Nemko Korea Co., Ltd.

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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 15.249 and IC RSS-210 Issue 8
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

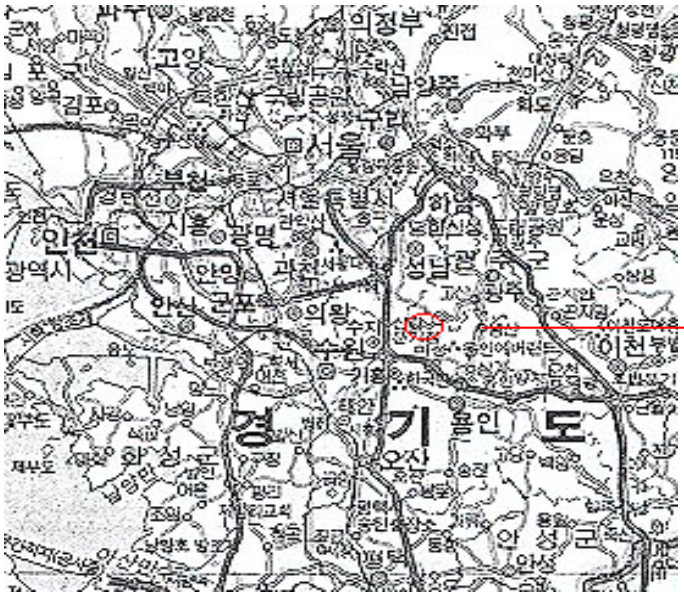
- FCC ID : R3YF-USB-US-V1
- IC : 10734A-FUSBUSV1
- Model: F-USB-US-V1
- Brand Name: SmartThings
- EUT Type: Extend USB Stick
- Classification: Digital modulation Transmitter
- Applied Standard: FCC 47 CFR Part 15 subpart C Sections 15.205, 15.207, 15.209 and 15.249 and IC RSS-210 Issue 8
- Test Procedure(s): ANSI C63.10-2013
- 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.
EMC Lab.
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Cheoin-Gu, Yongin-Si, Gyeonggi-Do
16885 KOREA, REPUBLIC OF
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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 constantly (Duty cycle < 98%).
The EUT was tested at the lowest channel, middle channel and the highest channel 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

Channel	Frequency (MHz)	Data Rate	Power Setting
1	908.40	40 kbps	10
2	908.42	9.6 kbps	11
3	916.00	100 kbps	15

3.1.2 Table of test channels

Test Channel (CH)	Frequency (MHz)	Modulation Type
1	908.40	FSK
2	908.42	FSK
3	916.00	GFSK

3.1.3 Table of test modes

Test Items	Frequency (MHz)	Data rate (Mbps)	Test Channel (CH)
Conducted Emissions	908.40	40 kbps	1
	908.42	9.6 kbps	2
	916.00	100 kbps	3
Radiated Emissions	908.40	40 kbps	1
	908.42	9.6 kbps	2
	916.00	100 kbps	3
Field Strength of Fundamental	908.40	40 kbps	1
	908.42	9.6 kbps	2
	916.00	100 kbps	3
Field Strength of Harmonics	908.40	40 kbps	1
	908.42	9.6 kbps	2
	916.00	100 kbps	3
Emissions Radiated Outside of the Fundamental Frequency Band	908.40	40 kbps	1
	908.42	9.6 kbps	2
	916.00	100 kbps	3

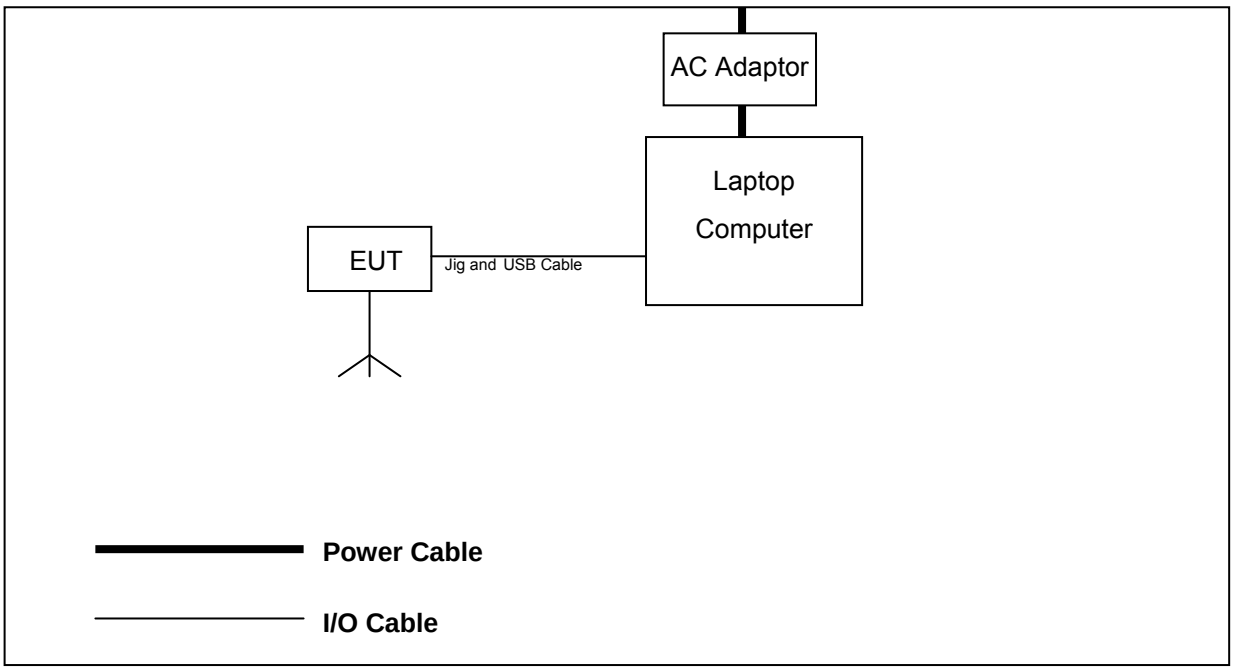
3.1.4 Antenna information:

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

3.2 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 Wireless 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	908.42 MHz, 908.40 MHz, 916.00 MHz
Number of Channels	3
Antenna Gain (peak)	Zigbee Ant : 3.6 dBi Z-wave Ant : 3.4 dBi
Antenna Setup	1TX / 1RX
Modulations	FSK (9.6 kbps) for 908.42 MHz FSK (40 kbps) for 908.40 MHz GFSK (100 kbps) for 916.00 MHz
Temperature Range	-20 ℃ ~ +50 ℃
Voltage	5.0 Vdc
Dimensions (W x H x D)	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	
Field Strength of Fundamental	15.249 (a)	RSS-210 Issue 8 A2.9 (a)	Complies	
Field Strength of Harmonics	15.249 (a)	RSS-210 Issue 8 A2.9 (a)	Complies	
Emissions Radiated Outside of the Fundamental Frequency Band	15.249 (d)	RSS-210 Issue 8 A2.9 (b)	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 15.249 of the FCC Rule and RSS-210 Issue 8 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.

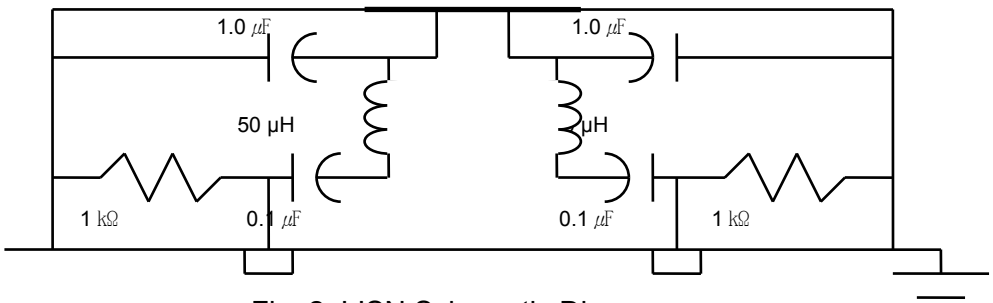


Fig. 2. LISN Schematic Diagram

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 ANSI 63.10 – 2013. 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* = 1 kHz, Detector = Peak, Trace mode = max hold, when the EUT was configured to transmit with duty cycle ≥ 98 percent.

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

Note :

**VBW was reduced until no significant variations in the displayed signal are observed in subsequent traces and VBW was no less than 1Hz as specified in 4.1.4.2.3 in ANSI 63.10-2013.*

7.3 Field Strength of Fundamental

Test Procedure

The Transmit Radiated Field Strength was measured at a 3-meter test distance. The EMI Receiver was used to obtain the final test data.

Fundamental frequency	Field strength of fundamental (millivolts/meter)
902-928 MHz	50
2400-2483.5 MHz	50
5725-5875 MHz	50
24.0-24.25 GHz	250

Limits per 47 CFR 15.249(a) and RSS-210 A2.9(a)

7.4 Field Strength of Harmonics

Test Procedure

The Transmit Radiated Field Strength was measured at a 3-meter test distance. The EMI Receiver was used to obtain the final test data.

Fundamental frequency	Field strength of harmonics (microvolts/meter)
902-928 MHz	500
2400-2483.5 MHz	500
5725-5875 MHz	500
24.0-24.25 GHz	2500

Limits per 47 CFR 15.249(a) and RSS-210 A2.9(a)

7.5 Emissions Radiated Outside of the Fundamental Frequency Band

‘

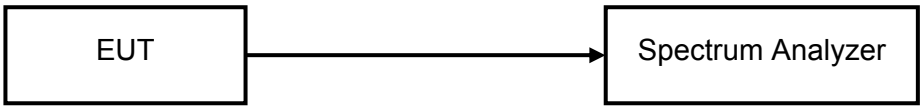
Test Procedure

The Band Edge measurement was measured using the EMI Receiver at a 3-meter test distance to obtain the final test data. The lower and upper channels were tuned during the low and high bandedge test.

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209 and RSS-Gen 8.9, whichever is the lesser attenuation.

7.6 Duty Cycle

Test Setup



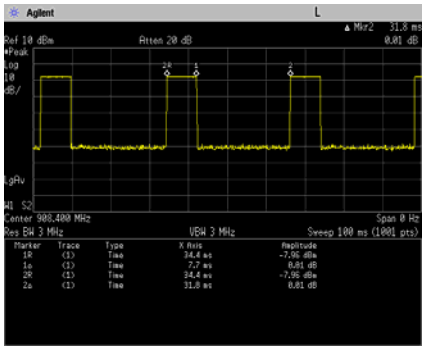
Test Procedure

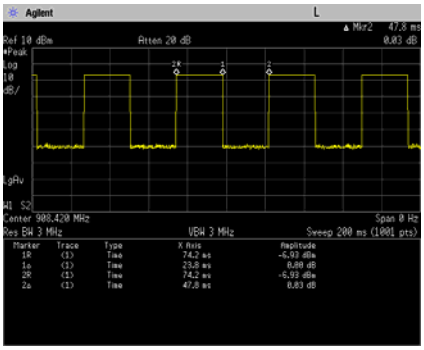
EUTs duty cycle are measured at middle channel with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level. The spectrum analyzer setting is as follows.

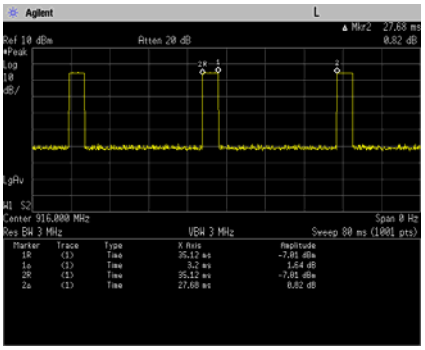
Center frequency = Center frequency of the transmission
Span = zero
RBW = 20 MHz
VBW = 20 MHz
Detector = peak
Sweep time = 5 ms
Trace mode = view
The marker function on the spectrum analyzer is used to determine the duty cycle.

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

Frequency (MHz)	Data Rate (kbps)	Duty Cycle (%)
908.40	40	24.21
908.42	9.6	49.79
916.00	100	11.56

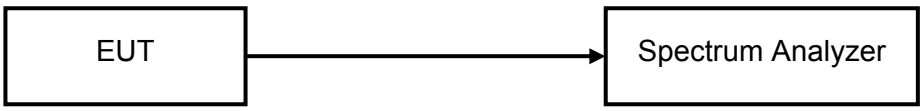






7.7 99% Emission Bandwidth

Test Setup



Test Procedure

EUTs 99% 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 = 1kHz
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 99% emission bandwidth.

8. TEST DATA

8.1 Conducted Emissions

FCC §15.207, IC RSS-Gen Issue 4

908.40 MHz

Frequency	Level(dBµV)		*)Factor	**) Line	Limit(dBµV)		Margin(dB)	
(MHz)	Q-Peak	Average	(dB)		Q-Peak	Average	Q-Peak	Average
0.18	41.8	38.1	10.3	L	64.5	54.5	22.7	16.4
0.41	43.6	37.6	10.5	N	57.6	47.6	14.0	10.0
0.47	47.3	36.6	10.5	N	56.5	46.5	9.2	9.9
0.53	49.2	39.8	10.5	N	56.0	46.0	6.8	6.2
0.94	48.2	35.4	10.5	N	56.0	46.0	7.8	10.6
15.10	43.4	39.6	11.5	L	60.0	50.0	16.6	10.4

Line Conducted Emissions Tabulated Data

908.42 MHz

Frequency	Level(dBµV)		*)Factor	**) Line	Limit(dBµV)		Margin(dB)	
(MHz)	Q-Peak	Average	(dB)		Q-Peak	Average	Q-Peak	Average
0.18	45.2	39.4	10.4	N	64.5	54.5	19.3	15.1
0.41	43.1	34.9	10.4	L	57.6	47.6	14.5	12.7
0.47	47.2	38.4	10.4	L	56.5	46.5	9.3	8.1
0.53	48.0	39.0	10.5	N	56.0	46.0	8.0	7.0
0.94	48.4	34.4	10.5	N	56.0	46.0	7.6	11.6
15.10	43.1	40.2	11.4	N	60.0	50.0	16.9	9.8

Line Conducted Emissions Tabulated Data

916.00 MHz

Frequency	Level(dBµV)		*)Factor	**) Line	Limit(dBµV)		Margin(dB)	
(MHz)	Q-Peak	Average	(dB)		Q-Peak	Average	Q-Peak	Average
0.18	41.6	37.7	10.3	L	64.5	54.5	22.9	16.8
0.24	40.1	37.8	10.4	N	62.1	52.1	22.0	14.3
0.41	44.2	37.9	10.5	N	57.6	47.6	13.4	9.7
0.53	48.9	39.8	10.5	N	56.0	46.0	7.1	6.2
0.94	48.0	33.5	10.5	N	56.0	46.0	8.0	12.5
15.10	43.4	40.0	11.5	L	60.0	50.0	16.6	10.0

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. *The limit is on the FCC Part section 15.207(a) and IC RSS-GEN Issue 4 8.8*

PLOTS OF EMISSIONS

Worst Channel : 908.42 MHz

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

NEMKO KOREA (NK-15-R-134) 24 Feb 2016 14:51

Conducted Emissions

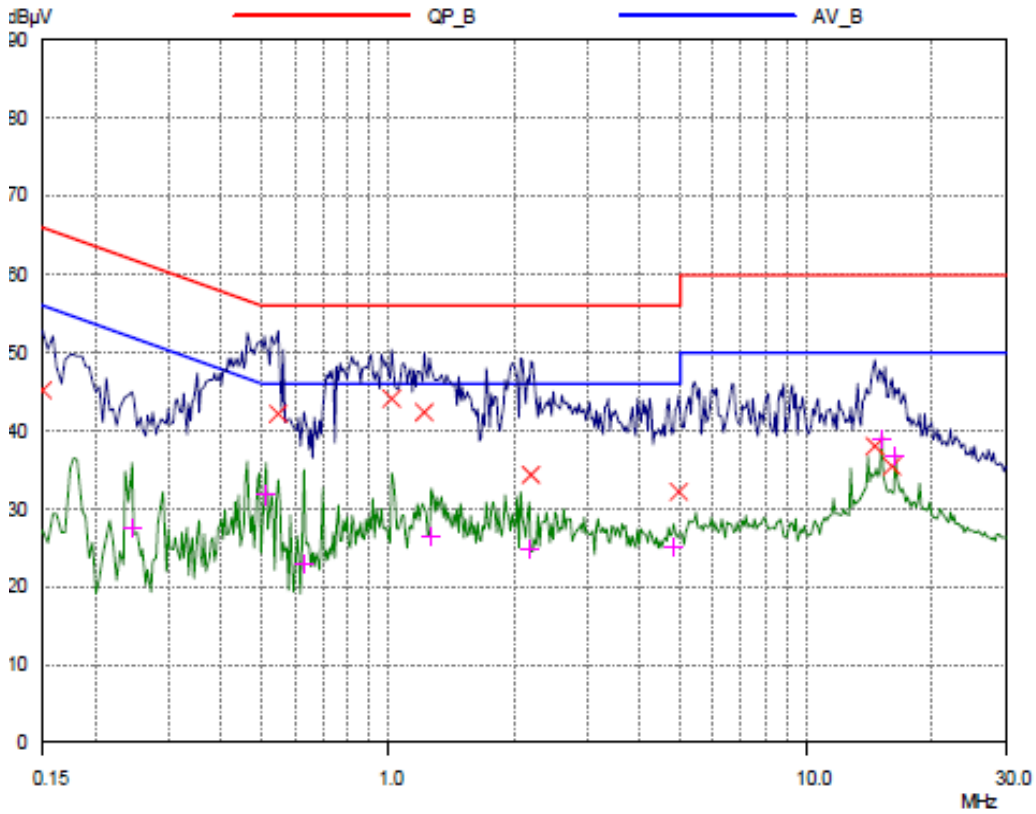
EUT:	Extend USB Stick
Manuf:	Samsung Electronics. Co., Ltd.
Op Cond:	a.c. 120 V / 60 Hz // Z-wave/908.42MHz
Operator:	Wonho. Son
Test Spec:	FCC Part 15
Comment:	MODEL : F-USB-US-K1
	LINE : NEUTRAL-PE
Result File:	r134-zl1.dat : New Measurement

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

Worst Channel : 908.42 MHz

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

NEMKO KOREA (NK-15-R-134) 24 Feb 2016 15:38
Conducted Emissions

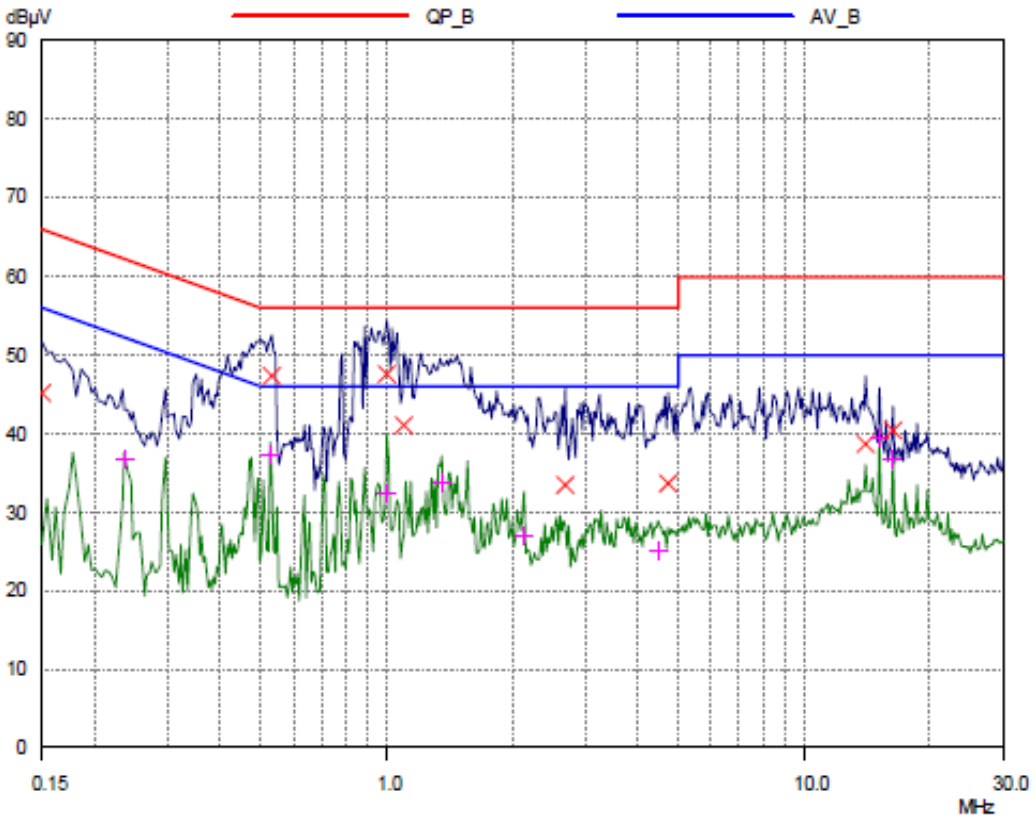
EUT:	Extend USB Stick
Manuf:	Samsung Electronics. Co., Ltd.
Op Cond:	a.c. 120 V / 60 Hz // Z-wave/908.42MHz
Operator:	Wonho. Son
Test Spec:	FCC Part 15
Comment:	MODEL : F-USB-US-K1
	LINE : NEUTRAL-PE
Result File:	r134-zn.dat : New Measurement

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

908.40 MHz (Below 1 GHz)

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)
312.13	54.90	H	100	234	-20.2	34.7	46.0	11.3
324.01	58.70	H	100	66	-19.8	38.9	46.0	7.1
335.99	53.10	H	100	60	-19.2	33.9	46.0	12.1
456.12	53.30	V	117	2	-16.4	36.9	46.0	9.1
528.00	50.20	H	170	19	-14.5	35.7	46.0	10.3
540.03	47.90	V	100	166	-14.3	33.6	46.0	12.4

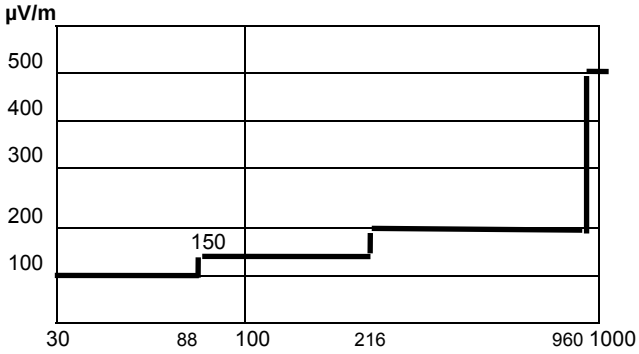
908.42 MHz (Below 1 GHz)

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)
312.03	55.20	H	100	131	-20.2	35.0	46.0	11.0
324.01	59.50	H	100	62	-19.8	39.7	46.0	6.3
444.14	50.30	H	185	34	-16.7	33.6	46.0	12.4
456.02	52.70	V	116	2	-16.4	36.3	46.0	9.7
528.05	47.70	H	170	19	-14.5	33.2	46.0	12.8
540.03	48.00	V	100	163	-14.3	33.7	46.0	12.3

916.00 MHz (Below 1 GHz)

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)
311.93	52.80	H	100	122	-20.2	32.6	46.0	13.4
324.01	59.70	H	100	58	-19.8	39.9	46.0	6.1
336.04	52.90	H	100	68	-19.2	33.7	46.0	12.3
456.02	52.80	H	221	35	-16.4	36.4	46.0	9.6
528.00	49.60	V	130	167	-14.5	35.1	46.0	10.9
539.98	49.60	V	116	167	-14.3	35.3	46.0	10.7

Radiated Measurements at 3meters



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.

Fig. 3. Limits at 3 meters

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

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

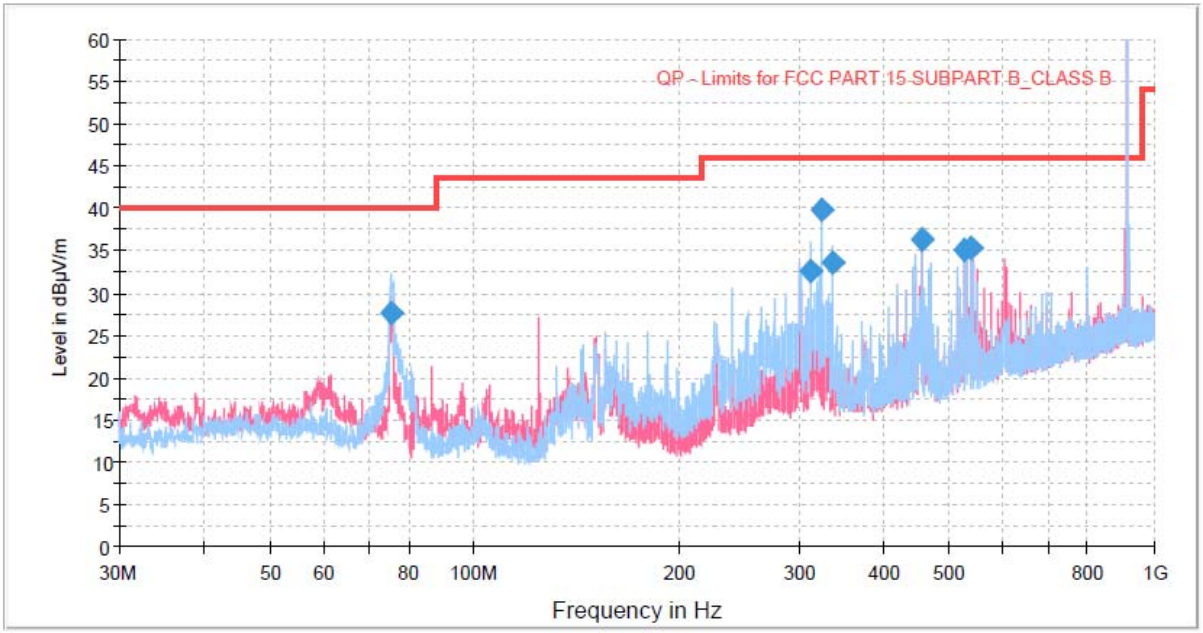
5. Measurements using CISPR quasi-peak mode.

6. There were no radiated emissions other than harmonics found below 30 MHz.

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

PLOTS OF EMISSIONS

Worst Channel : 916.00 MHz (below 1GHz)



FCC §15.209, IC RSS-Gen Issue 4

908.40 (Above 1 GHz with Field Strength of Harmonics)

Frequency (MHz)	Pol* (H/V)	Detector** (PK/AV)	AF+CL+Amp (dB)***	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Comment
1061.25	V	PK	-3.9	41.6	74.0	32.4	
1061.25	V	AV	-3.9	29.6	54.0	24.4	
1816.84	V	PK	-1.8	40.4	74.0	33.6	2nd Harmonic
1816.84	V	AV	-1.8	33.5	54.0	20.5	2nd Harmonic
2132.50	V	PK	-0.4	49.7	74.0	24.3	
2132.50	V	AV	-0.4	33.1	54.0	20.9	

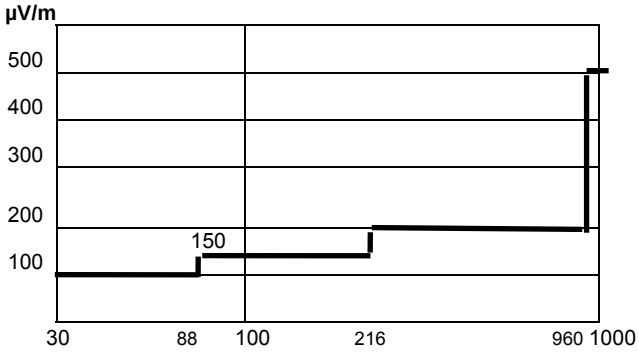
908.42 (Above 1 GHz with Field Strength of Harmonics)

Frequency (MHz)	Pol* (H/V)	Detector** (PK/AV)	AF+CL+Amp (dB)***	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Comment
1056.75	V	PK	-3.9	41.0	74.0	33.0	
1056.75	V	AV	-3.9	29.7	54.0	24.3	
1816.94	V	PK	-1.8	40.8	74.0	33.2	2nd Harmonic
1816.94	V	AV	-1.8	34.1	54.0	19.9	2nd Harmonic
2124.50	V	PK	-0.5	48.9	74.0	25.1	
2124.50	V	AV	-0.5	34.0	54.0	20.0	

916.00 (Above 1 GHz with Field Strength of Harmonics)

Frequency (MHz)	Pol* (H/V)	Detector** (PK/AV)	AF+CL+Amp (dB)***	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Comment
1056.50	V	PK	-3.9	39.5	74.0	34.5	
1056.50	V	AV	-3.9	30.0	54.0	24.0	
1832.01	V	PK	-1.7	41.0	74.0	33.0	2nd Harmonic
1832.01	V	AV	-1.7	32.2	54.0	21.8	2nd Harmonic
2128.50	V	PK	-0.5	48.9	74.0	25.1	
2128.50	V	AV	-0.5	32.9	54.0	21.1	
2362.25	V	PK	0.3	42.7	74.0	31.3	
2362.25	V	AV	0.3	33.3	54.0	20.7	

Radiated Measurements at 3meters



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.

Fig. 3. Limits at 3 meters

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

*4. ** Detector. PK = Peak, AV = Average.*

For 2nd Harmonic, Peak detector was used in AV measurements with RBW = 1 MHz, VBW = 1 kHz.

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

6. Measurements using peak and average mode.

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

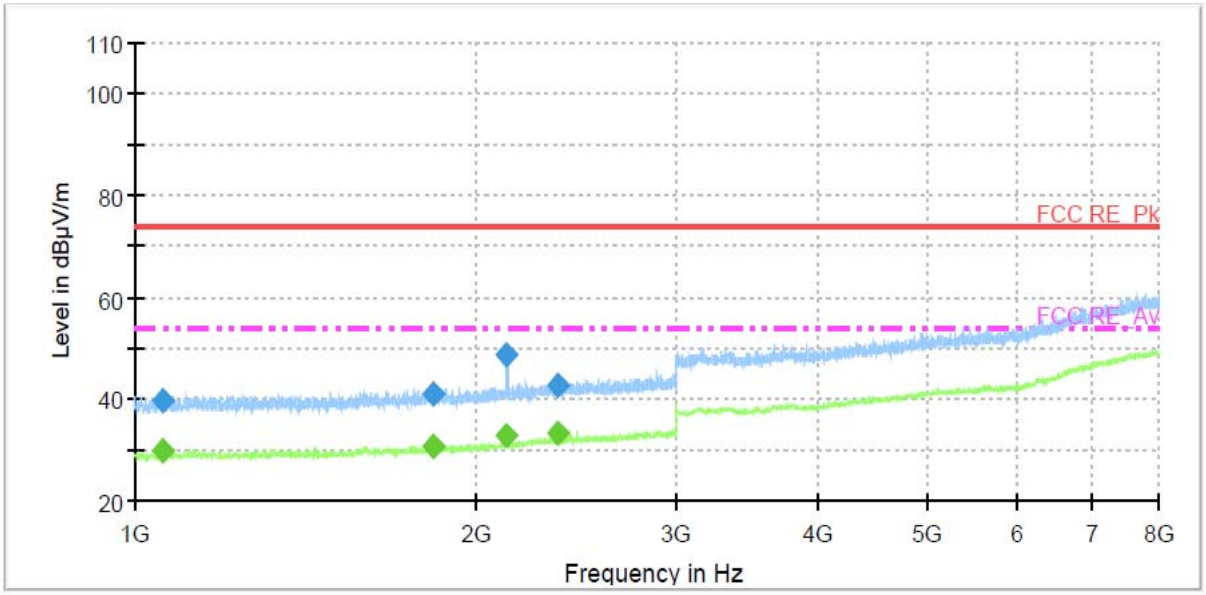
8. The spectrum was measured from 9 kHz to 10th harmonic and the worst-case emissions were reported.

9. No significant emissions were found beyond the 2nd harmonic for this device.

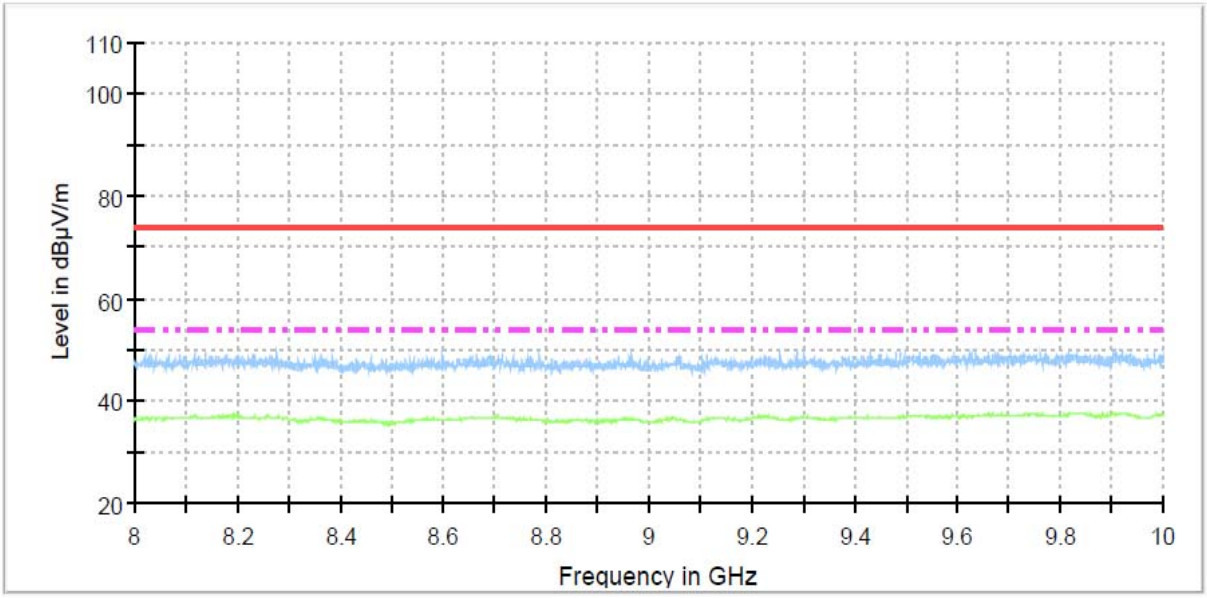
PLOTS OF EMISSIONS

Above 1GHz to 10th Harmonic of highest fundamental frequency

Worst Channel (916.00 MHz) : 1GHz to 8GHz



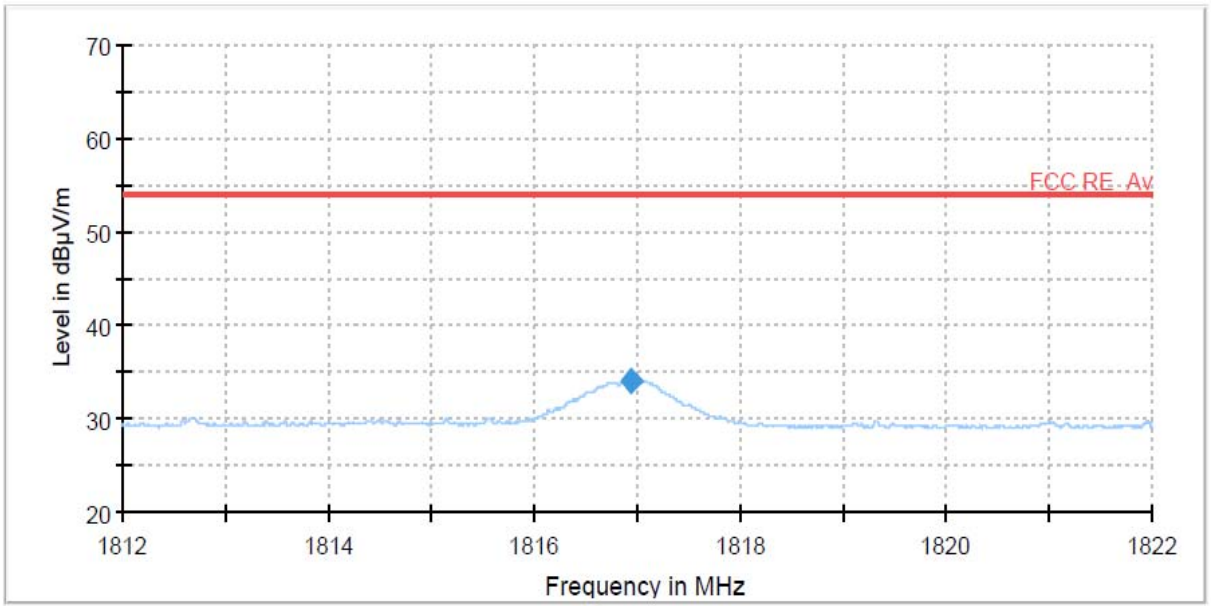
Worst Channel (916.00 MHz) : 8GHz to 10GHz



PLOTS OF EMISSIONS

Field Strength of Harmonics

Worst Channel (908.42 MHz) : 2nd Harmonic



8.3 Field Strength of Fundamental

FCC §15.249, IC RSS-210 Issue 8, A2.9(a)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

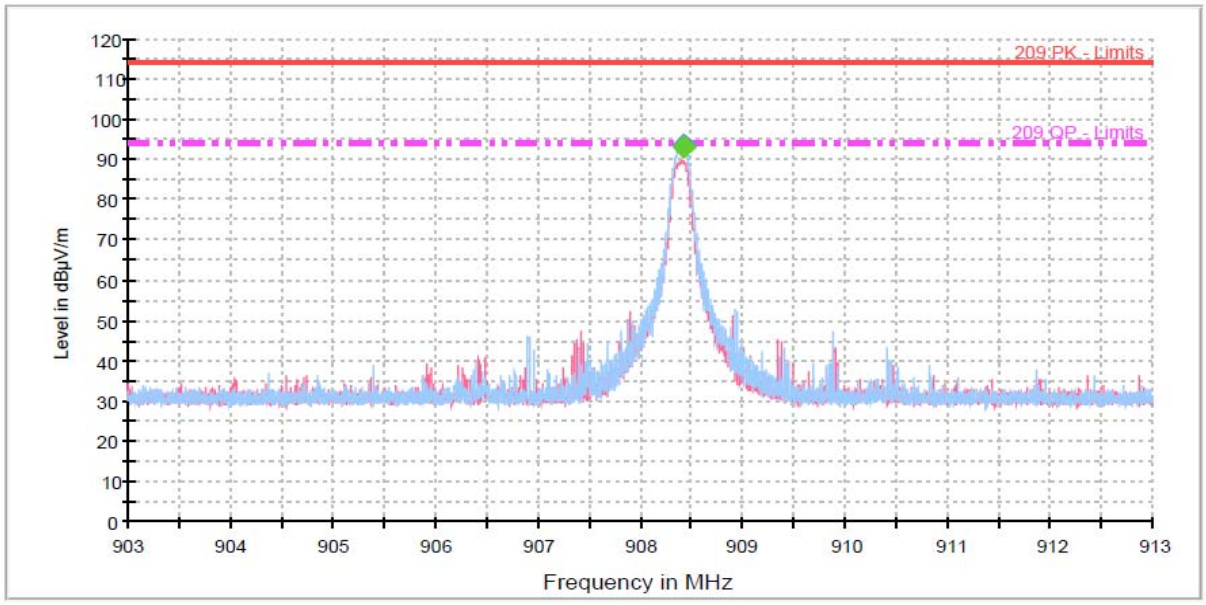
Frequency (MHz)	Reading (dBµV/m)	Pol* (H/V)	Antenna Heights (cm)	Turntable Angles (°)	AF+CL+Amp (dB)**	Result (dBµV/m)	Detector (PK/QP)***	Limit (dBµV/m)	Margin (dB)
908.40	102.30	H	100	229	-8.8	93.5	PK	114.0	20.5
908.40	102.20	H	100	229	-8.8	93.4	QP	94.0	0.6
908.42	102.50	H	100	43	-8.8	93.7	PK	114.0	20.3
908.42	102.40	H	100	43	-8.8	93.6	QP	94.0	0.4
916.00	103.00	H	100	220	-8.7	94.3	PK	114.0	19.7
916.00	102.40	H	100	220	-8.7	93.7	QP	94.0	0.3

Notes:

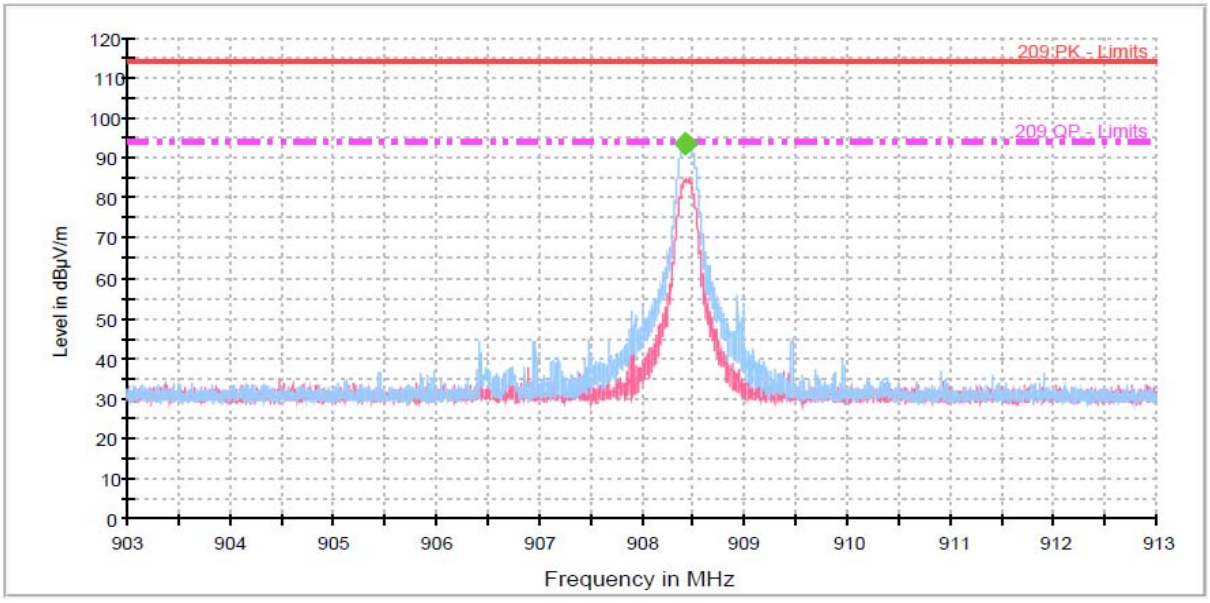
1. *Pol. H = Horizontal, V = Vertical*
2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.*
3. ***Detector. PK = Peak, QP = Quasi Peak*
4. *RBW = 120 kHz, VBW = 300 kHz*
5. *The radiated emissions testing were made by rotating through three orthogonal axes. The worst date was recorded.*

PLOTS OF EMISSIONS

908.40 MHz

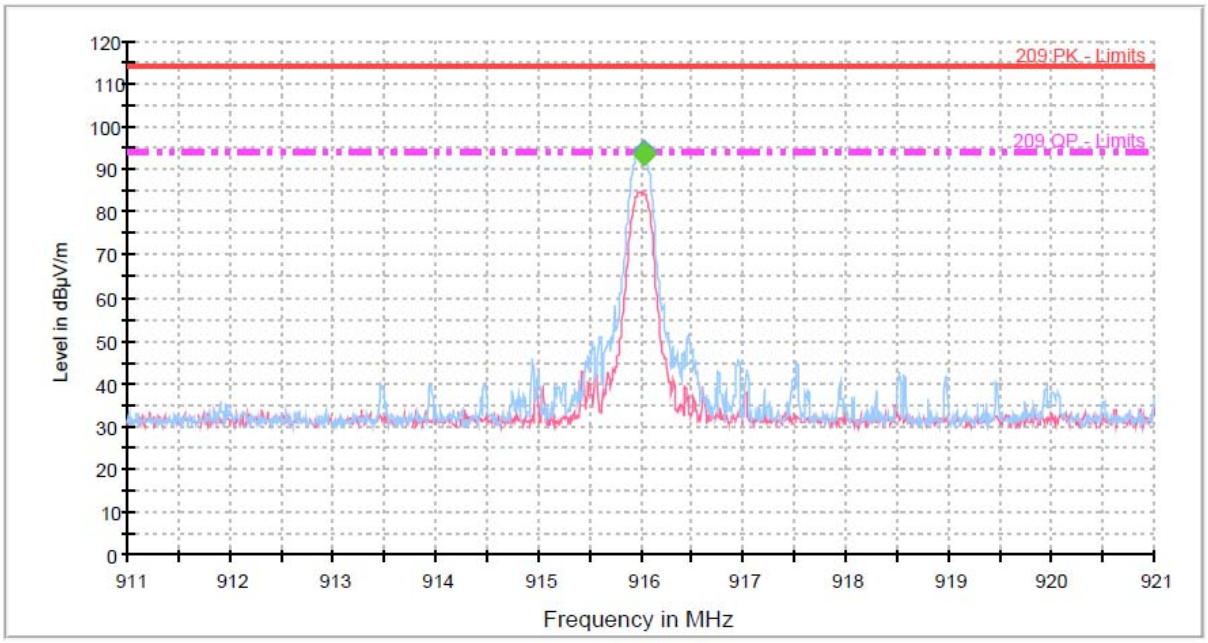


908.42 MHz



PLOTS OF EMISSIONS

916.00 MHz



8.4 Emissions Radiated Outside of the Fundamental Frequency band

FCC §15.249, IC RSS-210 Issue 8, A2.9 (b)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

908.40 MHz

Frequency (MHz)	Reading (dBµV/m)	Pol** (H/V)	Antenna Heights (cm)	Turntable Angles (°)	AF+CL+Amp (dB)***	Result (dBµV/m)	****Detector PK/QP	Limit (dBµV/m)	Margin (dB)
901.12	51.80	H	100	40	-9.0	42.8	PK	46.0	3.2
902.00	41.50	V	200	67	-9.0	32.5	PK	46.0	13.5
*908.39	-	-	-	-	-	-	-	-	-
928.00	38.10	V	100	238	-9.2	28.9	PK	46.0	17.1
929.40	37.90	V	200	284	-9.2	28.7	PK	46.0	17.3

908.42 MHz

Frequency (MHz)	Reading (dBµV/m)	Pol** (H/V)	Antenna Heights (cm)	Turntable Angles (°)	AF+CL+Amp (dB)***	Result (dBµV/m)	****Detector PK	Limit (dBµV/m)	Margin (dB)
883.59	40.00	V	200	33	-9.3	30.7	PK	46.0	15.3
869.02	44.60	H	100	114	-9.1	35.5	PK	46.0	10.5
901.25	50.10	H	100	284	-9.0	41.1	PK	46.0	4.9
902.00	37.60	H	400	143	-9.0	28.6	PK	46.0	17.4
*908.42	-	-	-	-	-	-	-	-	-
928.00	37.50	V	300	18	-9.2	28.3	PK	46.0	17.7
930.33	39.60	V	400	299	-9.2	30.4	PK	46.0	15.6
939.16	37.80	V	300	39	-9.3	28.5	PK	46.0	17.5

916.00 MHz

Frequency (MHz)	Reading (dBµV/m)	Pol** (H/V)	Antenna Heights (cm)	Turntable Angles (°)	AF+CL+Amp (dB)***	Result (dBµV/m)	****Detector PK	Limit (dBµV/m)	Margin (dB)
883.60	39.80	V	200	314	-9.3	30.5	PK	46.0	15.5
892.89	40.40	V	300	325	-9.1	31.3	PK	46.0	14.7
902.00	37.90	H	200	280	-9.0	28.9	PK	46.0	17.1
*916.00	-	-	-	-	-	-	-	-	-
928.00	42.90	H	100	60	-9.2	33.7	PK	46.0	12.3
931.17	37.80	H	200	121	-9.2	28.6	PK	46.0	17.4
934.79	37.20	H	200	222	-9.2	28.0	PK	46.0	18.0

Note(s):

*1. " * " : Fundamental frequency*

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

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

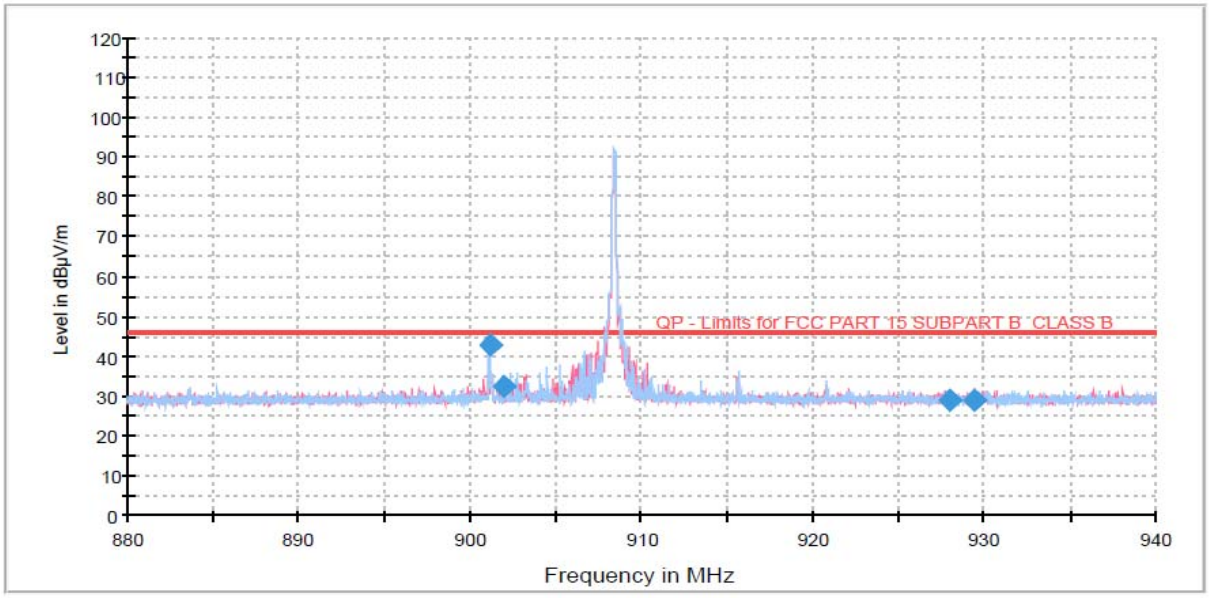
*4. ****Detector PK = Peak*

5. 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.

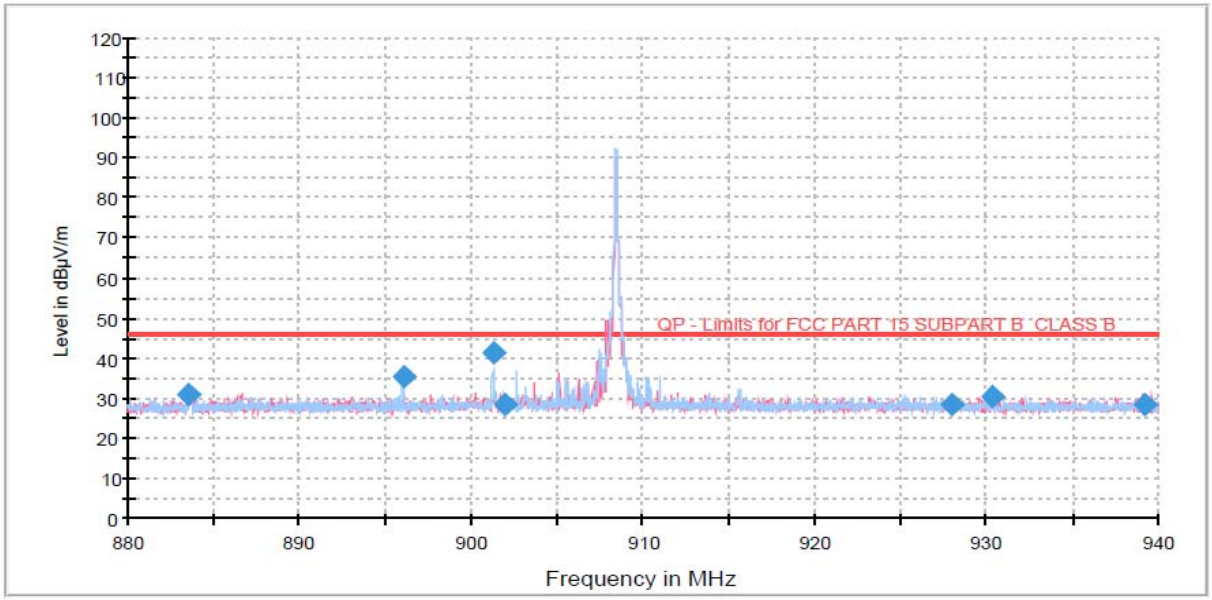
6. Peak emissions were measured using RBW = 100 kHz, VBW = 300 kHz

PLOT OF TEST DATA

908.40 MHz

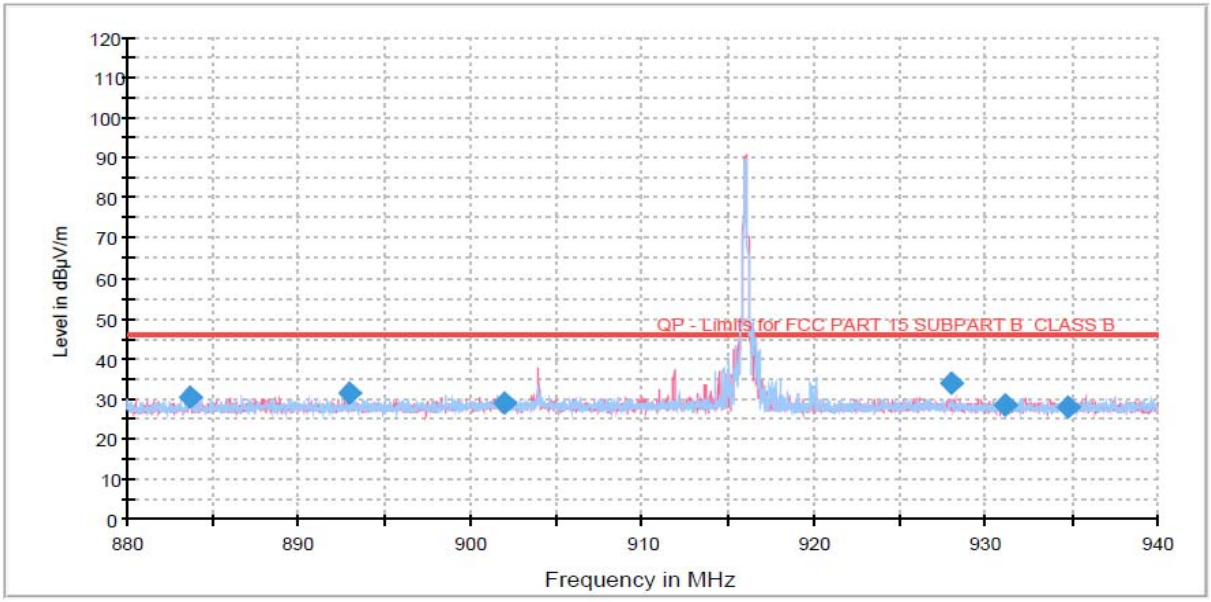


908.42 MHz



PLOT OF TEST DATA

916.00 MHz



8.5 99% Emission Bandwidth

IC RSS-GEN Issue 4 6.6

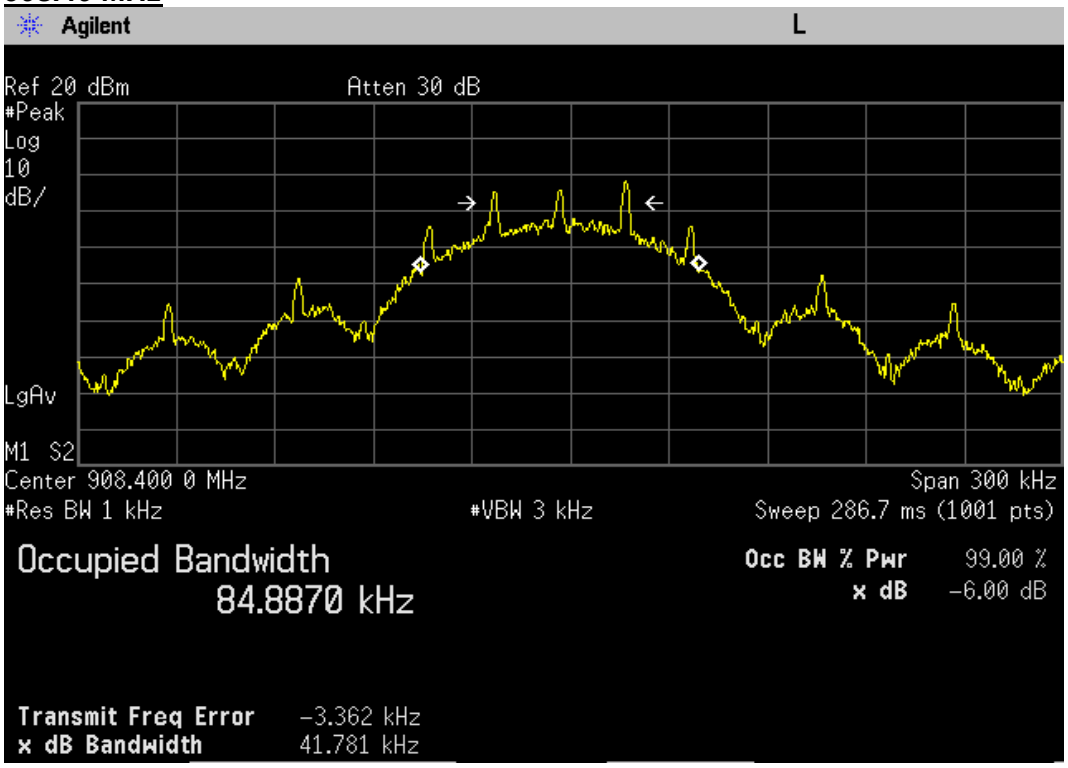
Channel	Frequency (MHz)	99% bandwidth (kHz)
Lowest	908.40	84.89
Middle	908.42	87.00
Highest	916.00	106.19

Notes:

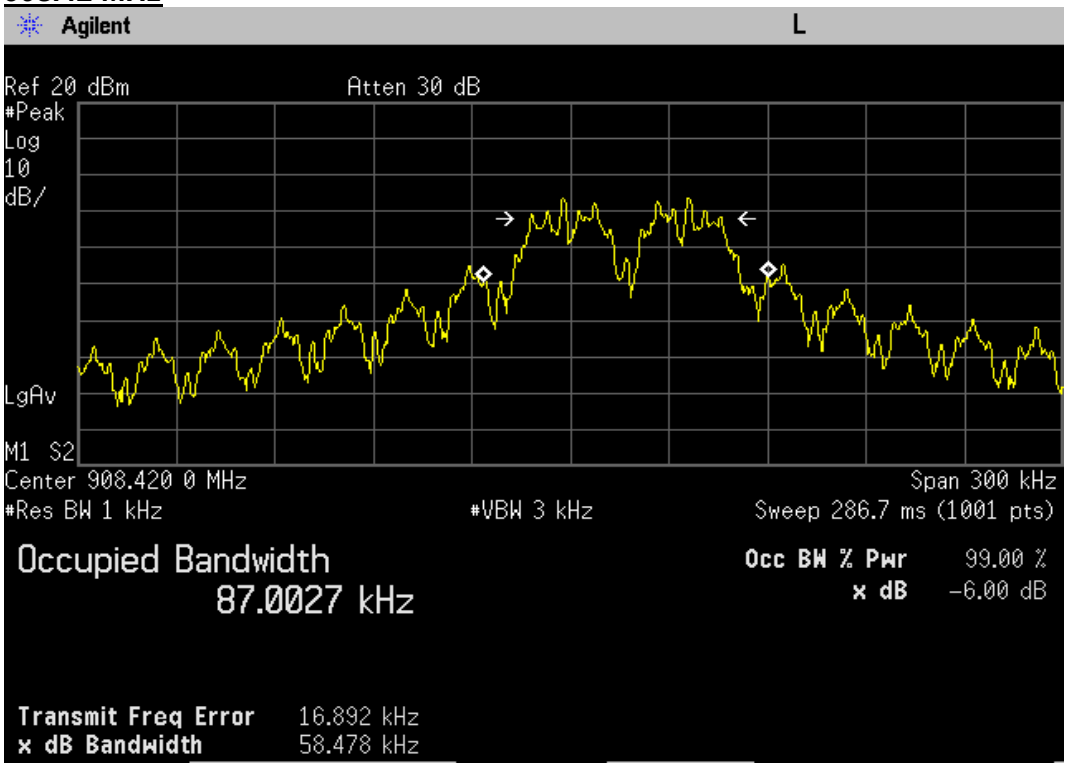
The cable and attenuator loss from 30 MHz to 25 GHz was reflected in spectrum analyzer with correction factor for this testing.

PLOTS OF EMISSIONS

908.40 MHz

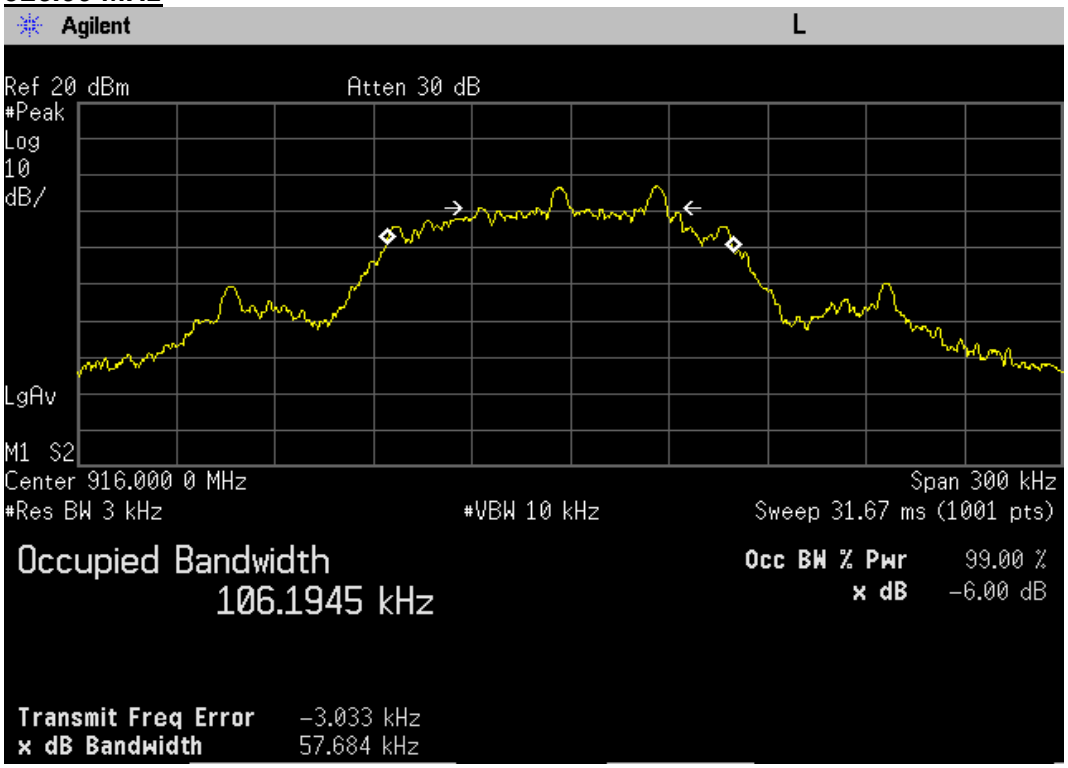


908.42 MHz



PLOTS OF EMISSIONS

916.00 MHz



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

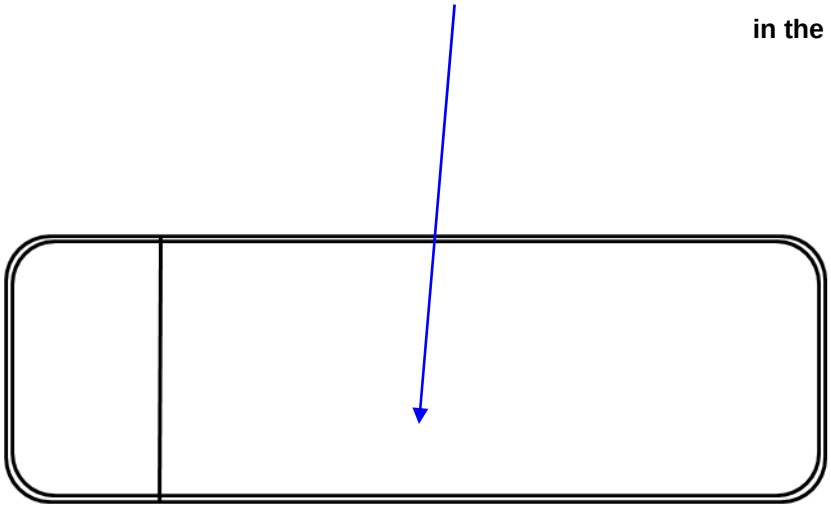
Source of Uncertainty	Xi	Uncertainty of Xi		Coverage factor k	u(Xi) (dB)	Ci	Ci u(Xi) (dB)
		Value (dB)	Probability Distribution				
Measurement System Repeatability	**RS**	0.34	normal 1	1.00	0.34	1	0.34
Receiver reading	**Ri**	± 0.02	normal 2	2.00	0.01	1	0.01
Sine wave voltage	**dVsw**	± 0.17	normal 2	2.00	0.09	1	0.09
Pulse amplitude response	**dVpa**	± 0.92	normal 2	2.00	0.46	1	0.46
Pulse repetition rate response	**dVpr**	± 0.35	normal 2	2.00	0.18	1	0.18
Noise floor proximity	**dVnf**	± 0.50	normal 2	2.00	0.25	1	0.25
Antenna Factor Calibration	**AF**	± 2.00	rectangular	$\sqrt{3}$	1.15	1	1.15
Cable Loss	**CL**	± 1.00	normal 2	2.00	0.50	1	0.50
Antenna Directivity	**AD**	± 0.00	rectangular	$\sqrt{3}$	0.00	1	0.00
Antenna Factor Height Dependence	**AH**	± 2.00	rectangular	$\sqrt{3}$	1.15	1	1.15
Antenna Phase Centre Variation	**AP**	± 0.20	rectangular	$\sqrt{3}$	0.12	1	0.12
Antenna Factor Frequency Interpolation	**Ai**	± 0.25	rectangular	$\sqrt{3}$	0.14	1	0.14
Site Imperfections	**Si**	± 4.00	triangular	$\sqrt{6}$	1.63	1	1.63
Measurement Distance Variation	**DV**	± 0.60	rectangular	$\sqrt{3}$	0.35	1	0.35
Antenna Balance	**Dbal**	± 0.90	rectangular	$\sqrt{3}$	0.52	1	0.52
Cross Polarisation	**DCross**	± 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	**Vd**	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 >

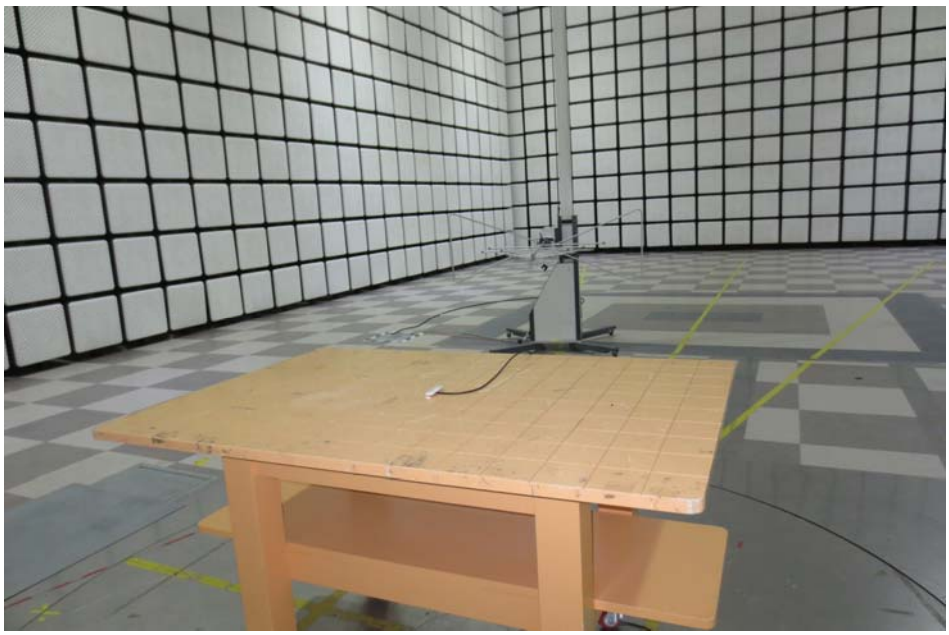
APPENDIX B – PHOTOGRAPHS OF TEST SET-UP

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

- **Conducted Test Picture(Front)**

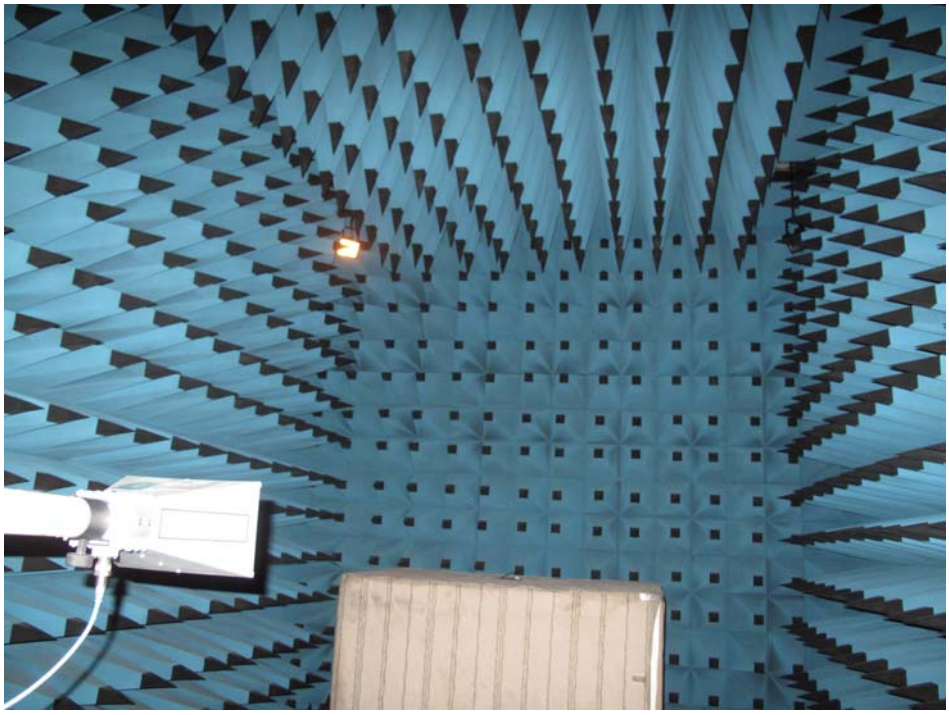
- **Conducted Test Picture(Rear)**

- **Radiated Test Picture (Front)**

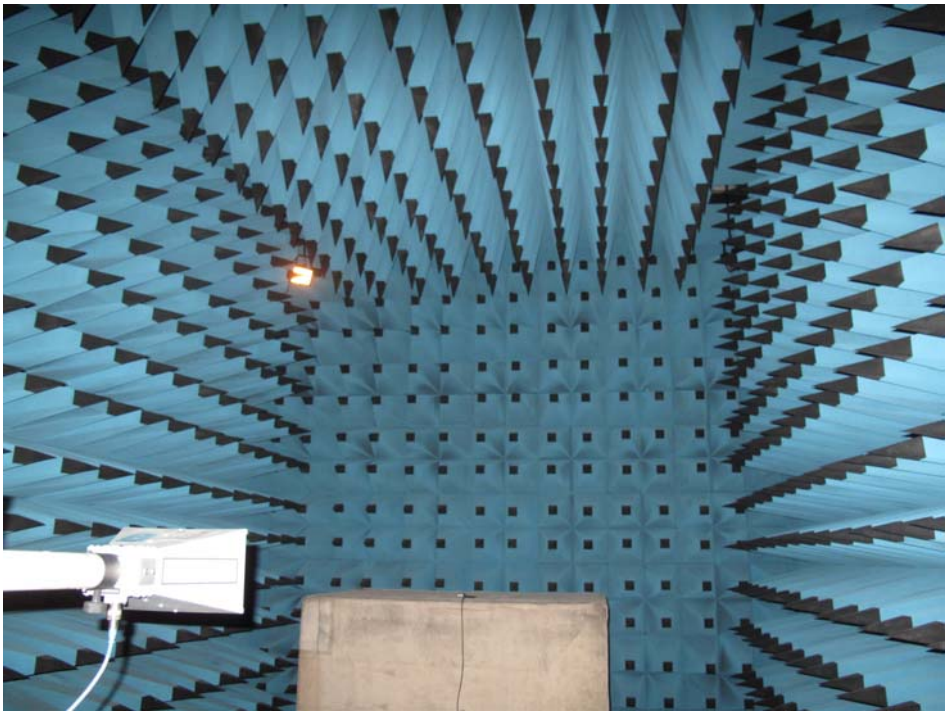


- **Radiated Test Picture (Rear)**

- **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

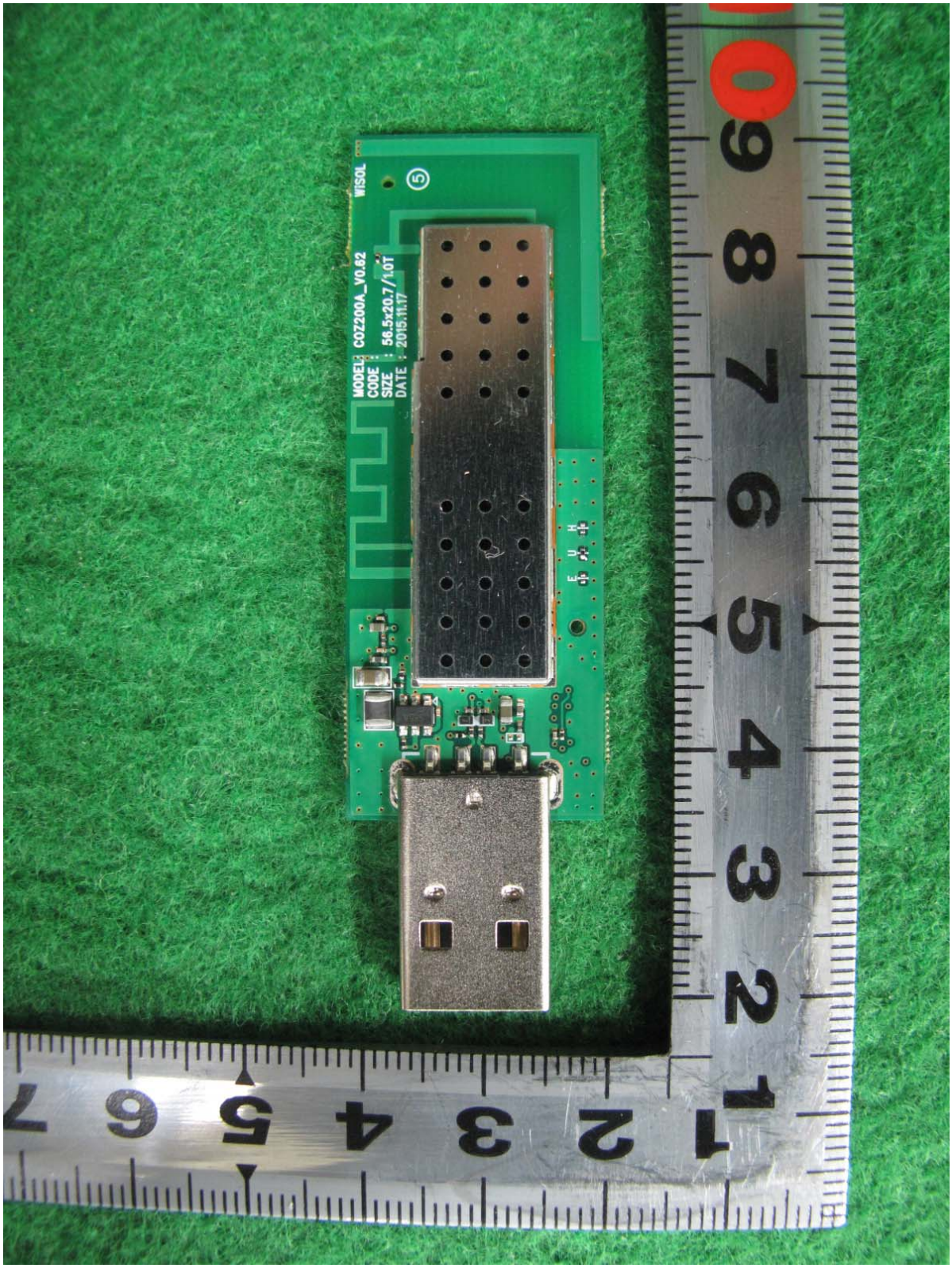
Right Side View of EUT

Top Side View of EUT

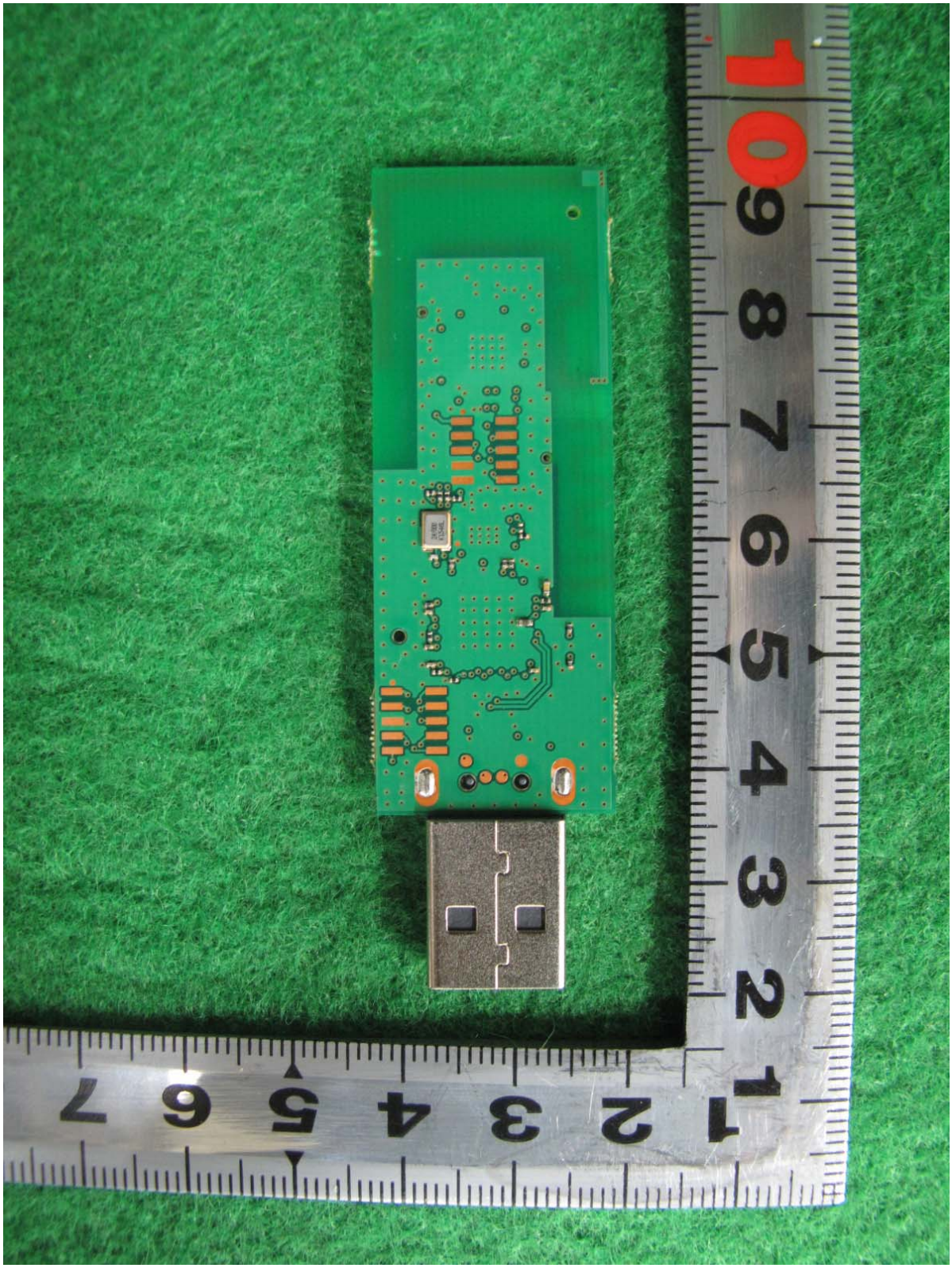
Bottom Side View of EUT

EUT without cover

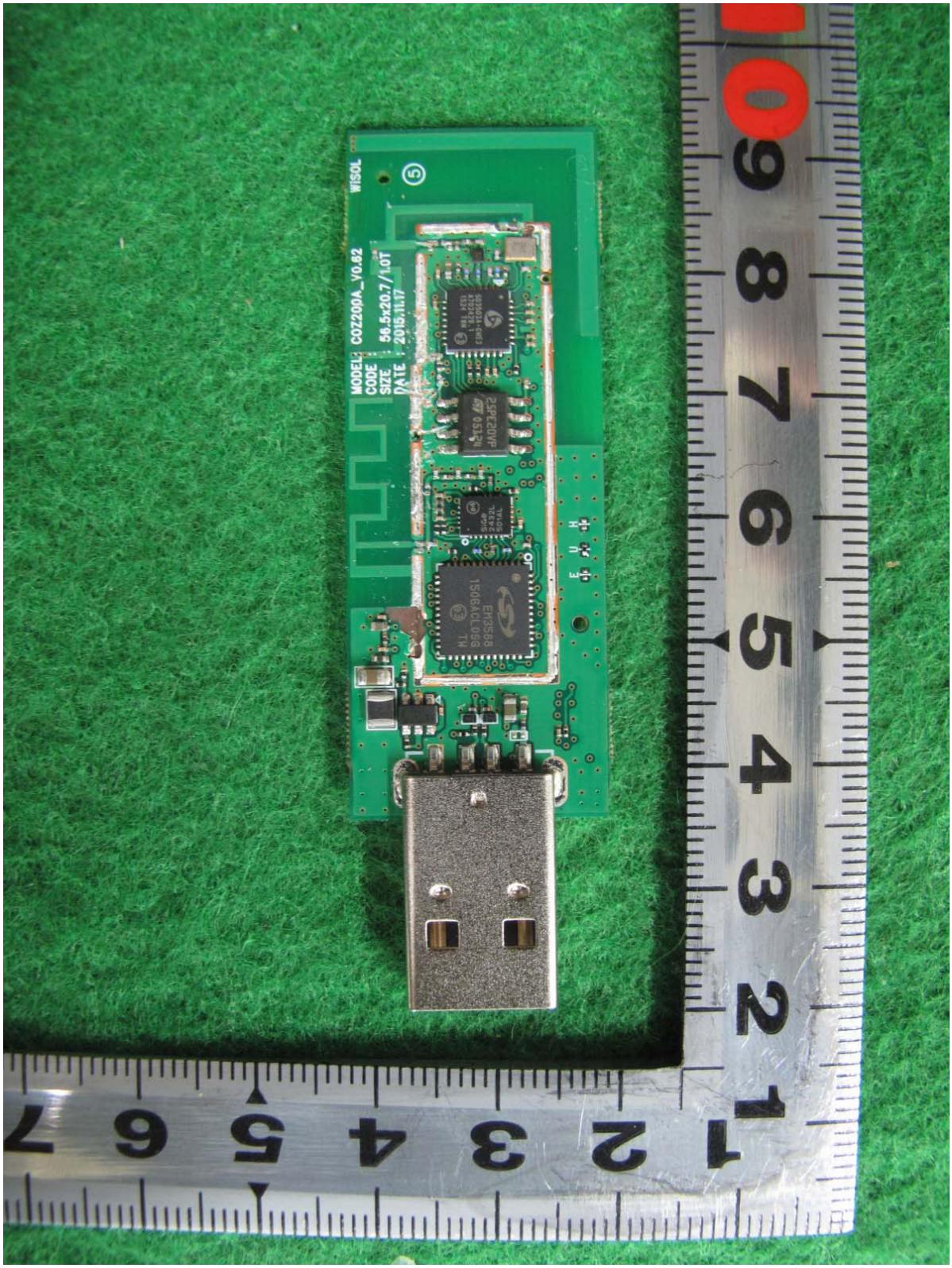
Front Side View of Mainboard



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, 0.61 ㎽/㎠. 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 :

900 MHz band

The maximum antenna gain is **3.4 dBi.**

Maximum peak output power at antenna input terminal:	-2.50	(dBm)
Maximum peak output power at antenna input terminal:	0.56	(mW)
Antenna gain(typical):	3.40	(dBi)
Maximum antenna gain:	2.19	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	916	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	0.61	(mW/cm^2)

Maximum allowable antenna gain:	37.37	(dBi)
Minimum Distance:	0.40	(cm)

Power density at prediction frequency : 0.000245 (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 -4.0 dBm and positive tolerance is 1.5 dB.