Nemko Korea Co., Ltd.

155 & 159, Osan-Ro, Mohyeon-Myeon, Cheoin-Gu, Yongin-Si, Gyeonggi-Do 16885 KOREA, REPUBLIC OF
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FCC and IC EVALUATION REPORT FOR CERTIFICATION

Applicant :

SmartThings Inc.
456 University Avenue,
Palo Alto, California, USA
(Post code : 94301)
Attn. : Martin Hernandez-Palomares

Dates of Issue : Mar 08, 2016
Test Report No. : NK-15-R-134
Test Site : Nemko Korea Co., Ltd.

FCC ID **IC**	**R3YF-USB-US-V1** **10734A-FUSBUSV1**
Brand Name	**SmartThings**
Contact Person	**SmartThings Inc.** **456 University Avenue,** **Palo Alto, California, USA, 94301.** **Martin Hernandez-Palomares** **Telephone No. : +1-650-600-8159**

Applied Standard: FCC 47 CFR Part 15.247 and IC RSS-247 Issue 1
Classification: Digital modulation Transmitter
EUT Type: Extend USB Stick

The device bearing the brand name and model specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in ANSI C63.10 - 2013. The client should not use it to claim product endorsement by TAF or any government agencies. The test results in the report only apply to the tested sample.

I attest to the accuracy of data and all measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

Mar 08, 2016
Tested By : Wonho Son
Engineer

Mar 08. 2016
Reviewed By : Deokha Ryu
Technical Manager

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1. SCOPE

Measurement and determination of electromagnetic emissions (EME) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission under FCC part 15 and IC RSS-247 Issue1.

Responsible Party :	SmartThings, Inc.
Contact Person :	Martin Hernandez-Palomares
Manufacturer :	SmartThings, Inc. 456 University Avenue, Palo Alto, California, USA, 94301

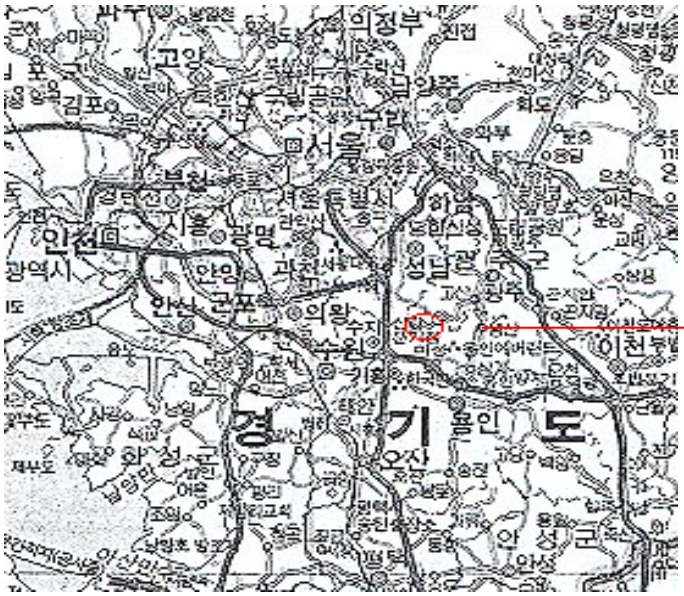
- FCC ID: R3YF-USB-US-V1
- IC: 10734A-FUSBUSV1
- Model: F-USB-US-V1
- Brand Name: SmartThings
- EUT Type: Extend USB Stick
- Classification: Digital modulation Transmitter
- Applied Standard: FCC 47 CFR Part 15.247 and IC RSS-247 Issue 1
- Test Procedure(s): ANSI C63.10-2013 and FCC guidance of 558074 D01 v03r03
- Dates of Test: January 25, 2016 ~ February 24, 2016
- Place of Tests: Nemko Korea Co., Ltd.

2. INTRODUCTION

2.1 Test facility

The measurement procedure described in American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (ANSI C63.4-2014), the American National Standard for Testing Unlicensed Wireless Devices (ANSI C63.10-2013) was used in determining radiated and conducted emissions emanating from **SmartThings, Inc. FCC ID : R3YF-USB-US-V1** and **IC : 10734A-FUSBUSV1**

These measurement tests were conducted at ***Nemko Korea Co., Ltd. EMC Laboratory*** .
The site address 155 & 159, Osan-Ro, Mohyeon-Myeon, Cheoin-Gu, Yongin-Si, Gyeonggi-Do 16885 KOREA, REPULIC OF.
The area of Nemko Korea Corporation Ltd. EMC Test Site is located in a mountain area at
80 km (48 miles) southeast and Incheon International Airport (Incheon Airport), 30 km (18miles) south-southeast from central Seoul.
It is located in the valley surrounded by mountains in all directions where ambient radio signal conditions are quiet and a favorable area to measure the radio frequency interference on open field test site for the computing and ISM devices manufactures.
The detailed description of the measurement facility was found to be in compliance with the requirements of ANSI C63.4-2014 according to §2.948.



Nemko Korea Co., Ltd.
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Fig. 1. The map above shows the Seoul in Korea vicinity area.
The map also shows Nemko Korea Corporation Ltd. EMC Lab. and Incheon Airport.

2.2 Accreditation and listing

Accreditation type		Accreditation number
	CAB Accreditation for DOC	Designation No. KR0026
	KOLAS Accredited Lab. (Korea Laboratory Accreditation Scheme)	Registration No. 155
Industry Canada	Canada IC Registered site	Site No. 2040E
	VCCI registration site(RE/CE/Telecom CE)	Member No. 2118
	EMC CBTL	-
	KCC(RRL)Designated Lab.	Registration No. KR0026

3. TEST CONDITIONS & EUT INFORMATION

3.1 Operation During Test

The EUT is the transceiver which is the module supporting the Zigbee/Z-wave mode. (1Tx / 1Rx)
During the test, The Laptop and Test Jig were used to control the EUT and then a test program(Tera-Term) was executed to operate duty cycle of EUT continuously (100% Duty cycle).
The EUT was tested at the lowest channel, middle channel and the last two channels(Highest_1, Highest_2) with the maximum output power in accordance with the manufacturer's specifications. The worst data were recorded in the report.

3.1.1 Table of test power setting

Frequency	Power setting Level
2405 MHz	-2
2440 MHz	-2
2475 MHz	-5
2480 MHz	-16

3.1.2 Table of test channels

Frequency band	Mode	Test Channel (CH)		Frequency (MHz)
2.4 GHz	Zigbee (802.15.4)	Lowest	11	2405
		Middle	18	2440
		Highest_1	25	2475
		Highest_2	26	2480

3.1.3 Table of test modes

Test Items	Mode	Data rate (kbps)	Test Channel (CH)
Conducted Emissions	802.15.4	250	18
Radiated Emissions	802.15.4	250	18
6 dB Bandwidth	802.15.4	250	11/18/25/26
Peak Output Power	802.15.4	250	11/18/25/26
Peak Power Spectral Density	802.15.4	250	11/18/25/26
Conducted Spurious Emission, Radiated Spurious Emission	802.15.4	250	11/18/25/26
Band edge Emission	802.15.4	250	11/25/26

3.1.4 Antenna information:

Frequency band	Mode	Antenna TX mode	Support MIMO
900 MHz	Z-wave	■ 1TX, □ 2TX	□ Yes, ■ No
2.4 GHz	Zigbee	■ 1TX, □ 2TX	□ Yes, ■ No

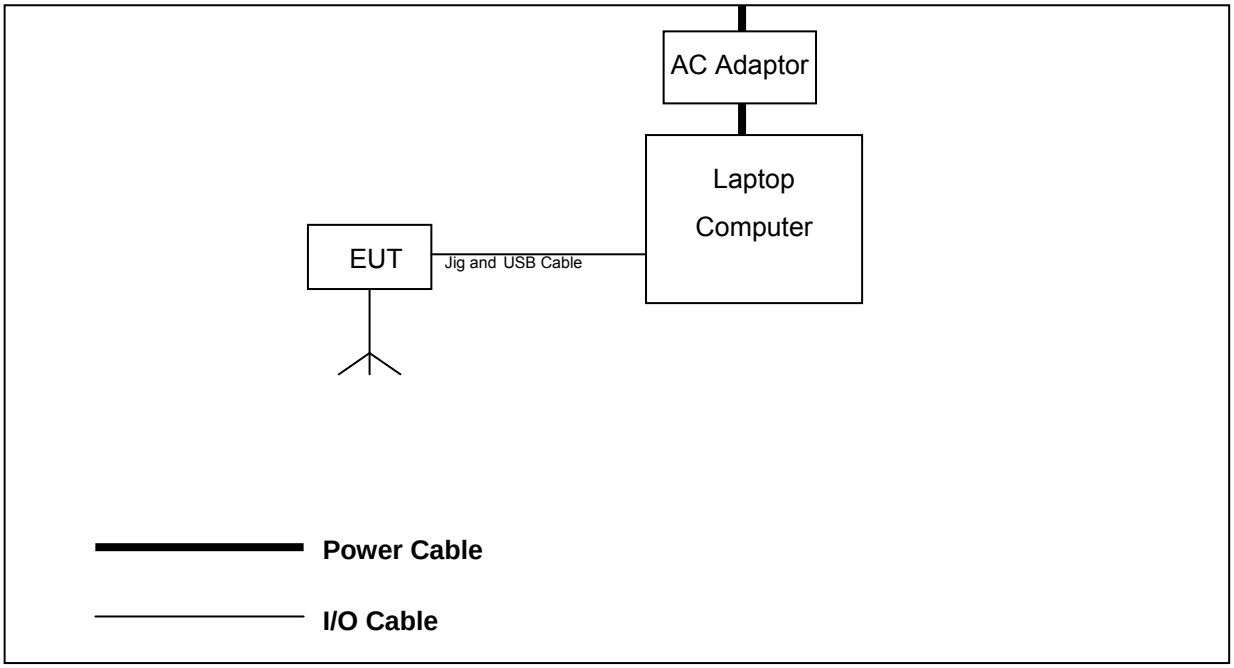
3.1.5. Additional Information Related to Testing

The cable and attenuator loss from 30MHz to 25GHz was reflected in spectrum analyzer with correction factor for all conducted testing.

3.2 Support Equipment

EUT	SmartThings, Inc. Model : F-USB-US-V1	S/N: N/A
Laptop Computer	Samsung Electronics Co., Ltd Model : NT-R580	FCC DOC S/N : ZNU793BZ200566M
AC/DC Adapter	Chicony Power Technology Co., Ltd Model : A10-090P1A 1.5 m unshielded power cable	FCC DOC S/N : AD-9019S

3.3 Setup Drawing



3.4 EUT Information

The EUT is the **SmartThings Zigbee/Z-wave Dongle FCC ID: R3YF-USB-US-V1, IC: 10734A-FUSBUSV1.**

Specifications:

Category	ZigBee/Z-wave Dongle
Model Name	F-USB-US-V1
Brand Name	SmartThings
Frequency of Operation	2405 MHz ~ 2480 MHz
Power Output (Conducted)	17.23 dBm
Channels	16 CH
Antenna Gain (peak)	Zigbee Ant : 3.6 dBi Z-wave Ant : 3.4 dBi
Antenna Setup	1TX / 1RX
Modulations	DSSS(O-QPSK) for 802.15.4
Temperature Range	-20 ℃ ~ +50 ℃
Voltage	5.0 Vdc
Dimensions (L x W x T)	80.1 mm x 20.6 mm X 7.0 mm
Weight	16 g
H/W Status	
S/W Status	-
Operational Description	F-USB-US-V1 is the 802.15.4 ZigBee, ITU-T G.9959 Z-wave COMBO Module that acts as a communication controller for users of a wireless device to connect to SMART TV.

4. SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specification:

Name of Test	FCC Paragraph No.	IC Paragraph No.	Result	Remark
Conducted Emission	15.207	RSS-GEN Issue 4 8.8	Complies	
Radiated Emission	15.209	RSS-GEN Issue 4 8.9	Complies	
6 dB Bandwidth	15.247(a)(2)	RSS-247 Issue 1 5.2	Complies	
Peak Output Power	15.247(b)(3)	RSS-247 Issue 1 5.4	Complies	
Peak Power Spectral Density	15.247(e)	RSS-247 Issue 1 5.2	Complies	
Conducted Spurious Emission	15.247(d)	RSS-247 Issue 1 5.5	Complies	
Radiated Spurious Emission	15.247(d)	RSS-247 Issue 1 5.5	Complies	
Maximum Permissible Exposure	1.1307(b)	RSS-102	Complies	

5. RECOMMENDATION/CONCLUSION

The data collected shows that the **SmartThings ZigBee/Z-wave Dongle FCC ID:R3YF-USB-US-V1, IC:10734A-FUSBUSV1** is in compliance with Part 15.247 of the FCC Rule and RSS-247 Issue 1 of the IC Specification.

6. ANTENNA REQUIREMENTS

§15.203 of the FCC Rules part 15 Subpart C

: An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

The antenna of the **SmartThings ZigBee/Z-wave Dongle FCC ID: R3YF-USB-US-V1, IC: 10734A-FUSBUSV1** is **permanently attached** and there are no provisions for connection to an external antenna. It complies with the requirement of §15.203.

7. DESCRIPTION OF TESTS

7.1 Conducted Emissions

The Line conducted emission test facility is located inside a 4 x 7 x 2.5 meter shielded enclosure. It is manufactured by EM engineering. The shielding effectiveness of the shielded room is in accordance with MIL-STD-285 or NSA 65-6. A 1 m x 1.5 m wooden table 0.8 m height is placed 0.4 m away from the vertical wall and 1.5 m away from the side of wall of the shielded room Rohde & Schwarz (ESH3-Z5) and (ESH2-Z5) of the 50 ohm/50 µH Line Impedance Stabilization Network (LISN) are bonded to the shielded room. The EUT is powered from the Rohde & Schwarz LISN (ESH3-Z5) and the support equipment is powered from the Rohde & Schwarz LISN (ESH2-Z5). Power to the LISNs are filtered by high-current high insertion loss Power line filters. The purpose of filter is to attenuate ambient signal interference and this filter is also bonded to shielded enclosure. All electrical cables are shielded by tinned copper zipper tubing with inner diameter of 1 / 2 ". If DC power device, power will be derived from the source power supply it normally will be powered from and this supply lines will be connected to the LISNs, All interconnecting cables more than 1 meter were shortened by non inductive bundling (serpentinefashion) to a 1 meter length. Sufficient time for EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the spectrum analyzer to determine the frequency producing the maximum EME from the EUT. The spectrum was scanned from 150 kHz to 30 MHz with 200 msec sweep time. The frequency producing the maximum level was re-examined using the EMI test receiver. (Rohde & Schwarz ESCS30). The detector functions were set to CISPR quasi-peak mode & average mode. The bandwidth of receiver was set to 9 kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each EME emission. Each emission was maximized by; switching power lines; varying the mode of operation or resolution; clock or data exchange speed; scrolling H pattern to the EUT and of support equipment, and powering the monitor from the floor mounted outlet box and computer aux AC outlet, if applicable; whichever determined the worst case emission.

Each EME reported was calibrated using the R&S signal generator.

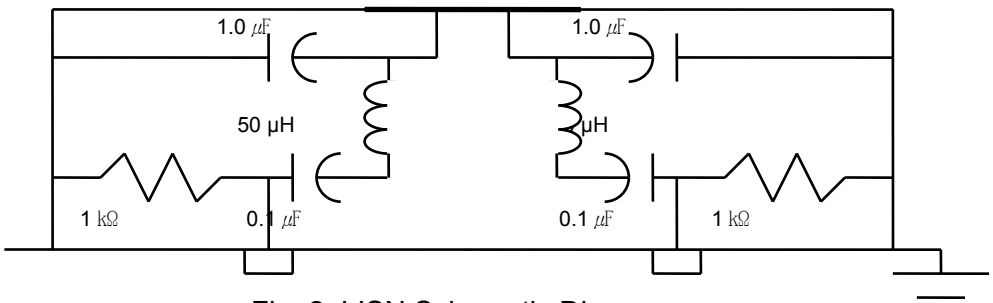


Fig. 2. LISN Schematic Diagram

7.2 Radiated Emissions

The measurement was performed at the test site that is specified in accordance with ANCI C63.10-2013.

The spurious emission was scanned from 9 kHz to 30 MHz using Loop Antenna(Rohde&Schwarz, HFH2-Z2) and 30 to 1000 MHz using Trilog broadband test antenna(Schwarzbeck, VULB 9163). Above 1 GHz, Horn antenna (Schwarzbeck BBHA 9120D: up to 18 GHz, Q-par Angus QSH20S20 : 18 to 26.5 GHz, QSH22K20: up to 40 GHz) was used.

For emissions testing at below 1GHz, The test equipment was placed on turntable with 0.8 m above ground. For emission measurements above 1 GHz, The test equipment was placed on turntable with 1.5 m above ground. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The EUT, cable, wire arrangement and mode of operation that has the highest amplitude relative to the limit was selected. Then, the turn table was rotated from 0° to 360° and an antenna mast was moved from 1 m to 4 m height to maximize the suspected highest amplitude signal. The final maximized level was recorded.

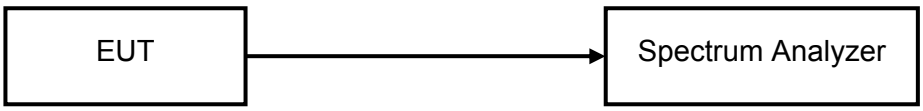
At frequencies below 1000 MHz, measurements performed using the CISPR quasi-peak detection. At frequencies above 1000 MHz, measurements performed using the peak and average measurement procedures described in KDB “558074 D01 DTS Meas Guidance v03r03” in section 12.2.4 and 12.2.5.1. Peak emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 3 MHz, Detector = Peak, Trace mode = max hold. Average emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 3 MHz, Detector = RMS, Trace averaging in power averaging (RMS) mode over a minimum of 100 traces, when the EUT was configured to transmit with duty cycle ≥ 98 percent. If continuous transmission of the EUT couldn’t be achieved and duty cycle was constant, a correction factor (10 log (1 / x)) was added to the measurement result.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009–0.490	2400/F(kHz)	300
0.490–1.705	24000/F(kHz)	30
1.705–30.0	30	30
30–88	100	3
88–216	150	3
216–960	200	3
Above 960	500	3

Radiated Emissions Limits per 47 CFR 15.209(a) and RSS-GEN Issue 4 8.9

7.3 6 dB Bandwidth

Test Setup

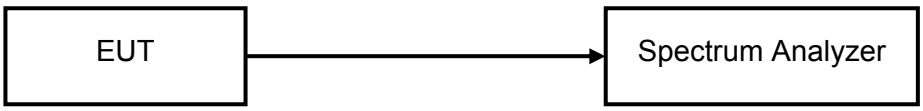


Test Procedure

EUTs 6 dB bandwidth is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.
The spectrum analyzer setting is as follows.
RBW = 100 kHz
VBW ≥ 3 x RBW
Detector = Peak
Trace mode = max hold
Sweep = auto couple
The bandwidth measurement function on the spectrum analyzer is used to measure the 6 dB bandwidth.

7.4 Maximum Peak Output Power

Test Setup

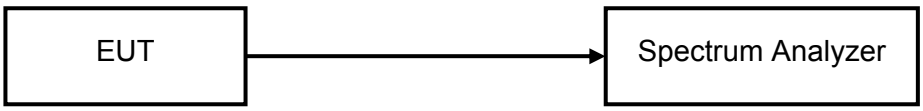


Test Procedure

EUTs Maximum Peak Conducted Output Power is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.
The spectrum analyzer setting is as follows.
RBW ≥ DTS bandwidth
VBW ≥ 3 x RBW
Span ≥ 3 x RBW
Detector = peak
Sweep time = auto couple
Trace mode = Max hold
Allow the trace to stabilize.
Use peak marker function to determine the peak amplitude level.

7.5 Peak Power Spectral Density

Test Setup



Test Procedure

EUTs Peak Power Spectral Density is measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.

The spectrum analyzer setting is as follows.

Center frequency = DTS channel center frequency

Span = 1.5 times the DTS channel bandwidth

RBW to : 3 kHz ≤ RBW ≤ 100 kHz

VBW ≥ 3 x RBW

Detector = peak

Sweep time = auto couple

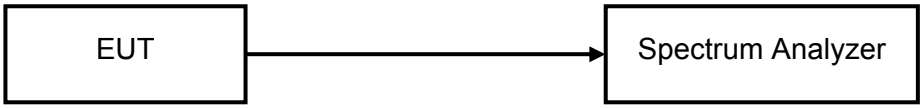
Trace mode = max hold

Allow the trace to stabilize.

The peak search function on the spectrum analyzer is used to determine the maximum amplitude level within the fundamental DTS bandwidth.

7.6 Conducted Spurious Emissions

Test Setup



Test Procedure

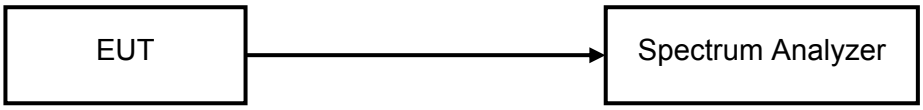
EUTs Conducted spurious emissions are measured at low, middle, high channels with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level. The spectrum analyzer setting is as follows.

1) Reference Level
Center frequency = DTS channel center frequency
Span ≥ 1.5 times the DTS bandwidth
RBW = 100 kHz
VBW ≥ 3 x RBW
Detector = peak
Sweep time = auto couple
Trace mode = max hold
Allow trace to fully stabilize.
The peak search function on the spectrum analyzer is used to determine the maximum PSD level.

2) Unwanted Emissions
Set the center frequency and span to encompass frequency range to be measured.
RBW = 100 kHz
VBW ≥ 3 x RBW
Detector = peak
Sweep time = auto couple
Trace mode = max hold
Allow trace to fully stabilize.
The peak marker function on the spectrum analyzer is used to determine the maximum amplitude level of all unwanted emissions outside of the authorized frequency band. The unwanted emissions are attenuated by at least the minimum requirements specified.

7.7 Duty Cycle

Test Setup



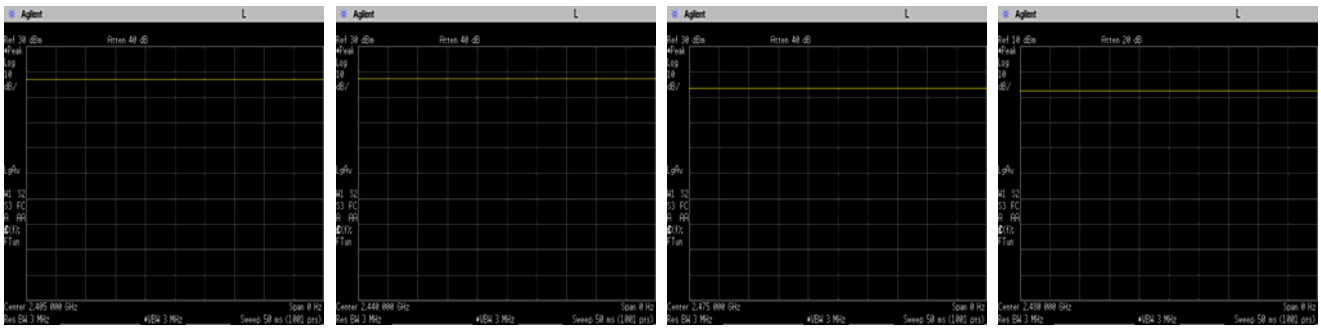
Test Procedure

EUTs duty cycle are measured at middle channel with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level. The spectrum analyzer setting is as follows.

Center frequency = Center frequency of the transmission
Span = zero
RBW = 3 MHz
VBW = 3 MHz
Detector = peak
Sweep time = 50 ms
Trace mode = view
The marker function on the spectrum analyzer is used to determine the duty cycle.

Following the result of the duty cycle measurement according to the above test procedure

Frequency (MHz)	Data Rate (kbps)	Duty Cycle (%)
2405	250	100
2440	250	100
2475	250	100
2480	250	100



8. TEST DATA

8.1 Conducted Emissions

FCC §15.207, IC RSS-GEN Issue 4 8.8

Frequency	Level(dBµV)		*)Factor	**) Line	Limit(dBµV)		Margin(dB)	
(MHz)	Q-Peak	Average	(dB)		Q-Peak	Average	Q-Peak	Average
0.18	44.2	37.5	10.3	L	64.5	54.5	20.3	17.0
0.24	40.1	37.5	10.4	N	62.1	52.1	22.0	14.6
0.41	44.0	35.5	10.5	N	57.6	47.6	13.6	12.1
0.53	49.1	38.4	10.4	L	56.0	46.0	6.9	7.6
0.94	46.7	34.9	10.5	N	56.0	46.0	9.3	11.1
15.10	43.6	40.1	11.5	L	60.0	50.0	16.4	9.9

Line Conducted Emissions Tabulated Data

Notes:

1. Measurements using CISPR quasi-peak mode & average mode.

2. All modes of operation were investigated and the worst -case emission are reported. See attached Plots.

*3. *) Factor = LISN + Cable Loss*

*4. **) LINE : L = Line , N = Neutral*

5. 2440MHz was the worst case channel.

6. The limit is on the FCC Part section 15.207(a) and IC RSS-GEN issue4 8.8.

PLOTS OF EMISSIONS

- ***Conducted Emission at the Mains port (Line)***

NEMKO KOREA (NK-15-R-134) 24 Feb 2016 16:03

Conducted Emissions

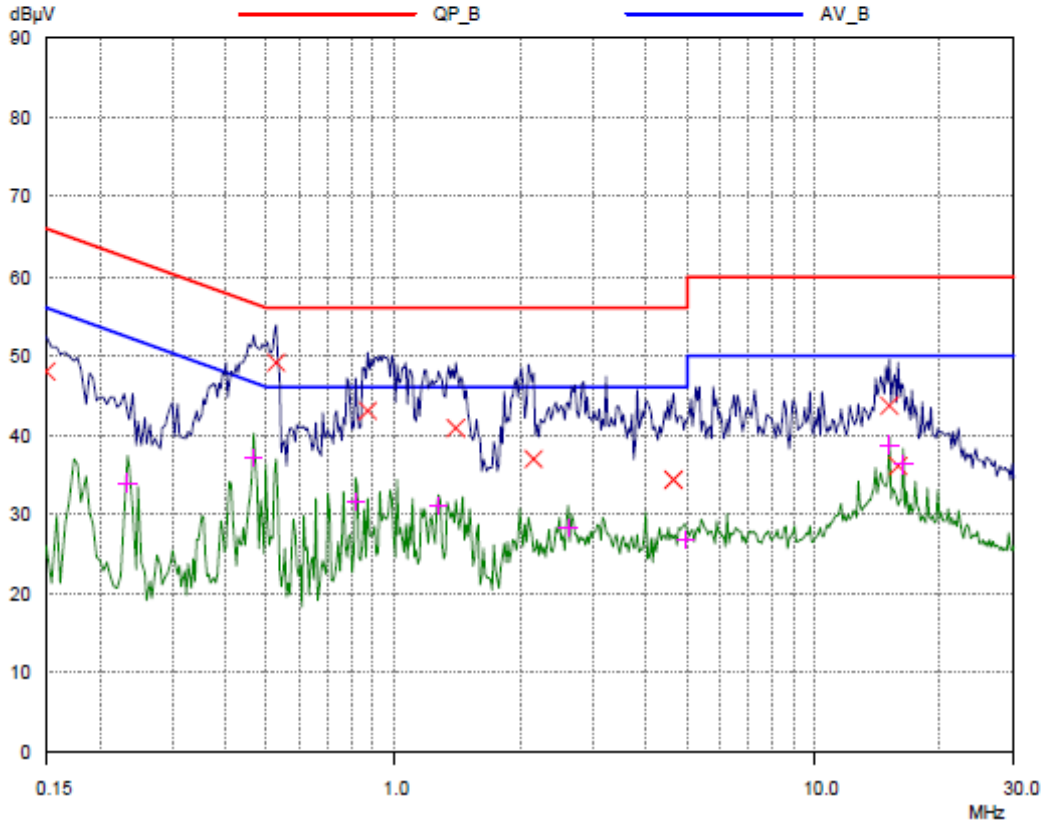
EUT:	Extend USB Stick
Manuf:	Samsung Electronics. Co., Ltd.
Op Cond:	a.c. 120 V / 60 Hz // Zigbee
Operator:	Wonho. Son
Test Spec:	FCC Part 15
Comment:	MODEL : F-USB-US-K1
	LINE : LINE-PE
Result File:	r134-zb.dat : New Measurement

Scan Settings (1 Range)

Frequencies			Receiver Settings					
Start	Stop	Step	IF BW	Detector	M-Time	Atten	Preamp	OpRge
150kHz	30MHz	3.9063kHz	9kHz	PK+AV	20msec	20 dB	OFF	60dB

Transducer	No.	Start	Stop	Name
	1	150kHz	30MHz	ESH3_Z5_Line

Final Measurement:		
	Detectors:	X QP / + AV
	Meas Time:	1sec
	Subranges:	8
	Acc Margin:	60 dB



PLOTS OF EMISSIONS

- ***Conducted Emission at the Mains port (Neutral)***

NEMKO KOREA (NK-15-R-134) 24 Feb 2016 16:12

Conducted Emissions

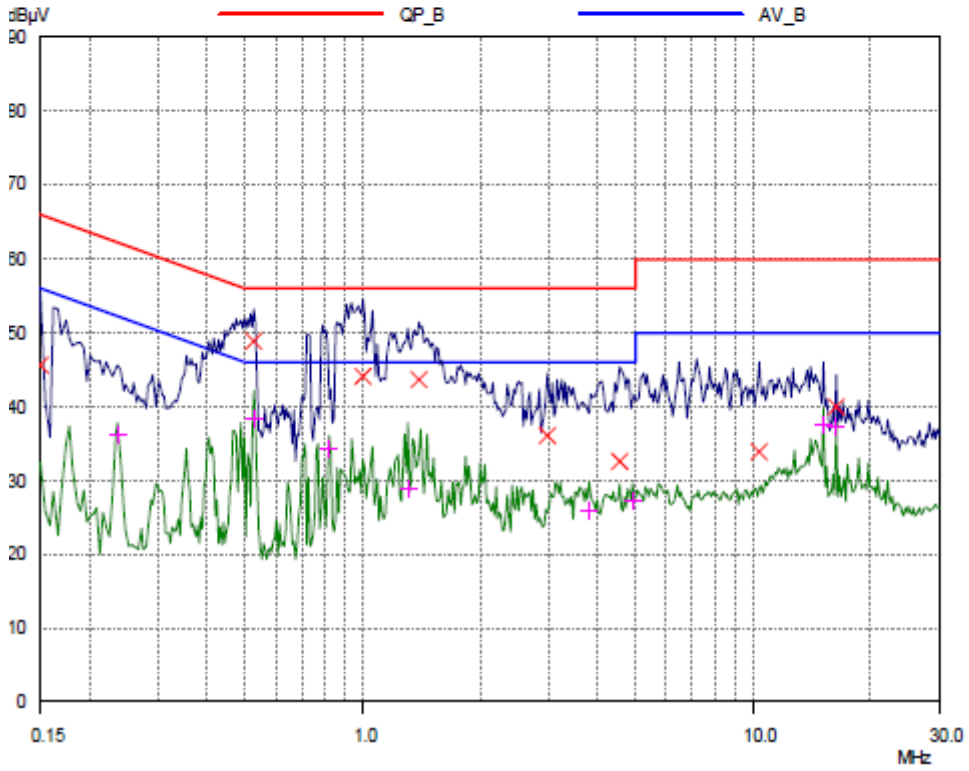
EUT:	Extend USB Stick
Manuf:	Samsung Electronics. Co., Ltd.
Op Cond:	a.c. 120 V / 60 Hz // Zigbee
Operator:	Wonho. Son
Test Spec:	FCC Part 15
Comment:	MODEL : F-USB-US-K1
	LINE : NEUTRAL-PE
Result File:	r134-zbL.dat : New Measurement

Scan Settings (1 Range)

Frequencies			Receiver Settings					
Start	Stop	Step	IF BW	Detector	M-Time	Atten	Preamp	OpRge
150kHz	30MHz	3.9063kHz	9kHz	PK+AV	20msec	20 dB	OFF	60dB

Transducer	No.	Start	Stop	Name
	1	150kHz	30MHz	ESH3_Z5_Neutral

Final Measurement:		
	Detectors:	X QP / + AV
	Meas Time:	1sec
	Subranges:	8
	Acc Margin:	60 dB



8.2 Radiated Emissions

FCC §15.209, IC RSS-GEN Issue 4 8.8

Frequency (MHz)	Reading (dBµV/m)	Pol* (H/V)	Antenna Heights (cm)	Turntable Angles (°)	AF+CL+Amp (dB)**	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
150.38	53.90	H	200	234	-27.8	26.1	43.5	17.4
155.91	52.80	H	200	250	-27.6	25.2	43.5	18.3
225.55	47.80	H	100	270	-23.6	24.2	46.0	21.8
286.27	53.60	H	100	294	-21.0	32.6	46.0	13.4
300.63	49.50	H	100	75	-20.4	29.1	46.0	16.9
606.28	41.20	V	100	322	-12.3	28.9	46.0	17.1

Radiated Measurements at 3meters

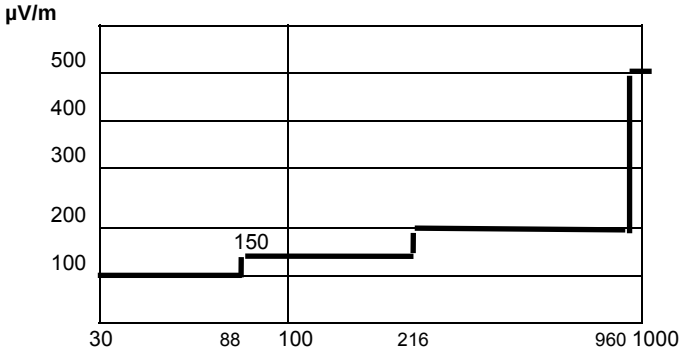


Fig. 3. Limits at 3 meters

Notes:

1. All modes were measured and the worst-case emission was reported.

2 The radiated limits are shown on Figure 3.

Above 1 GHz the limit is 500 µV/m.

*3. *Pol. H = Horizontal, V = Vertical*

*4. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.*

5. Measurements using CISPR quasi-peak mode.

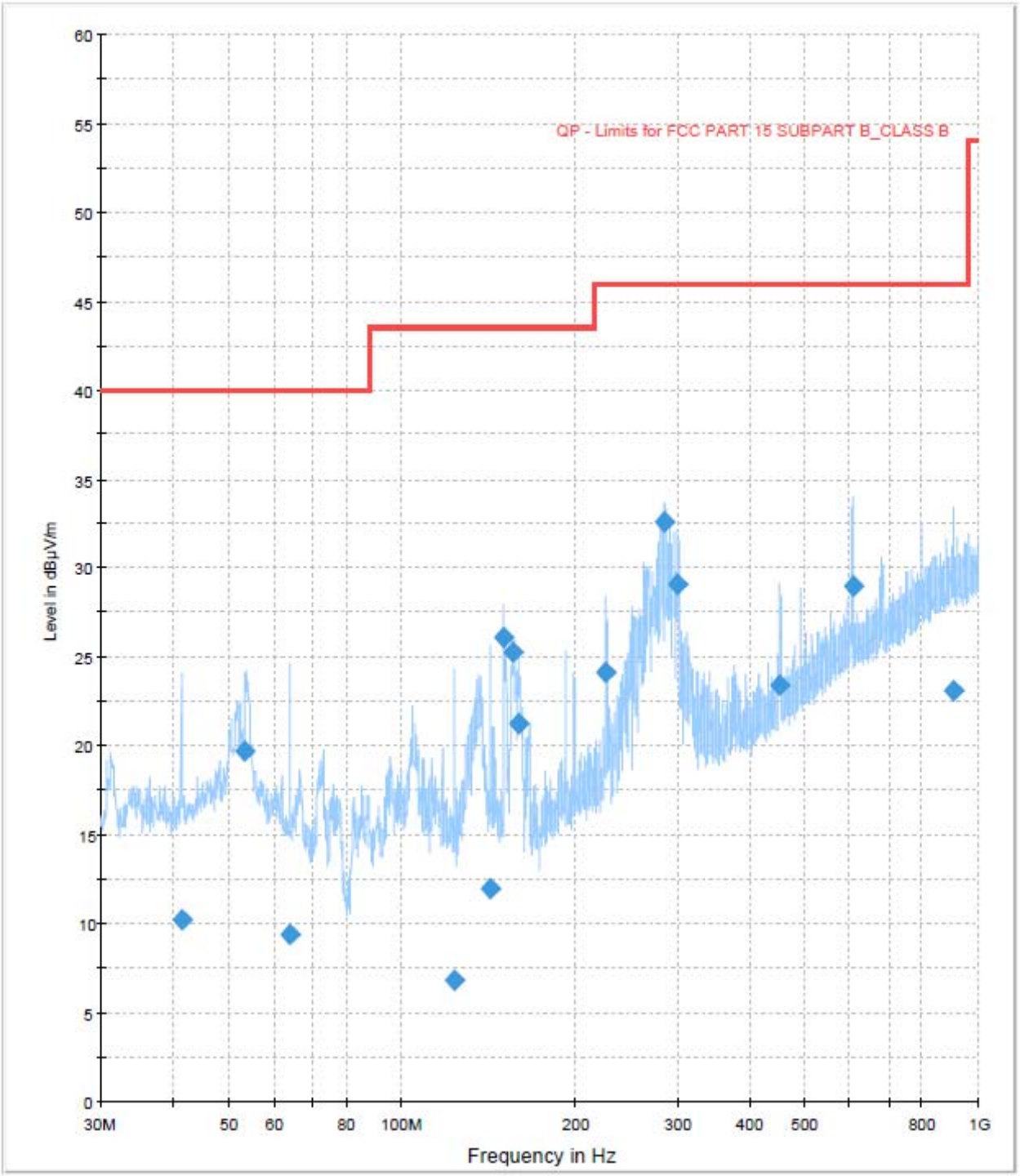
6. The radiated emissions testing were made by rotating through three orthogonal axes. The worst date was recorded.

7. There were no radiated emissions other than harmonics found below 30 MHz (9kHz~30MHz). 2440MHz is the worst case channel.

8. The limit is on the FCC §15.209 and RSS-Gen Issue4 8.9.

PLOTS OF EMISSIONS

Worst case Channel (2440 MHz)



8.3 6 dB Modulated Bandwidth

FCC §15.247(a)(2), IC RSS-247 Issue 1 5.2

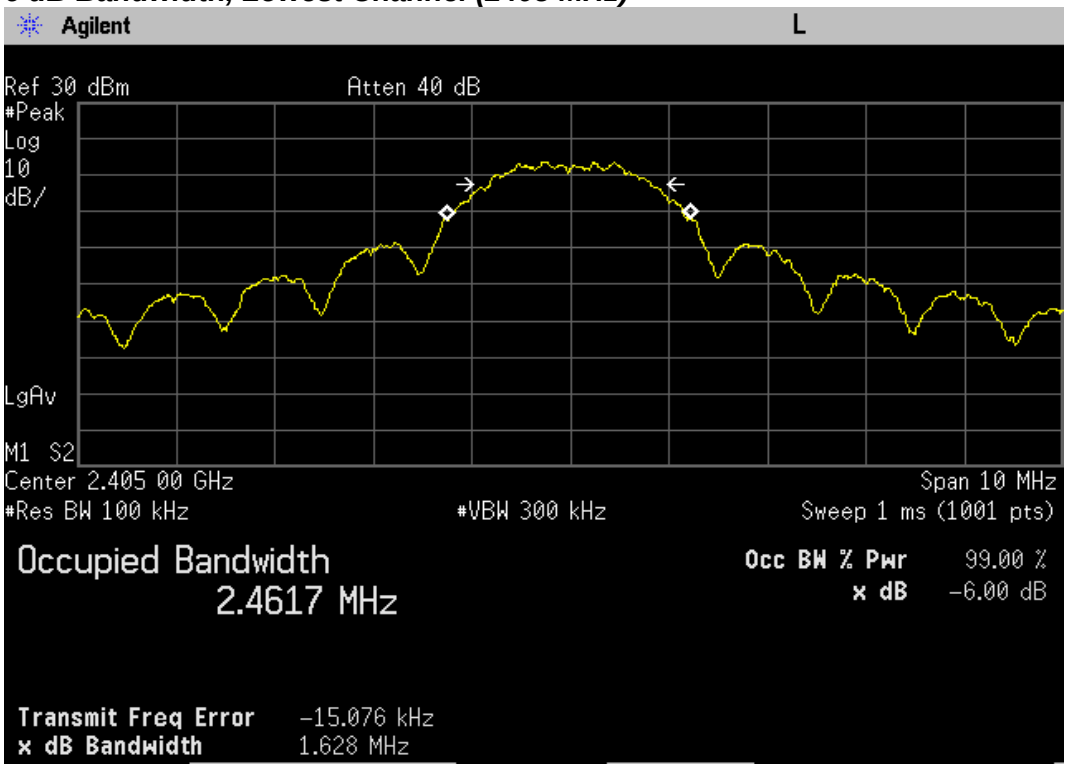
Test Mode : Set to Lowest channel, Middle channel, Highest1 channel and Highest2 channel

Result

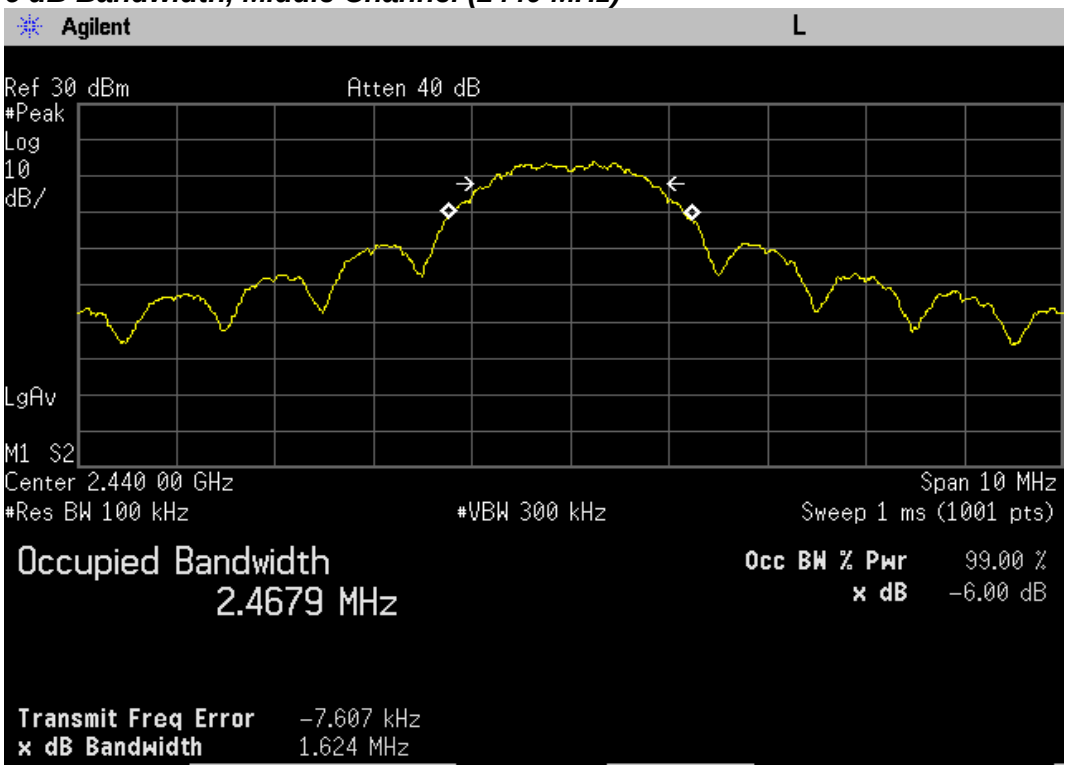
Channel	Frequency (MHz)	6 dB modulated bandwidth (MHz)	Limit (MHz)	Margin (MHz)
Lowest	2405	1.63	0.50	1.13
Middle	2440	1.62	0.50	1.12
Highest_1	2475	1.60	0.50	1.10
Highest_2	2480	1.63	0.50	1.13

PLOTS OF EMISSIONS

6 dB Bandwidth, Lowest Channel (2405 MHz)

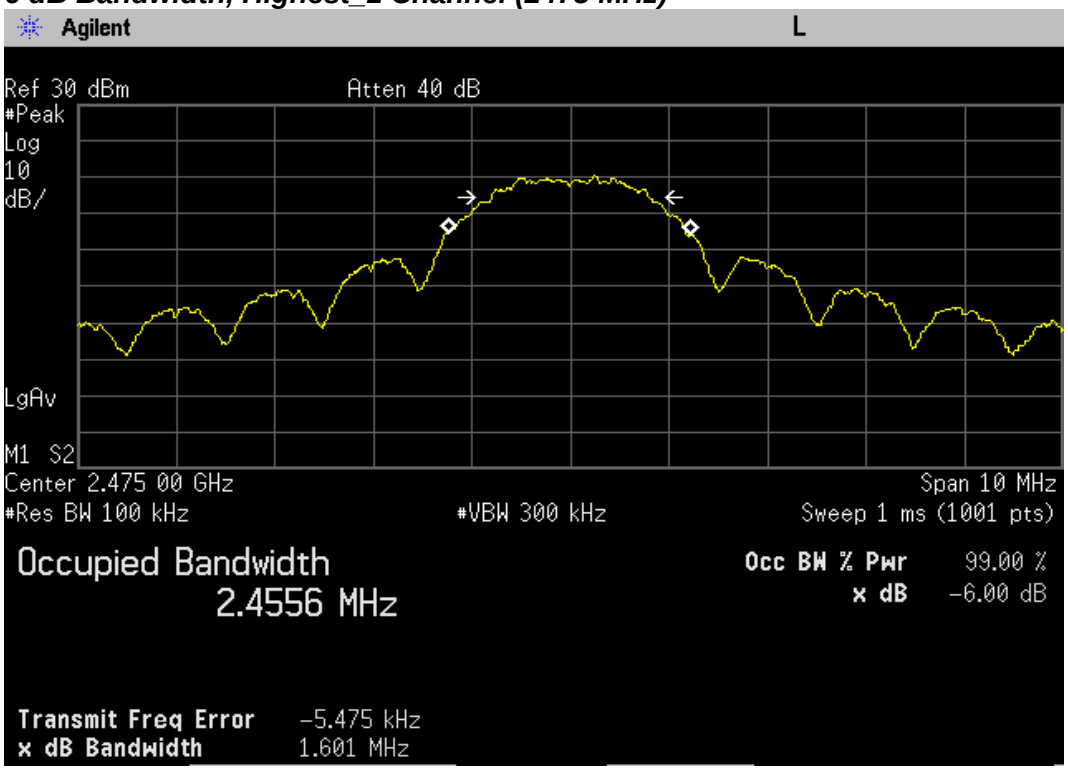


6 dB Bandwidth, Middle Channel (2440 MHz)

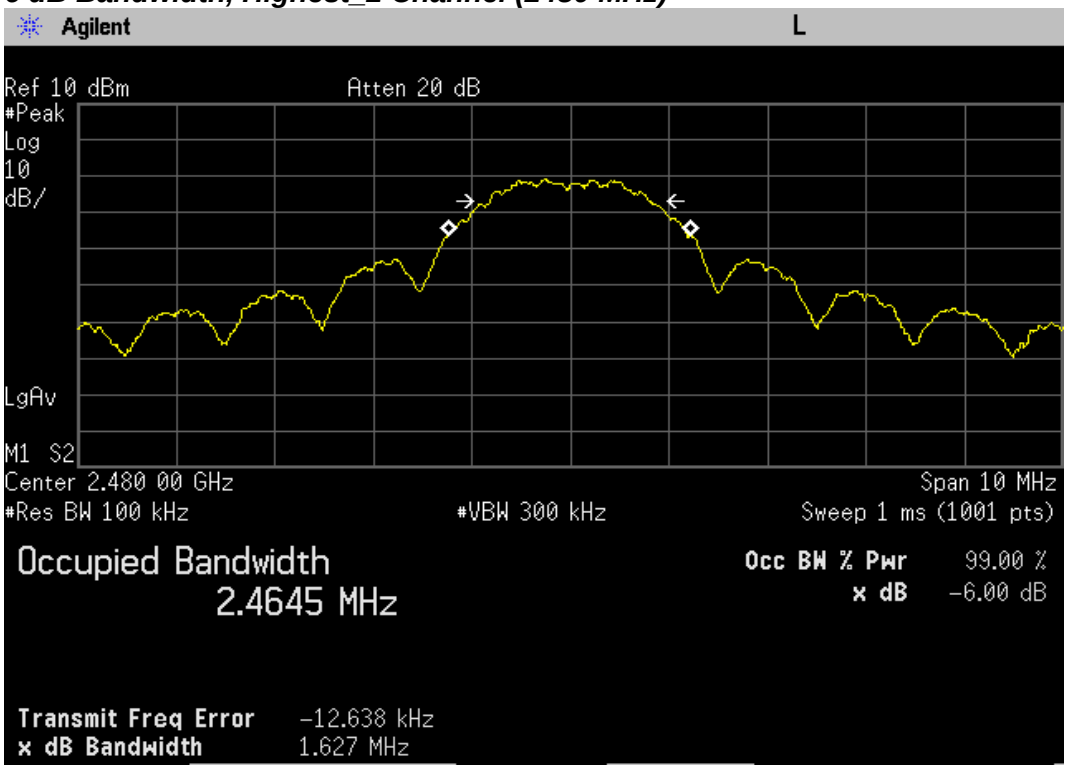


PLOTS OF EMISSIONS

6 dB Bandwidth, Highest_1 Channel (2475 MHz)



6 dB Bandwidth, Highest_2 Channel (2480 MHz)



8.4 Peak Output Power

FCC §15.247(b)(3), IC RSS-247 Issue 1 5.4

Test Mode : Set to Lowest channel, Middle channel, Highest1 channel and Highest2 channel

Result

Frequency (MHz)	Data rate (kbps)	Conducted Output Power (dBm)	FCC / IC Conducted Limit (dBm)	E.I.R.P (dBm)	IC E.I.R.P Limit (dBm)
2405	250	17.06	30.00	20.66	36.00
2440	250	17.23	30.00	20.83	36.00
2475	250	13.55	30.00	17.15	36.00
2480	250	-7.54	30.00	-3.94	36.00

Note:

1. E.I.R.P was calculated by following equation according to KDB412172 D01 Determining ERP and EIRP v01

$E.I.R.P = P_T + G_T – Lc$

P_T = Peak outputpower (dBm)

*G_T = Gain of the transmitting antenna in dBi, Directional antenna gain is **3.6 dBi.***

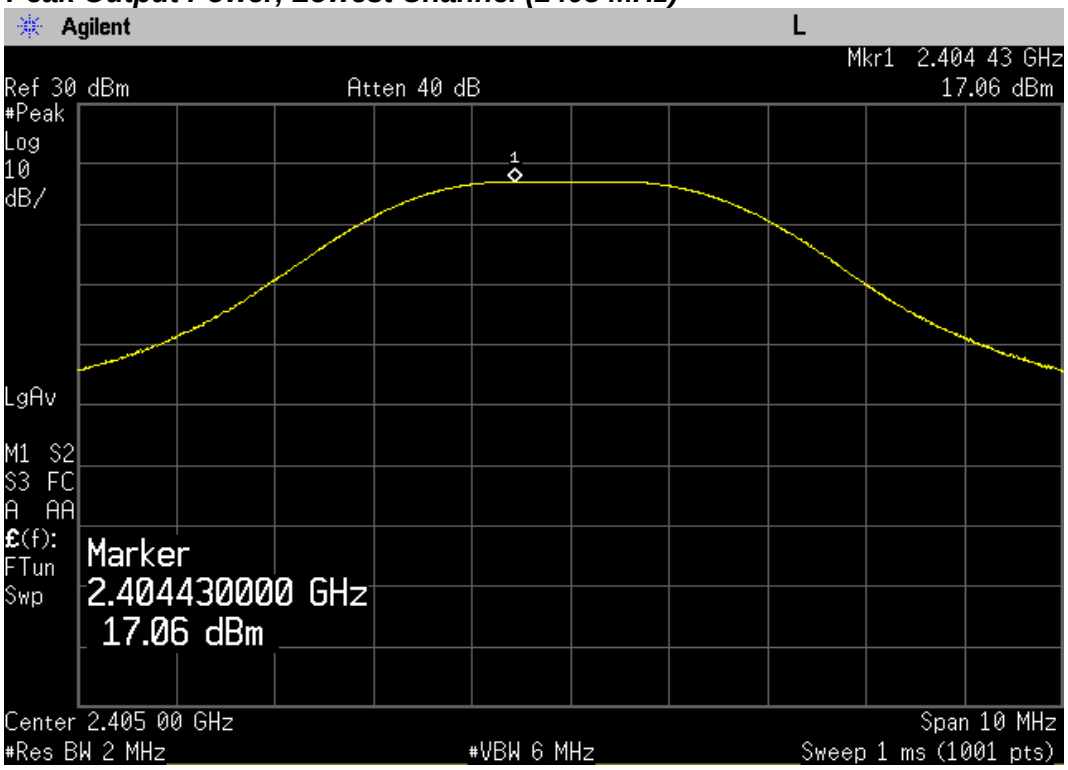
L_C = Signal attenuation in the connecting cable between the transmitter and antenna in dB. This factor of an integral antenna is negligible.

2. The following equation was used for spectrum offset:

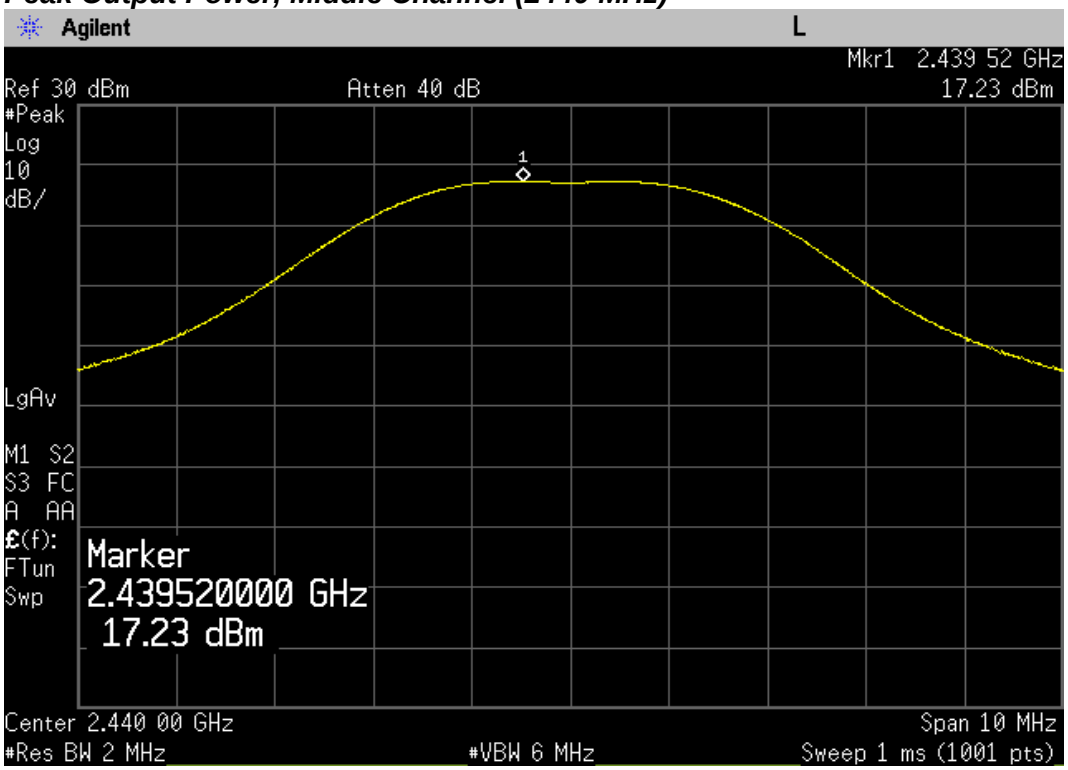
Spectrum offset (dB) = Attenuator (dB) + Cable Loss (dB) + SMA Type Connector Loss (dB)

PLOT OF TEST DATA

Peak Output Power, Lowest Channel (2405 MHz)

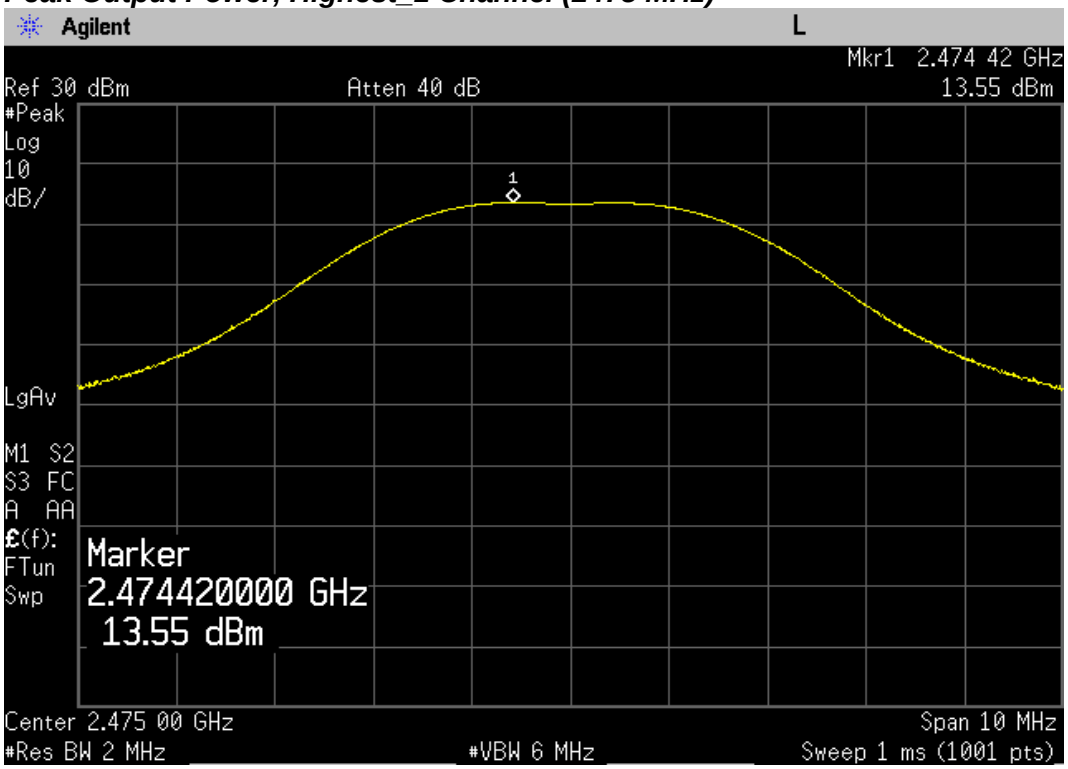


Peak Output Power, Middle Channel (2440 MHz)

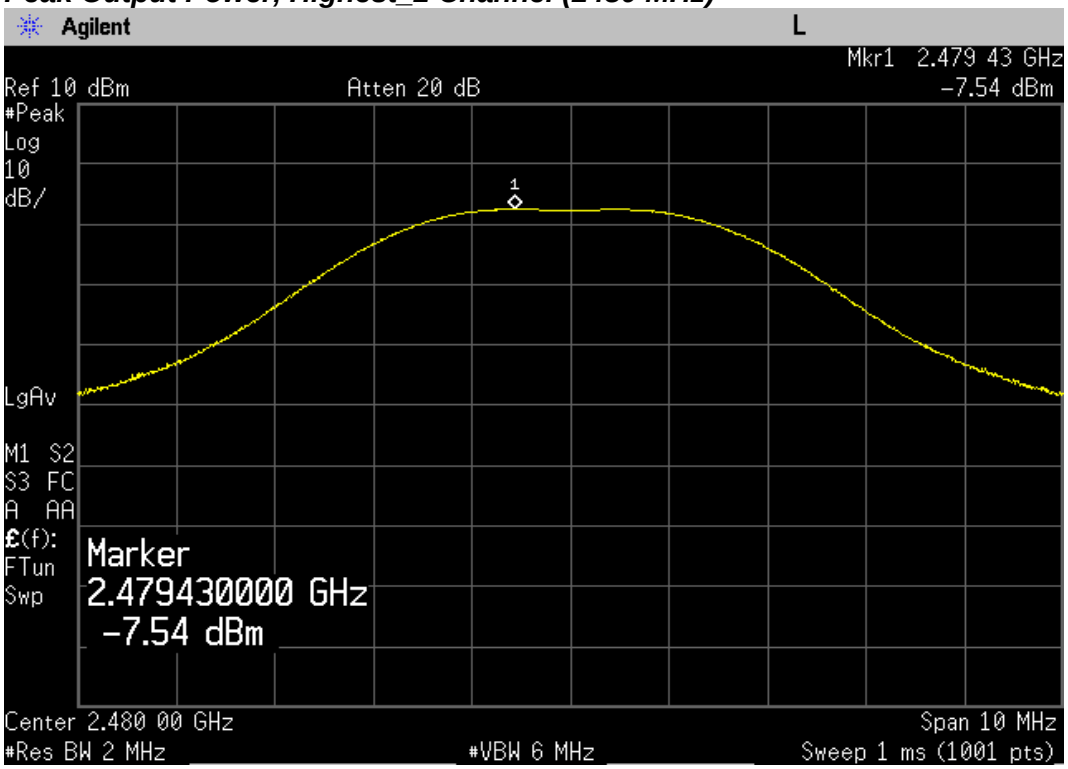


PLOT OF TEST DATA

Peak Output Power, Highest_1 Channel (2475 MHz)



Peak Output Power, Highest_2 Channel (2480 MHz)



8.5 Peak Power Spectral Density

FCC §15.247(e), IC RSS-247 Issue 1 5.2

Test Mode : Set to Lowest channel, Middle channel, Highest1 channel and Highest2 channel

Result

Channel	Frequency(MHz)	Result(dBm/3kHz)	Limit (dBm/3kHz)
Low	2405	2.80	8.0
Middle	2440	2.34	8.0
High_1	2475	-1.66	8.0
High_2	2480	-22.52	8.0

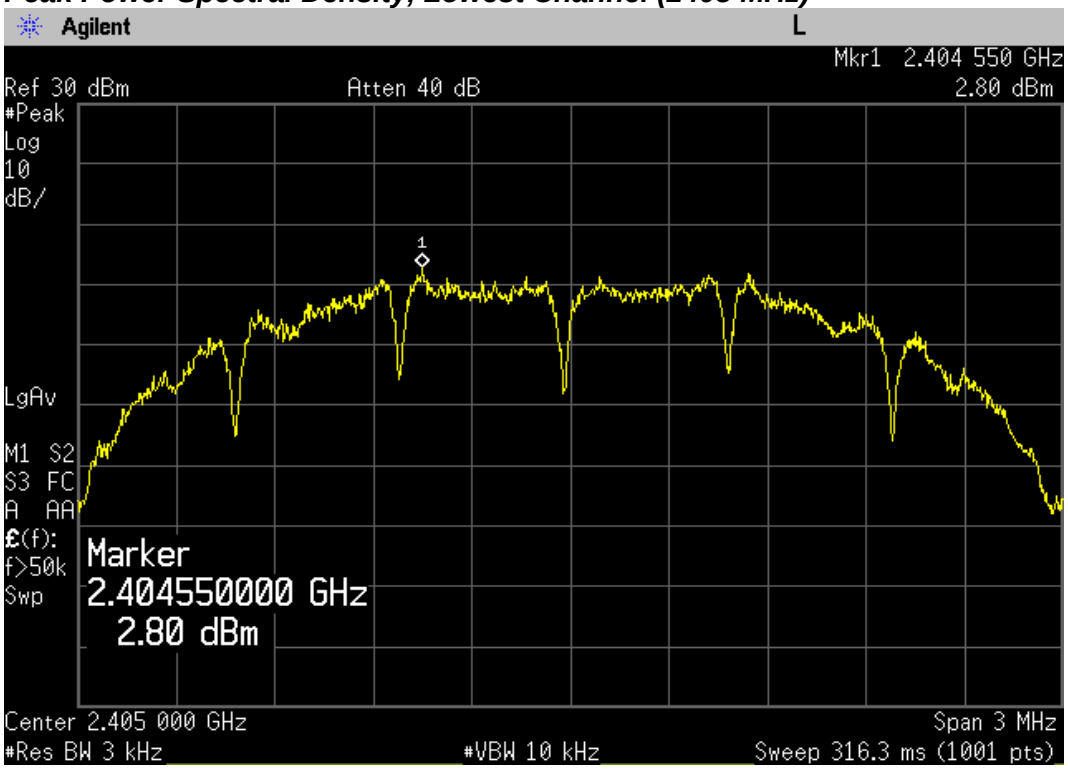
Note:

The following equation was used for spectrum offset:

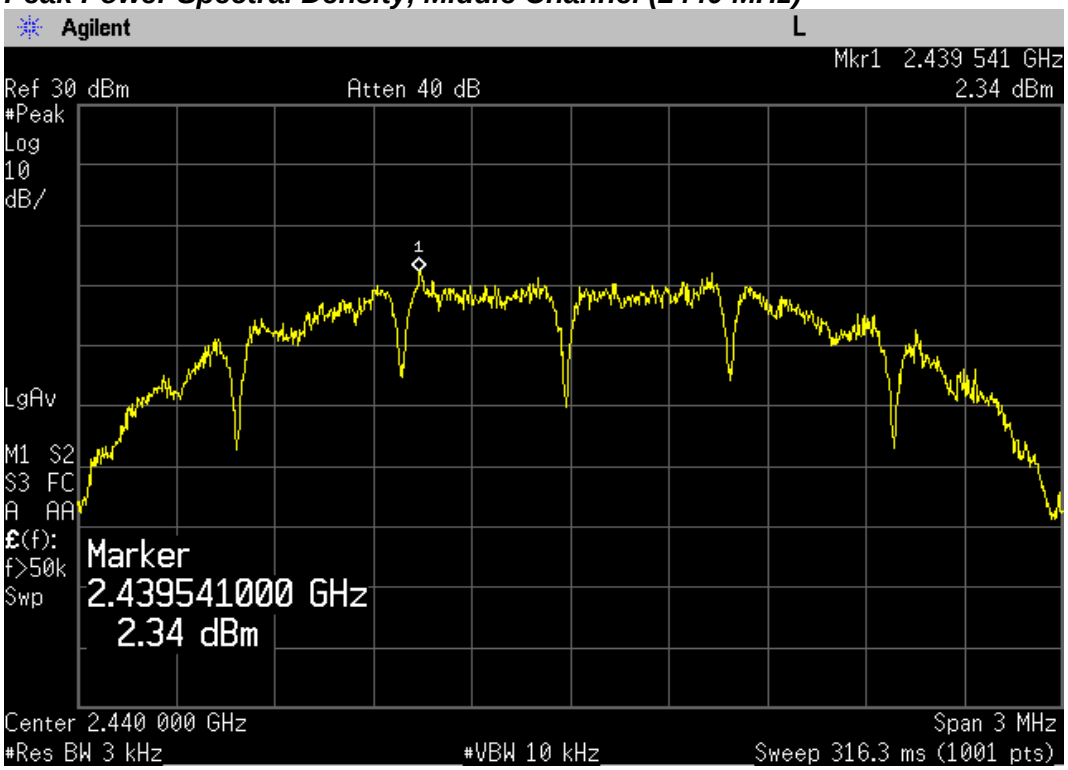
Spectrum offset (dB) = Attenuator (dB) + Cable Loss (dB) + SMA Type Connector Loss (dB)

PLOT OF TEST DATA

Peak Power Spectral Density, Lowest Channel (2405 MHz)

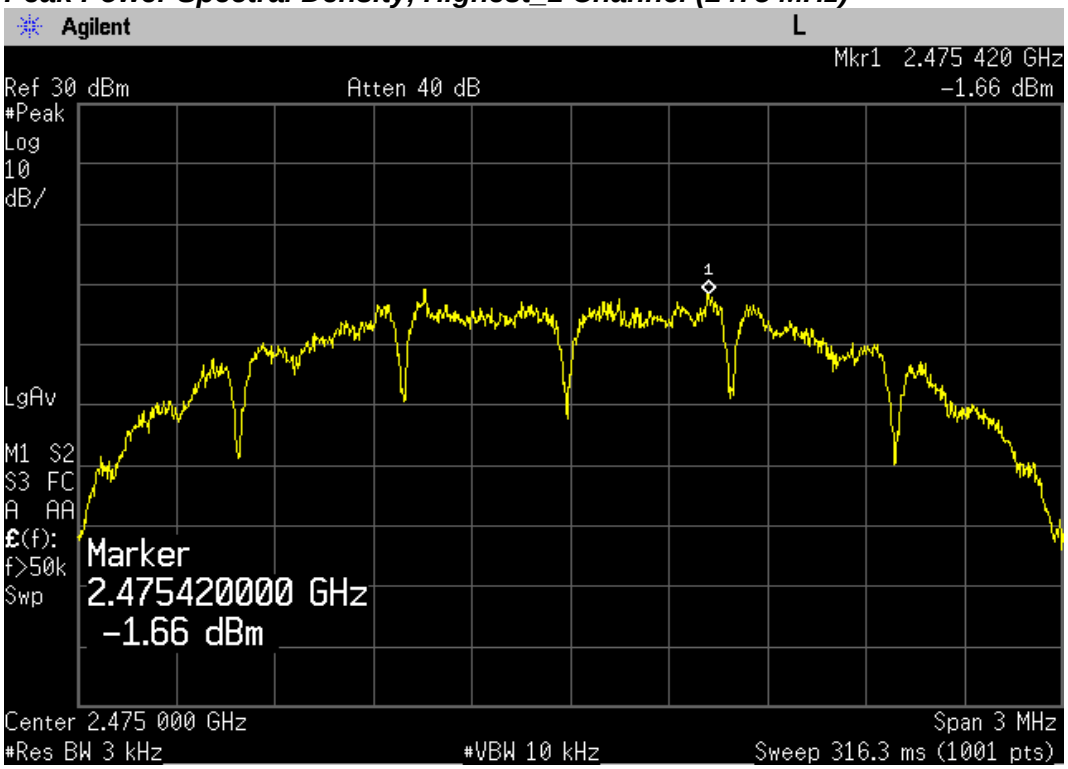


Peak Power Spectral Density, Middle Channel (2440 MHz)

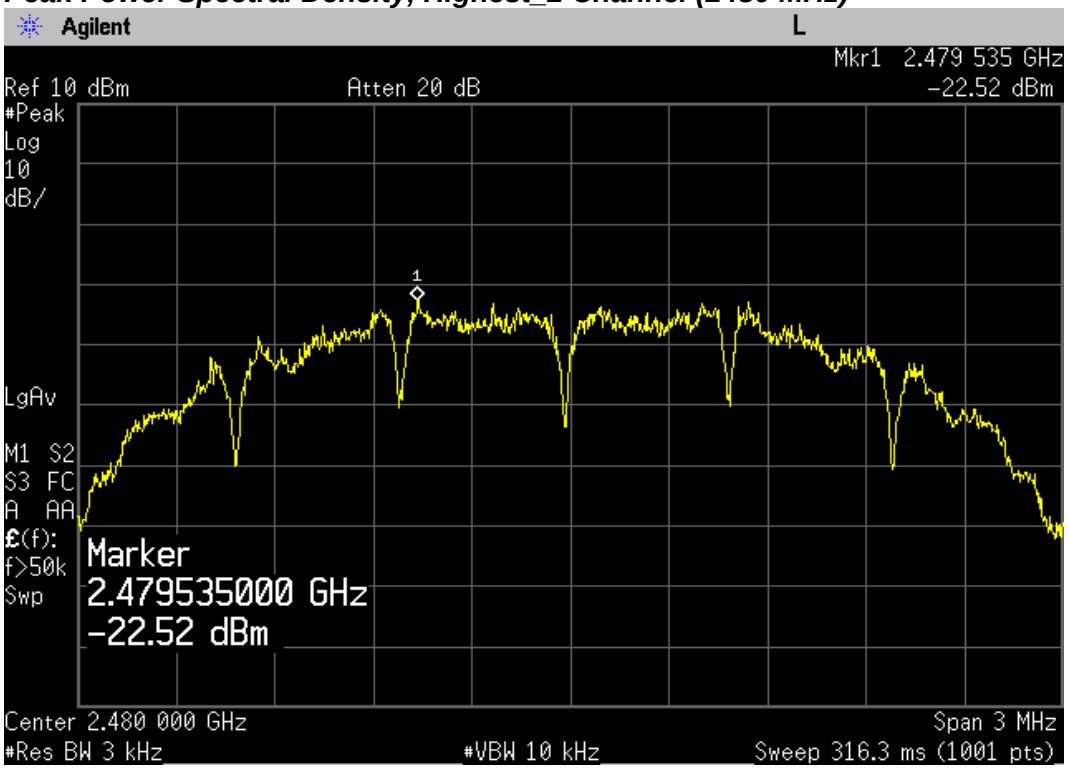


PLOT OF TEST DATA

Peak Power Spectral Density, Highest_1 Channel (2475 MHz)



Peak Power Spectral Density, Highest_2 Channel (2480 MHz)



8.6 Conducted Spurious Emissions

FCC §15.247(d), IC RSS-247 Issue 1 5.5

Test Mode : Set to Lowest channel, Middle channel, Highest1 channel and Highest2 channel

Result

Channel	Frequency (MHz)	Reference Level (dBm)	Conducted Spurious Emissions (dBc)	Limit (dBc)
Low	2405	13.67	More than 20 dBc	20
Middle	2440	13.91	More than 20 dBc	20
High_1	2475	10.29	More than 20 dBc	20
High_2	2480	-11.03	More than 20 dBc	20

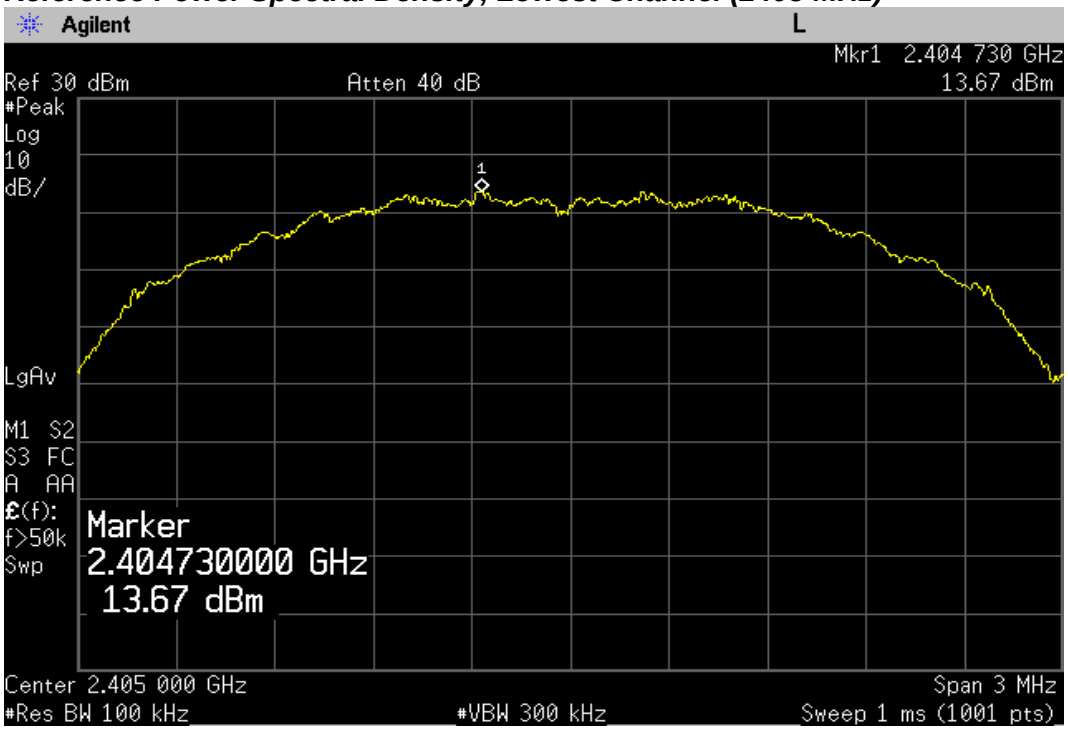
Notes:

1. *The cable and attenuator loss from 30 MHz to 25 GHz was reflected in spectrum analyzer with correction factor for the spurious emissions test.*
2. *The display line shown in the following plots indicates the limit at 20 dB below the fundamental emission level measured in a 100 kHz bandwidth.*
3. *In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)) and was demonstrated with radiated spurious emission measurement in 8.7 clause in this report.*

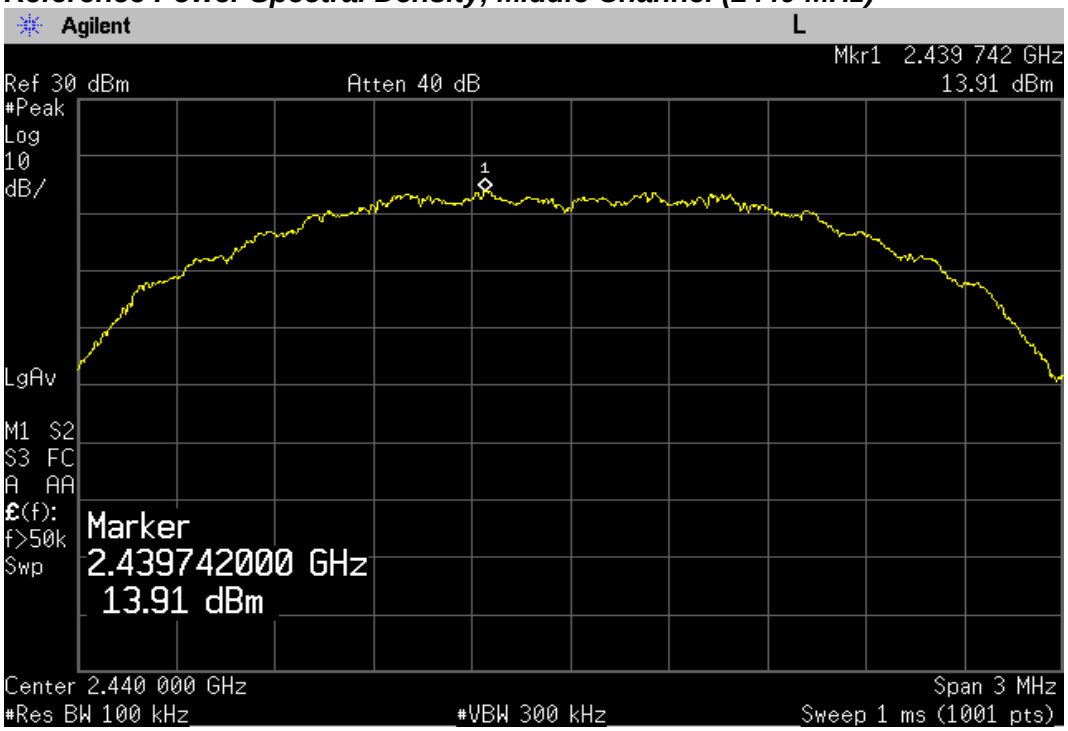
PLOT OF TEST DATA

Reference level

Reference Power Spectral Density, Lowest Channel (2405 MHz)

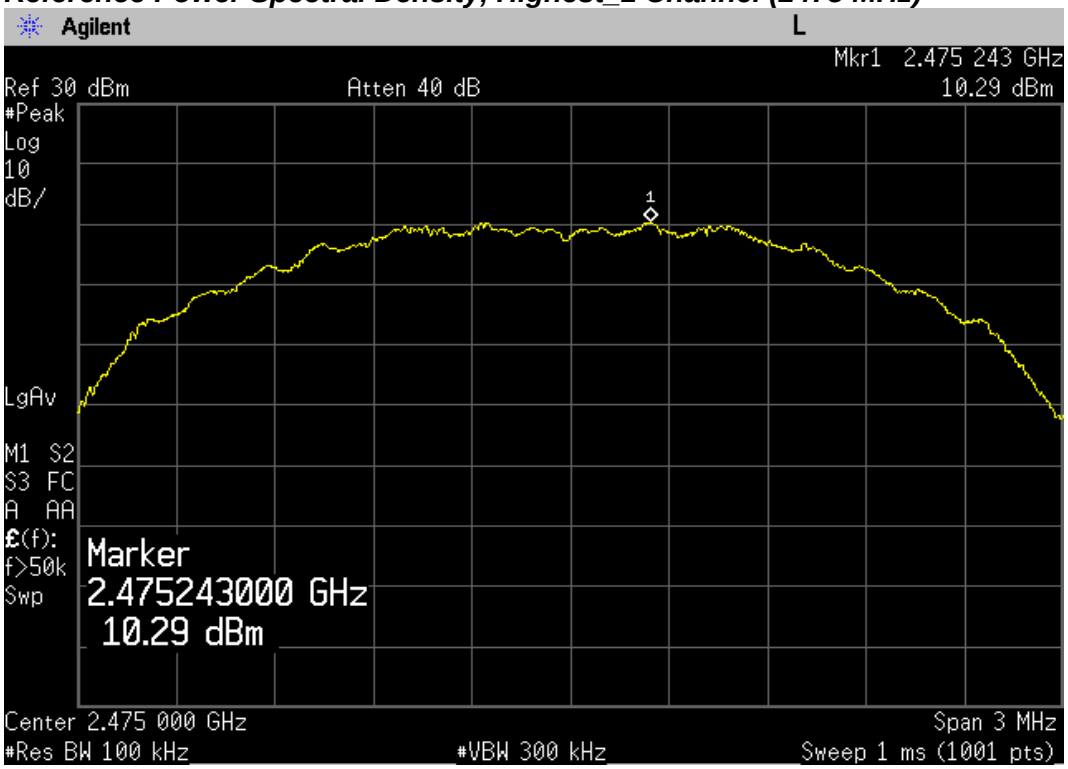


Reference Power Spectral Density, Middle Channel (2440 MHz)

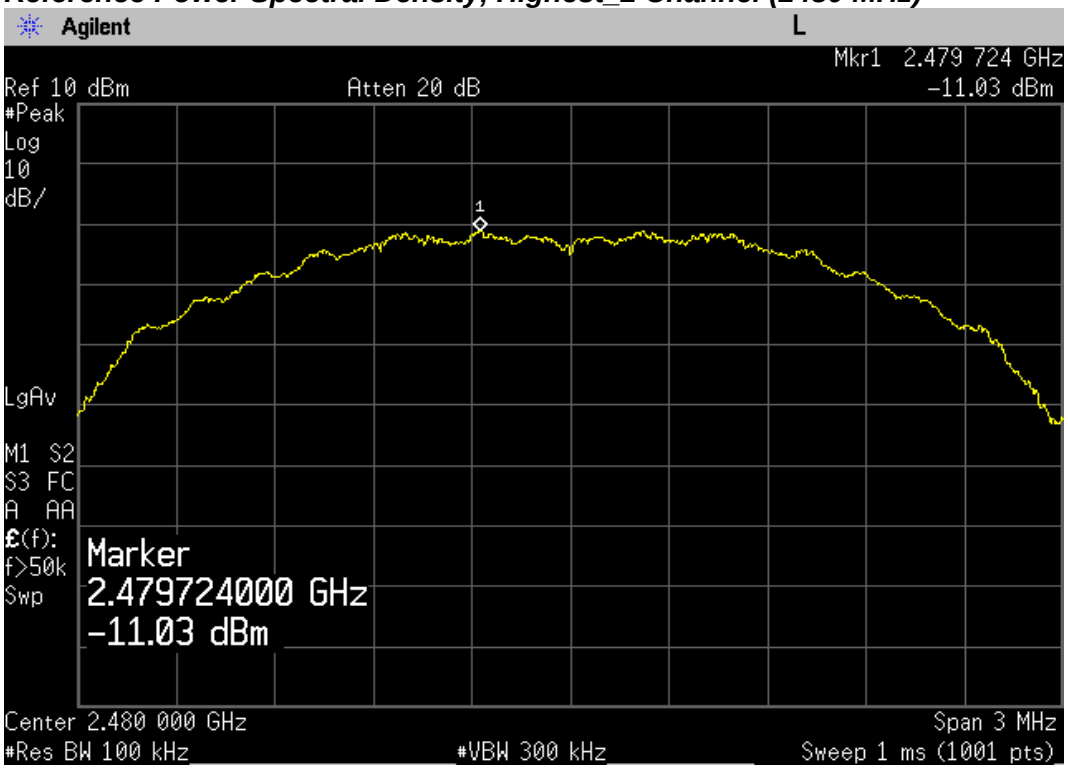


PLOT OF TEST DATA

Reference Power Spectral Density, Highest_1 Channel (2475 MHz)

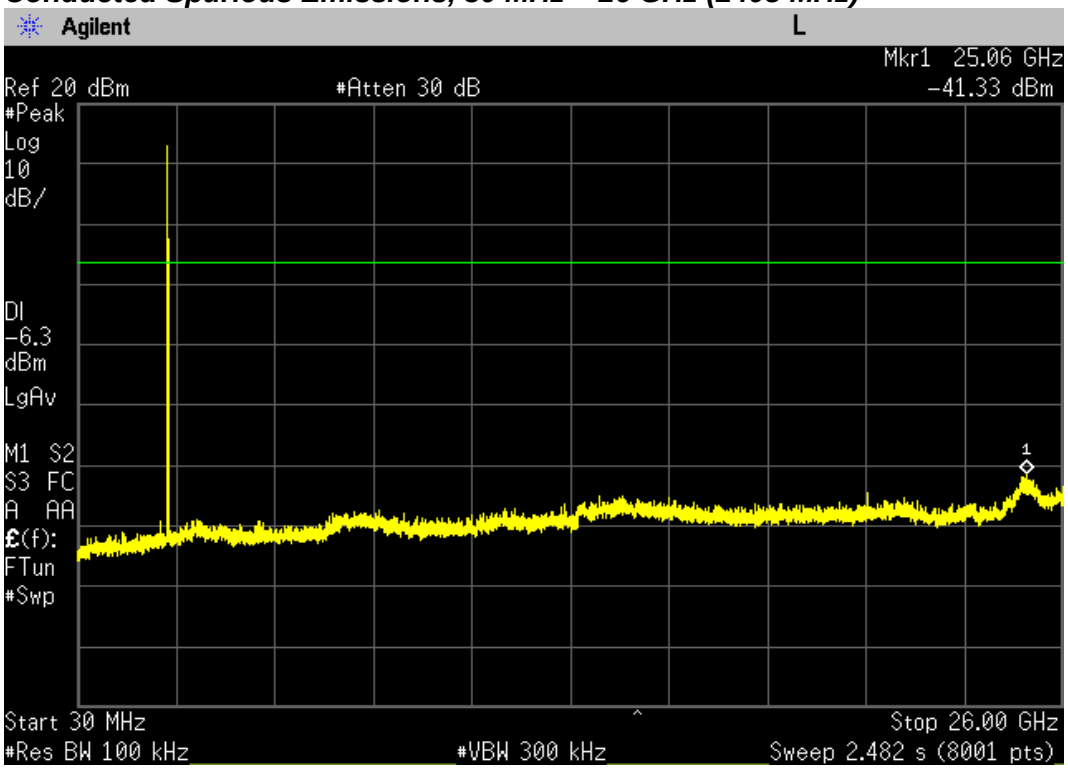


Reference Power Spectral Density, Highest_2 Channel (2480 MHz)

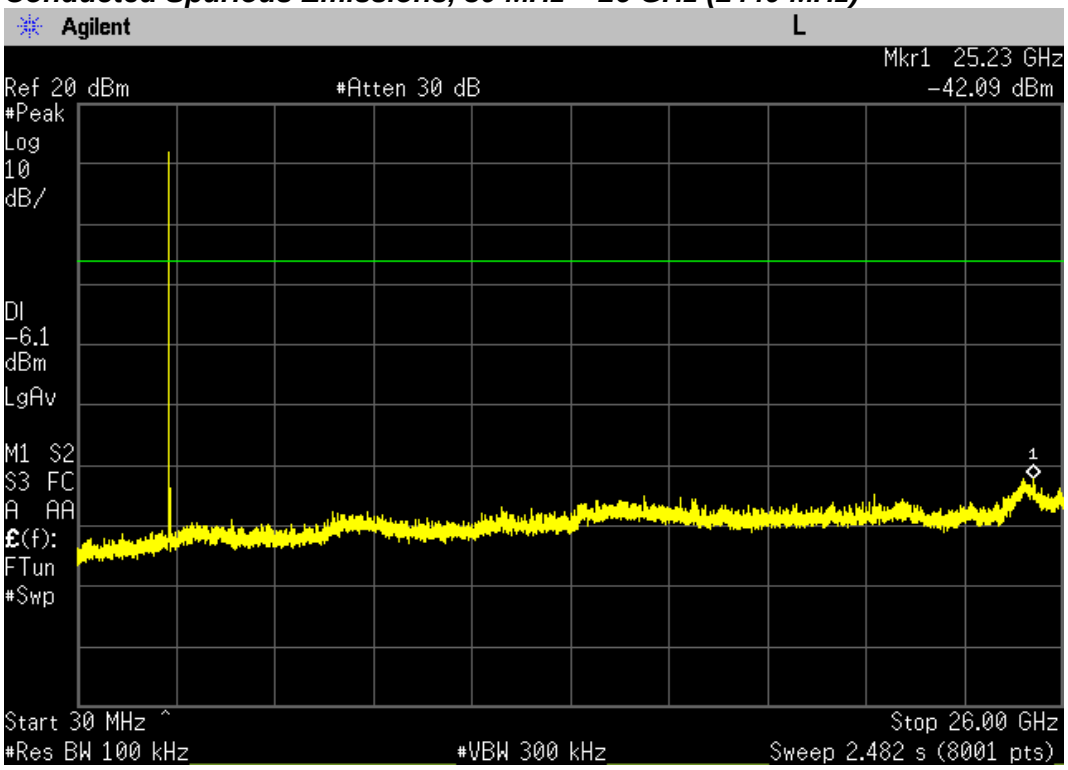


PLOT OF TEST DATA

Conducted Spurious Emissions, 30 MHz ~ 26 GHz (2405 MHz)

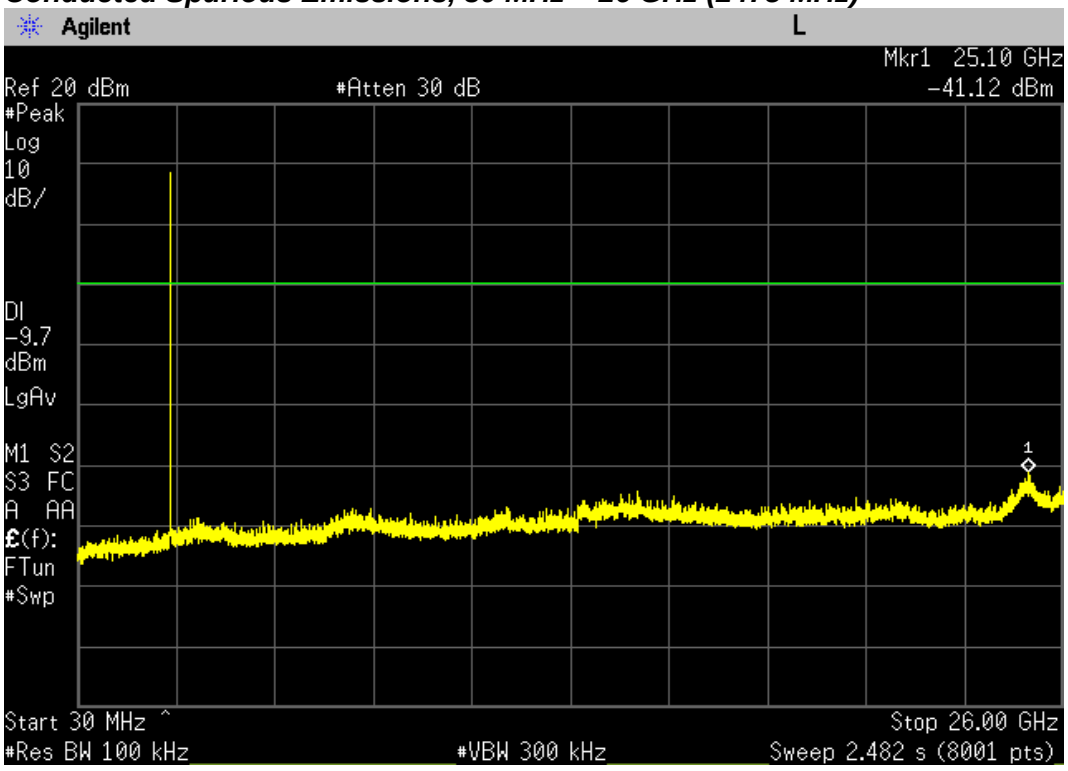


Conducted Spurious Emissions, 30 MHz ~ 26 GHz (2440 MHz)

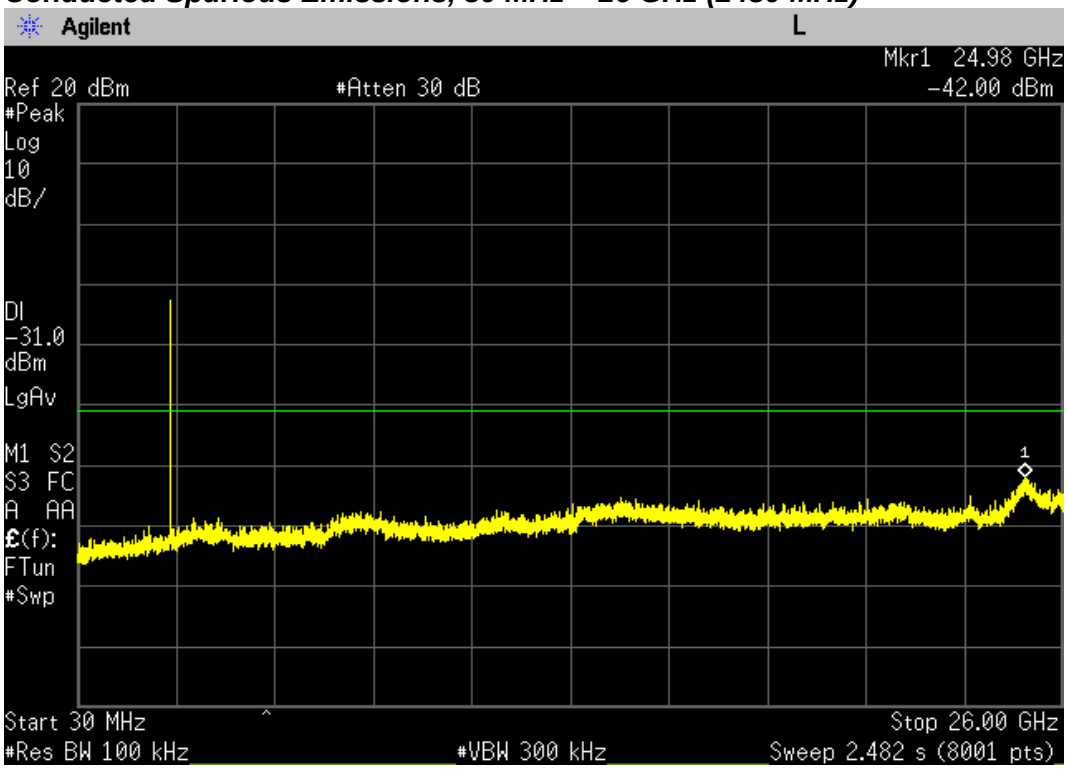


PLOT OF TEST DATA

Conducted Spurious Emissions, 30 MHz ~ 26 GHz (2475 MHz)

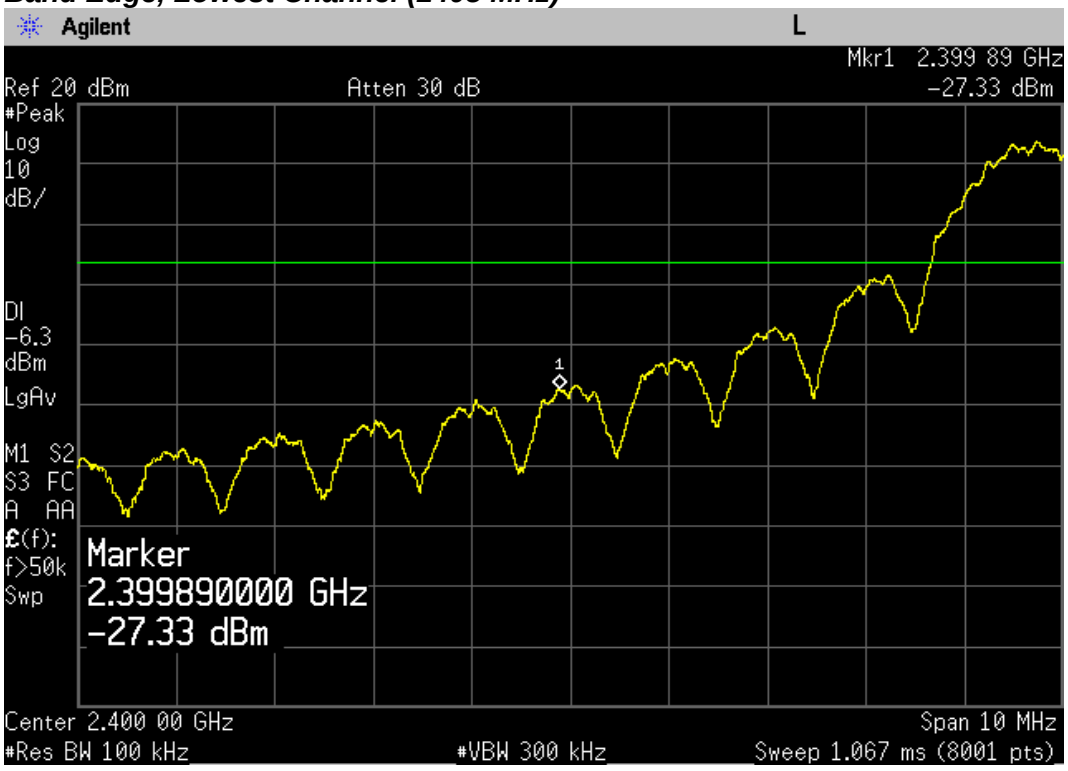


Conducted Spurious Emissions, 30 MHz ~ 26 GHz (2480 MHz)

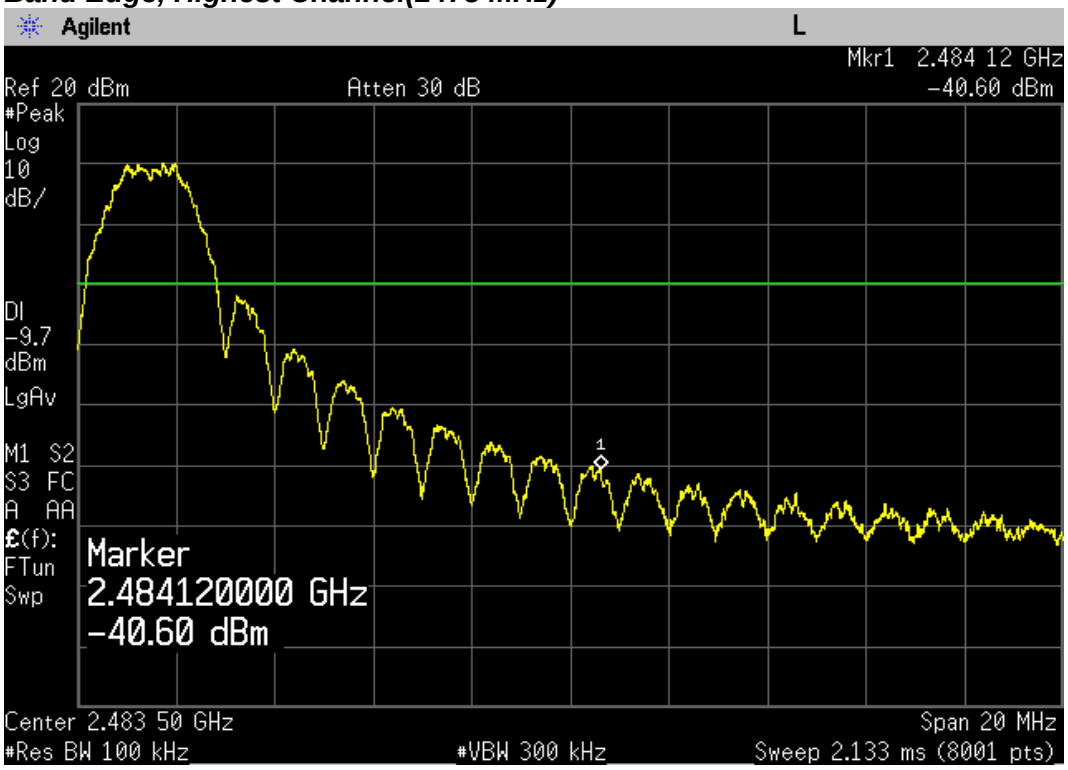


PLOT OF TEST DATA

Band Edge, Lowest Channel (2405 MHz)



Band Edge, Highest Channel(2475 MHz)



PLOT OF TEST DATA

Band Edge, Highest Channel(2480 MHz)

TEST DATA

8.7 Radiated Spurious Emissions

FCC §15.247(d), IC RSS-247 Issue 1 5.5

Test Mode : Set to Lowest channel, Middle channel, Highest1 channel and Highest2 channel

Result

Lowest Channel (2405MHz)

Frequency (MHz)	Reading (dBµV/m)	Pol* (H/V)	Detector	AF+CL+Amp (dB)**	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
4810.91	46.9	H	Peak	9.4	56.3	74.0	17.7
4810.91	40.1	H	Average	9.4	49.5	54.0	4.5
7213.57	42.7	H	Peak	16.3	59.0	74.0	15.0
7213.57	32.3	H	Average	16.3	48.6	54.0	5.4
9621.94	51.4	V	Peak	2.5	53.9	74.0	20.1
9621.94	46.5	V	Average	2.5	49.0	54.0	5.0
12022.35	49.4	V	Peak	4.8	54.2	74.0	19.8
12022.35	35.6	V	Average	4.8	40.4	54.0	13.6

TEST DATA

Middle Channel (2440MHz)

Frequency (MHz)	Reading (dBµV/m)	Pol* (H/V)	Detector	AF+CL+Amp (dB)**	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
4881.00	47.7	H	Peak	9.6	57.3	74.0	16.7
4881.00	43.1	H	Average	9.6	52.7	54.0	1.3
7321.36	42.8	H	Peak	16.8	59.6	74.0	14.4
7321.36	34.1	H	Average	16.8	50.9	54.0	3.1
9757.86	53.3	H	Peak	2.3	55.6	74.0	18.4
9757.86	50.5	H	Average	2.3	52.8	54.0	1.2
12202.43	49.5	V	Peak	4.7	54.2	74.0	19.8
12202.43	35.6	V	Average	4.7	40.3	54.0	13.7

Highest_1 Channel (2475MHz)

Frequency (MHz)	Reading (dBµV/m)	Pol* (H/V)	Detector	AF+CL+Amp (dB)**	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
4951.00	48.9	H	Peak	9.9	58.8	74.0	15.2
4951.00	43.0	H	Average	9.9	52.9	54.0	1.1
7426.51	42.0	H	Peak	17.0	59.0	74.0	15.0
7426.51	33.8	H	Average	17.0	50.8	54.0	3.2

Highest_2 Channel (2480MHz)

Frequency (MHz)	Reading (dBµV/m)	Pol* (H/V)	Detector	AF+CL+Amp (dB)**	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
1599.00	45.3	V	Peak	-2.5	42.8	74.0	31.2
1599.00	36.3	V	Average	-2.5	33.8	54.0	20.2
4960.46	40.3	H	Peak	9.9	50.2	74.0	23.8
4960.46	30.8	H	Average	9.9	40.7	54.0	13.3

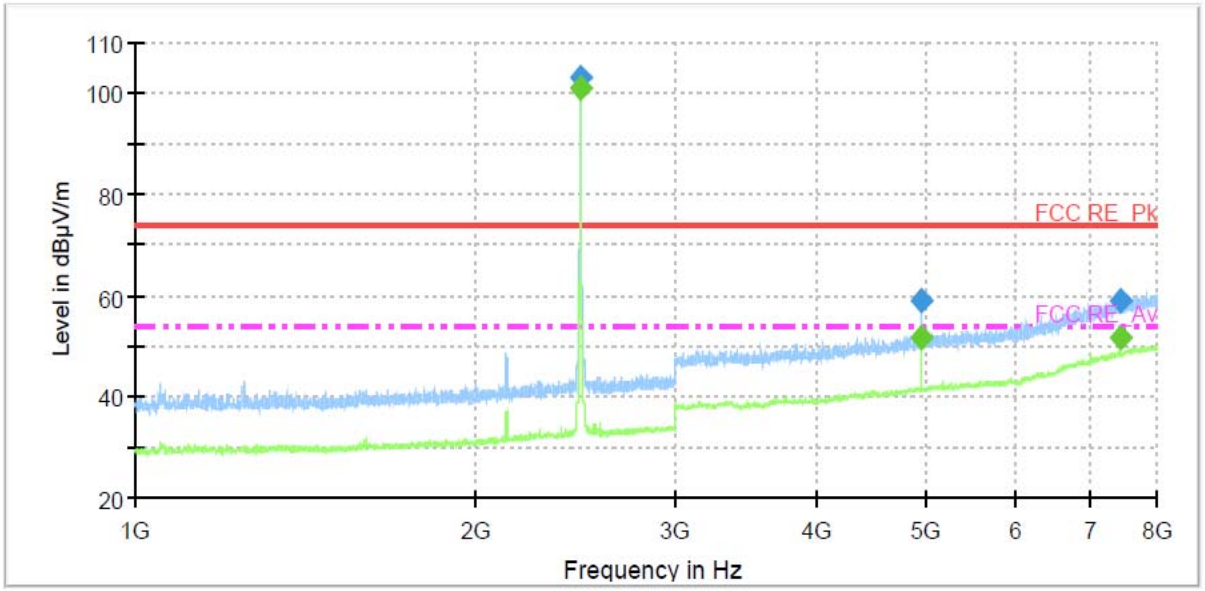
TEST DATA

Note(s):

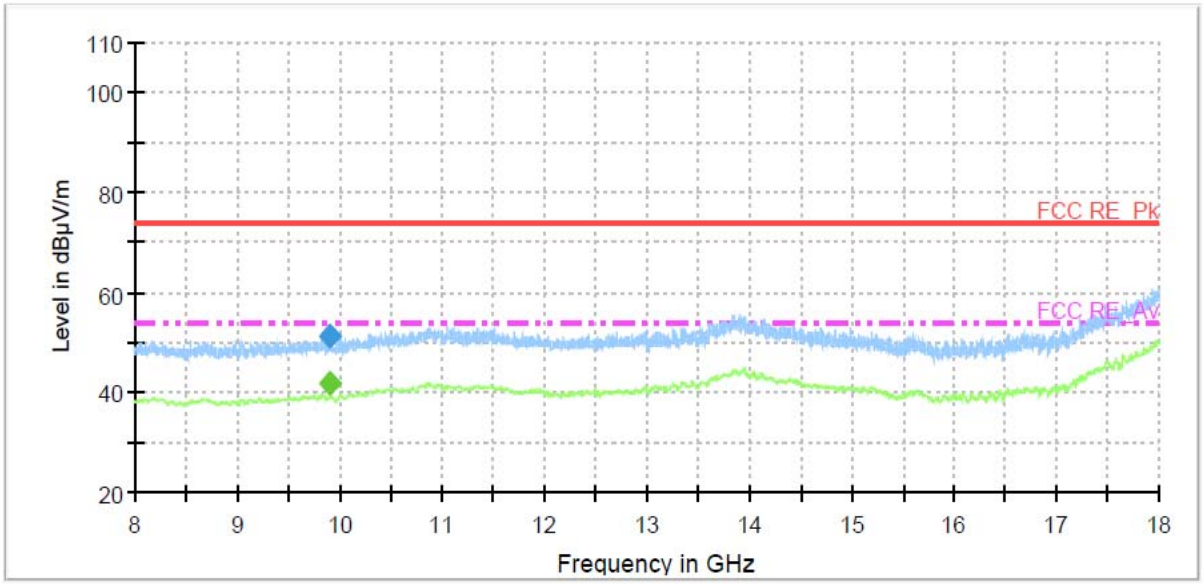
1. *Pol. H = Horizontal V = Vertical
2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
3. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization. The worst data was recorded.
4. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak
5. For average measurements, "12.2.5.1 Average Power Measurement Procedures" at "558074 D01 DTS Meas Guidance v03r03" was used.
6. The spectrum was measured from 9 kHz to 10^{th} harmonic and the worst-case emissions were reported. No significant emissions were found beyond the 2^{nd} harmonic for this device.
7. 2475MHz was the worst case channel.
8. At frequencies above 1 GHz, EUT was placed at a height of 1.5m above the floor on a support according to ANSI 63.10-2013.

PLOTS OF EMISSIONS

Radiated Spurious Emissions, 1 GHz ~ 8 GHz (2475 MHz)

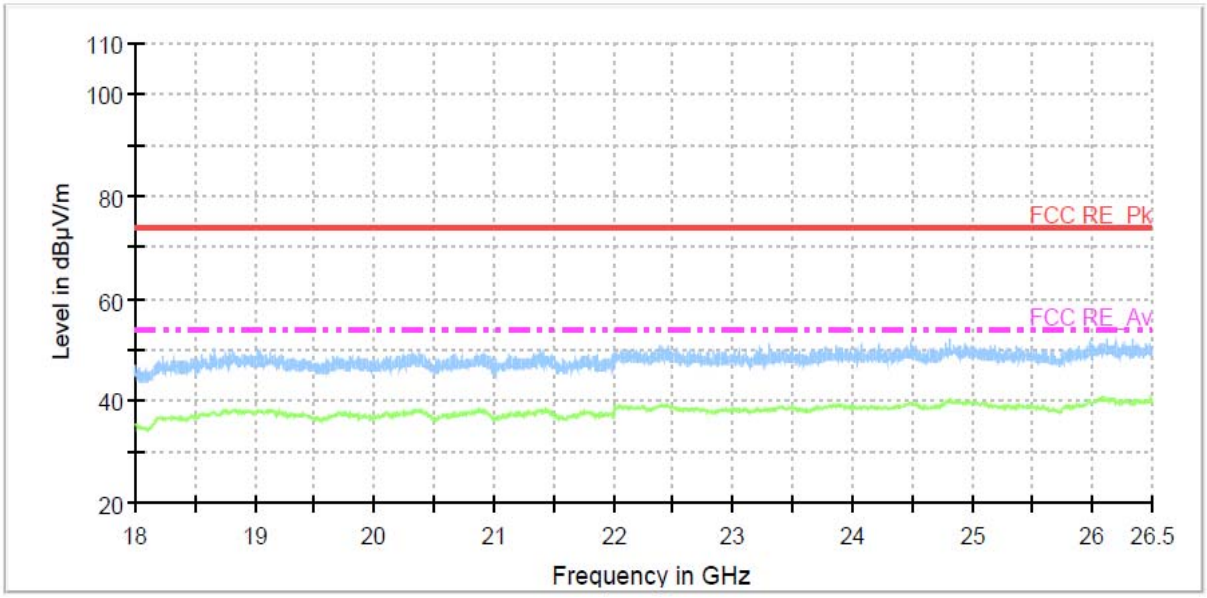


Radiated Spurious Emissions, 8 GHz ~ 18 GHz (2475 MHz)

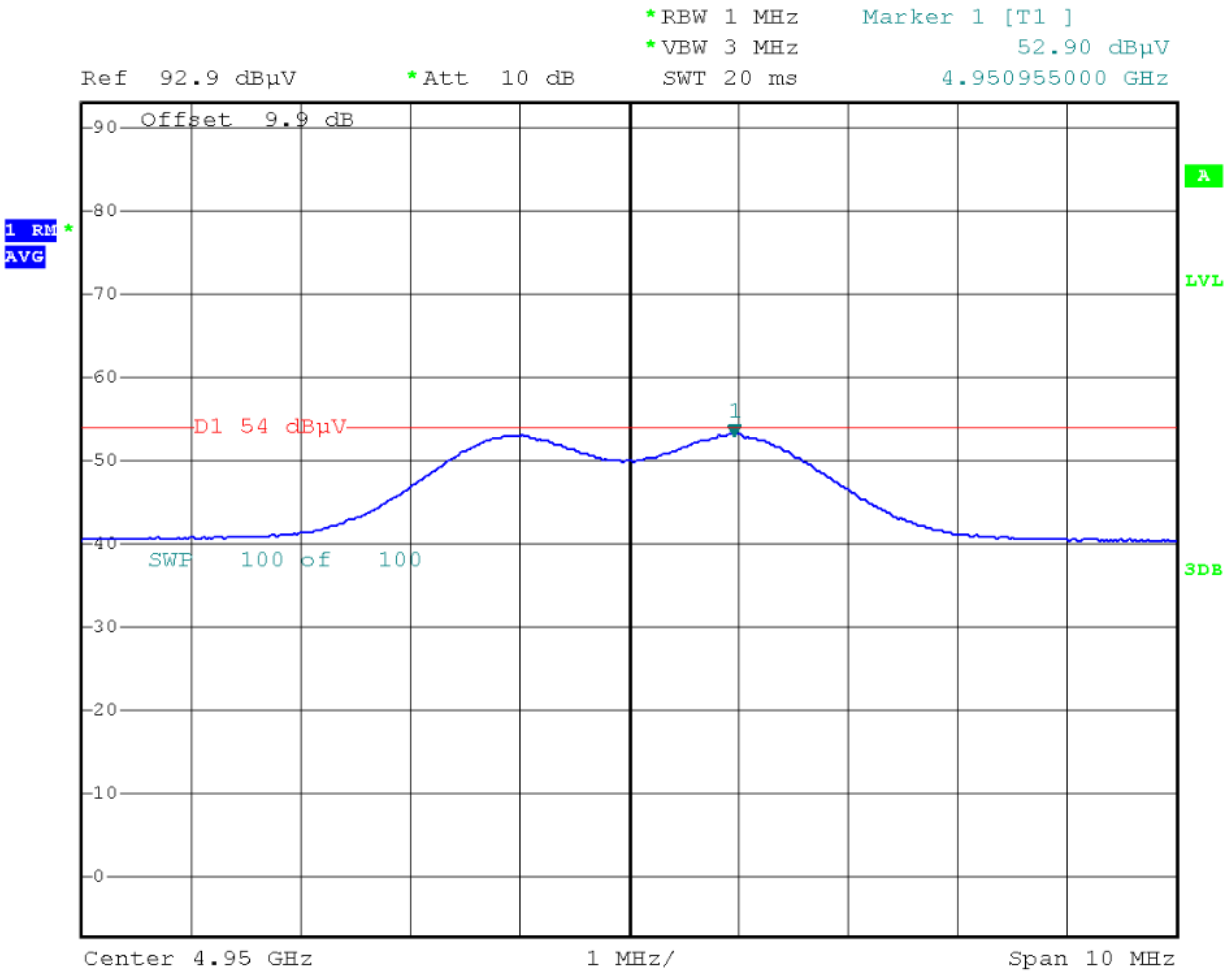


PLOTS OF EMISSIONS

Radiated Spurious Emissions, 18 GHz ~ 26 GHz (2475 MHz)

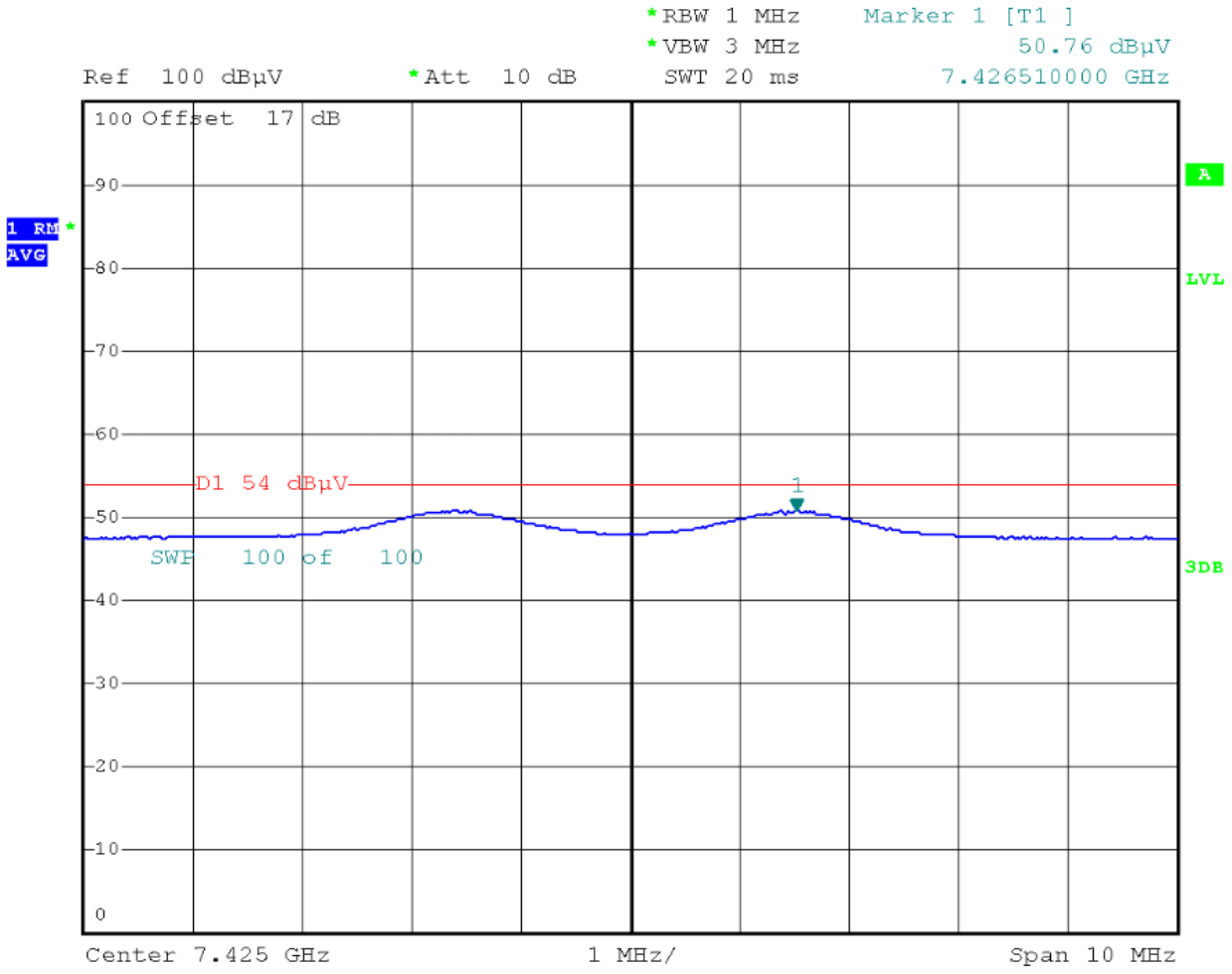


2nd Harmonic Emission (2475MHz)



PLOTS OF EMISSIONS

3rd Harmonic Emission (2475MHz)



8.8 Radiated Band Edge

FCC §15.247(d), IC RSS-247 Issue 1 5.5

Test Mode : Set to Lowest channel, Highest1 channel and Highest2 channel

Result

Lowest and Highest_1 Channel

Frequency (MHz)	Reading (dBµV/m)	Pol* (H/V)	Detector	AF+CL+Amp (dB)**	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2390.00	50.7	V	Peak	0.4	51.1	74.0	22.9
2390.00	41.4	V	Average	0.4	41.8	54.0	12.2
2483.50	58.6	V	Peak	0.8	59.4	74.0	14.6
2483.50	52.1	V	Average	0.8	52.9	54.0	1.1

Highest_2 Channel

Frequency (MHz)	Reading (dBµV/m)	Pol* (H/V)	Detector	AF+CL+Amp (dB)**	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2483.50	55.9	V	Peak	0.8	56.7	74.0	17.3
2483.50	49.4	V	Average	0.8	50.2	54.0	3.8

Note(s):

*1. *Pol. H = Horizontal V = Vertical*

*2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.*

3. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization. The worst data was recorded.

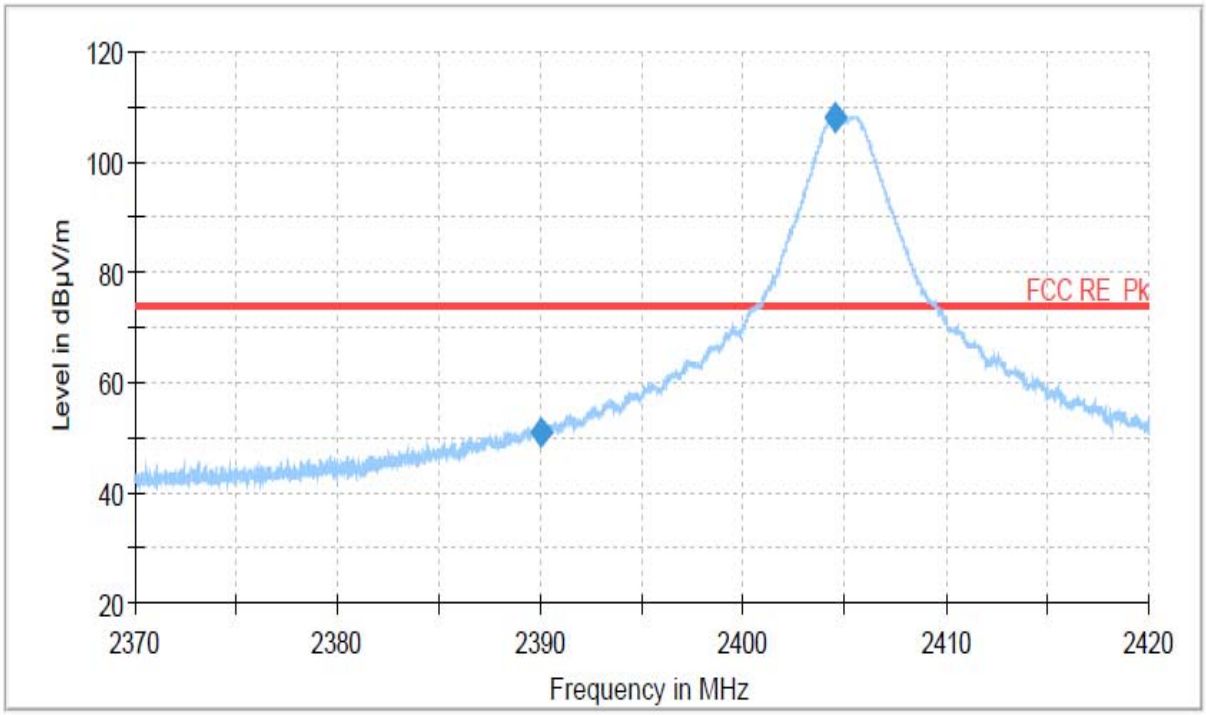
4. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak

5. For average measurements, "12.2.5.1 Average Power Measurement Procedures" at "558074 D01 DTS Meas Guidance v03r03" was used.

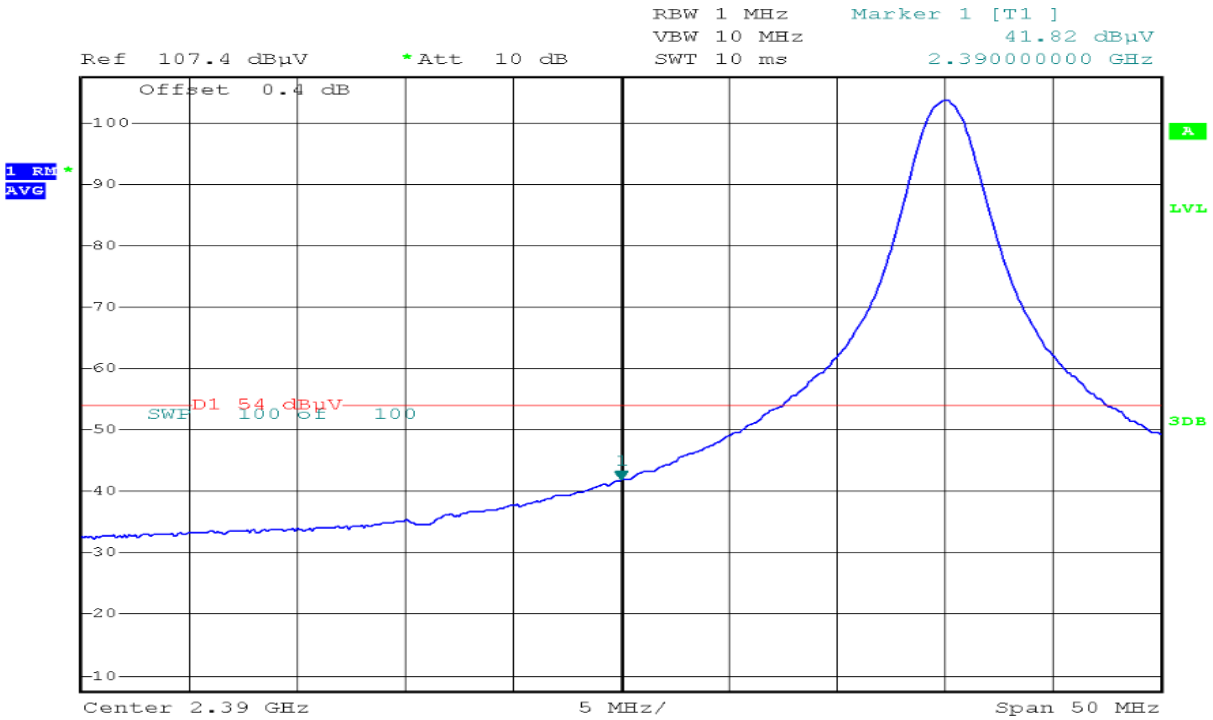
6. At frequencies above 1 GHz, EUT was placed at a height of 1.5m above the floor on a support according to ANSI 63.10-2013.

PLOTS OF EMISSIONS

Lowest Channel (2405 MHz : Peak)

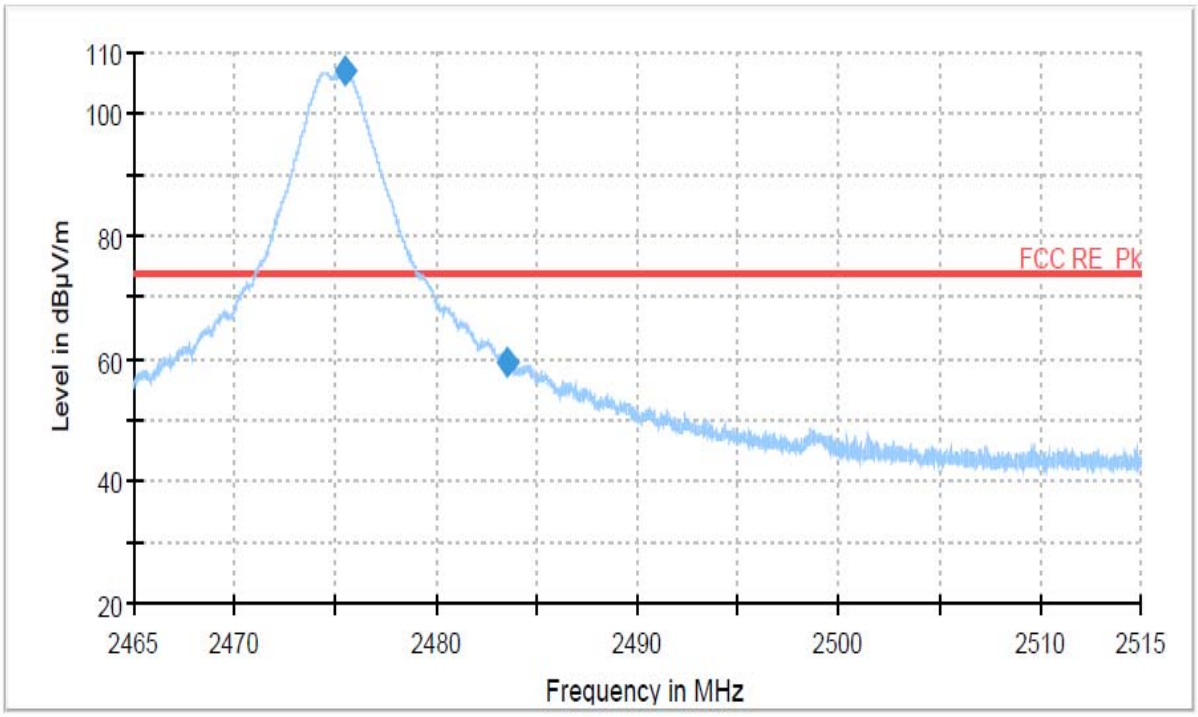


Lowest Channel (2405 MHz : Average)

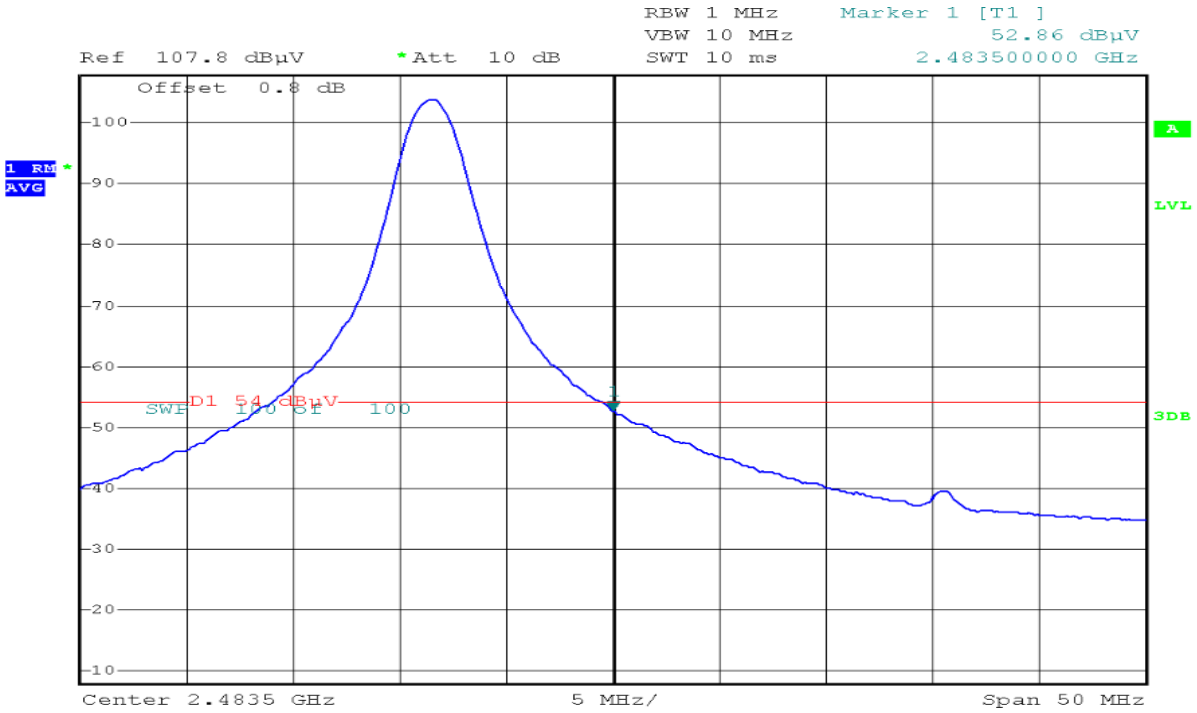


PLOTS OF EMISSIONS

Highest_1 Channel (2475 MHz : Peak)

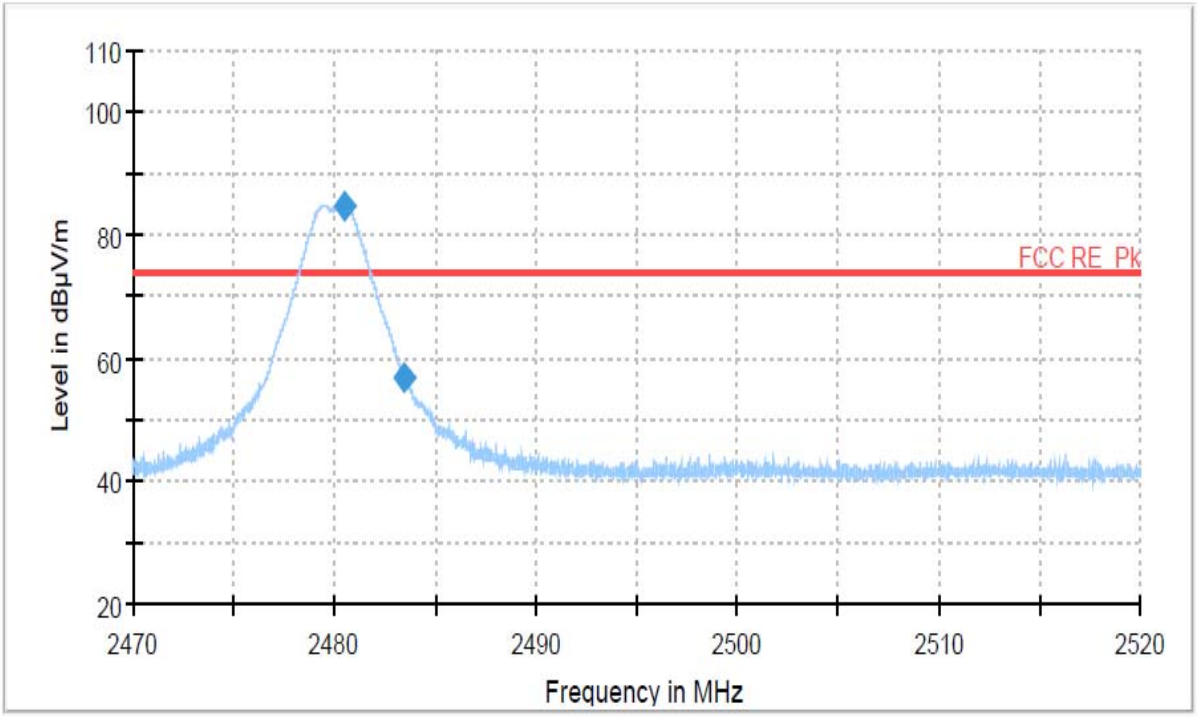


Highest_1 Channel (2475 MHz : Average)

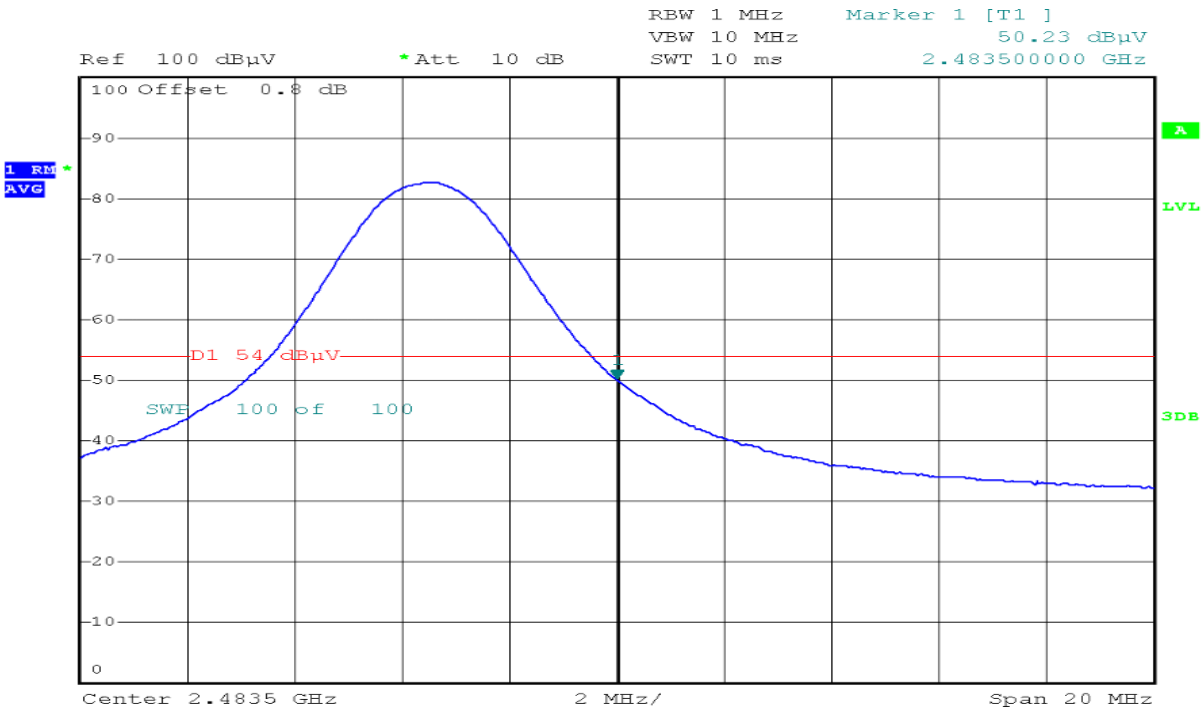


PLOTS OF EMISSIONS

Highest_2 Channel (2480 MHz : Peak)



Highest_2 Channel (2480 MHz : Average)



9. TEST EQUIPMENT

No.	Instrument	Manufacturer	Model	Serial No.	Calibration Date	Calibration Interval
1	*Test Receiver	R & S	ESU 40	100202	Apr. 01 2015	1 year
2	*Test Receiver	R & S	ESCS30	100302	Oct. 06 2015	1 year
3	Attenuator	AGILENT	8491B	57773	Oct. 06 2015	1 year
4	*Attenuator	FAIRVIEW	SA3N5W-06	N/A	Apr. 01 2015	1 year
5	*Attenuator	FAIRVIEW	SA3N5W-10	N/A	Apr. 01 2015	1 year
6	*Attenuator	WEINSCHEL	56-10	58765	Apr. 02 2015	1 year
7	*Amplifier	R & S	SCU 01	10030	Apr. 01 2015	1 year
8	*Amplifier	R & S	SCU18	10065	Apr. 01 2015	1 year
9	*Amplifier	R & S	SCU26	10011	Jul. 17 2015	1 year
10	*Amplifier	R & S	SCU40	10008	Aug. 10 2015	1 year
11	*Pre Amplifier	HP	8449B	3008A00107	Jan. 07 2016	1 year
12	Spectrum Analyzer	R & S	FSW43	100732	Apr. 07 2015	1 year
13	*Spectrum Analyzer	Agilent	E4440A	MY44022567	Apr. 01 2015	1 year
14	*Spectrum Analyzer	R&S	FSP40	100361	Jul. 16 2015	1 year
15	DC Power Supply	HP	6574A	US36340190	Jul. 17 2015	1 year
16	*Loop Antenna	R & S	HFH2-Z2	100279	Feb. 22 2016	2 year
17	Wideband Power Sensor	R & S	NRP-Z81	100634	Jul. 17 2015	1 year
18	*Horn Antenna	SCHWARZBECK	BBHA9120D	9120D-474	Sep. 01 2014	2 year
19	*Horn Antenna	Q-par Angus	QSH20S20	8179	Apr. 30 2015	2 year
20	*Horn Antenna	Q-par Angus	QSH22K20	8180	Apr. 30 2015	2 year
21	*Trilog-Broadband Antenna	SCHWARZBECK	VULB 9163	9163-454	Nov. 11 2014	2 year
22	*LISN	R & S	ESH3-Z5	833874/006	Oct. 06 2015	1 year
23	*Controller	INNCO	CO2000-G	CO2000/562/23890210/L	N/A	N/A
24	*Turn Table	INNCO	DT3000-3T	N/A	N/A	N/A
25	*Antenna Mast	INNCO	MA4000-EP	N/A	N/A	N/A
26	*Open Switch And Control Unit	R & S	OSP-120	100015	N/A	N/A
27	*Anechoic Chamber	Seo-Young EMC	N/A	N/A	N/A	N/A
28	*Position Controller	INNCO	CO2000	12480406/L	N/A	N/A
29	*Turn Table	INNCO	DS1200S	N/A	N/A	N/A
30	*Antenna Mast	INNCO	MA4000	N/A	N/A	N/A
31	*Anechoic Chamber	Seo-Young EMC	N/A	N/A	N/A	N/A
32	Shielded Room	Seo-Young EMC	N/A	N/A	N/A	N/A
33	*Open Switch And Control Unit	R & S	OSP-120	100081	N/A	N/A

*) Test equipment used during the test

10. ACCURACY OF MEASUREMENT

The Measurement Uncertainties stated were calculated in accordance with the requirements of measurement uncertainty contained in CISPR 16-4-2 with the confidence level of 95%

1. Conducted Uncertainty Calculation

Source of Uncertainty	Xi	Uncertainty of Xi		Coverage factor k	u(Xi) (dB)	Ci	Ci u(Xi) (dB)
		Value (dB)	Probability Distribution				
Receiver reading	RI	± 0.1	normal 1	1.000	0.1	1	0.1
Attenuation AMN-Receiver	LC	± 0.08	normal 2	2.000	0.04	1	0.04
AMN Voltage division factor	LAMN	± 0.8	normal 2	2.000	0.4	1	0.4
Sine wave voltage	dVSW	± 2.00	normal 2	2.000	1.00	1	1.00
Pulse amplitude response	dVPA	± 1.50	rectangular	1.732	0.87	1	0.87
Pulse repetition rate response	dVPR	± 1.50	rectangular	1.732	0.87	1	0.87
Noise floor proximity	dVNF	± 0.00	-	-	0.00	1	0.00
AMN Impedance	dZ	± 1.80	triangular	2.449	0.73	1	0.73
ⓐ Mismatch	M	+ 0.70	U-Shaped	1.414	0.49	1	0.49
ⓑ Mismatch	M	- 0.80	U-Shaped	1.414	- 0.56	1	- 0.56
Measurement System Repeatability	RS	0.05	normal 1	1.000	0.05	1	0.05
Remark	ⓐ: AMN-Receiver Mismatch : + ⓑ: AMN-Receiver Mismatch : -						
Combined Standard Uncertainty	Normal			± 1.88			
Expended Uncertainty U	Normal (k = 2)			± 3.76			

2. Radiation Uncertainty Calculation

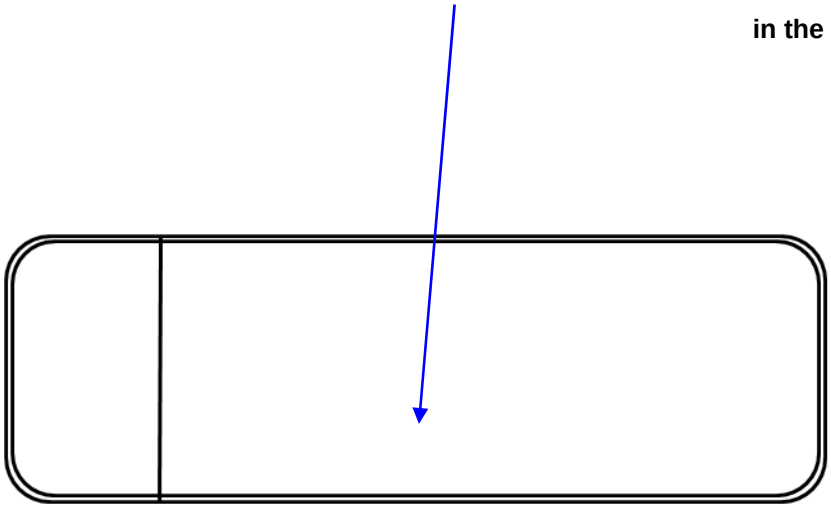
Source of Uncertainty	Xi	Uncertainty of Xi		Coverage factor k	u(Xi) (dB)	Ci	Ci u(Xi) (dB)
		Value (dB)	Probability Distribution				
Measurement System Repeatability	**RI**	0.34	normal 1	1.00	0.34	1	0.34
Receiver reading	**dVsw**	± 0.02	normal 2	2.00	0.01	1	0.01
Sine wave voltage	**dVpa**	± 0.17	normal 2	2.00	0.09	1	0.09
Pulse amplitude response	**dVpr**	± 0.92	normal 2	2.00	0.46	1	0.46
Pulse repetition rate response	**dVnf**	± 0.35	normal 2	2.00	0.18	1	0.18
Noise floor proximity	**AF**	± 0.50	normal 2	2.00	0.25	1	0.25
Antenna Factor Calibration	**CL**	± 2.00	rectangular	$\sqrt{3}$	1.15	1	1.15
Cable Loss	**AD**	± 1.00	normal 2	2.00	0.50	1	0.50
Antenna Directivity	**AH**	± 0.00	rectangular	$\sqrt{3}$	0.00	1	0.00
Antenna Factor Height Dependence	**AP**	± 2.00	rectangular	$\sqrt{3}$	1.15	1	1.15
Antenna Phase Centre Variation	**AI**	± 0.20	rectangular	$\sqrt{3}$	0.12	1	0.12
Antenna Factor Frequency Interpolation	**SI**	± 0.25	rectangular	$\sqrt{3}$	0.14	1	0.14
Site Imperfections	**DV**	± 4.00	triangular	$\sqrt{6}$	1.63	1	1.63
Measurement Distance Variation	**Dbal**	± 0.60	rectangular	$\sqrt{3}$	0.35	1	0.35
Antenna Balance	**DCross**	± 0.90	rectangular	$\sqrt{3}$	0.52	1	0.52
Cross Polarisation	**M**	± 0.00	rectangular	$\sqrt{3}$	0.00	1	0.18
Mismatch	**M**	+ 0.98 - 1.11	U-Shaped	$\sqrt{2}$	0.74	1	0.74
EUT Volume Diameter	**M**	0.33	normal 1	1.00	0.33	1	0.11
Remark							
Combined Standard Uncertainty	Normal						
Expended Uncertainty U	Normal (k = 2)						

APPENDIX A – LABELLING REQUIREMENTS

Labelling Requirements

The sample label shown shall be *permanently affixed* at a conspicuous location on the device and be readily visible to the user at the time of purchase.

※ See other informations in the manual



< Bottom Side of EUT >

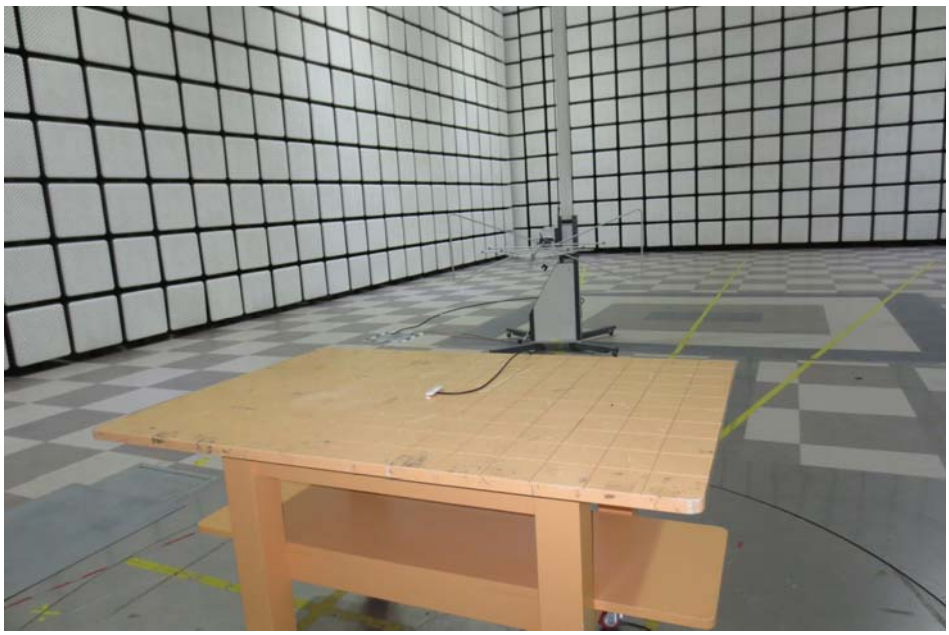
APPENDIX B – PHOTOGRAPHS OF TEST SET-UP

The **Conducted Test Picture** and **Radiated Test Picture** and show the worst-case configuration and cable placement.

- **Conducted Test Picture(Front)**

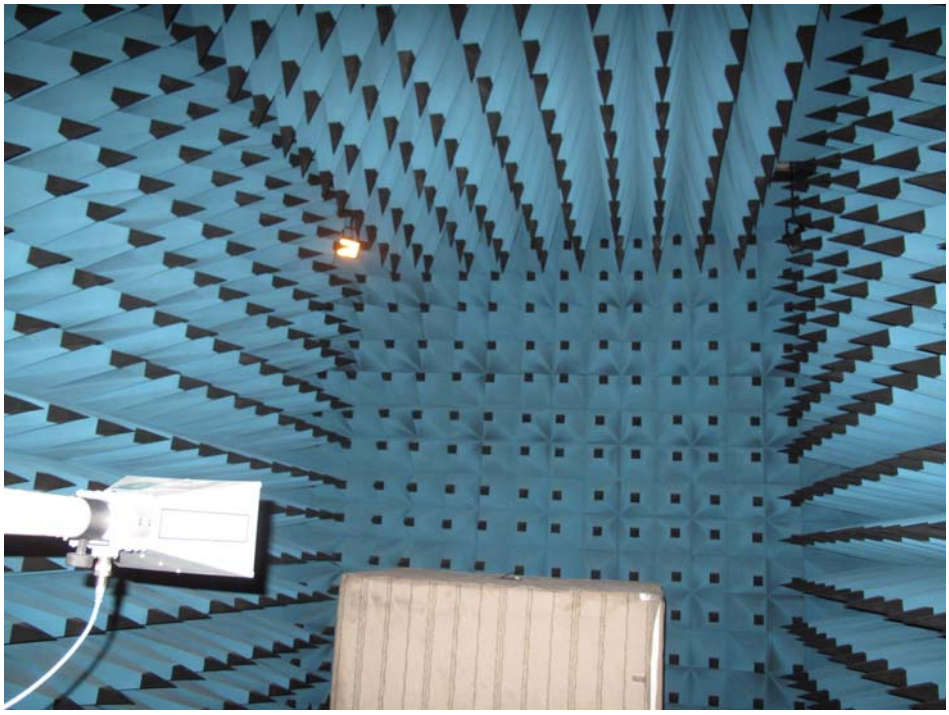
- **Conducted Test Picture(Rear)**

- **Radiated Test Picture (Front)**

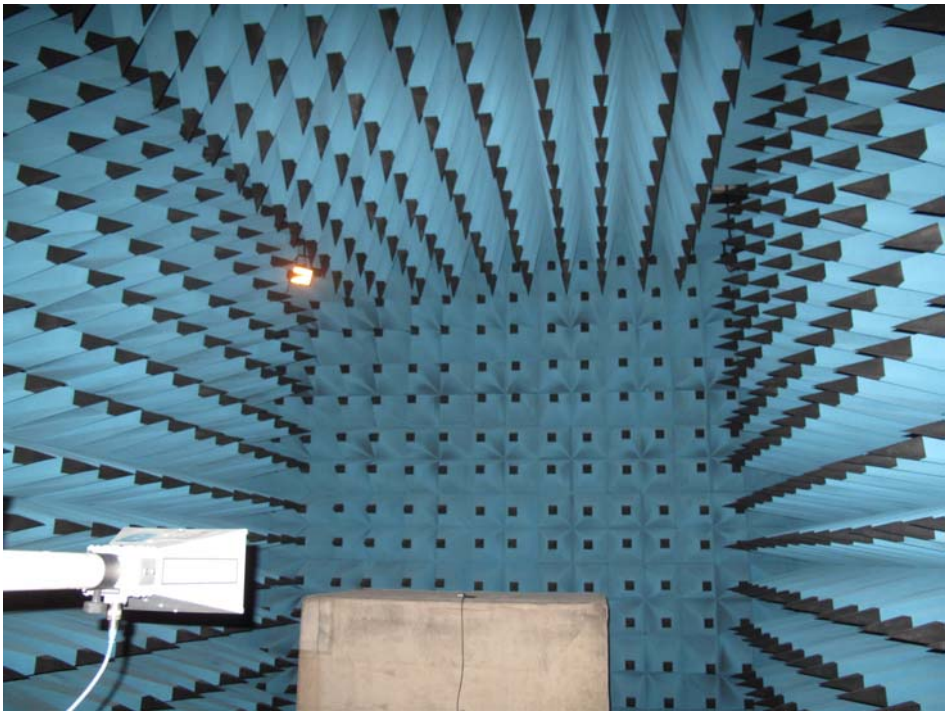


- **Radiated Test Picture (Rear)**

- **Above 1GHz Radiated Test Picture (Front)**



- **Above 1GHz Radiated Test Picture (Rear)**



APPENDIX C – EUT PHOTOGRAPHS

Front Side View of EUT

Rear Side View of EUT

Left Side View of EUT

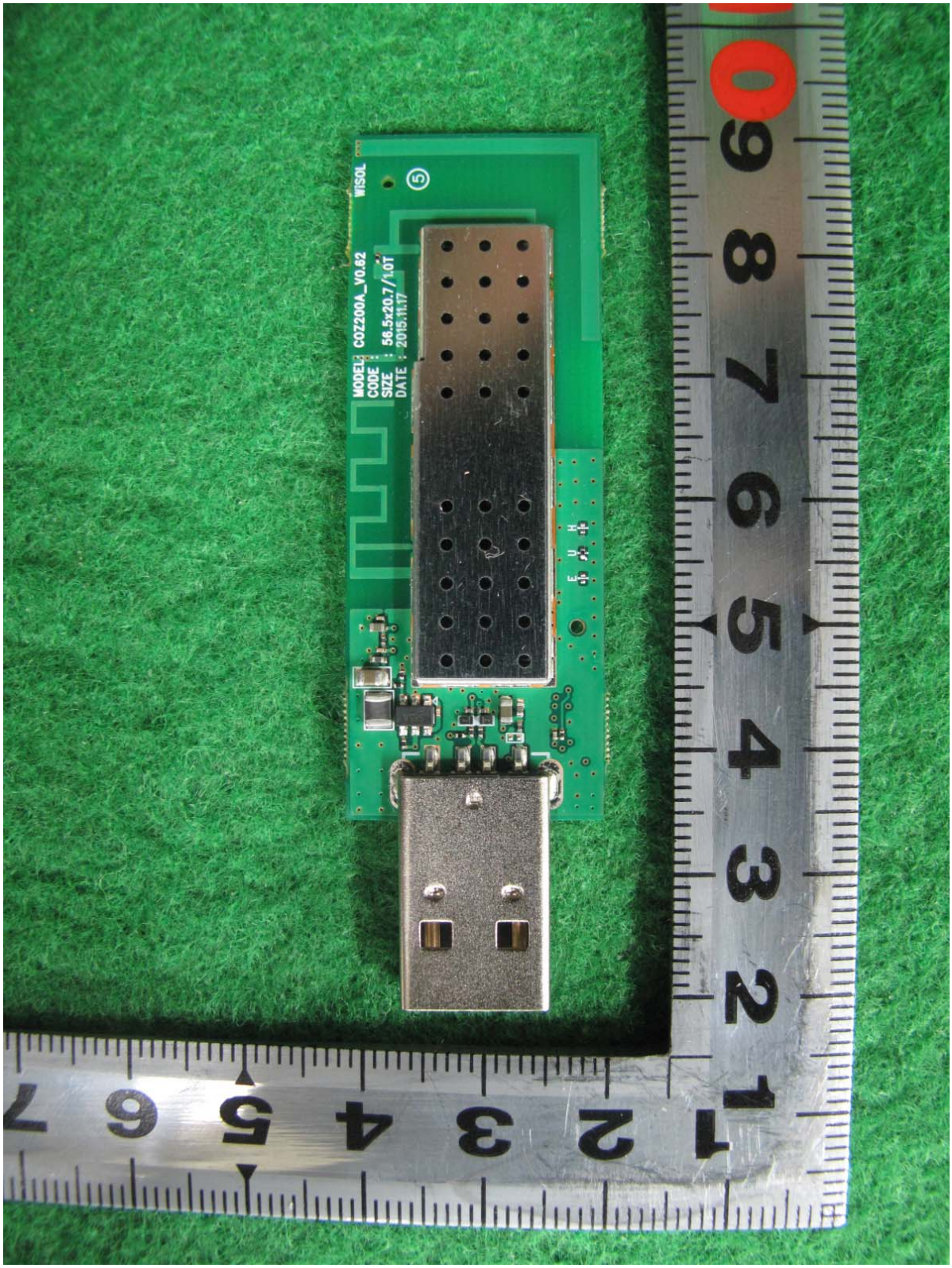
Right Side View of EUT

Top Side View of EUT

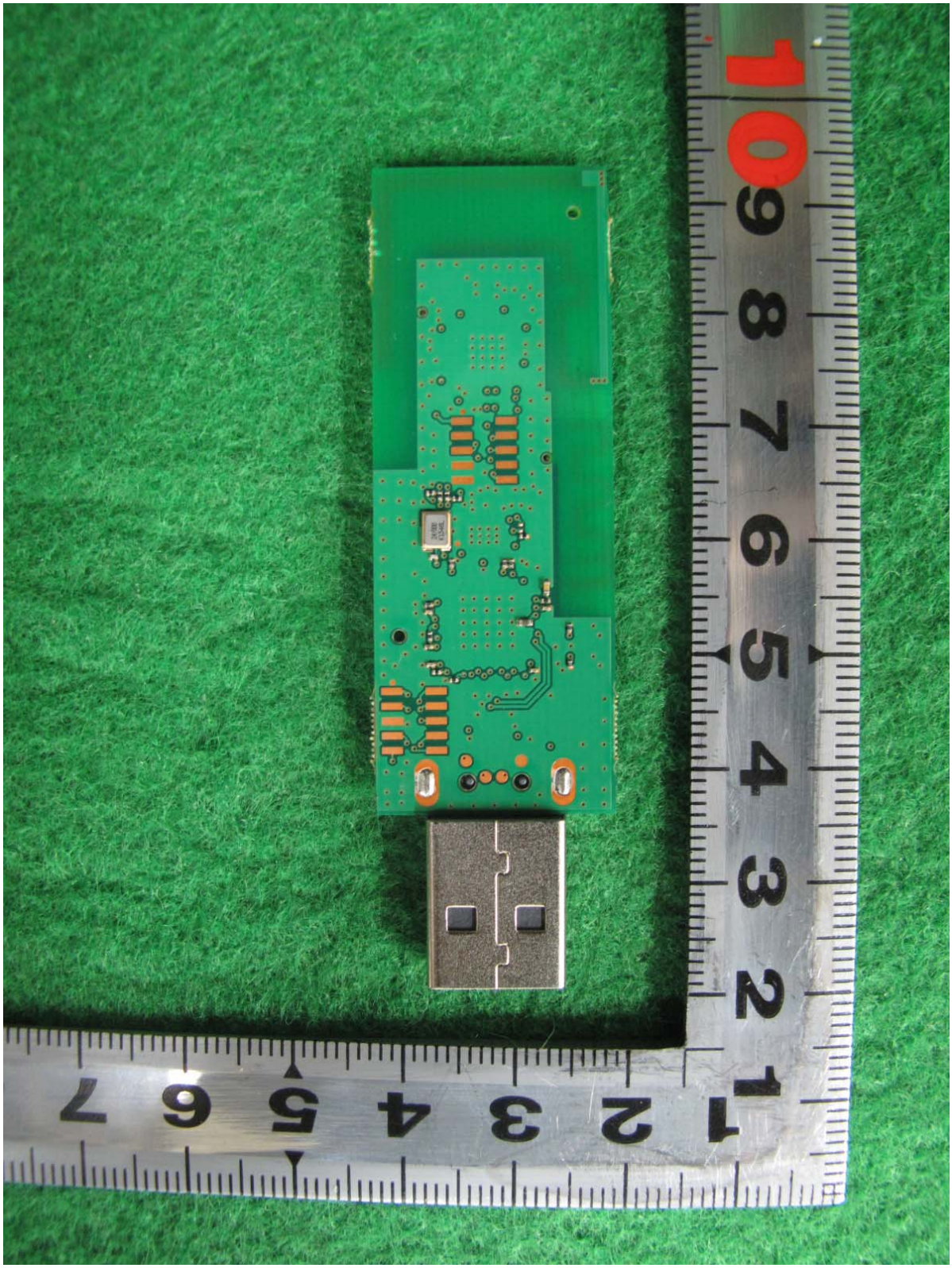
Bottom Side View of EUT

EUT without cover

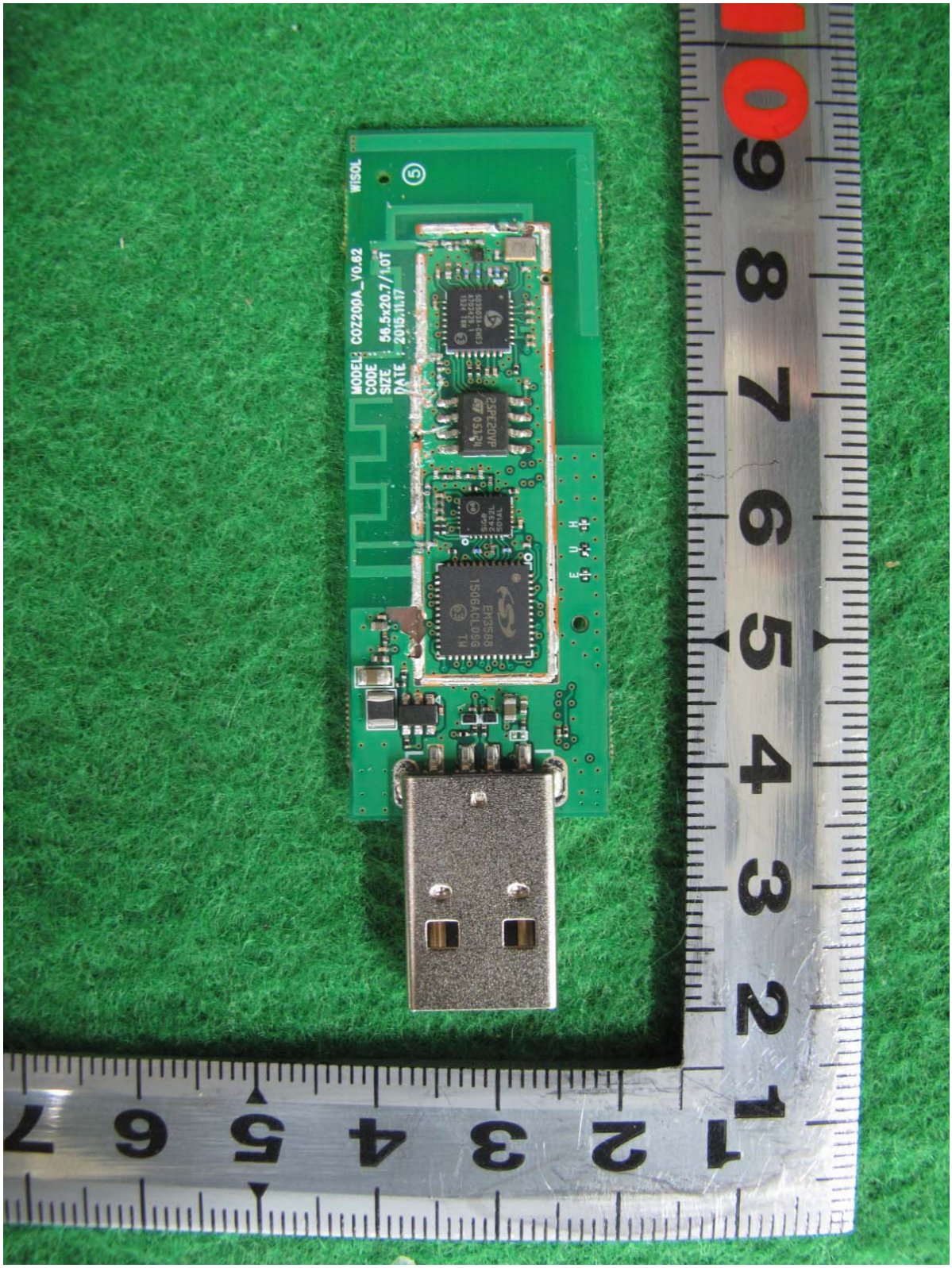
Front Side View of Mainboard



Rear Side View of Mainboard



Front Side View of Mainboard without Shielding can



APPENDIX D – Maximum Permissible Exposure

FCC RF Exposure Limit

According to FCC 1.1310: The criteria listed in the following table shall be used to evaluate the Environmental of human exposure to radio frequency (RF) radiation as specified in 1.1307(b)

Limits for Maximum Permissible Exposure (MPE)

Frequency Range(MHz)	Electric Field Strength(V/m)	Magnetic Field Strength(A/m)	Power Density (mW/cm^2)	Averaging Time (Minutes)
(A) Limits for occupational / Contral Exposure				
30 - 300	61.4	0.163	1	6
300 - 1500	…	…	F/300	6
1500 - 100000	…	…	5	6
(B) Limits for General Population / Uncontrolled Exposure				
30 - 300	27.5	0.073	0.2	30
300 - 1500	…	…	F/1500	30
1500 - 100000	…	…	1	30

F = Frequency (MHz)

Fries formula

Fries transmission formula : $Pd = (Pout * G) / (4 * \pi * r^2)$

$r = \sqrt{((Pout * G) / 4 * \pi * Pd)}$

Where

Pd = Power density in ㎽/㎠

Pout = Output power to antenna in ㎽

G = Gain of antenna in linear scale

π= 3.1416

r = Distance between observation point center of the radiator in cm

Pd is the limit of MPE, 1 ㎽/㎠. If we know the Maximum Gain of the antenna and the total power input to the antenna, through the calculation, we will know the Maximum distance r where the MPE limit is reached and Power density at prediction frequency.

Test Result :

2.4 GHz band

The maximum antenna gain is **3.6 dBi**.

Maximum peak output power at antenna input terminal:	21.00	(dBm)
Maximum peak output power at antenna input terminal:	125.89	(mW)
Antenna gain(typical):	3.60	(dBi)
Maximum antenna gain:	2.29	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2440	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)

Maximum allowable antenna gain:	16.01	(dBi)
Maximum Distance:	4.79	(cm)

Power density at prediction frequency : 0.057376 (mW/cm^2)

Test result: PASS

Note(s)

The MPE was calculated with maximum permitted output level add to positive power tolerance. According to the operational description submitted by manufacturer, maximum permitted output power is 18.0 dBm and positive tolerance is 3.0 dB.