

ELECTROMAGNETIC EMISSION COMPLIANCE REPORT FOR LOW-POWER, NON-LICENSED TRANSMITTER

Test Report No. : E146R-078
AGR No. : A145A-089
Applicant : Remote Solution Co., Ltd.
Address : 92, Chogokri, Nammyun, Kimchon city, Kyungbuk, Korea, 740-871
Manufacturer : Remote Solution Co., Ltd.
Address : 92, Chogokri, Nammyun, Kimchon city, Kyungbuk, Korea, 740-871
Type of Equipment : Smart Home Ethernet Gateway
FCC ID. : TX4ES50A
Model Name : ES50A
Multiple Model Name : ES50B, ES50C, ES50D, ES50E, ES50F, ES50G, ES50H, ES50J, ES50K,
ES50L, ES50M, ES50N, ES50P, ES50Q, ES50R, ES50S, ES50T, ES50U,
ES50U, ES50V, ES50W, ES50X, ES50Y, ES50Z
Serial number : N/A
Total page of Report : 59 pages (including this page)
Date of Incoming : June 04, 2014
Date of issue : June 24, 2014

SUMMARY

The equipment complies with the regulation; *FCC PART 15 SUBPART C Section 15.247*
 This test report only contains the result of a single test of the sample supplied for the examination.
 It is not a generally valid assessment of the features of the respective products of the mass-production.

Prepared by: 

 Ki-Hong, Nam / Senior Engineer
 ONETECH Corp.

Approved by: 

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 ONETECH Corp.

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Revision History

Issued Report No.	Issued Date	Revisions	Effect Section
E146R-078	June 24, 2014	Initial Issue	All

1. VERIFICATION OF COMPLIANCE

Applicant : Remote Solution Co., Ltd.
 Address : 92, Chogokri, Nammyun, Kimchon city, Kyungbuk, Korea, 740-871
 Contact Person : Ku Yeong Hwa / Assistant Research Engineer
 Telephone No. : +82-54-420-4500
 FCC ID : TX4ES50A
 Model Name : ES50A
 Serial Number : N/A
 Date : June 24, 2014

EQUIPMENT CLASS	<i>DTS – DIGITAL TRNSMISSION SYSTEM</i>
E.U.T. DESCRIPTION	Smart Home Ethernet Gateway
THIS REPORT CONCERNS	Original Grant
MEASUREMENT PROCEDURES	ANSI C63.10: 2009 and FCC KDB D01 DTS Meas Guidance v03r02
TYPE OF EQUIPMENT TESTED	Pre-Production
KIND OF EQUIPMENT AUTHORIZATION REQUESTED	Certification
EQUIPMENT WILL BE OPERATED UNDER FCC RULES PART(S)	FCC PART 15 SUBPART C Section 15.247
MODIFICATIONS ON THE EQUIPMENT TO ACHIEVE COMPLIANCE	None
FINAL TEST WAS CONDUCTED ON	3 m semi anechoic chamber.

-. The above equipment was tested by ONETECH Corp. for compliance with the requirement set forth in the FCC Rules and Regulations. This said equipment in the configuration described in this report, shows the maximum emission levels emanating from equipment are within the compliance requirements.

2. TEST SUMMARY

2.1 Test items and results

SECTION	TEST ITEMS	RESULTS
15.247 (a) (2)	Minimum 6 dB Bandwidth	Met the Limit / PASS
15.247 (b) (3)	Maximum Peak Conducted Output Power	Met the Limit / PASS
15.247 (d)	100 kHz Bandwidth Outside the Frequency Band	Met the Limit / PASS
15.247 (d)	Radiated Emission which fall in the Restricted Band	Met the Limit / PASS
15.247 (e)	Peak Power Spectral Density	Met the Limit / PASS
15.209	Radiated Emission Limits	Met the Limit / PASS
15.207	Conducted Limits	Met the Limit / PASS
15.203	Antenna Requirement	Met requirement / PASS

2.2 Additions, deviations, exclusions from standards

No additions, deviations or exclusions have been made from standard.

2.3 Related Submittal(s) / Grant(s)

Original submittal only

2.4 Purpose of the test

To determine whether the equipment under test fulfills the requirements of the regulation stated in section 2.1.

2.5 Test Methodology

Radiated testing was performed according to the procedures in ANSI C63.10: 2009 at a distance of 3 m from EUT to the antenna.

2.6 Test Facility

The Onetech Corp. has been designated to perform equipment testing in compliance with ISO/IEC 17025.

The Electromagnetic compatibility measurement facilities are located at 301-14, Daessangnyeong-ri, Chowol-eup, Gwangju-si, Gyeonggi-do, 464-862 Korea.

-. Site Filing:

VCCI (Voluntary Control Council for Interference) – Registration No. R-4112/ C-4617/ G-666/ T-1842 IC (Industry Canada) – Registration No. Site# 3736-3

-. Site Accreditation:

KOLAS (Korea Laboratory Accreditation Scheme) - Accreditation No. 85

FCC (Federal Communications Commission) - Accreditation No. KR0013

RRA (Radio Research Agency) – Designation No. KR0013

3. GENERAL INFORMATION

3.1 Product Description

The Remote Solution Co., Ltd., Model ES50A (referred to as the EUT in this report) is a Smart Home Ethernet Gateway. Product specification information described herein was obtained from product data sheet or user’s manual.

DEVICE TYPE	Portable Device
FREQUENCY RANGE	2 405 MHz ~ 2 475 MHz
Channel Number	15
MAX. RF OUTPUT POWER:	Antenna 0: 18.94 dBm Antenna 1: 18.94 dBm
NUMBER OF LAYER	4 Layers
ANTENNA TYPE	PCB Antenna
ANTENNA GAIN	Antenna 0: 3.251 dBi Antenna 1: 3.244 dBi
MODULATION METHOD	GFSK
USED RF CHIP	Marker: GreenPeak Technologies Model Name: GP_P405_RDD_01709
List of each Osc. or crystal Freq.(Freq. >= 1 MHz)	16 MHz, 25 MHz
POWER REQUIREMENT	DC 5.0 V
EXTERNAL CONNECTOR	USB, RJ45

3.2 Alternative type(s)/model(s); also covered by this test report.

-. The following lists consist of the added model and their differences.

Model Name	Differences	Tested
ES50A	Basic Model	<input checked="" type="checkbox"/>
ES50B, ES50C, ES50D, ES50E, ES50F, ES50G, ES50H, ES50J, ES50K, ES50L, ES50M, ES50N, ES50P, ES50Q, ES50R, ES50S, ES50T, ES50U, ES50V, ES50W, ES50X, ES50Y, ES50Z	These models are identical to basic model except for the model name only.	<input type="checkbox"/>

Note: 1. Applicant consigns only basic model to test. Therefore this test report just guarantees the units, which have been tested.

2. The Applicant/manufacturer is responsible for the compliance of all variants.

4. EUT MODIFICATIONS

-. None

5. SYSTEM TEST CONFIGURATION

5.1 Justification

This device was configured for testing in a typical way as a normal customer is supposed to be used. During the test, the following components were installed inside of the EUT.

DEVICE TYPE	MANUFACTURER	MODEL/PART NUMBER	FCC ID
Main Board	Remote Solution Co., Ltd.	1BF-0387A	N/A

5.2 Peripheral equipment

Defined as equipment needed for correct operation of the EUT, but not considered as tested:

Model	Manufacturer	Description	Connected to
ES50A	Remote Solution Co., Ltd.	Smart Home Ethernet Gateway (EUT)	-

5.3 Mode of operation during the test

For the testing, software used to control the EUT for staying in continuous transmitting mode is programmed.

-. The EUT was set at Low Channel (2 405 MHz), Middle Channel (2 440 MHz), and High Channel (2 475 MHz). To get a maximum radiated emission levels from the EUT

5.4 Configuration of Test System

Line Conducted Test: The EUT was connected to Adaptor was connected to LISN. All supporting equipments were connected to another LISN. Preliminary Power line Conducted Emission tests were performed by using the procedure in ANSI C63.10: 2009 to determine the worse operating conditions.

Radiated Emission Test: Preliminary radiated emissions test were conducted using the procedure in ANSI C63.10: 2009 to determine the worse operating conditions. Final radiated emission tests were conducted at 3 m open area test site.
The turntable was rotated through 360 degrees and the EUT was tested by positioned three orthogonal planes to obtain the highest reading on the field strength meter. Once maximum reading was determined, the search antenna was raised and lowered in both vertical and horizontal polarization.

5.5 Antenna Requirement

For intentional device, according to 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.

Antenna Construction:

The antenna of the EUT is a PCB Antenna on the main board in the EUT, so no consideration of replacement by the user.

6. PRELIMINARY TEST

6.1 AC Power line Conducted Emissions Tests

During Preliminary Tests, the following operating mode was investigated

Operation Mode	The Worse operating condition (Please check one only)
Charging and Transmitter Mode	X

6.2 General Radiated Emissions Tests

During Preliminary Tests, the following operating modes were investigated

Operation Mode	The Worse operating condition (Please check one only)
Transmitter Mode	X

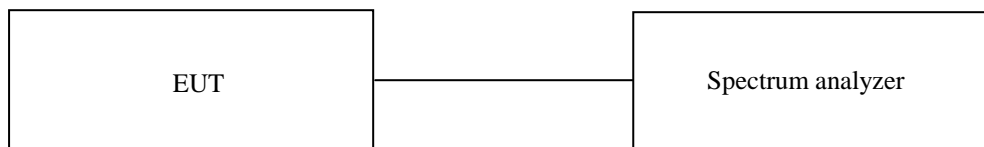
7. MIMIMUM 6 dB BANDWIDTH

7.1 Operating environment

Temperature : 25 °C
Relative humidity : 44 % R.H.

7.2 Test set-up

The antenna output of the EUT was connected to the spectrum analyzer. The resolution bandwidth is set to 100 kHz, and peak detection was used. The 6 dB bandwidth is defined as the total spectrum over which the power is higher than the peak power minus 6 dB.



7.3 Test equipment used

Model Number	Manufacturer	Description	Serial Number	Last Cal.
■ - FSV30	R/S	Spectrum Analyzer	101372	Apr. 28, 2014(1Y)

All test equipment used is calibrated on a regular basis.

7.4 Test data for Antenna 0

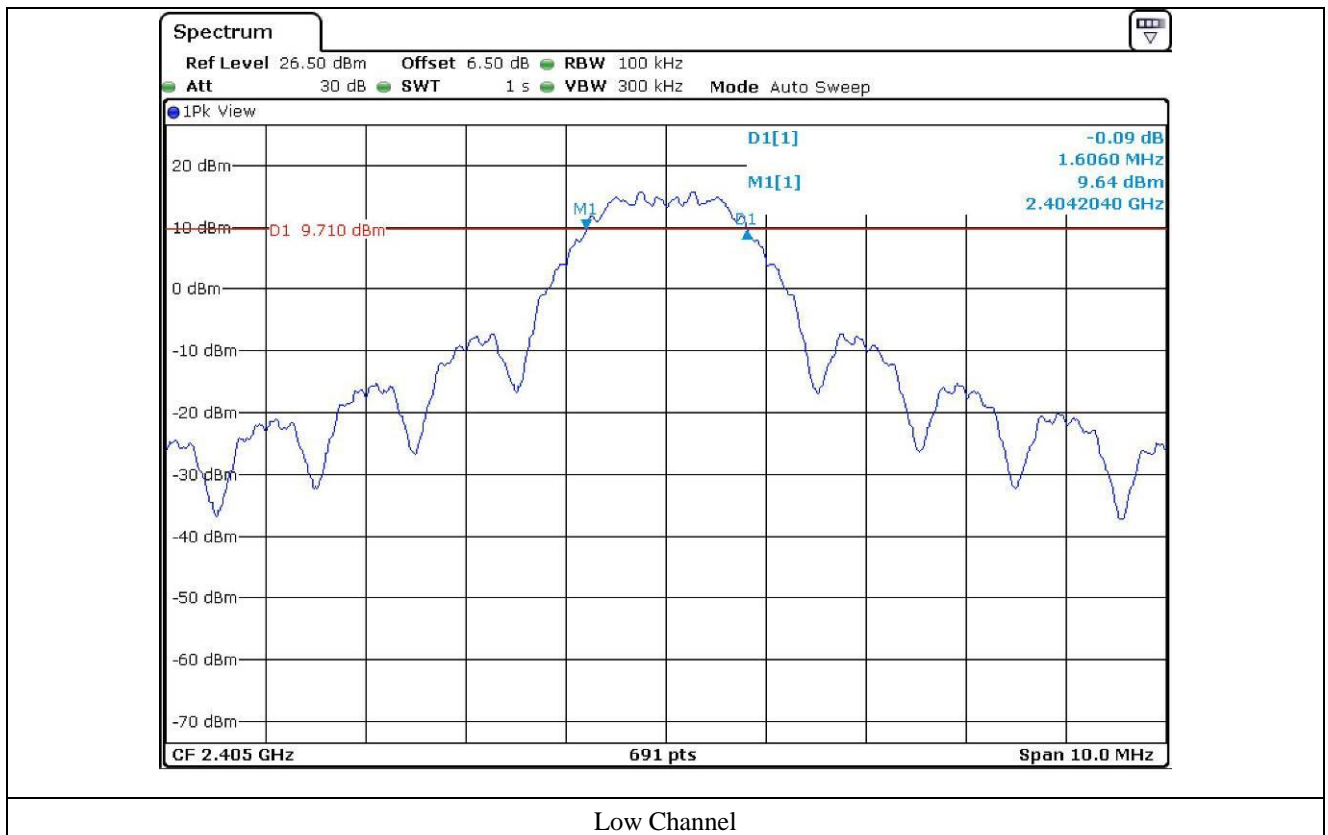
-. Test Date : June 19, 2014
-. Test Result : Pass

CHANNEL	FREQUENCY(MHz)	MEASURED VALUE (MHz)	LIMIT (MHz)	MARGIN (MHz)
Low	2 405	1.61	0.5	1.11
Middle	2 440	1.59	0.5	1.09
High	2 475	1.61	0.5	1.11

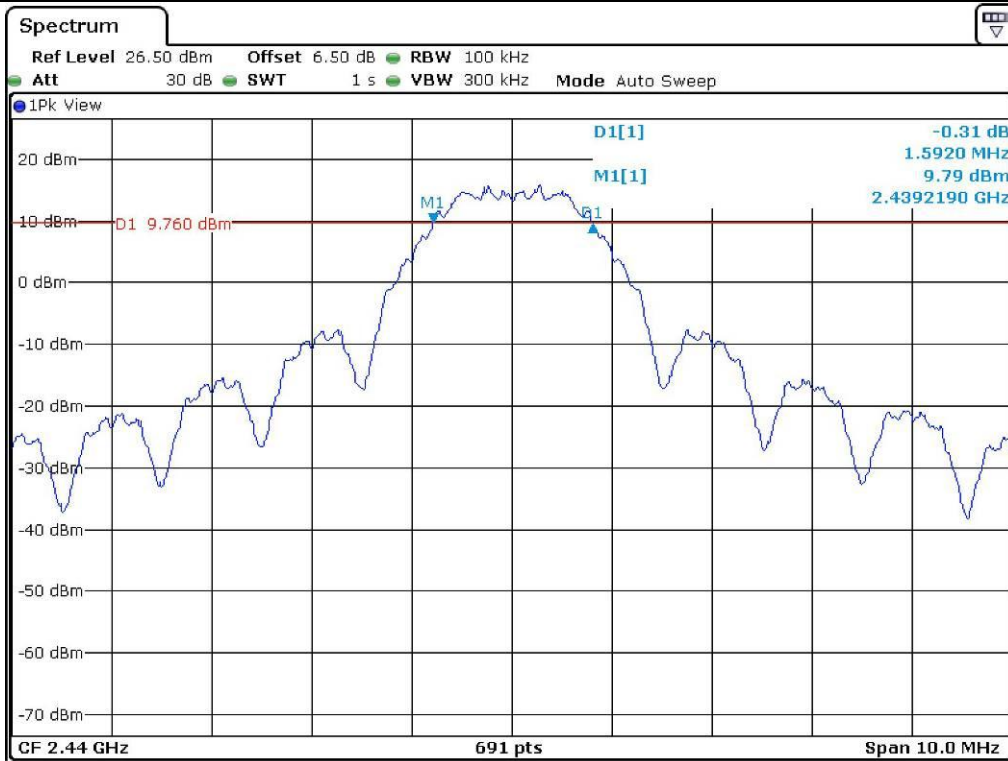
Remark. Margin = Measured Value - Limit



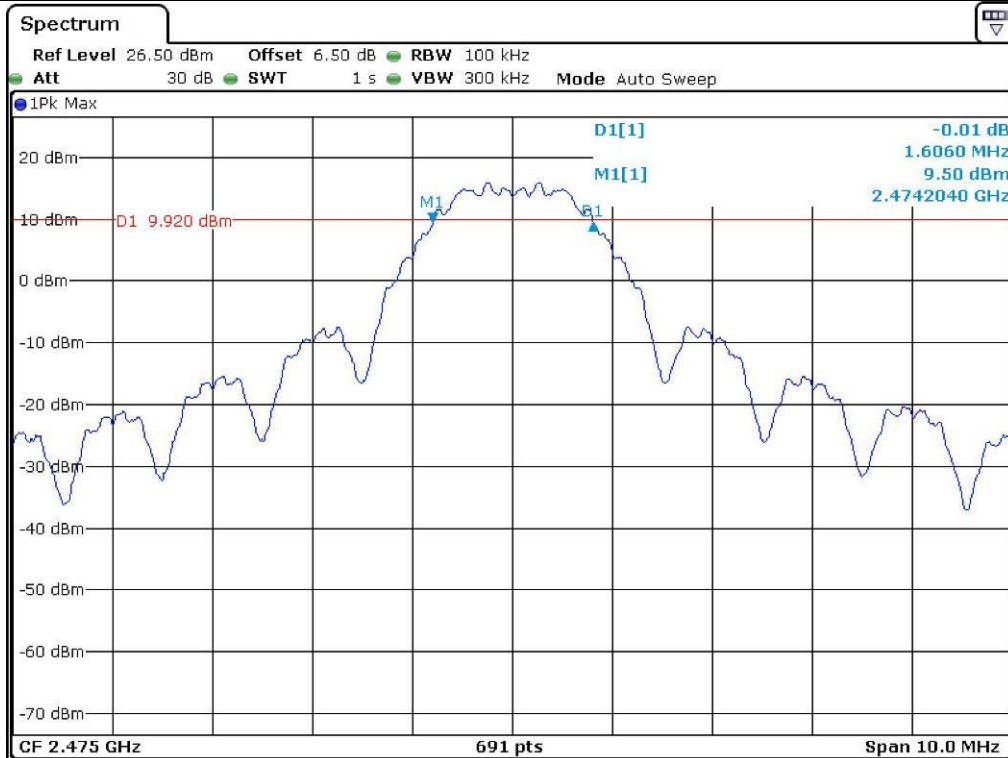
Tested by: Tae-Ho, Kim / Project Engineer



Low Channel



Middle Channel



High Channel

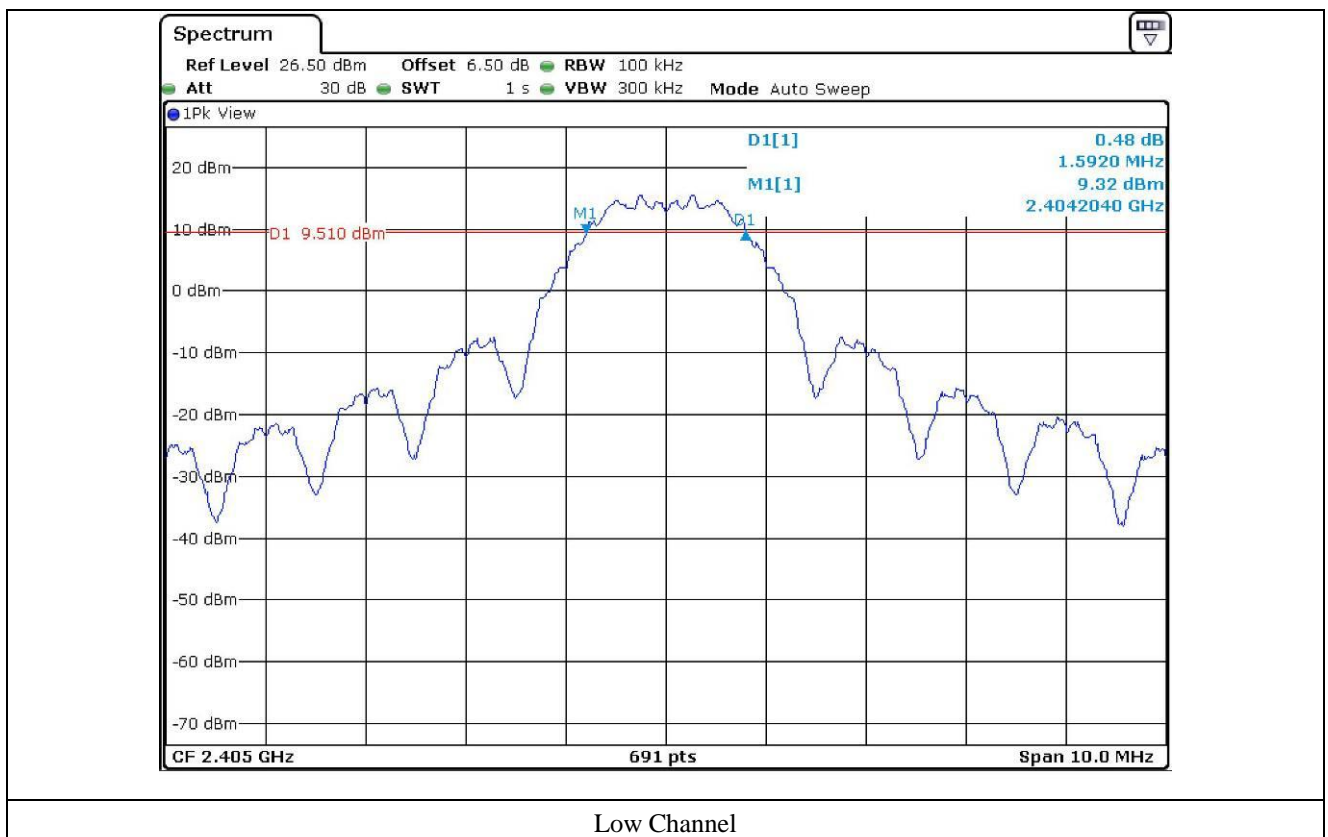
7.5 Test data for Antenna 1

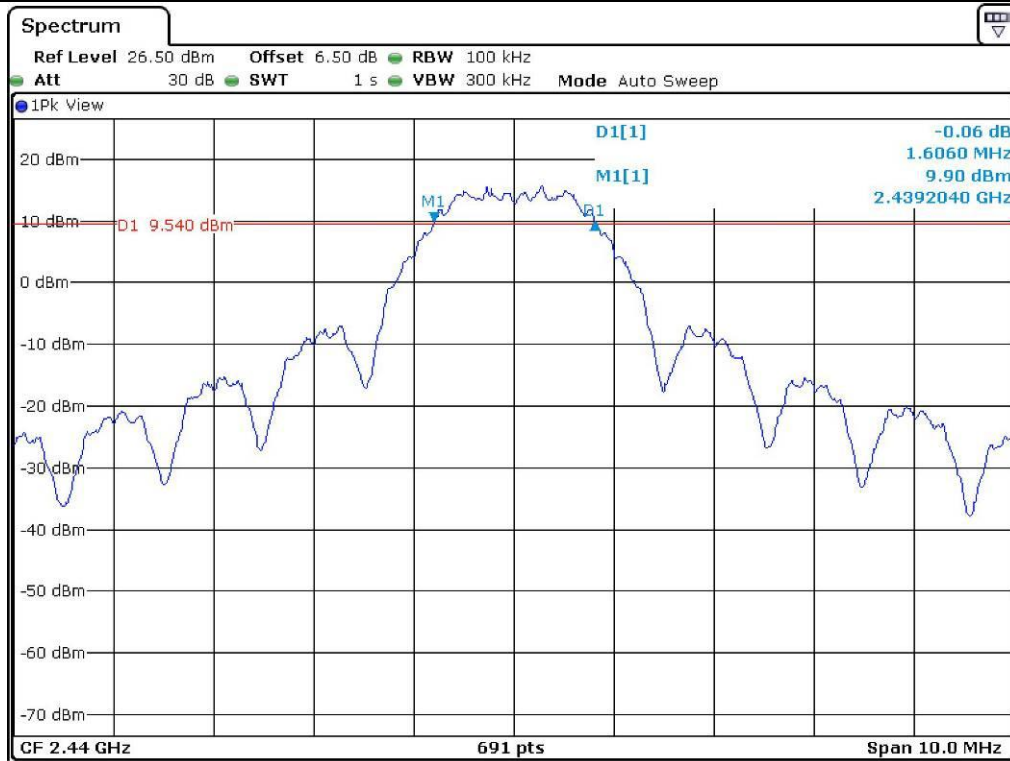
-. Test Date : June 19, 2014
-. Test Result : Pass

CHANNEL	FREQUENCY(MHz)	MEASURED VALUE (MHz)	LIMIT (MHz)	MARGIN (MHz)
Low	2 405	1.59	0.5	1.09
Middle	2 440	1.61	0.5	1.11
High	2 475	1.61	0.5	1.11

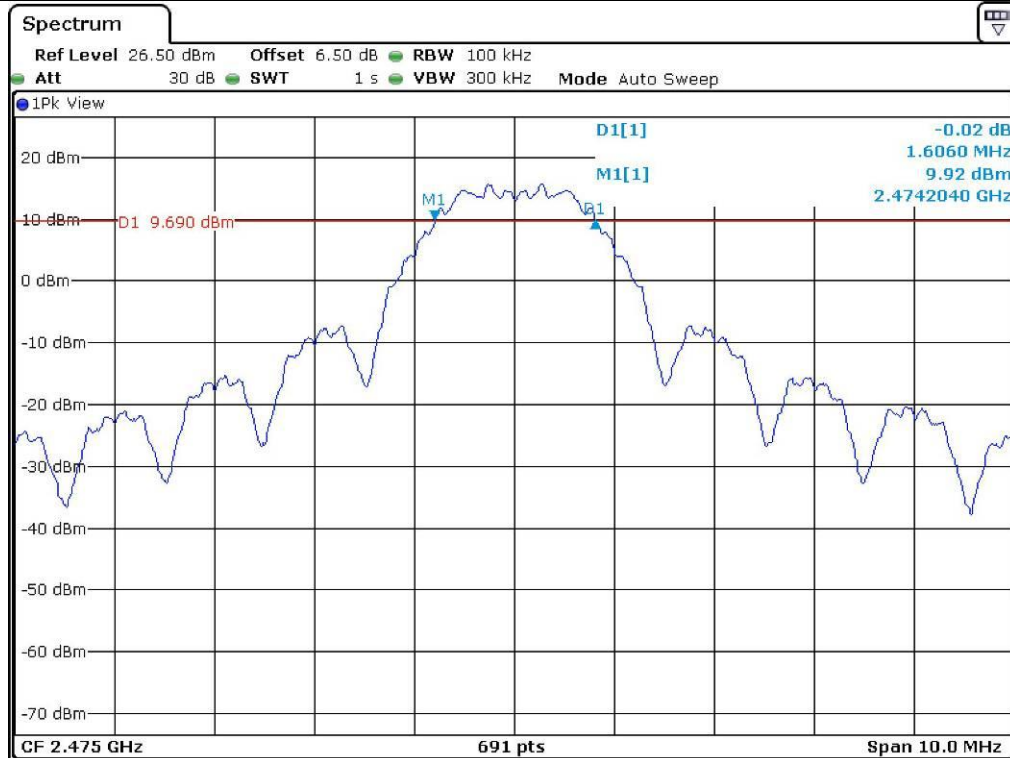
Remark. Margin = Measured Value - Limit

Tested by: Tae-Ho, Kim / Project Engineer





Middle Channel



High Channel

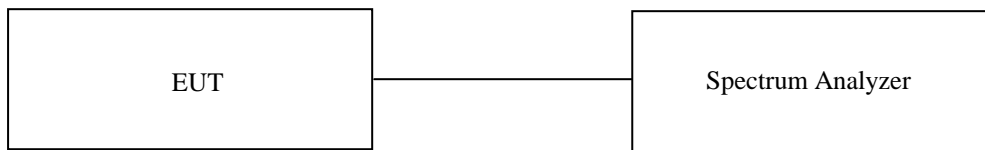
8. MAXIMUM PEAK OUTPUT POWER

8.1 Operating environment

Temperature : 25 °C
Relative humidity : 44 % R.H.

8.2 Test set-up

The maximum peak output power was measured with the spectrum analyzer connected to the antenna output of the EUT. The EUT was operating in transmit mode at the appropriate center frequency.



8.3 Test equipment used

Model Number	Manufacturer	Description	Serial Number	Last Cal.
■ - FSV30	R/S	Spectrum Analyzer	101372	Apr. 28, 2014(1Y)

All test equipment used is calibrated on a regular basis.

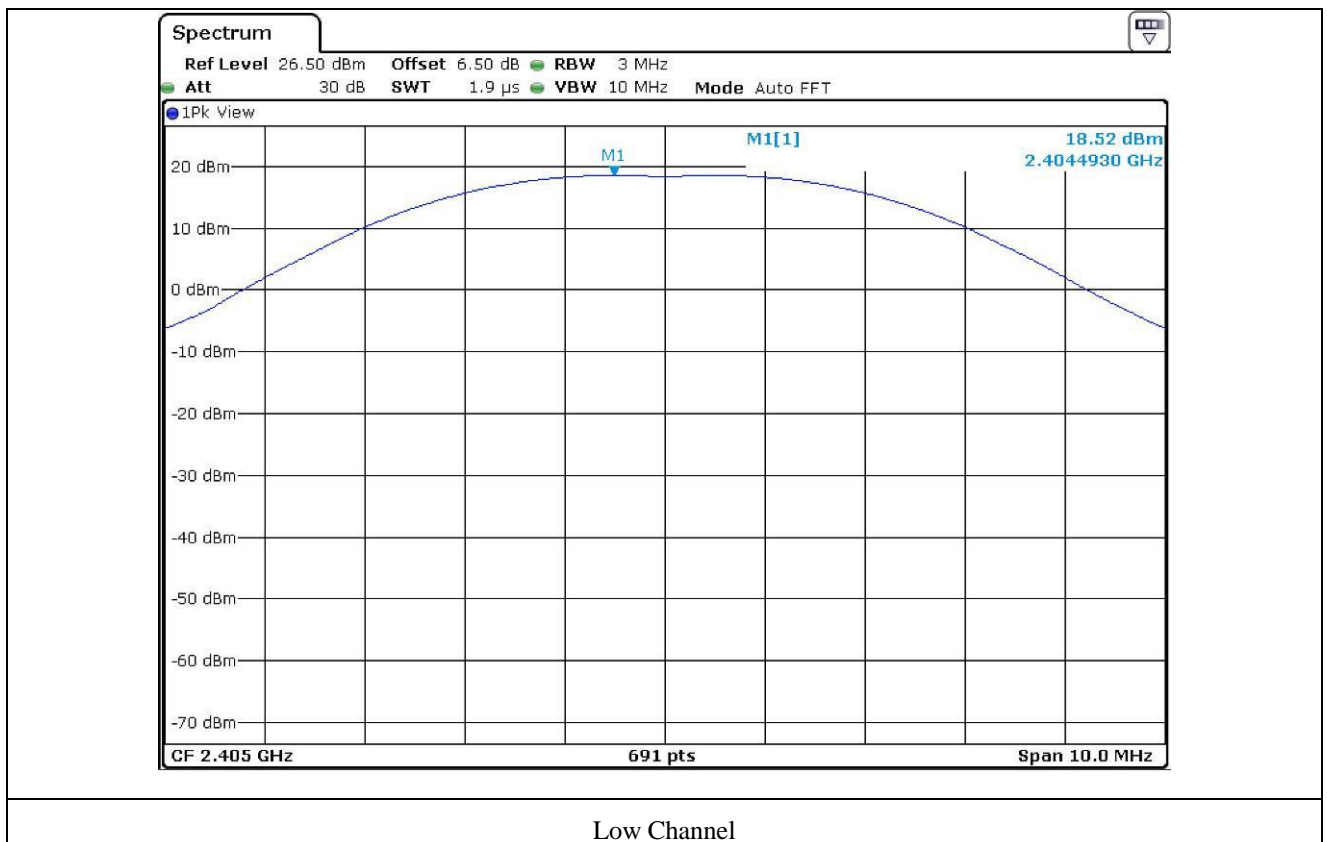
8.4 Test data for Antenna 0

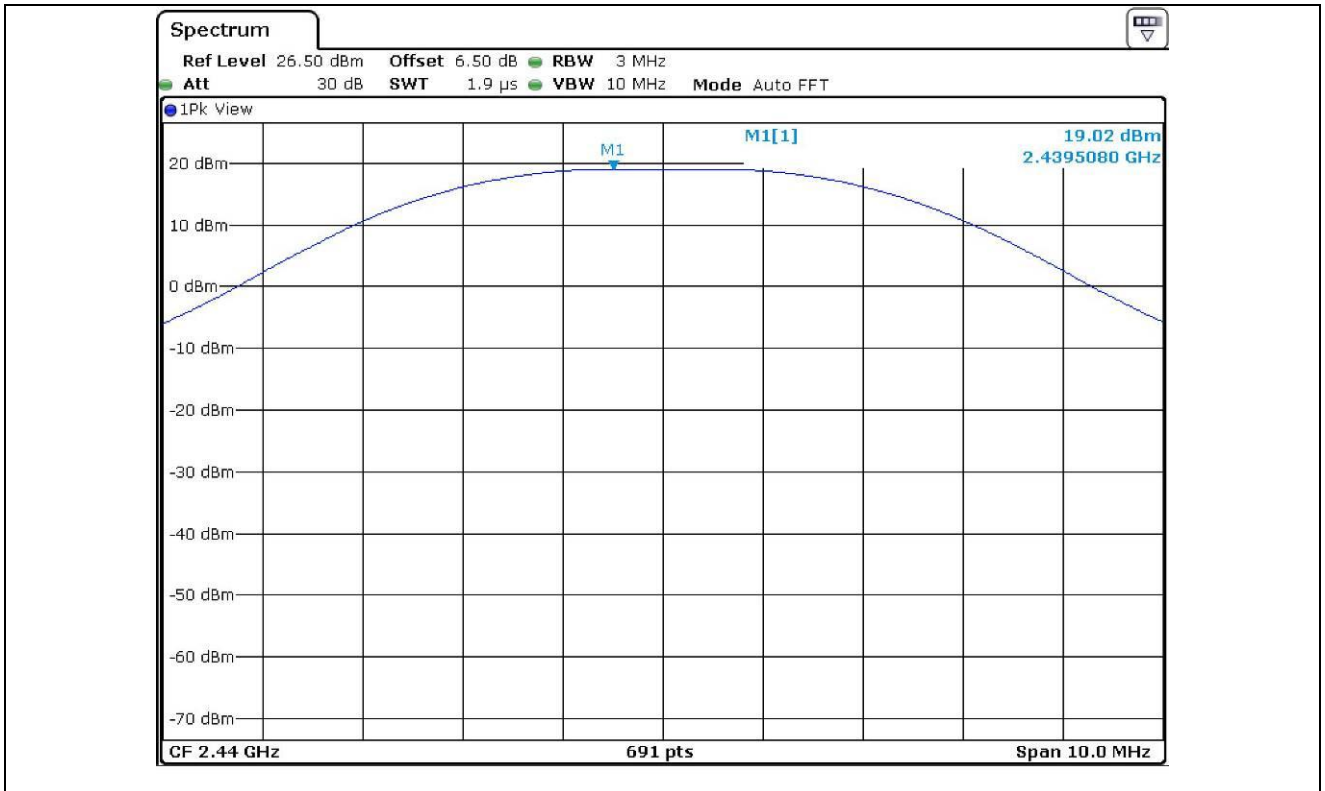
- Test Date : June 19, 2014
- Test Result : Pass

CHANNEL	FREQUENCY (MHz)	DTS (MHz)	MEASURED VLAUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 405	1.61	18.52	30	11.48
MIDDLE	2 440	1.59	19.02	30	10.98
HIGH	2 475	1.61	19.23	30	10.77

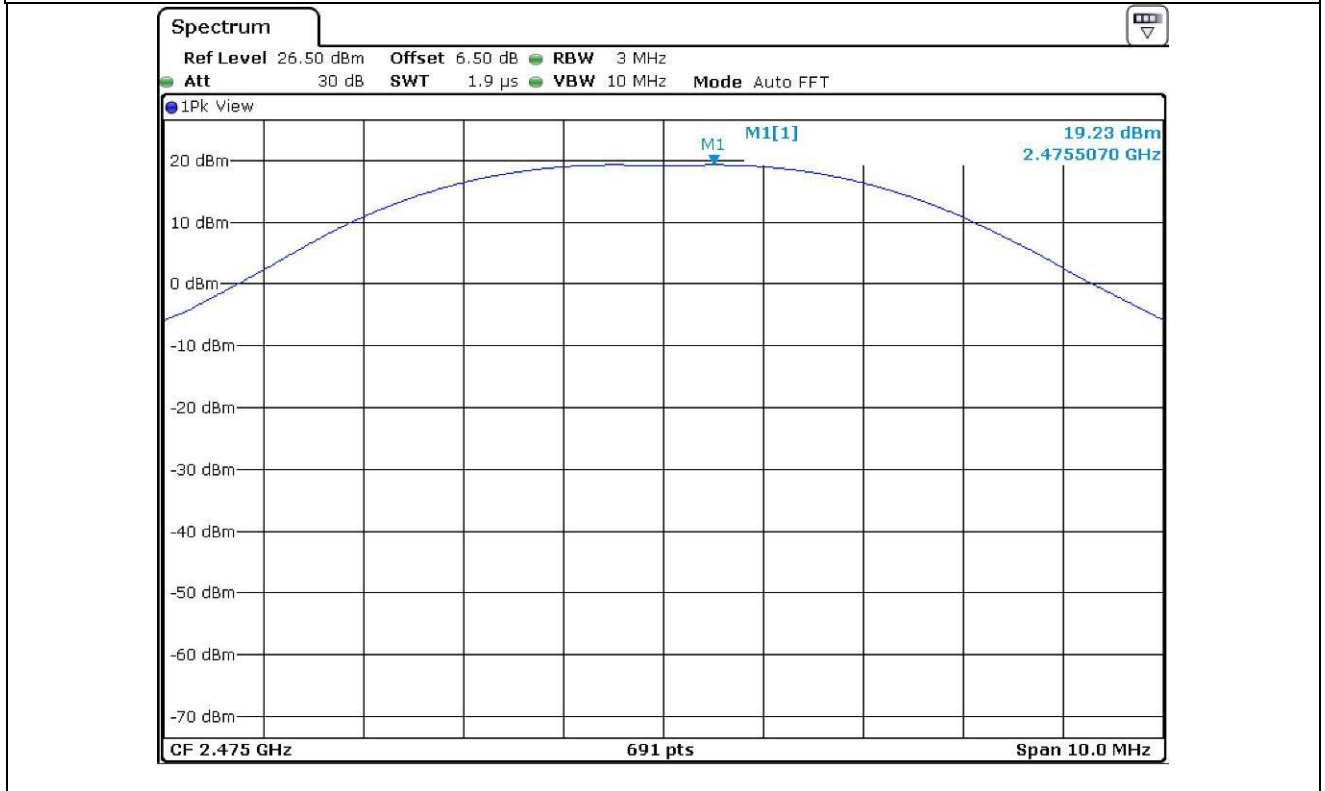
Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)

Tested by: Tae-Ho, Kim / Project Engineer





Middle Channel



High Channel

8.5 Test data for Antenna 1

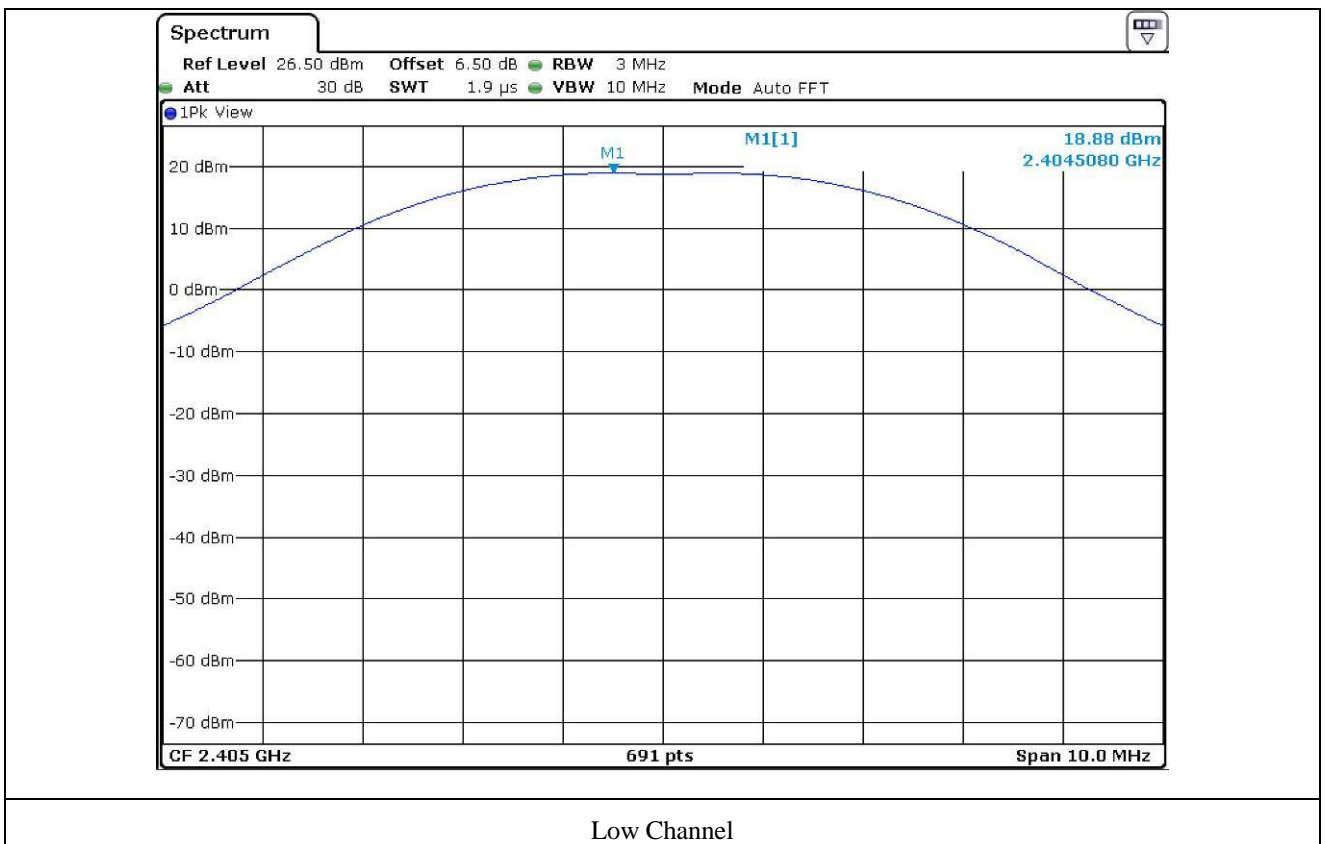
- Test Date : June 19, 2014
- Test Result : Pass

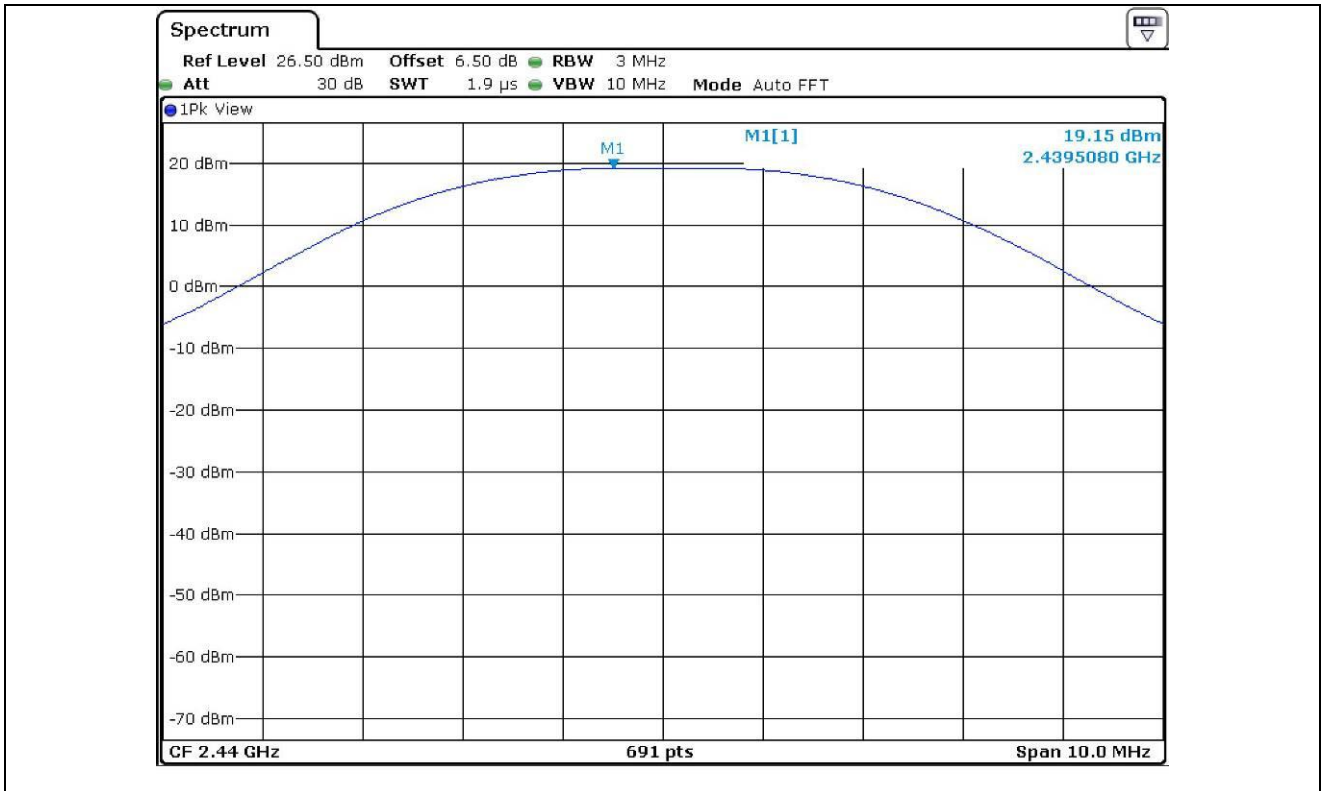
CHANNEL	FREQUENCY (MHz)	DTS (MHz)	MEASURED VLAUE (dBm)	LIMIT (dBm)	MARGIN (dB)
LOW	2 405	1.59	18.88	30	11.12
MIDDLE	2 440	1.61	19.15	30	10.85
HIGH	2 475	1.61	19.41	30	10.59

Remark. Margin = Limit – Measured Value (=Receiver Reading + Cable Loss)

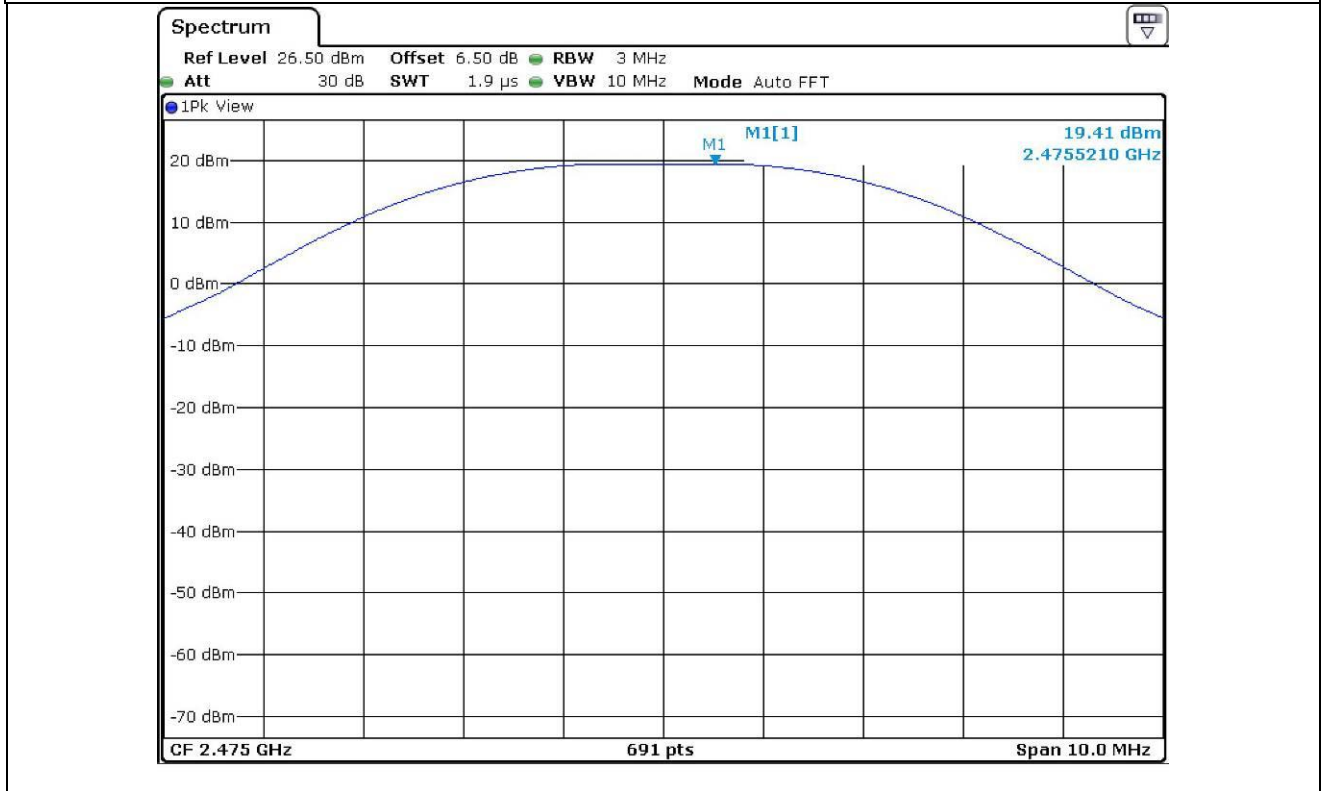


Tested by: Tae-Ho, Kim / Project Engineer





Middle Channel



High Channel

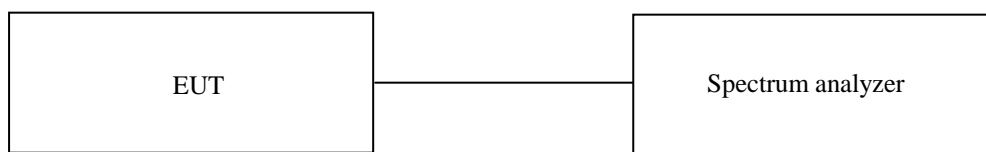
9. 100 kHz BANDWIDTH OUTSIDE THE FREQUENCY BAND

9.1 Operating environment

Temperature : 25 °C
Relative humidity : 45 % R.H.

9.2 Test set-up for conducted measurement

The antenna output of the EUT was connected to the spectrum analyzer. The resolution and video bandwidth is set to 100 kHz, and peak detection was used.



9.3 Test set-up for radiated measurement

The radiated emissions measurements were performed on the 3 m, open-field test site. The EUT was placed on a non-conductive turntable approximately 0.8 m above the ground plane.

The frequency spectrum from 30 MHz to 26.5 GHz was scanned and maximum emission levels at each frequency recorded. The system was rotated 360°, and the antenna was varied in the height between 1.0 m and 4.0 m in order to determine the maximum emission levels. This procedure was performed for horizontal and vertical polarization of the receiving antenna.

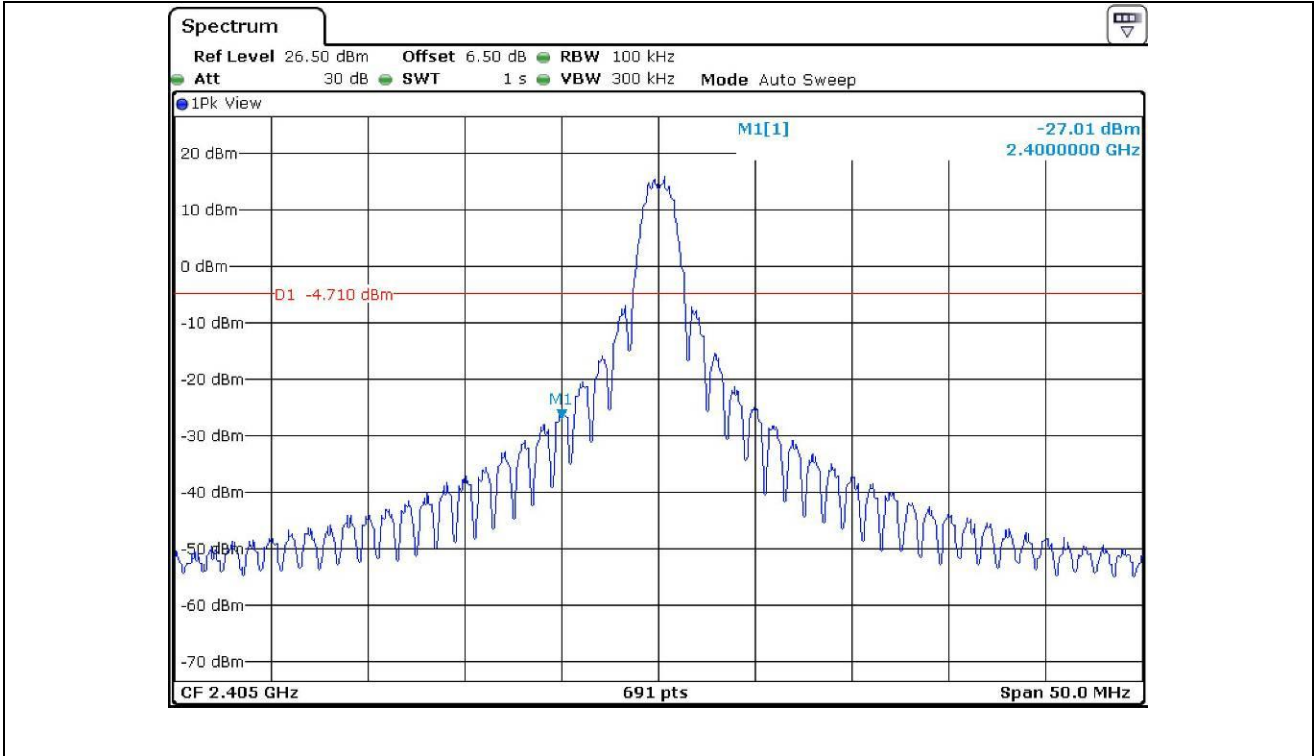
9.4 Test equipment used

	Model Number	Manufacturer	Description	Serial Number	Last Cal.(Interval)
■ -	8564E	HP	Spectrum Analyzer	3650A00756	Apr. 28, 2014(1Y)
■ -	ESU	Rohde & Schwarz	EMI Test Receiver	100261	Apr. 29, 2014(1Y)
■ -	310N	Sonoma Instrument	AMPLIFIER	312544	Apr. 28, 2014(1Y)
■ -	FSV30	Rohde & Schwarz	Signal Analyzer	101372	Apr. 28, 2014(1Y)
■ -	SCU-18	Rohde & Schwarz	PRE-AMPLIFIER	10041	Jan. 20, 2014(1Y)
■ -	MA220	HD	Turn Table	N/A	N/A
■ -	HD240	HD	Antenna Mast	N/A	N/A
■ -	VULB9163	Schwarzbeck	TRILOG Broadband Antenna	9163-255	May 05, 2014(2Y)
■ -	BBHA9120D	Schwarzbeck	Horn Antenna	BBHA9120D295	Sep. 05, 2013 (2Y)
■ -	BBHA9170	Schwarzbeck	Horn Antenna	BBHA9170178	N/A

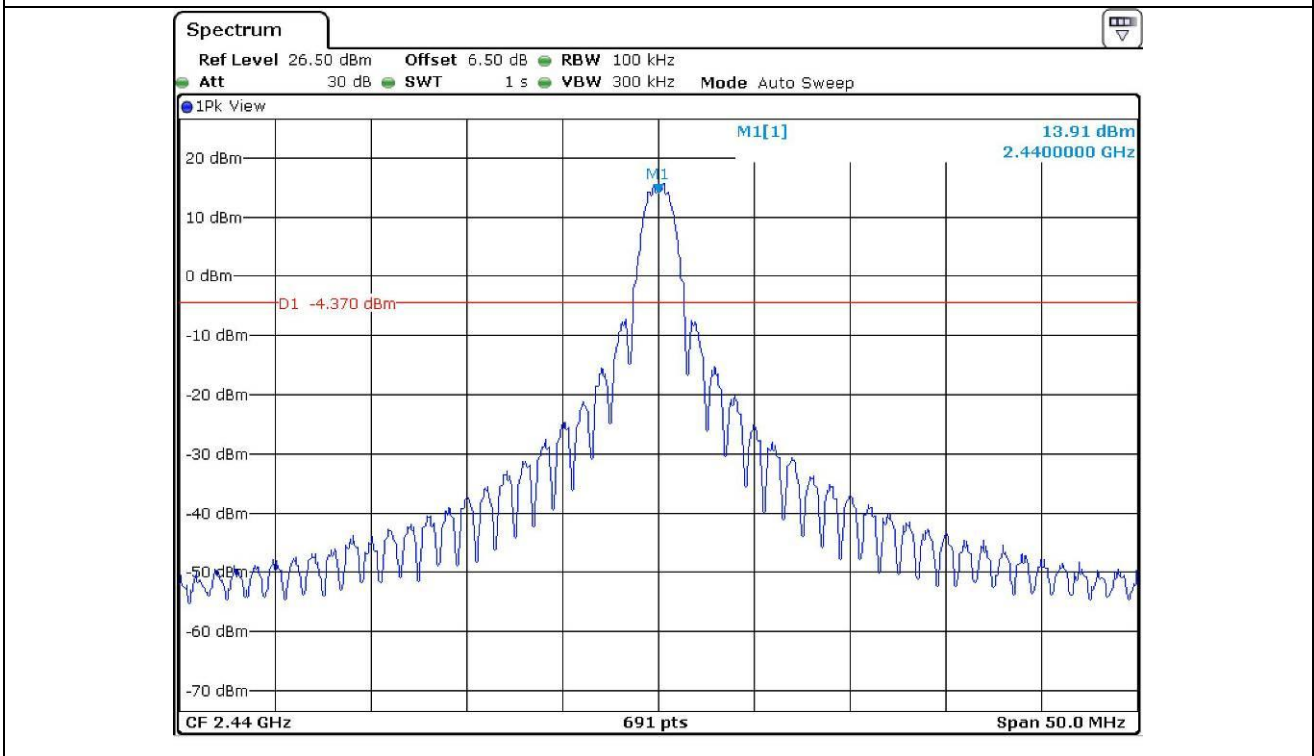
All test equipment used is calibrated on a regular basis.

9.5 Test data for conducted emission

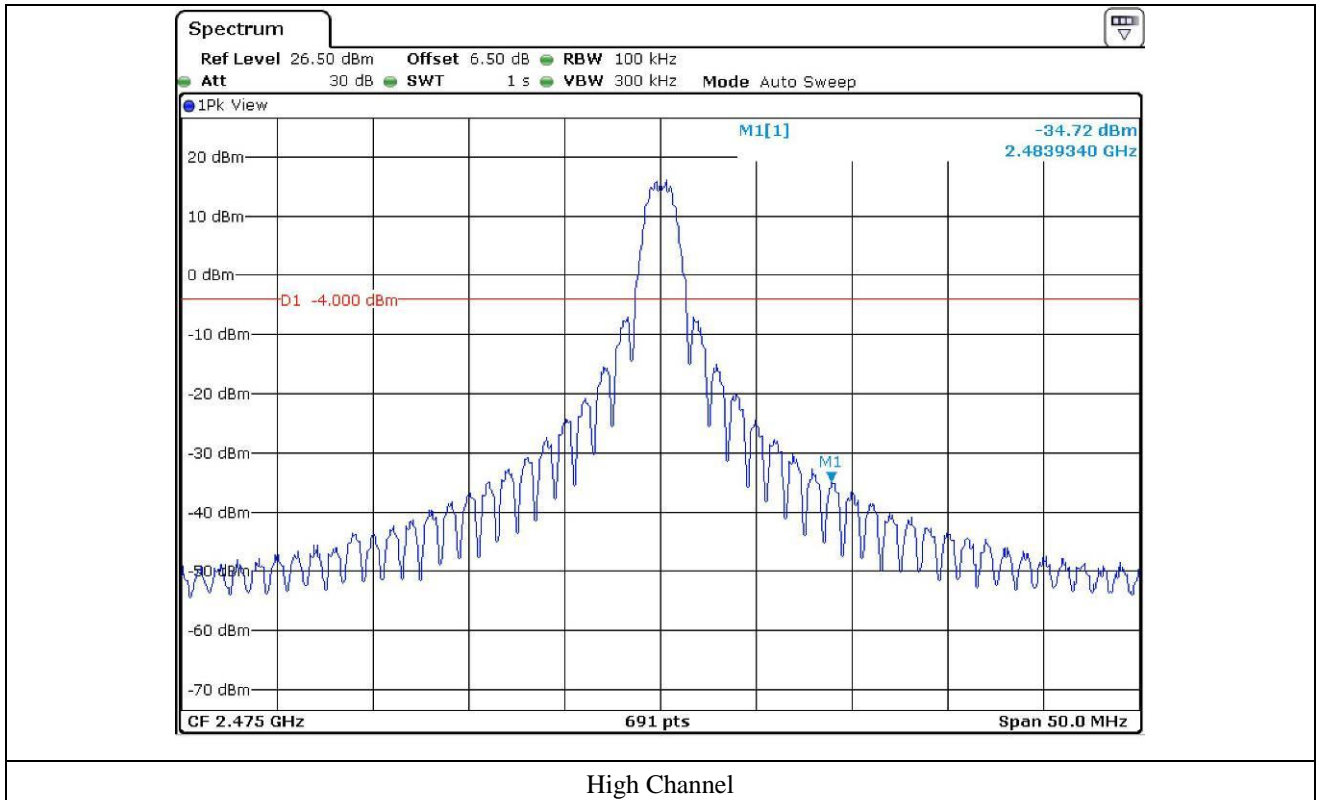
9.5.1 Test data for Antenna 0

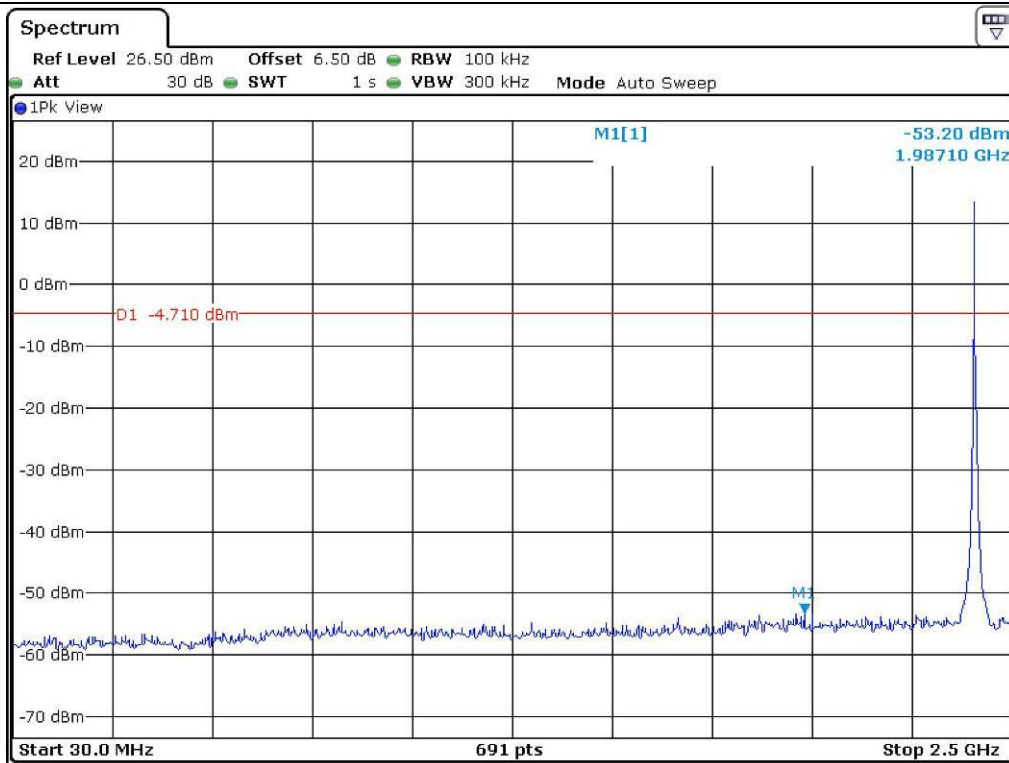


Low Channel

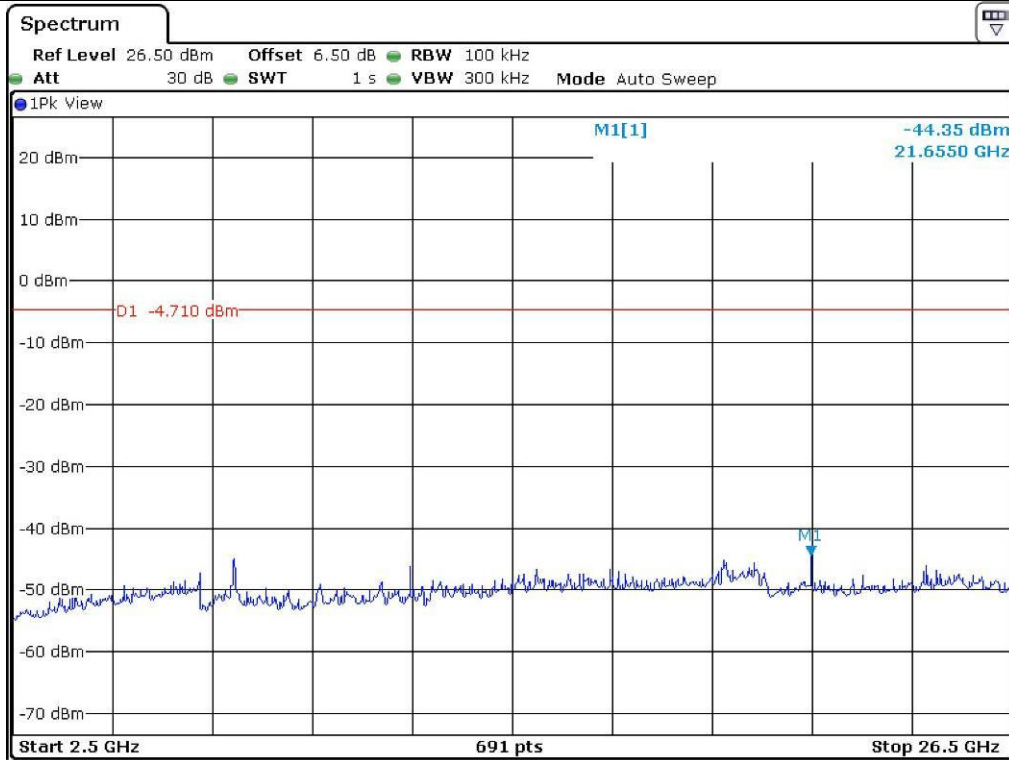


Middle Channel

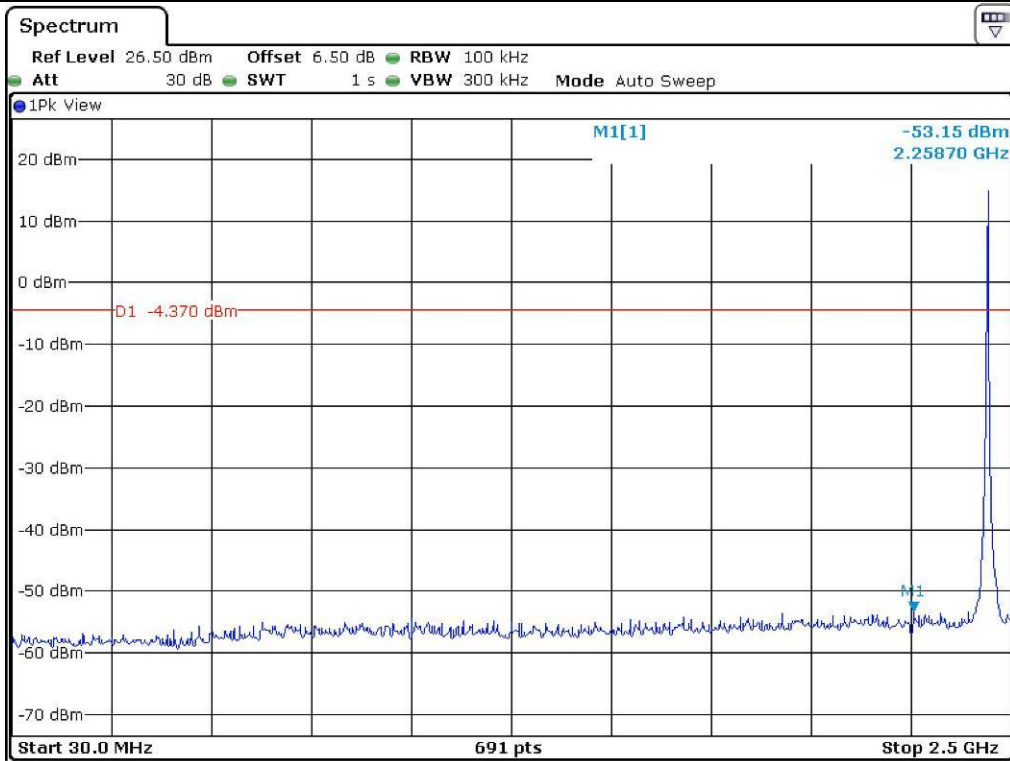




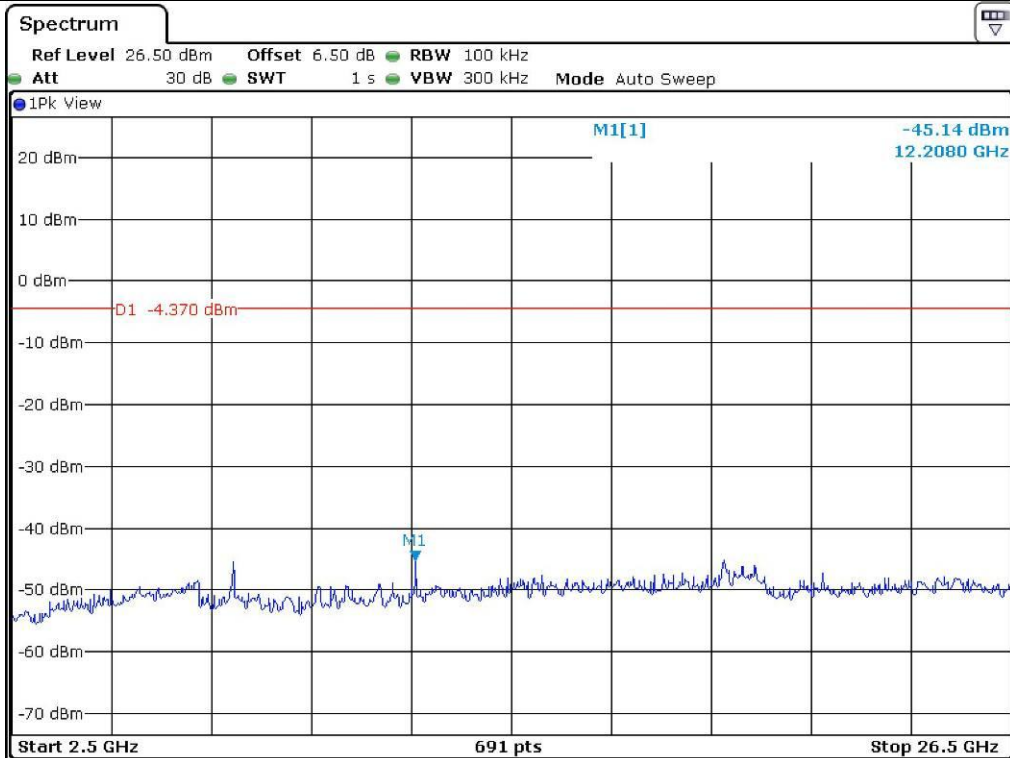
Low Channel



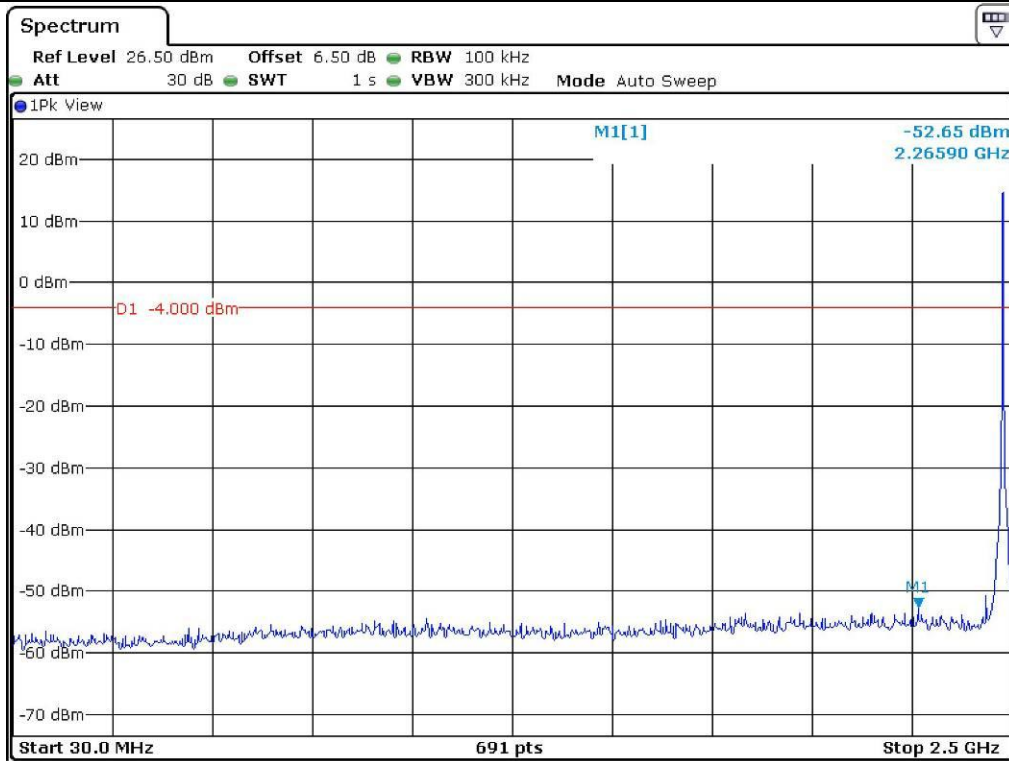
Low Channel



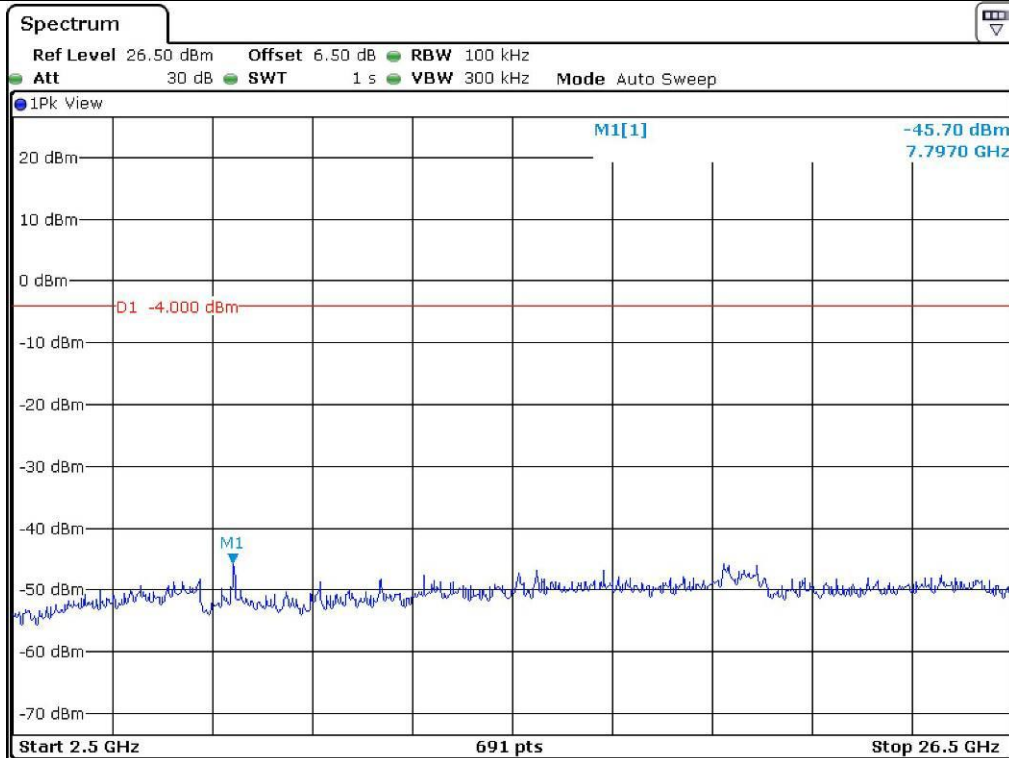
Middle Channel



Middle Channel

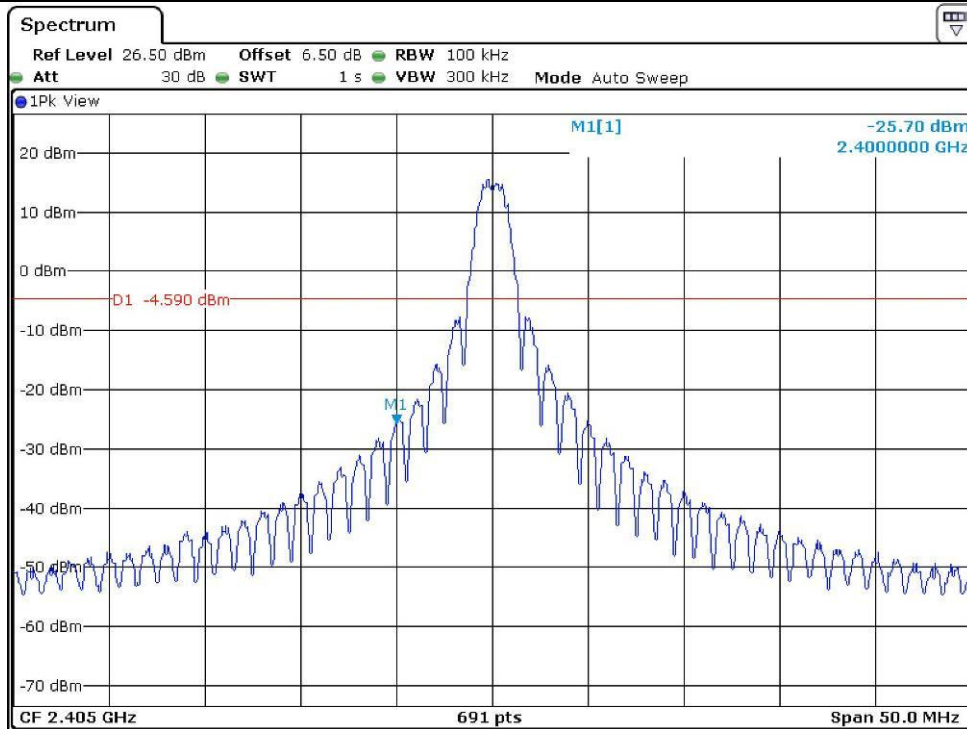


High Channel

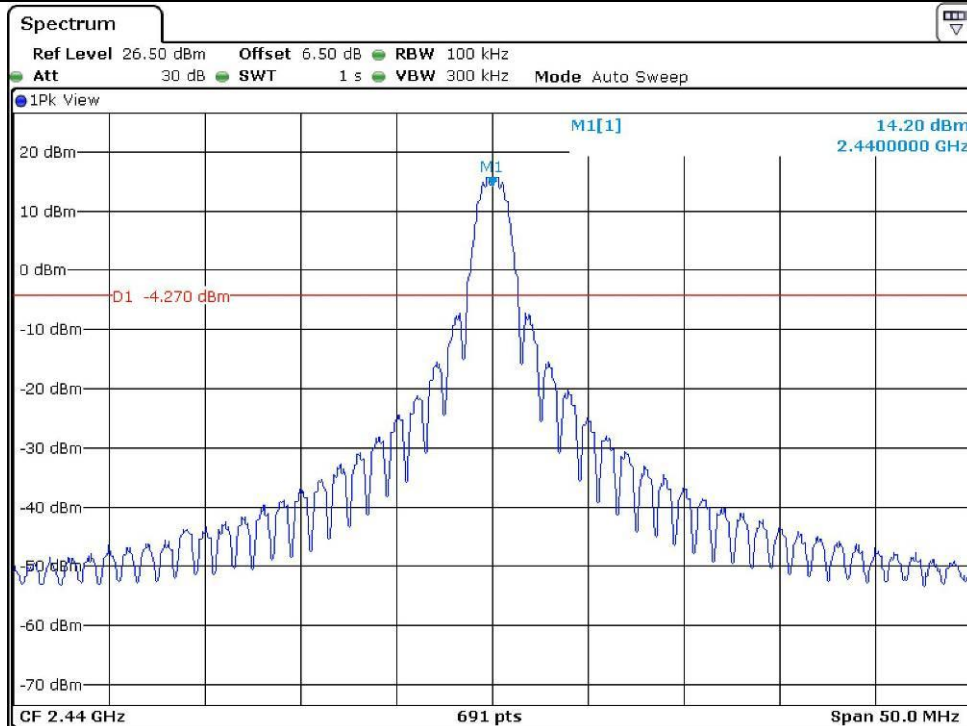


High Channel

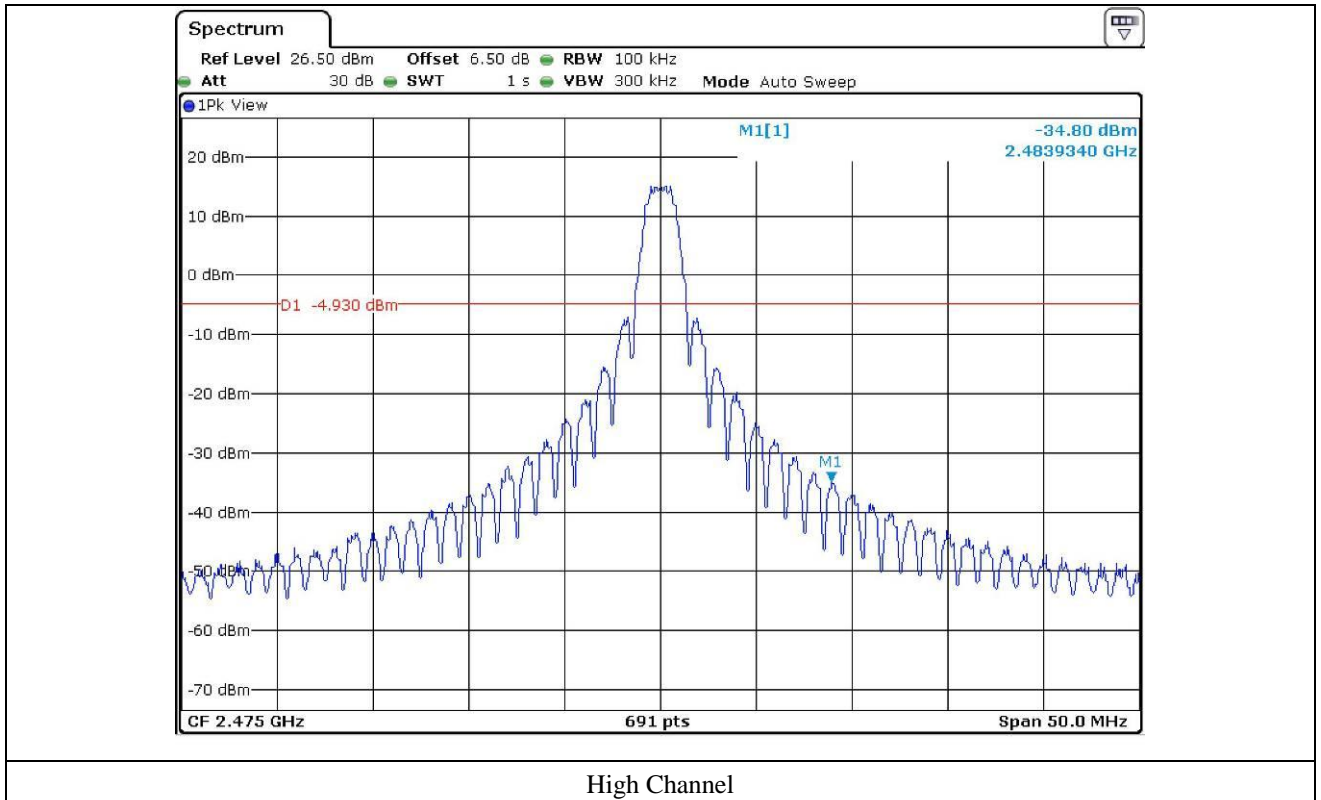
9.5.2 Test data for Antenna 1



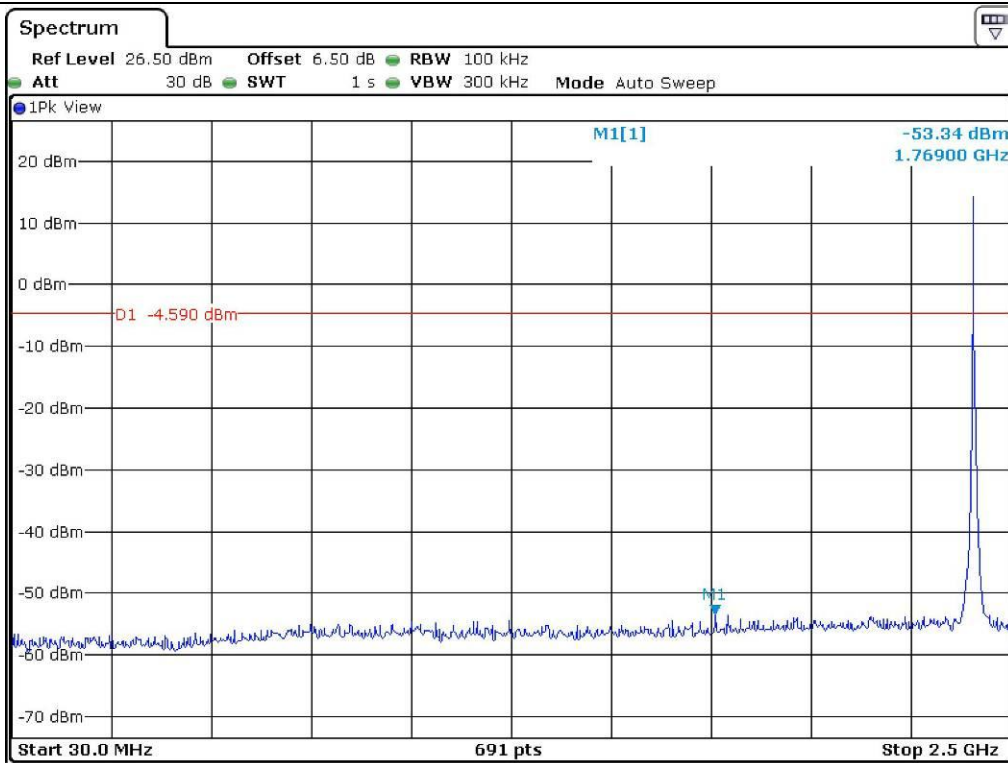
Low Channel



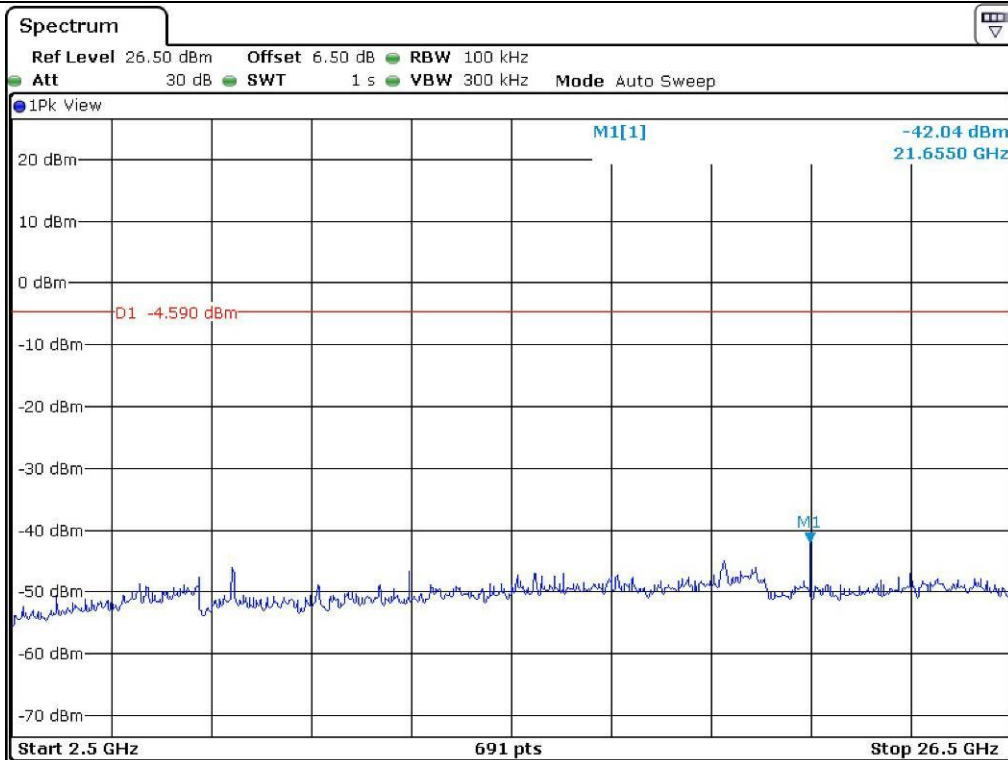
Middle Channel



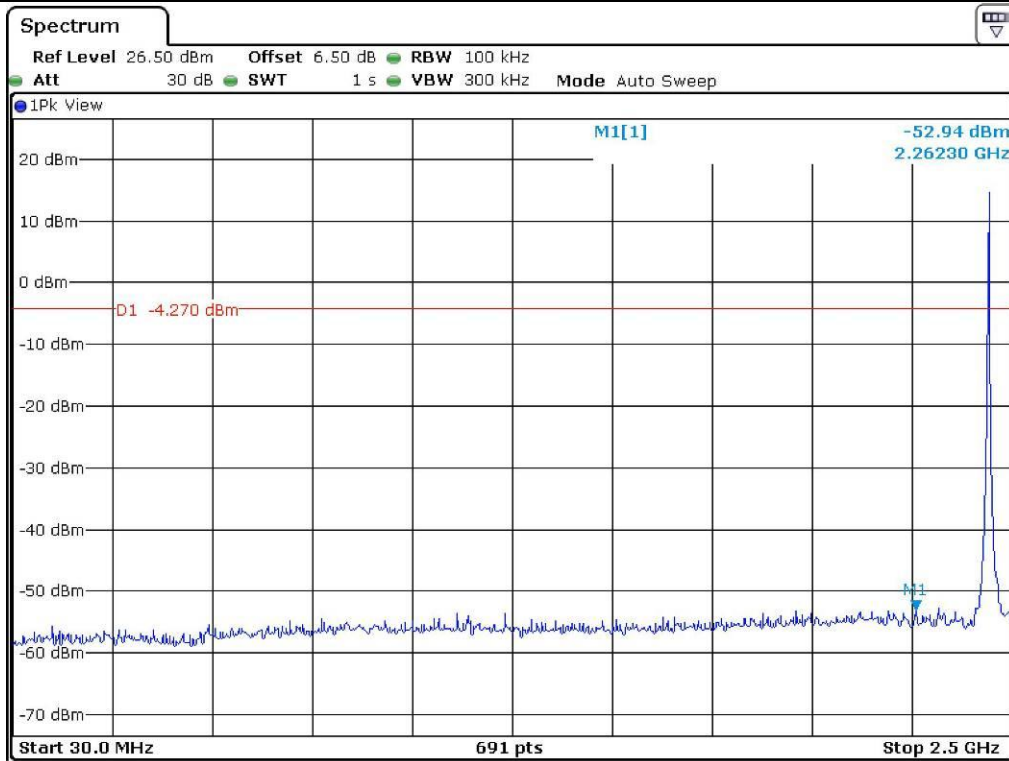
High Channel



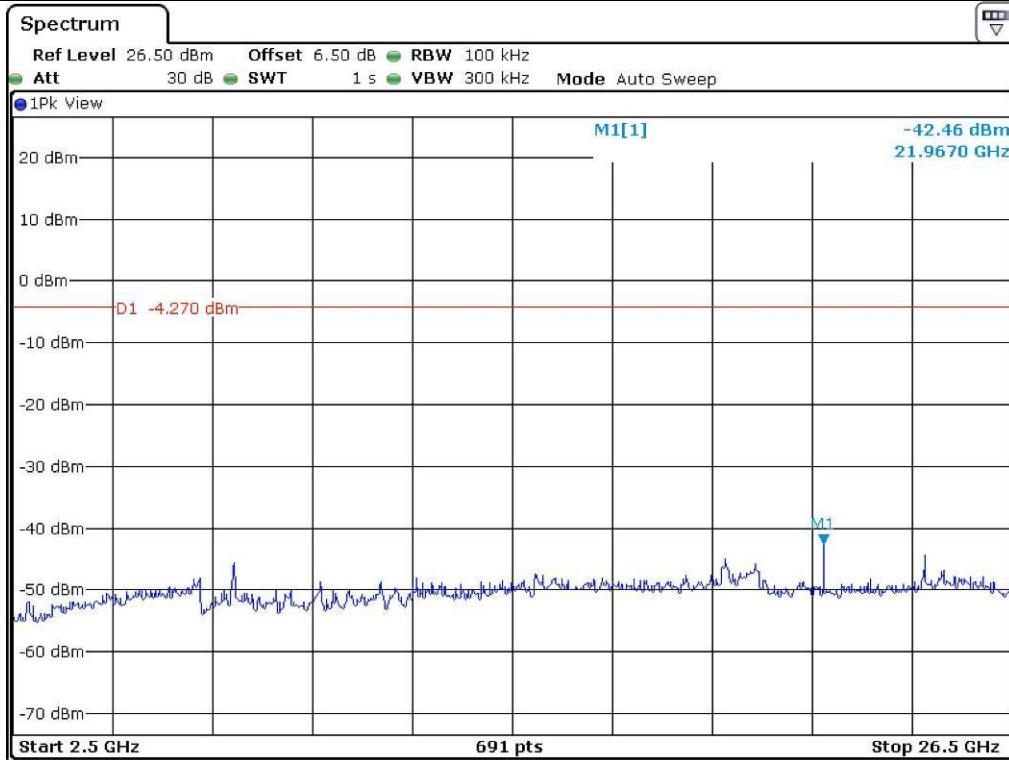
Low Channel



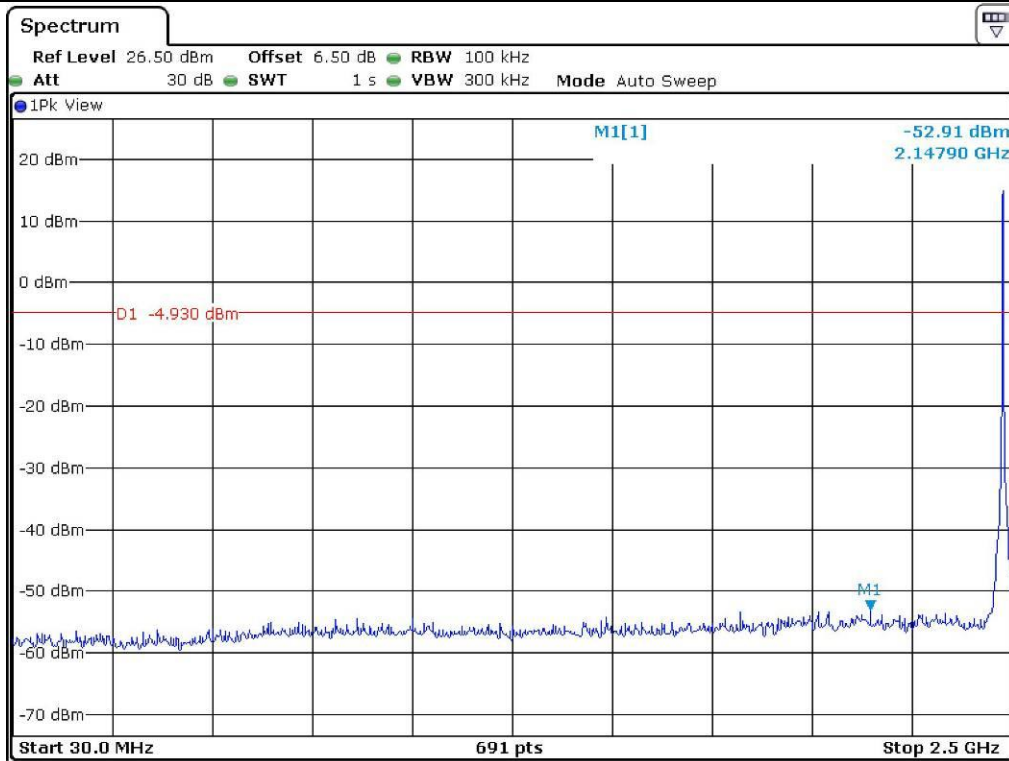
Low Channel



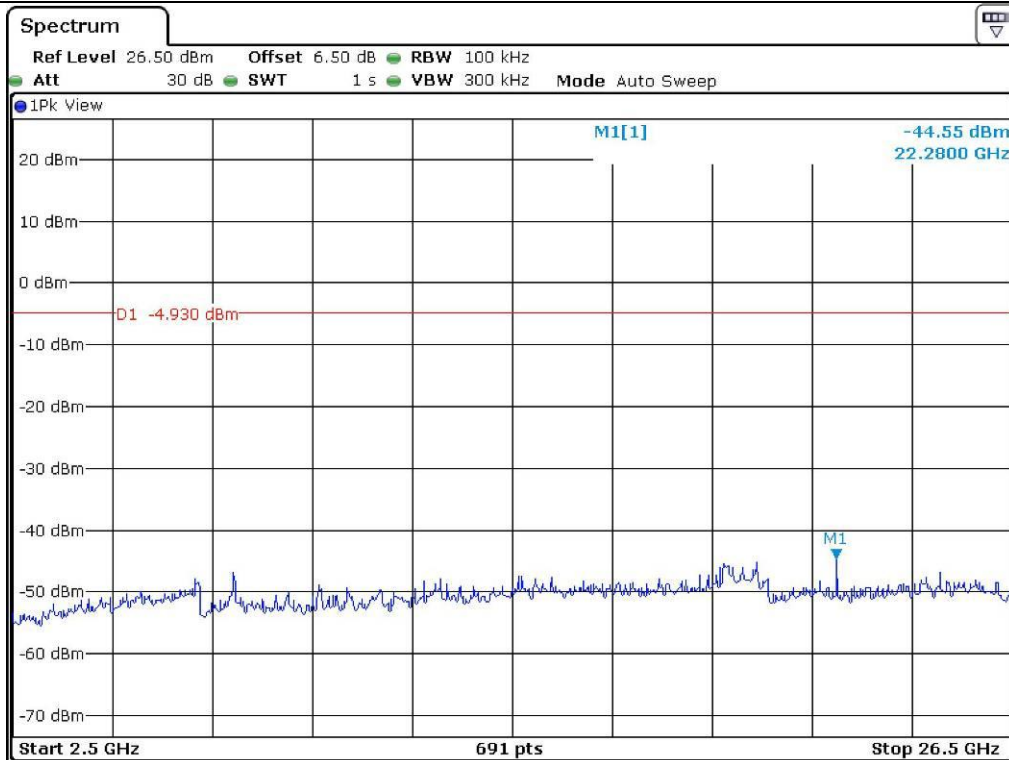
Middle Channel



Middle Channel



High Channel



High Channel

9.6 Test data for radiated emission

9.6.1 Radiated Emission which fall in the Restricted Band

9.6.1.1 Test data for Antenna 0

- . Test Date : June 18, 2014
- . Resolution bandwidth : 100 kHz for Peak and Average Mode at 30 MHz ~ 1 GHz
1 MHz for Peak and Average Mode at above 1 GHz
- . Video bandwidth : 100 kHz for Peak and Average Mode at 30 MHz ~ 1 GHz
1 MHz for Peak and 10 Hz for Average Mode at above 1 GHz
- . Frequency range : 30 MHz ~ 26.5 GHz
- . Measurement distance : 3 m
- . Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel									
2 398.70	58.80	Peak	H	27.20	7.10	43.10	50.00	74.00	24.00
	46.70	Average	H				37.90	54.00	16.10
2 400.00	47.34	Peak	V				38.54	74.00	35.46
	35.26	Average	V				26.46	54.00	27.54
Test Data for High Channel									
2 483.50	46.96	Peak	H	27.40	7.10	43.10	38.36	74.00	35.64
	30.39	Average	H				21.79	54.00	32.21
2 483.53	43.77	Peak	V				35.17	74.00	38.83
	29.97	Average	V				21.37	54.00	32.63

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical

$$\text{Margin (dB)} = \text{Limits (dB}\mu\text{V/m)} - \text{Total Level (dB}\mu\text{V/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} - \text{Pre-Amplifier Gain}$$



Tested by: Tae-Ho, Kim / Project Engineer

9.6.1.2 Test data for Antenna 1

- . Test Date : June 18, 2014
- . Resolution bandwidth : 1 MHz for Peak and Average Mode
- . Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- . Frequency range : 30 MHz ~ 26.5 GHz
- . Measurement distance : 3 m
- . Result : PASSED

Frequency (MHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel									
2 398.70	58.80	Peak	H	27.20	7.10	43.10	50.00	74.00	24.00
	46.70	Average	H				37.90	54.00	16.10
2 400.00	47.34	Peak	V				38.54	74.00	35.46
	35.26	Average	V				26.46	54.00	27.54
Test Data for High Channel									
2 483.50	46.96	Peak	H	27.40	7.10	43.10	38.36	74.00	35.64
	30.39	Average	H				21.79	54.00	32.21
2 483.53	43.77	Peak	V				35.17	74.00	38.83
	29.97	Average	V				21.37	54.00	32.63

Tabulated test data for Restricted Band

Remark: “H”: Horizontal, “V”: Vertical

$$\text{Margin (dB)} = \text{Limits (dB}\mu\text{V/m)} - \text{Total Level (dB}\mu\text{V/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} - \text{Pre-Amplifier Gain}$$



Tested by: Tae-Ho, Kim / Project Engineer

9.6.2 Spurious & Harmonic Radiated Emission

9.6.2.1 Test data for Antenna 0

- Test Date : June 18, 2014
- Resolution bandwidth : 1 MHz for Peak and Average Mode for the emissions fall in restricted band,
100 kHz for Peak Mode for the emissions outside restricted band
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Result : PASSED

Frequency (GHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel									
2 405.00	87.45	Peak	H	27.20	7.10	43.10	78.65	113.98	35.33
	80.49	Average	H				71.69	93.98	22.29
	77.42	Peak	V				68.62	113.98	45.36
	71.86	Average	V				63.06	93.98	30.92
4 810.00	57.31	Peak	H	31.10	9.60	42.40	55.61	73.98	18.37
	50.12	Average	H				48.42	53.98	5.56
	58.61	Peak	V				56.91	73.98	17.07
	50.61	Average	V				48.91	53.98	5.07
Test Data for Middle Channel									
2 440.00	94.24	Peak	H	27.30	7.10	43.10	85.54	113.98	28.44
	85.89	Average	H				77.19	93.98	16.79
	93.65	Peak	V				84.95	113.98	29.03
	84.33	Average	V				75.63	93.98	18.35
4 880.00	62.14	Peak	H	31.30	9.80	42.40	60.84	73.98	13.14
	46.08	Average	H				44.78	53.98	9.20
	59.04	Peak	V				57.74	73.98	16.24
	43.58	Average	V				42.28	53.98	11.70

Test Data for High Channel									
2 475.00	94.22	Peak	H	27.30	7.10	43.10	85.52	113.98	28.46
	85.45	Average	H				76.75	93.98	17.23
	92.47	Peak	V				83.77	113.98	30.21
	83.76	Average	V				75.06	93.98	18.92
4 950.00	62.68	Peak	H	31.30	9.90	42.30	61.58	73.98	12.40
	45.77	Average	H				44.67	53.98	9.31
	58.35	Peak	V				57.25	73.98	16.73
	42.43	Average	V				41.33	53.98	12.65

Tabulated test data for Restricted Band

Remark: “H”: Horizontal, “V”: Vertical

$$\text{Margin (dB)} = \text{Limits (dB}\mu\text{V/m)} - \text{Total Level (dB}\mu\text{V/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} - \text{Pre-Amplifier Gain}$$



Tested by: Tae-Ho, Kim / Project Engineer

9.6.2.2 Test data for Antenna 1

- Test Date : June 18, 2014
- Resolution bandwidth : 1 MHz for Peak and Average Mode for the emissions fall in restricted band,
100 kHz for Peak Mode for the emissions outside restricted band
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Result : PASSED

Frequency (GHz)	Reading (dBμV)	Detector Mode	Ant. Pol. (H/V)	Ant. Factor	Cable Loss	Amp Gain	Total (dBμV/m)	Limits (dBμV/m)	Margin (dB)
Test Data for Low Channel									
2 405.00	87.45	Peak	H	27.20	7.10	43.10	78.65	113.98	35.33
	80.49	Average	H				71.69	93.98	22.29
	77.42	Peak	V				68.62	113.98	45.36
	71.86	Average	V				63.06	93.98	30.92
4 810.00	57.31	Peak	H	31.10	9.60	42.40	55.61	73.98	18.37
	50.12	Average	H				48.42	53.98	5.56
	58.61	Peak	V				56.91	73.98	17.07
	50.61	Average	V				48.91	53.98	5.07
Test Data for Middle Channel									
2 440.00	94.24	Peak	H	27.30	7.10	43.10	85.54	113.98	28.44
	85.89	Average	H				77.19	93.98	16.79
	93.65	Peak	V				84.95	113.98	29.03
	84.33	Average	V				75.63	93.98	18.35
4 880.00	62.14	Peak	H	31.30	9.80	42.40	60.84	73.98	13.14
	46.08	Average	H				44.78	53.98	9.20
	59.04	Peak	V				57.74	73.98	16.24
	43.58	Average	V				42.28	53.98	11.70

Test Data for High Channel									
2 475.00	94.22	Peak	H	27.30	7.10	43.10	85.52	113.98	28.46
	85.45	Average	H				76.75	93.98	17.23
	92.47	Peak	V				83.77	113.98	30.21
	83.76	Average	V				75.06	93.98	18.92
4 950.00	62.68	Peak	H	31.30	9.90	42.30	61.58	73.98	12.40
	45.77	Average	H				44.67	53.98	9.31
	58.35	Peak	V				57.25	73.98	16.73
	42.43	Average	V				41.33	53.98	12.65

Tabulated test data for Restricted Band

Remark: "H": Horizontal, "V": Vertical

$$\text{Margin (dB)} = \text{Limits (dB}\mu\text{V/m)} - \text{Total Level (dB}\mu\text{V/m)}$$

$$\text{Total Level} = \text{Reading} + \text{Antenna Factor} + \text{Cable Loss} - \text{Pre-Amplifier Gain}$$



Tested by: Tae-Ho, Kim / Project Engineer

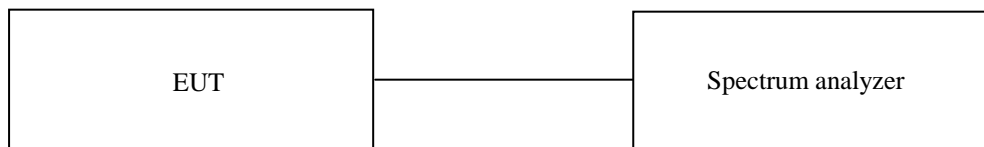
10 PEAK POWER SPECTRUL DENSITY

10.1 Operating environment

Temperature : 25 °C
Relative humidity : 44 % R.H.

10.2 Test set-up

The antenna output of the EUT was connected to the spectrum analyzer. The resolution bandwidth is set to 3 kHz, the video bandwidth is set to 3 times the resolution bandwidth. The maximum level form the EUT in 3 kHz bandwidth was measured with above condition.



10.3 Test equipment used

Model Number	Manufacturer	Description	Serial Number	Last Cal.
■ - FSV30	R/S	Spectrum Analyzer	101372	Apr. 28, 2014(1Y)

All test equipment used is calibrated on a regular basis.

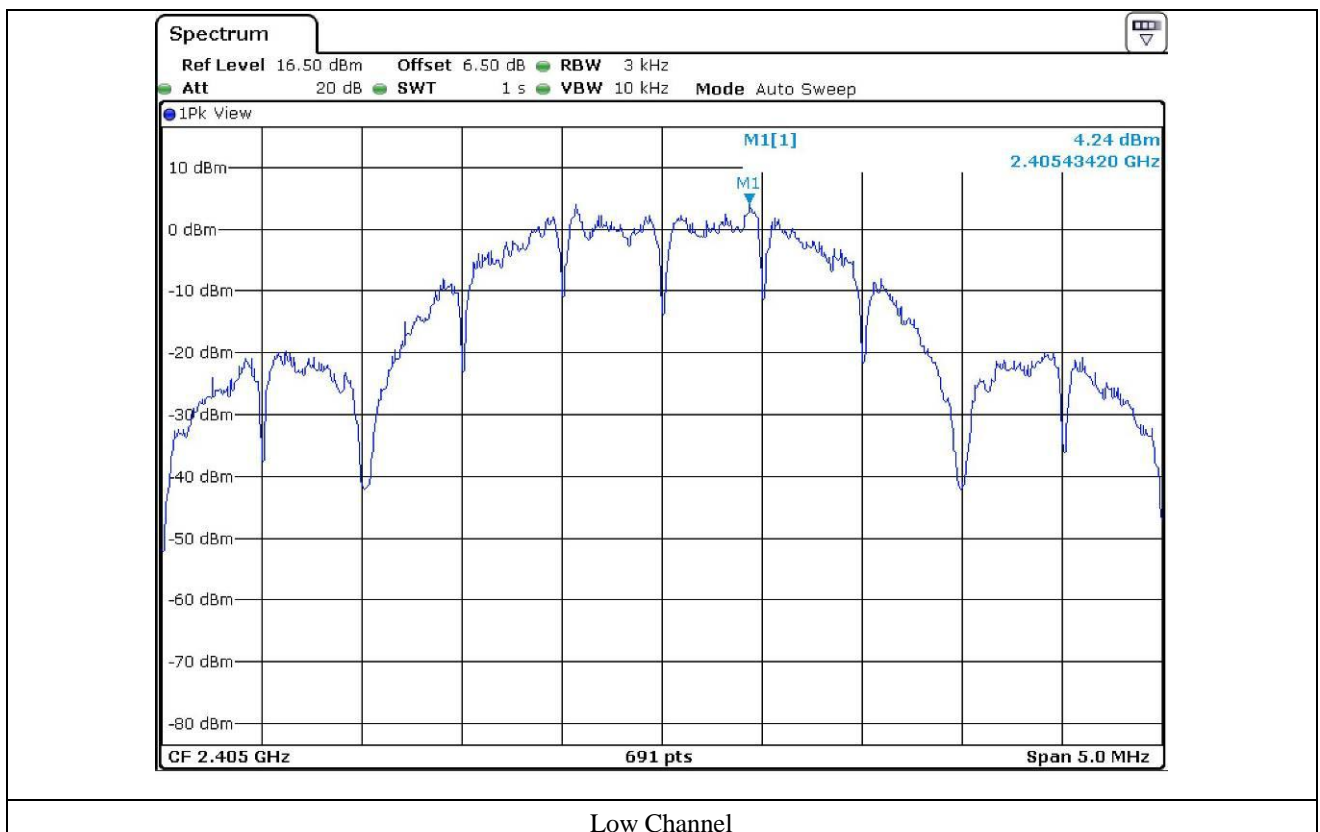
10.4 Test data for Antenna 0

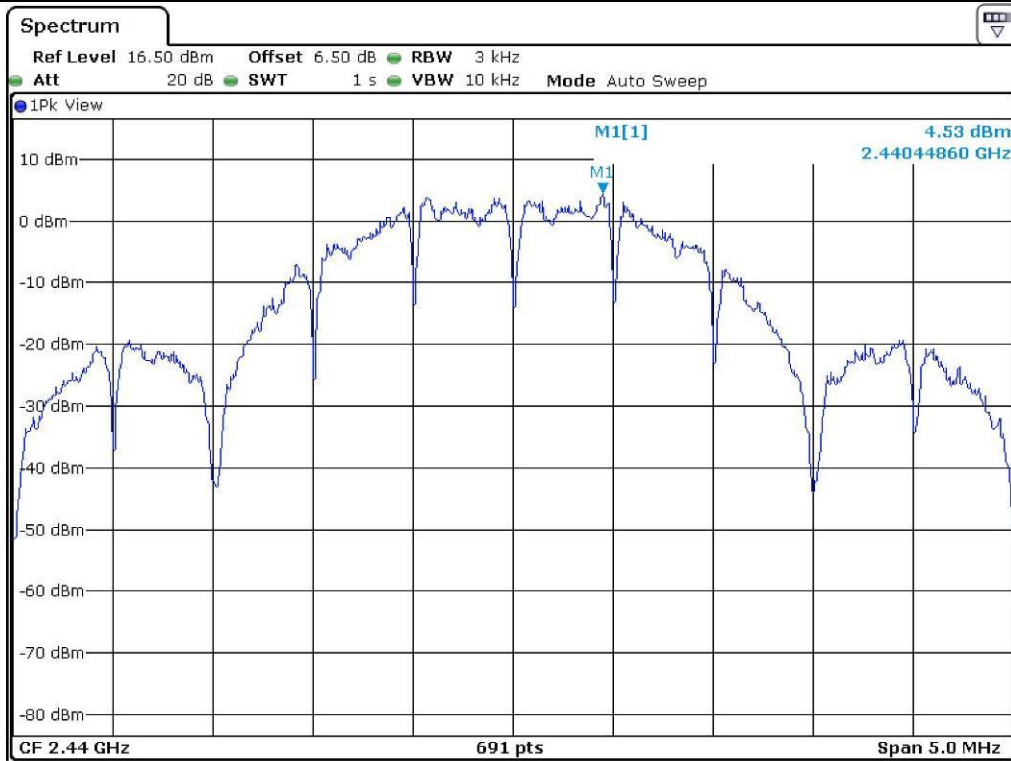
- Test Date : June 19, 2014
- Test Result : Pass
- Operating Condition : Continuous transmitting mode

CHANNEL	FREQUENCY(MHz)	MEASURED VLAUE (dBm)	LIMIT (dBm)	MARGIN (dB)
Low	2 405	4.24	8.00	3.76
Middle	2 440	4.53	8.00	3.47
High	2 475	4.13	8.00	3.87

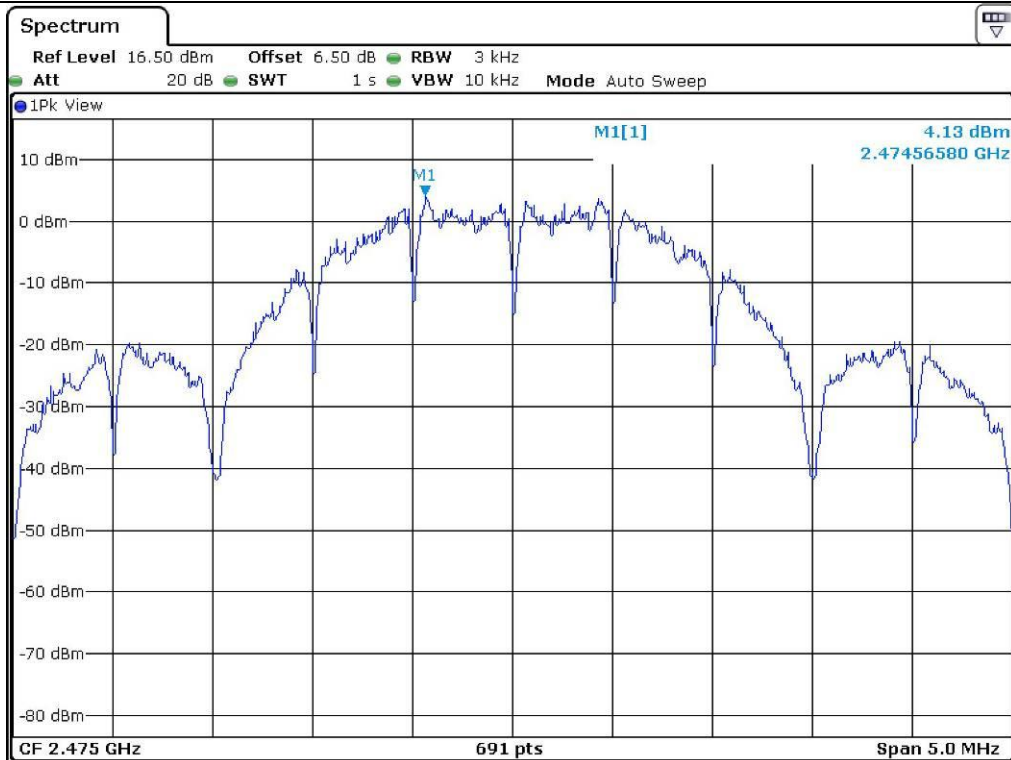
Remark. Margin = Limit – Measured value

Tested by: Tae-Ho, Kim / Project Engineer





Middle Channel



High Channel

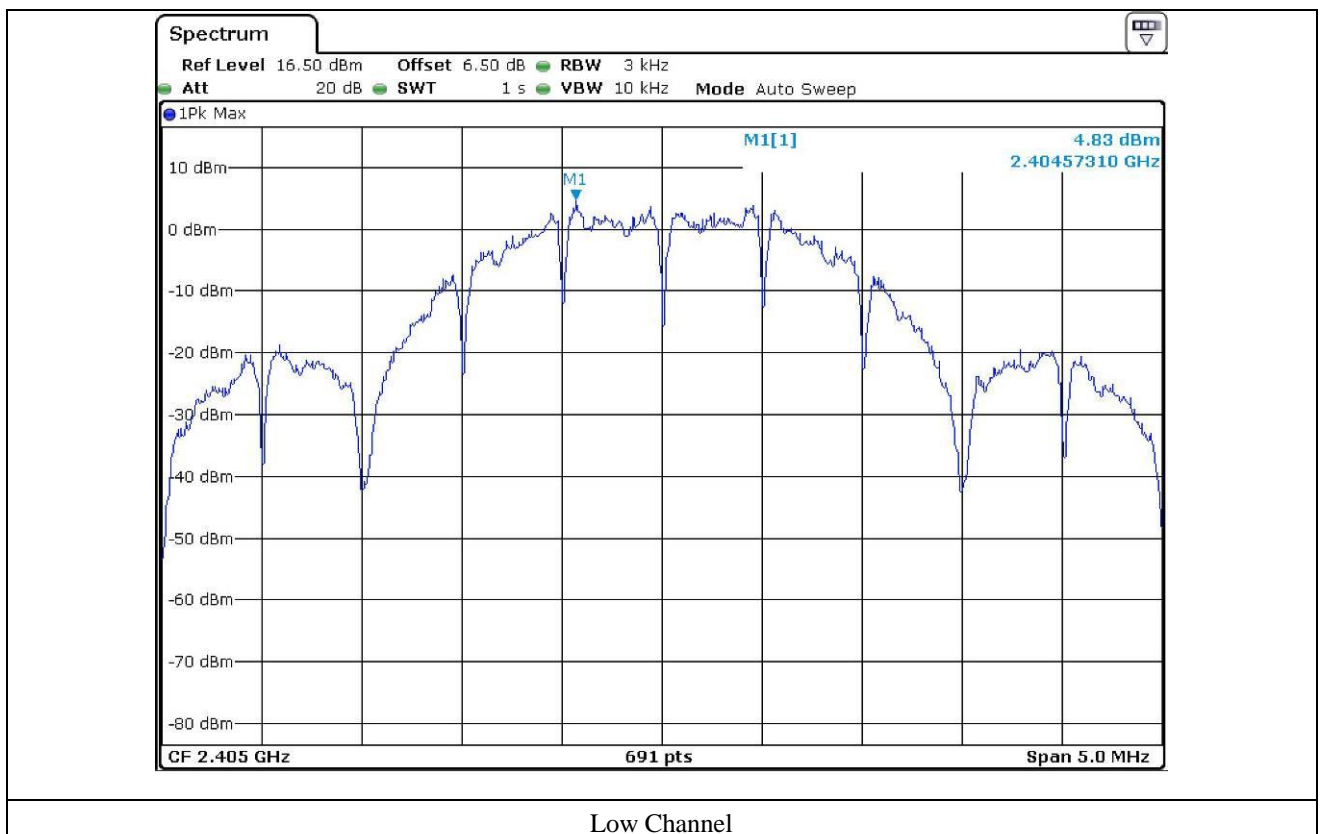
10.5 Test data for Antenna 1

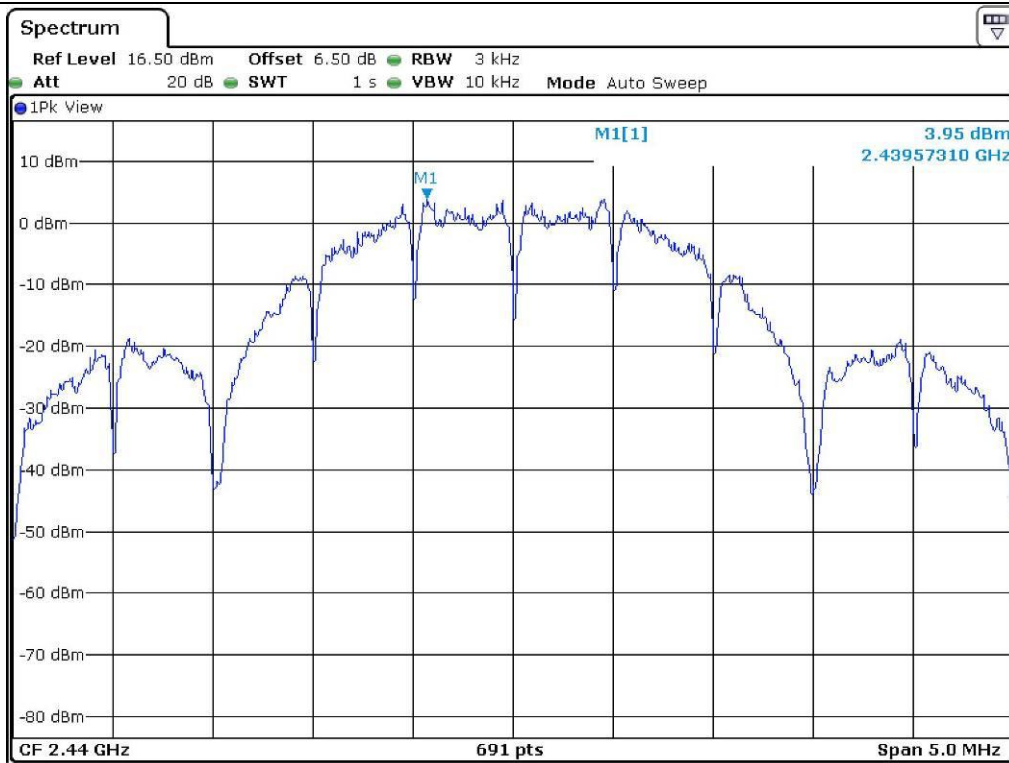
- Test Date : June 19, 2014
- Test Result : Pass
- Operating Condition : Continuous transmitting mode

CHANNEL	FREQUENCY(MHz)	MEASURED VLAUE (dBm)	LIMIT (dBm)	MARGIN (dB)
Low	2 405	4.83	8.00	3.17
Middle	2 440	3.95	8.00	4.05
High	2 475	4.63	8.00	3.37

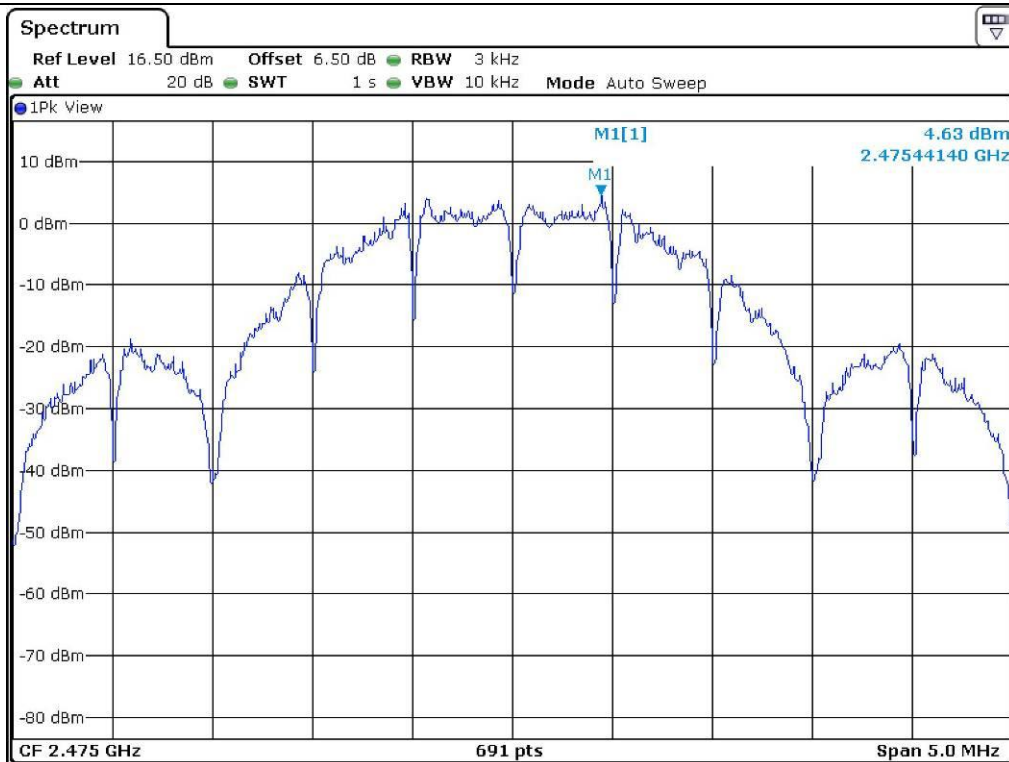
Remark. Margin = Limit – Measured value

Tested by: Tae-Ho, Kim / Project Engineer





Middle Channel



High Channel

11. RADIATED EMISSION TEST

11.1 Operating environment

Temperature : 22 °C
Relative humidity : 41 % R.H.

11.2 Test set-up

The radiated emissions measurements were on the 3 meters, open-field test site. The EUT and other support equipment were placed on a non-conductive turntable above the ground plane. The interconnecting cables from outside test site were inserted into ferrite clamps at the point where the cables reach the turntable.

The frequency spectrum from 9 kHz to 26.5 GHz was scanned and emission levels maximized at each frequency recorded. The system was rotated 360°, and the antenna was varied in height between 1.0 and 4.0 meters in order to determine the maximum emission levels. This procedure was performed for both horizontal and vertical polarization of the receiving antenna.

11.3 Test equipment used

	Model Number	Manufacturer	Description	Serial Number	Last Cal.(Interval)
□ -	ESCI	Rohde & Schwarz	EMI Test Receiver	101012	Nov. 18, 2013(1Y)
■ -	ESU	Rohde & Schwarz	EMI Test Receiver	100261	Apr. 29, 2014(1Y)
■ -	310N	Sonoma Instrument	AMPLIFIER	312544	Apr. 28, 2014(1Y)
■ -	FSV30	Rohde & Schwarz	Signal Analyzer	101372	Apr. 28, 2014(1Y)
■ -	SCU-18	Rohde & Schwarz	PRE-AMPLIFIER	10041	Jan. 20, 2014(1Y)
■ -	MA220	HD	Turn Table	N/A	N/A
■ -	HD240	HD	Antenna Mast	N/A	N/A
■ -	VULB9163	Schwarzbeck	TRILOG Broadband Antenna	VULB9163-255	May 05, 2014(2Y)
■ -	BBHA9120D	Schwarzbeck	Horn Antenna	BBHA9120D295	Sep. 05, 2013 (2Y)
■ -	83051A	Agilent	Microwave System Preamplifier	3950M00201	Apr. 30, 2014(1Y)
■ -	BBHA9170	Schwarzbeck	Horn Antenna	BBHA9170178	N/A
■ -	HFH2-Z2	Rohde & Schwarz	Loop Antenna	889 285 / 26	Dec. 11, 2012 (2Y)

All test equipment used is calibrated on a regular basis.

11.4 Test data for Antenna 0

11.4.1 Test data for Below 30 MHz

- Test Date : June 20, 2014
- Resolution bandwidth : 200 Hz (from 9 kHz to 0.15 MHz), 9 kHz (from 0.15 MHz to 30 MHz)
- Frequency range : 9 kHz ~ 30 MHz
- Measurement distance : 3 m
- Operating mode : Transmitting mode

Frequency (MHz)	Reading (dBμV)	Ant. Pol. (H/V)	Ant. Height (m)	Angle (°)	Ant. Factor (dB/m)	Cable Loss	Emission Level(dBμV/m)	Limits (dBμV/m)	Margin (dB)
It was not observed any emissions from the EUT.									

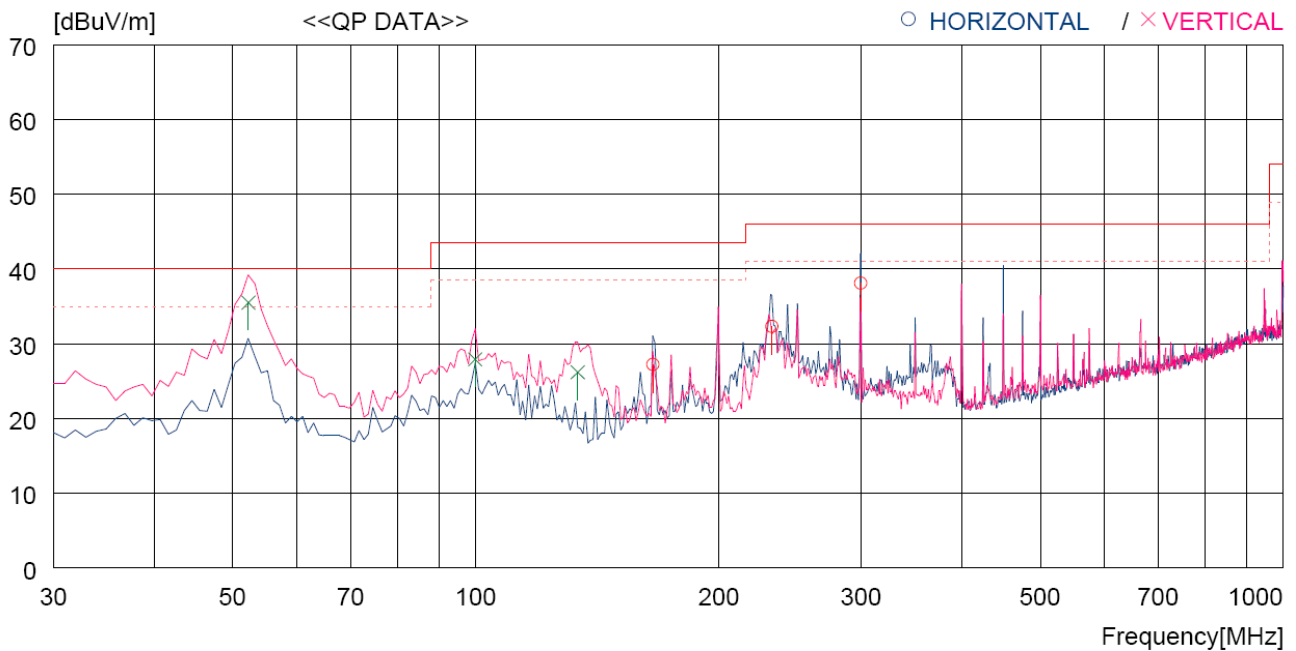


Tested by: Tae-Ho, Kim / Project Engineer

11.4.2 Test data for 30 MHz ~ 1 000 MHz

- Test Date : June 20, 2014
- Resolution bandwidth : 120 kHz
- Frequency range : 30 MHz ~ 1 000 MHz
- Measurement distance : 3 m
- Operating mode : Transmitting mode

Operating condition : Low Channel

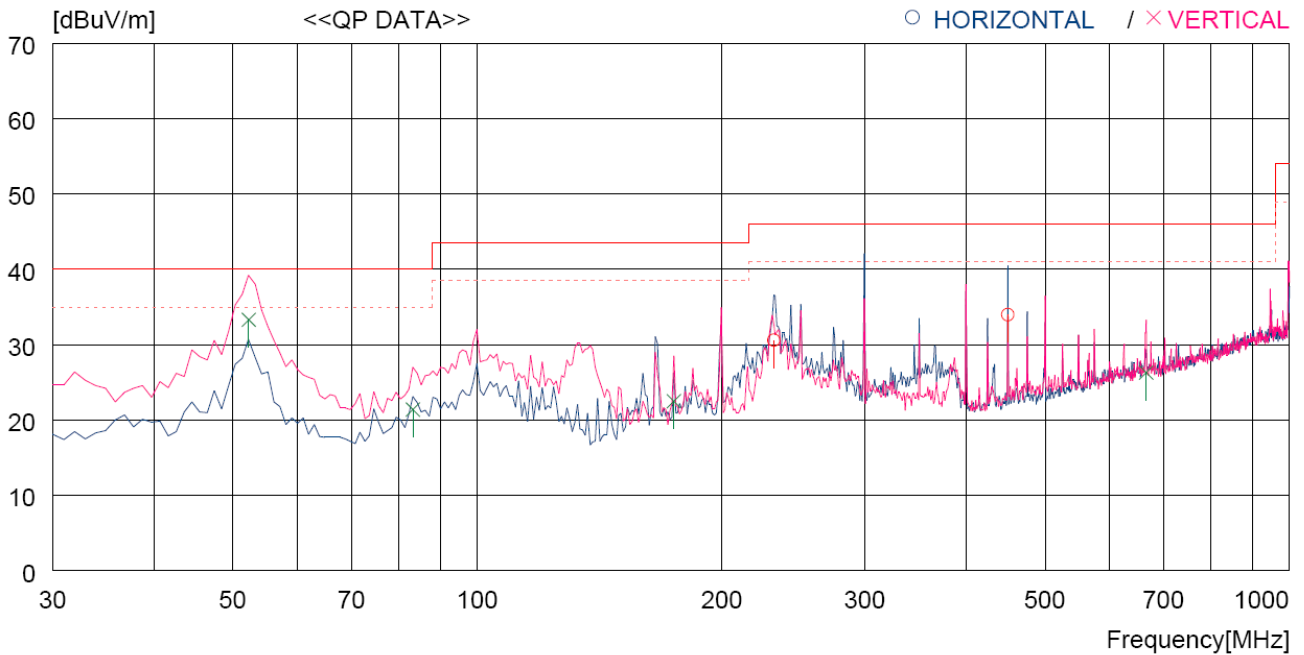


No.	FREQ [MHz]	READING QP [dBuV]	ANT FACTOR [dB]	LOSS [dB]	GAIN [dB]	RESULT [dBuV/m]	LIMIT [dBuV/m]	MARGIN [dB]	ANTENNA [cm]	TABLE [DEG]
----- Horizontal -----										
1	165.800	42.1	9.5	8.6	33.0	27.2	43.5	16.3	200	359
2	232.730	43.1	13.1	9.1	33.0	32.3	46.0	13.7	100	47
3	299.660	46.8	14.8	9.5	33.0	38.1	46.0	7.9	100	0
----- Vertical -----										
4	52.310	46.4	14.9	7.4	33.2	35.5	40.0	4.5	100	359
5	99.840	39.4	13.6	8.0	33.1	27.9	43.5	15.6	100	47
6	133.790	41.2	9.9	8.2	33.1	26.2	43.5	17.3	100	359

Remark: Margin (dB) = Limit – Result and Result = Reading Quasi- Peak + Antenna Factor + Loss – Gain

Loss and Gain in above table means Cable Loss and Pre-amplifier gain.

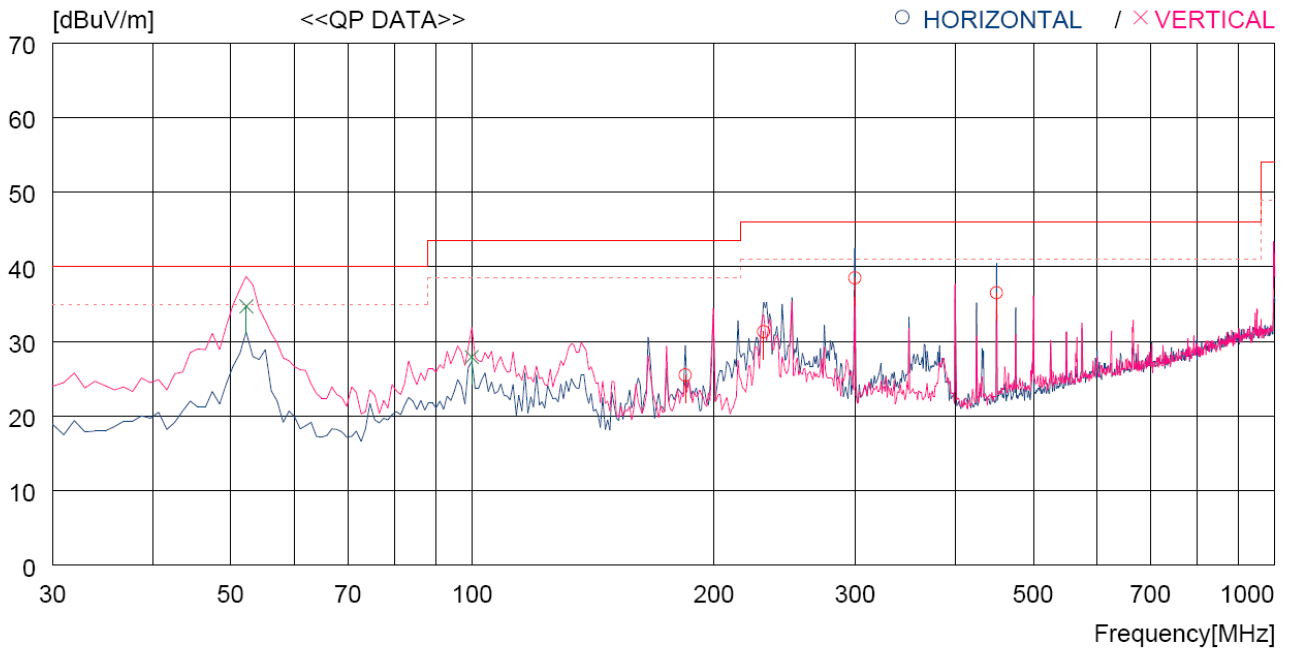
Operating condition : Middle Channel



No.	FREQ [MHz]	READING QP [dBuV]	ANT FACTOR [dB]	LOSS [dB]	GAIN [dB]	RESULT [dBuV/m]	LIMIT [dBuV/m]	MARGIN [dB]	ANTENNA [cm]	TABLE [DEG]
----- Horizontal -----										
1	231.760	42.6	11.8	9.1	32.9	30.6	46.0	15.4	100	0
2	450.011	40.1	16.6	10.4	33.1	34.0	46.0	12.0	100	0
----- Vertical -----										
3	52.310	45.3	13.6	7.4	33.0	33.3	40.0	6.7	100	359
4	83.350	38.4	8.3	7.8	33.1	21.4	40.0	18.6	100	61
5	174.530	37.5	9.4	8.6	33.0	22.5	43.5	21.0	100	359
6	666.316	28.7	19.5	11.4	33.3	26.3	46.0	19.7	100	264

Remark: Margin (dB) = Limit – Result and Result = Reading Quasi- Peak + Antenna Factor + Loss – Gain
Loss and Gain in above table means Cable Loss and Pre-amplifier gain.

Operating condition : High Channel



No.	FREQ [MHz]	READING QP [dBuV]	ANT FACTOR [dB]	LOSS [dB]	GAIN [dB]	RESULT [dBuV/m]	LIMIT [dBuV/m]	MARGIN [dB]	ANTENNA [cm]	TABLE [DEG]
----- Horizontal -----										
1	184.230	39.8	9.9	8.7	32.9	25.5	43.5	18.0	100	61
2	230.790	43.3	11.8	9.1	32.9	31.3	46.0	14.7	100	0
3	299.660	48.3	13.6	9.5	32.9	38.5	46.0	7.5	100	0
4	450.011	42.6	16.6	10.4	33.1	36.5	46.0	9.5	100	0
----- Vertical -----										
5	52.310	46.7	13.6	7.4	33.0	34.7	40.0	5.3	100	359
6	99.840	41.1	11.9	8.0	33.1	27.9	43.5	15.6	100	359

Remark: Margin (dB) = Limit – Result and Result = Reading Quasi- Peak + Antenna Factor + Loss – Gain
Loss and Gain in above table means Cable Loss and Pre-amplifier gain.

Tested by: Tae-Ho, Kim / Project Engineer

11.4.3 Test data for above 1 GHz

- Test Date : June 20, 2014
- Resolution bandwidth : 1 MHz for Peak and Average Mode
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Operating mode : Transmitting mode

Frequency (MHz)	Reading (dBμV)	Ant. Pol. (H/V)	Ant. Height (m)	Angle (°)	Ant. Factor (dB/m)	Cable Loss	Emission Level (dBμV/m)	Limits (dBμV/m)	Margin (dB)
It was not observed any emissions from the EUT.									



Tested by: Tae-Ho, Kim / Project Engineer

11.5 Test data for Antenna 1

11.5.2 Test data for Below 30 MHz

- Test Date : June 20, 2014
- Resolution bandwidth : 200 Hz (from 9 kHz to 0.15 MHz), 9 kHz (from 0.15 MHz to 30 MHz)
- Frequency range : 9 kHz ~ 30 MHz
- Measurement distance : 3 m
- Operating mode : Transmitting mode

Frequency (MHz)	Reading (dBμV)	Ant. Pol. (H/V)	Ant. Height (m)	Angle (°)	Ant. Factor (dB/m)	Cable Loss	Emission Level(dBμV/m)	Limits (dBμV/m)	Margin (dB)
It was not observed any emissions from the EUT.									

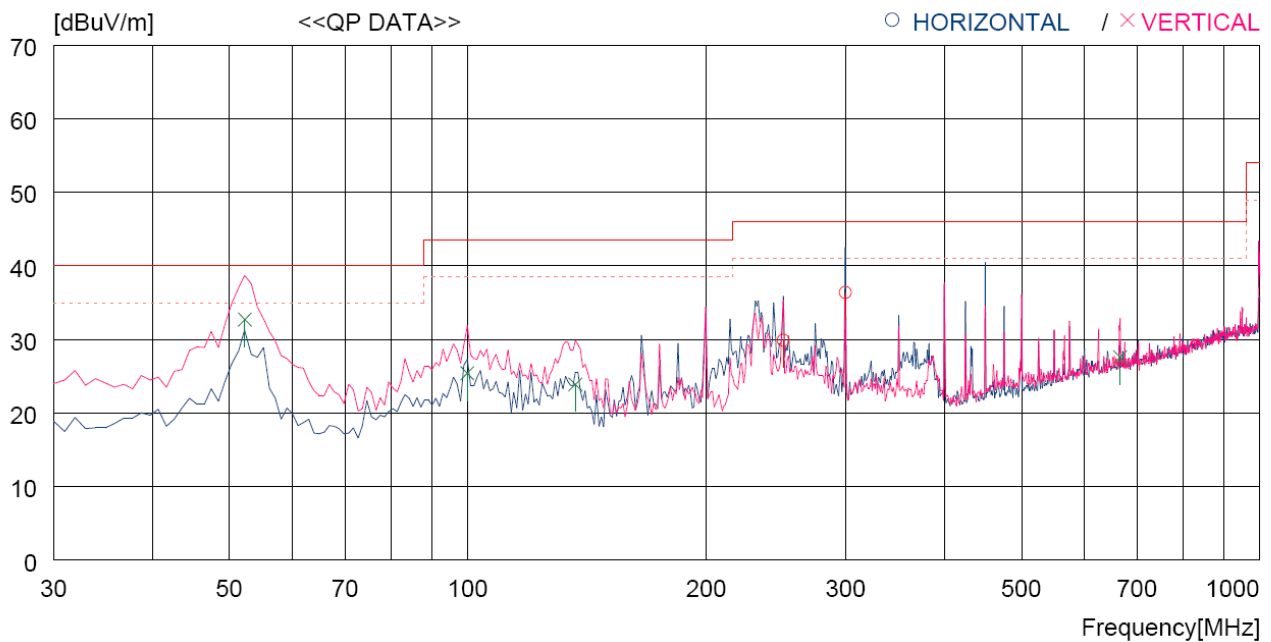


Tested by: Tae-Ho, Kim / Project Engineer

11.5.1 Test data for 30 MHz ~ 1 000 MHz

- Test Date : June 20, 2014
- Resolution bandwidth : 120 kHz
- Frequency range : 30 MHz ~ 1 000 MHz
- Measurement distance : 3 m
- Operating mode : Transmitting mode

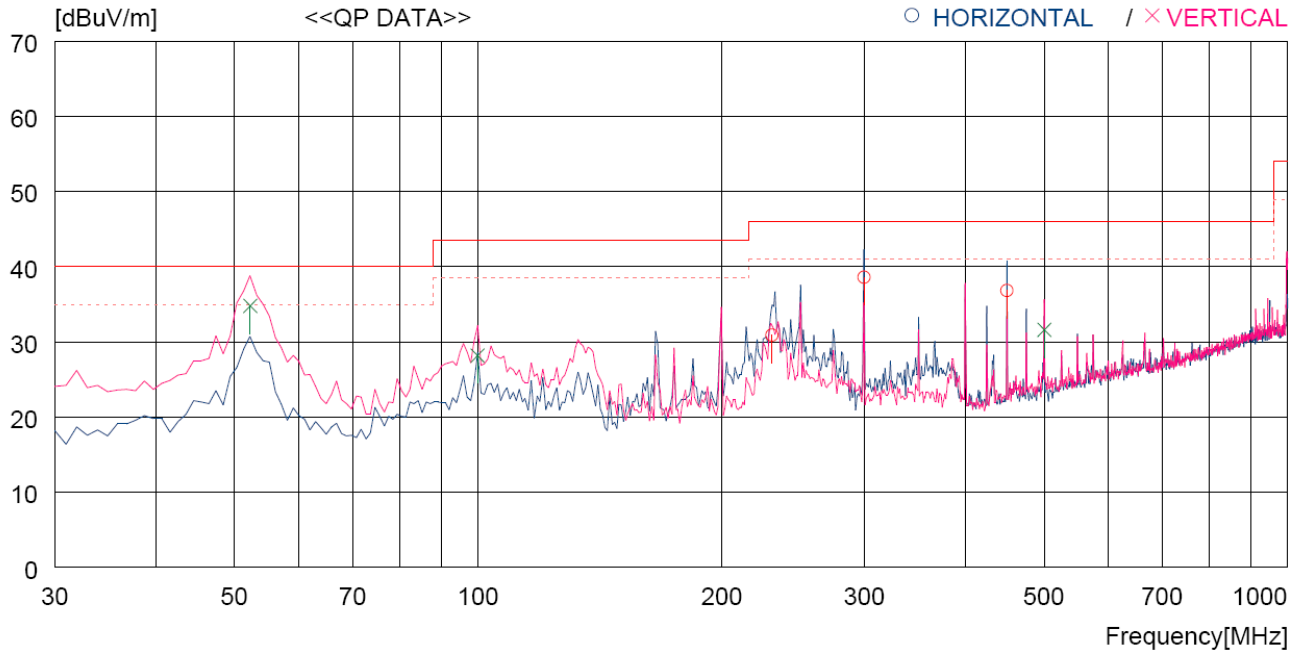
Operating condition : Low Channel



No.	FREQ [MHz]	READING QP [dBuV]	ANT FACTOR [dB]	LOSS [dB]	GAIN [dB]	RESULT [dBuV/m]	LIMIT [dBuV/m]	MARGIN [dB]	ANTENNA [cm]	TABLE [DEG]
----- Horizontal -----										
1	250.190	40.1	13.6	9.2	33.0	29.9	46.0	16.1	100	88
2	299.660	45.1	14.8	9.5	33.0	36.4	46.0	9.6	100	0
----- Vertical -----										
3	52.310	43.6	14.9	7.4	33.2	32.7	40.0	7.3	100	359
4	99.840	36.9	13.6	8.0	33.1	25.4	43.5	18.1	100	359
5	136.700	39.2	9.5	8.3	33.1	23.9	43.5	19.6	100	359
6	666.316	28.9	20.6	11.4	33.3	27.6	46.0	18.4	100	359

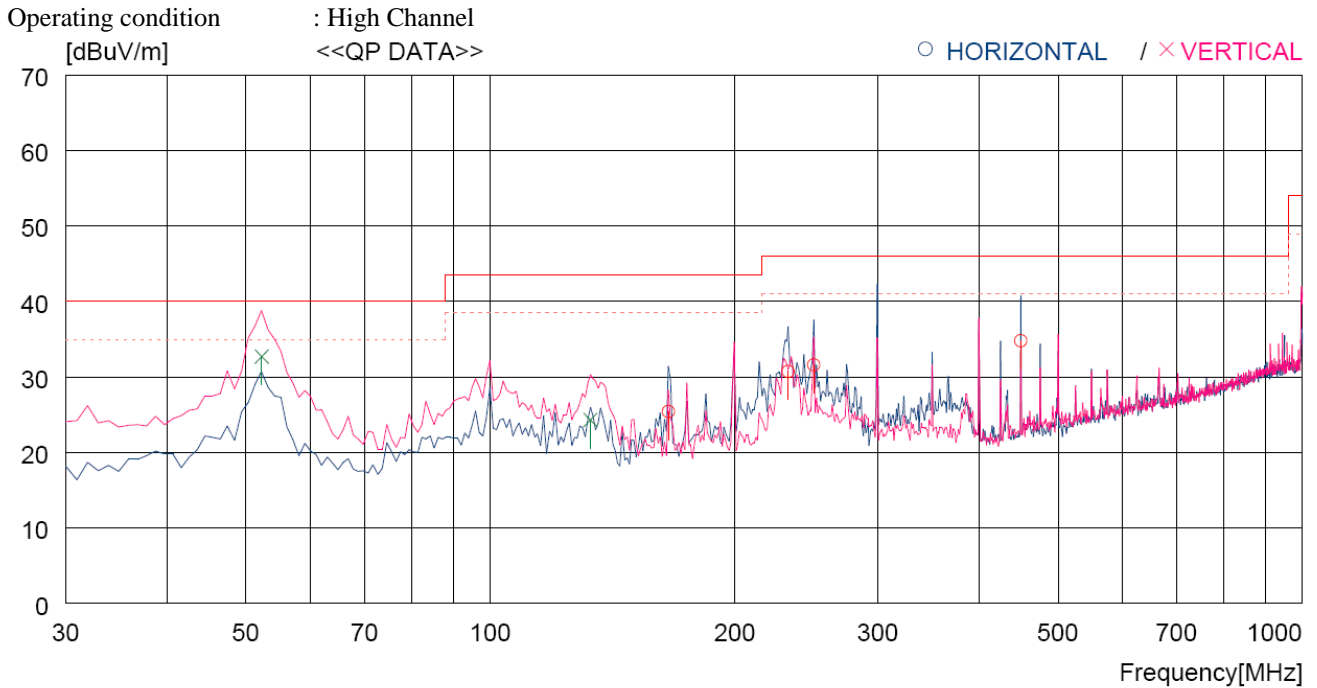
Remark: Margin (dB) = Limit – Result and Result = Reading Quasi- Peak + Antenna Factor + Loss – Gain
Loss and Gain in above table means Cable Loss and Pre-amplifier gain.

Operating condition : Middle Channel



No.	FREQ [MHz]	READING QP [dBuV]	ANT FACTOR [dB]	LOSS [dB]	GAIN [dB]	RESULT [dBuV/m]	LIMIT [dBuV/m]	MARGIN [dB]	ANTENNA [cm]	TABLE [DEG]
----- Horizontal -----										
1	230.790	42.9	11.8	9.1	32.9	30.9	46.0	15.1	100	39
2	299.660	48.4	13.6	9.5	32.9	38.6	46.0	7.4	100	0
3	450.011	42.9	16.6	10.4	33.1	36.8	46.0	9.2	100	334
----- Vertical -----										
4	52.310	46.8	13.6	7.4	33.0	34.8	40.0	5.2	100	39
5	99.840	41.4	11.9	8.0	33.1	28.2	43.5	15.3	100	117
6	500.451	36.9	17.3	10.6	33.2	31.6	46.0	14.4	100	0

Remark: Margin (dB) = Limit – Result and Result = Reading Quasi- Peak + Antenna Factor + Loss – Gain
Loss and Gain in above table means Cable Loss and Pre-amplifier gain.



No.	FREQ [MHz]	READING QP [dBuV]	ANT FACTOR [dB]	LOSS [dB]	GAIN [dB]	RESULT [dBuV/m]	LIMIT [dBuV/m]	MARGIN [dB]	ANTENNA [cm]	TABLE [DEG]
----- Horizontal -----										
1	165.800	40.9	8.9	8.6	33.0	25.4	43.5	18.1	200	359
2	232.730	42.7	11.8	9.1	32.9	30.7	46.0	15.3	100	52
3	250.190	42.9	12.4	9.2	32.9	31.6	46.0	14.4	100	102
4	450.011	40.9	16.6	10.4	33.1	34.8	46.0	11.2	100	334
----- Vertical -----										
5	52.310	44.7	13.6	7.4	33.0	32.7	40.0	7.3	100	39
6	132.820	40.2	8.9	8.2	33.0	24.3	43.5	19.2	100	117

Remark: Margin (dB) = Limit – Result and Result = Reading Quasi- Peak + Antenna Factor + Loss – Gain
Loss and Gain in above table means Cable Loss and Pre-amplifier gain.

Tested by: Tae-Ho, Kim / Project Engineer

11.5.3 Test data for above 1 GHz

- Test Date : June 20, 2014
- Resolution bandwidth : 1 MHz for Peak and Average Mode
- Video bandwidth : 1 MHz for Peak Mode, 10 Hz for Average Mode
- Frequency range : 1 GHz ~ 26.5 GHz
- Measurement distance : 3 m
- Operating mode : Transmitting mode

Frequency (MHz)	Reading (dBµV)	Ant. Pol. (H/V)	Ant. Height (m)	Angle (°)	Ant. Factor (dB/m)	Cable Loss	Emission Level(dBµV/m)	Limits (dBµV/m)	Margin (dB)
It was not observed any emissions from the EUT.									



Tested by: Tae-Ho, Kim / Project Engineer

12. CONDUCTED EMISSION TEST

12.1 Operating environment

Temperature : (23 ~ 24) °C
Relative humidity : (42 ~ 43) % R.H.

12.2 Test set-up

The EUT was placed on a wooden table, 0.8 m height above the floor. The EUT was connected to notebook PC and power of notebook PC was fed to the EUT through a 50 Ω / 50 μH + 5 Ω Artificial Mains Network (AMN). The ground plane was electrically bonded to the reference ground system and all power lines were filtered from ambient.

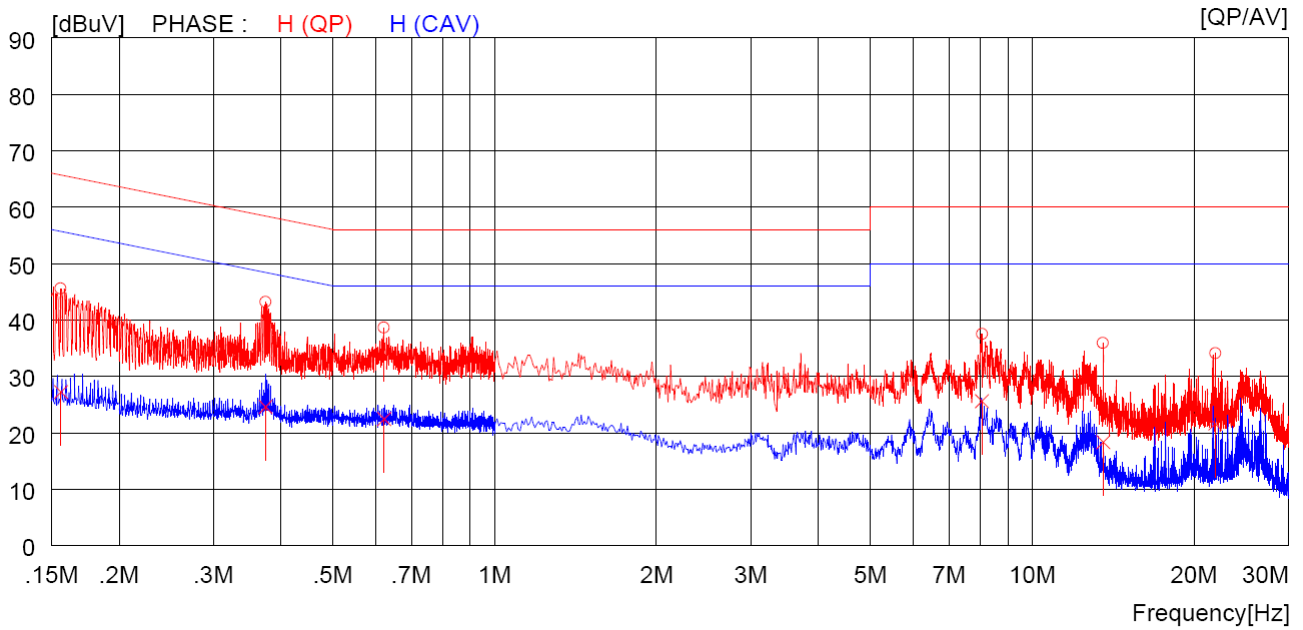
12.3 Test equipment used

Model Number	Manufacturer	Description	Serial Number	Last Cal. (Interval)
■ - ESCI	Rohde & Schwarz	Test Receiver	101012	Nov. 18, 2013 (1Y)
□ - ESHS10	Rohde & Schwarz	Test Receiver	834467/007	Jul. 02, 2013 (1Y)
■ - NSLK8128	Schwarzbeck	AMN	8128-216	Apr. 11, 2014 (1Y)
□ - NSLK 8126	Schwarzbeck	AMN	8126-404	Apr. 29, 2014 (1Y)
□ - 3825/2	EMCO	AMN	9109-1869	Apr. 29, 2014 (1Y)
□ - 3825/2	EMCO	AMN	9109-1867	Apr 29, 2014 (1Y)

All test equipment used is calibrated on a regular basis.

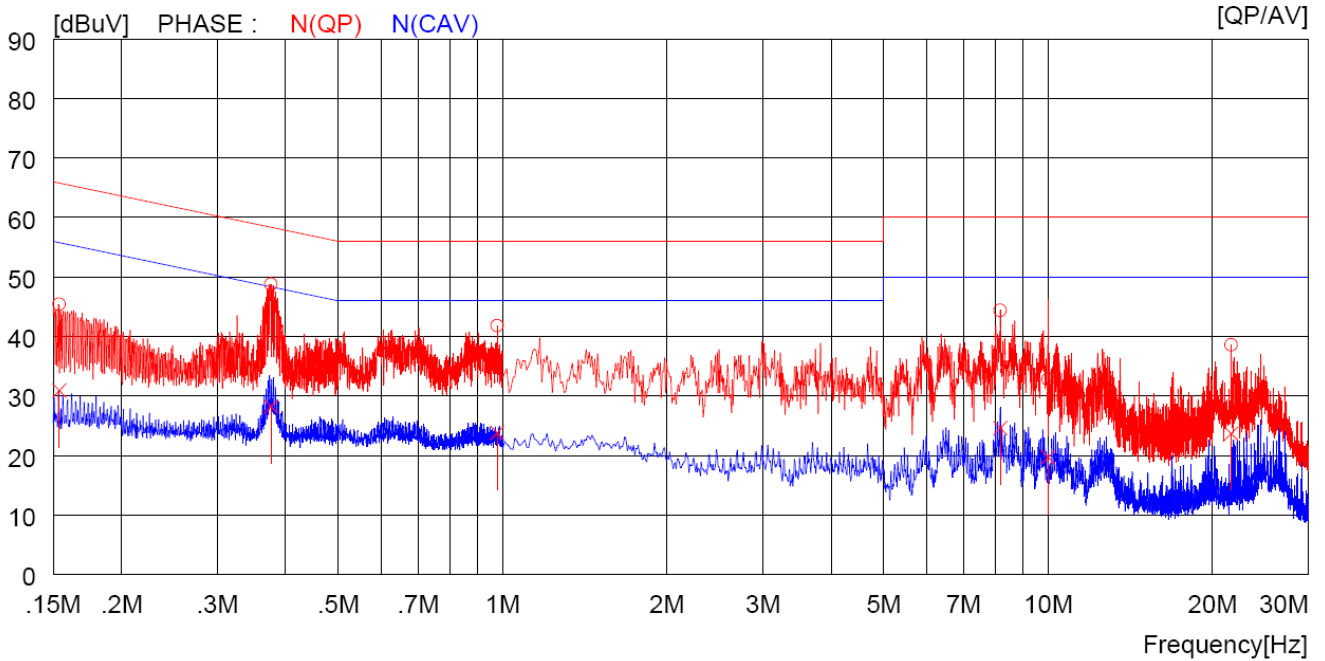
12.4 Test data

- Test Date : June 20, 2014
- Resolution bandwidth : 9 kHz
- Frequency range : 0.15 MHz ~ 30 MHz
- Tested Line : HOT LINE



NO	FREQ [MHz]	READING		C. FACTOR [dB]	RESULT		LIMIT		MARGIN		PHASE
		QP [dBuV]	AV [dBuV]		QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	
1	0.15600	35.7	----	9.9	45.6	----	65.7	----	20.1	----	H (QP)
2	0.37500	33.3	----	9.9	43.2	----	58.4	----	15.2	----	H (QP)
3	0.62300	28.7	----	10.0	38.7	----	56.0	----	17.3	----	H (QP)
4	8.06500	27.3	----	10.2	37.5	----	60.0	----	22.5	----	H (QP)
5	13.56000	25.6	----	10.3	35.9	----	60.0	----	24.1	----	H (QP)
6	21.90000	23.4	----	10.7	34.1	----	60.0	----	25.9	----	H (QP)
7	0.15600	----	17.3	9.9	----	27.2	----	55.7	----	28.5	H (CAV)
8	0.37500	----	14.7	9.9	----	24.6	----	48.4	----	23.8	H (CAV)
9	0.62300	----	12.4	10.0	----	22.4	----	46.0	----	23.6	H (CAV)
10	8.06500	----	15.4	10.2	----	25.6	----	50.0	----	24.4	H (CAV)
11	13.56000	----	8.0	10.3	----	18.3	----	50.0	----	31.7	H (CAV)
12	21.90000	----	10.9	10.7	----	21.6	----	50.0	----	28.4	H (CAV)

-. Tested Line : NEUTRAL LINE



NO	FREQ [MHz]	READING		C. FACTOR [dB]	RESULT		LIMIT		MARGIN		PHASE
		QP [dBuV]	AV [dBuV]		QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	QP [dBuV]	AV [dBuV]	
1	0.15400	35.5	----	9.9	45.4	----	65.8	----	20.4	----	N (QP)
2	0.37600	38.9	----	9.9	48.8	----	58.4	----	9.6	----	N (QP)
3	0.97800	31.8	----	10.0	41.8	----	56.0	----	14.2	----	N (QP)
4	8.17300	34.2	----	10.2	44.4	----	60.0	----	15.6	----	N (QP)
5	10.00000	22.6	----	10.2	32.8	----	60.0	----	27.2	----	N (QP)
6	21.66000	27.9	----	10.7	38.6	----	60.0	----	21.4	----	N (QP)
7	0.15400	----	21.0	9.9	----	30.9	----	55.8	----	24.9	N (CAV)
8	0.37600	----	18.3	9.9	----	28.2	----	48.4	----	20.2	N (CAV)
9	0.97800	----	13.8	10.0	----	23.8	----	46.0	----	22.2	N (CAV)
10	8.17300	----	14.4	10.2	----	24.6	----	50.0	----	25.4	N (CAV)
11	10.00000	----	9.5	10.2	----	19.7	----	50.0	----	30.3	N (CAV)
12	21.66000	----	13.0	10.7	----	23.7	----	50.0	----	26.3	N (CAV)

Remark: Margin (dB) = Limit – Level (Result)

The emission level in above table is included the transducer factor that means insertion loss (LISN), cable loss and attenuator.

Tested by: Tae-Ho, Kim / Project Engineer

13. RADIO FREQUENCY EXPOSURE

13.1 RF Exposure Calculation

According to the FCC rule 1.1310 table 1B, the limit for the maximum permissible RF exposure for an uncontrolled environment are $f/1500$ mW/cm² for the frequency range between 300 MHz and 1 500 MHz and 1.0 mW/cm² for the frequency range between 1 500 MHz and 100 000 MHz.

The electric field generated for a 1 mW/cm² exposure is calculated as follows:

$$E = \sqrt{(30 * P * G)} / d, \text{ and } S = E^2 / Z = E^2 / 377, \text{ because } 1 \text{ mW/cm}^2 = 10 \text{ W/m}^2$$

Where

S = Power density in mW/cm², Z = Impedance of free space, 377 Ω

E = Electric field strength in V/m, G = Numeric antenna gain, and d = distance in meter

Combining equations and rearranging the terms to express the distance as a function of the remaining variable

$$d = \sqrt{(30 * P * G) / (377 * 10 S)}$$

Changing to units of mW and cm, using $P \text{ (mW)} = P \text{ (W)} / 1 000$, $d \text{ (cm)} = 0.01 * d \text{ (m)}$

$$d = 0.282 * \sqrt{(P * G) / S}$$

Where

d = distance in cm, P = Power in mW, G = Numeric antenna gain, and S = Power density in mW/cm²

13.2 Calculated MPE Safe Distance

Test data for Antenna 0

According to above equation, the following result was obtained.

Operating Freq. Band (MHz)	Peak Output Power		Antenna Gain		Safe Distance (cm)	Power Density (mW/cm ²) @ 20 cm Separation	Limit (mW/cm ²)
	(dBm)	(mW)	Log	Linear			
2 405 ~ 2 475	18.94	78.34	3.25	2.11	3.63	0.0329	1.00

$$D = 0.282 * \sqrt{(78.34 * 2.11)/1.00} = 3.63 \text{ cm.}$$

For getting power density at 20 cm separation in above table, following formula was used.

$$S = P * G / (4\pi * R^2) = 78.34 * 2.11 / (4 * 3.14 * 20^2) = 0.0329$$

Where:

S = Power Density,

P = Power input to the external antenna (Output power from the EUT antenna port (dBm) – cable loss (dB)),

G = Gain of Transmit Antenna (linear gain), R = Distance from Transmitting Antenna

Test data for Antenna 1

According to above equation, the following result was obtained.

Operating Freq. Band (MHz)	Peak Output Power		Antenna Gain		Safe Distance (cm)	Power Density (mW/cm ²) @ 20 cm Separation	Limit (mW/cm ²)
	(dBm)	(mW)	Log	Linear			
2 405 ~ 2 475	18.94	78.34	3.24	2.11	3.63	0.0329	1.00

$$D = 0.282 * \sqrt{(78.34 * 2.11)/1.00} = 3.63 \text{ cm.}$$

For getting power density at 20 cm separation in above table, following formula was used.

$$S = P * G / (4\pi * R^2) = 78.34 * 2.11 / (4 * 3.14 * 20^2) = 0.0329$$

Where:

S = Power Density,

P = Power input to the external antenna (Output power from the EUT antenna port (dBm) – cable loss (dB)),

G = Gain of Transmit Antenna (linear gain), R = Distance from Transmitting Antenna