FCC Part 15 Subpart B&C §15.247

Test Report

Equipment Under Test	**Car Audio**
Model Name	**HAGM1010**
FCC ID	**YRN-HAGM1010**
Applicant	**Humax Automotive co.,Ltd**
Manufacturer	**Humax Automotive co.,Ltd**
Date of Test(s)	**2017. 05. 11 ~ 2017. 05. 18**
Date of Issue	**2017. 05. 19**

In the configuration tested, the EUT complied with the standards specified above.

Issue to	Issue by
Humax Automotive co.,Ltd. (Yubang-dong, 3F), 2, Yeongmulro, Cheoin-gu Yong-in-si, Gyeonggi-do, South Korea Tel.: +82-31-697-4883 Fax: +82-31-697-4804	**MOVON Corporation** 498-2, Geumeo-ro, Pogok-eup, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea, 449-812 Tel.: +82-31-338-8837 Fax: +82-31-338-8847

Revision history

Revision	Date of issue	Description	Revised by
--	May. 19, 2017	Initial	--

Table of contents

1. Attestation of test results

1.1. Details of applicant and manufacturer

Applicant	:	Humax Automotive co.,Ltd.
Address	:	(Yubang-dong, 3F), 2, Yeongmulro, Cheoin-gu Yong-in-si, Gyeonggi-do, South Korea
Contact Person	:	Il kwon Lee
Telephone	:	+82-31-697-4883
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1.2. Summary of test results

The EUT has been tested according to the following specifications;

Section in FCC part 15	Description	Result
§15.205(a) §15.209 §15.247(d)	Transmitter radiated spurious emissions, Conducted spurious emission	C
§15.109(a)	Receiver radiated spurious emission	C
§15.247(a)(1)	20 dB bandwidth	C
§15.247(b)(1)	Maximum peak output power	C
§15.247(a)(1)	Frequency separation	C
§15.247(a)(1)(iii)	Number of hopping frequency	C
§15.247(a)(1)(iii)	Time of occupancy(Dwell time)	C
§15.247(i) §1.1307(b)(1)	RF exposure evaluation	C

The sample was tested according to the following specification:
FCC Parts 15.247; ANSI C63.4:2014, ANSI C63.10:2013
FCC Public Notice DA 00-705
TEST SITE REGISTRATION NUMBER: ***FCC(KR0151)***

※ Abbreviation

C Complied
N/A Not applicable
F Fail

Approval Signatories

Test and Report Completed by :	Report Approval by :
Kin Son Test Engineer MOVON CORPORATION	Issac Jin Technical Manager MOVON CORPORATION

2. EUT Description

Kind of product	Car Audio
Model	HAGM1010
FCC ID	YRN-HAGM1010
Serial Number	N/A
Power supply	DC 14.4V
Frequency range	2 402 ㎒ ~ 2 480 ㎒
Modulation technique	GFSK, Pi/4DQPSK, 8DPSK
Number of channels	79
Antenna gain	-1.06 ㏈i (Max.)
TEST SITE REGISTRATION NUMBER	FCC(KR0151)

2.1. Declarations by the manufacturer

None

2.2. Details of modification

None

3. Frequency Hopping System Requirements

3.1. Standard Applicable

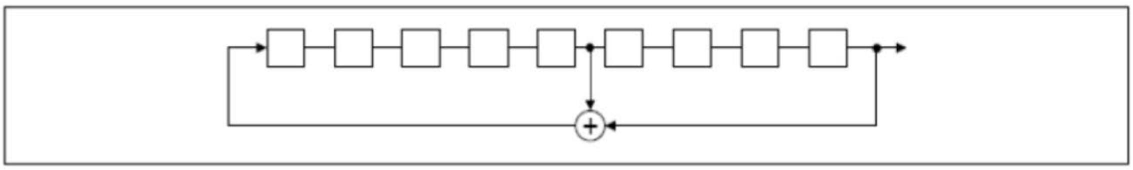
According to FCC Part 15.247(a)(1), The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths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

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

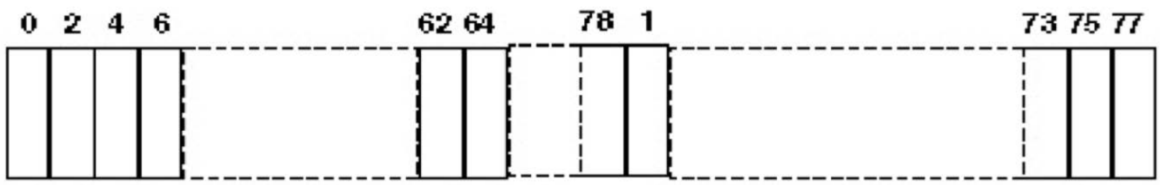
(h) The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination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

3.2. EUT Pseudorandom Frequency Hopping Sequence

The pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage, and the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONEs; i.e. the shift register is initialized with nine ones. Number of shift register stages: 9 Length of pseudo-random sequence: 29-1 = 511 bits Longest sequence of zeros: 8 (non-inverted signal)



Linear Feedback Shift Register for Generation of the PRBS sequence



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

3.3. Frequency Hopping System

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

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

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

Measurement equipment

Equipment	Manufacturer	Model	Serial number	Calibration Interval	Calibration due.
Test Receiver	R&S	ESVS30	829673/015	1 year	2017-12-09
Signal Generator	R&S	SMA100A	102188	1 year	2017-12-09
Spectrum Analyzer	R&S	FSV-40	100832	1 year	2017-11-09
Power Meter	Agilent	E4416A	GB41290645	1 year	2017-06-28
Power Sensor	Agilent	9327A	US40441490	1 year	2017-06-28
Horn Antenna	R&S	HF906	100236	2 year	2019-04-25
Horn Antenna	AH Systems	SAS-573	164	2 year	2018-05-03
TRILOG Supper Broadband test Antenna	SCHWARZBECK	SAS-521-7	9161-4159	2 year	2018-06-14
Power Amplifier	MITEQ	AM-1431	1497315	1 year	2017-06-28
Power Amplifier	MITEQ	AFS43-01002600	1374382	1 year	2017-11-03
High Pass Filter	Wainwright	WHK3.0/18G-10SS	508	1 year	2017-06-29
Controller	INNCO	CO2000	co200/064/6961003/L	N/A	N/A
Antenna Master	INNCO	MA4000	MA4000/038/6961003/L	N/A	N/A
Loop Antenna	ETS LINDGREN	6502	00118166	2 year	2018-02-23
TWO LINE-V-NETWORK	R&S	ESH3-Z5	100296	1 year	2017-12-09
Power Amplifier	MITEQ	AFS43-01002600	1374382	1 year	2017-11-03
Power Divider	HP	11636B	12481	1year	2017-06-29
Bluetooth Tester	TESCOM	TC-3000B	3000B6C0182	1 year	2017-06-28

※ Remark;

Support equipment

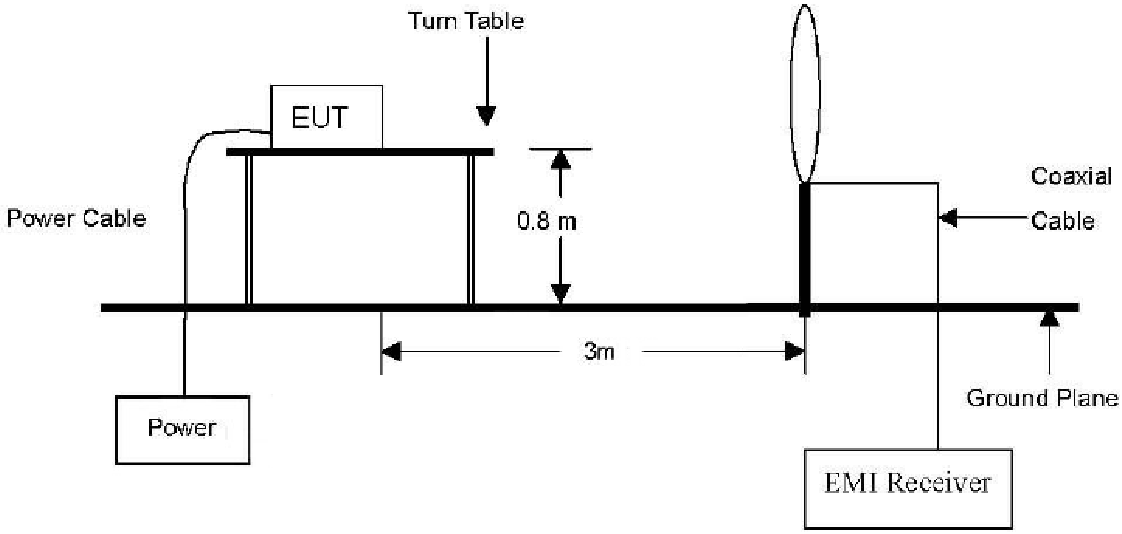
Description	Manufacturer	Model	Serial number
Notebook computer	DELL	Lattitude D510	-

4. Transmitter radiated spurious emissions and conducted spurious emissions

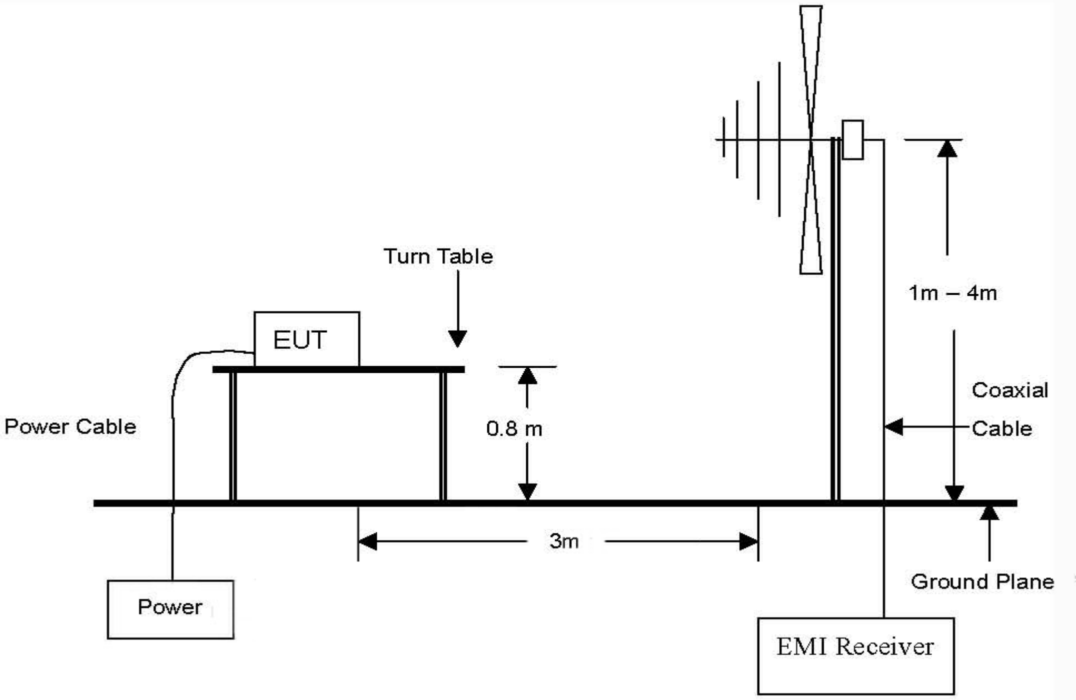
4.1. Test setup

4.1.1. Transmitter radiated spurious emissions

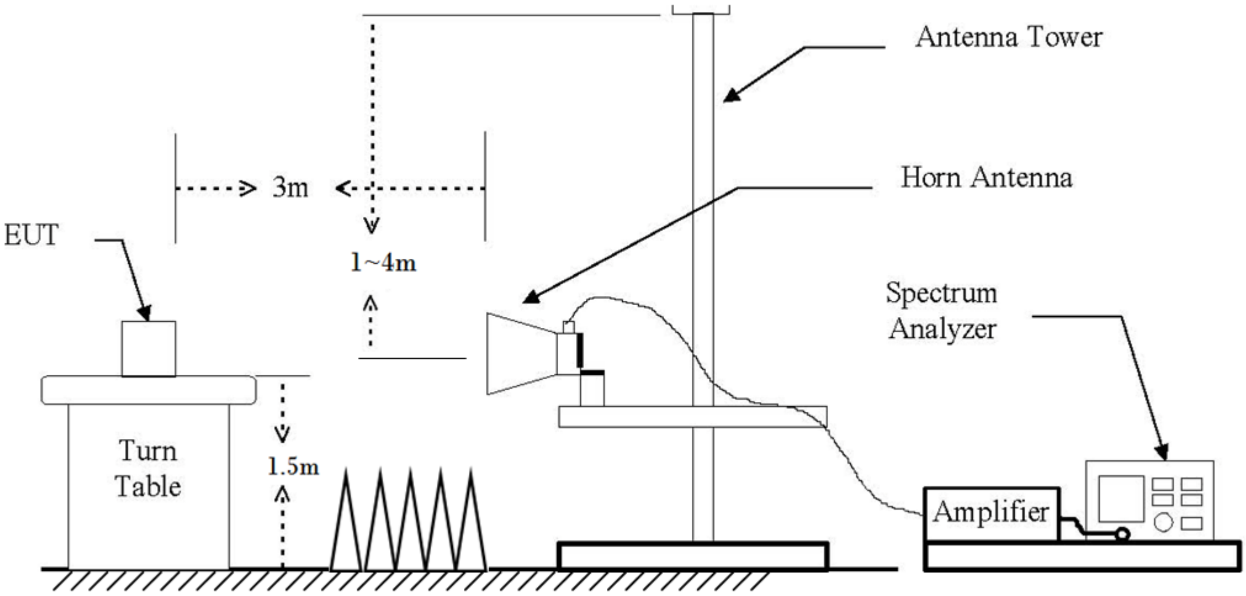
The diagram below shows the test setup that is utilized to make the measurements for emission from 9kHz to 30MHz Emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 30 ㎒ to 1 ㎓ emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission Above 1 ㎓ emissions.



4.2. Limit

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 emission which in the restricted band, as define in section §15.205(a), must also comply the radiated emission limits specified in section §15.209(a) (see section §15.205(c))

According to § 15.109(a), for an intentional radiator devices, the general required of field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values：

Frequency (㎒)	Distance (Meters)	Radiated at 3M (㏈㎶/m)	Radiated (㎶/m)
0.009–0.490	300	See the remark	2400/F(㎑)
0.490–1.705	30		24000/F(㎑)
1.705–30.0	30		30
30 - 88	3	40.0	100
88 – 216	3	43.5	150
216 – 960	3	46.0	200
Above 960	3	54.0	500

*Remark

1. Emission level in ㏈ uV/m = 20 log (uV/m)
2. Measurement was performed at an antenna to the closed point of EUT distance of meters.
3. Distance extrapolation factor = 40log(Specific distance/ test distance) (㏈)
   Limit line=Specific limits(㏈ uV) + distance extrapolation factor.

4.3. Test procedures

Radiated emissions from the EUT were measured according to the dictates of ANSI C63.4:2014
In case of the air temperature of the test site is out of the range is 10 to 40°C before the testing proceeds the warm-up time of EUT maintain adequately

4.3.1. Test procedures for radiated spurious emissions

1. The EUT is placed on a turntable, which is 0.8 m (Below 1 ㎓.) **/** 1.5 m (Above 1 ㎓) above ground plane.
2. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
3. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
4. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
5. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
6. Repeat above procedures until the measurements for all frequencies are complete.

※ Remark;

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 10 ㎑ for Peak detection (PK) at frequency below 30 ㎒
2. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 ㎑ for Peak detection (PK) or Quasi-peak detection (QP) at frequency below 1 ㎓.
3. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 ㎒ for Peak detection and frequency above 1 ㎓.
4. The resolution bandwidth of test receiver/spectrum analyzer is 1 ㎒z and the video bandwidth is 10 ㎐ for Average detection (AV) at frequency above 1 ㎓.

4.4. Test result

Ambient temperature: 23℃
Relative humidity: 45 % R.H.

4.4.1. Spurious radiated emission

The frequency spectrum from 9㎑ to 30 ㎒ was investigated. Emission levels are not reported much lower than the limits by over 20 ㏈. All reading values are peak values.
To get a maximum emission levels from the EUT, the EUT was moved throughout the XY, XZ, and YZ planes.

Operation mode : BDR
A. Low channel (2 402 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	C.L (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

B. Middle channel (2 441 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	C.L (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

C. High channel (2 480 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	C.L (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

※ Remark
1. Actual = Reading + Ant. factor + CL (Cable loss)
2. Distance extrapolation factor = 40 log (specific distance / test distance) (dB)
3. Limit line = specific Limits (dBuV) + Distance extrapolation factor
4. 15.31 Measurement standards.
The amplitude of spurious emissions from intentional radiators and emissions from unintentional radiators which are attenuated more than 20 dB below the permissible value need not be reported unless specifically required elsewhere in this part.

Operation mode : EDR

A. Low channel (2 402 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	C.L (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

B. Middle channel (2 441 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	C.L (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

C. High channel (2 480 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	C.L (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

※ Remark

1. Actual = Reading + Ant. factor + CL (Cable loss)
2. Distance extrapolation factor = 40 log (specific distance / test distance) (dB)
3. Limit line = specific Limits (dBuV) + Distance extrapolation factor
4. 15.31 Measurement standards.

The amplitude of spurious emissions from intentional radiators and emissions from unintentional radiators which are attenuated more than 20 dB below the permissible value need not be reported unless specifically required elsewhere in this part.

4.4.2. Spurious radiated emission

The frequency spectrum from 30 ㎒ to 1 000 ㎒ was investigated. Emission levels are not reported much lower than the limits by over 20 ㏈. All reading values are peak values.
To get a maximum emission levels from the EUT, the EUT was moved throughout the XY, XZ, and YZ planes.

Operation mode: BDR

A. Low channel (2 402 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (㏈/m)	CL(dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (㏈)
167.47	8.35	Peak	V	18.44	2.72	29.51	40.00	10.49
359.42	14.63	Peak	H	14.79	4.03	33.45	43.52	10.07
564.83	13.36	Peak	V	19.09	5.11	37.56	46.02	8.46
Above 700.00	Not Detected	-	-	-		-	-	-

B. Middle channel (2 441 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (㏈/m)	CL(dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (㏈)
169.55	7.77	Peak	H	17.93	2.74	28.44	40.00	11.56
355.64	17.81	Peak	V	14.70	4.00	36.51	43.52	7.01
564.71	11.64	Peak	V	19.09	5.11	35.84	46.02	10.18
Above 700.00	Not Detected	-	-	-		-	-	-

C. High channel (2 480 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	CL(dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
173.55	7.46	Peak	H	16.97	2.77	27.20	40.00	12.80
354.18	14.80	Peak	H	14.66	4.00	33.46	43.52	10.06
563.48	13.49	Peak	V	19.06	5.11	37.66	46.02	8.36
Above 700.00	Not Detected	-	-	-		-	-	-

※ Remark

1. Actual = Reading + Ant. factor + CL (Cable loss)
2. 15.31 Measurement standards.

The amplitude of spurious emissions from intentional radiators and emissions from unintentional radiators which are attenuated more than 20 dB below the permissible value need not be reported unless specifically required elsewhere in this part.

Operation mode: EDR

A. Low channel (2 402 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	CL(dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
169.53	5.91	Peak	V	17.94	2.74	26.59	40.00	13.41
376.48	8.37	Peak	V	15.20	4.13	27.70	43.52	15.82
590.71	15.51	Peak	V	19.55	5.24	40.30	46.02	5.72
Above 700.00	Not Detected	-	-	-		-	-	-

B. Middle channel (2 441 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	CL(dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
175.00	6.08	Peak	H	16.62	2.78	25.48	40.00	14.52
352.14	7.82	Peak	V	14.61	3.98	26.41	43.52	17.11
594.23	12.20	Peak	H	19.61	5.25	37.06	46.02	8.96
Above 700.00	Not Detected	-	-	-		-	-	-

C. High channel (2 480 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	CL(dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
168.14	3.56	Peak	H	18.27	2.73	24.56	40.00	15.44
354.12	10.09	Peak	H	14.66	3.99	28.74	43.52	14.78
605.41	16.17	Peak	V	19.80	5.30	41.27	46.02	4.75
Above 700.00	Not Detected	-	-	-		-	-	-

※ **Remark**

1. Actual = Reading + Ant. factor + CL (Cable loss)
2. 15.31 Measurement standards.

The amplitude of spurious emissions from intentional radiators and emissions from unintentional radiators which are attenuated more than 20 dB below the permissible value need not be reported unless specifically required elsewhere in this part.

4.4.3. Spurious radiated emission

The frequency spectrum above 1 000 ㎒ was investigated. Emission levels are not reported much lower than the limits by over 20 ㏈.
To get a maximum emission levels from the EUT, the EUT was moved throughout the XY, XZ, and YZ planes.

Operation mode: BDR
A. Low channel (2 402 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

B. Middle channel (2 441 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

C. High channel (2 480 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

※ Remark

1. Measuring frequencies from 1 ㎓ to the 10th harmonic of highest fundamental Frequency.
2. Radiated emissions measured in frequency above 1 000 ㎒ were made with an instrument using peak/average detector mode.
3. Average test would be performed if the peak result were greater than the average limit.
4. Actual = Reading + Ant. factor - Amp + CL (Cable loss)
5. 15.31 Measurement standards

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THE AMPLITUDE OF SPURIOUS EMISSIONS FROM INTENTIONAL RADIATORS AND EMISSIONS FROM UNINTENTIONAL RADIATORS WHICH ARE ATTENUATED MORE THAN 20 DB BELOW THE PERMISSIBLE VALUE NEED NOT BE REPORTED UNLESS SPECIFICALLY REQUIRED ELSEWHERE IN THIS PART.

Operation mode: EDR

A. Low channel (2 402 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

B. Middle channel (2 441 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

C. High channel (2 480 ㎒)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
No other emissions were detected at a level greater than 20dB below limit.								

※ Remark

1. Measuring frequencies from 1 ㎓ to the 10th harmonic of highest fundamental Frequency.
2. Radiated emissions measured in frequency above 1 000 ㎒ were made with an instrument using peak/average detector mode.
3. Average test would be performed if the peak result were greater than the average limit.
4. Actual = Reading + Ant. factor - Amp + CL (Cable loss)
5. 15.31 Measurement standards.

THE AMPLITUDE OF SPURIOUS EMISSIONS FROM INTENTIONAL RADIATORS AND EMISSIONS FROM UNINTENTIONAL RADIATORS WHICH ARE ATTENUATED MORE THAN 20 DB BELOW THE PERMISSIBLE VALUE NEED NOT BE REPORTED UNLESS SPECIFICALLY REQUIRED ELSEWHERE IN THIS PART.

4.4.4. Band Edge

Operation mode: BDR

A. 2 310 - 2 390 ㎒ measurement (2 402MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 372.01	41.31	Peak	V	28.09	36.34	49.56	74.00	24.44
2 369.41	28.46	Average	V	28.09	36.34	36.71	54.00	17.29
2 367.09	41.25	Peak	H	28.09	36.34	49.50	74.00	24.50
2 369.41	28.46	Average	H	28.09	36.34	36.71	54.00	17.29

B. 2 483.5 – 2 500 ㎒ measurement (2 480MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 483.50	41.5	Peak	V	28.09	36.34	49.75	74.00	24.25
2 483.50	28.42	Average	V	28.09	36.34	36.67	54.00	17.33
2 484.48	42.33	Peak	H	28.09	36.34	50.58	74.00	23.42
2 484.02	31.06	Average	H	28.09	36.34	39.31	54.00	14.69

Operation mode: EDR

A. 2 310 - 2 390 ㎒ measurement (2 402MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 383.44	41.07	Peak	V	28.09	36.34	49.32	74.00	24.68
2 383.44	28.46	Average	V	28.09	36.34	36.71	54.00	17.29
2 378.67	40.35	Peak	H	28.09	36.34	48.60	74.00	25.40
2 383.44	28.46	Average	H	28.09	36.34	36.71	54.00	17.29

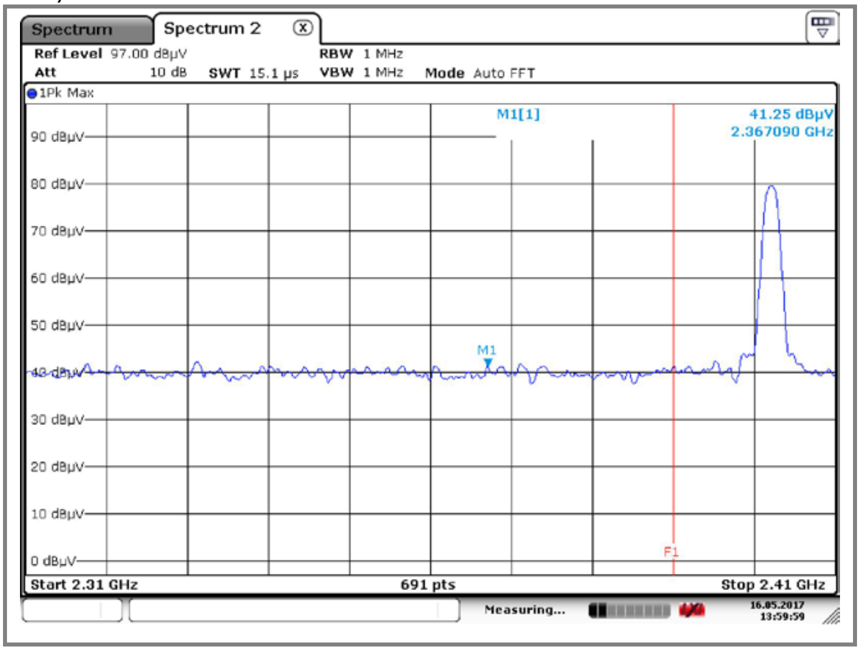
B. 2 483.5 – 2 500 ㎒ measurement (2 480MHz)

Radiated emissions			Ant.	Correction factors		Total	Limit	
Frequency (㎒)	Reading (dB㎶)	Detector mode	Pol.	Ant. factor (dB/m)	Amp + CL (dB)	Actual (dB㎶/m)	Limit (dB㎶/m)	Margin (dB)
2 483.50	45.84	Peak	V	28.09	36.34	54.09	74.00	19.91
2 483.50	31.93	Average	V	28.09	36.34	40.18	54.00	13.82
2 483.50	41.21	Peak	H	28.09	36.34	49.46	74.00	24.54
2 483.50	28.8	Average	H	28.09	36.34	37.05	54.00	16.95

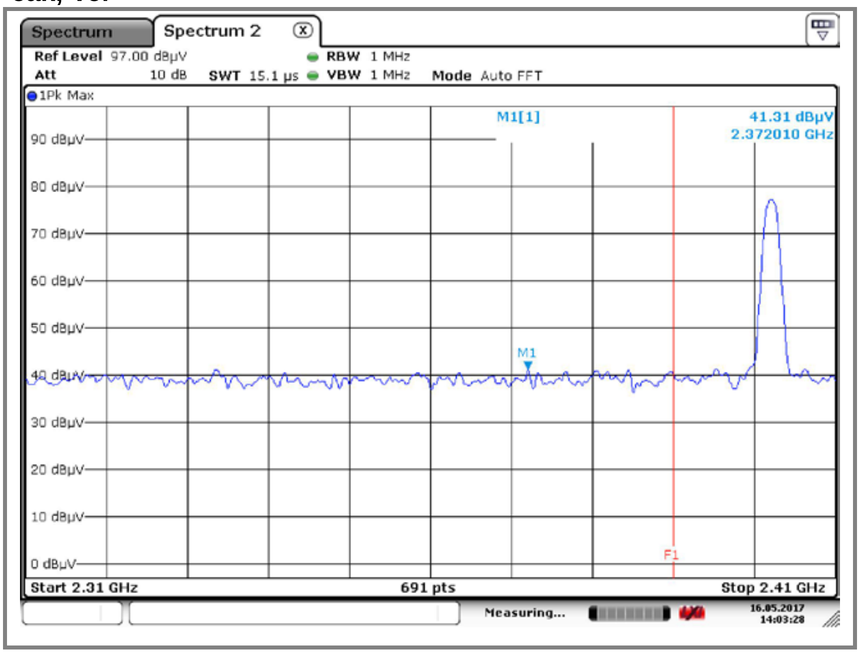
Operation mode: BDR mode

A. Low channel(2 402 ㎒)

Detected Mode : Peak, Hor

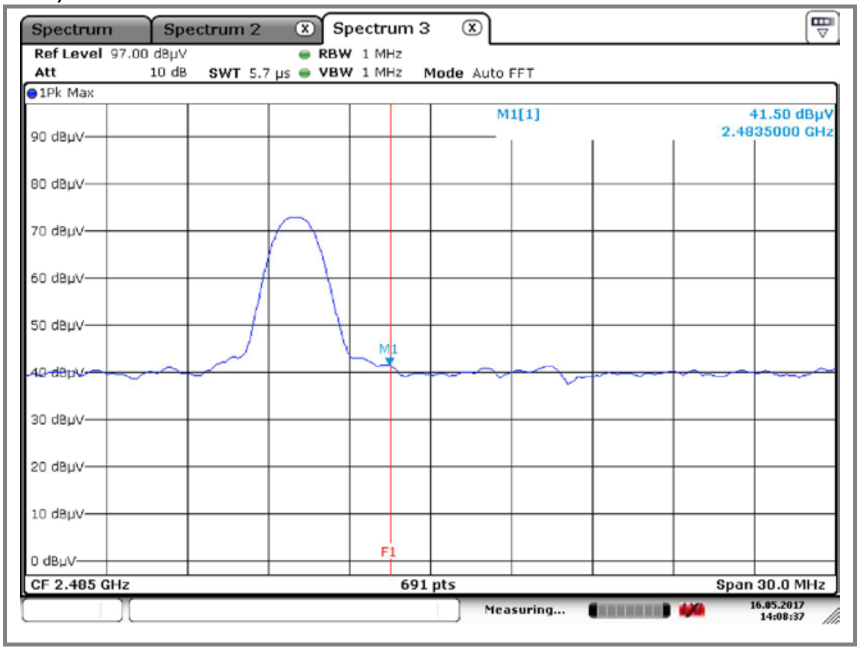


Detected Mode : Peak, Ver

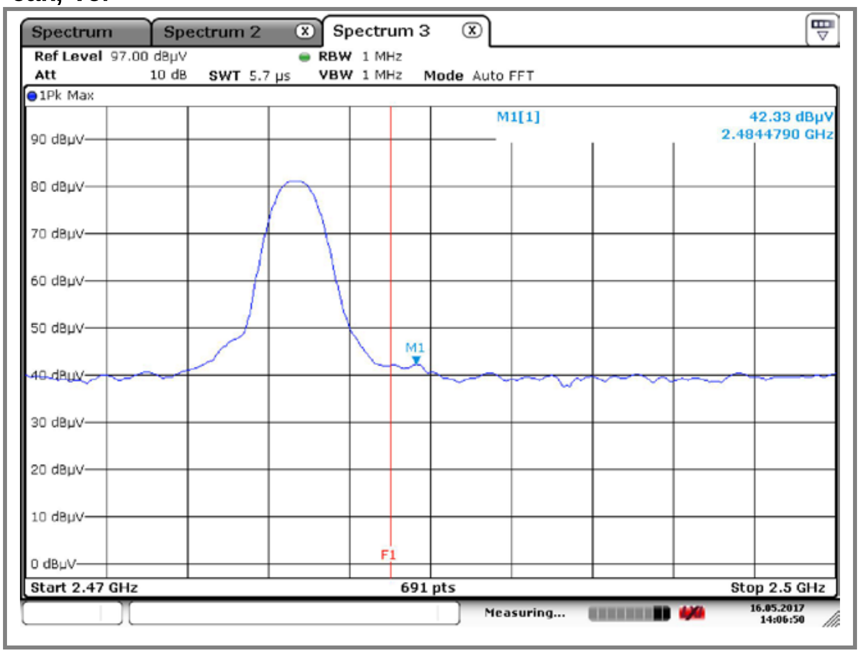


B. High channel(2 480 ㎒)

Detected Mode : Peak, Hor



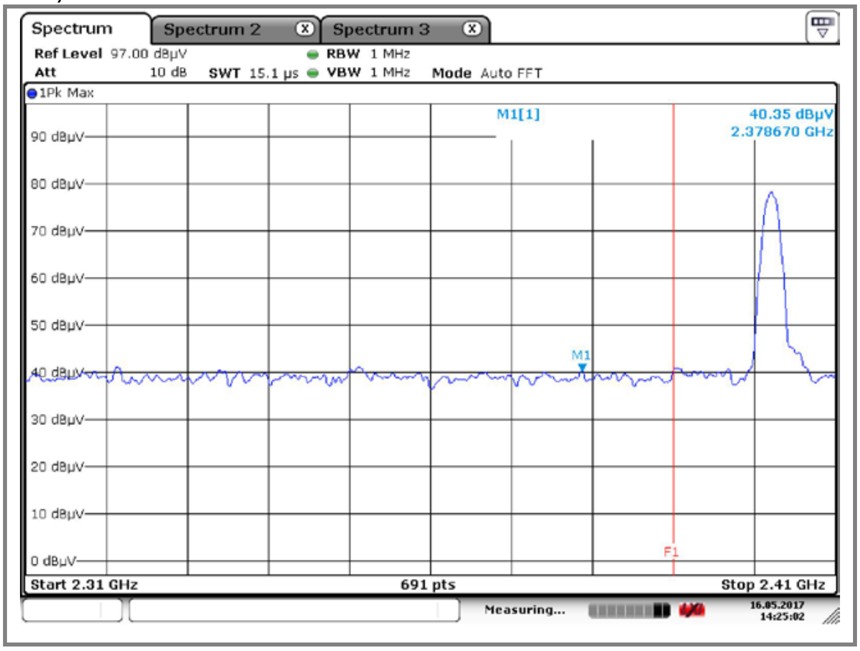
Detected Mode : Peak, Ver



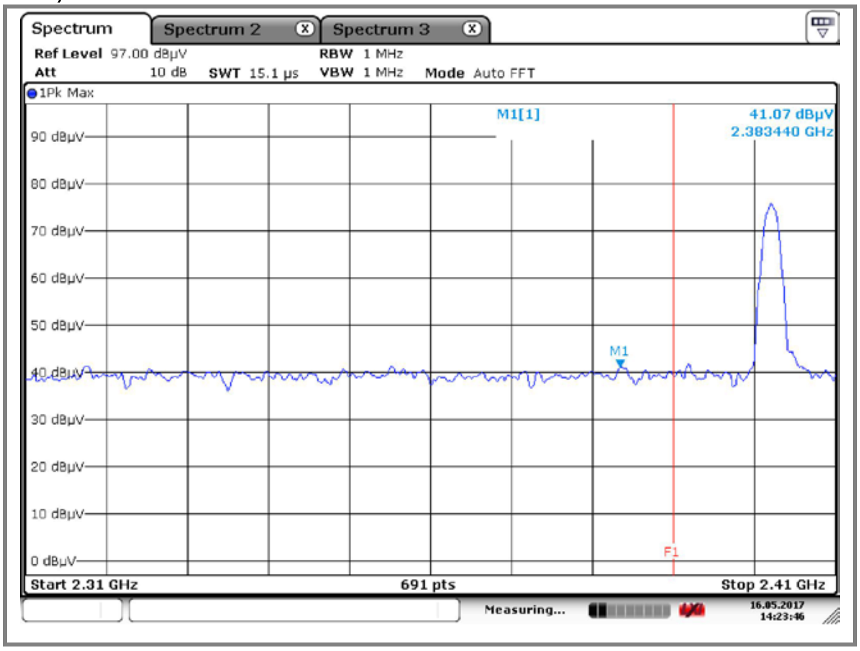
Operation mode: EDR mode

A. Low channel(2 402 ㎒)

Detected Mode : Peak, Hor

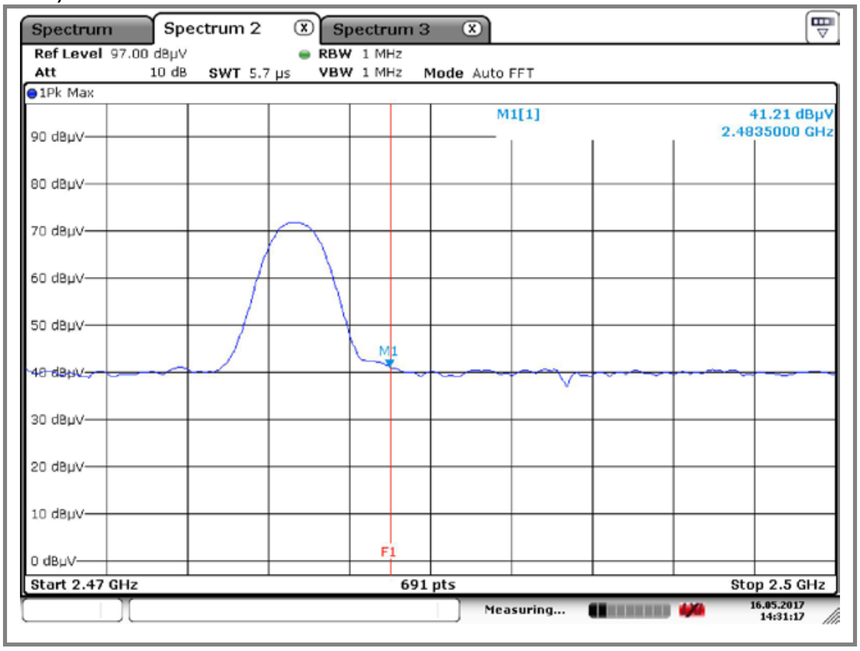


Detected Mode : Peak, Ver

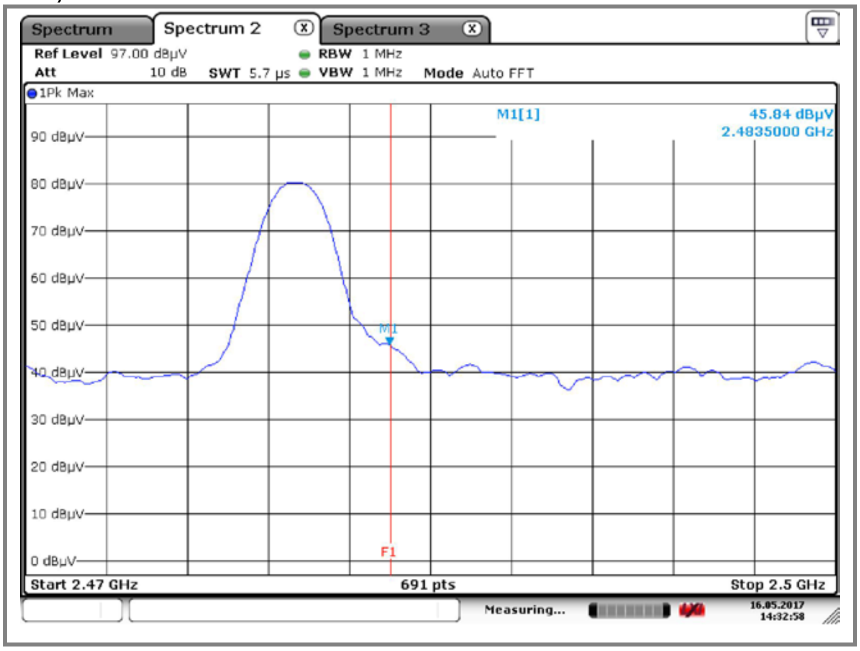


B. High channel(2 480 ㎒)

Detected Mode : Peak, Hor

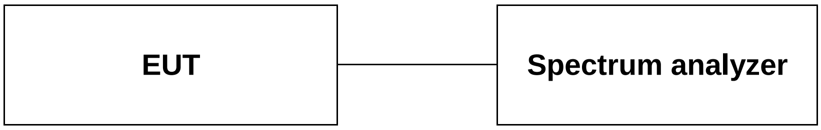


Detected Mode : Peak, Ver



5. 20 ㏈ bandwidth measurement

5.1. Test setup



5.2. Limit

Not applicable

5.3. Test procedure

1. The 20 ㏈ band width was measured with a spectrum analyzer connected to RF antenna connector (conducted measurement) while EUT was operating in transmit mode at the appropriate center frequency. The analyzer center frequency was set to the EUT carrier frequency, using the analyzer. Display Line and Marker Delta functions, the 20 ㏈ band width of the emission was determined.
2. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using RBW ≥ 10 ㎑, VBW ≥ 10 ㎑, Span = 3 ㎒.

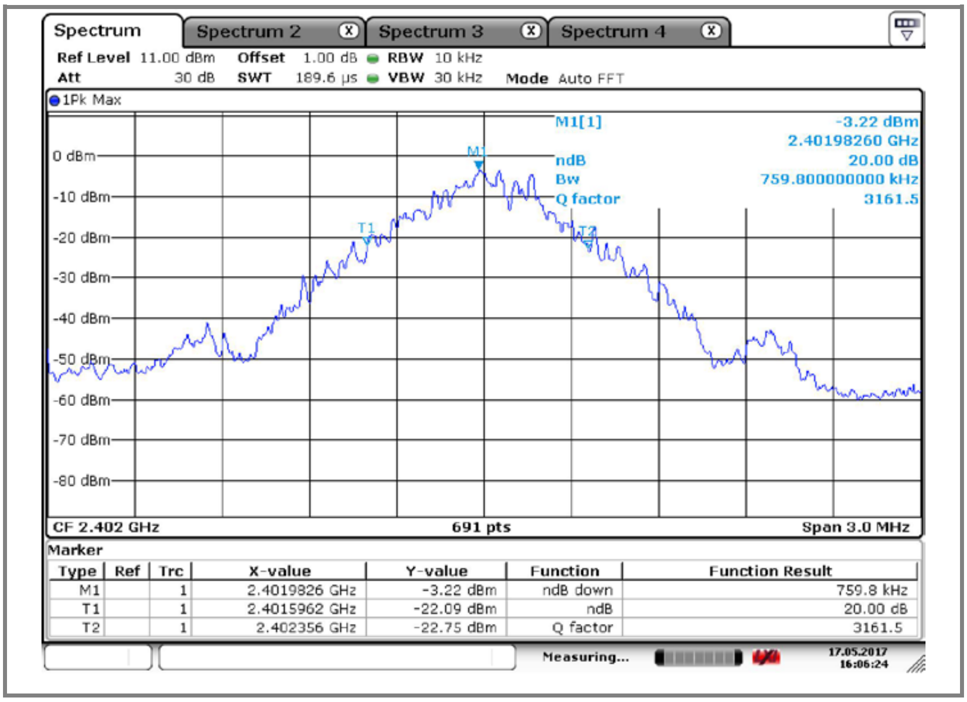
5.4. Test results

Ambient temperature: 22 ℃
Relative humidity: 45 % R.H.

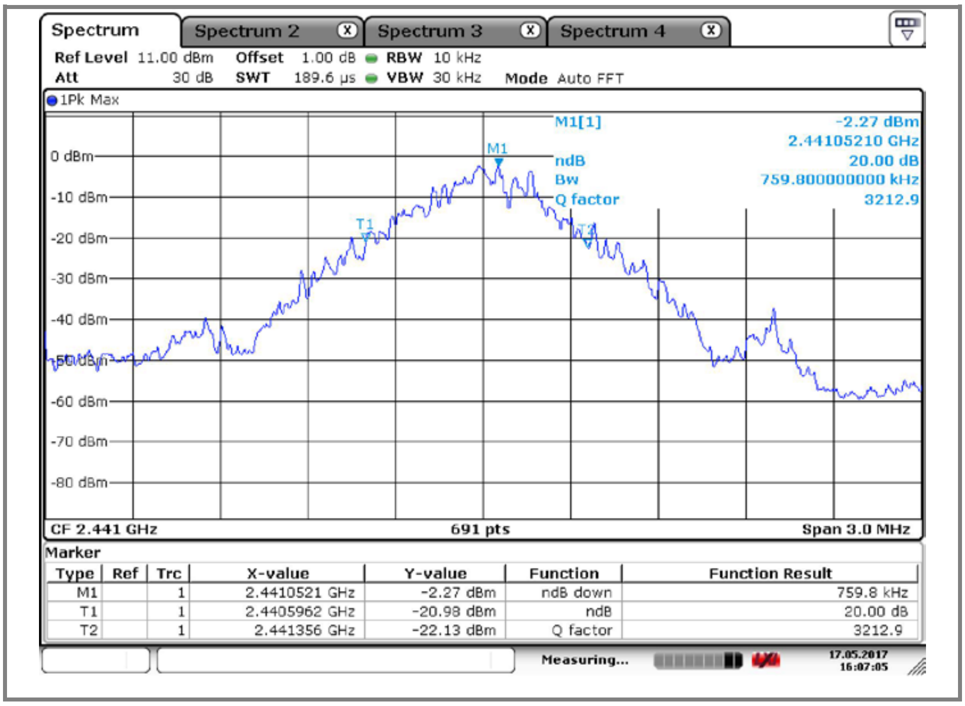
Operation mode	Frequency (㎒)	20 ㏈ bandwidth (㎒)
BDR	2 402	0.760
	2 441	0.760
	2 480	0.760
EDR	2 402	1.224
	2 441	1.259
	2 480	1.263

Operation mode: BDR

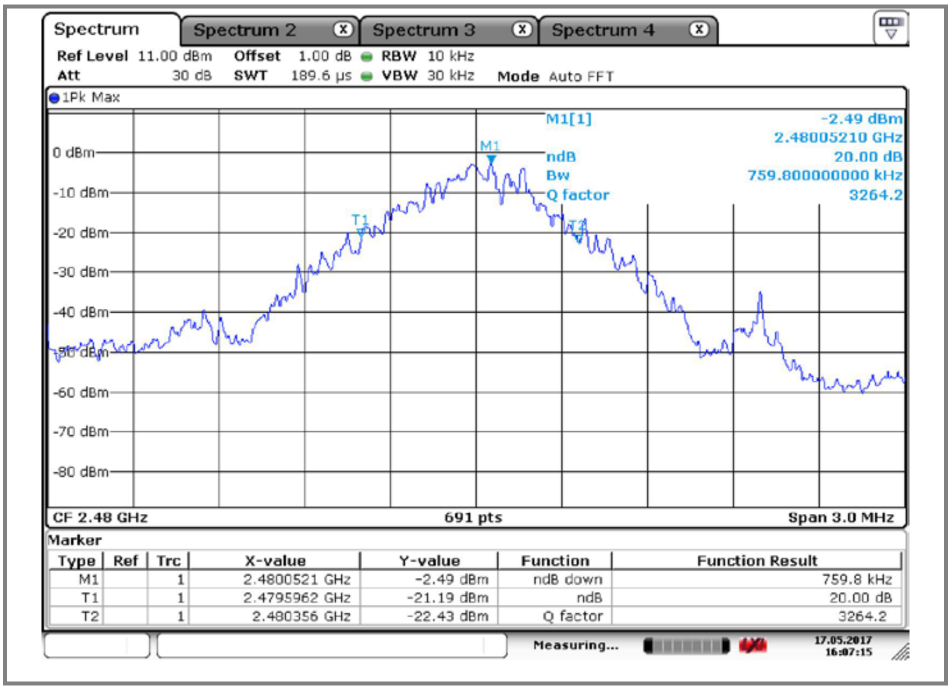
A. Low channel (2 402 ㎒) – 20 ㏈ bandwidth



B. Middle channel (2 441 ㎒) – 20 ㏈ bandwidth



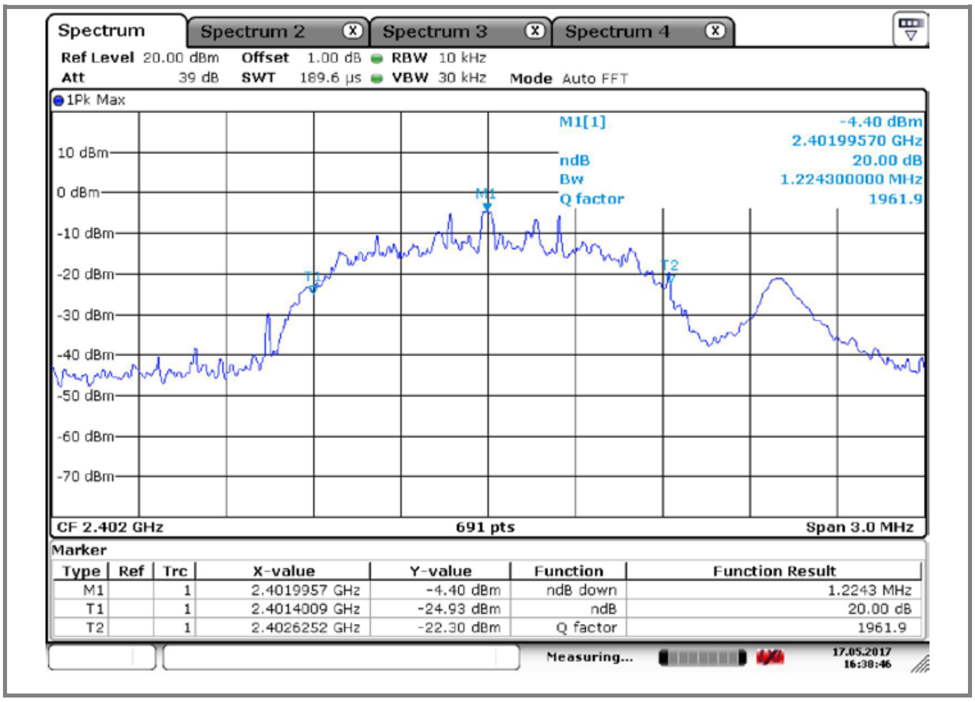
C. High channel (2 480 ㎒) – 20 ㏈ bandwidth



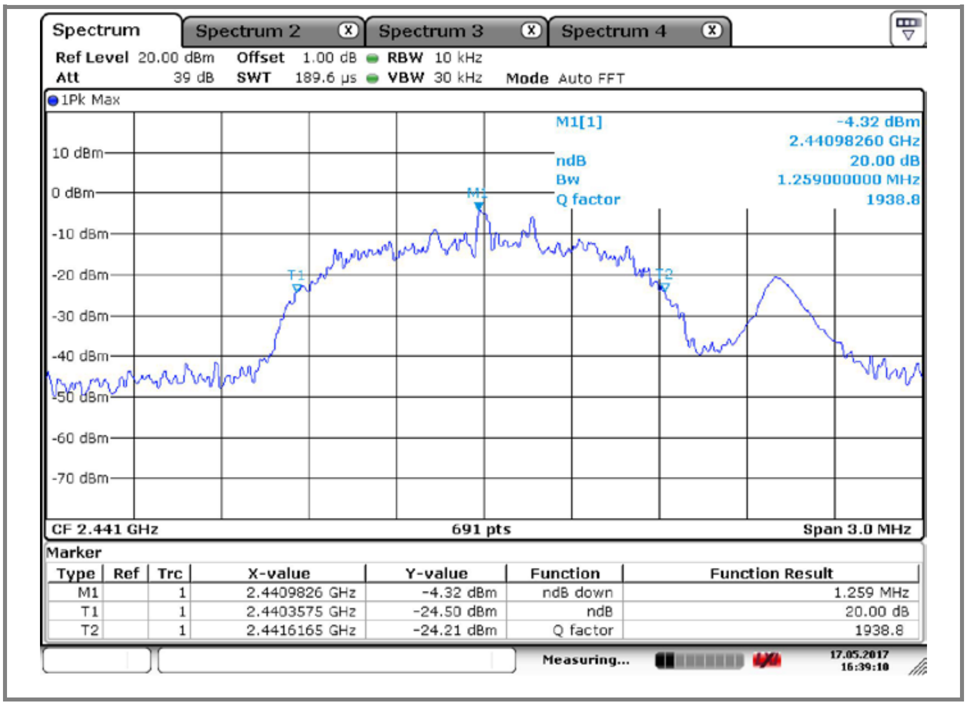
Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4800521 GHz	-2.49 dBm	ndB down	759.8 kHz
T1		1	2.4795962 GHz	-21.19 dBm	ndB	20.00 dB
T2		1	2.480356 GHz	-22.43 dBm	Q factor	3264.2

Operation mode: EDR

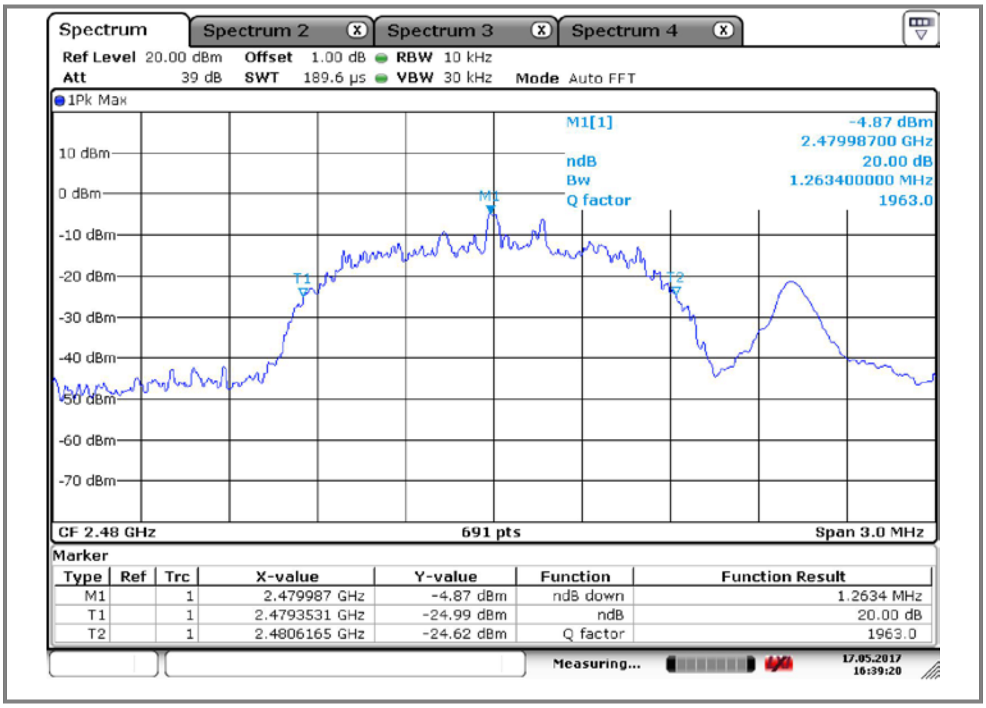
A. Low channel (2 402 ㎒)– 20 ㏈ bandwidth



B. Middle channel (2 441 ㎒)– 20 ㏈ bandwidth

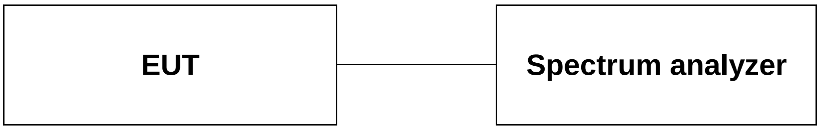


C. High channel (2 480 ㎒)– 20 ㏈ bandwidth



6. Maximum peak output power measurement

6.1. Test setup.



6.2. Limit

The maximum peak output power of the intentional radiator shall not exceed the following:

1. §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, provided the systems operate with an output power no greater than 125 ㎽
2. §15.247(b)(1), For frequency hopping systems operating in the 2 400 – 2 483.5 ㎒ employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725 – 5 805 ㎒ band: 1 Watt.

6.3. Test procedure

1. The RF power output was measured with a Spectrum analyzer connected to the RF Antenna connector(conducted measurement) while EUT was operating in transmit mode at the appropriate center frequency, A spectrum analyzer was used to record the shape of the transmit signal.
2. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using;
   Span = approximately 5 times the 20 ㏈ bandwidth, centered on a hopping channel
   RBW ≥ 20 ㏈ BW, VBW ≥ RBW, Sweep = auto, Detector function = peak, Trace = max hold

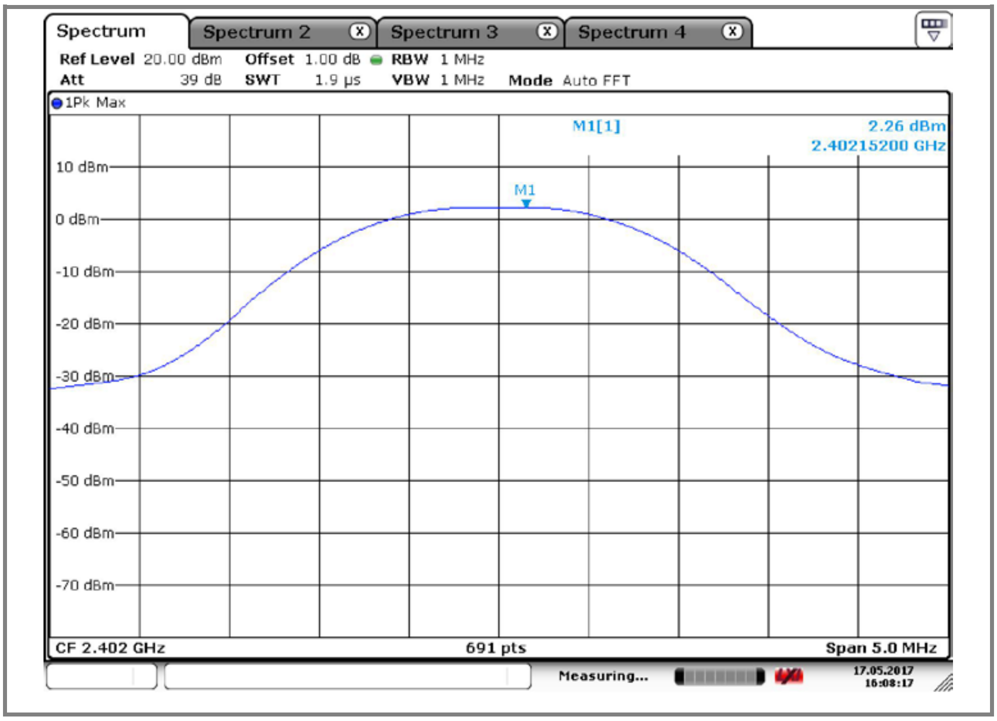
6.4. Test results

Ambient temperature: 22 ℃
Relative humidity: 45 % R.H.

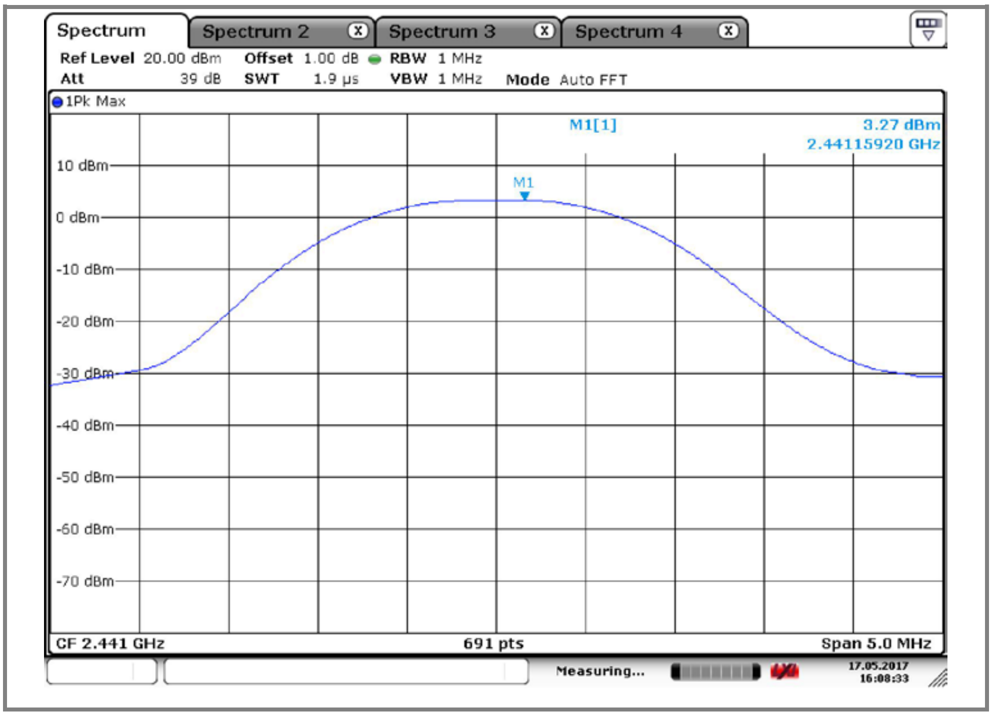
Operation mode	Frequency(㎒)	Peak output power(㏈m)	Limit(㏈m)
BDR	2 402	2.26	30
	2 441	3.27	30
	2 480	3.08	30
EDR	2 402	1.15	30
	2 441	2.17	30
	2 480	1.72	30

Operation mode: BDR

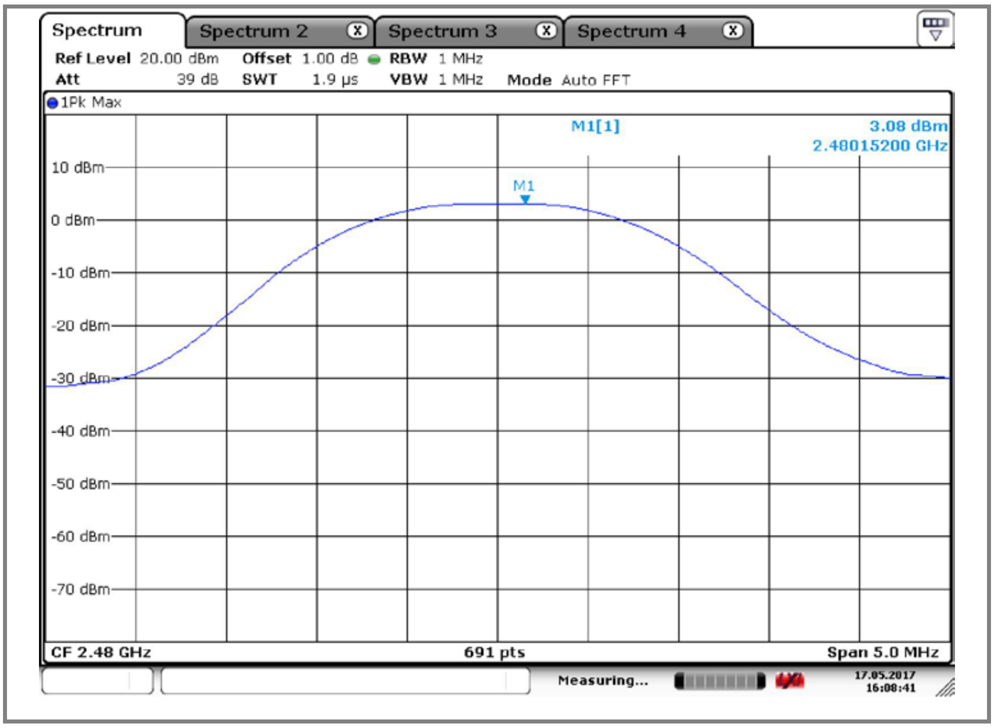
A. Low channel (2 402 ㎒)



B. Middle channel (2 441 ㎒)

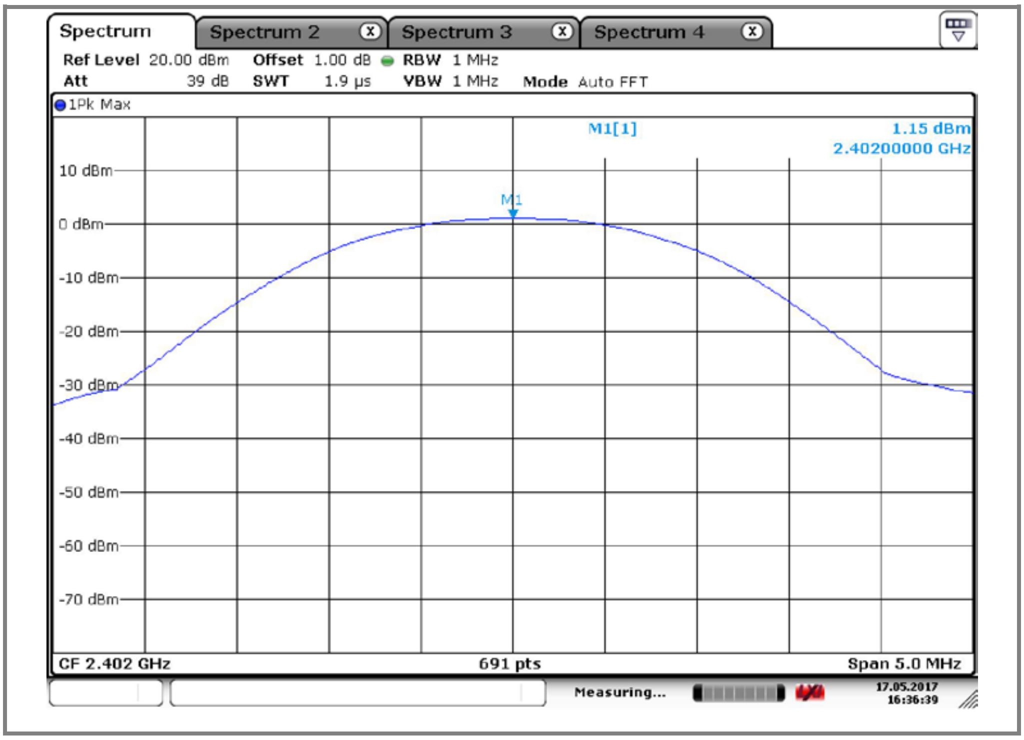


C. High channel (2 480 ㎒)

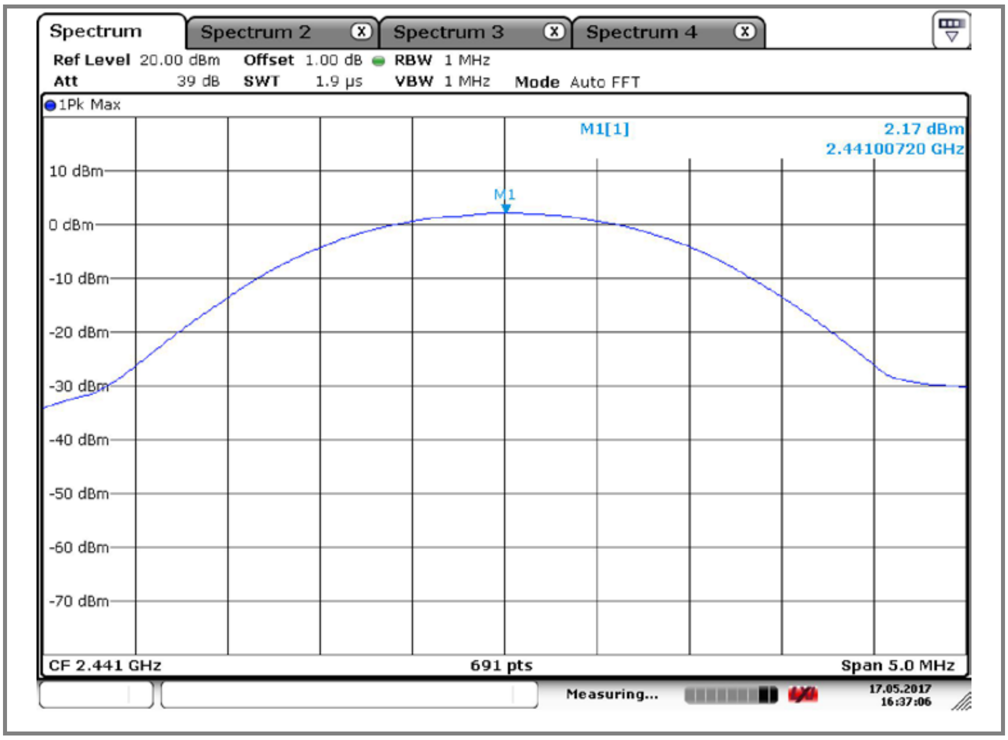


Operation mode: EDR

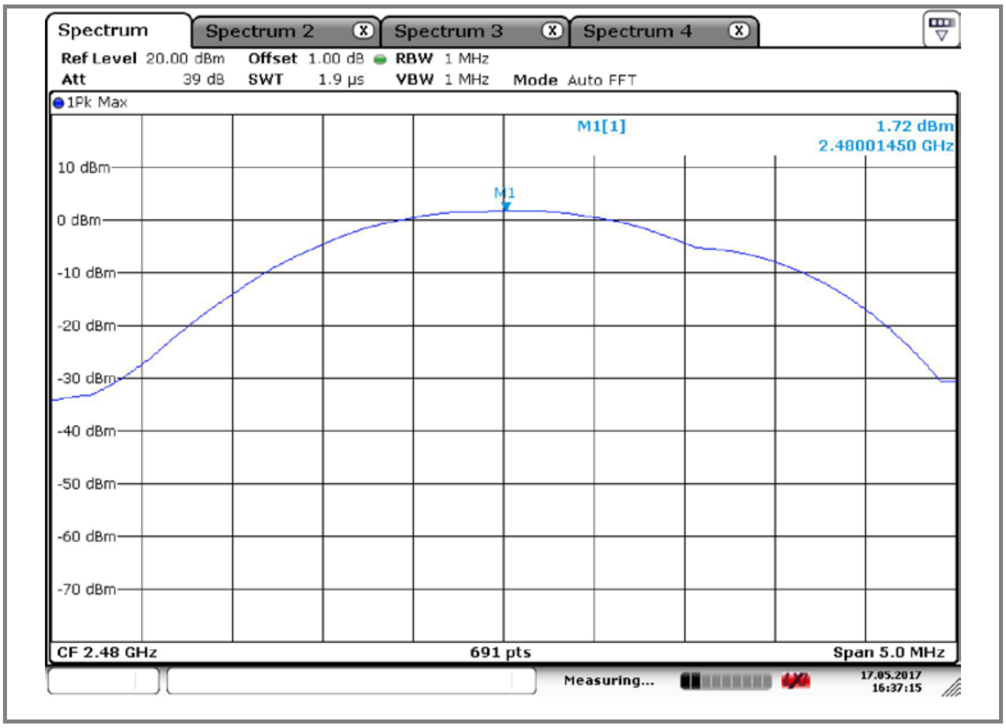
A. Low channel (2 402 ㎒)



B. Middle channel (2 441 ㎒)

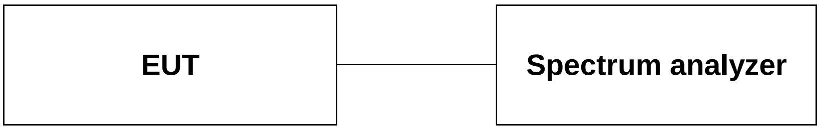


C. High channel (2 480 ㎒)



7. Hopping channel separation

7.1. Test setup



7.2. Limit

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

7.3. Test procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in test setup without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range.
3. By using the max hold function record the separation of adjacent channels.
4. Measure the frequency difference of these two adjacent channels by spectrum analyzer mark function. And then plot the result on spectrum analyzer screen.
5. Repeat above procedures until all frequencies measured were complete.
6. Set center frequency of spectrum analyzer = middle of hopping channel.
7. Set the spectrum analyzer as RBW = 10 ㎑, VBW = 10 ㎑, Span = 3 ㎒ and Sweep = auto.

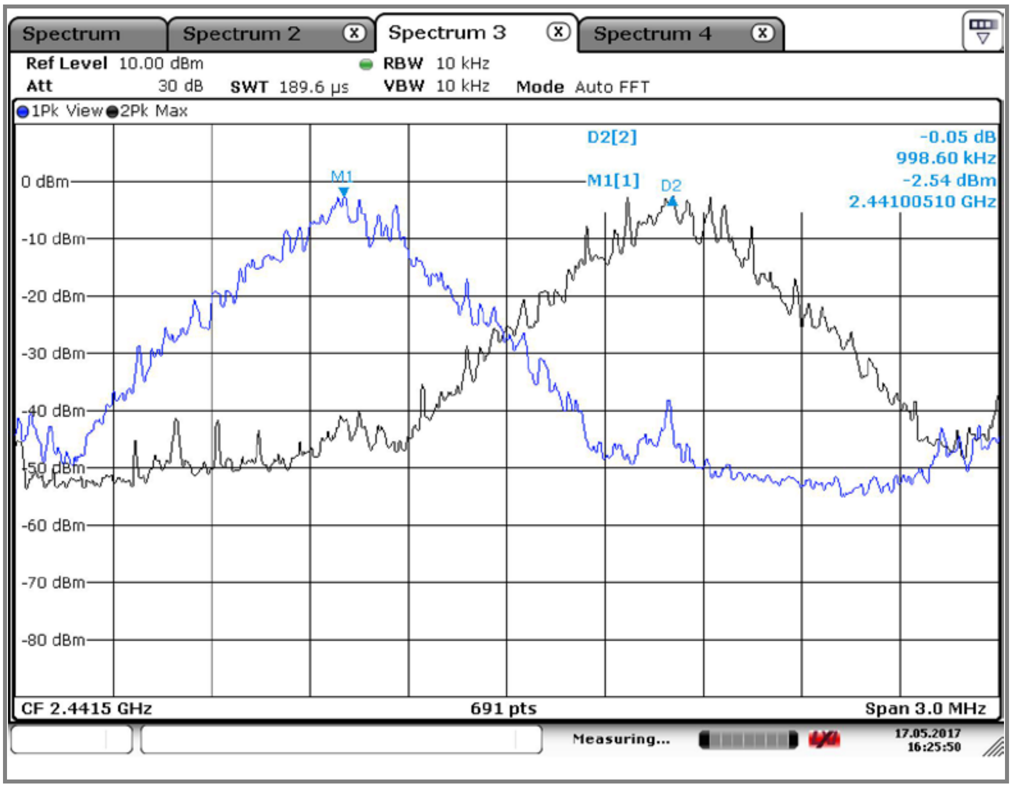
7.4. Test results

Ambient temperature: 22 ℃
Relative humidity: 45 % R.H.

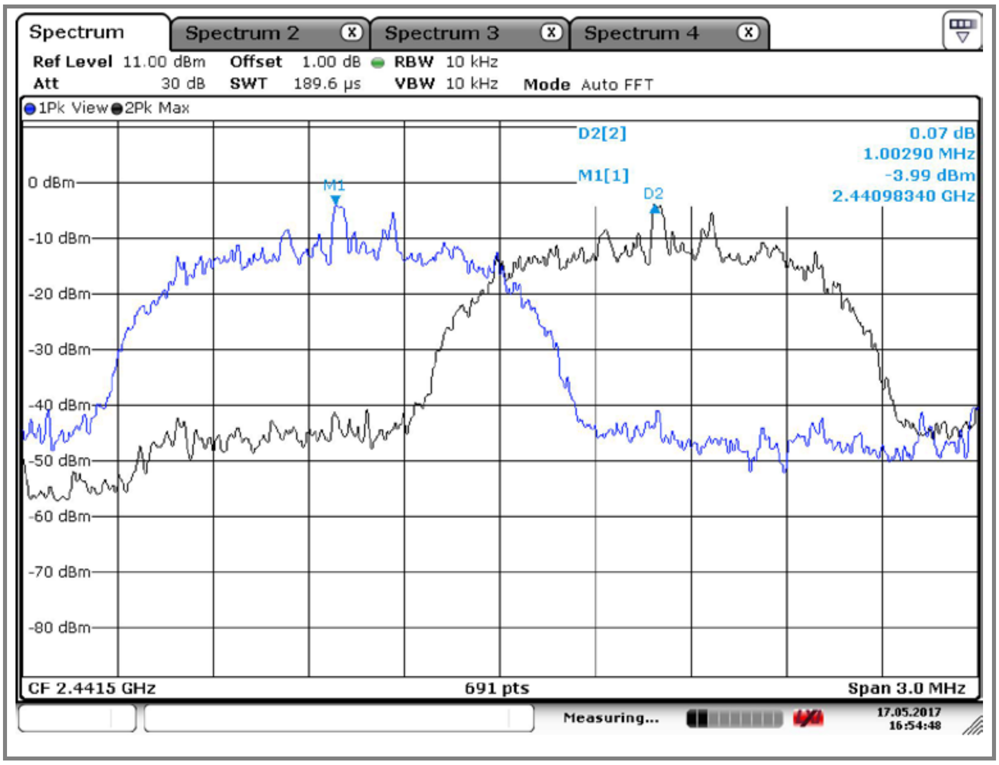
Operation mode	Frequency (㎒)	Adjacent hopping Channel separation (㎑)	Two-third of 20 ㏈ bandwidth (㎑)	Minimum bandwidth (㎑)
BDR	2 441	998.60	501.6	25
EDR	2 441	998.60	833.6	25

※ Remark:
20 ㏈ bandwidth measurement, the measured channel separation should be greater than two-third of 20 ㏈ bandwidth or Minimum bandwidth.

Operation mode : BDR

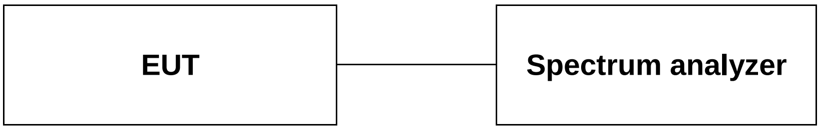


Operation mode: EDR



8. Number of hopping frequency

8.1. Test setup



8.2. Limit

§15.247(a)(1)(iii) For frequency hopping system operating in the 2 400 - 2 483.5 ㎒ bands shall use at least 15 hopping frequencies.

8.3. Test procedure

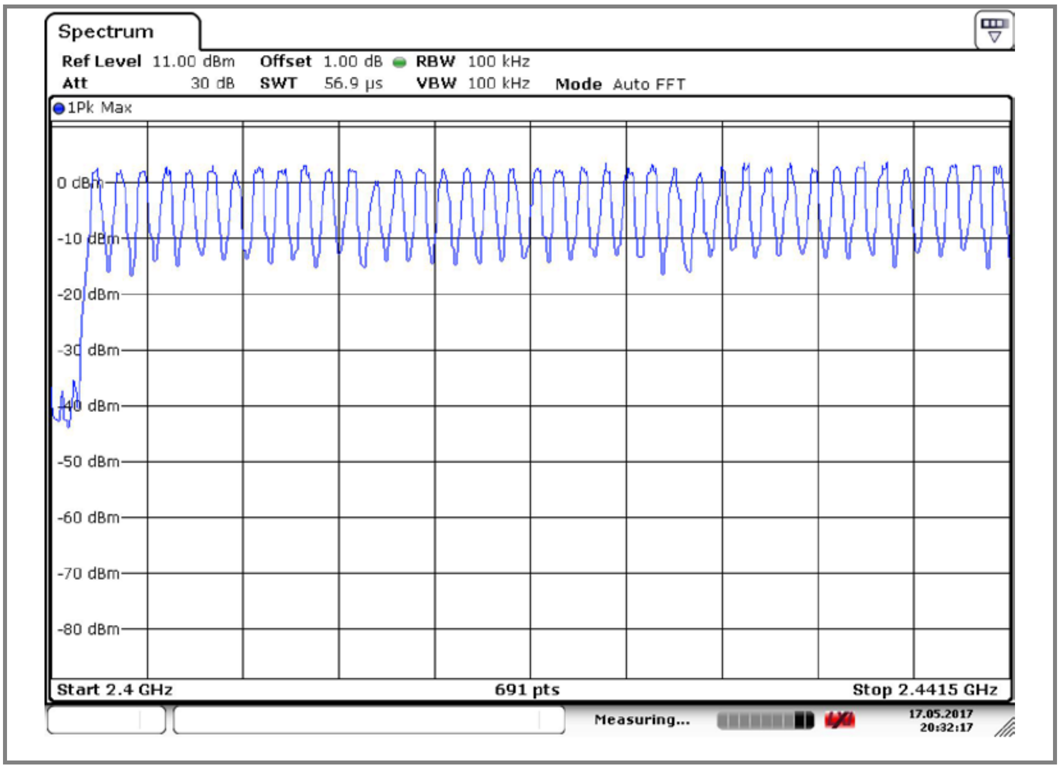
1. Place the EUT on the table and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna the port to the Spectrum analyzer
3. Set spectrum analyzer Start = 2 400 ㎒, Stop = 2 441.5 ㎒, Sweep = auto and Start = 2 441.5 ㎒, Stop = 2 483.5 ㎒, Sweep = auto.
4. Set the spectrum analyzer as RBW, VBW = 100 ㎑.
5. Max hold, view and count how many channel in the band.

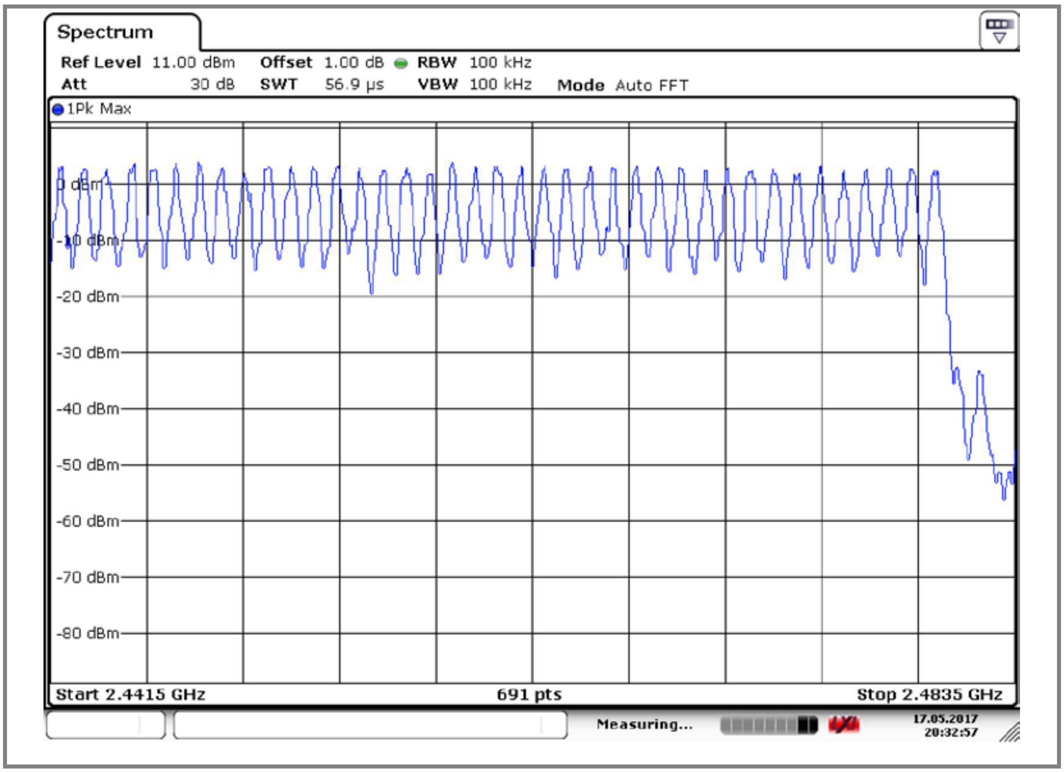
9.4. Test results

Ambient temperature: 22 ℃
Relative humidity: 45 % R.H.

Number of Hopping Frequency	Limit
79	≥ 15

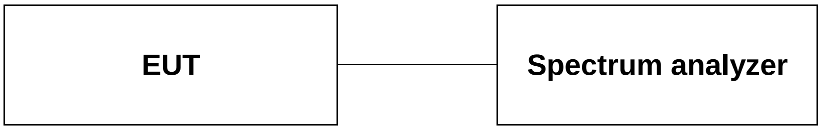
Operation mode: Hopping mode





9. Time of occupancy (Dwell time)

9.1. Test setup



9.2. Limit

§15.247(a)(1)(iii) For frequency hopping system operating in the 2 400 – 2 483.5 ㎒ band, the average time of occupancy on any frequency shall not be greater than 0.4 second within a 31.6 second period.

A period time = 0.4(s) * 79 = 31.6(s)

9.3. Test procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in test setup without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable.
3. Adjust the center frequency of spectrum analyzer on any frequency be measured and set spectrum analyzer to zero span mode. And then, set RBW and VBW of spectrum analyzer to proper value.
4. Measure the time duration of one transmission on the measured frequency. And then plot the result with time difference of this time duration.
5. Repeat above procedures until all frequencies measured were complete.
6. The hopping rate is 1 600 per second.

9.4. Test results

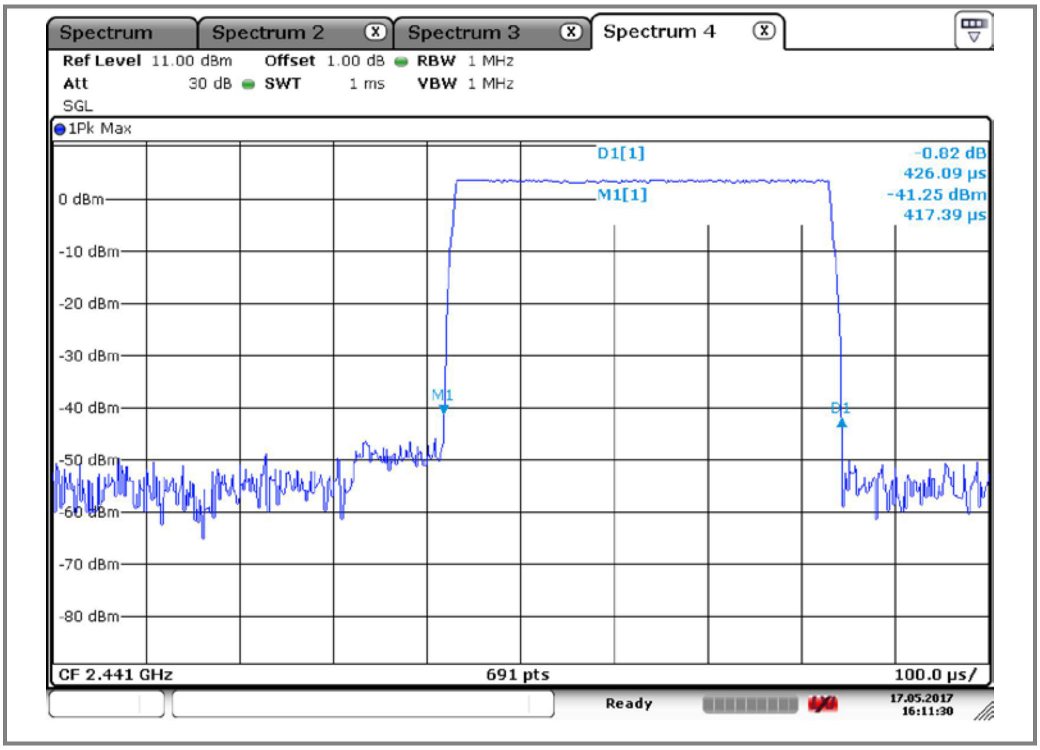
Ambient temperature: 22 ℃
Relative humidity: 45 % R.H.

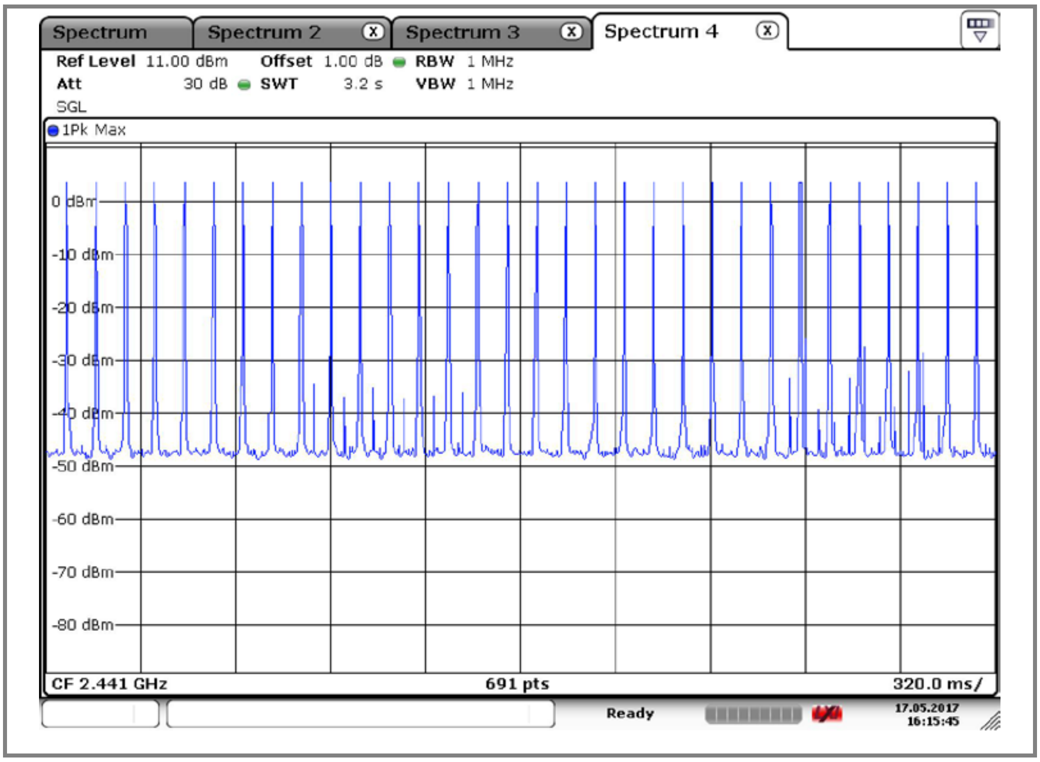
0.4 seconds within a 30 second period per any frequency

Mode	Number of transmission in a 31.6s (79Hopping*0.4)	Length of Transmission Time (msec)	Result (msec)	Limit (msec)
DH1	32(Times / 3.16sec) *10 = 320	0.426	136.32	400
DH3	16(Times / 3.16sec) *10= 160	1.687	269.92	400
DH5	11(Times / 3.16sec) *10= 110	2.919	321.09	400
2-DH5	11(Times / 3.16sec) *10= 110	2.933	322.63	400
3-DH5	11(Times / 3.16sec) *10= 110	2.933	322.63	400

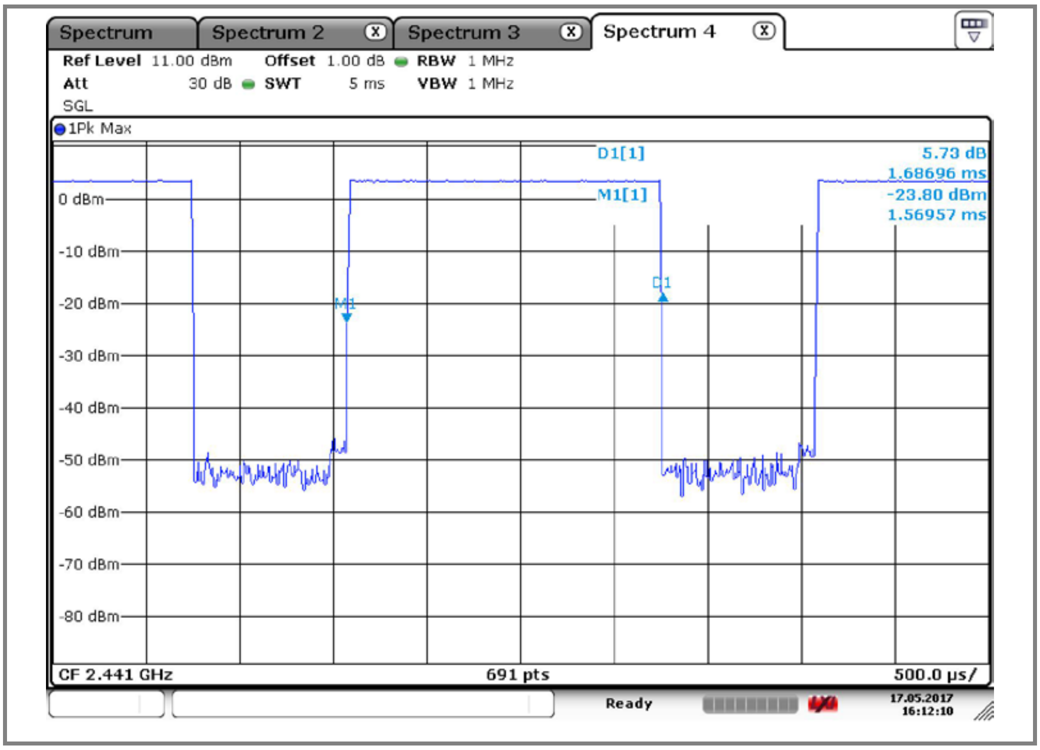
※ Remark:
dwell time = {(number of hopping per second / number of slot) x duration time per channel} x 0.4 ms

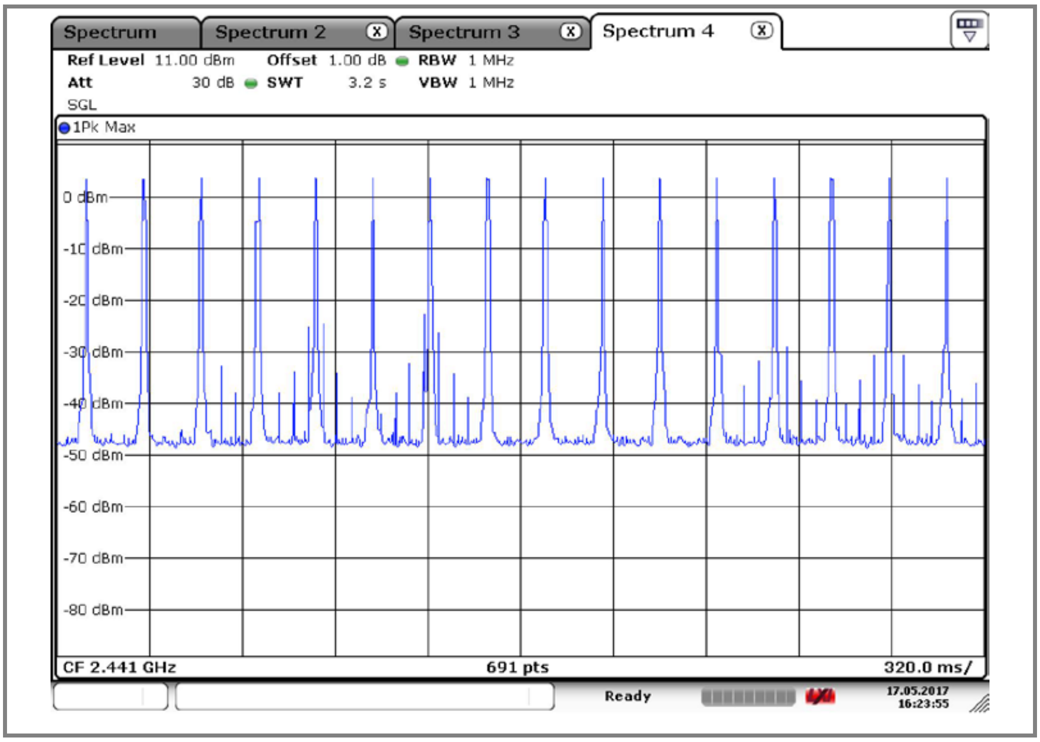
A. DH1


Spectrum
Spectrum 2
Spectrum 3
Spectrum 4
Ref Level 11.00 dBm Offset 1.00 dB RBW 1 MHz
Att 30 dB SWT 1 ms VBW 1 MHz
SGL
1Pk Max
D1[1] -0.82 dB
426.09 µs
M1[1] -41.25 dBm
417.39 µs
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
D1
CF 2.441 GHz
691 pts
100.0 µs/
Ready
17.05.2017
16:11:30

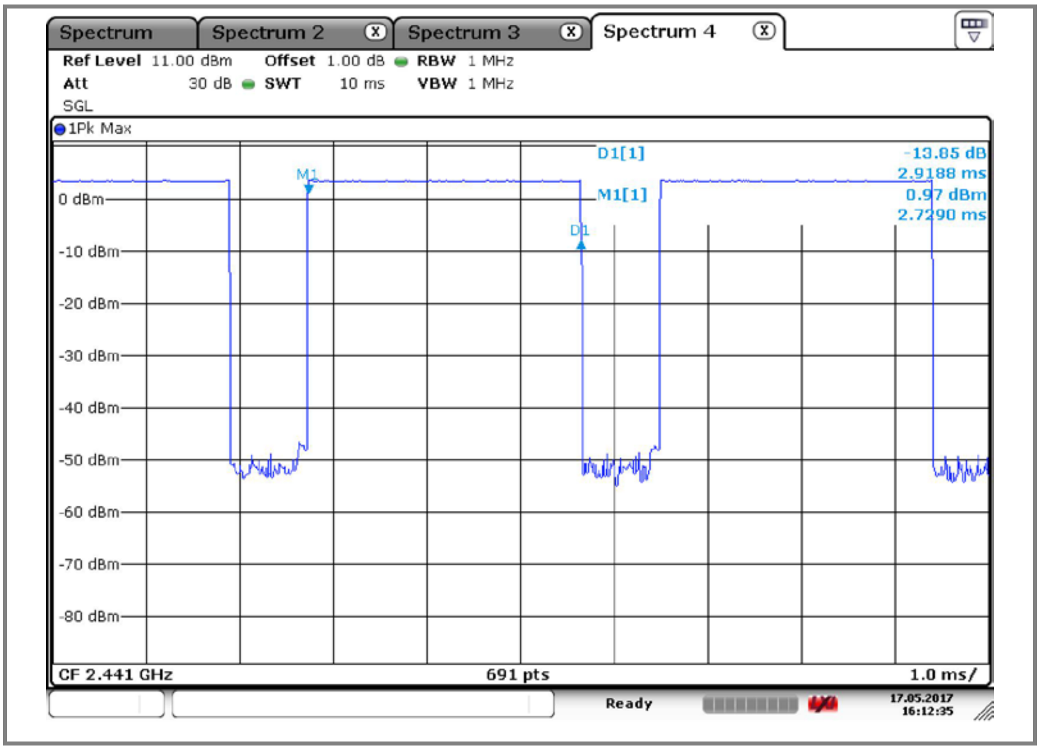

Spectrum
Spectrum 2
Spectrum 3
Spectrum 4
Ref Level 11.00 dBm Offset 1.00 dB RBW 1 MHz
Att 30 dB SWT 3.2 s VBW 1 MHz
SGL
1Pk Max
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
691 pts
320.0 ms/
Ready
17.05.2017
16:15:45

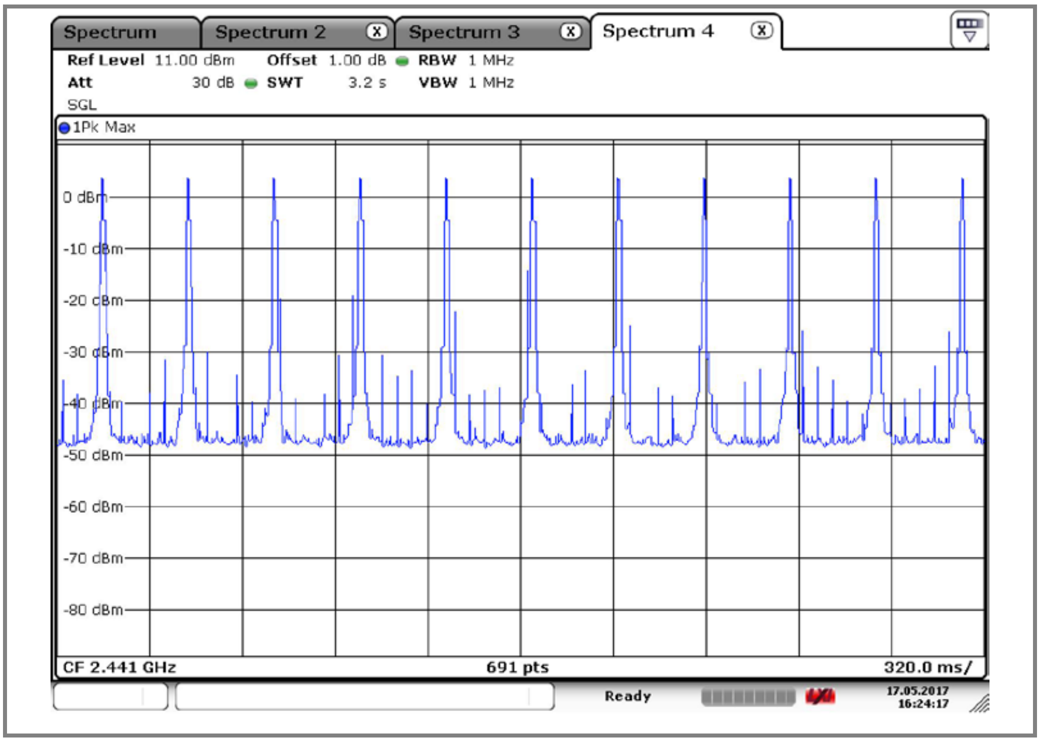
B. DH3


Spectrum
Spectrum 2
Spectrum 3
Spectrum 4
Ref Level 11.00 dBm Offset 1.00 dB RBW 1 MHz
Att 30 dB SWT 5 ms VBW 1 MHz
SGL
1Pk Max
D1[1] 5.73 dB
1.68696 ms
M1[1] -23.80 dBm
1.56957 ms
CF 2.441 GHz
691 pts
500.0 µs/
Ready
17.05.2017
16:12:10

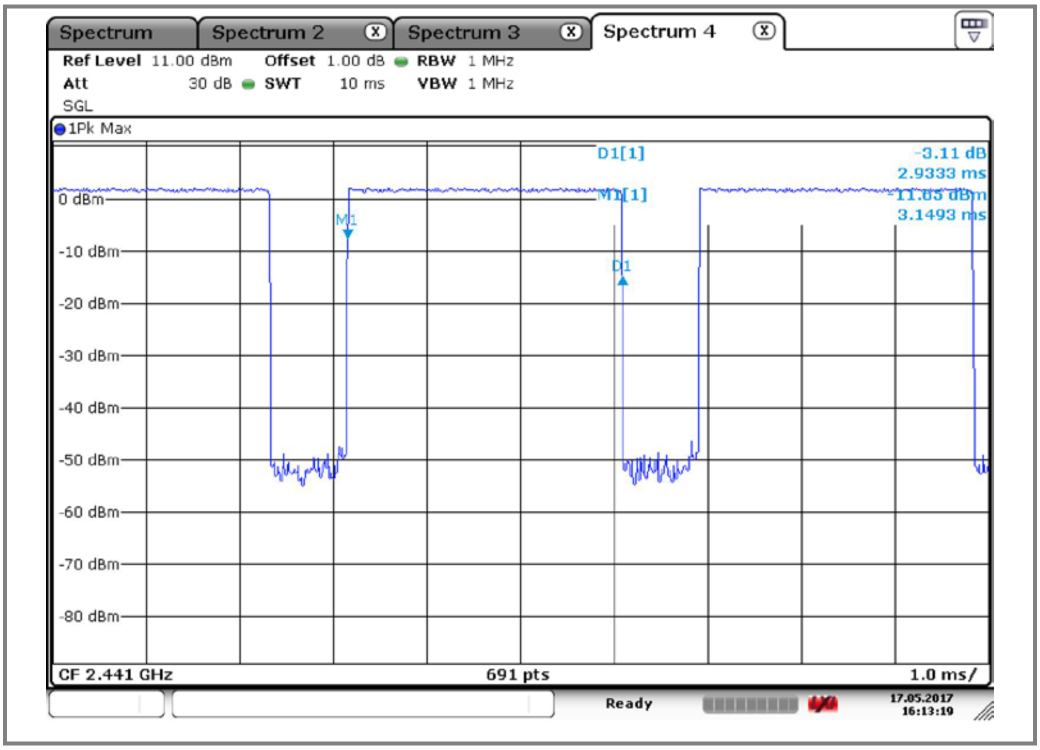

Spectrum
Spectrum 2
Spectrum 3
Spectrum 4
Ref Level 11.00 dBm Offset 1.00 dB RBW 1 MHz
Att 30 dB SWT 3.2 s VBW 1 MHz
SGL
1Pk Max
CF 2.441 GHz
691 pts
320.0 ms/
Ready
17.05.2017
16:23:55

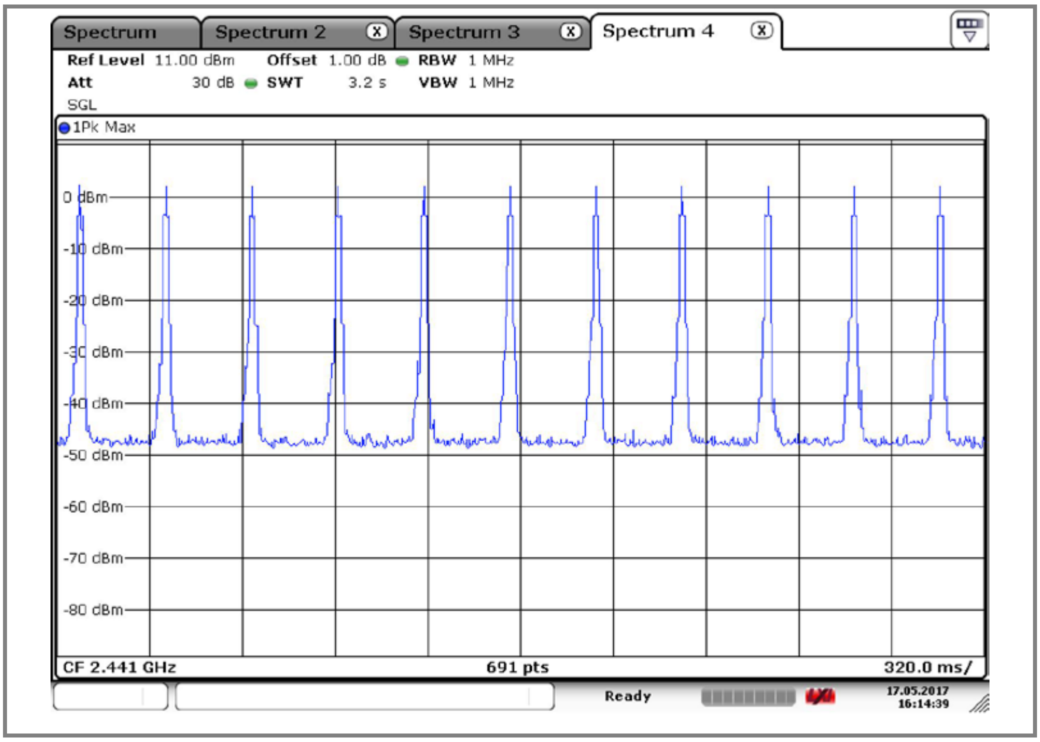
C. DH5


Spectrum
Spectrum 2
Spectrum 3
Spectrum 4
Ref Level 11.00 dBm Offset 1.00 dB RBW 1 MHz
Att 30 dB SWT 10 ms VBW 1 MHz
SGL
1Pk Max
D1[1] -13.85 dB
2.9188 ms
M1[1] 0.97 dBm
2.7290 ms
CF 2.441 GHz
691 pts
1.0 ms/
Ready
17.05.2017
16:12:35

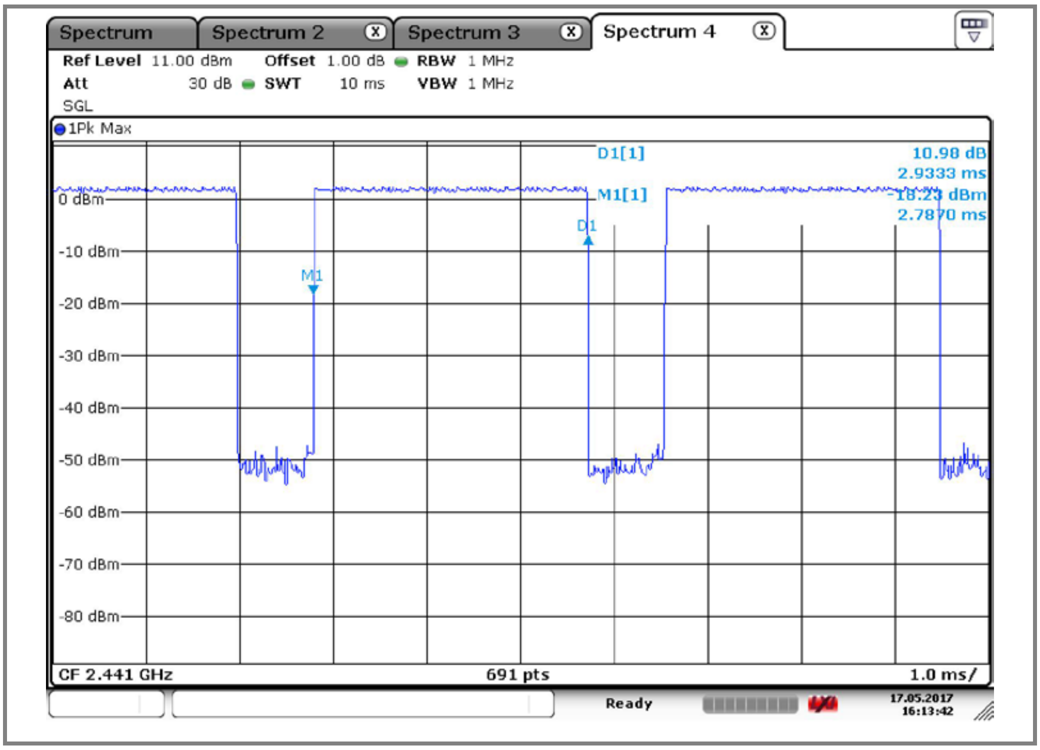

Spectrum
Spectrum 2
Spectrum 3
Spectrum 4
Ref Level 11.00 dBm Offset 1.00 dB RBW 1 MHz
Att 30 dB SWT 3.2 s VBW 1 MHz
SGL
1Pk Max
CF 2.441 GHz
691 pts
320.0 ms/
Ready
17.05.2017
16:24:17

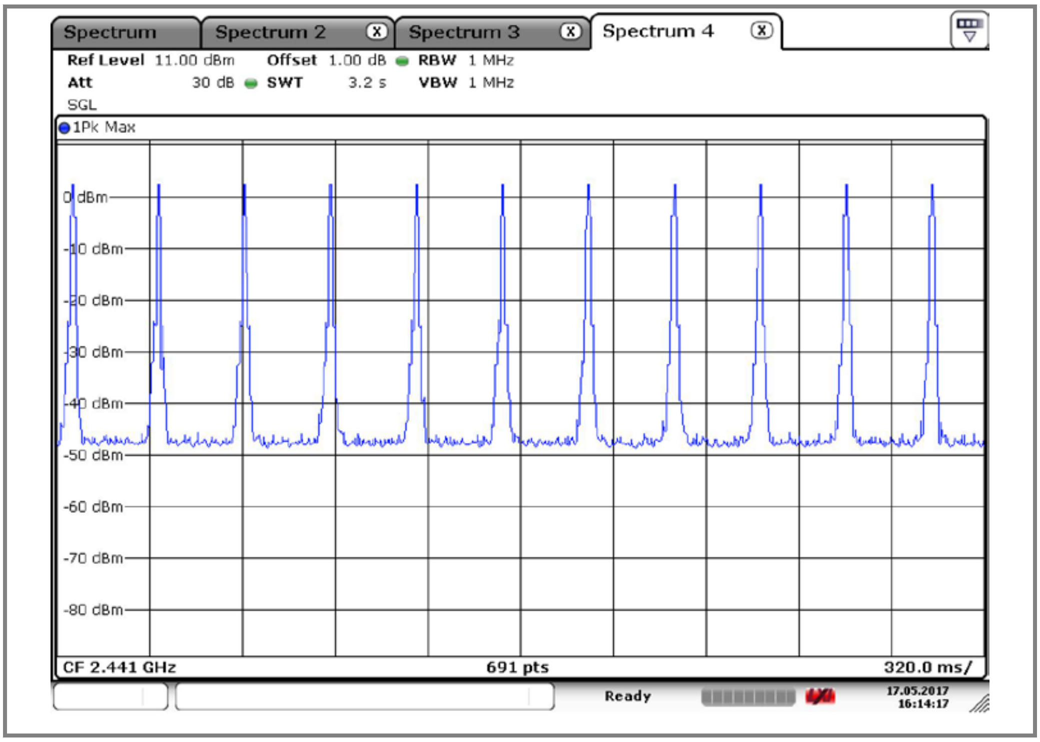
D.2-DH5


Spectrum
Spectrum 2
Spectrum 3
Spectrum 4
Ref Level 11.00 dBm
Offset 1.00 dB
RBW 1 MHz
Att 30 dB
SWT 10 ms
VBW 1 MHz
SGL
1Pk Max
D1[1]
-3.11 dB
2.9333 ms
M1[1]
11.63 dBm
3.1493 ms
CF 2.441 GHz
691 pts
1.0 ms/
Ready
17.05.2017
16:13:19


Spectrum
Spectrum 2
Spectrum 3
Spectrum 4
Ref Level 11.00 dBm
Offset 1.00 dB
RBW 1 MHz
Att 30 dB
SWT 3.2 s
VBW 1 MHz
SGL
1Pk Max
CF 2.441 GHz
691 pts
320.0 ms/
Ready
17.05.2017
16:14:39

E. 3-DH5


Spectrum
Spectrum 2
Spectrum 3
Spectrum 4
Ref Level 11.00 dBm Offset 1.00 dB RBW 1 MHz
Att 30 dB SWT 10 ms VBW 1 MHz
SGL
1Pk Max
D1[1] 10.98 dB
2.9333 ms
M1[1] -18.23 dBm
2.7870 ms
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
691 pts
1.0 ms/
Ready
17.05.2017
16:13:42


Spectrum
Spectrum 2
Spectrum 3
Spectrum 4
Ref Level 11.00 dBm Offset 1.00 dB RBW 1 MHz
Att 30 dB SWT 3.2 s VBW 1 MHz
SGL
1Pk Max
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
691 pts
320.0 ms/
Ready
17.05.2017
16:14:17

10. Antenna requirement

10.1. Standard Applicable

For intentional device, according to FCC 47 CFR 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. And according to FCC 47 CFR Section §15.247 (b) if transmitting antennas of directional gain greater than 6 dBi are used.

10.2. Antenna Connected Construction

Antenna used in this product is PCB antenna

Antenna gain is -1.06 dBi.

11. RF exposure evaluation

11.1 Environmental evaluation and exposure limit according to FCC CFR 47 part 1, 1.1307(b), 1.1310

According to §15.247(e)(i) and §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines. According to KDB 447498 (2)(a)(i)

Limits for maximum permissible exposure (MPE)

Frequency range (㎒)	Electric field strength(V/m)	Magnetic field strength (A/m)	Power density (㎽/㎠)	Average time
(A) Limits for Occupational / Control exposures				
300 – 1 500	--	--	F/300	6
1 500 – 100 000	--	--	5	6
(B) Limits for General Population / Uncontrol Exposures				
300 – 1 500	--	--	F/1 500	6
1 500 – 100 000	--	--	1	30

RF exposure evaluation is required if the separation distance between the user and the device's radiating element is greater than 20 cm, except when the device operates as follows:

below 1.5 GHz and the maximum e.i.r.p. of the device is equal to or less than 2.5 W;

at or above 1.5 GHz and the maximum e.i.r.p. of the device is equal to or less than 5 W.

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.

11.2. Friis transmission formula : Pd=(Pout*G)\(4*pi*R2)

Where
Pd= Power density in ㎽/㎠
Pout=output power to antenna in ㎽
G= Numeric gain of the antenna relative to isotropic antenna
Pi=3.1416
R= distance between observation point and center of the radiator in cm
Pd the limit of MPE, 1 ㎽/㎠. If we know the maximum gain of the antenna and total power input to the antenna, through the calculation, we will know the distance where the MPE limit is reached.

11.3. Test result of RF exposure evaluation

Test Item : RF Exposure evaluation data

Test Mode : Normal operation

11.4. Output power into antenna & RF exposure evaluation distance

Antenna gain: -1.06 dBi

Operation mode : BDR mode

Frequency (MHz)	Output Peak power to antenna (dBm)	Antenna gain (dBi)	Antenna Gain (dBi) Numeric	Power density at 20 cm (mW/cm²)	e.i.r.p. (mW)	e.i.r.p. Limits (W)	Power density Limits (mW/cm²)
2 402	2.26	-1.06	0.78	0.000 26	1.32	5	1
2 441	3.27	-1.06	0.78	0.000 33	1.66		
2 480	3.08	-1.06	0.78	0.000 32	1.59		

Operation mode : EDR mode

Frequency (MHz)	Output Peak power to antenna (dBm)	Antenna gain (dBi)	Antenna Gain (dBi) Numeric	Power density at 20 cm (mW/cm²)	e.i.r.p. (mW)	e.i.r.p. Limits (W)	Power density Limits (mW/cm²)
2 402	1.15	-1.06	0.78	0.000 20	1.02	5	1
2 441	2.17	-1.06	0.78	0.000 26	1.29		
2 480	1.72	-1.06	0.78	0.000 23	1.16		

※ Remark

The power density P_d (5th column) at a distance of 20 cm calculated from the friis transmission formula is far below the limit of 1 mW/cm².