



FCC TEST REPORT

Test report
On Behalf of
Hangzhou Roombanker Technology Co., Ltd.
For
Outdoor LoRa Gateway
Model No: DSGW-014, DSGW-014-x(x:1~8)
FCC ID: 2AUXBDSGW-014

Prepared for : Hangzhou Roombanker Technology Co., Ltd.
A#801 Wantong center, Hangzhou, China

Prepared By : Shenzhen Tongzhou Testing Co., Ltd
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Date of Test: Apr.3, 2023~May.26, 2023

Date of Report: May.29, 2023

Report Number: TZ230404203-E2

The test report apply only to the specific sample(s) tested under stated test conditions
It is not permitted to copy extracts of these test result without the written permission of the test laboratory.



TEST RESULT CERTIFICATION

Applicant's name : **Hangzhou Roombanker Technology Co., Ltd.**

Address : A#801 Wantong center, Hangzhou, China

Manufacture's Name : Hangzhou Roombanker Technology Co., Ltd.

Address : A#801 Wantong center, Hangzhou, China

Product description

Trade Mark : Dusun

Product name : Outdoor LoRa Gateway

Model No : DSGW-014, DSGW-014-x(x:1~8)

Standards : FCC Rules and Regulations Part 15 Subpart C Section 15.247

Standards : ANSI C63.10: 2013

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Date of Test :

Date (s) of performance of tests : **Apr.3, 2023~May.26, 2023**

Date of Issue : **May.29, 2023**

Test Result : **PASS**

Testing Engineer : Nancy Li
(Nancy Li)

Technical Manager : Hugo Chen
(Hugo Chen)

Authorized Signatory : Andy Zhang
(Andy Zhang)



Revision History

Revision	Issue Date	Revisions	Revised By
00	May.29, 2023	Initial Issue	Andy Zhang



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1. GENERAL INFORMATION

1.1. Description of Device (EUT)

Product Name	: Outdoor LoRa Gateway
Model Number	: DSGW-014, DSGW-014-x(x:1~8)
Model Difference Declaration	: All the same except for the model name
Test Model	: DSGW-014
Power Supply	: DC 48V supply by POE
Hardware version	: B45161209A
Software version	: V1.0
Sample ID	: TZ230404203-1#&TZ230404203-2#

LoRa

LoRa-Hybrid Mode

Frequency Range	: 902.3 – 914.9 MHz
Channel Number	: 64 Channels
Modulation Technology	: LORA
Antenna Type And Gain	: External Antenna /1.2 dBi(Max)

Bluetooth

Bluetooth Version	: V2.1
Operation Frequency	: 2402- 2480 MHz
Channel Number	: 79 Channels for Bluetooth BR/EDR(DSS)
Modulation Technology	: GFSK, $\pi/4$ -DQPSK, 8-DPSK for Bluetooth BR/EDR (DSS)
Data Rates	: Bluetooth BR/EDR (DSS): 1/2/3Mbps
Antenna Type And Gain	: External Antenna /3.0 dBi(Max)

WiFi

WLAN	: Supported IEEE 802.11a/b/g/n/ac IEEE 802.11b:2412-2462MHz IEEE 802.11g:2412-2462MHz IEEE 802.11n HT20:2412-2462MHz / 5180-5240MHz / 5745-5825MHz
WLAN FCC Operation Frequency	: IEEE 802.11n HT40: 2422-2452MHz / 5190-5230MHz / 5755-5795MHz IEEE 802.11a: 5180-5240MHz / 5745-5825MHz IEEE 802.11ac VHT20: 5180-5240MHz / 5745-5825MHz IEEE 802.11ac VHT40: 5190-5230MHz / 5755-5795MHz IEEE 802.11ac VHT80: 5210MHz / 5775MHz
WLAN Channel Number	: 11 Channels for 2412-2462MHz(IEEE 802.11b/g/n HT20) 7 Channels for 2422-2452MHz(IEEE 802.11n HT40) 4 Channels for 5180-5240MHz (IEEE 802.11a/ac VHT20/n HT20) 2 Channels for 5190-5230MHz (IEEE 802.11ac VHT40/n HT40) 1 Channels for 5210MHz (IEEE 802.11ac VHT80) 5 Channels for 5745-5825MHz(IEEE 802.11a/ac VHT20/n HT20) 2 Channels for 5755-5795MHz(IEEE 802.11ac VHT40/n HT40) 1 Channels for 5775MHz(IEEE 802.11ac VHT80)
WLAN Modulation Technology	: IEEE 802.11b: DSSS(CCK,DQPSK,DBPSK) IEEE 802.11g: OFDM (64QAM, 16QAM, QPSK, BPSK)



IEEE 802.11n: OFDM (64QAM, 16QAM, QPSK, BPSK)
IEEE 802.11a: OFDM (64QAM, 16QAM, QPSK, BPSK)
IEEE 802.11ac: OFDM (256QAM, 64QAM, 16QAM, QPSK, BPSK)

Antenna Type And Gain : 3.00dBi (Max.), for TX/RX (WLAN 2.4G Band)
: 1.78dBi (Max.), for TX/RX (WLAN 5.2G Band)
: 2.09dBi (Max.), for TX/RX (WLAN 5.8G Band)

UTRA

UTRA FCC Operation Frequency : WCDMA BAND II (UL: 1850 – 1910 MHz/DL: 1930 – 1990 MHz)
: WCDMA BAND IV (UL: 1710 – 1755 MHz/DL: 2110 – 2155 MHz)
: WCDMA BAND V (UL: 824 – 849 MHz/DL: 869 – 894 MHz)

Channel Separation : 0.2MHz

Modulation Technology : OFDM (16QAM, QPSK)

Antenna Type And Gain : External Antenna
: WCDMA BAND II: 1.8dBi
: WCDMA BAND IV: 1.5dBi
: WCDMA BAND V: -0.6dBi

E-UTRA

E-UTRA FCC Operation Frequency : FDD Band 2 (UL: 1850 – 1910 MHz/DL: 1930 – 1990 MHz)
: FDD Band 4 (UL: 1710 – 1755 MHz/DL: 2110 – 2155 MHz)
: FDD Band 5 (UL: 824 – 849 MHz/DL: 869 – 894 MHz)
: FDD Band 12(UL: 699 – 716 MHz/DL: 729 – 746 MHz)
: FDD Band 13(UL: 777 – 787 MHz/DL: 746 – 756 MHz)
: FDD Band 25(UL: 1850 – 1915 MHz/DL: 1930 – 1995 MHz)
: FDD Band 26 (UL: 814 – 849 MHz/DL: 859 – 894 MHz)

Channel Separation : 0.1 MHz

Modulation Technology : OFDM (16QAM, QPSK)

Antenna Type And Gain : External Antenna
: FDD Band 2:1.8 dBi
: FDD Band 4:1.5 dBi
: FDD Band 5:-0.6 dBi
: FDD Band 12:-1.2 dBi
: FDD Band 13:-1.1 dBi
: FDD Band 25:1.8dBi
: FDD Band 26:-0.6 dBi

Note 1: Antenna position refer to EUT Photos.

Note 2: the above information was supplied by the applicant.



1.2 EUT configuration

The following peripheral devices and interface cables were connected during the measurement:

supplied by the lab supplied by the manufacturer

Manufacturer	Description	Model	Serial Number	Certificate
TRENDnet	N/A	TPE-S44	N/A	N/A

1.3. External I/O Cable

I/O Port Description	Quantity	Cable
LAN Port	1	N/A

1.4 Description of Test Facility

FCC

Designation Number: CN1275

Test Firm Registration Number: 167722

Shenzhen Tongzhou Testing Co.,Ltd has been listed on the US Federal Communications Commission

list of test facilities recognized to perform electromagnetic emissions measurements.

A2LA

Certificate Number: 5463.01

Shenzhen Tongzhou Testing Co.,Ltd has been listed by American Association for Laboratory Accreditation to perform electromagnetic emission measurement.

IC

ISED#: 22033

CAB identifier: CN0099

Shenzhen Tongzhou Testing Co.,Ltd has been listed by Innovation, Science and Economic Development Canada to perform electromagnetic emission measurement.

The 3m-Semi anechoic test site fulfils CISPR 16-1-4 according to ANSI C63.10 and CISPR 16-1-4:2010



1.5 Statement of the Measurement Uncertainty

The data and results referenced in this document are true and accurate. The reader is cautioned that there may be errors within the calibration limits of the equipment and facilities. The measurement uncertainty was calculated for all measurements listed in this test report acc. To CISPR 16 – 4 “Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC Measurements” and is documented in the Shenzhen Tongzhou Testing Co.,Ltd quality system acc. To DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

1.6 Measurement Uncertainty

Test Item	Frequency Range	Uncertainty	Note
Radiation Uncertainty	9KHz~30MHz	±3.08dB	(1)
	30MHz~1000MHz	±4.42dB	(1)
	1GHz~40GHz	±4.06dB	(1)
Conduction Uncertainty	150kHz~30MHz	±2.23dB	(1)

(1). This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

1.7 Description of Test Modes

LoRa operates in the unlicensed Band at 902 – 928 MHz. All test modes were tested, only the result of the worst case was recorded in the report.

Mode of Operations	Test Frequency (MHz)
Hybrid	902.3(LCH)
	908.7(MCH)
	914.9(HCH)
	Hopping
For Radiated Emission	
Test Mode	TX Mode

Note: LCH means Low Channel; MCH means Middle Channel; HCH means High Channel

Worst-case mode and channel used for 9kHz-1000 MHz radiated emissions was the mode and channel with the highest output power, that was determined to be TX(MCH).



1.8. Frequency of Channels

LoRa-Hybrid

Channel	Frequency(MHz)	Channel	Frequency(MHz)
1	902.3	33	908.7
2	902.5	34	908.9
3	902.7	35	909.1
4	902.9	36	909.3
5	903.1	37	909.5
6	903.3	38	909.7
7	903.5	39	909.9
8	903.7	40	910.1
9	903.9	41	910.3
10	904.1	42	910.5
11	904.3	43	910.7
12	904.5	44	910.9
13	904.7	45	911.1
14	904.9	46	911.3
15	905.1	47	911.5
16	905.3	48	911.7
17	905.5	49	911.9
18	905.7	50	912.1
19	905.9	51	912.3
20	906.1	52	912.5
21	906.3	53	912.7
22	906.5	54	912.9
23	906.7	55	913.1
24	906.9	56	913.3
25	907.1	57	913.5
26	907.3	58	913.7
27	907.5	59	913.9
28	907.7	60	914.1
29	907.9	61	914.3
30	908.1	62	914.5
31	908.3	63	914.7
32	908.5	64	914.9



2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.10-2013, FCC CFR PART 15C 15.207, 15.209, 15.247 and DA 00-705.

2.1 EUT Configuration

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

2.2 EUT Exercise

The EUT was operated in the normal operating mode for Hopping Numbers and Dwell Time test and a continuous transmits mode for other tests.

According to its specifications, the EUT must comply with the requirements of the Section 15.207, 15.209, 15.247 under the FCC Rules Part 15 Subpart C.

2.3 General Test Procedures

2.3.1 Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2.1 of ANSI C63.10-2013 Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using Quasi-peak and average detector modes.

2.3.2 Radiated Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3m away from the receiving antenna, which varied from 1m to 4m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the maximum emissions, exploratory radiated emission measurements were made according to the requirements in Section 6.3 of ANSI C63.10-2013

2.4. Test Sample

The application provides 2 samples to meet requirement;

Sample ID	Description
TZ230404203-1#	Engineer sample – continuous transmit
TZ230404203-2#	Normal sample – Intermittent transmit



3. SYSTEM TEST CONFIGURATION

3.1 Justification

The system was configured for testing in a continuous transmits condition.

3.2 EUT Exercise Software

The system was configured for testing in a continuous transmits condition and change test channels by software (PuTTY 0.73) provided by application.

3.3 Special Accessories

No.	Equipment	Manufacturer	Model No.	Serial No.	Length	shielded/ unshielded	Notes
1	PC	ASUS	X454L	15105-0038A1 00	/	/	/

3.4 Block Diagram/Schematics

Please refer to the related document.

3.5 Equipment Modifications

Shenzhen Tongzhou Testing Co.,Ltd has not done any modification on the EUT.

3.6 Test Setup

Please refer to the test setup photo.



4. SUMMARY OF TEST RESULTS

Applied Standard: FCC Part 15 Subpart C			
FCC Rules	Description of Test	Test Sample(s)	Result
§15.247(b)(1)	Maximum Peak Conducted Output Power	TZ230404203-1#	Compliant
§15.247(c)	Frequency Separation And 20 dB Bandwidth	TZ230404203-1#	Compliant
N/A	99% Bandwidth	TZ230404203-1#	Compliant
§15.247(a)(1)(ii)	Number Of Hopping Frequency	TZ230404203-2#	Compliant
§15.247(a)(1)(iii)	Time Of Occupancy (Dwell Time)	TZ230404203-1#	Compliant
§15.209, §15.247(d)	Conducted Spurious Emissions and Band Edges Test	TZ230404203-1#	Compliant
§15.209, §15.247(d)	Radiated Emissions	TZ230404203-1#	Compliant
§15.205	Emissions at Restricted Band	TZ230404203-1#	Compliant
§15.207(a)	Conducted Emissions	TZ230404203-1# TZ230404203-2#	Compliant
§15.203	Antenna Requirements	N/A	Compliant
§15.247(e)	Power Spectral Density	TZ230404203-1#	Compliant

Remark: The measurement uncertainty is not included in the test result.



5. SUMMARY OF TEST EQUIPMENT

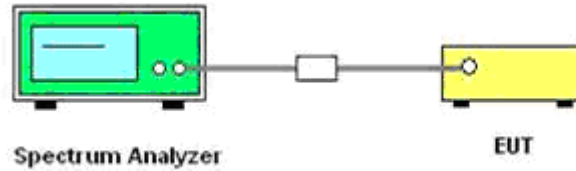
Item	Test Equipment	Manufacturer	Model No.	Serial No.	Calibration Date	Calibration Due Date
1	MXA Signal Analyzer	Keysight	N9020A	MY52091623	2022/12/28	2023/12/27
2	Power Sensor	Agilent	U2021XA	MY5365004	2022/12/28	2023/12/27
3	Power Meter	Agilent	U2531A	TW53323507	2022/12/28	2023/12/27
4	Loop Antenna	schwarzbeck	FMZB1519B	00023	2022/11/13	2025/11/12
5	Wideband Antenna	schwarzbeck	VULB 9163	958	2022/11/13	2025/11/12
6	Horn Antenna	schwarzbeck	BBHA 9120D	01989	2022/11/13	2025/11/12
7	EMI Test Receiver	R&S	ESCI	100849/003	2022/12/28	2023/12/27
8	Controller	MF	MF7802	N/A	N/A	N/A
9	Amplifier	schwarzbeck	BBV 9743	209	2022/12/28	2023/12/27
10	Amplifier	Tonscend	TSAMP-0518SE	--	2022/12/28	2023/12/27
11	RF Cable(below 1GHz)	HUBER+SUHNER	RG214	N/A	2022/12/28	2023/12/27
12	RF Cable(above 1GHz)	HUBER+SUHNER	RG214	N/A	2022/12/28	2023/12/27
12	Artificial Mains	ROHDE & SCHWARZ	ENV 216	101333-IP	2022/12/28	2023/12/27
14	EMI Test Software	ROHDE & SCHWARZ	ESK1	V1.71	N/A	N/A
15	RE test software	Tonscend	JS32-RE	V2.0.2.0	N/A	N/A
16	Test Software	Tonscend	JS1120-3	V2.5.77.0418	N/A	N/A
17	Horn Antenna	A-INFO	LB-180400-KF	J211020657	2022/10/12	2024/10/11
18	Amplifier	CDSA	PAP-1840	17021	2022/10/10	2023/10/09
19	Spectrum Analyzer	R&S	FSP40	100550	2023/1/10	2024/1/9



6. MEASUREMENT RESULTS

6.1 Peak Power

6.1.1 Block Diagram of Test Setup



6.1.2 Limit

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

For intentional device, according to FCC 47 CFR Section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. And according to FCC 47 CFR Section 15.247 (b), if transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

6.1.3 Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

6.1.4 Test Results

Pass

Remark:

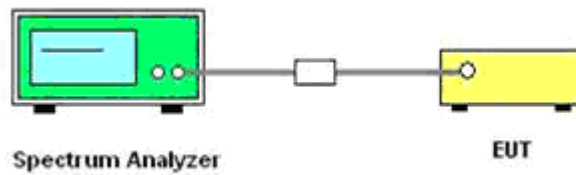
1. *Test results including cable loss;*
4. *Plesase See appendix for Peak Output Power test data*

6.2 Frequency Separation

6.2.1 Limit

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

6.2.2 Block Diagram of Test Setup



6.2.3 Test Procedure

Frequency separation test procedure :

- 1). Place the EUT on the table and set it in transmitting mode.
- 2). Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the Spectrum Analyzer.
- 3). Set center frequency of Spectrum Analyzer = middle of hopping channel.
- 4). Set the Spectrum Analyzer as RBW = 100 kHz, VBW = 300 kHz, Span = wide enough to capture the peaks of two adjacent channels, Sweep = auto.
- 5). Max hold, mark 2 peaks of hopping channel and record the 2 peaks frequency.

6.2.4 Test Results

Pass

Remark:

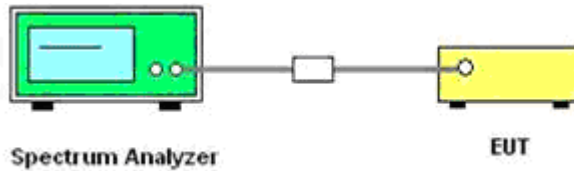
1. *Test results including cable loss;*
2. *Please See appendix for Carrier Frequency Separation test data*

6.3 Number of Hopping Frequency

6.3.1 Limit

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies

6.3.2 Block Diagram of Test Setup



6.3.3 Test Procedure

- 1). Place the EUT on the table and set it in transmitting mode.
- 2). Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the Spectrum Analyzer.
- 3). Set Spectrum Analyzer Start=902MHz, Stop = 908MHz, Sweep = auto.
- 4). Set the Spectrum Analyzer as RBW=100KHz, VBW=300KHz.
- 5). Max hold, view and count how many channel in the band.

6.3.4 Test Results

Pass

Note: Plesase See appendix for Hopping Channel Number test data

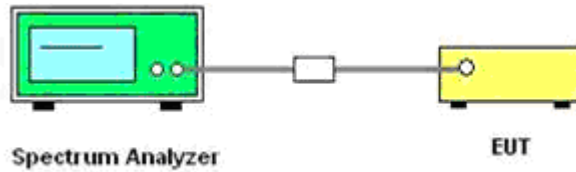


6.4 Time of Occupancy (Dwell Time)

6.4.1 Limit

The average time of occupancy on any channels shall not greater than 0.4 s within a period 0.4 s multiplied by the number of hopping channels employed.

6.4.2 Block Diagram of Test Setup



6.4.3 Test Procedure

- 1). Place the EUT on the table and set it in transmitting mode.
- 2). Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the Spectrum Analyzer.
- 3). Set center frequency of Spectrum Analyzer = operating frequency.
- 4). Set the Spectrum Analyzer as RBW, VBW=1MHz, Span = 0Hz, Sweep = auto.
- 5). Use software to collect the data form spectrum analyzer, and calculate the total on points
$$\text{Dwell time} = (\text{TX}_{\text{ON}} \text{ Points}) / \text{Total sweep points} * \text{sweep time}$$
- 6). Repeat above procedures until all frequency measured was complete.

6.4.4 Test Results

Pass

Remark:

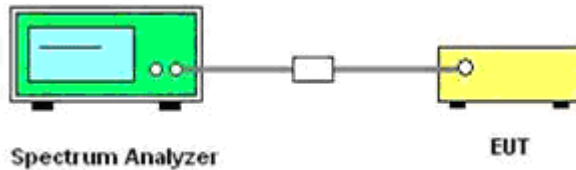
1. *Test results including cable loss;*
2. *Plesase See appendix for Dwell Time test data*

6.5 Conducted Spurious Emissions and Band Edges Test

6.5.1 Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required.

6.5.2 Block Diagram of Test Setup



6.5.3 Test Procedure

Conducted RF measurements of the transmitter output were made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer. The resolution bandwidth is set to 100 KHz. The video bandwidth is set to 300 KHz.

Measurements are made over the 9 kHz to 10GHz range with the transmitter set to the lowest, middle, and highest channels

6.5.4 Test Results of Conducted Spurious Emissions

Pass

Remark:

1. *Test results including cable loss;*
2. *please refer to following plots;*
3. *Plesase See appendix for Band-edge Emissions test data*
4. *Plesase See appendix for Conducted Spurious Emissions test data*



6.6 Radiated Emission and Restricted Band Emission

6.6.1. Standard Applicable

15.205 (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
\1\ 0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293.	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	(2\)
13.36-13.41			

\1\ Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.

\2\ Above 38.6

According to §15.247 (d): 20dBc in any 100 kHz bandwidth outside the operating frequency band. In case the emission fall within the restricted band specified on 15.205(a), then the 15.209(a) limit in the table below has to be followed.

Frequencies (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

6.6.2. Measuring Instruments and Setting

Please refer to section 6 of equipment list in this report. The following table is the setting of spectrum analyzer and receiver.

Spectrum Parameter	Setting
Attenuation	Auto
Start Frequency	1000 MHz
Stop Frequency	10 th carrier harmonic
RB / VB (Emission in restricted band)	1MHz / 1MHz for Peak, 1 MHz / 1/B kHz for Average
RB / VB (Emission in non-restricted band)	1MHz / 1MHz for Peak, 1 MHz / 1/B kHz for Average



Receiver Parameter	Setting
Attenuation	Auto
Start ~ Stop Frequency	9kHz~150kHz / RB/VB 200Hz/1KHz for QP/AVG
Start ~ Stop Frequency	150kHz~30MHz / RB/VB 9kHz/30KHz for QP/AVG
Start ~ Stop Frequency	30MHz~1000MHz / RB/VB 120kHz/1MHz for QP

6.6.3. Test Procedures

1) Sequence of testing 9 kHz to 30 MHz

Setup:

- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.
- If the EUT is a tabletop system, a rotatable table with 0.8 m height is used.
- If the EUT is a floor standing device, it is placed on the ground.
- Auxiliary equipment and cables were positioned to simulate normal operation conditions.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- The measurement distance is 3 meter.
- The EUT was set into operation.

Premeasurement:

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna height is 1.3 meter.
- At each turntable position the analyzer sweeps with peak detection to find the maximum of all emissions

Final measurement:

- Identified emissions during the premeasurement the software maximizes by rotating the turntable position (0° to 360°) and by rotating the elevation axes (0° to 360°).
- The final measurement will be done in the position (turntable and elevation) causing the highest emissions with QPK detector.
- The final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.



2) Sequence of testing 30 MHz to 1 GHz

Setup:

- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.
- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables were positioned to simulate normal operation conditions
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- The measurement distance is 3 meter.
- The EUT was set into operation.

Premeasurement:

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1 to 3 meter.
- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement:

- The final measurement will be performed with minimum the six highest peaks.
- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position ($\pm 45^\circ$) and antenna movement between 1 and 4 meter.
- The final measurement will be done with QP detector with an EMI receiver.
- The final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.



3) Sequence of testing 1 GHz to 10 GHz

Setup:

- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.
- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables were positioned to simulate normal operation conditions
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- The measurement distance is 3 meter.
- The EUT was set into operation.

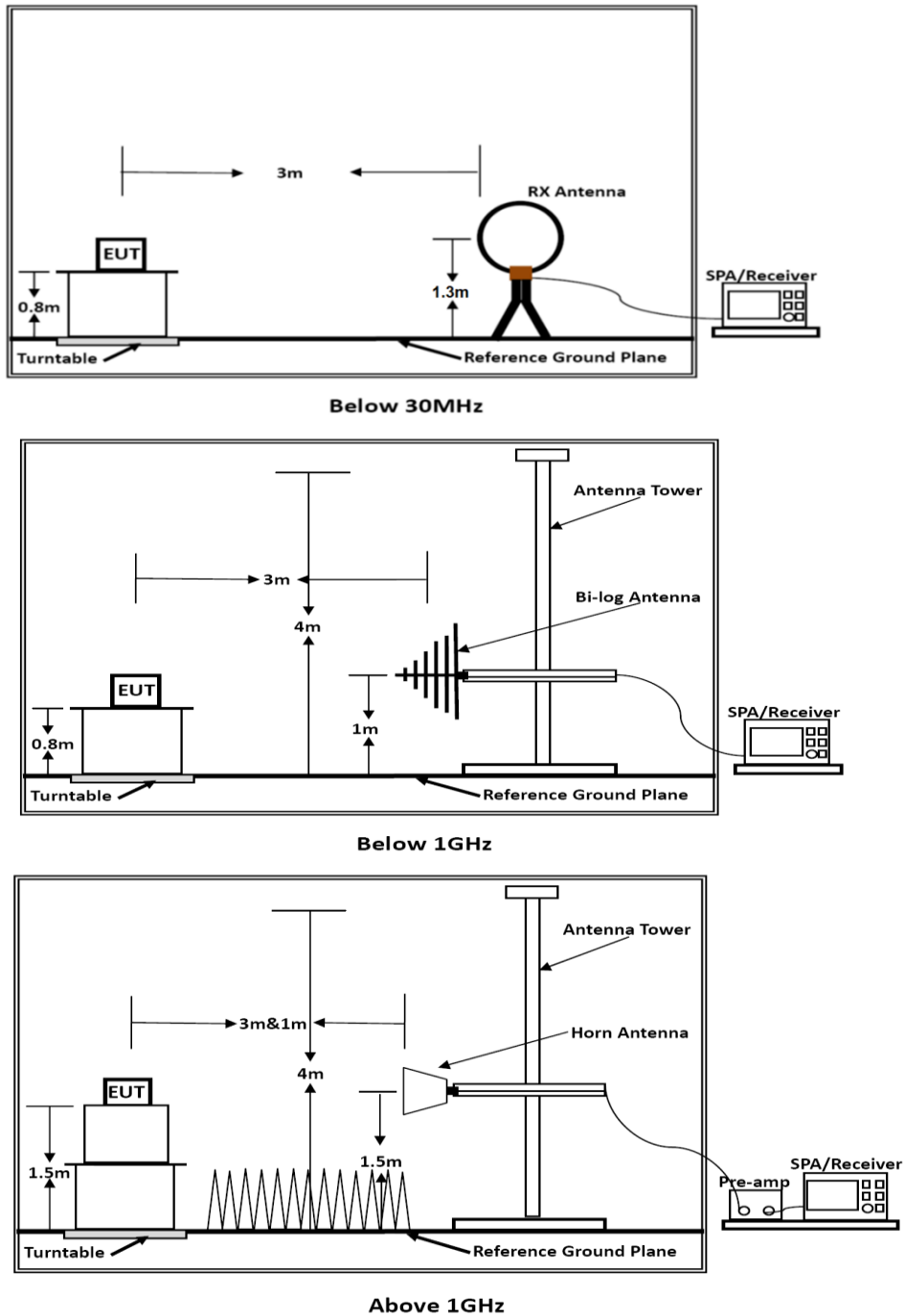
Premeasurement:

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height scan range is 1 meter to 2.5 meter.
- At each turntable position and antenna polarization the analyzer sweeps with peak detection to find the maximum of all emissions.

Final measurement:

- The final measurement will be performed with minimum the six highest peaks.
- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position ($\pm 45^\circ$) and antenna movement between 1 and 4 meter. This procedure is repeated for both antenna polarizations.
- The final measurement will be done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and Average detector.
- The final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

6.6.4. Test Setup Layout



Distance extrapolation factor = $20 \log (\text{specific distanc [3m]} / \text{test distance [1.5m]})$ (dB);
 Limit line = specific limits (dBuV) + distance extrapolation factor [6 dB].



6.6.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

6.6.6. Results of Radiated Emissions

PASS.

Only record the worst test result in this report.

The test data please refer to following page.

Results of Radiated Emissions (9 kHz~30MHz)

Temperature	24.3°C	Humidity	48%
Test Engineer	Anna Hu	Configurations	LoRa-Hybrid

Freq. (MHz)	Level (dBuV)	Over Limit (dB)	Over Limit (dBuV)	Remark
-	-	-	-	See Note

Note:

The amplitude of spurious emissions which are attenuated by more than 20 dB below the permissible value has no need to be reported.

Distance extrapolation factor = $40 \log(\text{specific distance} / \text{test distance})$ (dB);

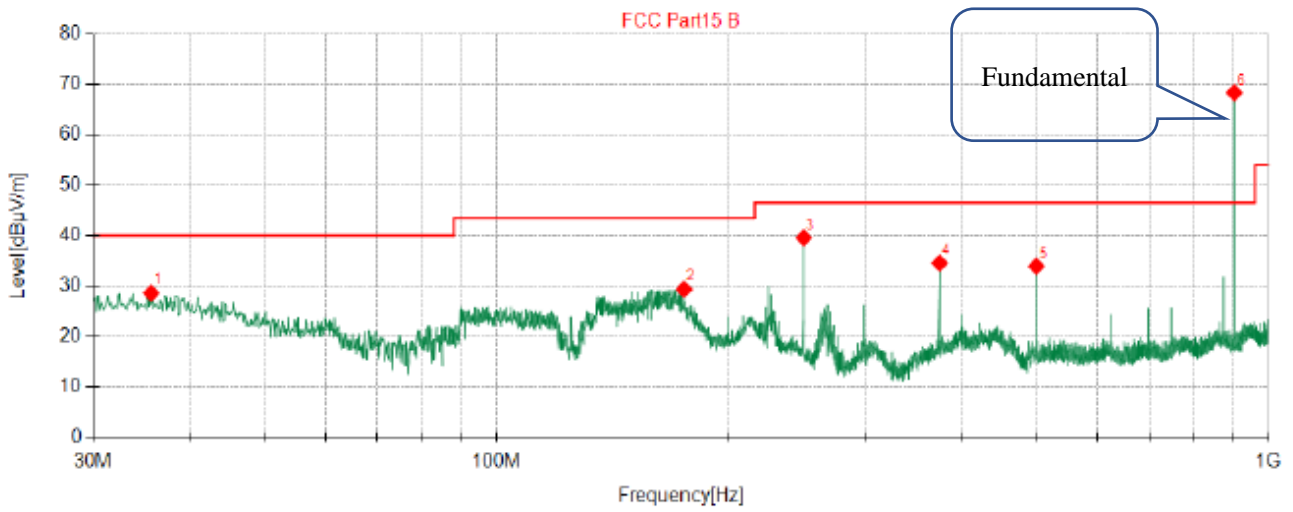
Limit line = specific limits (dBuV) + distance extrapolation factor.



Results of Radiated Emissions (30MHz)~1GHz)

Low Channel

Vertical



◆ QP Detector

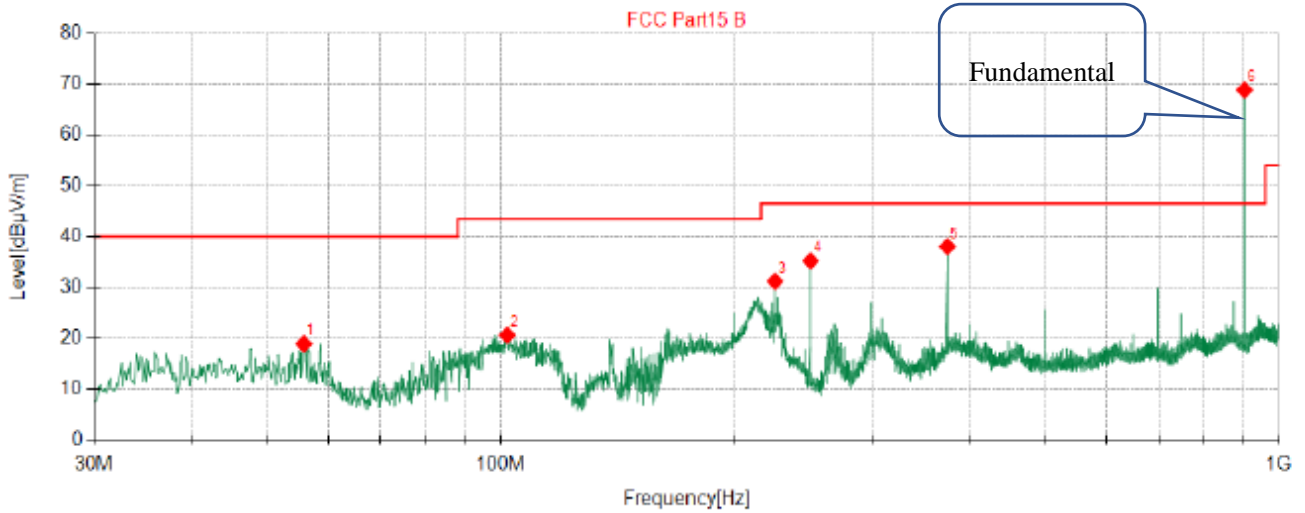
Suspected Data List								
NO.	Freq. [MHz]	Factor [dB/m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	35.698	-15.33	28.63	40.00	11.37	100	59	Vertical
2	174.89	-16.90	29.37	43.50	14.13	100	262	Vertical
3	249.94	-13.77	39.55	46.50	6.95	100	341	Vertical
4	374.95	-10.83	34.54	46.50	11.96	100	123	Vertical
5	499.96	-8.46	33.92	46.50	12.58	100	182	Vertical
6	902.39	-1.20	68.28	46.50	-21.78	100	120	Vertical

***Note:

1. Level [dBµV/m] = Reading [dBµV] + Factor [dB/m]
2. Margin [dB] = Limit [dBµV/m] - Level [dBµV/m]



Horizontal



◆ QP Detector

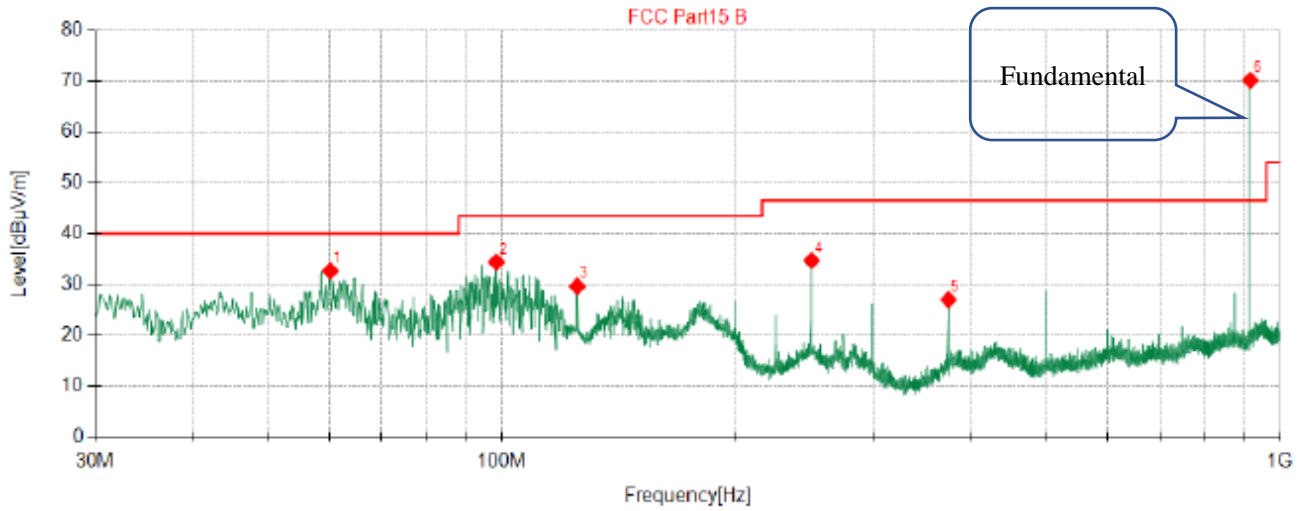
Suspected Data List								
NO.	Freq. [MHz]	Factor [dB/m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	55.826	-15.03	18.95	40.00	21.05	100	163	Horizontal
2	101.90	-15.99	20.67	43.50	22.83	100	275	Horizontal
3	224.97	-14.66	31.22	46.50	15.28	100	256	Horizontal
4	250.06	-13.87	35.22	46.50	11.28	100	74	Horizontal
5	374.95	-10.73	38.03	46.50	8.47	100	87	Horizontal
6	902.39	-1.02	68.80	46.50	-22.30	100	163	Horizontal

***Note:

1. Level [dBµV/m] = Reading [dBµV] + Factor [dB/m]
2. Margin [dB] = Limit [dBµV/m] - Level [dBµV/m]



High Channel
Vertical



◆ QP Detector

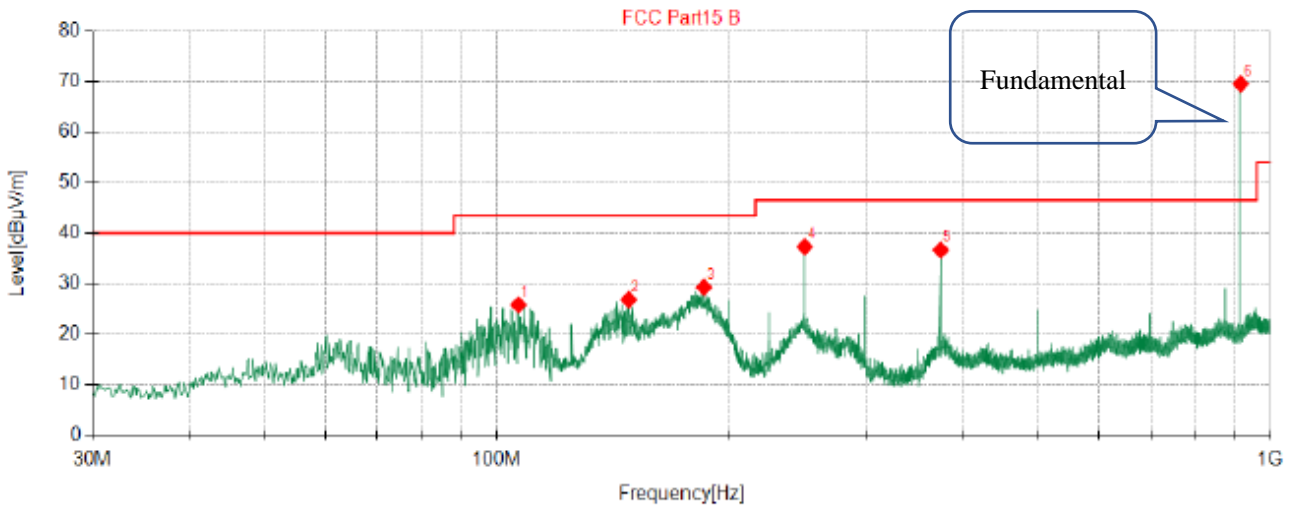
Suspected Data List								
NO.	Freq. [MHz]	Factor [dB/m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	60.191	-15.09	32.66	40.00	7.04	100	158	Vertical
2	98.385	-15.67	34.39	43.50	8.81	100	149	Vertical
3	124.93	-17.44	29.64	43.50	13.56	100	234	Vertical
4	250.06	-13.77	34.70	46.50	11.50	100	320	Vertical
5	374.95	-10.83	27.05	46.50	19.15	100	38	Vertical
6	915.00	-0.97	70.10	46.50	-23.60	100	234	Vertical

***Note:

1. Level [dBµV/m] = Reading [dBµV] + Factor [dB/m]
2. Margin [dB] = Limit [dBµV/m] - Level [dBµV/m]



Horizontal



◆ QP Detector

Suspected Data List								
NO.	Freq. [MHz]	Factor [dB/m]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	106.63	-16.00	25.86	43.50	18.24	100	300	Horizontal
2	148.09	-19.17	26.88	43.50	17.22	100	313	Horizontal
3	185.2	-16.94	29.31	43.50	14.79	100	294	Horizontal
4	250.06	-13.87	37.30	46.50	9.80	100	294	Horizontal
5	374.95	-10.73	36.65	46.50	10.45	100	88	Horizontal
6	915.00	-0.86	69.48	46.50	-22.98	100	162	Horizontal

***Note:

1. Level [dBµV/m] = Reading [dBµV] + Factor [dB/m]
2. Margin [dB] = Limit [dBµV/m] - Level [dBµV/m]



Results of Radiated Emissions (1GHz ~10GHz)

Low Channel: 902.3MHz

Freq. MHz	Reading dBuv	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuv/m	Limit dBuv/m	Margin dB	Remark	Pol.
1805.06	46.99	33.06	35.04	3.94	48.95	74.00	25.05	Peak	Horizontal
1805.58	47.14	33.06	35.04	3.94	49.10	74.00	24.90	Peak	Vertical
2707.03	49.04	33.06	35.04	3.94	51.00	74.00	23.00	Peak	Horizontal
2707.32	47.38	33.06	35.04	3.94	49.34	74.00	24.66	Peak	Vertical

Middle Channel: 908.7MHz

Freq. MHz	Reading dBuv	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuv/m	Limit dBuv/m	Margin dB	Remark	Pol.
1817.82	46.76	33.16	35.15	3.96	48.73	74.00	25.27	Peak	Horizontal
1817.96	46.79	33.16	35.15	3.96	48.76	74.00	25.24	Peak	Vertical
2727.00	48.12	33.16	35.15	3.96	50.09	74.00	23.91	Peak	Horizontal
2726.98	47.12	33.16	35.15	3.96	49.09	74.00	24.91	Peak	Vertical

High Channel: 914.9MHz

Freq. MHz	Reading dBuv	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuv/m	Limit dBuv/m	Margin dB	Remark	Pol.
1830.39	44.59	33.26	35.14	3.98	46.69	74.00	27.31	Peak	Horizontal
1830.16	49.84	33.26	35.14	3.98	51.94	74.00	22.06	Peak	Vertical
2745.10	49.44	33.26	35.14	3.98	51.54	74.00	22.46	Peak	Horizontal
2744.98	49.56	33.26	35.14	3.98	51.66	74.00	22.34	Peak	Vertical

Notes:

- 1). Measuring frequencies from 9k~10th harmonic (ex. 10GHz), No emission found between lowest internal used/generated frequency to 30 MHz.
- 2). Radiated emissions measured in frequency range from 9k~10th harmonic (ex. 10GHz) were made with an instrument using Peak detector mode.
- 3). Measured = Reading + Ant. Fac - Pre. Fac. + Cab. Loss; Margin = Limit - Measured

6.7. AC Power line conducted emissions

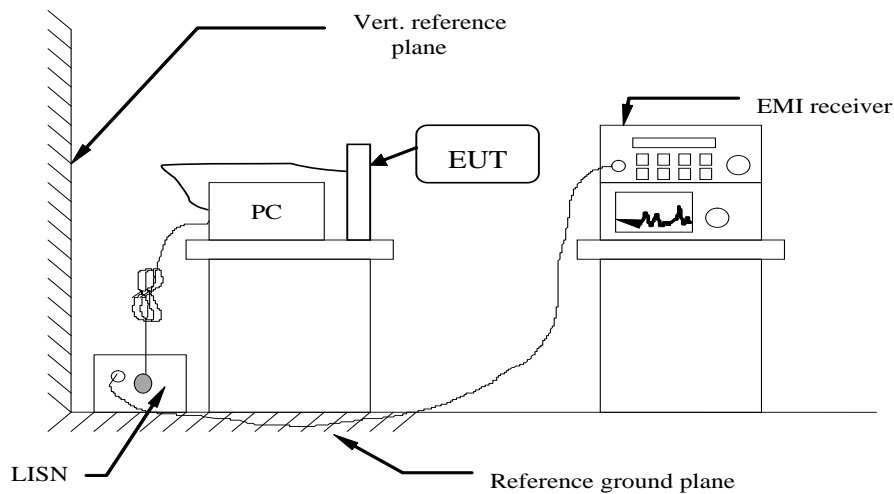
6.7.1 Standard Applicable

According to §15.207 (a): For an intentional radiator which is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed 250 microvolts (The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz). The limits at specific frequency range is listed as follows:

Frequency Range (MHz)	Limits (dB μ V)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.50 to 5	56	46
5 to 30	60	50

* Decreasing linearly with the logarithm of the frequency

6.7.2 Block Diagram of Test Setup



6.7.3 Test Results

N/A



6.8 Antenna requirement

6.8.1 Standard Applicable

According to antenna requirement of §15.203.

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. 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 manufacturer may design the unit so that a broken antenna can be re-placed by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

For intentional device, according to FCC 47 CFR Section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. And according to FCC 47 CFR Section 15.247 (b), if transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

6.8.2 Antenna Connected Construction

6.8.2.1. Standard Applicable

According to § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

6.8.2.2. Antenna Connector Construction

The directional gains of antenna refer to section 1.1 of this report, and the antenna is an External antenna connect to EUT with Anti-SMA connector and no consideration of replacement. Please see EUT photo for details.

6.8.2.3. Results: Compliance.

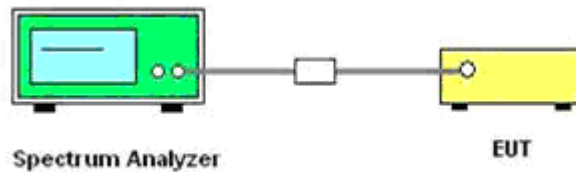


6.9 20 dB Bandwidth and 99% Bandwidth

6.9.1 Limit

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

6.9.2 Block Diagram of Test Setup



6.9.3 Test Procedure

20dB and 99% bandwidth test procedure :

- 1). Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel.
- 2). RBW $\geq 1\%$ of the 20 dB bandwidth, VBW \geq RBW.
- 3). Detector function = peak.
- 4). Trace = max hold.

6.9.4 Test Results

PASS.

Remark:

1. *Test results including cable loss;*
2. *please refer to following plots;*
3. *Measured at difference Packet Type for each mode and recorded worst case for each mode.*
4. ***Plesase See appendix for 20dB Bandwidth test data***

6.10. Maximum Peak Power Spectral Density Measurement

6.10.1. Standard Applicable

According to §15.247(e): For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

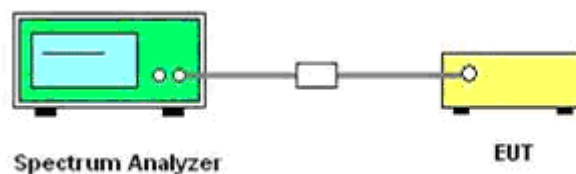
6.10.2. Measuring Instruments and Setting

Please refer to section 6 of equipment list in this report. The following table is the setting of Spectrum Analyzer.

6.10.3. Test Procedures

1. Use this procedure when the maximum peak conducted output power in the fundamental emission is used to demonstrate compliance.
2. The power was monitored at the coupler port with a Spectrum Analyzer. The power level was set to the maximum level.
3. Set the RBW = 3kHz.
4. Set the VBW $\geq 3 \times$ RBW
5. Set the span to 1.5 times the DTS channel bandwidth.
6. Detector = peak.
7. Sweep time = auto couple.
8. Trace mode = max hold.
9. Allow trace to fully stabilize.
10. Use the peak marker function to determine the maximum power level.
11. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.
12. The resulting peak PSD level must be 8dBm.

6.10.4. Test Setup Layout



6.10.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.



6.10.6. Test Result of Power Spectral Density

PASS.

Remark:

1. *Test results including cable loss;*
2. *please refer to following plots;*
3. *Measured at difference Packet Type for each mode and recorded worst case for each mode.*
4. ***Plesase See appendix for Maximum Peak power spectral density test data***



7. TEST SETUP PHOTOGRAPHS

Please refer to separated files for Test Setup Photos of the EUT.

8.EXTERNAL PHOTOS OF THE EUT

Please refer to separated files for External Photos of the EUT.

9.INTERIOR PHOTOS OF THE EUT

Please refer to separated files for Internal Photos of the EUT.

-----THE END OF REPORT-----