

FCC Part 15 EMI TEST REPORT of

E.U.T. : Camera with Digital Wireless Auto Pair
Transmitter

Model : WVCMS130AP

FCC ID : HQXWVCMS130AP

for

APPLICANT : SYSGRATION LTD.

ADDRESS : 6F-2.,No.1,Sec.1,Tiding Blvd.,Neihu Dist., Taipei
City 114, Taiwan

Test Performed by

ELECTRONICS TESTING CENTER, TAIWAN

NO. 34. LIN 5, DINGFU VIL., LINKOU DIST.,
NEW TAIPEI CITY, TAIWAN, 24442, R.O.C.

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Report Number : 14-09-RBF-017

TEST REPORT CERTIFICATION

Applicant : SYSGRATION LTD.
6F-2.,No.1,Sec.1,Tiding Blvd.,Neihu Dist., Taipei City 114, Taiwan

Manufacture : SYSGRATION LTD.(Nan-Kang Factory)
No.28,North Industry Rd., Nan-Kang Industrial Zone, Nan-Tou City,
Nan-Tou County 540, Taiwan

Description of Device :

a) Type of EUT : Camera with Digital Wireless Auto Pair Transmitter

b) Trade Name : Voyager

c) Model No. : WVCMS130AP

d) Power Supply : DC 12V

Regulation Applied : FCC Rules and Regulations Part 15 Subpart C

I HEREBY CERTIFY THAT: The data shown in this report were made in accordance with the procedures given in ANSI C63.4, and the energy emitted by the device was founded to be within the limits applicable. I assume full responsibility for accuracy and completeness of these data.

Note: 1. The result of the testing report relate only to the item tested.
2. The testing report shall not be reproduced expect in full, without the written approval of ETC.

Summary of Tests

Test	Results
Radiated Emission	Pass
Conducted Emission	N/A
Hopping Channel Separation	Pass
Number of Hopping frequencies used	Pass
Hopping Channel Bandwidth	Pass
Dwell Time of each frequency	Pass
Output Power Requirement	Pass
100 kHz Bandwidth of Frequency Band Edges Requirement	Pass
Out-of-Band Conducted Emission Requirement	Pass

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1 GENERAL INFORMATION

1.1 Product Description

- a) Type of EUT : Camera with Digital Wireless Auto Pair Transmitter
- b) Trade Name : Voyager
- c) Model No. : WVCMS130AP
- d) Power Supply : DC 12V

1.2 Test Methodology

Both conducted and radiated emissions were performed according to the procedures illustrated in ANSI C63.4 (2003). Other required measurements were illustrated in separate sections of this test report for details. FCC DA 00-705 was used as the referencing measurement procedure of RF tests.

There are three types of modulation in the module: 16QAM, QPSK and BPSK. Pretests have been performed with these modulations. There is no difference observed in the parameters such as band width and band edge. The 16QAM mode was found the worst case so it was chosen for the final test and the test data was recorded in the test report. The duty cycle is up to 100%.

1.3 Test Facility

The open area test site and conducted measurement facility used to collect the radiated data is located on the roof top of Building at NO. 34. LIN 5, DINGFU VIL., LINKOU DIST., NEW TAIPEI CITY, TAIWAN, 24442, R.O.C.

This site has been fully described in a report submitted to your office, and accepted in a letter dated Jan. 29, 2014.

2 PROVISIONS APPLICABLE

2.1 Definition

Unintentional radiator:

A device that intentionally generates and radio frequency energy for use within the device, or that sends radio frequency signals by conduction to associated equipment via connecting wiring, but which is not intended to emit RF energy by radiation or induction.

Class A Digital Device:

A digital device which is marketed for use in commercial or business environment; exclusive of a device which is market for use by the general public, or which is intended to be used in the home.

Class B Digital Device :

A digital device which is marketed for use in a residential environment notwithstanding use in a commercial, business of industrial environment. Example of such devices that are marketed for the general public.

Note : A manufacturer may also qualify a device intended to be marketed in a commercial, business, or industrial environment as a Class B digital device, and in fact is encouraged to do so, provided the device complies with the technical specifications for a Class B Digital Device. In the event that a particular type of device has been found to repeatedly cause harmful interference to radio communications, the Commission may classify such a digital device as a Class B Digital Device, Regardless of its intended use.

Intentional radiator:

A device that intentionally generates and emits radio frequency energy by radiation or induction.

2.2 Requirement for Compliance

(1) Conducted Emission Requirement

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

Frequency MHz	Quasi Peak dB μ V	Average dB μ V
0.15 - 0.5	66-56*	56-46*
0.5 - 5.0	56	46
5.0 - 30.0	60	50

* Decreases with the logarithm of the frequency

For intentional device, according to §15.207(a) Line Conducted Emission Limits is same as above table.

(2) Radiated Emission Requirement

For unintentional device, according to §15.109(a), except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency MHz	Distance Meters	Radiated dB μ V/m	Radiated μ V/m
30 - 88	3	40.0	100
88 - 216	3	43.5	150
216 - 960	3	46.0	200
Above 960	3	54.0	500

For intentional device, according to §15.209(a), the general requirement of field strength of radiated emissions from intentional radiators at a distance of 3 meters shall not exceed the above table.

(3) Antenna Requirement

For intentional device, 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.

(4) Hopping Channel Separation

According to 15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

(5) Number of Hopping frequencies used

According to 15.247(a)(1)(iii), frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.

(6) Hopping Channel Bandwidth

For frequency hopping system operating in the 2400–2483.5 MHz band, there is no requirement for the maximum 20dB bandwidth of the hopping channel. The measurement of the hopping channel bandwidth is for the reference of the hopping channel separation requirement.

(7) Dwell Time of each frequency

According to 15.247(a)(1)(iii), for frequency hopping system operating in the 2400-2483.5 band, 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.

(8) Output Power Requirement

According to 15.247(b)(1), for frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

(9) 100 kHz Bandwidth of Frequency Band Edges Requirement

According to 15.247(d), in any 100 kHz 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 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided 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 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required.

(10) Out-of-Band Conducted Emission Requirement

According to 15.247(d), in any 100 kHz 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 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided 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 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required.

2.3 Restricted Bands of Operation

Only spurious emissions are permitted in any of the frequency bands listed below :

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42-16.423	399.9-410	4.5-5.15
0.495 - 0.505 **	16.69475 - 16.69525	608-614	5.35-5.46
2.1735 - 2.1905	16.80425 - 16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475 - 156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2655-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3360-4400	Above 38.6
13.36-13.41			

** : Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz

2.4 Labeling Requirement

The device shall bear the following statement in a conspicuous location on the device :

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions : (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

2.5 User Information

The users manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual.

The Federal Communications Commission Radio Frequency Interference Statement includes the following paragraph.

This equipment has been tested and found to comply with the limits for a Class B Digital Device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction may cause harmful interference to radio communication. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.

- Increase the separation between the equipment and receiver.

- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

- Consult the dealer or an experienced radio / TV technician for help.

3 SYSTEM TEST CONFIGURATION

3.1 Justification

For both radiated and conducted emissions, the system was configured for testing in a typical fashion as a customer would normally use it. The peripherals other than EUT were connected in normally standing by situation. Three highest emissions were verified with varying placement of the transmitting antenna connected to EUT (if applicable) to maximize the emission from EUT.

For conducted and radiated emissions, whichever RF channel is operated, the digital circuits' function identically. As the reason, measurement of emissions from digital circuits is performed with the highest, middle and the lowest channel by transmitting mode.

3.2 Devices for Tested System

Device	Manufacture	Model / FCC ID.	Description
Camera with Digital Wireless Auto Pair Transmitter *	SYSGRATION LTD.	WVCMS130AP / HQXWVCMS130AP	0.8m Unshielded DC Power Line
Battery	YUASA	YTX9-BS	----

Remark “*” means equipment under test.

4 RADIATED EMISSION MEASUREMENT

4.1 Applicable Standard

For unintentional radiator, the radiated emission shall comply with §15.109(a).

For intentional radiators, according to §15.247 (a), operation under this provision is limited to frequency hopping and direct sequence spread spectrum, and the out band emission shall be comply with §15.247 (c)

4.2 Measurement Procedure

1. Setup the configuration per figure 1 and 2 for frequencies measured below and above 1 GHz respectively.
2. For emission frequencies measured below 1 GHz, a pre-scan is performed in a shielded chamber to determine the accurate frequencies of higher emissions will be checked on a open test site. As the same purpose, for emission frequencies measured above 1 GHz, a pre-scan also be performed with a 1 meter measuring distance before final test.
3. For emission frequencies measured below and above 1 GHz, set the spectrum analyzer on a 100 kHz and 1 MHz resolution bandwidth respectively for each frequency measured in step 2.
4. The search antenna is to be raised and lowered over a range from 1 to 4 meters in horizontally polarized orientation. Position the highness when the highest value is indicated on spectrum analyzer, then change the orientation of EUT on test table over a range from 0 ° to 360 ° with a speed as slow as possible, and keep the azimuth that highest emission is indicated on the spectrum analyzer. Vary the antenna position again and record the highest value as a final reading. A RF test receiver is also used to confirm emissions measured.
5. Repeat step 4 until all frequencies need to be measured were complete.
6. Repeat step 5 with search antenna in vertical polarized orientations.
7. Check the three frequencies of highest emission with varying the placement of cables associated with EUT to obtain the worse case and record the result.

Figure 1 : Frequencies measured below 1 GHz configuration

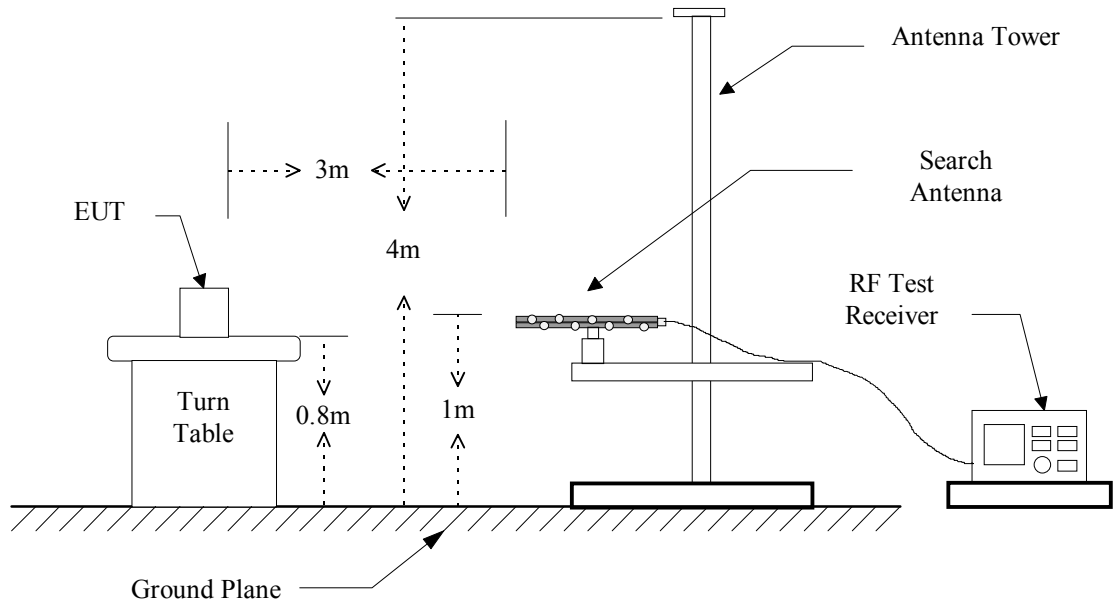
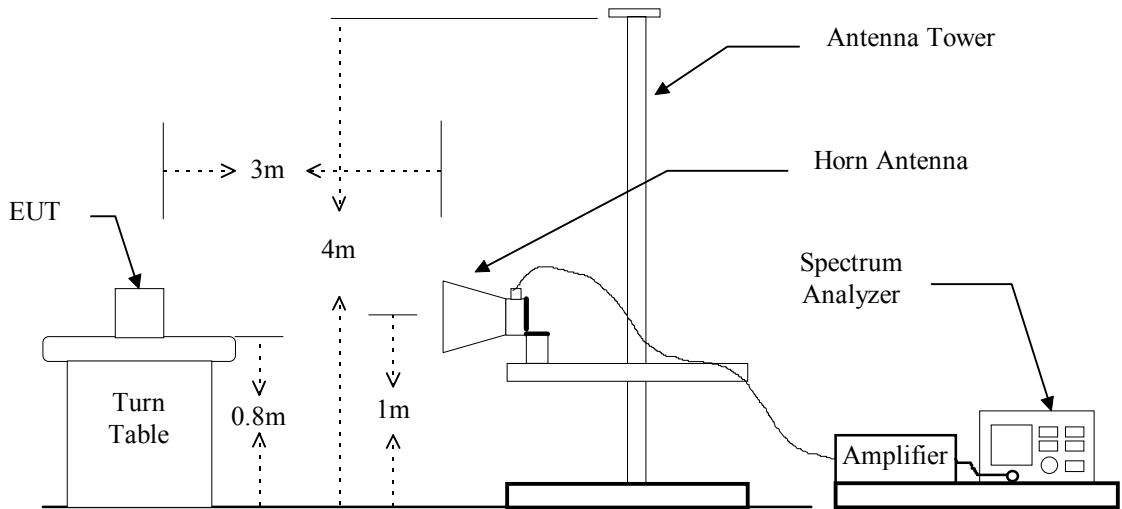


Figure 2 : Frequencies measured above 1 GHz configuration



4.3 Measuring Instrument

The following instrument are used for radiated emissions measurement:

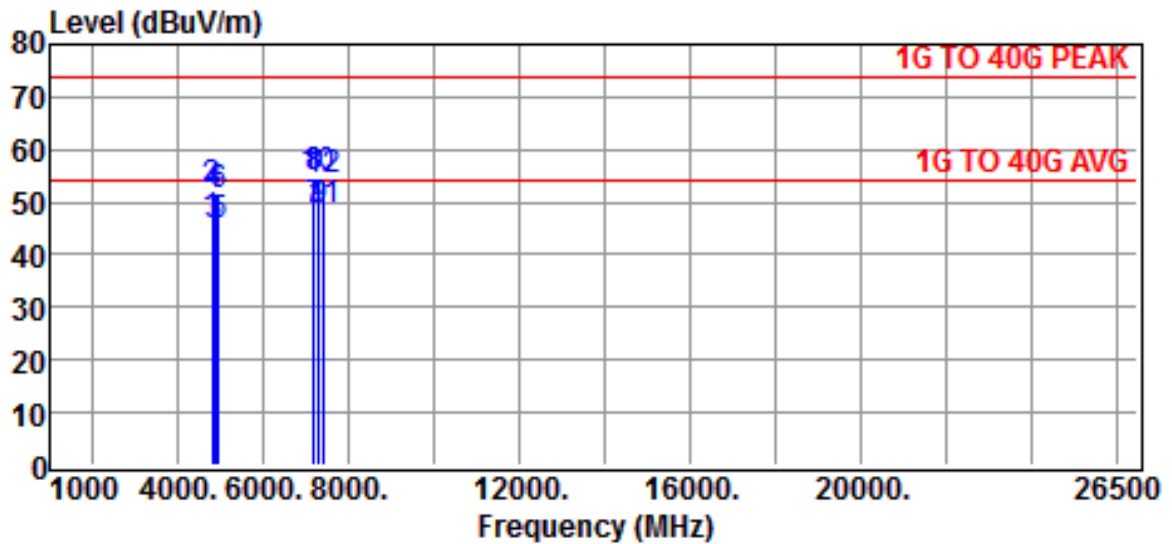
Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
Test Receiver	Rohde & Schwarz	ESVS30	2014/05/29	2015/05/28
EMI Test Receiver	Rohde & Schwarz	ESL	2014/09/26	2015/09/25
Bi-Log Antenna	ETC	MCTD 2756	2014/01/03	2015/01/02
Log-periodic Antenna	EMCO	3146	2013/10/25	2014/10/24
Biconical Antenna	EMCO	3110	2013/10/25	2014/10/24
Double Ridged Antenna	EMCO	3115	2014/08/18	2015/08/17
Amplifier	HP	8449B	2014/08/12	2015/08/11
Amplifier	HP	83051A	2014/05/06	2015/05/05
Amplifier	HP	8447D	2014/08/12	2015/08/11
EMI Test Receiver	Rohde & Schwarz	ESU 40	2014/08/15	2015/08/14

Measuring instrument setup in measured frequency band when specified detector function is used :

Frequency Band (MHz)	Instrument	Function	Resolution bandwidth	Video Bandwidth
30 to 1000	RF Test Receiver	Quasi-Peak	120 kHz	N/A
	Spectrum Analyzer	Peak	100 kHz	100 kHz
Above 1000	Spectrum Analyzer	Peak	1 MHz	1 MHz
	Spectrum Analyzer	Average	1 MHz	10 Hz

4.4 Radiated Emission Data

4.4.1 Harmonics radiated emission

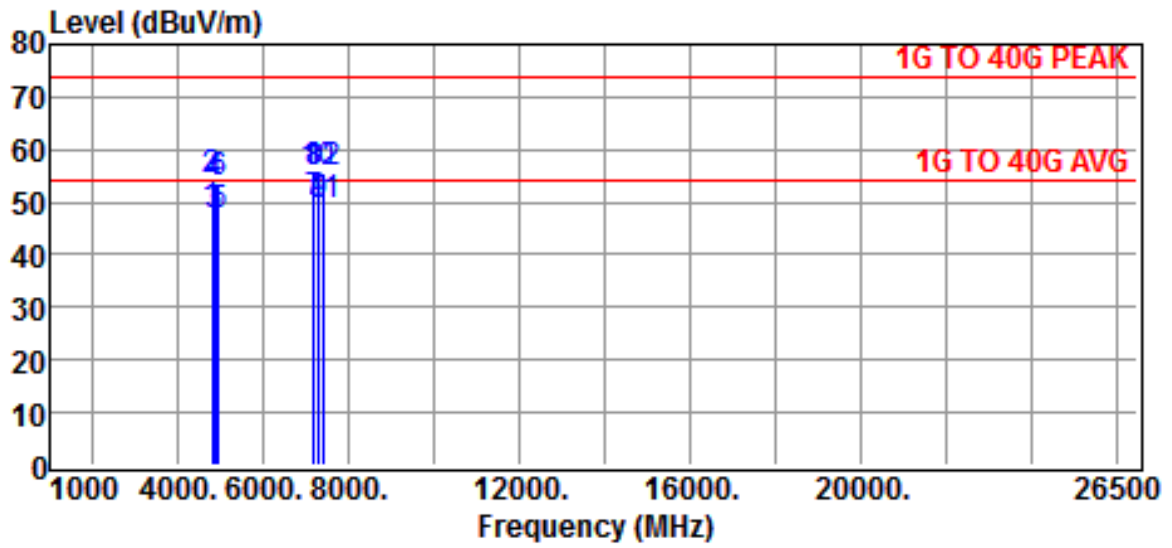


Site :Chamber #2 Date :2014-10-08
 EUT :Camera with Digital Wireless Auto Pair TransmitterAnt. Pol. :HORIZONTAL
 Model :WVCMS130AP Detector :
 Power Rating :DC 12V Engineer :Jiapeng
 Limit :1G TO 40G PEAK Temp. :25° C
 Memo :TXRX-CH LO 2403 - MI 2442 - HI 2478MHz Humi. :65 %

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Detector
4806.0000	44.4	1.4	45.8	54.0	-8.2	Average
4806.0000	50.7	1.4	52.1	74.0	-21.9	Peak
4884.0000	44.1	1.5	45.6	54.0	-8.4	Average
4884.0000	50.3	1.5	51.8	74.0	-22.2	Peak
4956.0000	43.6	1.8	45.4	54.0	-8.6	Average
4956.0000	49.6	1.8	51.4	74.0	-22.6	Peak
7209.0000	42.7	5.7	48.4	54.0	-5.6	Average
7209.0000	48.8	5.7	54.5	74.0	-19.5	Peak
7326.0000	42.5	5.9	48.4	54.0	-5.6	Average
7326.0000	48.6	5.9	54.5	74.0	-19.5	Peak
7434.0000	42.1	6.2	48.3	54.0	-5.7	Average
7434.0000	48.0	6.2	54.2	74.0	-19.8	Peak

Note :

1. Result = Reading + Corrected Factor
2. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
3. The margin value=Limit - Result



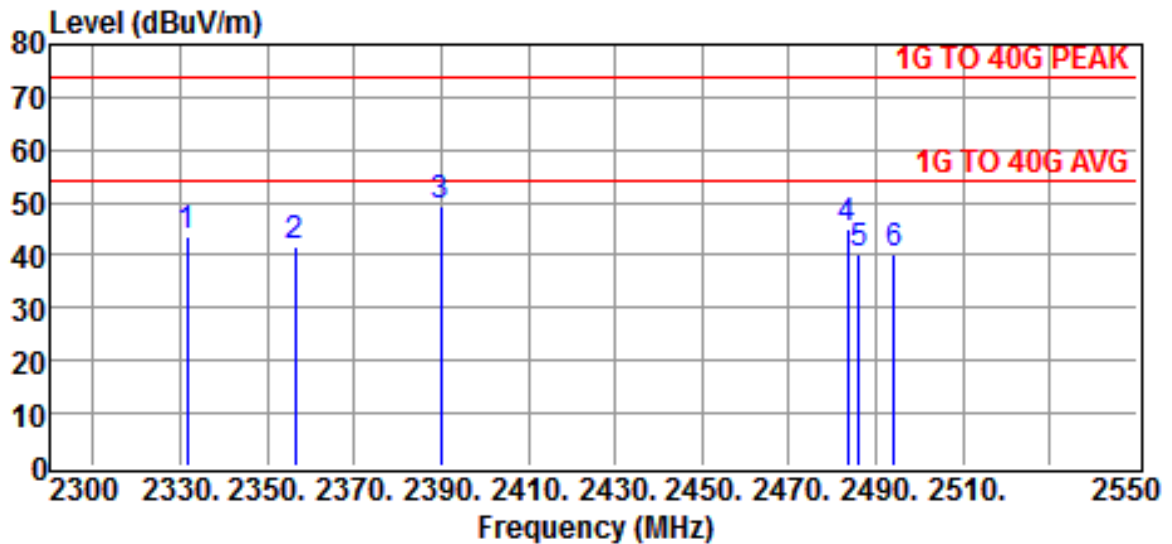
Site :Chamber #2 Date :2014-10-08
 EUT :Camera with Digital Wireless Auto Pair TransmitterAnt. Pol. :VERTICAL
 Model :WVCMS130AP Detector :
 Power Rating :DC 12V Engineer : Jiapeng
 Limit :1G TO 40G PEAK Temp. :25° C
 Memo :TXRX-CH LO 2403 - MI 2442 - HI 2478MHz Humi. :65 %

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Detector
4806.0000	46.4	1.4	47.8	54.0	-6.2	Average
4806.0000	52.6	1.4	54.0	74.0	-20.0	Peak
4884.0000	46.1	1.5	47.6	54.0	-6.4	Average
4884.0000	52.3	1.5	53.8	74.0	-20.2	Peak
4956.0000	45.6	1.8	47.4	54.0	-6.6	Average
4956.0000	51.6	1.8	53.4	74.0	-20.6	Peak
7209.0000	44.1	5.7	49.8	54.0	-4.2	Average
7209.0000	50.0	5.7	55.7	74.0	-18.3	Peak
7326.0000	43.6	5.9	49.5	54.0	-4.5	Average
7326.0000	49.8	5.9	55.7	74.0	-18.3	Peak
7434.0000	43.1	6.2	49.3	54.0	-4.7	Average
7434.0000	49.2	6.2	55.4	74.0	-18.6	Peak

Note :

1. Result = Reading + Corrected Factor
2. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
3. The margin value=Limit - Result

4.4.2 Radiated Emissions in Restricted Bands

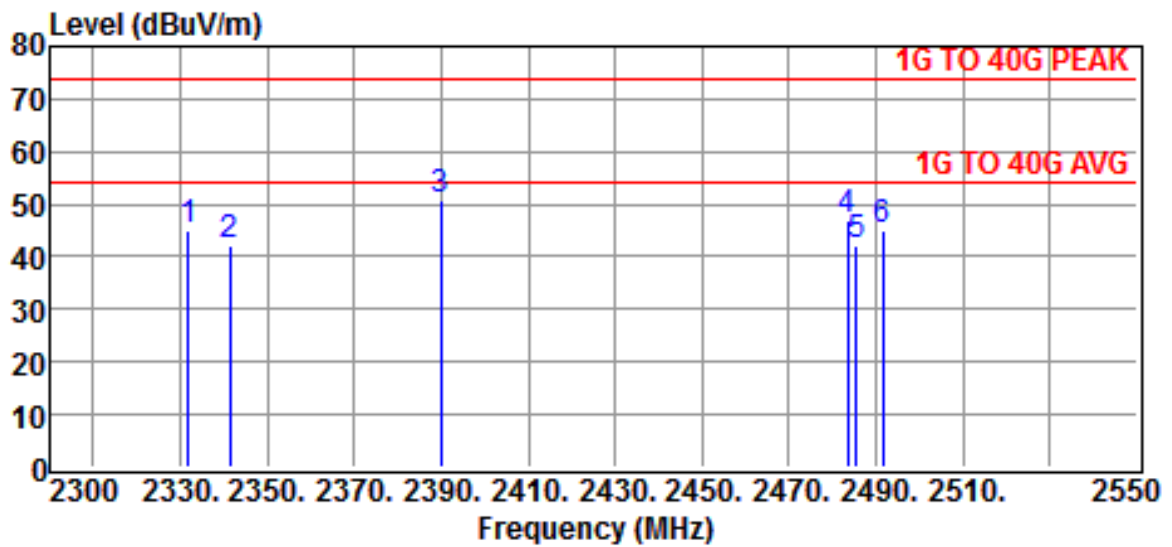


Site	:Chamber #2	Date	:2014-10-08
EUT	:Camera with Digital Wireless Auto Pair Transmitter	Ant. Pol.	:HORIZONTAL
Model	:WVCMS130AP	Detector	:
Power Rating	:DC 12V	Engineer	:Jiapeng
Limit	:1G TO 40G PEAK	Temp.	:25 °C
Memo	:CH LO & HI - Restricted Bands	Humi.	:65 %

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Detector
2331.5000	49.4	-5.9	43.5	74.0	-30.5	Peak
2356.5000	47.6	-5.8	41.8	74.0	-32.2	Peak
2390.0000	55.1	-5.6	49.5	74.0	-24.5	Peak
2483.5000	50.6	-5.4	45.2	74.0	-28.8	Peak
2486.0000	45.7	-5.4	40.3	74.0	-33.7	Peak
2494.0000	45.8	-5.4	40.4	74.0	-33.6	Peak

Note :

1. Result = Reading + Corrected Factor
2. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
3. The margin value=Limit – Result
4. Peak measurements are compared to the average limit - as peak measurements are below the average limit, they also comply with the peak limit.



Site	:Chamber #2	Date	:2014-10-08
EUT	:Camera with Digital Wireless Auto Pair Transmitter	Ant. Pol.	:VERTICAL
Model	:WVCMS130AP	Detector	:
Power Rating	:DC 12V	Engineer	: Jiapeng
Limit	:1G TO 40G PEAK	Temp.	:25 °C
Memo	:CH LO & HI - Restricted Bands	Humi.	:65 %

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Detector
2332.0000	50.8	-5.9	44.9	74.0	-29.1	Peak
2341.5000	48.3	-5.9	42.4	74.0	-31.6	Peak
2390.0000	56.3	-5.6	50.7	74.0	-23.3	Peak
2483.5000	52.2	-5.4	46.8	74.0	-27.2	Peak
2485.5000	47.7	-5.4	42.3	74.0	-31.7	Peak
2491.5000	50.5	-5.4	45.1	74.0	-28.9	Peak

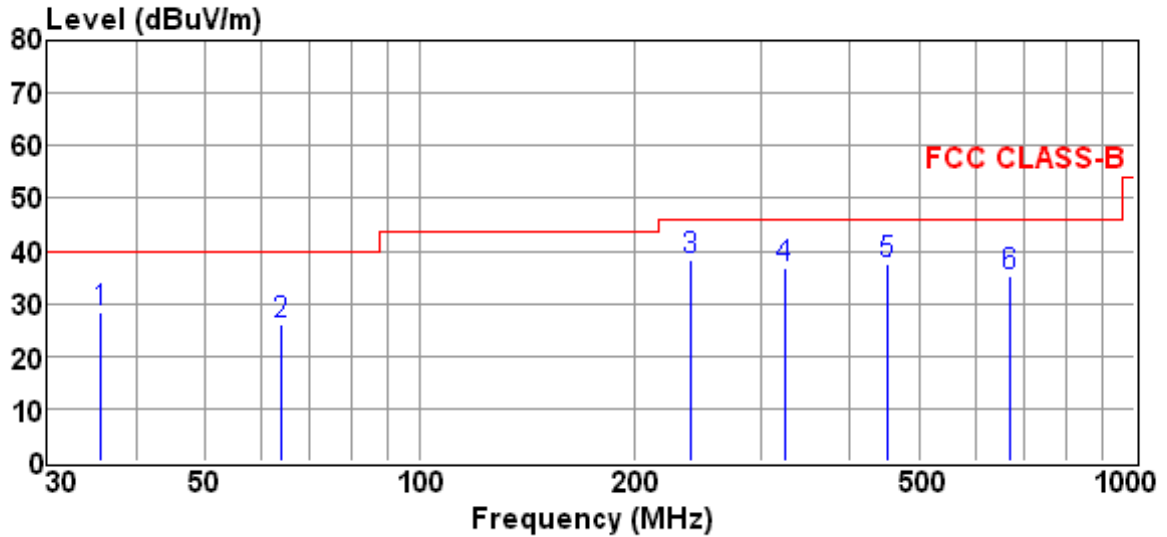
Note :

1. Result = Reading + Corrected Factor
2. Corrected Factor = Antenna Factor + Cable Loss - Amplifier Gain (if any)
3. The margin value=Limit - Result
4. Peak measurements are compared to the average limit - as peak measurements are below the average limit, they also comply with the peak limit.

4.4.3 Other Spurious Emissions

a) Emission frequencies below 1 GHz

Test Date : Oct. 06, 2014 Temperature : 25 °C Humidity : 65 %



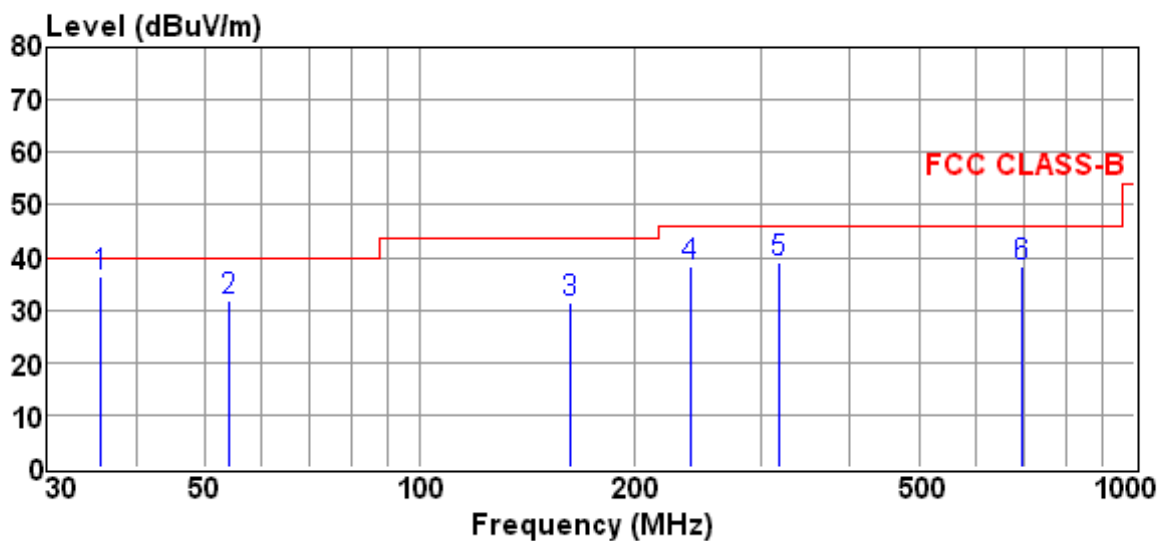
Site	:Open site #2	Date	:2014-10-06
EUT	:Camera with Digital Wireless Auto Pair Transmitter	Ant. Pol.	:HORIZONTAL
Model	:WVCMS130AP	Detector	:
Power Rating	:DC 12V	Engineer	: Jiapeng
Limit	:FCC CLASS-B	Temp.	:25 °C
Memo	:OPERATION MODE	Humi.	:65 %

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Remark dB
35.8200	14.05	14.35	28.40	40.00	-11.60	QP
63.9500	14.83	11.07	25.90	40.00	-14.10	QP
239.5200	24.46	13.74	38.20	46.00	-7.80	QP
323.9100	18.97	17.63	36.60	46.00	-9.40	QP
450.0100	17.26	20.34	37.60	46.00	-8.40	QP
670.2000	10.75	24.45	35.20	46.00	-10.80	QP

Note :

1. Result = Reading + Corrected Factor
2. Corrected Factor = Antenna Factor + Cable Loss
3. The margin value=Limit - Result

Test Date : Oct. 06, 2014 Temperature : 25 °C Humidity : 65 %



Site	:Open site #2	Date	:2014-10-06
EUT	:Camera with Digital Wireless Auto Pair Transmitter	Ant. Pol.	:VERTICAL
Model	:WVCMS130AP	Detector	:
Power Rating	:DC 12V	Engineer	: Jiapeng
Limit	:FCC CLASS-B	Temp.	:25 °C
Memo	:OPERATION MODE	Humi.	:65 %

Freq MHz	Reading dBuV	Correction Factor dB	Result dBuV/m	Limits dBuV/m	Over limit dB	Remark dB
35.8200	22.05	14.35	36.40	40.00	-3.60	QP
53.9980	19.80	11.80	31.60	40.00	-8.40	QP
161.9200	17.15	14.25	31.40	43.50	-12.10	QP
239.5200	24.56	13.74	38.30	46.00	-7.70	QP
317.1200	21.32	17.58	38.90	46.00	-7.10	QP
697.3600	13.21	25.09	38.30	46.00	-7.70	QP

Note :

1. Result = Reading + Corrected Factor
2. Corrected Factor = Antenna Factor + Cable Loss
3. The margin value=Limit - Result

b) Emission frequencies above 1 GHz

Radiated emission frequencies above 1 GHz to 25 GHz were too low to be measured with a pre-amplifier of 35 dB.

4.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor, High Pass Filter Loss (if used) and Cable Loss, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation calculation is as follows:

$$\mathbf{Result = Reading + Corrected Factor}$$

where Corrected Factor

$$= \text{Antenna FACTOR} + \text{Cable Loss} + \text{High Pass Filter Loss} - \text{Amplifier Gain}$$

4.6 Photos of Radiation Measuring Setup



5 CONDUCTED EMISSION MEASUREMENT

5.1 Standard Applicable

This EUT is excused from investigation of conducted emission, for it is powered by DC battery only. According to §15.207 (d), measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines.

6 ANTENNA REQUIREMENT

6.1 Standard Applicable

For intentional device, 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.

6.2 Antenna Construction

The antenna is a 2.0 dBi gain omni-directional antenna with reverse SMA connector. Please see photos and antenna specifications submitted in Exhibits.

7 HOPPING CHANNEL SEPARATION

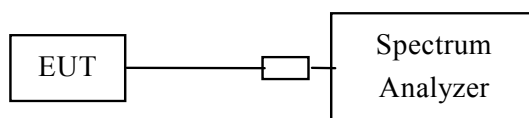
7.1 Standard Applicable

According to 15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

7.2 Measurement 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 figure 4 without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. The EUT must have its hopping function enabled. Then set it to any one convenient frequency within its operating range.
3. Use the following spectrum analyzer settings:
 - Span = wide enough to capture the peaks of two adjacent channels
 - Resolution (or IF) Bandwidth (RBW) $\geq 1\%$ of the span
 - Video (or Average) Bandwidth (VBW) \geq RBW
 - Sweep = auto
 - Detector function = peak
 - Trace = max hold
4. Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Plot the result on the screen of spectrum analyzer.
5. Repeat above procedures until all frequencies measured were complete.

Figure 4 : Measurement configuration.



7.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
EMI Test Receiver	Rohde & Schwarz	ESU 40	2014/08/15	2015/08/14
Attenuator	Weinschel Engineering	1	N/A	N/A

7.4 Measurement Data

Test Date : Oct. 08, 2014 Temperature : 25 °C Humidity : 65 %

- a) Channel Low : Adjacent Hopping Channel Separation is 3.000 MHz
- b) Channel Middle : Adjacent Hopping Channel Separation is 3.000 MHz
- c) Channel High : Adjacent Hopping Channel Separation is 3.000 MHz

Note : The expanded uncertainty: frequency $\times 1.65 \times 10^{-6}$ ($1 \text{ GHz} < f \leq 18 \text{ GHz}$).

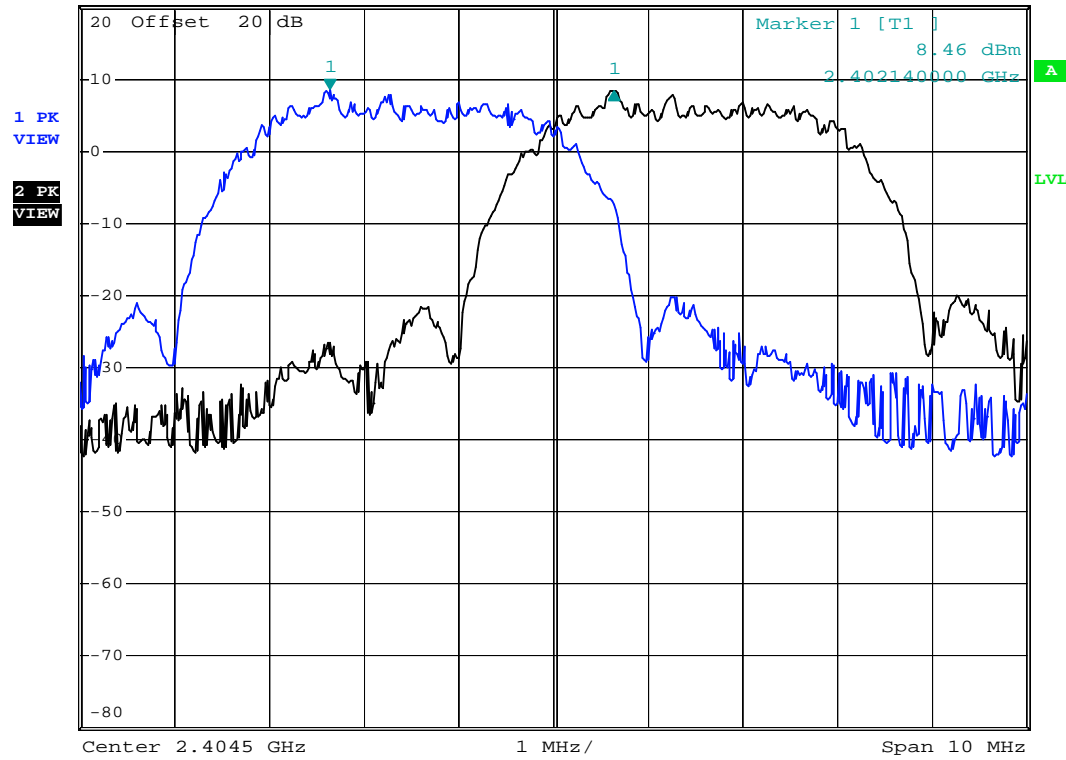
Test Mode: Channel Low



*RBW 100 kHz Delta 1 [T2]
*VBW 300 kHz -0.14 dB
SWT 2.5 ms 3.000000000 MHz

Ref 20 dBm

Att 30 dB



Date: 8.OCT.2014 10:31:56

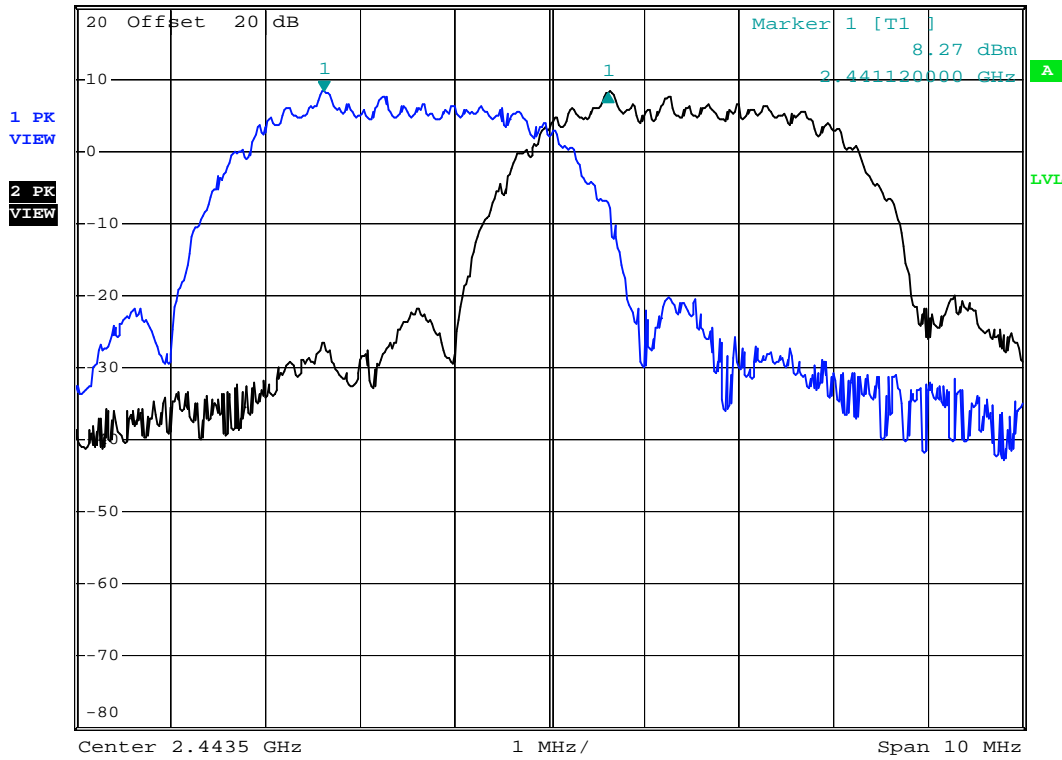
Test Mode: Channel Middle



*RBW 100 kHz Delta 1 [T2]
VBW 300 kHz -0.16 dB
SWT 2.5 ms 3.000000000 MHz

Ref 20 dBm

Att 30 dB



Date: 8.OCT.2014 10:40:53

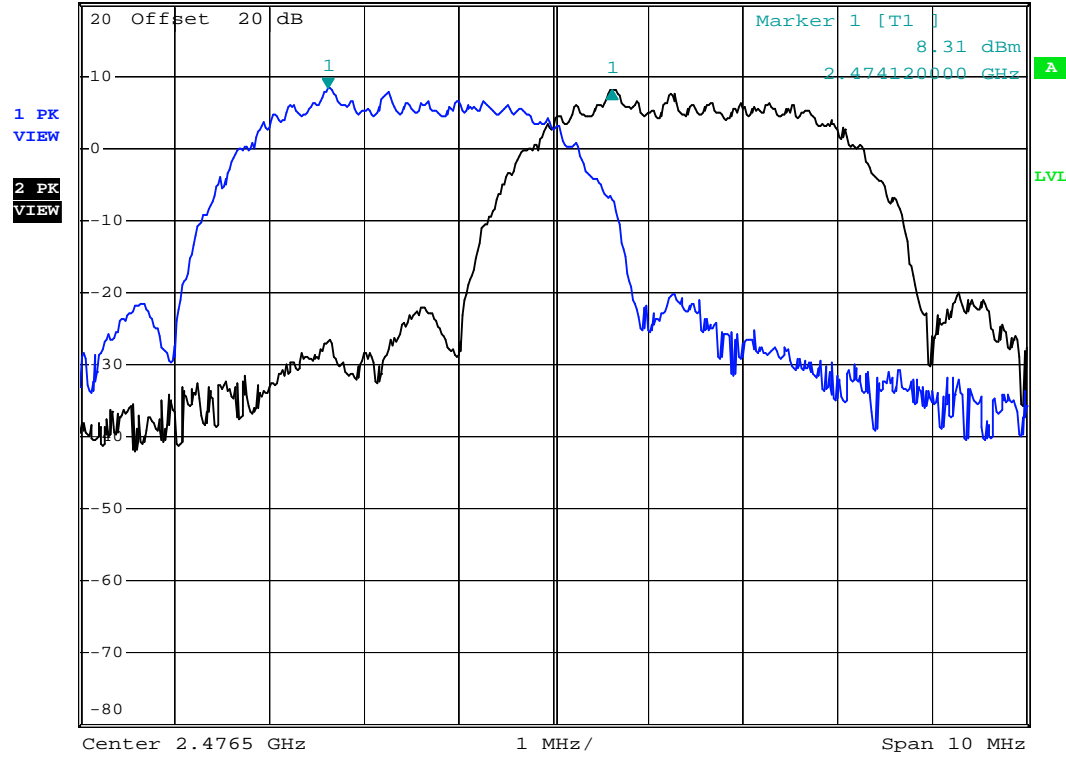
Test Mode: Channel High



*RBW 100 kHz Delta 1 [T2]
VBW 300 kHz -0.22 dB
SWT 2.5 ms 3.000000000 MHz

Ref 20 dBm

Att 30 dB



Date: 8.OCT.2014 10:51:34

8 NUMBER OF HOPPING FREQUENCY USED

8.1 Standard Applicable

According to 15.247(a)(1)(iii), frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.

8.2 Measurement 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 figure 4 without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. The EUT must have its hopping function enabled.
3. Use the following spectrum analyzer settings:
 - Span = the frequency band of operation
 - RBW \geq 1% of the span
 - VBW \geq RBW
 - Sweep = auto
 - Detector function = peak
 - Trace = max hold
4. Allow the trace to stabilize. Plot the result on the screen of spectrum analyzer.
5. Repeat above procedures until all frequencies measured were complete.

8.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
EMI Test Receiver	Rohde & Schwarz	ESU 40	2014/08/15	2015/08/14
Attenuator	Weinschel Engineering	1	N/A	N/A

8.4 Measurement Data

Test Date : Oct. 08, 2014 Temperature : 25 °C Humidity : 65 %

There are 26 hopping frequencies used.

Note : The expanded uncertainty: frequency $\times 1.65 \times 10^{-6}$ (1 GHz $< f \leq 18$ GHz).

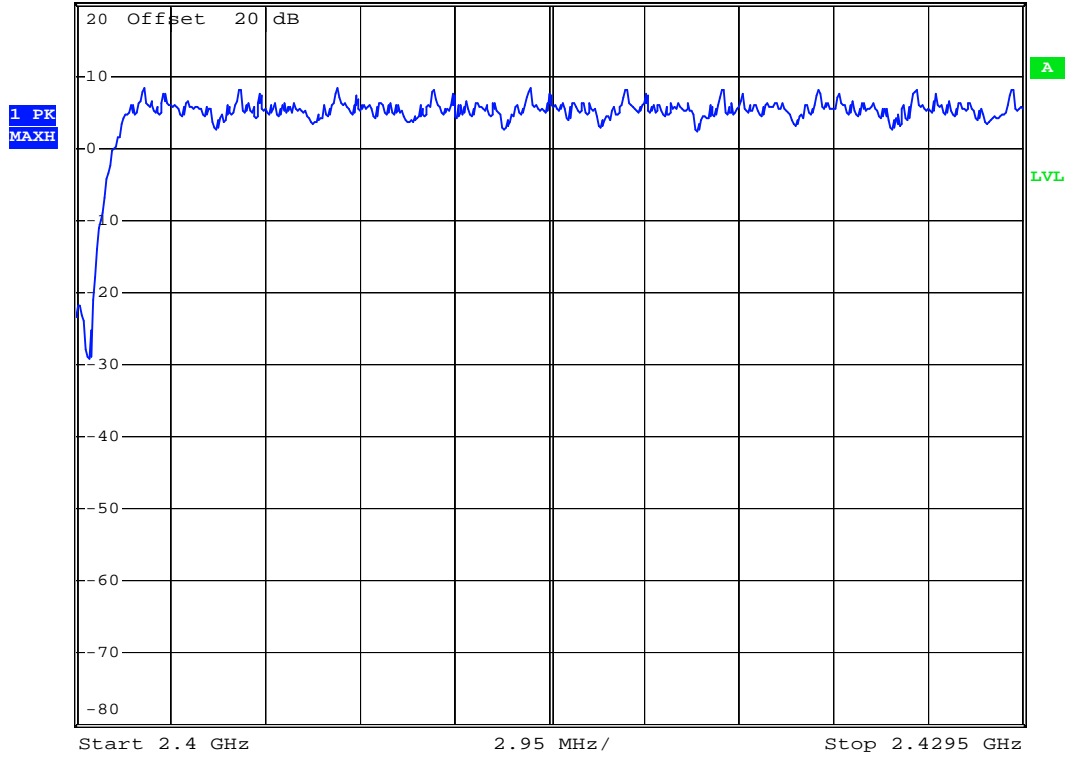
Test Mode: Channel Low



*RBW 100 kHz
VBW 300 kHz
SWT 5 ms

Ref 20 dBm

*Att 10 dB



Date: 8.OCT.2014 11:02:50

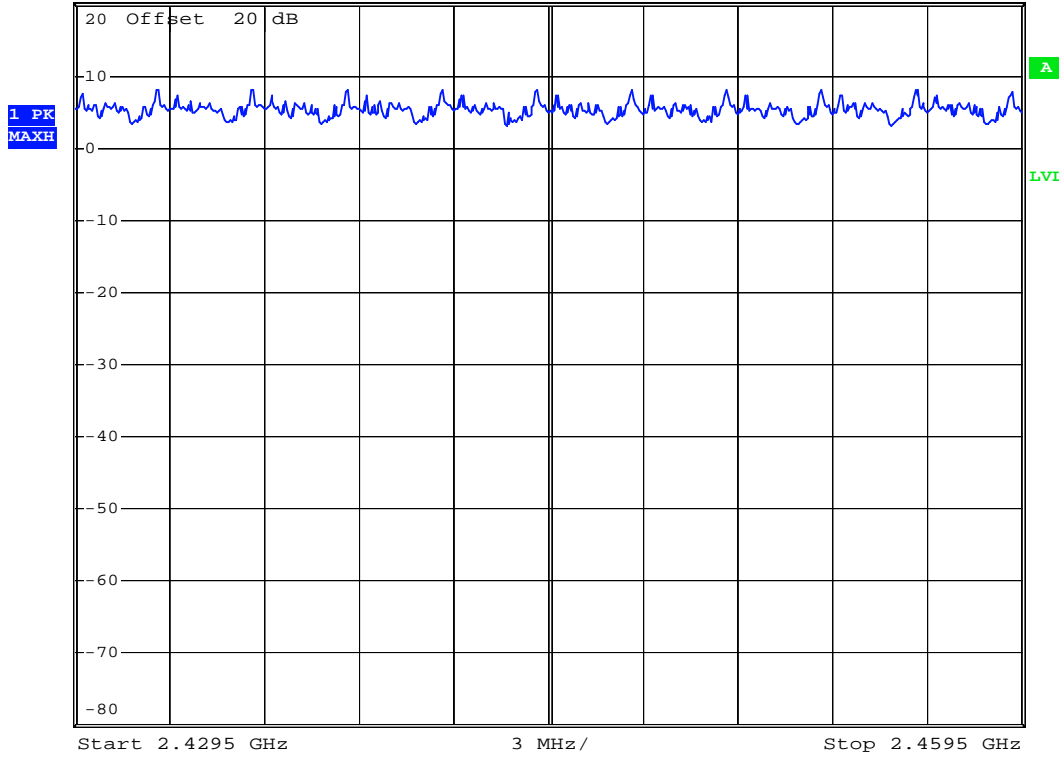
Test Mode: Channel Middle



*RBW 100 kHz
VBW 300 kHz
SWT 5 ms

Ref 20 dBm

*Att 10 dB



Date: 8.OCT.2014 11:06:20

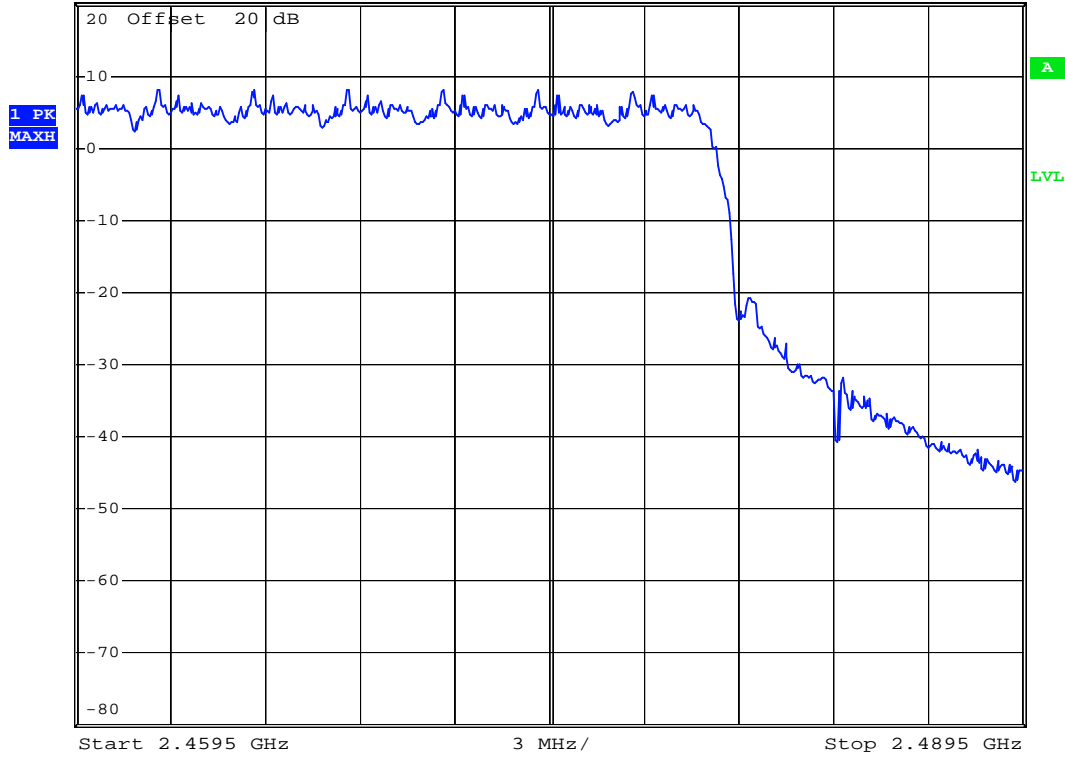
Test Mode: Channel High



*RBW 100 kHz
VBW 300 kHz
SWT 5 ms

Ref 20 dBm

*Att 10 dB



Date: 8.OCT.2014 11:08:45

9 CHANNEL BANDWIDTH

9.1 Standard Applicable

For frequency hopping system operating in the 2400–2483.5 MHz band, there is no requirement for the maximum 20dB bandwidth of the hopping channel. The measurement of the hopping channel bandwidth is for the reference of the hopping channel separation requirement.

9.2 Measurement 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 figure 4 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. Use the following spectrum analyzer settings:
 - Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
 - RBW \geq 1% of the 20 dB bandwidth
 - VBW \geq RBW
 - Sweep = auto
 - Detector function = peak
 - Trace = max hold
4. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. Use the marker-delta function to measure 20 dB down one side of the emission. Reset the marker-delta function, and move the marker to the other side of the emission, until it is (as close as possible to) even with the reference marker level. The marker-delta reading at this point is the 20 dB bandwidth of the emission. Plot the result on the screen of spectrum analyzer.
5. Repeat above procedures until all frequencies measured were complete.

9.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
EMI Test Receiver	Rohde & Schwarz	ESU 40	2014/08/15	2015/08/14
Attenuator	Weinschel Engineering	1	N/A	N/A

9.4 Measurement Data

Test Date : Oct. 08, 2014 Temperature : 25 °C Humidity : 65 %

- a) Channel Low : Channel Bandwidth is 4.500 MHz
- b) Channel Middle : Channel Bandwidth is 4.500 MHz
- c) Channel High : Channel Bandwidth is 4.500 MHz

Note : The expanded uncertainty: frequency $\times 1.65 \times 10^{-6}$ ($1 \text{ GHz} < f \leq 18 \text{ GHz}$).

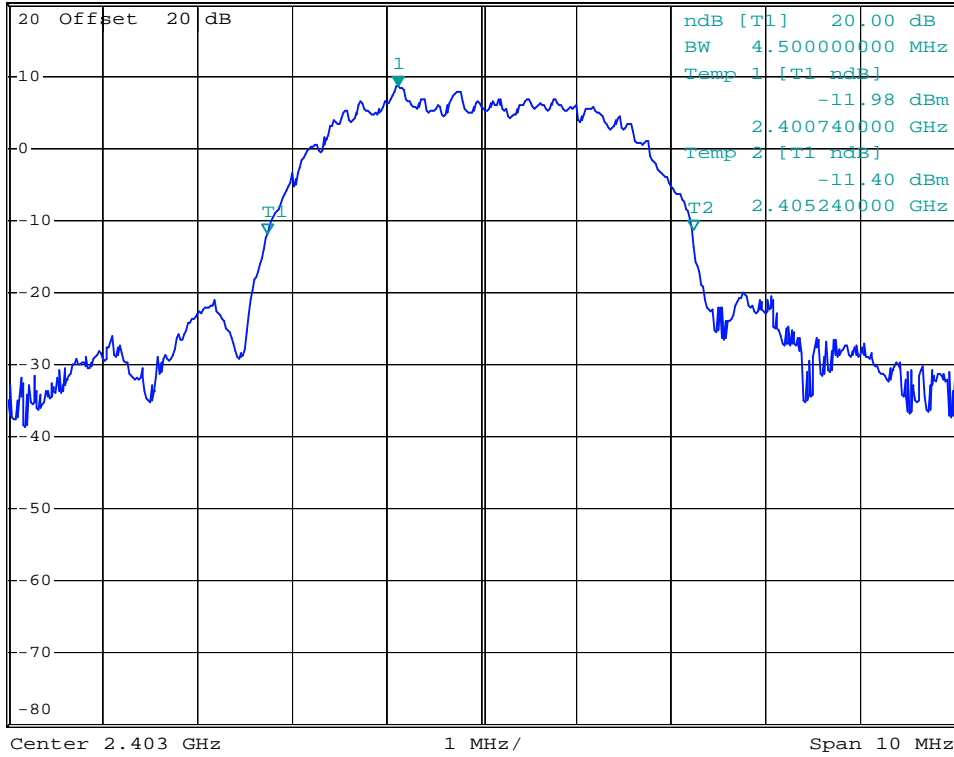
Test Mode: Channel Low



*RBW 100 kHz Marker 1 [T1]
*VBW 300 kHz 8.55 dBm
SWT 2.5 ms 2.402120000 GHz

Ref 20 dBm

Att 30 dB



Date: 8.OCT.2014 10:29:19

Test Mode: Channel Middle

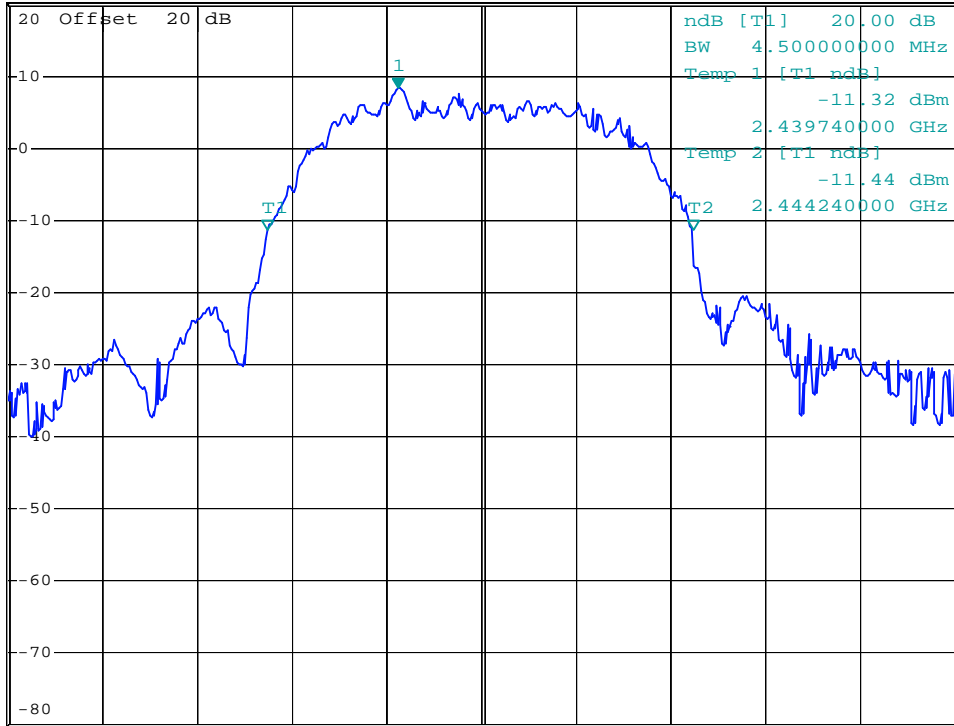


*RBW 100 kHz Marker 1 [T1]
VBW 300 kHz 8.31 dBm
SWT 2.5 ms 2.441120000 GHz

Ref 20 dBm

Att 30 dB

1 PK
VIEW



Center 2.442 GHz

1 MHz/

Span 10 MHz

Date: 8.OCT.2014 10:39:39

Test Mode: Channel High

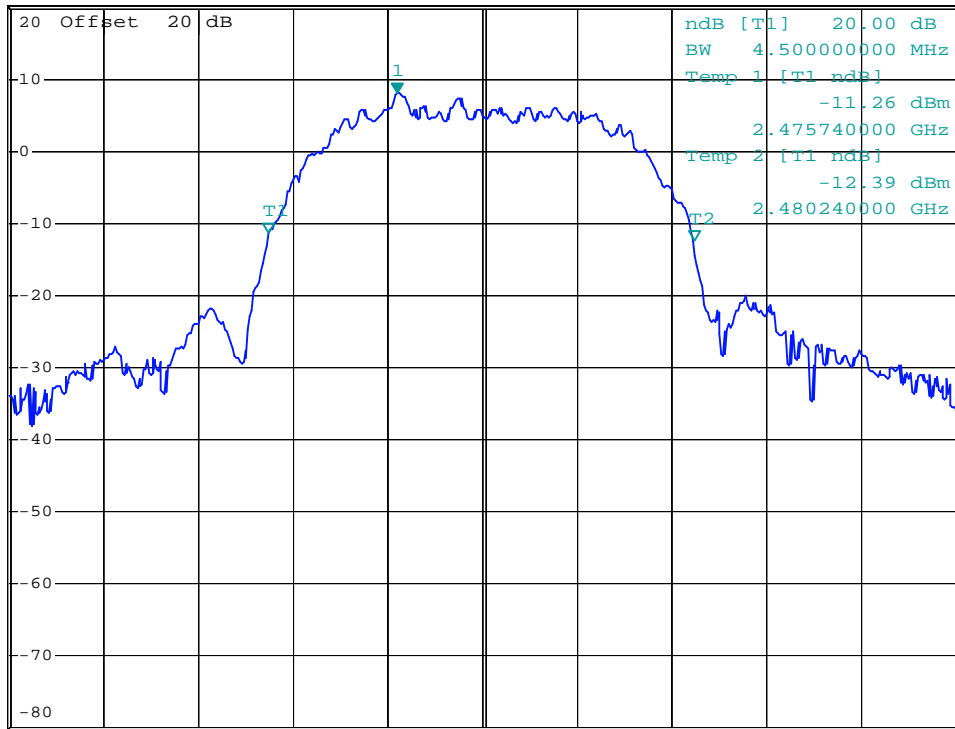


*RBW 100 kHz Marker 1 [T1]
VBW 300 kHz 7.93 dBm
SWT 2.5 ms 2.477100000 GHz

Ref 20 dBm

Att 30 dB

1 PK
VIEW



Center 2.478 GHz

1 MHz/

Span 10 MHz

Date: 8.OCT.2014 10:48:29

10 DWELL TIME ON EACH CHANNEL

10.1 Standard Applicable

According to 15.247(a)(1)(iii), for frequency hopping system operating in the 2400-2483.5 band, 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.

10.2 Measurement 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 figure 4 without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. The EUT must have its hopping function enabled.
3. Use the following spectrum analyzer settings:
 - Span = zero span, centered on a hopping channel
 - RBW = 1 MHz
 - VBW \geq RBW
 - Sweep = as necessary to capture the entire dwell time per hopping channel
 - Detector function = peak
 - Trace = max hold
4. Use the marker-delta function to determine the dwell time. Plot the result on the screen of spectrum analyzer.
5. Repeat above procedures until all frequencies measured were complete.

10.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
EMI Test Receiver	Rohde & Schwarz	ESU 40	2014/08/15	2015/08/14
Attenuator	Weinschel Engineering	1	N/A	N/A

10.4 Measurement Data

Test Date : Nov. 04, 2014 Temperature : 25 °C Humidity : 65 %

Period = 0.4(seconds) x 26(channels) = 10.4 seconds

a) Test Channel : Low (2403MHz)

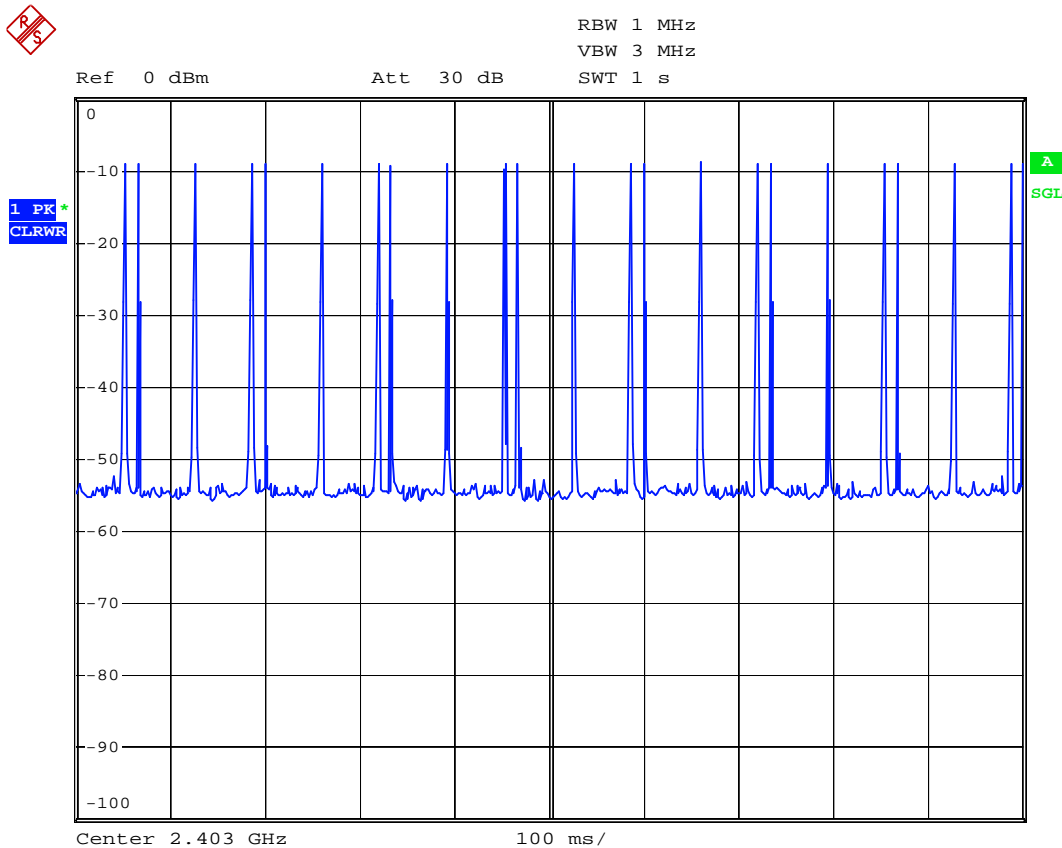
The pulse tran components:

The maximum time of occupancy = $[(0.24\text{ms} \times 23)] \times 10.4 = 57.408 \text{ ms}$

The maximum time of occupancy for a particular channel is 57.408 ms in any 10.4 second period, which is less than the 400 ms allowed by the rules; therefore, it meets the requirements of this section.

Note : The expanded uncertainty of dwell time on each channel tests is 2dB.

Pulses within 1 second

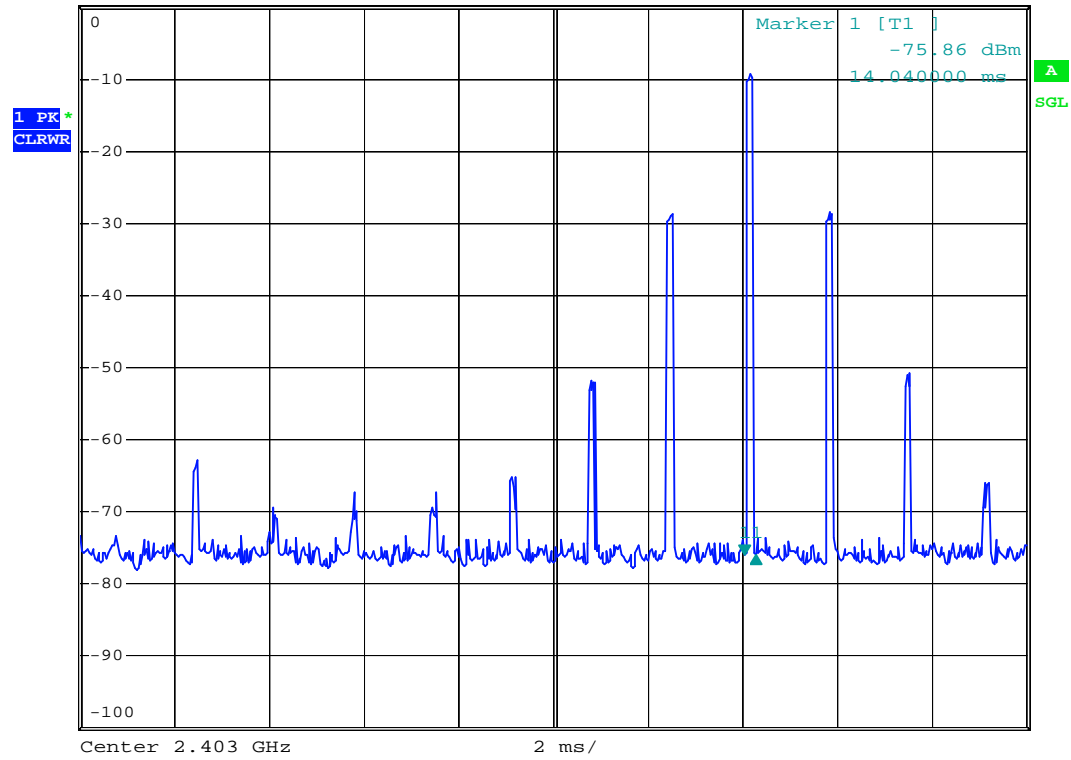


Date: 4.NOV.2014 17:56:04

Single pulse



RBW 1 MHz Delta 1 [T1]
VBW 3 MHz -0.22 dB
SWT 20 ms 240.000000 μ s
Ref 0 dBm *Att 10 dB



Date: 8.OCT.2014 12:09:47

11 OUTPUT POWER MEASUREMENT

11.1 Standard Applicable

According to 15.247(b)(1), for frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

11.2 Measurement 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 figure 4 without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
3. Use the following spectrum analyzer settings:
 - Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel
 - RBW > the 20 dB bandwidth of the emission being measured
 - VBW ≥ RBW
 - Sweep = auto
 - Detector function = peak
 - Trace = max hold
4. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power. Plot the result on the screen of spectrum analyzer.
5. Repeat above procedures until all frequencies measured were complete.

11.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
EMI Test Receiver	Rohde & Schwarz	ESU 40	2014/08/15	2015/08/14
Attenuator	Weinschel Engineering	1	N/A	N/A

11.4 Measurement Data

Test Date : Oct. 08, 2014 Temperature : 25 °C Humidity : 65 %

- a) Channel Low : Output Peak Power is 16.46 dBm = **44.259** mW
- b) Channel Middle : Output Peak Power is 16.00 dBm = **39.811** mW
- c) Channel High : Output Peak Power is 15.51 dBm = **35.563** mW

Note : The expanded uncertainty: 2dB.

Test Mode: Channel Low

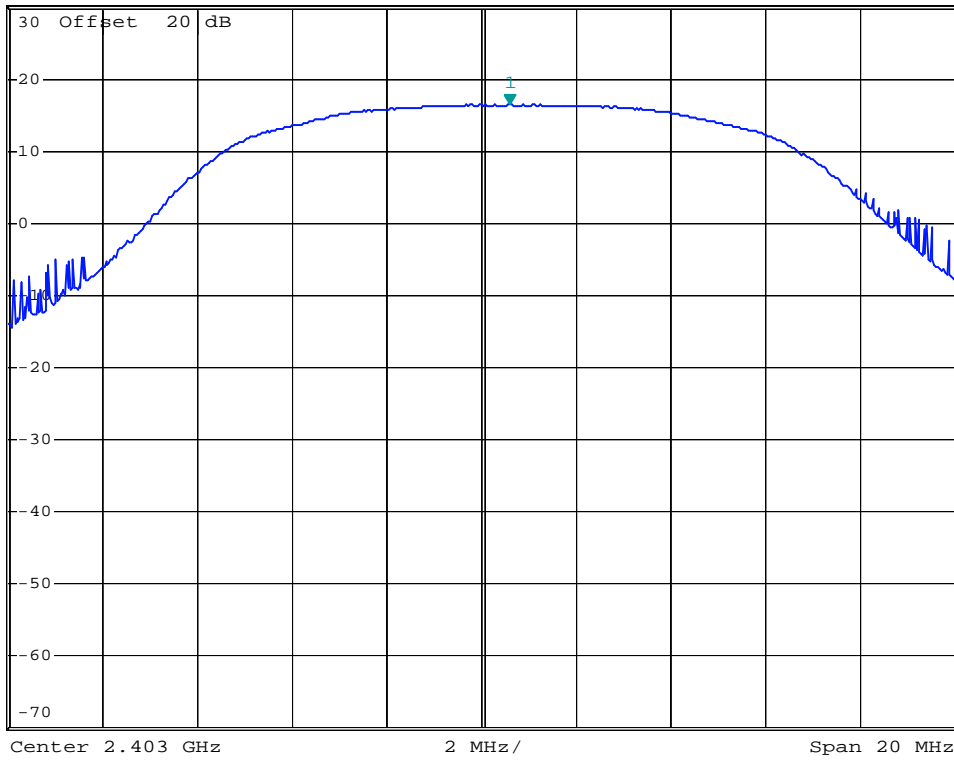


*RBW 10 MHz Marker 1 [T1]
VBW 10 MHz 16.46 dBm
SWT 2.5 ms 2.403600000 GHz

Ref 30 dBm

Att 40 dB

1 PK
VIEW



Date: 8.OCT.2014 10:28:17

Test Mode: Channel Middle

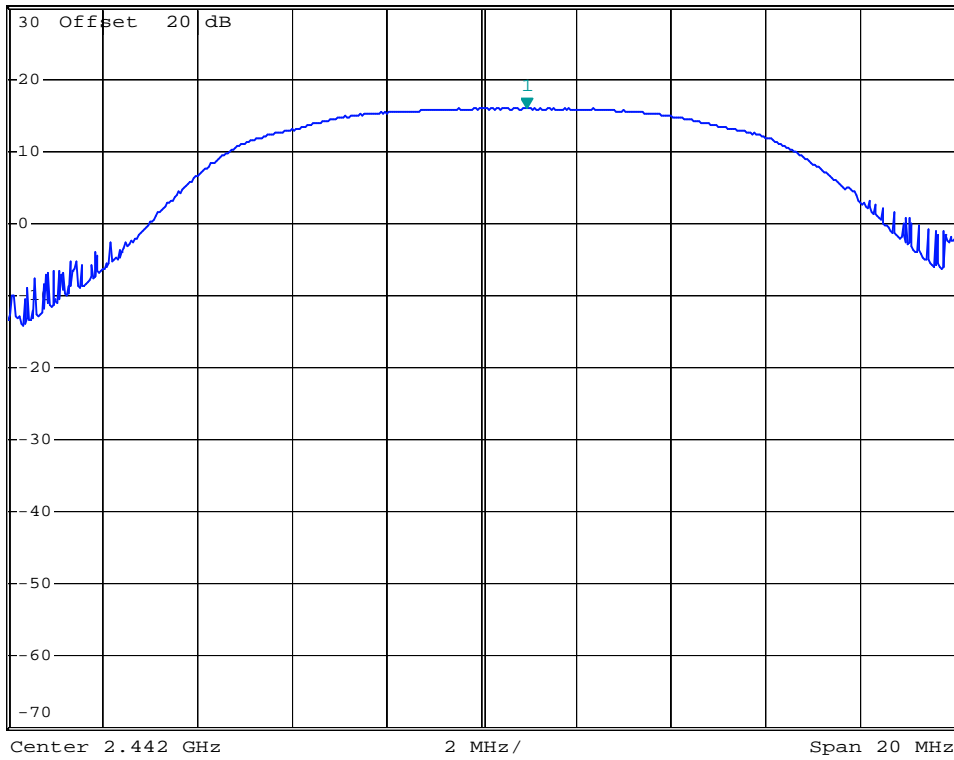


*RBW 10 MHz Marker 1 [T1]
VBW 10 MHz 16.00 dBm
SWT 2.5 ms 2.442960000 GHz

Ref 30 dBm

Att 40 dB

1 PK
VIEW



Date: 8.OCT.2014 10:39:06

Test Mode: Channel High

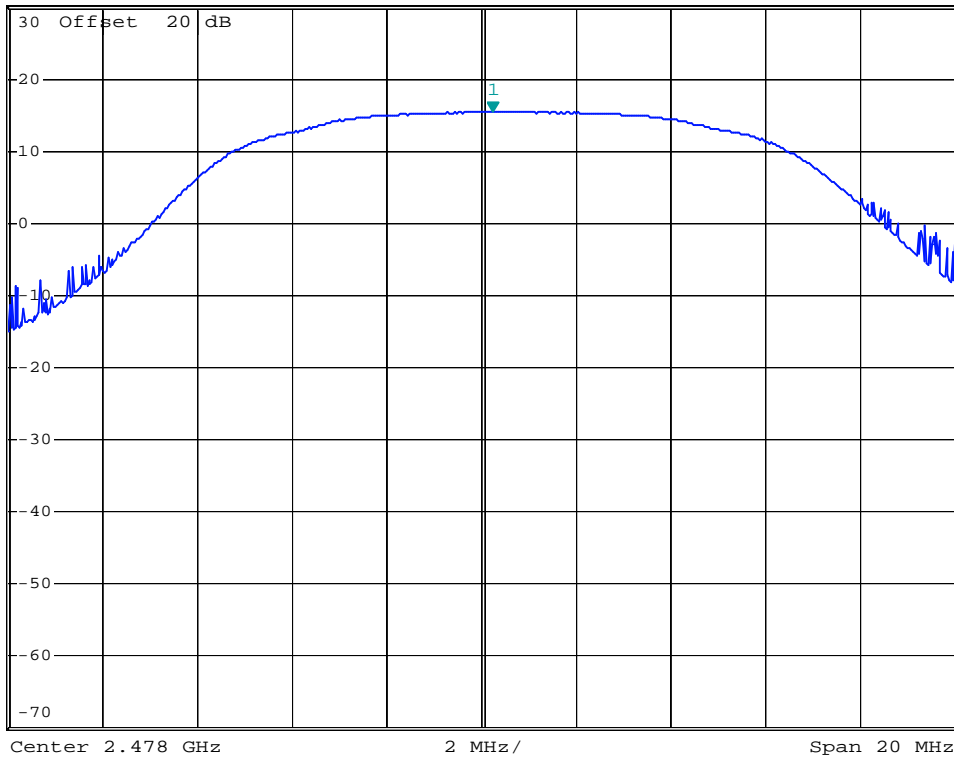


*RBW 10 MHz Marker 1 [T1]
VBW 10 MHz 15.51 dBm
SWT 2.5 ms 2.478240000 GHz

Ref 30 dBm

Att 40 dB

1 PK
VIEW



Date: 8.OCT.2014 10:46:54

12 100 kHz BANDWIDTH OF BAND EDGES MEASUREMENT

12.1 Standard Applicable

According to 15.247(d), in any 100 kHz 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 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided 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 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required.

12.2 Measurement 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 figure 4 without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
3. Use the following spectrum analyzer settings:
 - Span = wide enough to capture the peak level of the emission operating on the channel closest to the bandedge, as well as any modulation products which fall outside of the authorized band of operation
 - RBW \geq 1% of the span
 - VBW \geq RBW
 - Sweep = auto
 - Detector function = peak
 - Trace = max hold
4. Allow the trace to stabilize. Set the marker on the emission at the bandedge, or on the highest modulation product outside of the band, if this level is greater than that at the bandedge. Enable the marker-delta function, then use the marker-to-peak function to move the marker to the peak of the in-band emission. Plot the result on the screen of spectrum analyzer.
5. Repeat above procedures until all measured frequencies were complete.

12.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
EMI Test Receiver	Rohde & Schwarz	ESU 40	2014/08/15	2015/08/14
Attenuator	Weinschel Engineering	1	N/A	N/A

12.4 Measurement Data

Test Date : Oct. 08, 2014 Temperature : 25 °C Humidity : 65 %

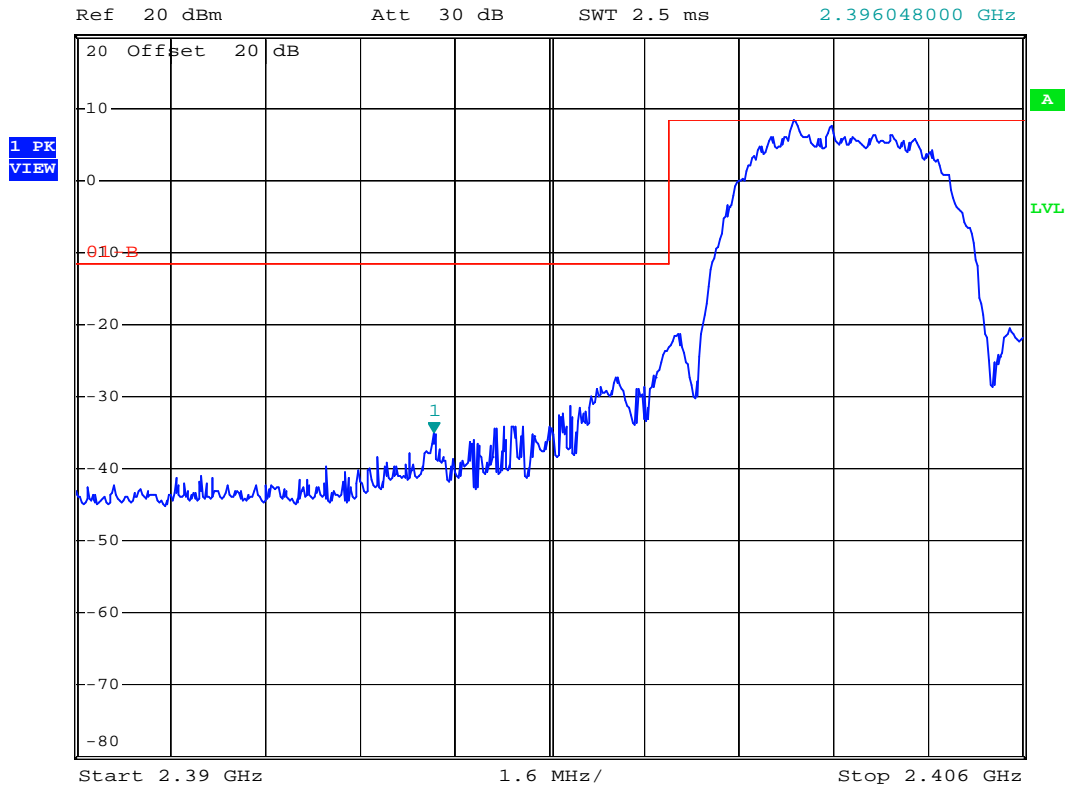
- a) Lower Band Edge : All emissions in this 100kHz bandwidth are attenuated more than 20dB from the carrier.
- b) Upper Band Edge : All emissions in this 100kHz bandwidth are attenuated more than 20dB from the carrier.

Note : The expanded uncertainty: 2dB.

Lower Band Edge (Hopping off)



*RBW 100 kHz Marker 1 [T1]
*VBW 300 kHz -35.00 dBm
SWT 2.5 ms 2.396048000 GHz

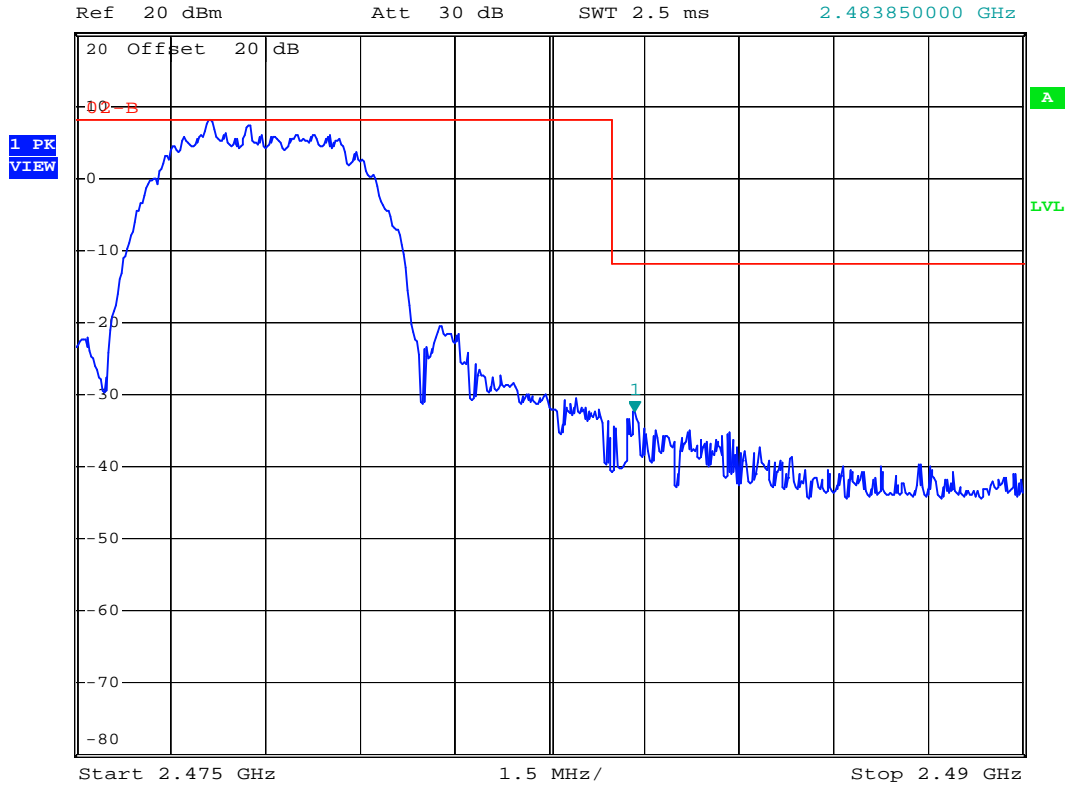


Date: 8.OCT.2014 10:35:27

Upper Band Edge (Hopping off)



*RBW 100 kHz Marker 1 [T1]
VBW 300 kHz -32.46 dBm
SWT 2.5 ms 2.483850000 GHz



Date: 8.OCT.2014 10:45:30

Lower Band Edge (Hopping on)

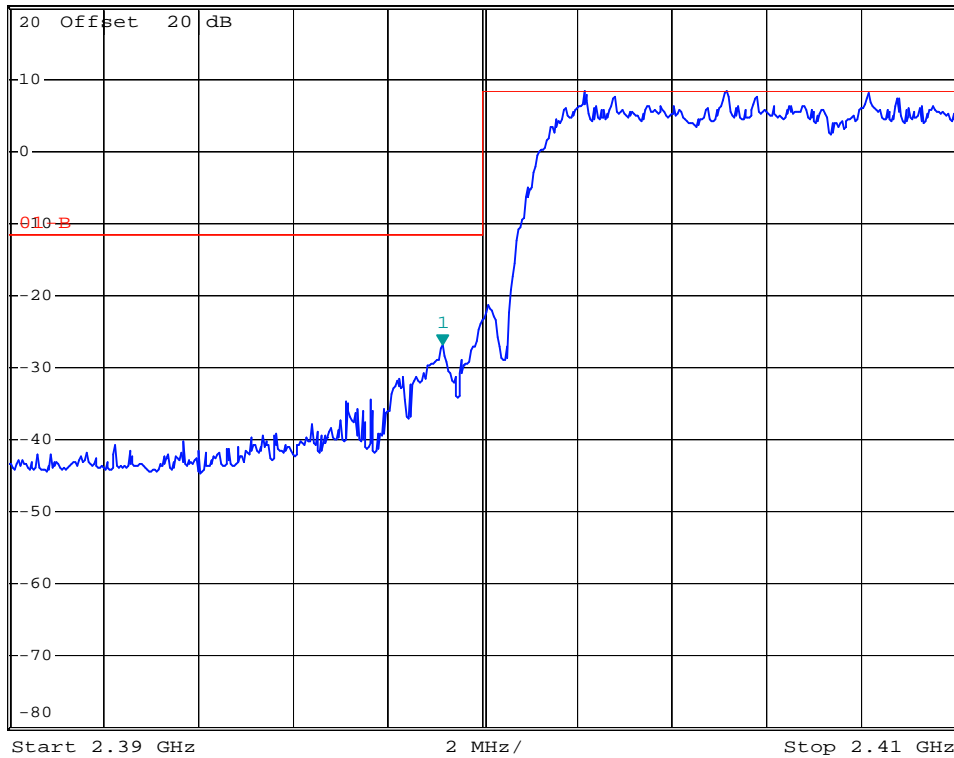


*RBW 100 kHz Marker 1 [T1]
*VBW 300 kHz -26.91 dBm
SWT 2.5 ms 2.399160000 GHz

Ref 20 dBm

Att 30 dB

1 PK
VIEW



Date: 8.OCT.2014 10:36:45

13 CONDUCTED SPURIOUS EMISSION MEASUREMENT

13.1 Standard Applicable

According to 15.247(d), in any 100 kHz 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 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided 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 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required.

13.2 Measurement 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 figure 4 without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
3. Use the following spectrum analyzer settings:
 - Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
 - RBW = 100 kHz
 - VBW \geq RBW
 - Sweep = auto
 - Detector function = peak
 - Trace = max hold.
4. Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded. Plot the result on the screen of spectrum analyzer.
5. Repeat above procedures until all measured frequencies were complete.

13.3 Measurement Equipment

Equipment	Manufacturer	Model No.	Calibration Date	Next Cal. Date
EMI Test Receiver	Rohde & Schwarz	ESU 40	2014/08/15	2015/08/14
Attenuator	Weinschel Engineering	1	N/A	N/A

13.4 Measurement Data

Test Date : Oct. 08, 2014 Temperature : 25 °C Humidity : 65 %

Mode : Low Channel

- a) 1 GHz to 3 GHz frequency band: All emissions are attenuated more than 20dB from the carrier.
- b) 3 GHz to 25 GHz frequency band: All emissions are attenuated more than 20dB from the carrier.

Mode : Mid Channel

- a) 1 GHz to 3 GHz frequency band: All emissions are attenuated more than 20dB from the carrier.
- b) 3 GHz to 25 GHz frequency band: All emissions are attenuated more than 20dB from the carrier.

Mode : Hi Channel

- a) 1 GHz to 3 GHz frequency band: All emissions are attenuated more than 20dB from the carrier.
- b) 3 GHz to 25 GHz frequency band: All emissions are attenuated more than 20dB from the carrier.

Note : The expanded uncertainty: 2dB.

Mode: Channel Low

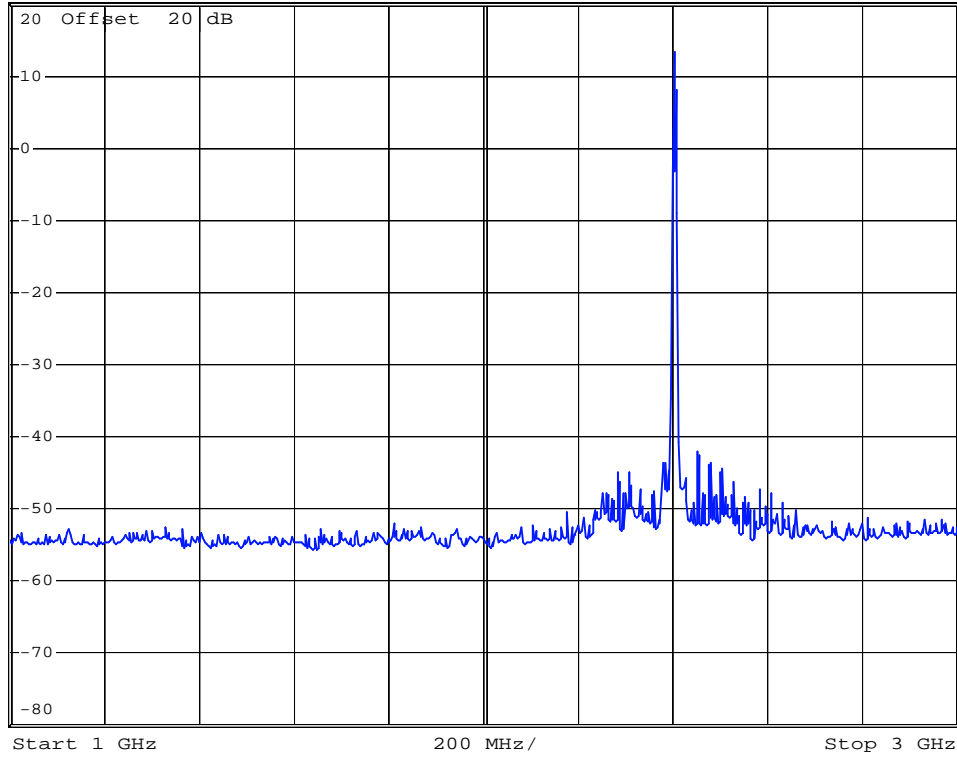


*RBW 1 MHz
VBW 3 MHz
SWT 10 ms

Ref 20 dBm

*Att 10 dB

1 PK
VIEW



Date: 8.OCT.2014 10:57:17

Mode: Channel Low

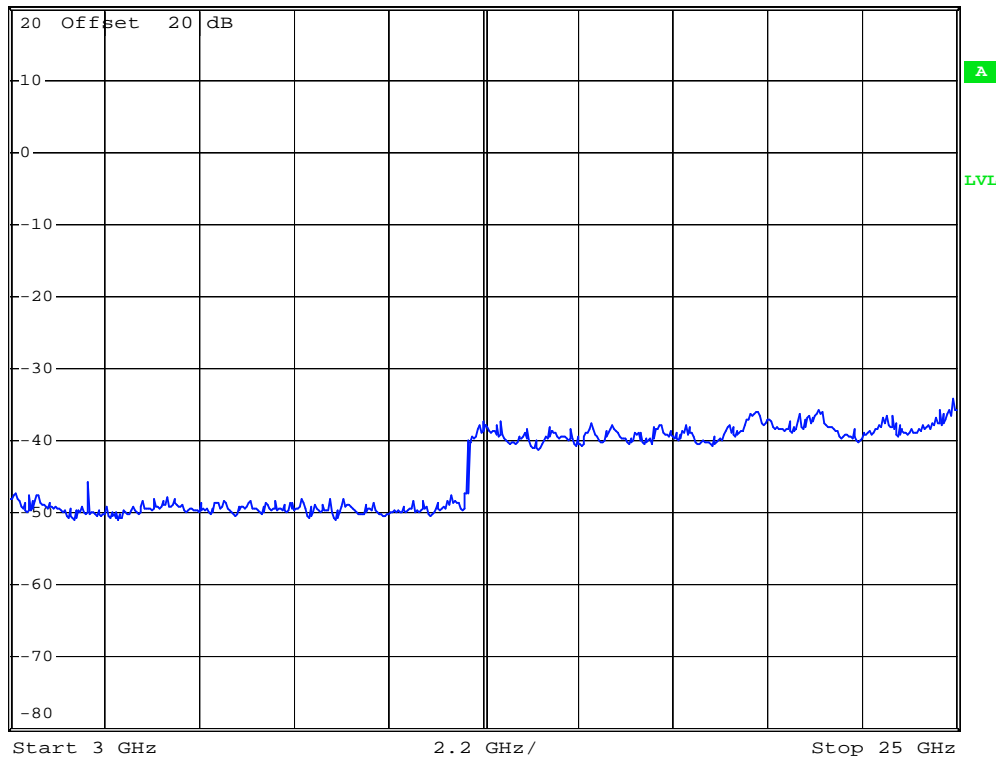


*RBW 1 MHz
VBW 3 MHz
SWT 440 ms

Ref 20 dBm

*Att 10 dB

1 PK
VIEW



Date: 8.OCT.2014 10:57:56

Mode: Channel Middle

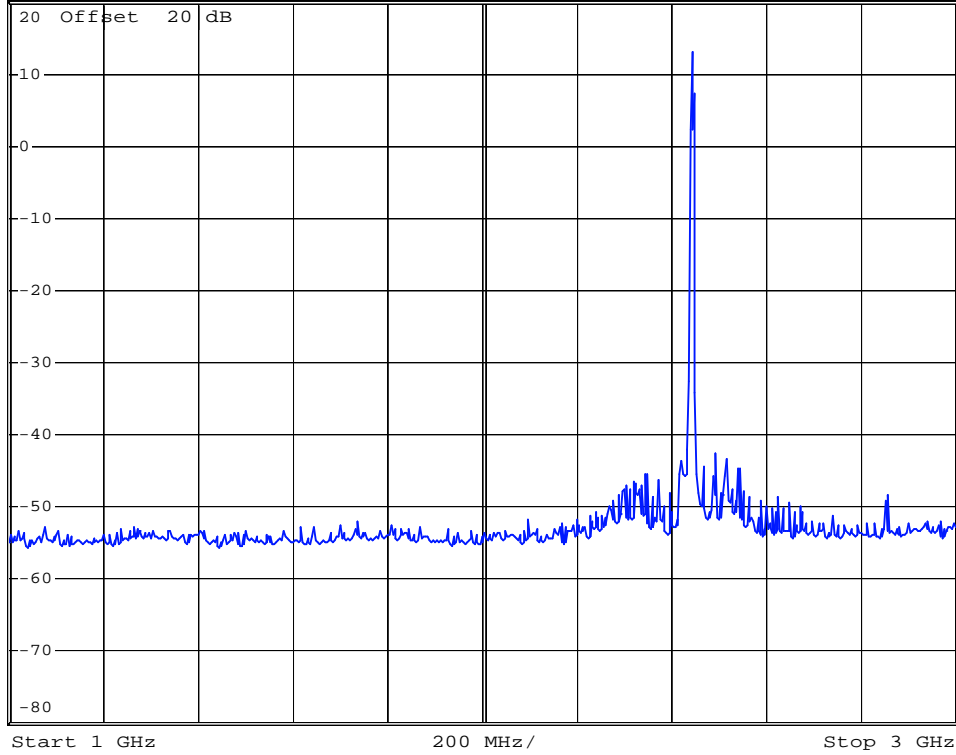


*RBW 1 MHz
VBW 3 MHz
SWT 10 ms

Ref 20 dBm

*Att 10 dB

1 PK
VIEW



Date: 8.OCT.2014 10:55:15

Mode: Channel Middle

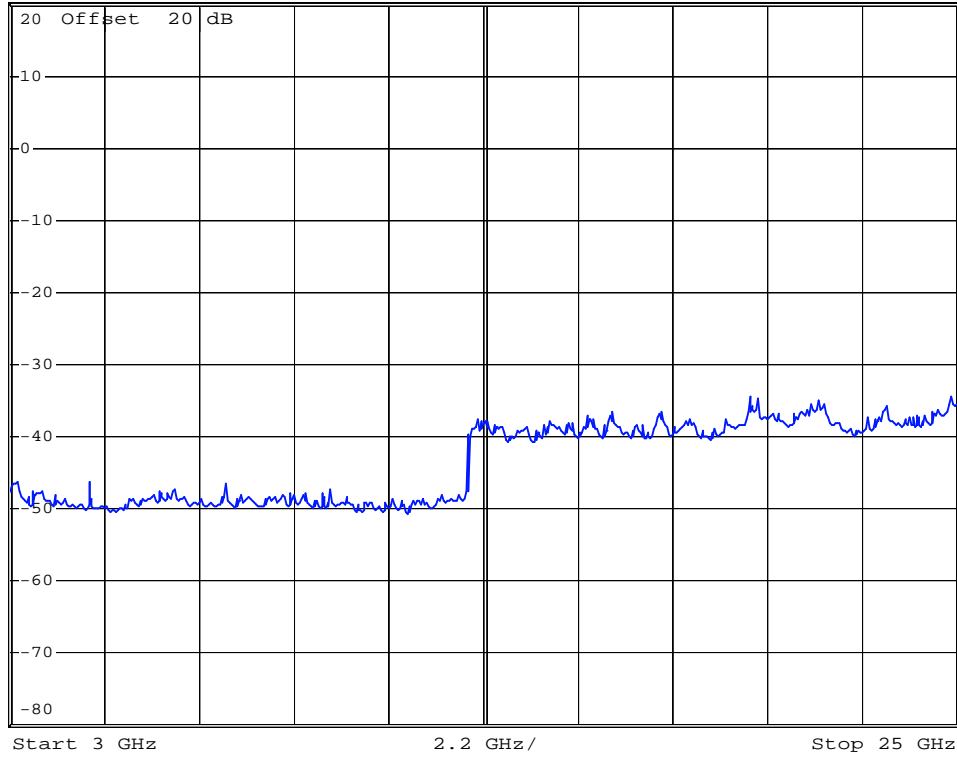


*RBW 1 MHz
VBW 3 MHz
SWT 440 ms

Ref 20 dBm

*Att 10 dB

1 PK
VIEW



Date: 8.OCT.2014 10:54:44

Mode: Channel High

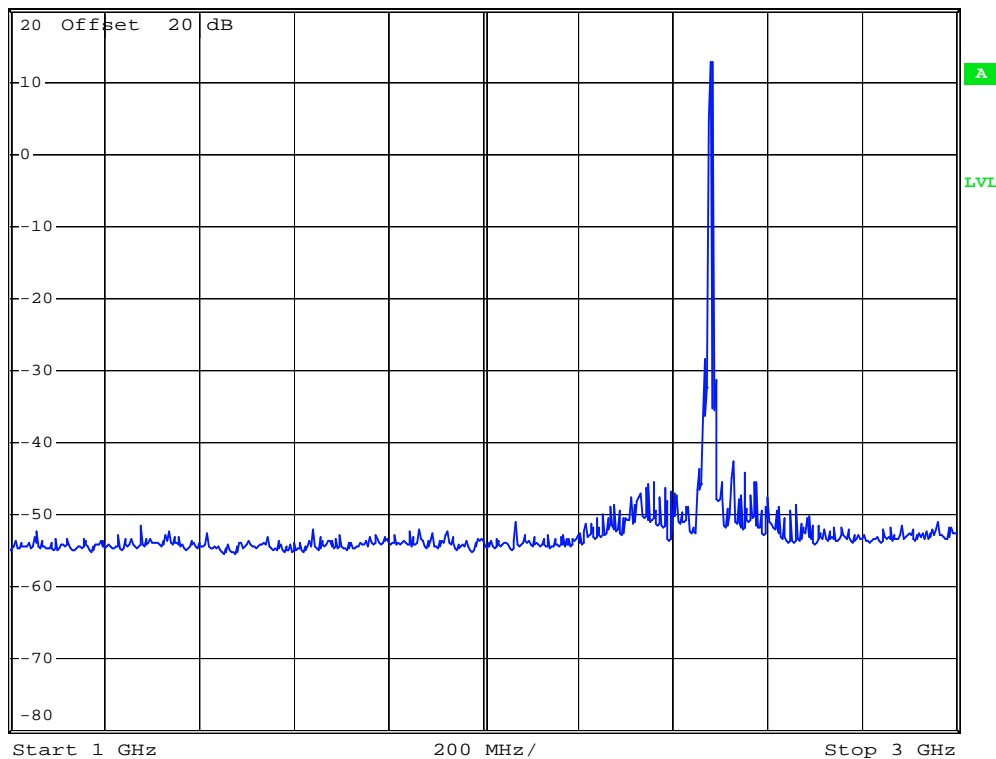


*RBW 1 MHz
VBW 3 MHz
SWT 10 ms

Ref 20 dBm

*Att 10 dB

1 PK
VIEW



Date: 8.OCT.2014 10:53:26

Mode: Channel High

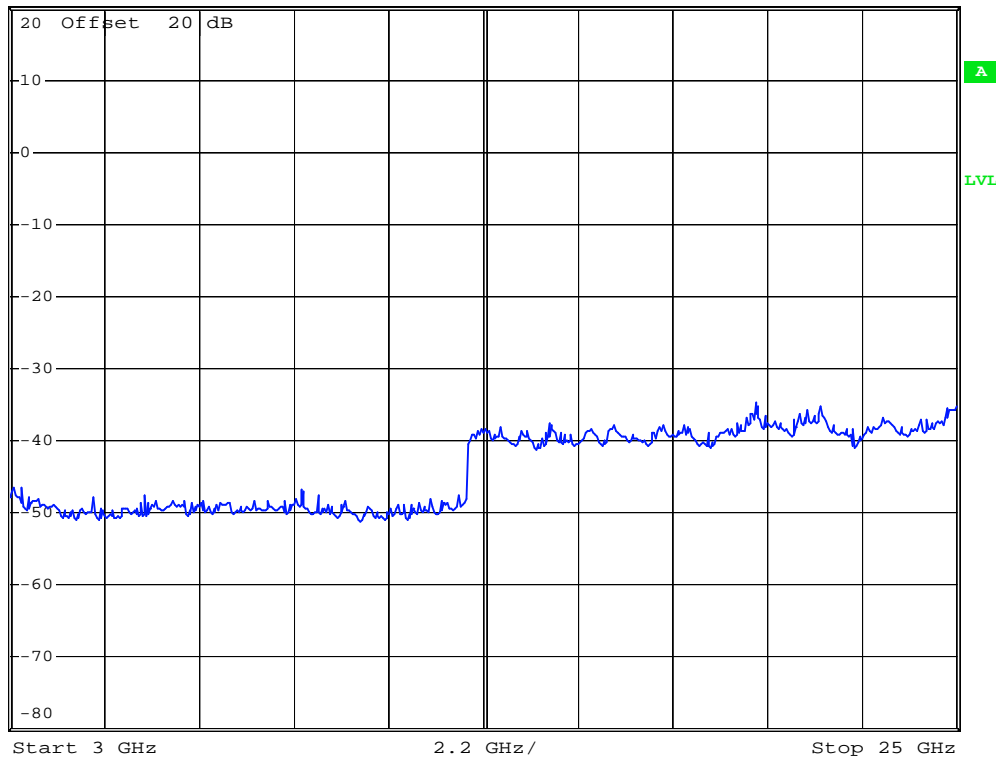


*RBW 1 MHz
VBW 3 MHz
SWT 440 ms

Ref 20 dBm

*Att 10 dB

1 PK
VIEW



Date: 8.OCT.2014 10:53:52