FCC TEST REPORT

For

Ring LLC

Motion Sensor

Test Model: 5SM1S8

Additional Model No.:N/A

Prepared for	:	Ring LLC
Address	:	1523 26th Street, Santa Monica, California 90404, United States
Prepared by	:	Shenzhen LCS Compliance Testing Laboratory Ltd.
Address	:	1/F., Xingyuan Industrial Park, Tongda Road, Bao'an Avenue, Bao'an District, Shenzhen, Guangdong, China
Tel	:	(+86)755-82591330
Fax	:	(+86)755-82591332
Web	:	www.LCS-cert.com
Mail	:	webmaster@LCS-cert.com
Date of receipt of test sample	:	November 14, 2018
Number of tested samples	:	1
Serial number	:	Prototype
Date of Test	:	November 17, 2018~ December 28, 2018
Date of Report	:	December 28, 2018

FCC TEST REPORT
FCC CFR 47 PART 15 C(15.247)

Report Reference No.	**:**	**LCS181114045AEB**
Date of Issue	:	December 28, 2018
Testing Laboratory Name..... :		**Shenzhen LCS Compliance Testing Laboratory Ltd.**
Address	:	1/F., Xingyuan Industrial Park, Tongda Road, Bao'an Avenue, Bao'an District, Shenzhen, Guangdong, China
Testing Location/ Procedure	:	Full application of Harmonised standards ■ Partial application of Harmonised standards □ Other standard testing method □
Applicant's Name ..... :		**Ring LLC**
Address	:	1523 26th Street, Santa Monica, California 90404 United States
Test Specification		
Standard	:	FCC CFR 47 PART 15 C(15.247)
Test Report Form No. ..... :		LCSEMC-1.0
TRF Originator	:	Shenzhen LCS Compliance Testing Laboratory Ltd.
Master TRF	:	Dated 2011-03

EUT Description. ..... :		Motion Sensor
Trade Mark	:	RING
Model/ Type reference	:	5SM1S8
Ratings	:	DC 4.5 by Battery(3*AAA)
Result	:	**Positive**

Compiled by:	**Supervised by:**	**Approved by:**
Peter Xiao	Calvin Weng	Gavin Liang
Peter Xiao/Administrators	Calvin Weng/Technique principal	Gavin Liang/ Manager

FCC -- TEST REPORT

Test Report No. : **LCS181114045AEB**	December 28, 2018 Date of issue

Type / Model.....	: 5SM1S8
EUT.....	: Motion Sensor
Applicant.....	**: Ring LLC**
Address.....	: 1523 26th Street, Santa Monica, California 90404 United States
Telephone.....	: /
Fax.....	: /
Manufacturer.....	**: Ring LLC**
Address.....	: 1523 26th Street, Santa Monica, California 90404 United States
Telephone.....	: /
Fax.....	: /
Factory.....	**: Ningbo Kliv Electronic Co.,Ltd**
Address.....	: No.448 LongFeiRoad,YunlongTown,YinZhou District,Ningbo, China
Telephone.....	: /
Fax.....	: /

Test Result	**Positive**

The test report merely corresponds to the test sample.

It is not permitted to copy extracts of these test result without the written permission of the test laboratory.

Revision History

Revision	Issue Date	Revisions	Revised By
000	December 28, 2018	Initial Issue	Gavin Liang

TABLE OF CONTENTS

1. GENERAL INFORMATION

1.1. Description of Device (EUT)

EUT	:	Motion Sensor
Test Model	:	5SM1S8
Additional Model No.	:	N/A
Model Declaration	:	N/A
Hardware Version	:	C20 V2.2 20181011
Software Version	:	0.7.5
Bluetooth	:	
Operation frequency		2402 – 2480 MHz
Bluetooth Version	:	V5.0
Bluetooth Channel Number	:	40 channels for Bluetooth V5.0
Bluetooth Channel Spacing	:	2MHz for Bluetooth V5.0
Bluetooth Modulation Type	:	GFSK for Bluetooth V5.0
Antenna Description	:	PCB Antenna, 1.1dBi (Max.)
LoRa		
Frequency Range	:	903-927.5 MHz
Modulation Type	:	CSS
Channel Number	:	26
Antenna Description	:	Internal Antenna, 1.1dBi (Max.)

1.2. Host System Configuration List and Details

Manufacturer	Description	Model	Serial Number	Certificate
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1.3. External I/O Cable

I/O Port Description	Quantity	Cable
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1.4. Description of Test Facility

FCC Registration Number. is 254912.
Industry Canada Registration Number. is 9642A-1.
ESMD Registration Number. is ARCB0108.
UL Registration Number. is 100571-492.
TUV SUD Registration Number. is SCN1081.
TUV RH Registration Number. is UA 50296516-001
NVLAP Registration Code is 600167-0

The 3m-Semi anechoic test site fulfils CISPR 16-1-4 according to ANSI C63.4:2014 and CISPR 16-1-4:2010 SVSWR requirement for radiated emission above 1GHz.

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 LCS 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	±3.10dB	(1)
		30MHz~200MHz	±2.96dB	(1)
		200MHz~1000MHz	±3.10dB	(1)
		1GHz~26.5GHz	±3.80dB	(1)
		26.5GHz~40GHz	±3.90dB	(1)
Conduction Uncertainty	:	150kHz~30MHz	±1.63dB	(1)
Power disturbance	:	30MHz~300MHz	±1.60dB	(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

The EUT has been tested under operating condition.

This test was performed with EUT in X, Y, Z position and the worst case was found when EUT in X position.

Worst-case mode and channel used for 9 KHz-1000 MHz radiated emissions was the mode and channel with the highest output power, that was determined to be Low Channel.

Worst-Case data rates were utilized from preliminary testing of the Chipset, worst-case data rates used during the testing are as follows:

1.8. Frequency of Channels

Modulation Technology	Operating Channel Bandwidth	Channel No.	Frequency	Channel No.	Frequency
	kHz		(MHz)		(MHz)
LoRa	500	1	903.0	14	916.0
	500	2	904.0	15	917.0
	500	3	905.0	16	918.0
	500	4	906.0	17	919.0
	500	5	907.0	18	920.0
	500	6	908.0	19	921.0
	500	7	909.0	20	922.5
	500	8	910.0	21	923.3
	500	9	911.0	22	924.1
	500	10	912.0	23	924.9
	500	11	913.0	24	925.7
	500	12	914.0	25	926.5
	500	13	915.0	26	927.5

2. TEST METHODOLOGY

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

The radiated testing was performed at an antenna-to-EUT distance of 3 meters. All radiated and conducted emissions measurement was performed at Shenzhen LCS Compliance Testing Laboratory Ltd.

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 engineering mode to fix the TX frequency that was for the purpose of the measurements.

According to FCC's request, Test Procedure KDB558074 D01 DTS Meas. Guidance are required to be used for this kind of FCC 15.247 digital modulation device.

According to its specifications, the EUT must comply with the requirements of the Section 15.203, 15.205, 15.207, 15.209 and 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 a turn table, 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.

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-64bit-0.70-installer_v1.0) provided by application.

3.3. Special Accessories

Manufacturer	Description	Model	Serial Number	Certificate
Lenovo	PC	Ideapad	--	DOC
Lenovo	Power adapter	CPA-A090	--	DOC

3.4. Block Diagram/Schematics

Please refer to the related document

3.5. Equipment Modifications

Shenzhen LCS Compliance Testing Laboratory 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	Result	Remark
/	On Time and Duty Cycle	/	Note 1
§15.247(b)	Maximum Conducted Output Power	Compliant	Note 1
§15.247(e)	Power Spectral Density	Compliant	Note 1
§15.247(a)(2)	6dB Bandwidth	Compliant	Note 1
§2.1049	99% Occupied Bandwidth	Compliant	Note 1
§15.209, §15.247(d)	Conducted Spurious Emissions	Compliant	Note 1
§15.209, §15.247(d)	Radiated Spurious Emissions	Compliant	Note 1
§15.205	Emissions at Restricted Band	Compliant	Note 1
§15.207(a)	AC Conducted Emissions	N/A*	Note 3
§15.203	Antenna Requirements	Compliant	Note 1
§15.247(i)§2.1091	RF Exposure	Compliant	Note 2

Remark:
1. Note 1 – Test results inside test report;
2. Note 2 – Test results in other test report (RF Exposure Evaluation);
3. Note 3 – Not Applicable!!!

5. TEST RESULT

5.1. On Time and Duty Cycle

5.1.1. Standard Applicable

None; for reporting purpose only.

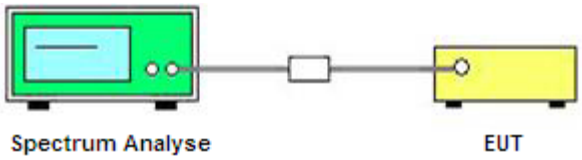
5.1.2. Measuring Instruments and Setting

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

5.1.3. Test Procedures

1. Set the center frequency of the spectrum analyzer to the transmitting frequency;
2. Set the span=0MHz, RBW=8MHz, VBW=50MHz, Sweep time=5ms;
3. Detector = peak;
4. Trace mode = Single hold.

5.1.4. Test Setup Layout

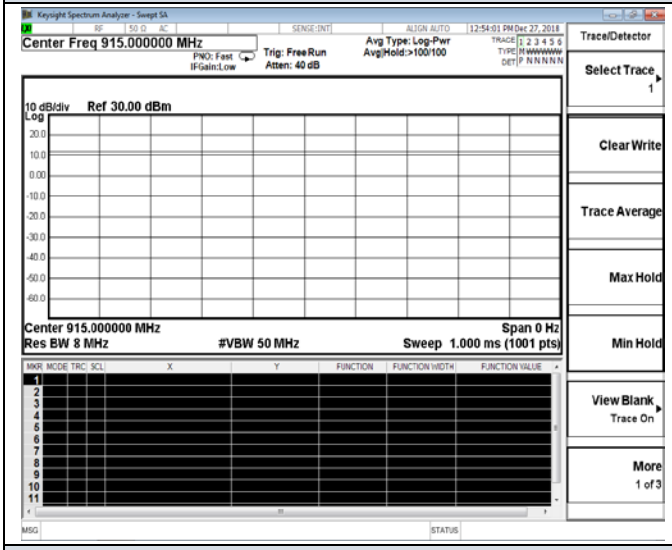


5.1.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

5.1.6. Test result

Mode	On Time B (ms)	Period (ms)	Duty Cycle x (Linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (KHz)
LORA 500KHz	5.0	5.0	1	100	0	0.01

On Time and Duty Cycle	
	
Channel 13 / 915 MHz	

5.2. Maximum Conducted Output Power Measurement

5.2.1. Standard Applicable

For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

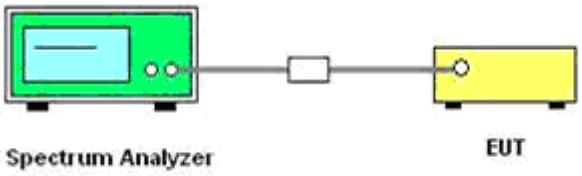
5.2.2. Measuring Instruments and Setting

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

5.2.3. Test Procedures

The transmitter output (antenna port) was connected to the spectrum analyzer.
According to KDB558074 D01 DTS Measurement Guidance Section 9.1 Maximum peak conducted output power 9.1.1.
This procedure shall be used when the measurement instrument has available a resolution bandwidth that is greater than the DTS bandwidth.
a) Set the RBW ≥ DTS bandwidth.
b) Set VBW ≥ 3 × RBW.
c) Set span ≥ 3 x RBW
d) Sweep time = auto couple.
e) Detector = peak.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use peak marker function to determine the peak amplitude level.

5.2.4. Test Setup Layout



5.2.5. EUT Operation during Test

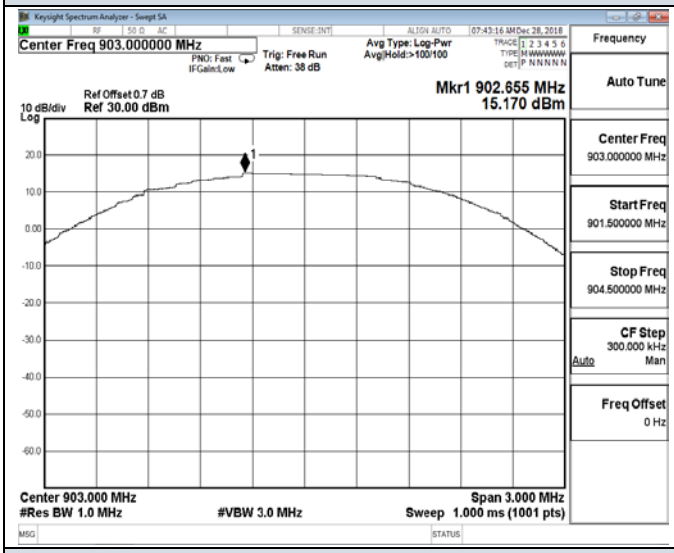
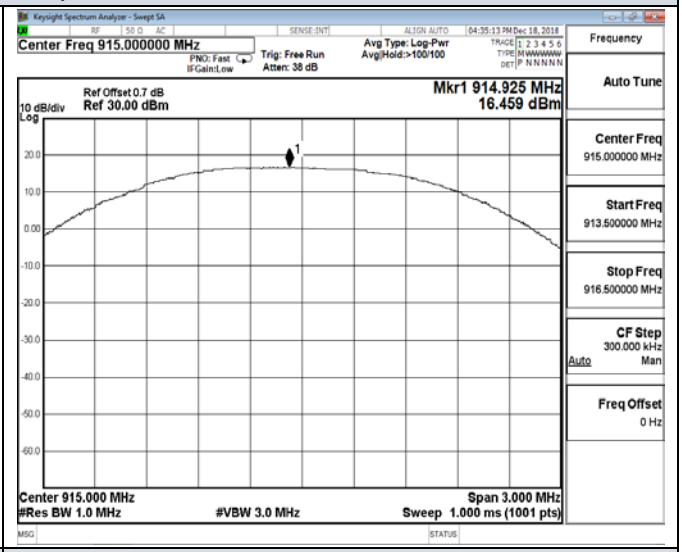
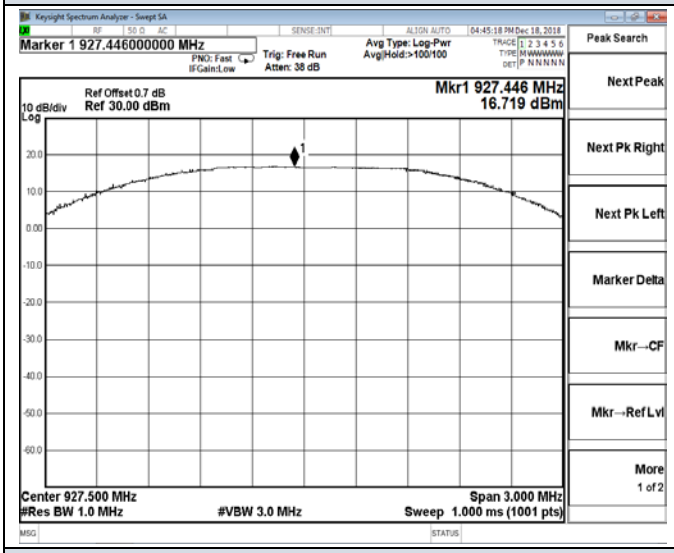
The EUT was programmed to be in continuously transmitting mode.

5.2.6. Test Result of Maximum Conducted Output Power

Channel	Frequency (MHz)	Measured Maximum Peak Power (dBm)	Limits (dBm)	Verdict
1	903.0	15.170	30	PASS
13	915.0	16.459		
26	927.5	16.719		

Remark:

1. *Test results including cable loss;*
2. *Please refer to following plots;*

Maximum Peak Output Power	
	
Channel 1 / 903.0 MHz	Channel 13 / 915 MHz
	
Channel 26 / 927.5 MHz	

5.3. Power Spectral Density Measurement

5.3.1. 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.

5.3.2. Measuring Instruments and Setting

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

5.3.3. 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 = 3 kHz.

4. Set the VBW ≥ 3*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.

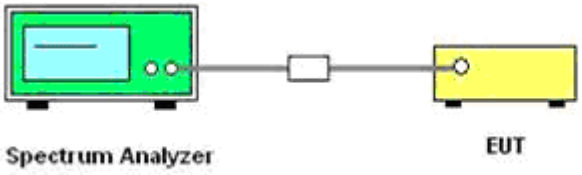
9. Allow trace to fully stabilize.

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 8 dBm.

5.3.4. Test Setup Layout



5.3.5. EUT Operation during Test

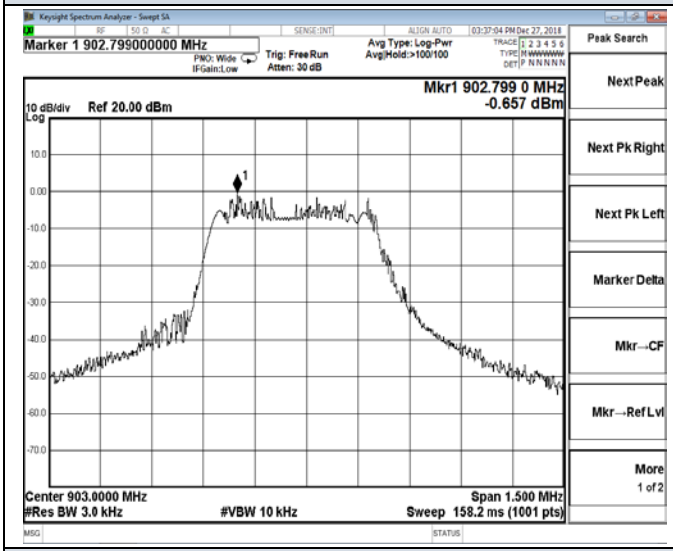
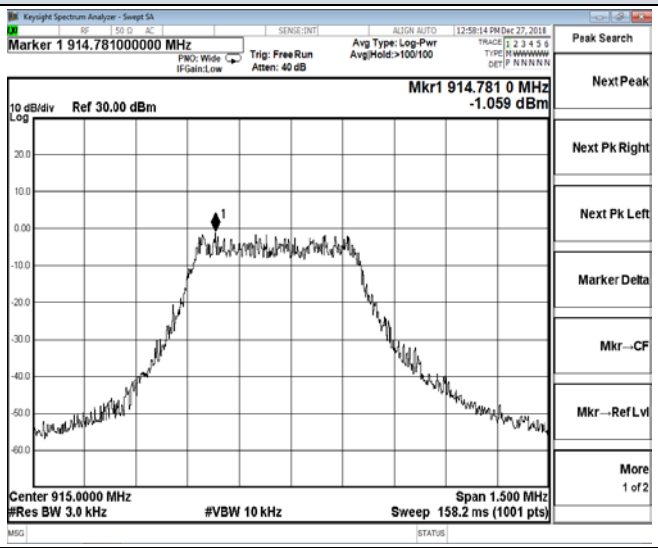
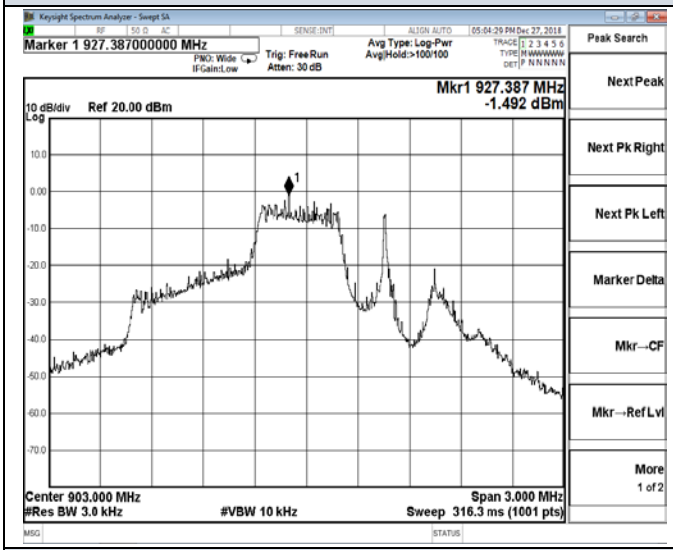
The EUT was programmed to be in continuously transmitting mode.

5.3.6. Test Result of Power Spectral Density

Channel	Frequency (MHz)	Measured Peak Power Spectral Density (dBm/3KHz)	Limits (dBm/3KHz)	Verdict
1	903.0	-0.657	8	PASS
13	915.0	-1.059		
26	927.5	-1.492		

Remark:

1. *Test results including cable loss;*
2. *Please refer to following plots;*

Peak Power Spectral Density	
	
Channel 1 / 903.0 MHz	*Channel 13 / 915 MHz*
	
Channel 26/ 927.5 MHz	

5.4. 6 dB and 99% Spectrum Bandwidth Measurement

5.4.1. Standard Applicable

According to §15.247(a) (2): For digital modulation systems, the minimum 6 dB bandwidth shall be at least 500 kHz.

5.4.2. Measuring Instruments and Setting

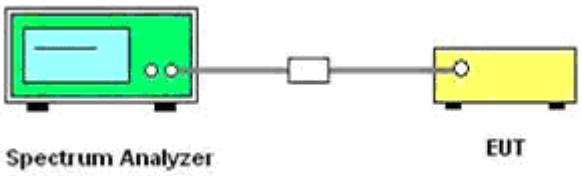
Please refer to equipment list in this report. The following table is the setting of the Spectrum Analyzer.

Spectrum Parameter	Setting
Attenuation	Auto
Span Frequency	> RBW
Detector	Peak
Trace	Max Hold
Sweep Time	100ms

5.4.3. Test Procedures

1. The transmitter output (antenna port) was connected to the spectrum analyzer in peak hold mode.
2. The resolution bandwidth and the video bandwidth were set according to KDB558074.
3. Measured the spectrum width with power higher than 6dB below carrier.

5.4.4. Test Setup Layout



5.4.5. EUT Operation during Test

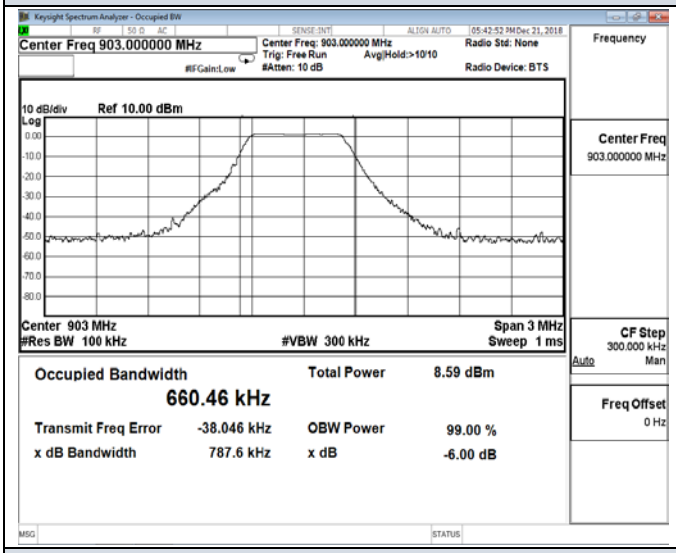
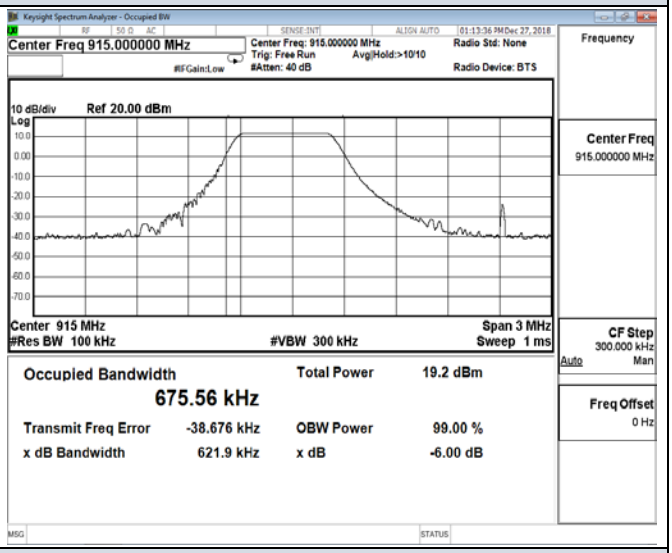
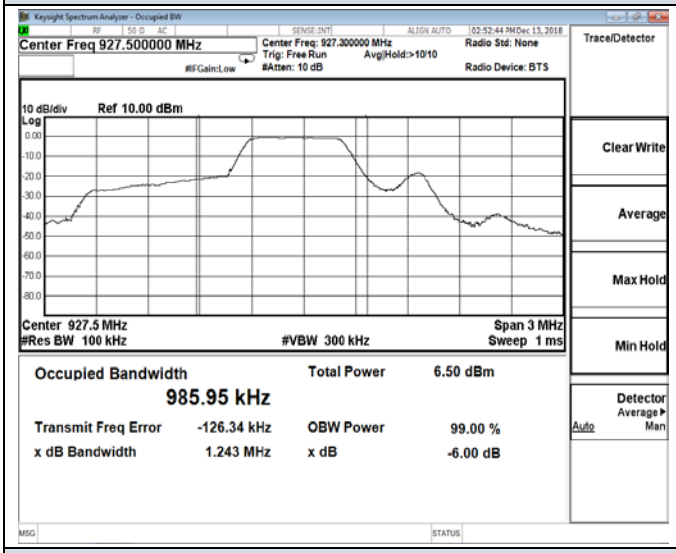
The EUT was programmed to be in continuously transmitting mode.

5.4.6. Test Result of 6dB and 99% Spectrum Bandwidth

Channel	Frequency (MHz)	6dB Bandwidth (KHz)	99% Bandwidth (KHz)	Limits (KHz)	Verdict
1	903.0	787.60	660.46	≥500	PASS
13	915.0	621.90	675.56		
26	927.5	1243.00	985.95		

Remark:

1. *Test results including cable loss;*
2. *Please refer to following plots;*

6dB and 99% Bandwidth	
	
Channel 1 / 903.0 MHz	Channel 13 / 915 MHz
	
Channel 26 / 927.5 MHz	

5.5. Radiated Emissions Measurement

5.5.1. 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 0.490-0.510MHz.

\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

5.5.2. Measuring Instruments and Setting

Please refer to 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	10th 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

5.5.3. 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 0.8 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 (± 45°) 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 18 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 (± 45°) 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.

4) Sequence of testing above 18 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 1 meter.

--- The EUT was set into operation.

Premeasurement:

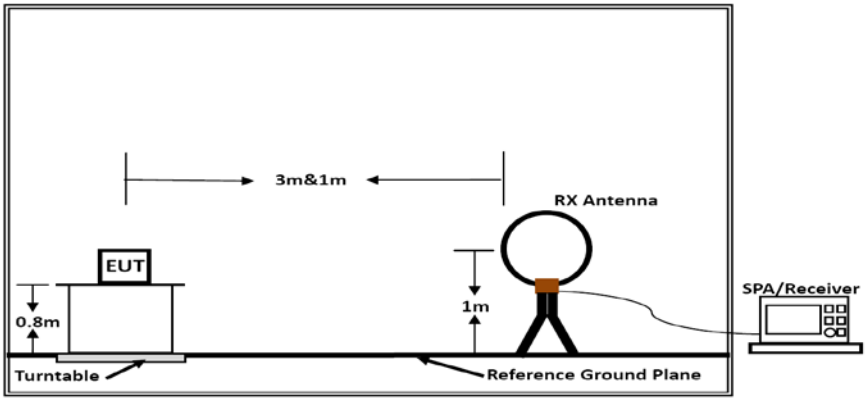
--- The antenna is moved spherical over the EUT in different polarizations of the antenna.

Final measurement:

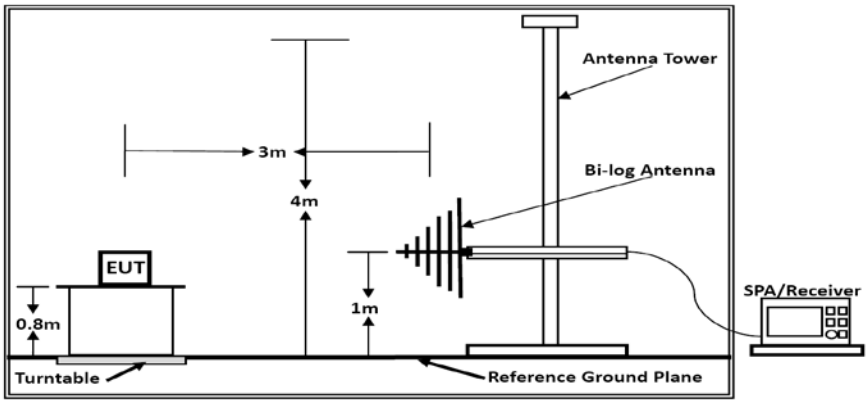
--- The final measurement will be performed at the position and antenna orientation for all detected emissions that were found during the premeasurements with Peak and Average detector.

--- The final levels, frequency, measuring time, bandwidth, 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.

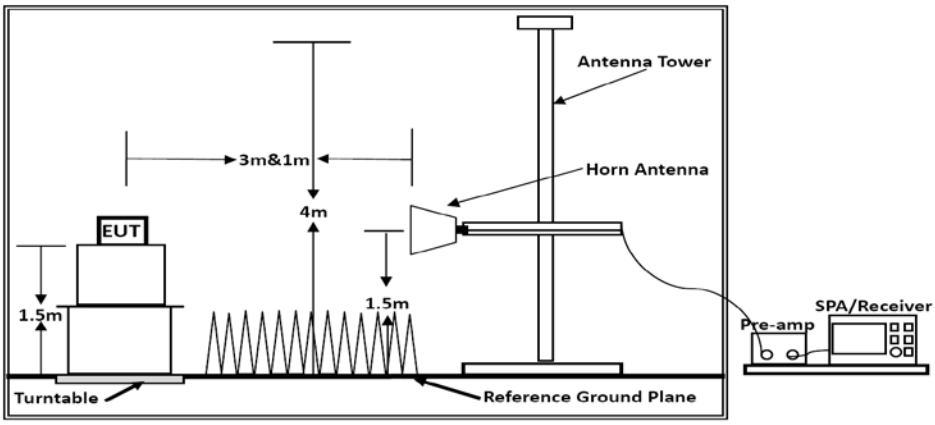
5.5.4. Test Setup Layout



Below 30MHz



Below 1GHz



Above 1GHz

Above 18 GHz shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade form 3m to 1m.

Distance extrapolation factor = 20 log (specific distanc [3m] / test distance [1m]) (dB);
Limit line = specific limits (dBuV) + distance extrapolation factor [6 dB].

5.5.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

5.5.6. Results of Radiated Emissions (9 KHz~30MHz)

Temperature	23.5℃	Humidity	52.6%
Test Engineer	Diamond Lu	Configurations	LORA 500KHz

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

Note:

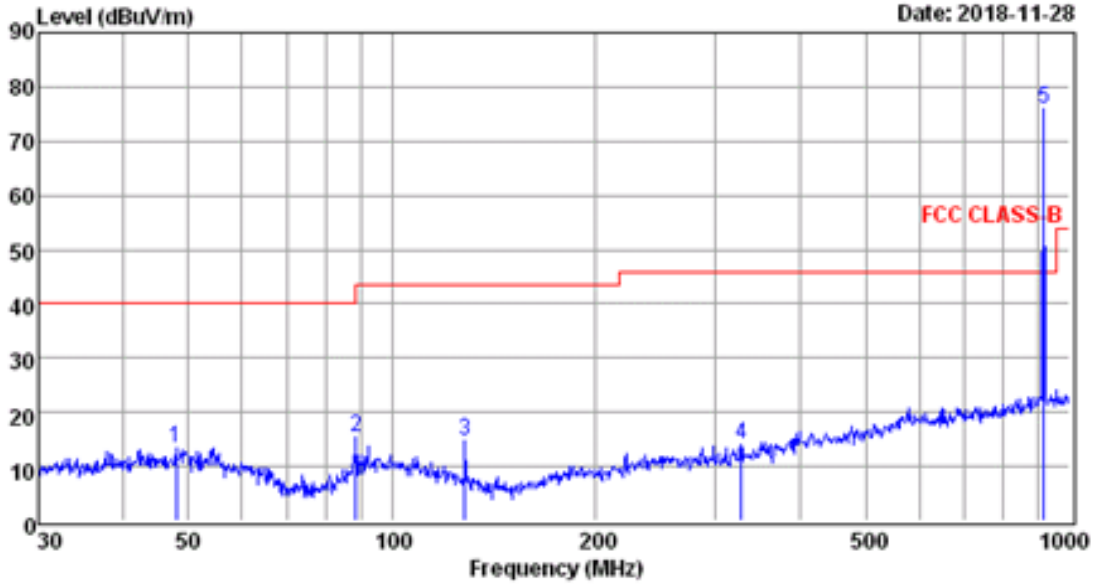
The amplitude of spurious emissions which are attenuated by more than 20 dB below the permissible value has no need to be reported.

Distance extrapolation factor = 40 log (specific distance / test distance) (dB);
Limit line = specific limits (dBuV) + distance extrapolation factor.

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

Temperature	23.5℃	Humidity	52.6%
Test Engineer	Diamond Lu	Configurations	LORA 500KHz

Vertical

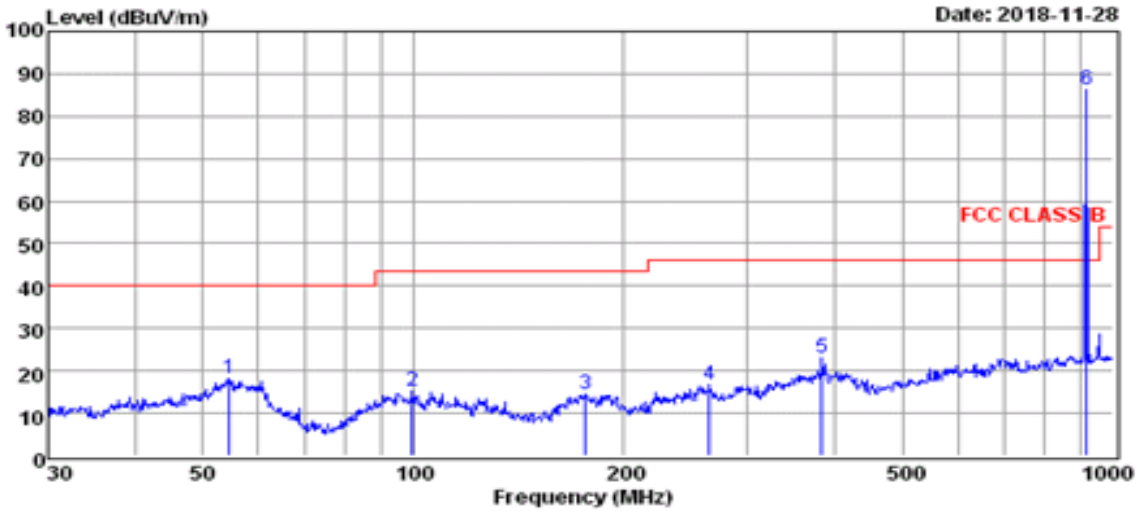


pol: VERTICAL

	Freq	Reading	CabLos	Antfac	Measured	Limit	Over	Remark
	MHz	dBuV	dB	dB/m	dBuV/m	dBuV/m	dB	
1	47.99	-0.23	0.35	13.37	13.49	40.00	-26.51	QP
2	88.34	3.35	0.68	11.37	15.40	43.50	-28.10	QP
3	128.11	4.85	0.67	9.22	14.74	43.50	-28.76	QP
4	327.89	-0.58	1.04	13.64	14.10	46.00	-31.90	QP
5	916.07	52.88	2.04	21.19	76.11	46.00	30.11	Peak

Note: 1. All readings are Quasi-peak values.
2. Measured= Reading + Antenna Factor + Cable Loss
3. The emission that are 20db below the official limit are not reported

Horizontal



pol: HORIZONTAL

	Freq	Reading	CabLos	Antfac	Measured	Limit	Over	Remark
	MHz	dBuV	dB	dB/m	dBuV/m	dBuV/m	dB	
1	54.45	4.73	0.46	13.05	18.24	40.00	-21.76	QP
2	99.53	1.39	0.61	13.13	15.13	43.50	-28.37	QP
3	176.27	4.46	0.73	9.42	14.61	43.50	-28.89	QP
4	264.75	3.42	1.03	12.20	16.65	46.00	-29.35	QP
5	383.93	7.32	1.13	14.68	23.13	46.00	-22.87	QP
6	916.07	63.19	2.04	21.19	86.42	46.00	40.42	Peak

Note: 1. All readings are Quasi-peak values.
2. Measured= Reading + Antenna Factor + Cable Loss
3. The emission that are 20db below the official limit are not reported

Note:

1). Pre-scan all modes and recorded the worst case results in this report.

2). Emission level (dBuV/m) = 20 log Emission level (uV/m).

3). Corrected Reading: Antenna Factor + Cable Loss + Read Level = Level.

5.5.8. Results for Radiated Emissions (Above 1GHz)

Channel 1 / 903.0 MHz

Freq. MHz	Reading dBuv	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuv/m	Limit dBuv/m	Margin dB	Remark	Pol.
1806.0	48.27	33.06	35.04	3.94	50.23	74.00	-23.77	Peak	Horizontal
1806.0	32.91	33.06	35.04	3.94	34.87	54.00	-19.13	Average	Horizontal
2709.0	48.02	33.06	35.04	3.94	49.98	74.00	-24.02	Peak	Horizontal
2709.0	34.79	33.06	35.04	3.94	36.75	54.00	-17.25	Average	Horizontal
1806.0	48.10	33.06	35.04	3.94	50.06	74.00	-23.94	Peak	Vertical
1806.0	32.84	33.06	35.04	3.94	34.80	54.00	-19.20	Average	Vertical
2709.0	49.34	33.06	35.04	3.94	51.30	74.00	-22.70	Peak	Vertical
2709.0	33.05	33.06	35.04	3.94	35.01	54.00	-18.99	Average	Vertical

Channel 13 / 915 MHz

Freq. MHz	Reading dBuv	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuv/m	Limit dBuv/m	Margin dB	Remark	Pol.
1830.0	48.55	33.16	35.15	3.96	50.52	74.00	-23.48	Peak	Horizontal
1830.0	33.85	33.16	35.15	3.96	35.82	54.00	-18.18	Average	Horizontal
2745.0	49.79	33.16	35.15	3.96	51.76	74.00	-22.24	Peak	Horizontal
2745.0	34.54	33.16	35.15	3.96	36.51	54.00	-17.49	Average	Horizontal
1830.0	47.18	33.16	35.15	3.96	49.15	74.00	-24.85	Peak	Vertical
1830.0	32.79	33.16	35.15	3.96	34.76	54.00	-19.24	Average	Vertical
2745.0	50.19	33.16	35.15	3.96	52.16	74.00	-21.84	Peak	Vertical
2745.0	34.18	33.16	35.15	3.96	36.15	54.00	-17.85	Average	Vertical

Channel 26/ 927.5 MHz

Freq. MHz	Reading dBuv	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuv/m	Limit dBuv/m	Margin dB	Remark	Pol.
1855.0	48.09	33.26	35.14	3.98	50.19	74.00	-23.81	Peak	Horizontal
1855.0	33.96	33.26	35.14	3.98	36.06	54.00	-17.94	Average	Horizontal
2782.0	50.38	33.26	35.14	3.98	52.48	74.00	-21.52	Peak	Horizontal
2782.0	35.66	33.26	35.14	3.98	37.76	54.00	-16.24	Average	Horizontal
1855.0	49.08	33.26	35.14	3.98	51.18	74.00	-22.82	Peak	Vertical
1855.0	33.70	33.26	35.14	3.98	35.80	54.00	-18.20	Average	Vertical
2782.0	50.21	33.26	35.14	3.98	52.31	74.00	-21.69	Peak	Vertical
2782.0	35.68	33.26	35.14	3.98	37.78	54.00	-16.22	Average	Vertical

Notes:

1). Measuring frequencies from 9 KHz~10th harmonic or 26.5GHz (which is less), No emission found between lowest internal used/generated frequency to 30MHz.
2). Radiated emissions measured in frequency range from 9 KHz~10th harmonic or 26.5GHz (which is less) were made with an instrument using Peak detector mode.
3). Data of measurement within this frequency range shown " --- " in the table above means the reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.
4). Measured radiated emission used 900-930 MHz band filter in order to avoid spectrum overload.

5.6. Conducted Spurious Emissions and Band Edges Test

5.6.1. Standard Applicable

According to §15.247 (d): 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. 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)).

5.6.2. Measuring Instruments and Setting

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

Spectrum Parameter	Setting
Detector	Peak
Attenuation	Auto
RB / VB (Emission in restricted band)	100KHz/300KHz
RB / VB (Emission in non-restricted band)	100KHz/300KHz

5.6.3. Test Procedures

The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz

The spectrum from 9 KHz to 10 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

5.6.4. Test Setup Layout

This test setup layout is the same as that shown in section 5.4.4.

5.6.5. EUT Operation during Test

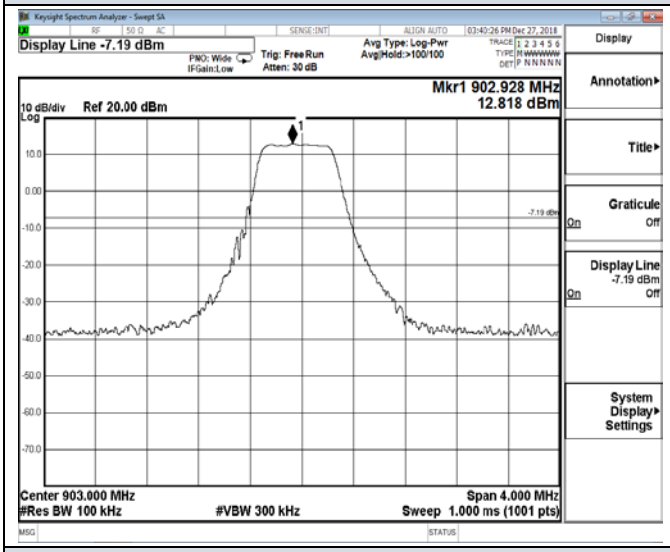
The EUT was programmed to be in continuously transmitting mode.

5.6.6. Test Results of Conducted Spurious Emissions

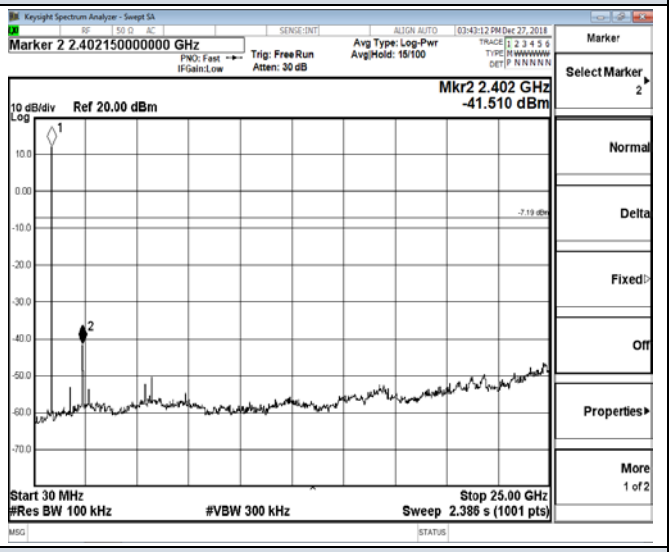
Temperature	23.5℃	Humidity	52.6%
Test Engineer	Diamond Lu	Configurations	LORA 500KHz

RF Conducted Spurious Emissions

Channel 1 / 903.0 MHz

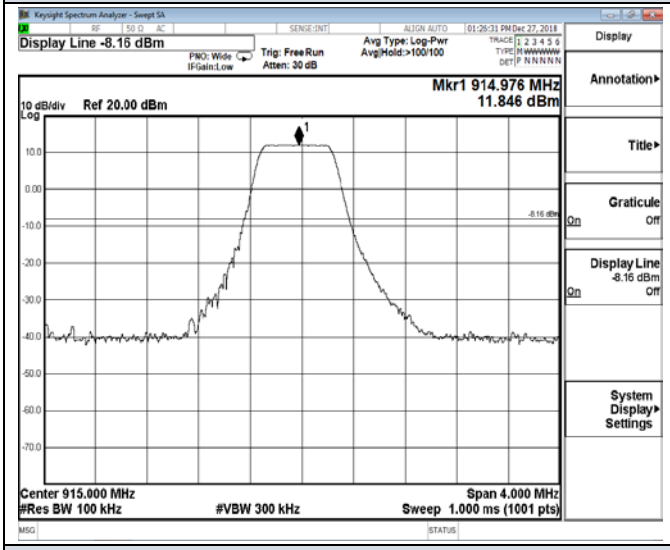


901 MHz – 905 MHz

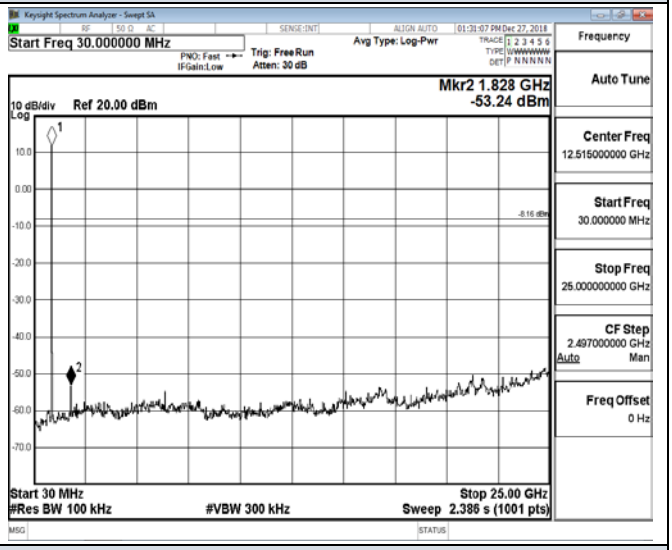


30 MHz – 25 GHz

Channel 13 / 915 MHz

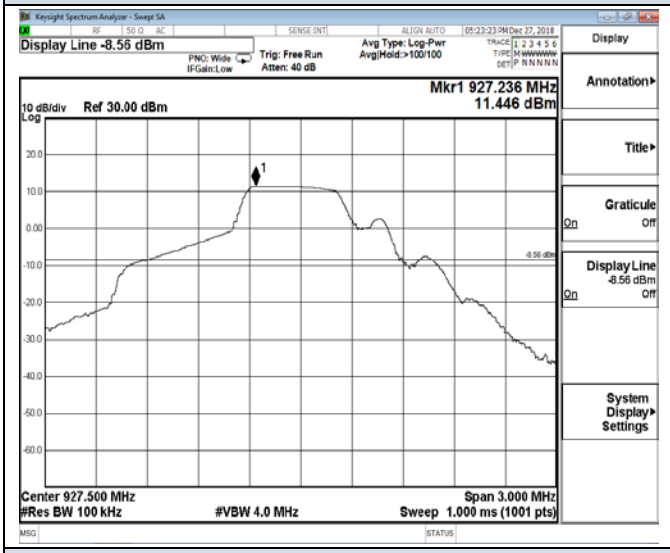


913 MHz – 917 MHz

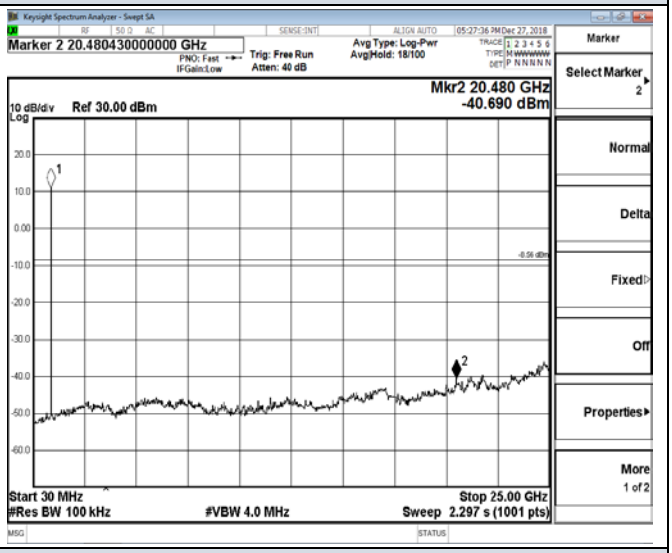


30 MHz – 25 GHz

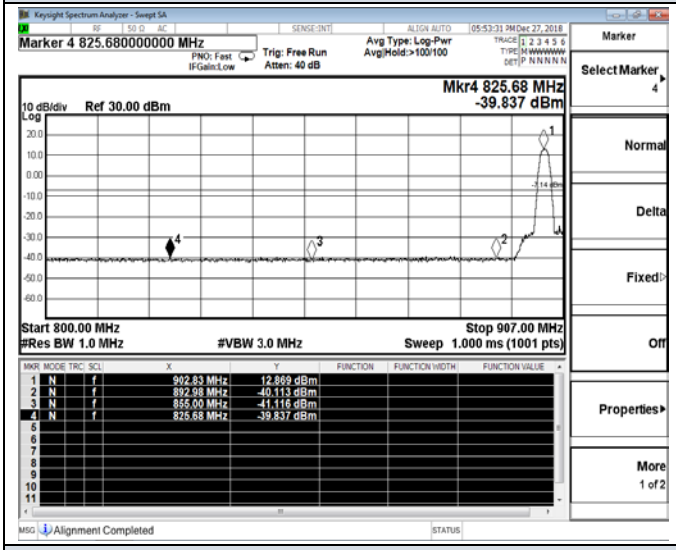
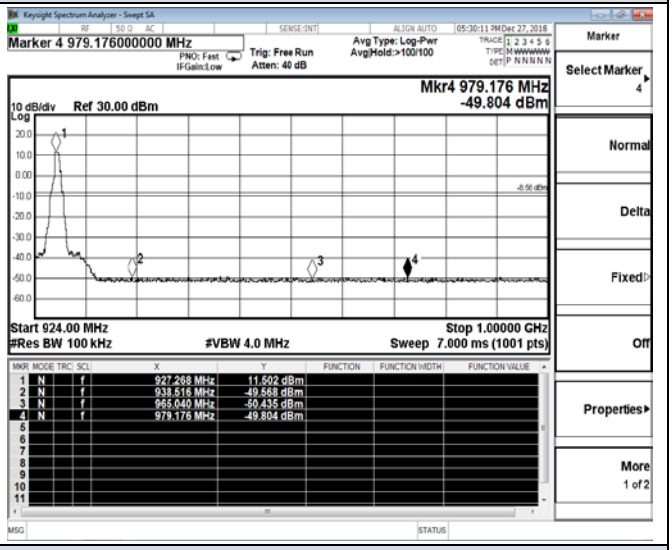
Channel 26 / 927.5 MHz



926 MHz – 929 MHz



30 MHz – 25 GHz

Band-edge measurements for conducted emissions	
	
Channel 1 / 903.0 MHz	Channel 26 / 927.5 MHz

5.7. AC Power Line Conducted Emissions (Not Applicable)

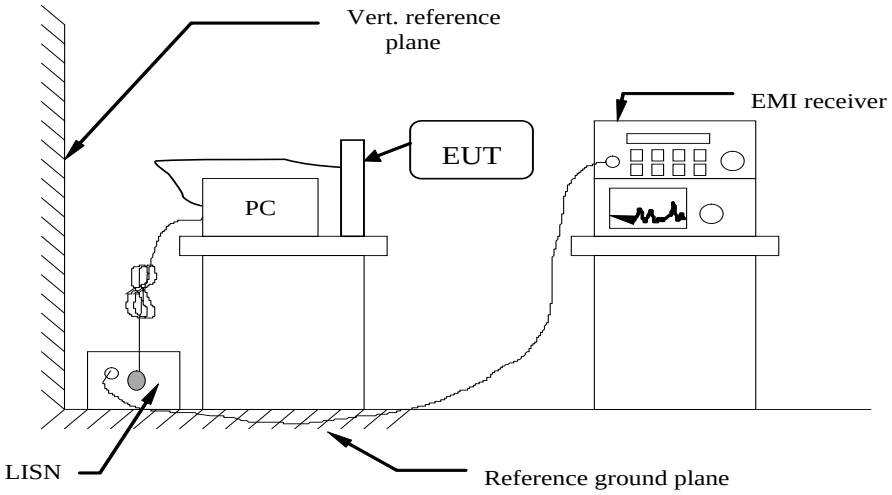
5.7.1 Standard Applicable

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 are listed as follows:

Frequency Range (MHz)	Limits (dBμV)	
	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

5.7.2 Block Diagram of Test Setup



5.7.3 Test Results

Not Applicable!!!

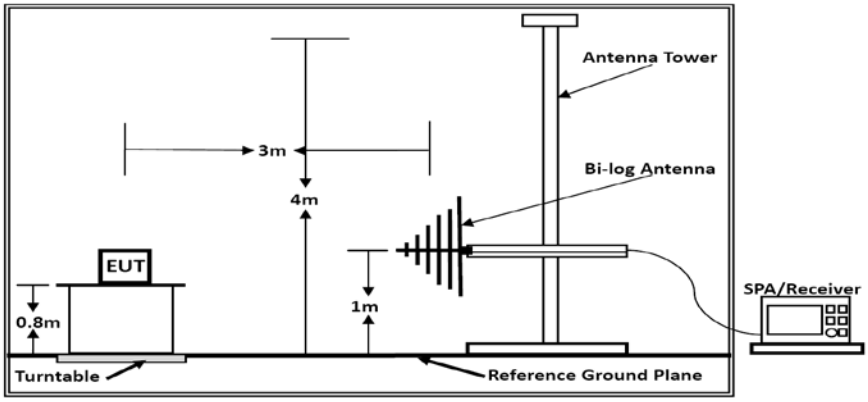
*The device was powered by DC battery (3*AAA battery)*

5.8. Band-edge Measurements for Radiated Emissions

5.8.1 Standard Applicable

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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

5.8.2. Test Setup Layout



Below 1GHz

5.8.3. Measuring Instruments and Setting

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

5.8.4. Test Procedures

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 (± 45°) and antenna movement between 1 and 4 meter.

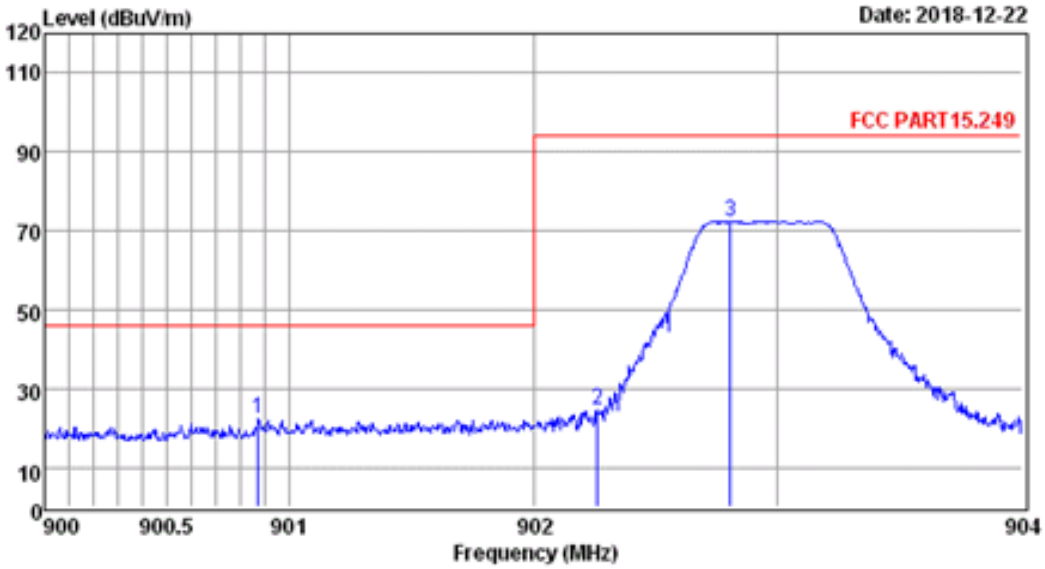
--- The final measurement will be done with QP detector with an EMI receiver.

--- 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.

5.8.5 Test Results

Channel 1 / 903.0 MHz

Horizontal and Vertical



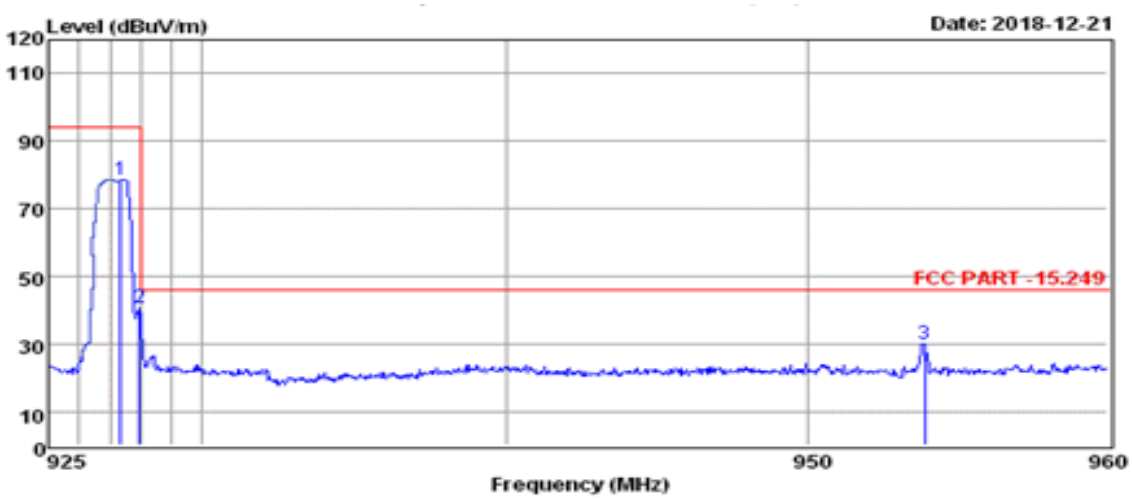
pol:

	Freq	Reading	CabLos	Antfac	Measured	Limit	Over	Remark
	MHz	dBuV	dB	dB/m	dBuV/m	dBuV/m	dB	
1	900.87	20.47	1.88	0.00	22.35	46.00	-23.65	QP
2	902.26	22.47	1.87	0.00	24.34	94.00	-69.66	QP
3	902.81	70.29	1.87	0.00	72.16	94.00	-21.84	QP

Note: 1. All readings are Quasi-peak values.
2. Measured= Reading + Antenna Factor + Cable Loss
3. The emission that are 20db below the official limit are not reported

Channel 26 / 927.5 MHz

Horizontal and Vertical



	Freq	Reading	CabLos	Antfac	Measured	Limit	Over	Remark
	MHz	dBuV	dB	dB/m	dBuV/m	dBuV/m	dB	
1	927.34	78.71	1.90	0.00	80.61	94.00	-13.39	QP
2	928.44	26.51	1.92	0.00	28.43	46.00	-17.57	QP
3	953.89	30.06	2.03	0.00	32.09	46.00	-13.91	QP

Note: 1. All readings are Quasi-peak values.
2. Measured= Reading + Antenna Factor + Cable Loss
3. The emission that are 20db below the official limit are not reported

Note:

1). Pre-scan all modes and recorded the worst case results in this report.

2). Emission level (dBuV/m) = 20 log Emission level (uV/m).

3). Corrected Reading: Antenna Factor + Cable Loss + Read Level = Level.

5.9. Antenna Requirements

5.9.1 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.

And according to §15.247(4)(1), system operating in the 2400-2483.5MHz bands that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.

5.9.2 Antenna Connected Construction

5.9.2.1. 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.

5.9.2.2. Antenna Connector Construction

The directional gains of antenna used for transmitting 1.1dBi, and the antenna is an internal antenna connect to PCB board and no consideration of replacement. Please see EUT photo for details.\

BT and ROLA share difference antenna.

5.9.2.3. Results: Compliance.

Measurement

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module.
Conducted power refers ANSI C63.10:2013 Output power test procedure for DTS devices.
Radiated power refers to ANSI C63.10:2013 Radiated emissions tests.

Measurement parameters

Measurement parameter	
Detector:	Peak
Sweep Time:	Auto
Resolution bandwidth:	1MHz
Video bandwidth:	3MHz
Trace-Mode:	Max hold

Note: The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module.

Limits

FCC	ISED
Antenna Gain	
6 dBi	

Tnom	Vnom	lowest channel 902.5MHz	middle channel 915 MHz	highest channel 927.5 MHz
Conducted power [dBm] Measured with LORA(CSS) modulation		15.170	16.459	16.719
Radiated power [dBm] Measured with LORA(CSS) modulation		15.911	17.551	17.536
Gain [dBi] Calculated		0.741	1.092	0.817
Measurement uncertainty			± 1.6 dB (cond.) / ± 3.8 dB (rad.)	

6. LIST OF MEASURING EQUIPMENTS

Item	Equipment	Manufacturer	Model No.	Serial No.	Cal Date	Due Date
1	Power Meter	R&S	NRVS	100444	2018-06-16	2019-06-15
2	Power Sensor	R&S	NRV-Z81	100458	2018-06-16	2019-06-15
3	Power Sensor	R&S	NRV-Z32	10057	2018-06-16	2019-06-15
4	Test Software	Tonscend	JS1120-2	N/A	N/A	N/A
5	RF Control Unit	Tonscend	JS0806-2	N/A	2018-06-16	2019-06-15
6	MXA Signal Analyzer	Agilent	N9020A	MY50510140	2018-06-16	2019-06-15
7	DC Power Supply	Agilent	E3642A	N/A	2018-11-15	2019-11-14
8	EMI Test Software	AUDIX	E3	N/A	N/A	N/A
9	3m Semi Anechoic Chamber	SIDT FRANKONIA	SAC-3M	03CH03-HY	2018-06-16	2019-06-15
10	Positioning Controller	MF	MF-7082	N/A	2018-06-16	2019-06-15
11	Active Loop Antenna	SCHWARZBECK	FMZB 1519B	00005	2018-07-26	2019-07-25
12	By-log Antenna	SCHWARZBECK	VULB9163	9163-470	2018-07-26	2019-07-25
13	Horn Antenna	SCHWARZBECK	BBHA 9120D	9120D-1925	2018-07-02	2019-07-01
14	Broadband Horn Antenna	SCHWARZBECK	BBHA 9170	791	2018-09-20	2019-09-19
15	Broadband Preamplifier	SCHWARZBECK	BBV 9719	9719-025	2018-09-20	2019-09-19
16	EMI Test Receiver	R&S	ESR 7	101181	2018-06-16	2019-06-15
17	RS SPECTRUM ANALYZER	R&S	FSP40	100503	2018-11-15	2019-11-14
18	AMPLIFIER	QuieTek	QTK	CHM/0809065	2018-11-15	2019-11-14
19	RF Cable-R03m	Jye Bao	RG142	CB021	2018-06-16	2019-06-15
20	RF Cable-HIGH	SUHNER	SUCOFLEX 106	03CH03-HY	2018-06-16	2019-06-15
21	6dB Attenuator	/	100W/6dB	1172040	2018-06-16	2019-06-15
22	3dB Attenuator	/	2N-3dB	/	2018-06-16	2019-06-15
23	EMI Test Receiver	R&S	ESPI	101840	2018-06-16	2019-06-15
24	Artificial Mains	R&S	ENV216	101288	2018-06-16	2019-06-15
25	10dB Attenuator	SCHWARZBECK	MTS-IMP-136	261115-001-0032	2018-06-16	2019-06-15
Note: All equipment is calibrated through GUANGZHOU LISAI CALIBRATION AND TEST CO.,LTD.						

7. TEST SETUP PHOTOGRAPHS OF EUT

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

8. EXTERIOR PHOTOGRAPHS OF THE EUT

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

9. INTERIOR PHOTOGRAPHS OF THE EUT

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

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