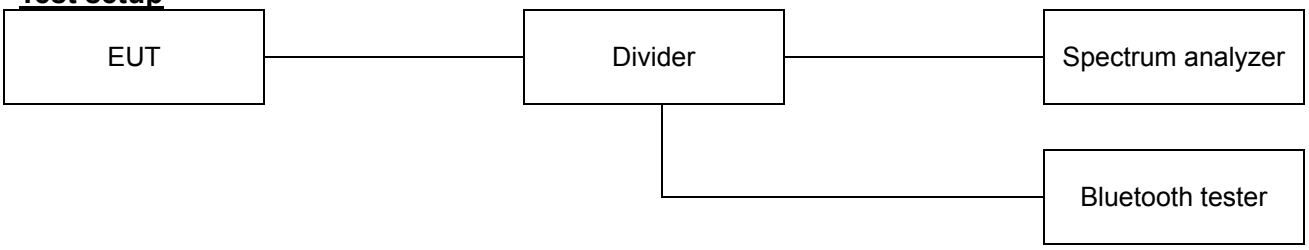
	Blank

7.3. 20dB channel bandwidth

Test setup



Limit

According to §15.247(a), 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 ㎽.

Test procedure

ANSI C63.10-2013 - Section 6.9.2

20dB channel bandwidth and Occupied bandwidth

Test settings

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.
b) Span: Two times and five times the OBW.
c) RBW = 1 % to 5 % of the OBW and VBW ≥ 3 x RBW
d) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation.
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) Detector: peak
g) Trace mode: max hold.
h) Allow the trace to stabilize.
i) Determine the "−xx ㏈ down amplitude" using ((reference value) − xx). Alternatively, this calculation may be made by using the marker-delta function of the instrument.
j) 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).

k) 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.

Test results

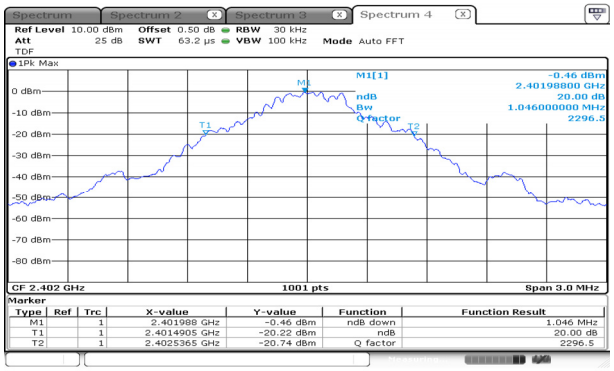
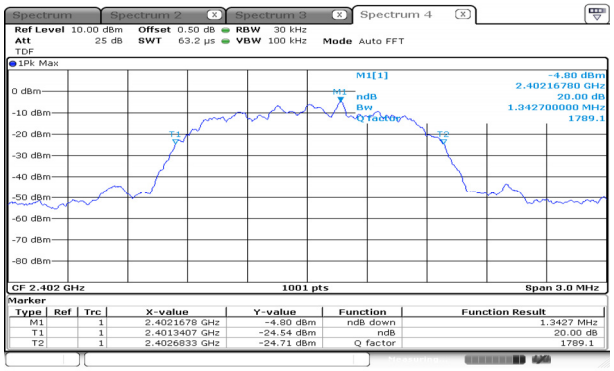
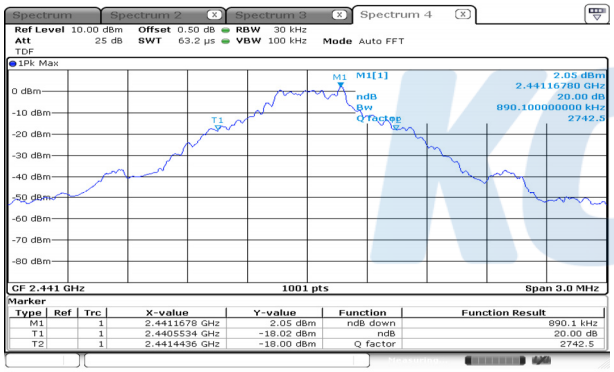
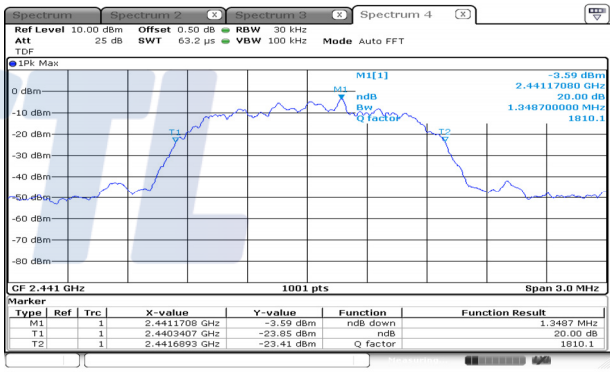
20 dB Bandwidth

Frequency(㎒)	Data rate (Mbps)	20 dB Bandwidth (㎒)
2 402	1	1.046
2 441	1	0.890
2 480	1	1.406
2 402	2	1.343
2 441	2	1.349
2 480	2	1.346
2 402	3	1.307
2 441	3	1.343
2 480	3	1.310

99% Bandwidth

Frequency(㎒)	Data rate (Mbps)	99% bandwidth(㎒)
2 402	1	0.935
2 441	1	0.911
2 480	1	0.914
2 402	2	1.202
2 441	2	1.208
2 480	2	1.205
2 402	3	1.202
2 441	3	1.214
2 480	3	1.202

20 dB bandwidth(㎒)

GFSK / Low ch.	π/4DQPSK / Low ch.
	
GFSK / Mid ch.	**π/4DQPSK / Mid ch.**
	
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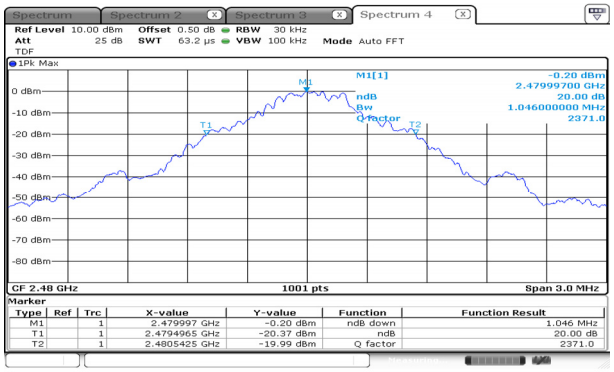
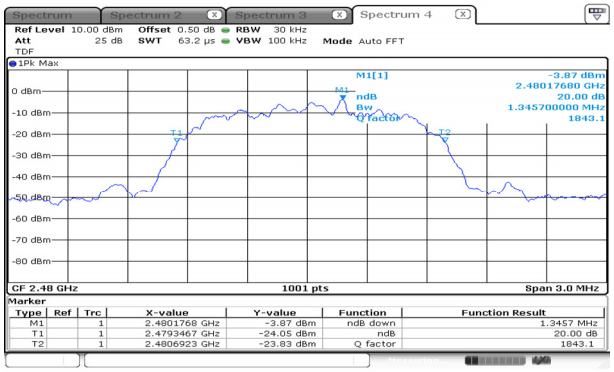
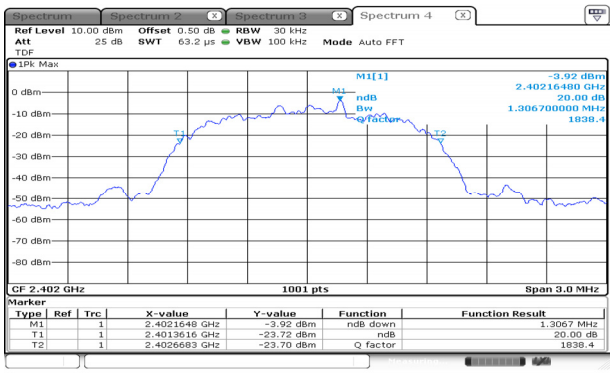
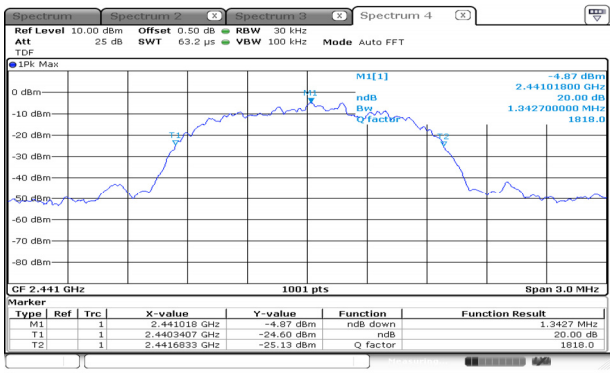
	

8DPSK / Low ch.	8DPSK / Mid ch.
	
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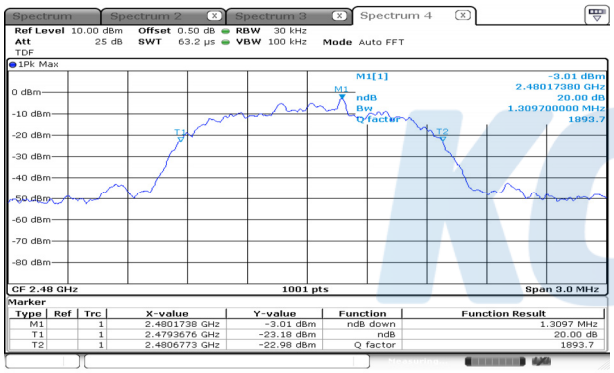
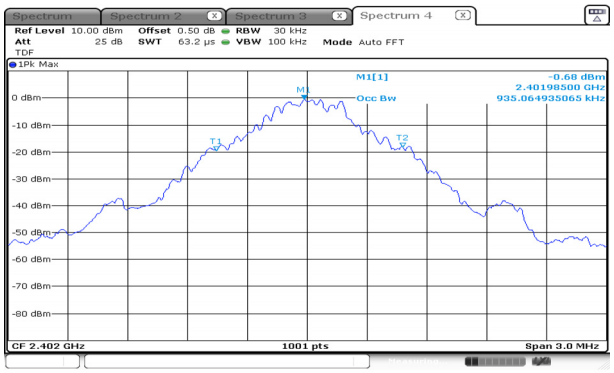
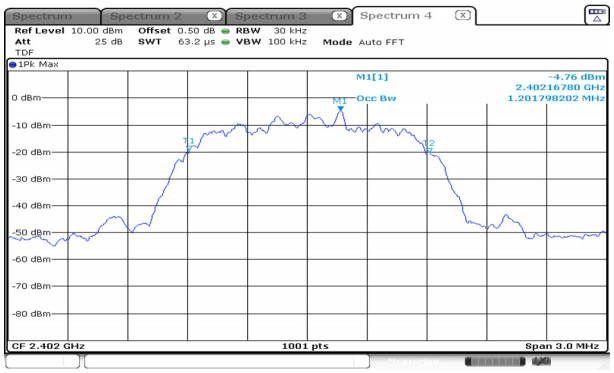
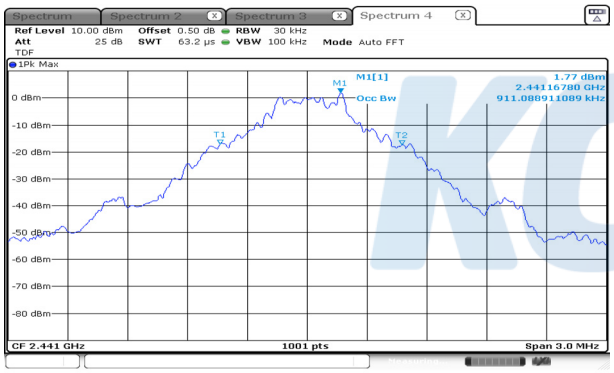
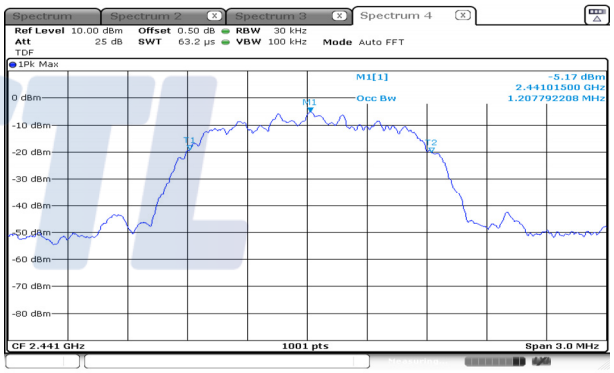
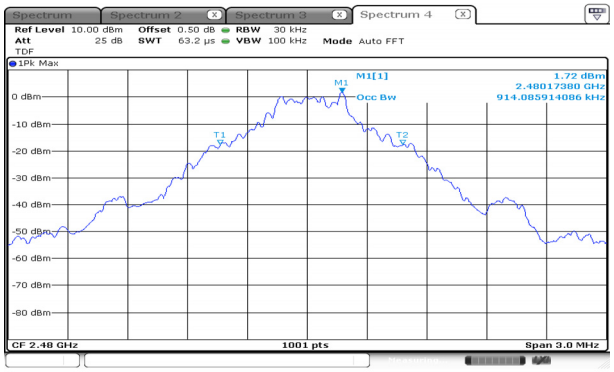
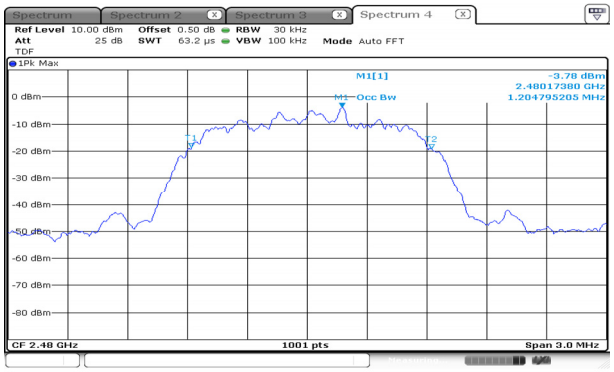
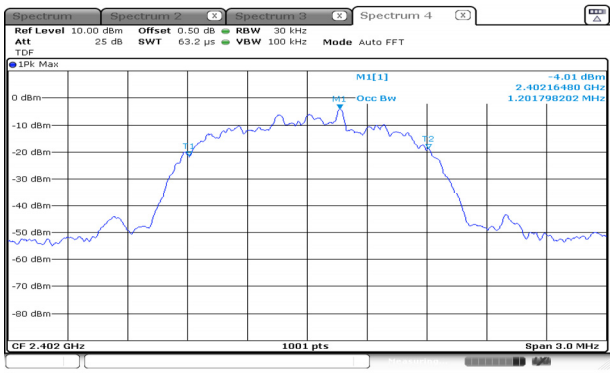
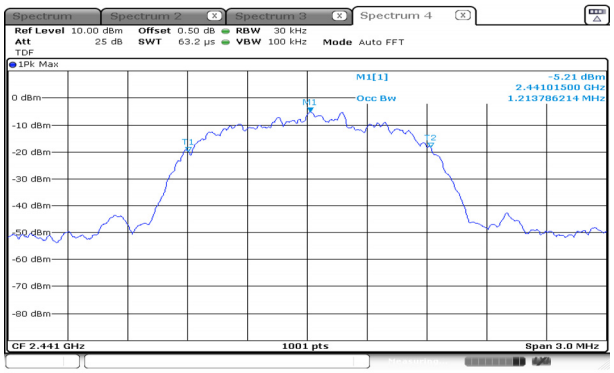
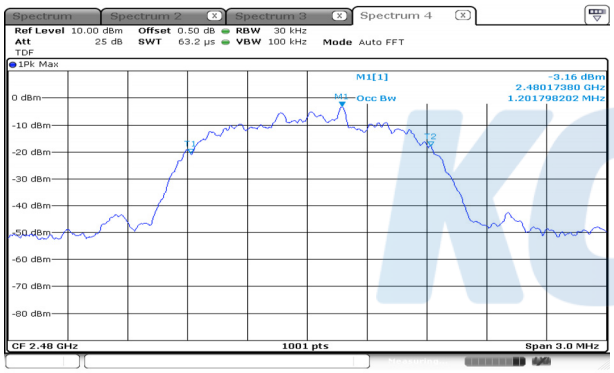
	Blank

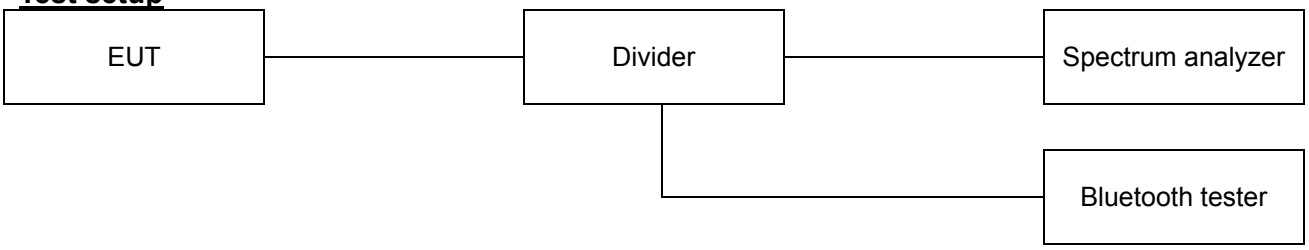
99 % bandwidth

GFSK / Low ch.	π/4DQPSK / Low ch.
	
GFSK / Mid ch.	**π/4DQPSK / Mid ch.**
	
GFSK / High ch.	**π/4DQPSK / High ch.**
	

8DPSK / Low ch.	8DPSK / Mid ch.
	
8DPSK / High ch.	
	Blank

7.4. Number of hopping channels

Test setup



Limit

According to §15.247(a)(1)(iii), frequency hopping systems in the 2 400-2 483.5 ㎒ band shall use at least 15 channels.

Test procedure

ANSI C63.10-2013 - Section 7.8.3

Test 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.

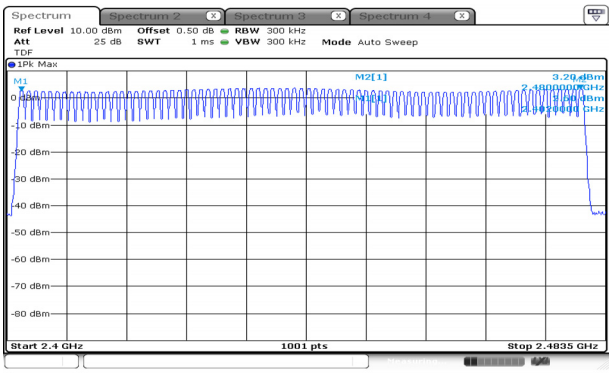
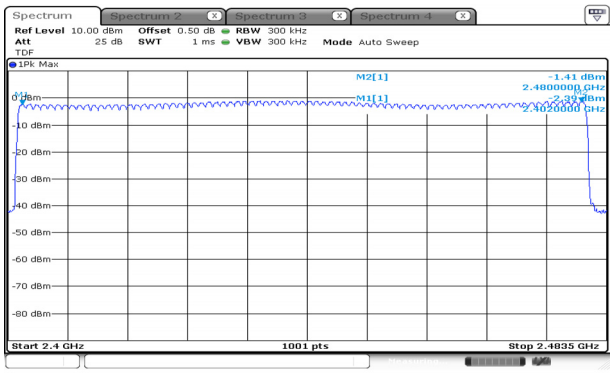
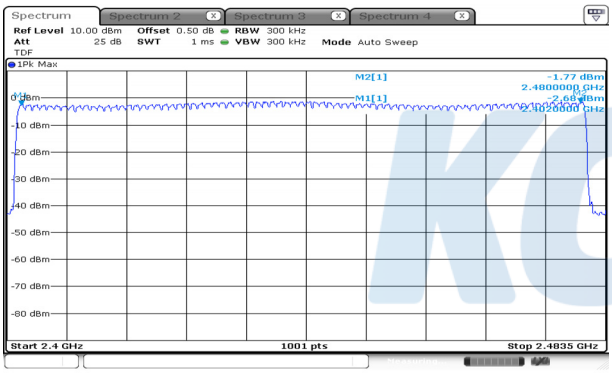
It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies. Compliance of an EUT with the appropriate regulatory limit shall be determined for the number of hopping channels. A plot of the data shall be included in the test report.

Test results

Mode	Number of hopping channel	Limit
GFSK	79	≥15
π/4DQPSK	79	≥15
8DPSK	79	≥15

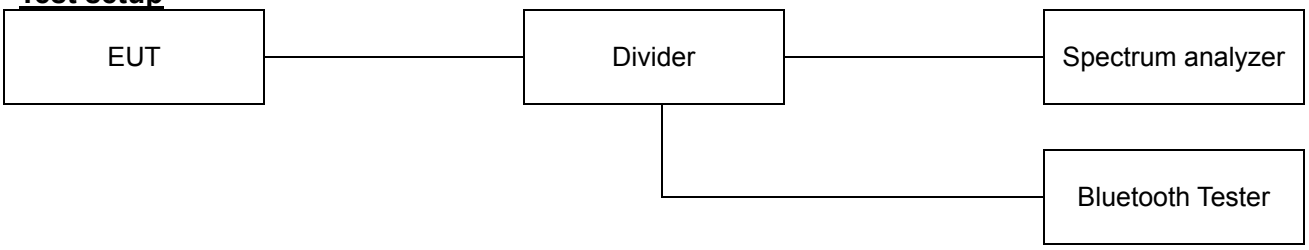
Note :

In case of AFH mode, minimum number of hopping channels is 20.

GFSK	π/4DQPSK
	
8DPSK	
	Blank

7.5. Time of occupancy(Dwell time)

Test setup



Limit

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.

Test procedure

ANSI C63.10-2013 - Section 7.8.4

Test settings

a) Span: Zero span, centered on a hopping channel.
b) RBW ≤ channel spacing and >> 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.
f) 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.

Test results

- Non-AFH

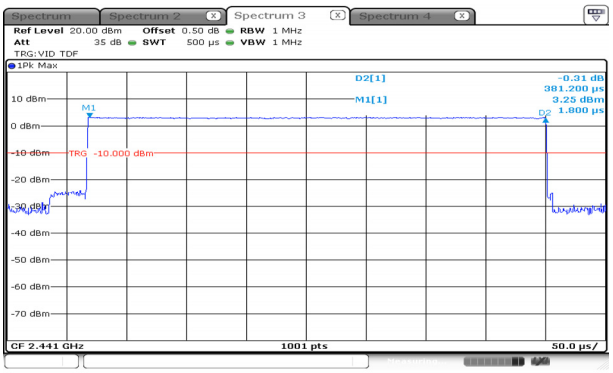
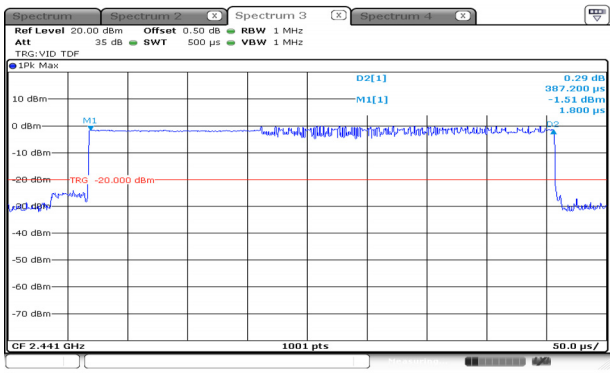
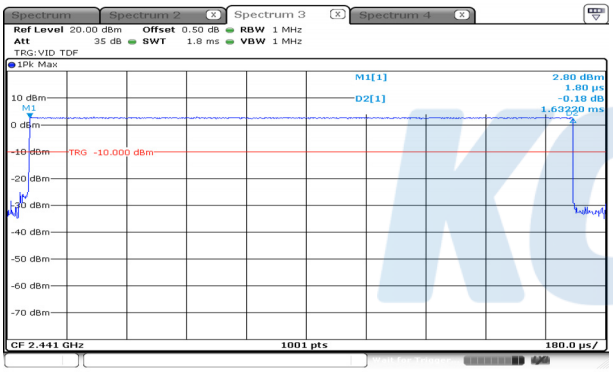
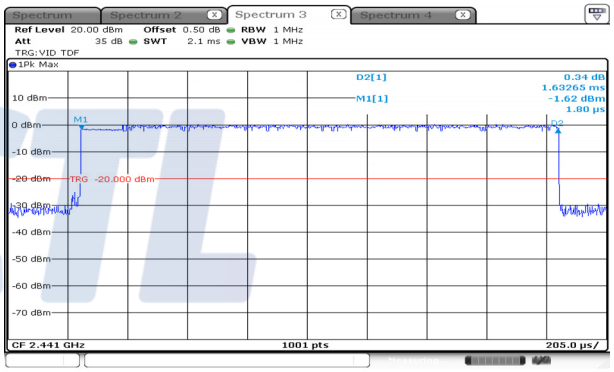
Modulation	Frequency (㎒)	Pulse Width (㎳)	Hopping rate (hop/s)	Number of Channels	Result (s)	Limit (s)
DH1	2 441	0.381	800.000	79	0.122	0.400
DH3	2 441	1.632	400.000	79	0.261	0.400
DH5	2 441	2.883	266.667	79	0.307	0.400
2-DH1	2 441	0.387	800.000	79	0.124	0.400
2-DH3	2 441	1.633	400.000	79	0.261	0.400
2-DH5	2 441	2.883	266.667	79	0.307	0.400
3-DH1	2 441	0.388	800.000	79	0.124	0.400
3-DH3	2 441	1.633	400.000	79	0.261	0.400
3-DH5	2 441	2.883	266.667	79	0.307	0.400

- AFH

Modulation	Frequency (㎒)	Pulse Width (㎳)	Hopping rate (hop/s)	Number of Channels	Result (s)	Limit (s)
DH1	2 441	0.381	400.000	20	0.061	0.400
DH3	2 441	1.632	200.000	20	0.131	0.400
DH5	2 441	2.883	133.333	20	0.154	0.400
2-DH1	2 441	0.387	400.000	20	0.062	0.400
2-DH3	2 441	1.633	200.000	20	0.131	0.400
2-DH5	2 441	2.883	133.333	20	0.154	0.400
3-DH1	2 441	0.388	400.000	20	0.062	0.400
3-DH3	2 441	1.633	200.000	20	0.131	0.400
3-DH5	2 441	2.883	133.333	20	0.154	0.400

Notes:

1. Non-AFH
   - Period Time: 0.4 sec x 79 channels = 31.6 sec
   - Result (s)= (Hopping rate (hop/s/slot) / 79 channels) x 31.6 sec x Pulse width (ms)
2. AFH
   - Period Time: 0.4 sec x 20 channels = 8 sec
   - Result (s)= (Hopping rate (hop/s/slot) / 20 channels) x 8 sec x Pulse width (ms)

GFSK / DH1	π/4DQPSK / 2-DH1
	
GFSK / DH3	**π/4DQPSK / 2-DH3**
	
GFSK / DH5	**π/4DQPSK / 2-DH5**