



FCC RF Test Report

APPLICANT : Republic Wireless Inc.
EQUIPMENT : Relay+
BRAND NAME : Relay by Republic Wireless
MODEL NAME : RW2266
FCC ID : 2AMBHRW2266
STANDARD : FCC Part 15 Subpart C §15.247
CLASSIFICATION : (DTS) Digital Transmission System

The product was received on May 08, 2019 and testing was completed on Feb. 24, 2020. We, Sporton International (Kunshan) Inc., would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International (Kunshan) Inc., the test report shall not be reproduced except in full.

Jason Jia

Reviewed by: Jason Jia / Supervisor

James Huang

Approved by: James Huang / Manager



Sporton International (Kunshan) Inc.

No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300
People's Republic of China



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REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FR950807E	Rev. 01	Initial issue of report	Mar. 05, 2020

SUMMARY OF TEST RESULT

Report Section	FCC Rule	Description	Limit	Result	Remark
3.1	15.247(a)(2)	6dB Bandwidth	$\geq 0.5\text{MHz}$	Pass	-
3.2	15.247(b)(3)	Peak Output Power	$\leq 30\text{dBm}$	Pass	-
3.3	15.247(e)	Power Spectral Density	$\leq 8\text{dBm}/3\text{kHz}$	Pass	-
3.4	15.247(d)	Conducted Band Edges and Spurious Emission	$\leq 20\text{dBc}$	Pass	-
3.5	15.247(d)	Radiated Band Edges and Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit 2.74 dB at 2744.000 MHz
3.6	15.207	AC Conducted Emission	15.207(a)	Pass	Under limit 18.04 dB at 0.150 MHz
3.7	15.203 & 15.247(b)	Antenna Requirement	N/A	Pass	-

Declaration of Conformity:

The test results with all measurement uncertainty excluded are presented in accordance with the regulation limits or requirements declared by manufacturers.

Comments and Explanations:

The declared of product specification for EUT presented in the report are provided by the manufacturer, and the manufacturer takes all the responsibilities for the accuracy of product specification.



1 General Description

1.1 Applicant

Republic Wireless Inc.

940 Main Campus Drive, Ste 300, Raleigh, NC 27606, USA

1.2 Manufacturer

Republic Wireless Inc.

940 Main Campus Drive, Ste 300, Raleigh, NC 27606, USA

1.3 Product Feature of Equipment Under Test

Product Feature	
Equipment	Relay+
Brand Name	Relay by Republic Wireless
Model Name	RW2266
FCC ID	2AMBHRW2266
EUT supports Radios application	WCDMA/HSPA/DC-HSDPA/ HSPA+(16QAM Uplink is not supported)/LTE/NFC/LoRa WLAN 2.4GHz 802.11b/g/n HT20/HT40 WLAN 5GHz 802.11a/n HT20/HT40 Bluetooth BR/EDR/LE GNSS/WPC(QI)
IMEI Code	Conduction/ Radiation: N/A
HW Version	B2
SW Version	1.15.0.28-DF
EUT Stage	Identical Prototype

Remark:

1. The above EUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.
2. According to the Operation Description, the maximum duty cycle of the device is 13.6%

1.4 Product Specification of Equipment Under Test

Standards-related Product Specification	
Tx/Rx Frequency Range	902 MHz ~ 928 MHz
Number of Channels	23
Bandwidth / Spread Factor	500kHz / 7
Maximum Output Power to Antenna	27.94 dBm (0.6223 W)
Antenna Type / Gain	Internal Antenna with gain -3.78 dBi
Type of Modulation	LoRa



1.5 Modification of EUT

No modifications are made to the EUT during all test items.

1.6 Testing Location

Sporton International (Kunshan) Inc. is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.02.

Test Firm	Sporton International (Kunshan) Inc.		
Test Site Location	No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China TEL : +86-512-57900158 FAX : +86-512-57900958		
Test Site No.	Sporton Site No.	FCC Designation No.	FCC Test Firm Registration No.
	CO01-KS 03CH05-KS TH01-KS	CN1257	314309

1.7 Test Software

Item	Site	Manufacture	Name	Version
1.	03CH05-KS	AUDIX	E3	6.2009-8-24al
2.	CO01-KS	AUDIX	E3	6.2009-8-24

1.8 Applicable Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

- ♦ 47 CFR Part 15 Subpart C §15.247
- ♦ FCC KDB 558074 D01 15.247 Meas Guidance v05r02
- ♦ ANSI C63.10-2013

Remark:

1. All test items were verified and recorded according to the standards and without any deviation during the test.
2. This EUT has also been tested and complied with the requirements of FCC Part 15, Subpart B, recorded in a separate test report.



2 Test Configuration of Equipment Under Test

2.1 Carrier Frequency Channel

Frequency Band	Channel	Freq. (MHz)	Channel	Freq. (MHz)
902-928 MHz	1	904	13	916
	2	905	14	917
	3	906	15	918
	4	907	16	919
	5	908	17	920
	6	909	18	921
	7	910	19	922
	8	911	20	923
	9	912	21	924
	10	913	22	925
	11	914	23	926
	12	915		

The above EUT's information was declared by manufacturer.

2.2 Test Mode

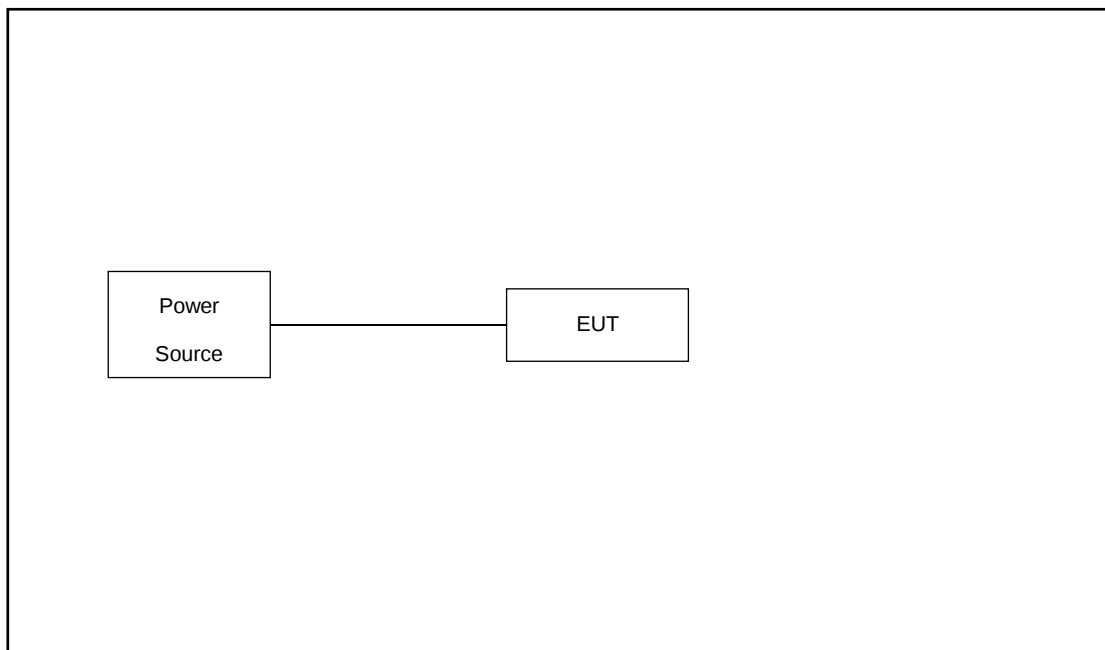
- a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated: conduction emission (150 kHz to 30 MHz), radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, pre-scanned in three orthogonal panels, X, Y, Z. The worst cases (Z plane) were recorded in this report.
- b. AC power line Conducted Emission was tested under maximum output power.

The following summary table is showing all test modes to demonstrate in compliance with the standard.

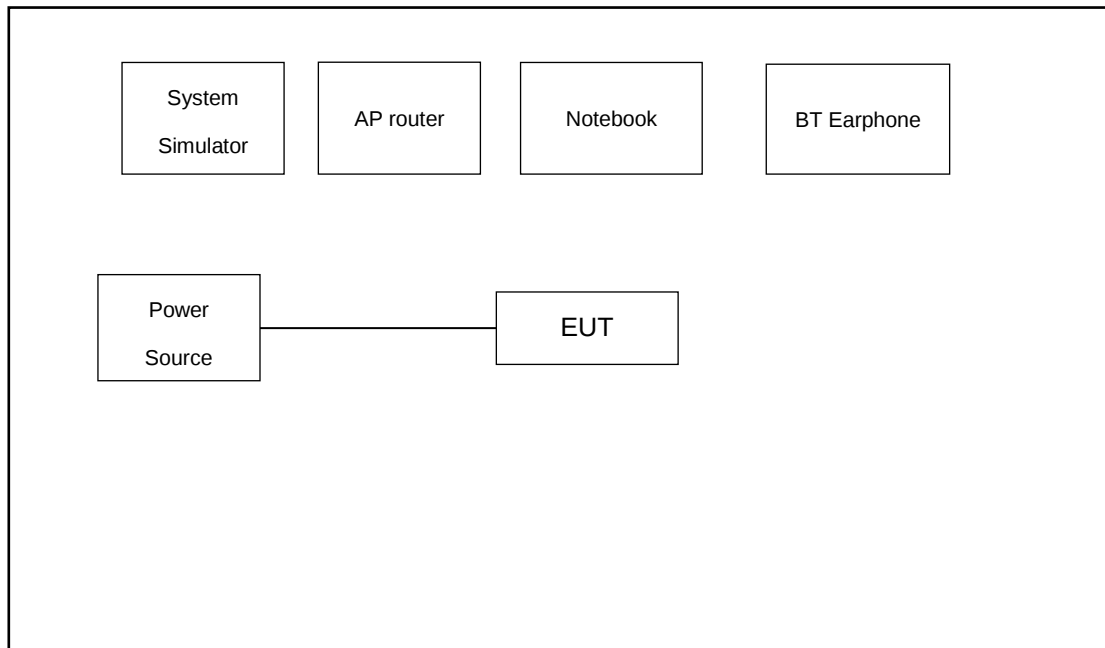
Summary table of Test Cases	
Test Item	Data Rate / Modulation
	LoRa / FSK
Conducted TCs	Mode 1: LoRa Tx CH01_904 MHz_1Mbps Mode 2: LoRa Tx CH12_915 MHz_1Mbps Mode 3: LoRa Tx CH23_926 MHz_1Mbps
Radiated TCs	Mode 1: LoRa Tx CH01_904 MHz_1Mbps Mode 2: LoRa Tx CH12_915 MHz_1Mbps Mode 3: LoRa Tx CH23_926 MHz_1Mbps
AC Conducted Emission	Mode 1: WCDMA Band V Idle + Bluetooth Link + WLAN Link (2.4G) + USB Cable(Charging from Adapter) + LoRa Tx

2.3 Connection Diagram of Test System

For Radiation



For Conducted Emission



2.4 Support Unit used in test configuration and system

Item	Equipment	Trade Name	Model Name	FCC ID	Data Cable	Power Cord
1.	Base Station	Anritsu	MT8820C	N/A	N/A	Unshielded,1.8m
2.	WLAN AP	D-link	DIR-655	KA21R655B1	N/A	Unshielded,1.8m
3.	Notebook	Lenovo	G480	QDS-BRCM1050I	N/A	AC I/P: Unshielded, 1.8 m DC O/P: Shielded, 1.8 m
4.	Bluetooth Earphone	Lenovo	LBH308	N/A	N/A	N/A

2.5 EUT Operation Test Setup

For LoRa function, the engineering test program was provided and enabled to make EUT continuous transmit/receive.

For AC power line conducted emissions, the EUT was set to connect with the WLAN AP under large package sizes transmission.

2.6 Measurement Results Explanation Example

For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Example :

The spectrum analyzer offset is derived from RF cable loss and attenuator factor.

Offset = RF cable loss + attenuator factor.

Following shows an offset computation example with cable loss 10.7 dB and 10dB attenuator.

$$\begin{aligned}
 \text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)}. \\
 &= 10.7 + 10 = 20.7 \text{ (dB)}
 \end{aligned}$$

3 Test Result

3.1 6dB Bandwidth Measurement

3.1.1 Limit of 6dB Bandwidth

The minimum 6 dB bandwidth shall be at least 500 kHz.

3.1.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.1.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 11.8
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. Set the Video bandwidth (VBW) = 300 kHz. In order to make an accurate measurement. The 6 dB bandwidth must be greater than 500 kHz.
5. Measure and record the results in the test report.

3.1.4 Test Setup

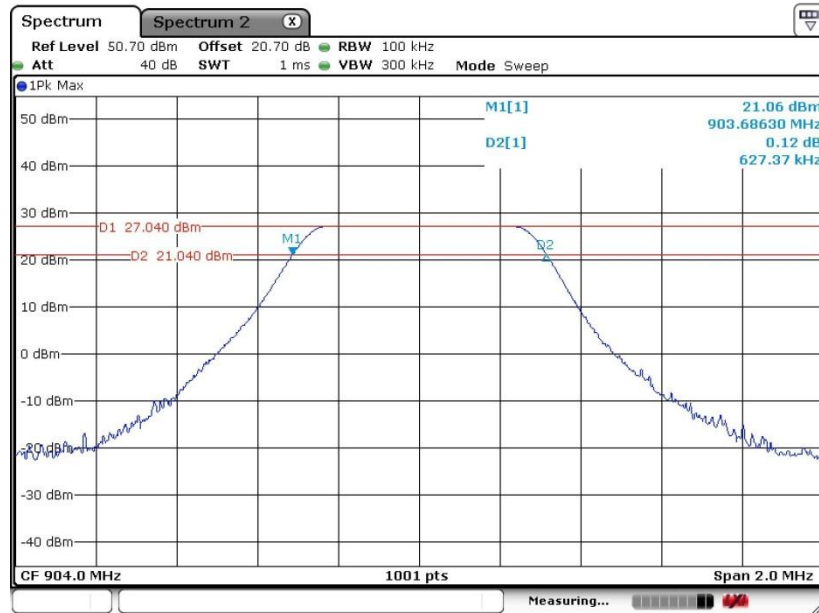




3.1.5 Test Result of 6dB Bandwidth

Please refer to Appendix A.

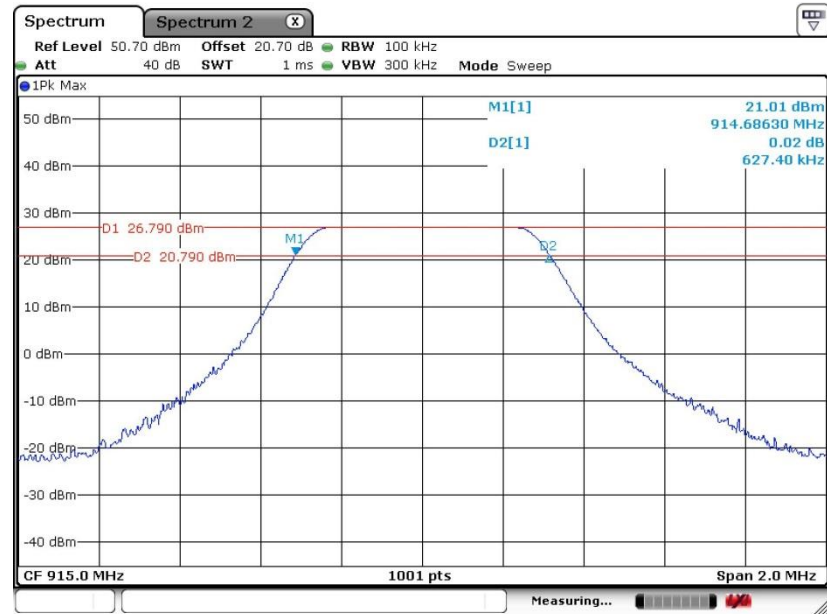
6 dB Bandwidth Plot on Channel 904MHz



Date: 24.FEB.2020 16:43:49

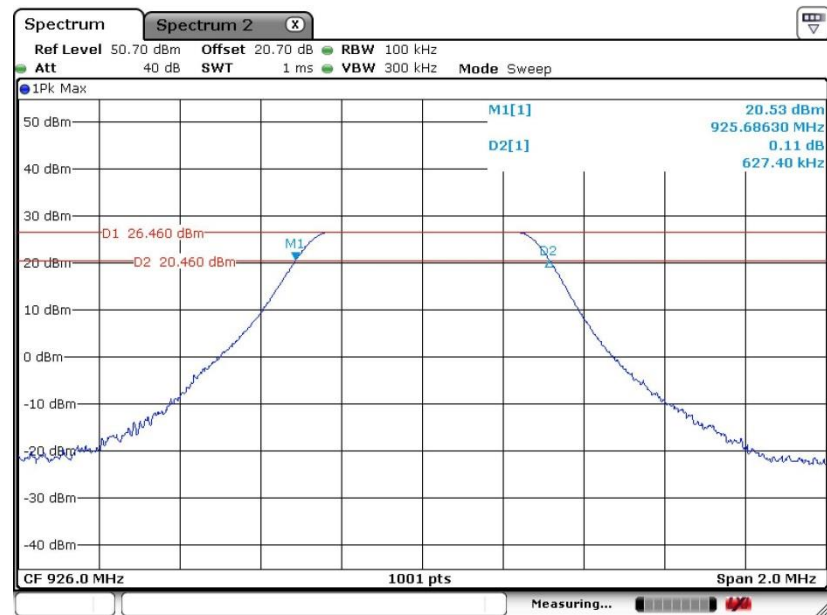


6 dB Bandwidth Plot on Channel 915MHz



Date: 24.FEB.2020 16:54:31

6 dB Bandwidth Plot on Channel 926MHz



Date: 24.FEB.2020 17:06:18

3.2 Output Power Measurement

3.2.1 Limit of Output Power

For systems using digital modulation in the 902-928MHz, the limit for peak output power is 30dBm. If transmitting antenna of directional gain greater than 6dBi is used, the peak output power from the intentional radiator shall be reduced below the above stated value by the amount in dB that the directional gain of the antenna exceeds 6 dBi. In case of point-to-point operation, the limit has to be reduced by 1dB for every 3dB that the directional gain of the antenna exceeds 6dBi.

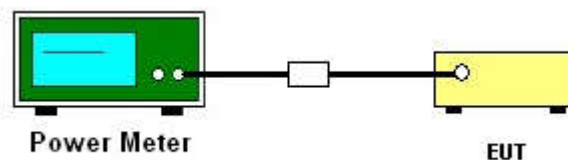
3.2.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.2.3 Test Procedures

1. The testing follows the Measurement Procedure of ANSI C63.10-2013 clause 11.9.1.3 PKPM1 Peak power meter or ANSI C63.10-2013 clause 11.9.2.3.2 Method AVGPM-G method.
2. The RF output of EUT was connected to the power meter (using a gated RF average-reading power meter) by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Measure the conducted output power and record the results in the test report.

3.2.4 Test Setup



3.2.5 Test Result of Peak Output Power

Please refer to Appendix A.

3.2.6 Test Result of Average Output Power (Reporting Only)

Please refer to Appendix A.

3.3 Power Spectral Density Measurement

3.3.1 Limit of Power Spectral Density

The peak power spectral density shall not be greater than 8dBm in any 3kHz band at any time interval of continuous transmission.

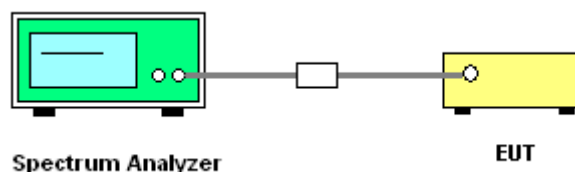
3.3.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.3.3 Test Procedures

1. The testing follows Measurement Procedure of ANSI C63.10-2013 clause 11.10.2 Method PKPSD.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 3 kHz. Video bandwidth VBW = 10 kHz In order to make an accurate measurement, set the span to 1.5 times DTS Channel Bandwidth. (6dB BW)
5. Detector = peak, Sweep time = auto couple, Trace mode = max hold, Allow trace to fully stabilize. Use the peak marker function to determine the maximum power level.
6. Measure and record the results in the test report.
7. The Measured power density (dBm)/ 100kHz is a reference level and used as 20dBc down limit line for Conducted Band Edges and Conducted Spurious Emission.

3.3.4 Test Setup



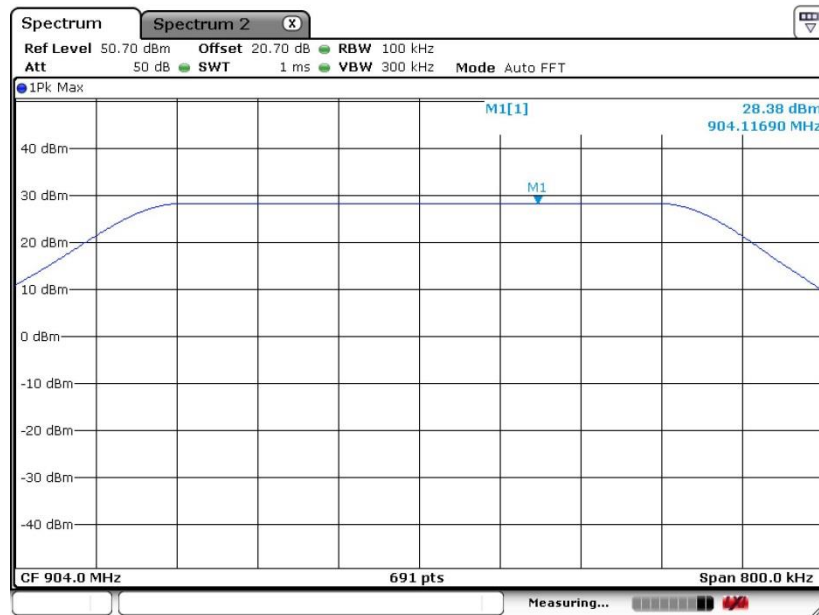
3.3.5 Test Result of Power Spectral Density

Please refer to Appendix A.



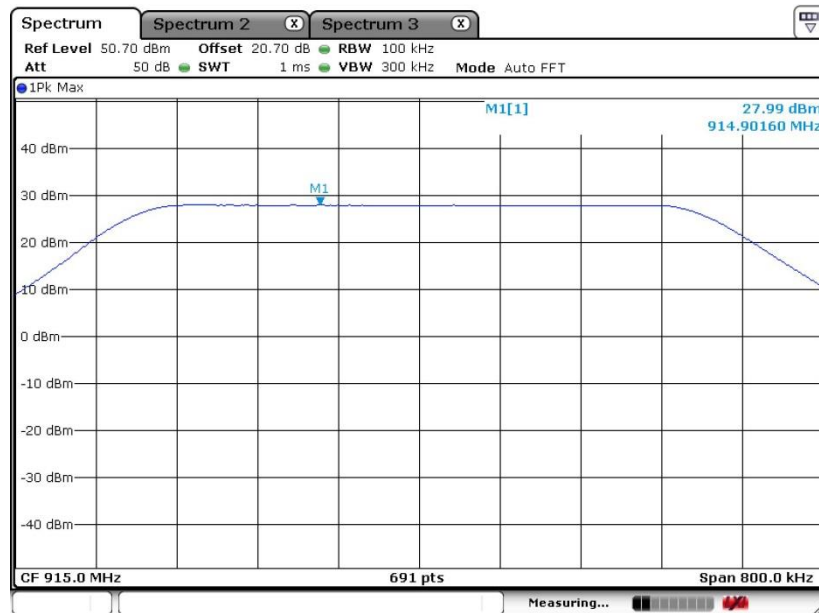
3.3.6 Test Result of Power Spectral Density Plots (100kHz)

PSD 100kHz Plot on Channel 904MHz



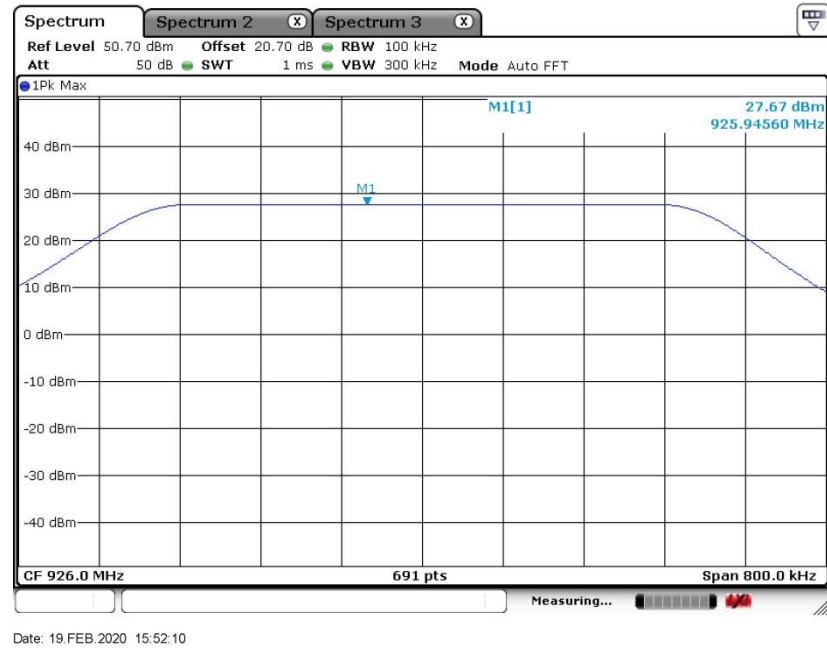
Date: 19.FEB.2020 15:27:34

PSD 100kHz Plot on Channel 915MHz



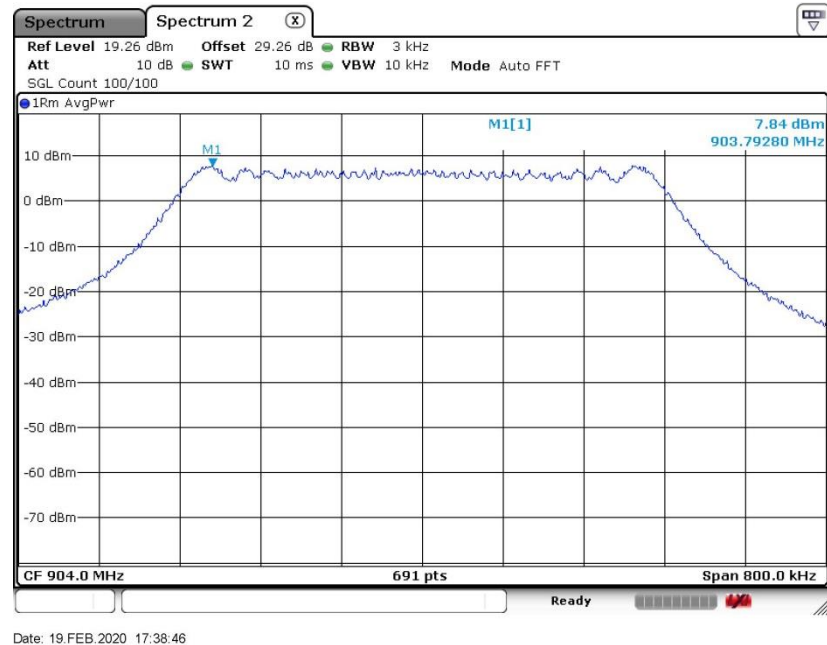
Date: 19.FEB.2020 15:46:02

PSD 100kHz Plot on Channel 926MHz



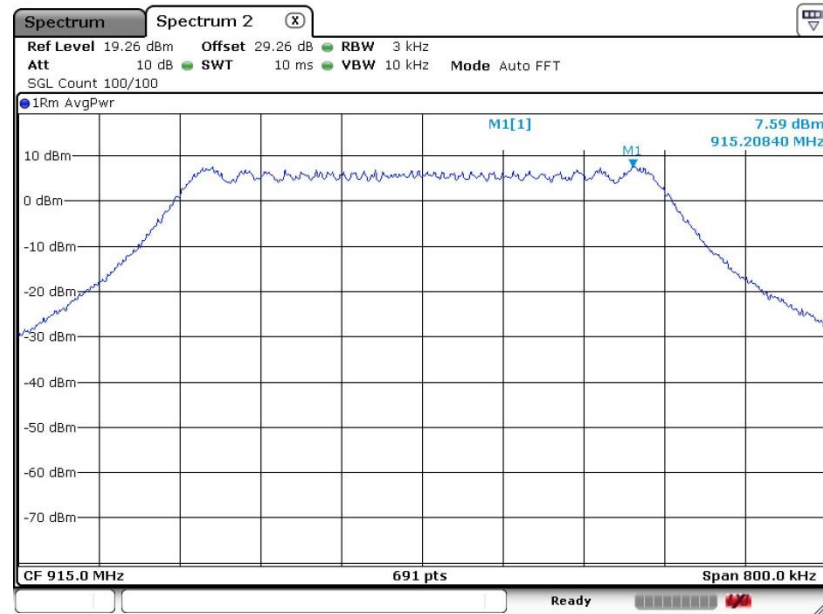
3.3.7 Test Result of Power Spectral Density Plots (3kHz)

PSD 3kHz Plot on Channel 904MHz



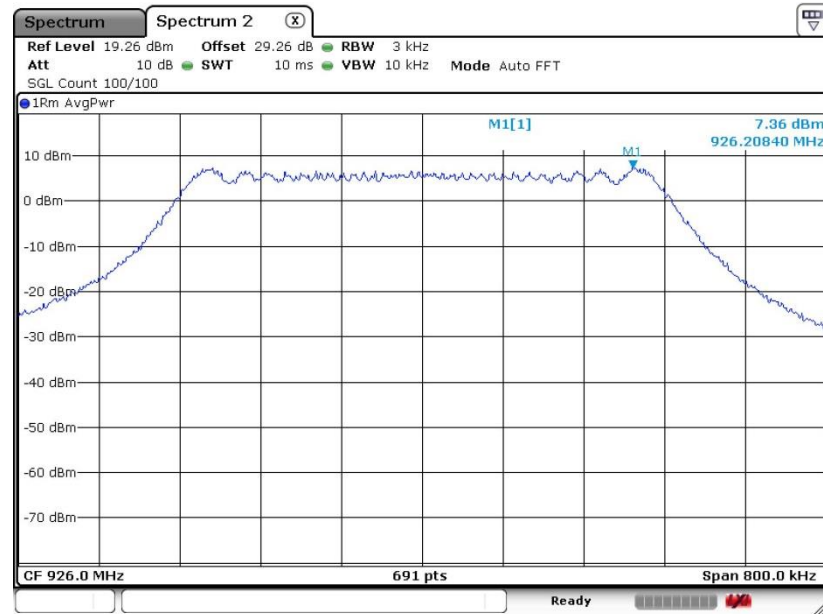


PSD 3kHz Plot on Channel 915MHz



Date: 19.FEB.2020 17:39:20

PSD 3kHz Plot on Channel 926MHz



Date: 19.FEB.2020 17:41:12

3.4 Conducted Band Edges and Spurious Emission Measurement

3.4.1 Limit of Conducted Band Edges and Spurious Emission

All harmonics/spurious must be at least 30 dB down from the highest emission level within the authorized band.

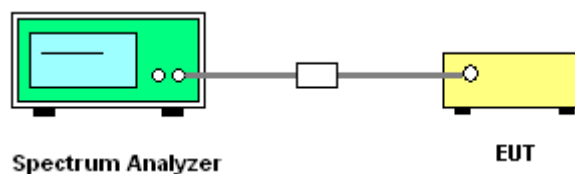
3.4.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.4.3 Test Procedure

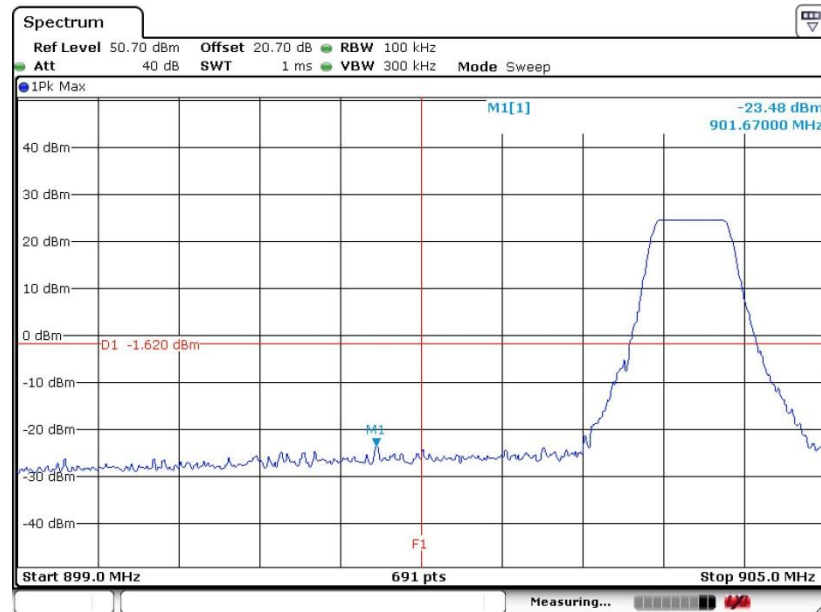
1. The testing follows ANSI C63.10-2013 clause 11.13
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Set RBW = 100 kHz, VBW=300 kHz, Peak Detector. Unwanted Emissions measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz when maximum peak conducted output power procedure is used. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.
5. Measure and record the results in the test report.
6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

3.4.4 Test Setup

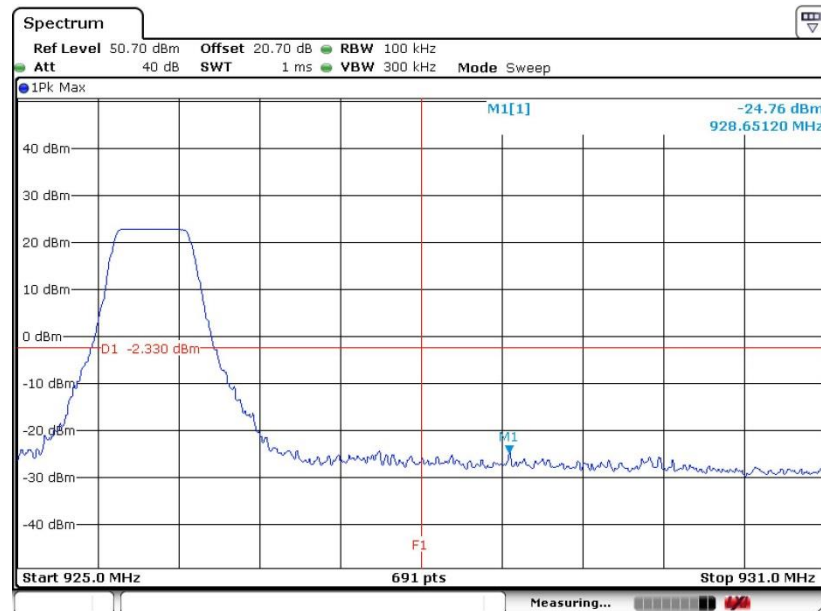


3.4.5 Test Result of Conducted Band Edges Plots

Low Band Edge Plot on Channel 904MHz

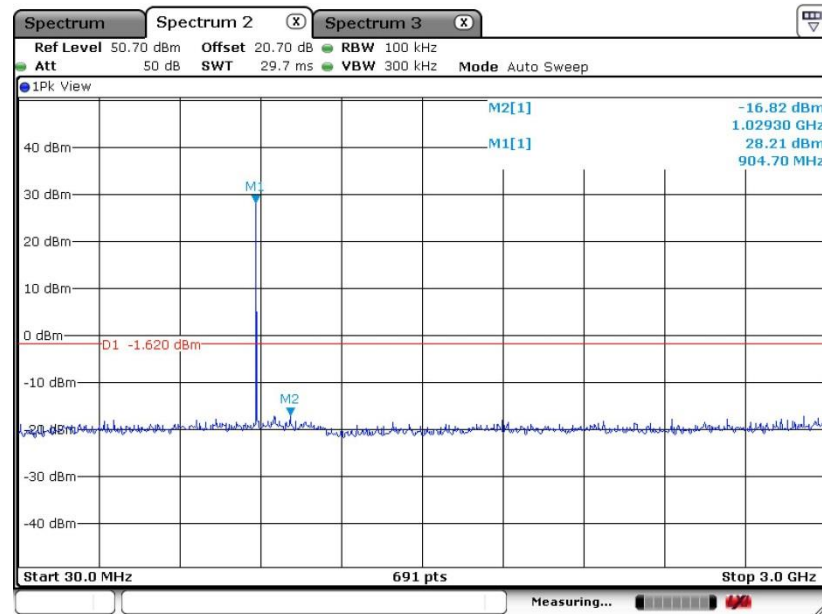


High Band Edge Plot on Channel 926MHz



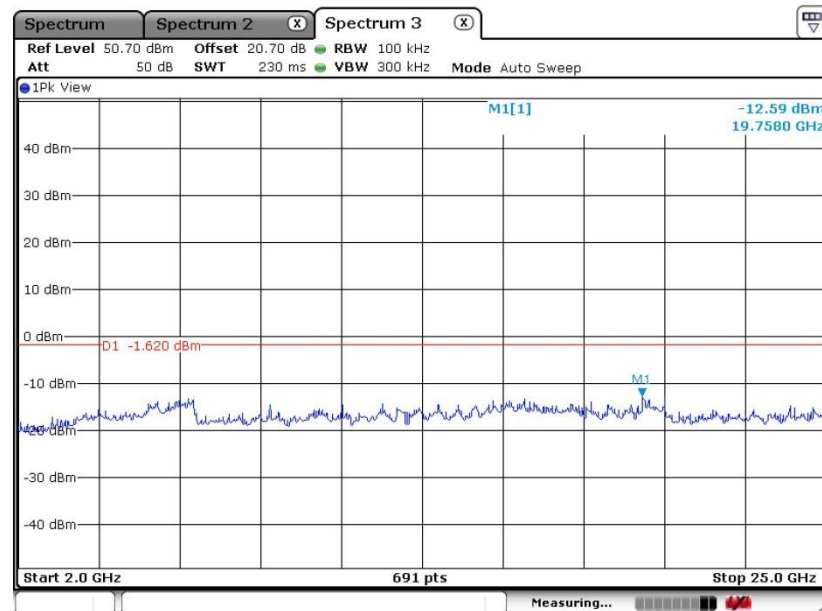
3.4.6 Test Result of Conducted Spurious Emission Plots

Channel 904MHz



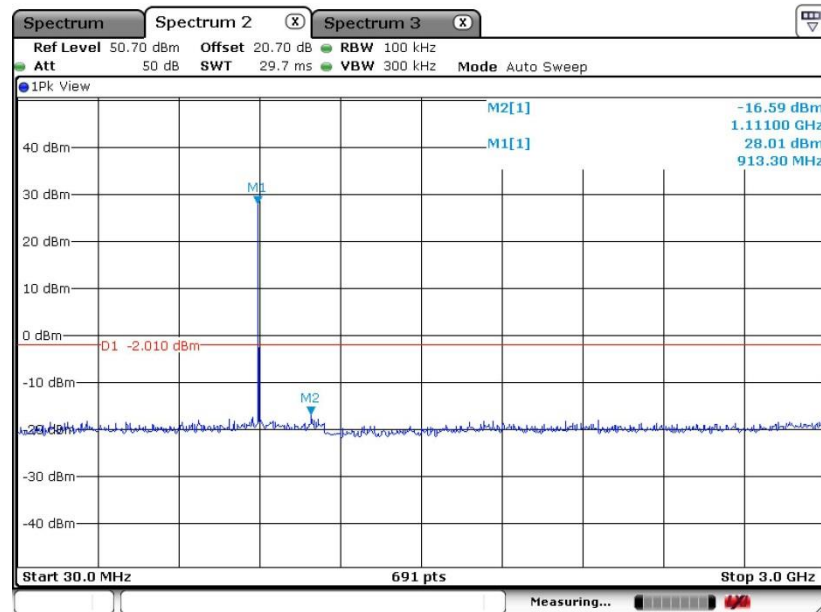
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Channel 904MHz



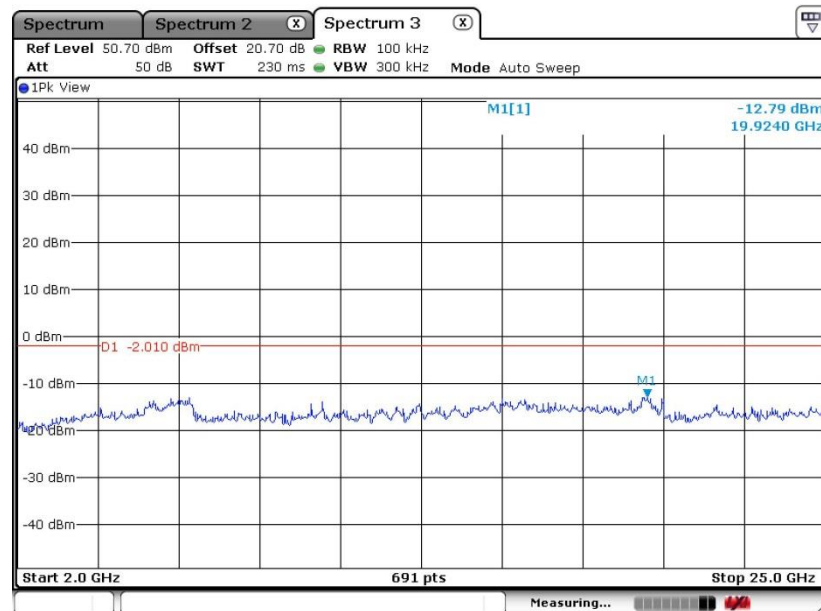
Date: 19.FEB.2020 15:43:29

Channel 915MHz



Date: 19.FEB.2020 15:47:27

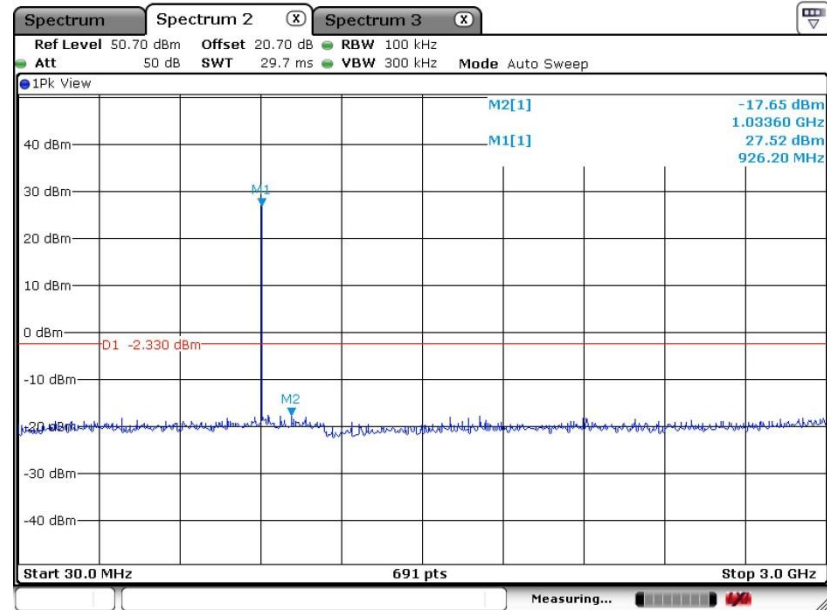
Channel 915MHz



Date: 19.FEB.2020 15:49:49

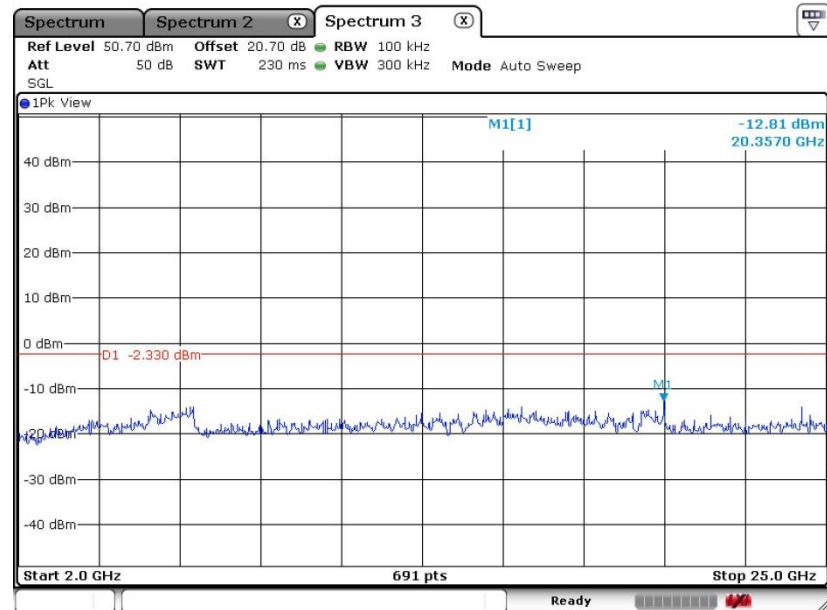


Channel 926MHz



Date: 19.FEB.2020 15:53:57

Channel 926MHz



Date: 19.FEB.2020 15:54:51

3.5 Radiated Band Edges and Spurious Emission Measurement

3.5.1 Limit of Radiated Band Edges and Spurious Emission

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)). In addition, radiated emissions which fall in the restricted bands must also comply with the limits as below.

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

3.5.2 Measuring Instruments

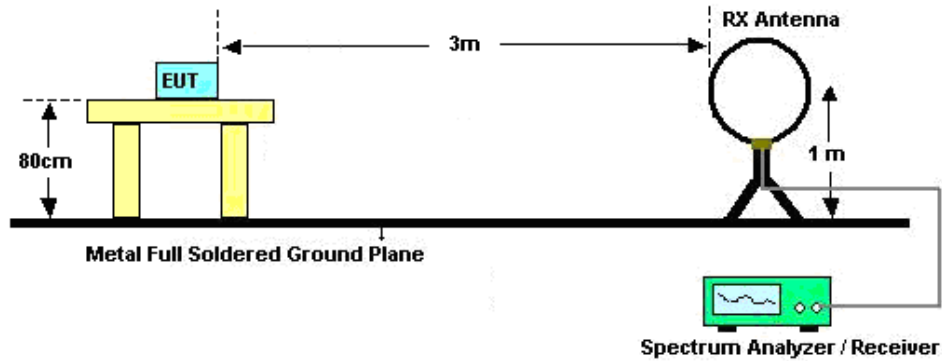
The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.5.3 Test Procedures

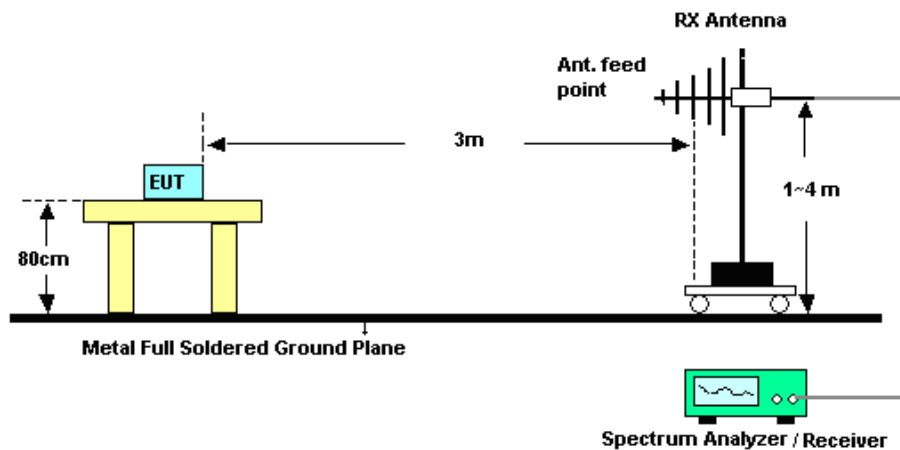
1. The testing follows ANSI C63.10-2013 clause 11.11 & 11.12
2. The EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level.
3. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
4. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
5. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
6. For testing below 1GHz, if the emission level of the EUT in peak mode was 3 dB lower than the limit specified, then peak values of EUT will be reported, otherwise, the emissions will be repeated one by one using the CISPR quasi-peak method and reported.
7. For testing above 1GHz, the emission level of the EUT in peak mode was 20dB lower than average limit (that means the emission level in average mode also complies with the limit in average mode), then peak values of EUT will be reported, otherwise, the emissions will be measured in average mode again and reported.
8. Use the following spectrum analyzer settings:
 - (1) Span shall wide enough to fully capture the emission being measured;
 - (2) Set RBW=100 kHz for $f < 1$ GHz; $VBW \geq RBW$; Sweep = auto; Detector function = peak; Trace = max hold;
 - (3) Set RBW = 1 MHz, VBW= 3MHz for $f \geq 1$ GHz for peak measurement.
For average measurement:
 - $VBW = 10$ Hz, when duty cycle is no less than 98 percent.
 - $VBW \geq 1/T$, when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.

3.5.4 Test Setup

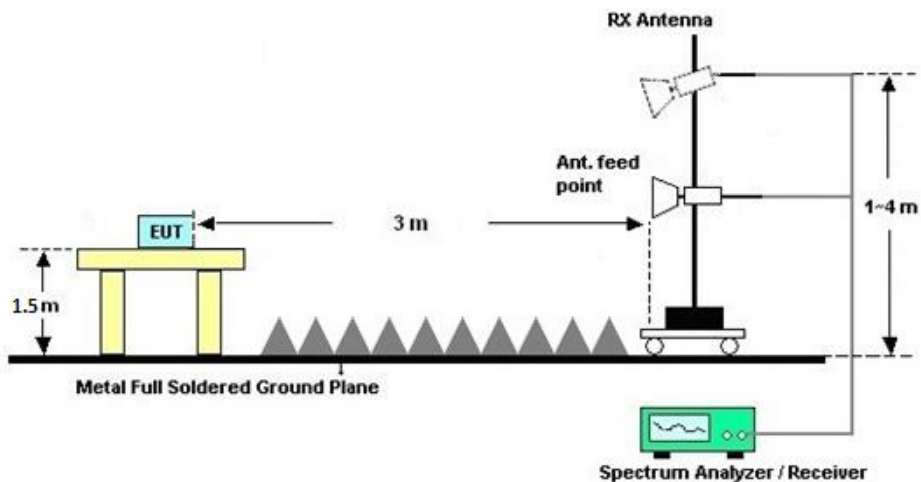
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz





3.5.5 Test Results of Radiated Spurious Emissions (9 kHz ~ 30 MHz)

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line was not reported.

There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

3.5.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix C.

3.5.7 Duty Cycle

Please refer to Appendix D.

3.5.8 Test Result of Radiated Spurious Emission (30MHz ~ 10th Harmonic)

Please refer to Appendix C.

3.6 AC Conducted Emission Measurement

3.6.1 Limit of AC Conducted Emission

For equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table.

Frequency of emission (MHz)	Conducted limit (dBμV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

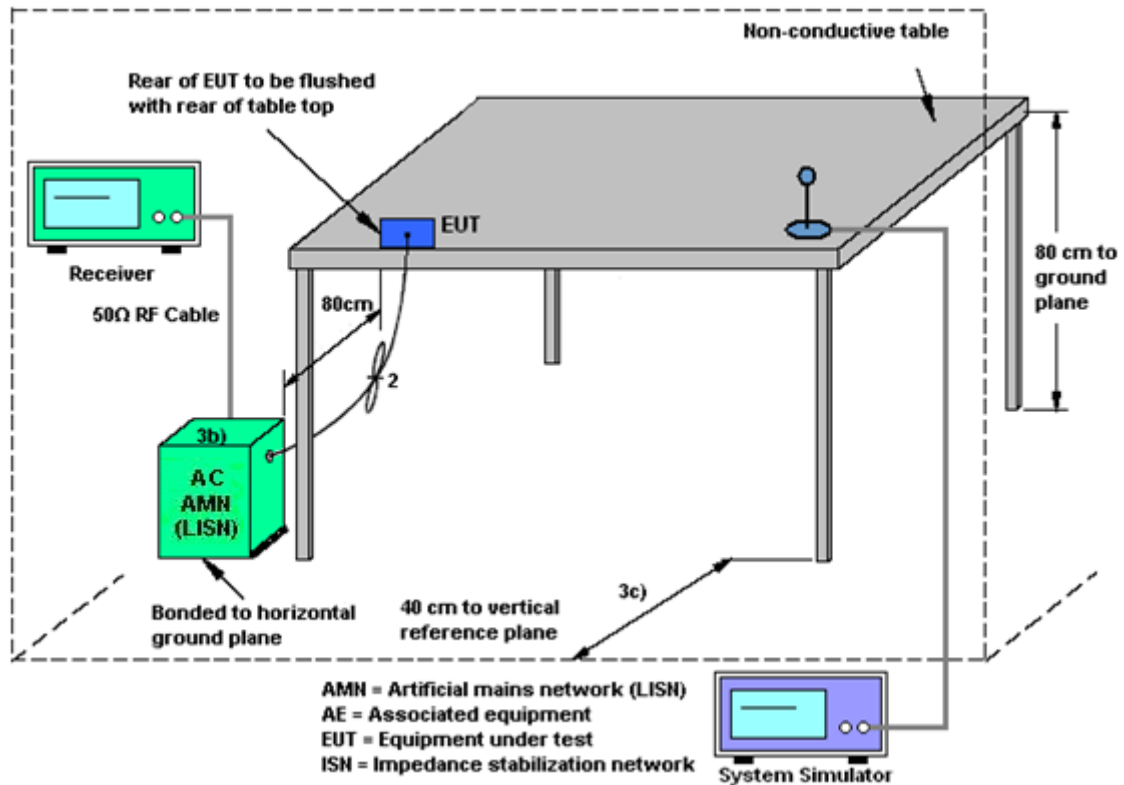
3.6.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.6.3 Test Procedures

1. The EUT was placed 0.4 meter from the conducting wall of the shielding room was kept at least 80 centimeters from any other grounded conducting surface.
2. Connect EUT to the power mains through a line impedance stabilization network (LISN).
3. All the support units are connecting to the other LISN.
4. The LISN provides 50 ohm coupling impedance for the measuring instrument.
5. The FCC states that a 50 ohm, 50 microhenry LISN should be used.
6. Both sides of AC line were checked for maximum conducted interference.
7. The frequency range from 150 kHz to 30 MHz was searched.
8. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF Bandwidth = 9kHz) with Maximum Hold Mode. Then measurement is also conducted by Average Detector and Quasi-Peak Detector Function respectively.

3.6.4 Test Setup



3.6.5 Test Result of AC Conducted Emission

Please refer to Appendix B.



3.7 Antenna Requirements

3.7.1 Standard Applicable

If directional gain of transmitting antennas is greater than 6dBi, the power shall be reduced by the same level in dB comparing to gain minus 6dBi. 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 rule.

3.7.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.7.3 Antenna Gain

The antenna peak gain of EUT is less than 6 dBi. Therefore, it is not necessary to reduce maximum peak output power limit.



4 List of Measuring Equipment

Instrument	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Spectrum Analyzer	R&S	FSV30	101338	10Hz~30GHz	Apr. 16, 2019	Feb. 19, 2020~ Feb. 24, 2020	Apr. 15, 2020	Conducted (TH01-KS)
Pulse Power Sensor	Anritsu	MA2411B	0917070	300MHz~40GHz	Jan. 08, 2020	Feb. 19, 2020~ Feb. 24, 2020	Jan. 07, 2021	Conducted (TH01-KS)
Power Meter	Anritsu	ML2495A	1005002	50MHz Bandwidth	Jan. 08, 2020	Feb. 19, 2020~ Feb. 24, 2020	Jan. 07, 2021	Conducted (TH01-KS)
EMI Test Receiver	Keysight	N9038A	MY57290151	3Hz~8.5GHz; Max 30dBm	Jul. 18, 2019	Feb. 22, 2020	Jul. 17, 2020	Radiation (03CH05-KS)
EXA Spectrum Analyzer	Keysight	N9010A	MY55150244	10Hz~44GHz, MAX 30dB	Apr. 16, 2019	Feb. 22, 2020	Apr. 15, 2020	Radiation (03CH05-KS)
Loop Antenna	R&S	HFH2-Z2	100321	9kHz~30MHz	Nov. 11, 2018	Feb. 22, 2020	Nov. 10, 2019	Radiation (03CH05-KS)
Bilog Antenna	TeseQ	CBL6111D	49922	30MHz~1GHz	May 30, 2019	Feb. 22, 2020	May 29, 2020	Radiation (03CH05-KS)
Double Ridge Horn Antenna	ETS-Lindgren	3117	75959	1GHz~18GHz	Jan. 26, 2020	Feb. 22, 2020	Jan. 25, 2021	Radiation (03CH05-KS)
SHF-EHF Horn	Com-power	AH-840	101070	18GHz~40GHz	Jan. 08, 2020	Feb. 22, 2020	Jan. 07, 2021	Radiation (03CH05-KS)
Amplifier	SONOMA	310N	187289	9KHz~1GHz	Aug. 06, 2019	Feb. 22, 2020	Aug. 05, 2020	Radiation (03CH05-KS)
Amplifier	MITEQ	TTA1840-35-HG	2014749	18~40GHz	Jan. 14, 2020	Feb. 22, 2020	Jan. 13, 2021	Radiation (03CH05-KS)
high gain Amplifier	MITEQ	AMF-7D-0010 1800-30-10P	2025788	1Ghz~18Ghz	Aug. 17, 2019	Feb. 22, 2020	Aug. 16, 2020	Radiation (03CH05-KS)
Amplifier	Keysight	83017A	MY53270316	500MHz~26.5GHz	Oct. 18, 2019	Feb. 22, 2020	Oct. 17, 2020	Radiation (03CH05-KS)
AC Power Source	Chroma	61601	F104090004	N/A	NCR	Feb. 22, 2020	NCR	Radiation (03CH05-KS)
Turn Table	ChamPro	EM 1000-T	060762-T	0~360 degree	NCR	Feb. 22, 2020	NCR	Radiation (03CH05-KS)
Antenna Mast	ChamPro	EM 1000-A	060762-A	1 m~4 m	NCR	Feb. 22, 2020	NCR	Radiation (03CH05-KS)
EMI Receiver	R&S	ESCI7	100768	9kHz~7GHz;	Apr. 16, 2019	Oct. 31, 2019	Apr. 15, 2020	Conduction (CO01-KS)
AC LISN	MessTec	AN3016	060103	9kHz~30MHz	Oct. 11, 2019	Oct. 31, 2019	Oct. 10, 2020	Conduction (CO01-KS)
AC LISN (for auxiliary equipment)	MessTec	AN3016	060105	9kHz~30MHz	Oct. 28, 2019	Oct. 31, 2019	Oct. 27, 2020	Conduction (CO01-KS)
AC Power Source	Chroma	61602	ABP000000811	AC 0V~300V, 45Hz~1000Hz	Oct. 11, 2019	Oct. 31, 2019	Oct. 10, 2020	Conduction (CO01-KS)

NCR: No Calibration Required.

5 Uncertainty of Evaluation

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI 63.10-2013. All the measurement uncertainty value were shown with a coverage $K=2$ to indicate 95% level of confidence. The measurement data show herein meets or exceeds the CISPR measurement uncertainty values specified in CISPR 16-4-2 and can be compared directly to specified limit to determine compliance.

Uncertainty of Conducted Emission Measurement (150 kHz ~ 30 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	2.9dB
---	-------

Uncertainty of Radiated Emission Measurement (30 MHz ~ 1000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.0dB
---	-------

Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.0dB
---	-------

Uncertainty of Radiated Emission Measurement (18000 MHz ~ 40000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.0dB
---	-------



Appendix A. Conducted Test Results

LORA

Test Engineer:	Asa Cheng	Temperature:	20~26	°C
Test Date:	2020/2/19~2020/2/24	Relative Humidity:	40~45	%

TEST RESULTS DATA
6dB and 99% Occupied Bandwidth

Mod.	NTx	Freq. (MHz)	99% Occupied BW (MHz)	6dB BW (MHz)	6dB BW Limit (MHz)	Pass/Fail
Lora	1	904	0.53	0.63	0.50	Pass
Lora	1	915	0.53	0.63	0.50	Pass
Lora	1	926	0.53	0.63	0.50	Pass

TEST RESULTS DATA
Average Power Table

Mod.	NTx	Freq. (MHz)		Average Conducted Power (dBm)	Limit
Lora	1	904		27.94	< 30dBm
Lora	1	915		27.58	< 30dBm
Lora	1	926		27.10	< 30dBm

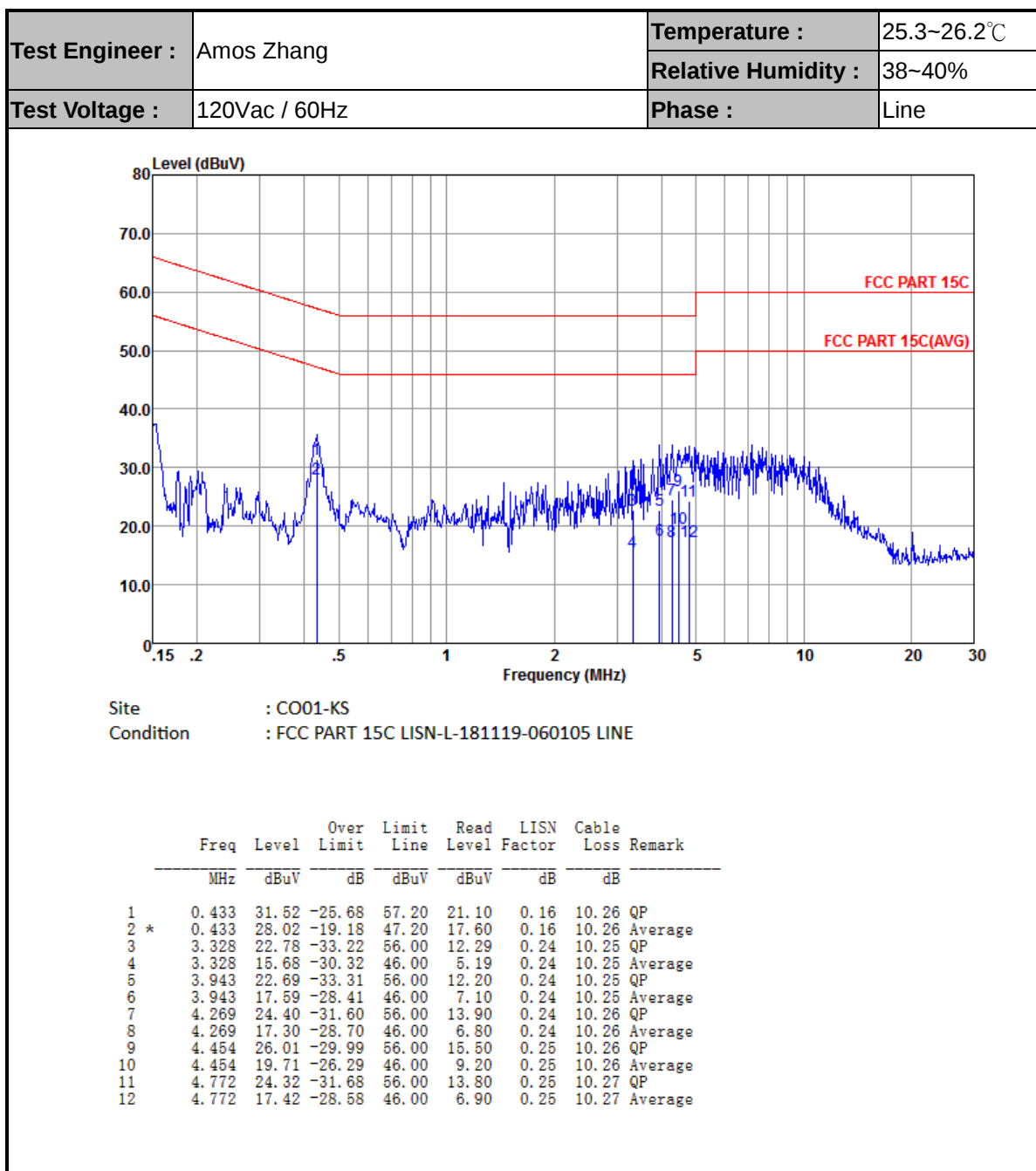
TEST RESULTS DATA
Peak Power Density

Mod.	NTx	Freq. (MHz)	Peak PSD (dBm /100kHz)	Peak PSD (dBm /3kHz)	DG (dBi)	Peak PSD Limit (dBm /3kHz)	Pass/Fail
Lora	1	904	28.38	7.84	-3.78	8.00	Pass
Lora	1	915	27.99	7.59	-3.78	8.00	Pass
Lora	1	926	27.67	7.36	-3.78	8.00	Pass

Note: PSD (dBm/ 100kHz) is a reference level used for Conducted Band Edges and Conducted Spurious Emission 20dBc limit.

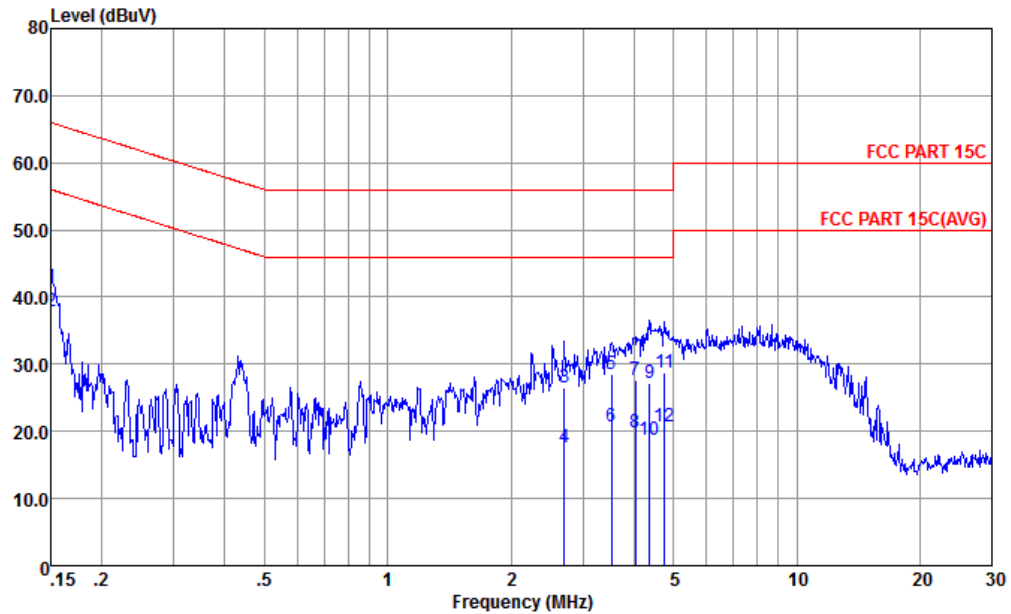


Appendix B. AC Conducted Emission Test Results





Test Engineer :	Amos Zhang	Temperature :	25.3~26.2℃
		Relative Humidity :	38~40%
Test Voltage :	120Vac / 60Hz	Phase :	Neutral



Site : CO01-KS
Condition : FCC PART 15C LISN-N-181119-060105 NEUTRAL

	Freq	Level	Over	Limit	Read	LISN	Cable	Remark
	MHz	dBuV	Limit	Line	Level	Factor	Loss	
			dB	dBuV	dBuV	dB	dB	
1	0.150	41.56	-24.44	66.00	30.90	0.18	10.48	QP
2 *	0.150	37.96	-18.04	56.00	27.30	0.18	10.48	Average
3	2.707	26.50	-29.50	56.00	16.10	0.16	10.24	QP
4	2.707	17.70	-28.30	46.00	7.30	0.16	10.24	Average
5	3.528	28.62	-27.38	56.00	18.20	0.17	10.25	QP
6	3.528	20.62	-25.38	46.00	10.20	0.17	10.25	Average
7	4.027	27.62	-28.38	56.00	17.20	0.17	10.25	QP
8	4.027	19.72	-26.28	46.00	9.30	0.17	10.25	Average
9	4.361	27.23	-28.77	56.00	16.79	0.18	10.26	QP
10	4.361	18.73	-27.27	46.00	8.29	0.18	10.26	Average
11	4.746	28.65	-27.35	56.00	18.20	0.18	10.27	QP
12	4.746	20.75	-25.25	46.00	10.30	0.18	10.27	Average

Note:

- Level(dBμV) = Read Level(dBμV) + LISN Factor(dB) + Cable Loss(dB)
- Over Limit(dB) = Level(dBμV) – Limit Line(dBμV)



Appendix C. Radiated Spurious Emission

Lora (Fundamental frequency @ 3m)

WIFI Ant. 1	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
904MHz	*	903.97	106.84	-	-	107.94	26.54	4.63	32.27	100	0	P	H
	*	903.97	106.05	-	-	107.15	26.54	4.63	32.27	200	360	P	V
915MHz	*	914.64	105.31	-	-	106.15	26.65	4.65	32.14	100	360	P	H
	*	914.64	105	-	-	105.84	26.65	4.65	32.14	200	0	P	V
926MHz	*	926.28	105.91	-	-	106.48	26.76	4.67	32	100	360	P	H
	*	926.28	100.83	-	-	101.4	26.76	4.67	32	200	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												



2.4GHz 2400~2483.5MHz

Lora (Harmonic @ 3m)

WIFI Ant. 1	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
904MHz	#	1808	50.84	-23.16	74	78.24	28.93	6.08	62.41	300	0	P	H
		2712	50.8	-23.2	74	73.68	32.21	7.46	62.55	300	12	P	H
		3616	42.78	-31.22	74	63.41	32.8	8.73	62.16	300	0	P	H
		4520	46.88	-27.12	74	66.35	33.42	9.76	62.65	300	0	P	H
		5424	40.79	-33.21	74	57.61	34.42	10.77	62.01	300	0	P	H
	#	6328	46.1	-27.9	74	63.4	35.12	11.44	63.86	300	0	P	H
	#	7232	56.15	-17.85	74	70.83	35.73	12.44	62.85	100	44	P	H
	#	1808	56.05	-17.95	74	83.45	28.93	6.08	62.41	119	204	P	V
		2712	45.79	-28.21	74	68.67	32.21	7.46	62.55	300	338	P	V
		3616	46.31	-27.69	74	66.94	32.8	8.73	62.16	300	338	P	V
		4520	44.52	-29.48	74	63.99	33.42	9.76	62.65	300	338	P	V
		5424	41.14	-32.86	74	57.96	34.42	10.77	62.01	300	338	P	V
	#	6328	41.79	-32.21	74	59.09	35.12	11.44	63.86	300	338	P	V
	#	7232	48.59	-25.41	74	63.27	35.73	12.44	62.85	300	338	P	V
915MHz	#	1832	48.64	-25.36	74	75.9	29.02	6.11	62.39	300	0	P	H
		2744	52.3	-21.7	74	75.12	32.25	7.49	62.56	100	251	P	H
		2744	51.26	-2.74	54	74.08	32.25	7.49	62.56	100	251	A	H
		3660	43.97	-30.03	74	64.3	33	8.78	62.11	300	0	P	H
		4576	44.77	-29.23	74	64.14	33.47	9.79	62.63	300	0	P	H
	#	5490	41.13	-32.87	74	57.78	34.51	10.77	61.93	300	0	P	H
	#	6405	44.54	-29.46	74	62.01	35.16	11.4	64.03	300	0	P	H
		7320	54.62	-19.38	74	69.74	35.89	12.64	63.65	106	65	P	H
		7320	51	-3.00	54	66.12	35.89	12.64	63.65	106	65	A	H
	#	1832	50.4	-23.6	74	77.66	29.02	6.11	62.39	100	0	P	V
		2744	50.61	-23.39	74	73.43	32.25	7.49	62.56	100	0	P	V
		3656	44.08	-29.92	74	64.41	33	8.78	62.11	100	0	P	V
		4576	42.19	-31.81	74	61.56	33.47	9.79	62.63	100	0	P	V
	#	5490	40.38	-33.62	74	57.03	34.51	10.77	61.93	100	0	P	V
	#	6405	40.89	-33.11	74	58.36	35.16	11.4	64.03	100	0	P	V



		7320	48.6	-25.4	74	63.72	35.89	12.64	63.65	100	0	P	V
926MHz	#	1856	45.11	-28.89	74	72.23	29.12	6.13	62.37	300	0	P	H
		2776	47.71	-26.29	74	70.51	32.26	7.51	62.57	300	0	P	H
		3704	44.69	-29.31	74	64.59	33.3	8.85	62.05	300	0	P	H
		4632	42.47	-31.53	74	61.74	33.53	9.81	62.61	300	0	P	H
	#	5556	42.39	-31.61	74	58.88	34.59	10.77	61.85	300	0	P	H
	#	6480	47.04	-26.96	74	64.48	35.19	11.53	64.16	300	0	P	H
		7408	48.66	-25.34	74	64.26	36.04	12.81	64.45	100	95	P	H
	#	1856	47.04	-26.96	74	74.16	29.12	6.13	62.37	100	0	P	V
		2776	49.35	-24.65	74	72.15	32.26	7.51	62.57	300	282	P	V
		3704	42.36	-31.64	74	62.26	33.3	8.85	62.05	100	0	P	V
		4630	43.1	-30.9	74	62.37	33.53	9.81	62.61	100	0	P	V
	#	5556	41.68	-32.32	74	58.17	34.59	10.77	61.85	100	0	P	V
	#	6482	41.97	-32.03	74	59.41	35.19	11.53	64.16	100	0	P	V
		7408	44.26	-29.74	74	59.86	36.04	12.81	64.45	100	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												



Emission below 1GHz

2.4GHz WIFI 802. Lora (LF)

WIFI	Note	Frequency	Level	Over	Limit	Read	Antenna	Cable	Preamp	Ant	Table	Peak	Pol.
Ant.				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
1		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
915MHz		58.13	33.34	-6.66	40	51.82	12.78	1.69	32.95			P	H
		137.67	35.98	-7.52	43.5	49.66	17.39	1.88	32.95			P	H
		246.31	41.14	-4.86	46	53.45	18.2	2.47	32.98	100	360	P	H
		344.28	37.86	-8.14	46	47.74	20.32	2.88	33.08			P	H
		466.5	36.38	-9.62	46	43.38	22.89	3.34	33.23			P	H
		696.39	36.06	-9.94	46	40.39	24.89	4.06	33.28			P	H
		57.16	34.29	-5.71	40	52.77	12.92	1.55	32.95	200	0	P	V
		120.21	29.59	-13.91	43.5	42.56	18.2	1.77	32.94			P	V
		247.28	37.1	-8.9	46	49.31	18.31	2.47	32.99			P	V
		408.3	33.45	-12.55	46	41.58	21.86	3.15	33.14			P	V
		532.46	34.16	-11.84	46	40.41	23.85	3.19	33.29			P	V
		760.41	34.59	-11.41	46	37.83	25.62	4.23	33.09			P	V
Remark	1. No other spurious found. 2. All results are PASS against limit line.												

**Note symbol**

*	Fundamental Frequency which can be ignored. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
!	Test result is over limit line.
#	The radiated frequency is out of the restricted band
P/A	P eak or A verage
H/V	H orizontal or V ertical



A calculation example for radiated spurious emission is shown as below:

WIFI	Note	Frequency	Level	Over	Limit	Read	Antenna	Cable	Preamp	Ant	Table	Peak	Pol.
Ant.				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
2		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
802.11b		2390	55.45	-18.55	74	54.51	32.22	4.58	35.86	103	308	P	H
CH 01													
2412MHz		2390	43.54	-10.46	54	42.6	32.22	4.58	35.86	103	308	A	H

1. Level(dBμV/m) =

Antenna Factor(dB/m) + Cable Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

2. Over Limit(dB) = Level(dBμV/m) – Limit Line(dBμV/m)

For Peak Limit @ 2390MHz:

1. Level(dBμV/m)

= Antenna Factor(dB/m) + Cable Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 54.51(dBμV) – 35.86 (dB)

= 55.45 (dBμV/m)

2. Over Limit(dB)

= Level(dBμV/m) – Limit Line(dBμV/m)

= 55.45(dBμV/m) – 74(dBμV/m)

= -18.55(dB)

For Average Limit @ 2390MHz:

1. Level(dBμV/m)

= Antenna Factor(dB/m) + Cable Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 42.6(dBμV) – 35.86 (dB)

= 43.54 (dBμV/m)

2. Over Limit(dB)

= Level(dBμV/m) – Limit Line(dBμV/m)

= 43.54(dBμV/m) – 54(dBμV/m)

= -10.46(dB)

Both peak and average measured complies with the limit line, so test result is “PASS”.

Appendix D. Duty Cycle Plots

Band	Duty Cycle(%)	T(ms)	1/T(KHz)	VBW Setting
LoRa	13.41	7.9710	0.1255	0.13kHz

