



FCC TEST REPORT

**Test report
On Behalf of
Shenzhen RAKwireless Technology Co.,Ltd.
For
LoRa module
Model No.: RAK4260(H)**

FCC ID: 2AF6B-RAK4260H

Prepared for : **Shenzhen RAKwireless Technology Co.,Ltd.**
Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan Street,XiLi town
Nanshan District, Shenzhen, China

Prepared By : **Shenzhen HUAK Testing Technology Co., Ltd.**
1F, B2 Building, Junfeng Zhongcheng Zhizao Innovation Park, Fuhai Street,
Bao'an District, Shenzhen City, China

Date of Test: December 2, 2019~ December 9, 2019
Date of Report: January 2, 2019
Report Number: HK1911122859-E2



TEST RESULT CERTIFICATION

Applicant's name : **Shenzhen RAKwireless Technology Co.,Ltd.**
Address : Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan
Street,XiLi town Nanshan District, Shenzhen, China
Manufacture's Name : **Shenzhen RAKwireless Technology Co.,Ltd.**
Address : Room 506, Bldg B, New Compark, Pingshan First Road, Taoyuan
Street,XiLi town Nanshan District, Shenzhen, China
Product description
Trade Mark : N/A
Product name : LoRa module
Model No : RAK4260(H)
Standards : FCC Rules and Regulations Part 15 Subpart C Section 15.247
ANSI C63.10: 2013

This publication may be reproduced in whole or in part for non-commercial purposes as long as the Shenzhen HUAKE Testing Technology Co., Ltd. is acknowledged as copyright owner and source of the material. Shenzhen HUAKE Testing Technology Co., Ltd. takes no responsibility for and will not assume liability for damages resulting from the reader's interpretation of the reproduced material due to its placement and context.

Date of Test :
Date (s) of performance of tests : December 23, 2019 - December 28, 2019
Date of Issue : January 2, 2019
Test Result : **Pass**

Testing Engineer :

(Gary Qian)

Technical Manager :

(Eden Hu)

Authorized Signatory :

(Jason Zhou)



Revision History

Revision	Issue Date	Revisions	Revised By
000	January 2, 2019	Initial Issue	Jason Zhou



TABLE OF CONTENTS

1. GENERAL INFORMATION	5
1.1. DESCRIPTION OF DEVICE (EUT)	5
1.2. HOST SYSTEM CONFIGURATION LIST AND DETAILS	5
1.3. EXTERNAL I/O CABLE	5
1.4. DESCRIPTION OF TEST FACILITY	5
1.5. STATEMENT OF THE MEASUREMENT UNCERTAINTY	6
1.6. MEASUREMENT UNCERTAINTY	6
1.7. DESCRIPTION OF TEST MODES	6
1.8. FREQUENCY OF CHANNELS	6
2. TEST METHODOLOGY	7
2.1. EUT CONFIGURATION.....	7
2.2. EUT EXERCISE	7
2.3. GENERAL TEST PROCEDURES	7
3. SYSTEM TEST CONFIGURATION.....	8
3.1. JUSTIFICATION.....	8
3.2. EUT EXERCISE SOFTWARE.....	8
3.3. SPECIAL ACCESSORIES	8
3.4. BLOCK DIAGRAM/SCHEMATICS.....	8
3.5. EQUIPMENT MODIFICATIONS	8
3.6. TEST SETUP	8
4. SUMMARY OF TEST RESULTS.....	9
5. TEST RESULT.....	10
5.1. ON TIME AND DUTY CYCLE	10
5.2. MAXIMUM CONDUCTED OUTPUT POWER MEASUREMENT.....	11
5.3. POWER SPECTRAL DENSITY MEASUREMENT	12
5.4. 6 dB SPECTRUM BANDWIDTH MEASUREMENT	14
5.5. RADIATED EMISSIONS MEASUREMENT.....	15
5.6. CONDUCTED SPURIOUS EMISSIONS AND BAND EDGES TEST.....	29
5.7. AC POWER LINE CONDUCTED EMISSIONS	30
5.8. BAND-EDGE MEASUREMENTS FOR RADIATED EMISSIONS	33
5.9. ANTENNA REQUIREMENTS.....	35
6. LIST OF MEASURING EQUIPMENTS	36
7. TEST SETUP PHOTOGRAPHS OF EUT.....	37
8. PHOTOGRAPHS OF THE EUT	37



1. GENERAL INFORMATION

1.1. Description of Device (EUT)

Product Name : LoRa module
Model Number : RAK4260(H)
Model Difference Declaration : N/A
Test Model : RAK4260(H)
Power Supply : DC 3.3V
Hardware version : V2.0
Software version : V1.0

LoRa-FHSS Mode

Frequency Range : 902.3 – 914.9 MHz
Channel Number : 64 Channels
Modulation Technology : ASK

LoRa-DTS Mode

Frequency Range : 903 – 927 MHz
Channel Number : 25 Channels
Modulation Technology : ASK
Antenna information : 3.0 dBi

Note1: Antenna position refer to EUT Photos.

Note2: this device is a hybrid device, it support FHSS and DTS Mode, This Report is for FHSS Mode.

1.2. Host System Configuration List and Details

Manufacturer	Description	Model	Serial Number	Certificate
N/A	N/A	N/A	N/A	N/A

1.3. External I/O Cable

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

1.4. Description of Test Facility

Designation Number: CN1229
Test Firm Registration Number: 616276

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 HUAKE 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

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.

Pre-test AC conducted emission at both voltage AC 120V/60Hz and AC 240V/60Hz, recorded worst case.

1.8. Frequency of Channels

LoRa-DTS

Channel	Frequency(MHz)	Channel	Frequency(MHz)
1	903	14	916
1	904	15	917
3	905	16	918
4	906	17	919
5	907	18	920
6	908	19	921
7	909	20	922
8	910	21	923
9	911	22	924
10	912	23	925
11	913	24	926
12	914	25	927
13	915		



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 HUAKE Testing Technology Co., 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 v04 and KDB 662911 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 Bluetooth testing in a continuous transmits condition and change test channels by software (CSR102xTools_3_1_1_45) provided by application.

3.3. Special Accessories

No.	Equipment	Manufacturer	Model No.	Serial No.	Length	shielded/ unshielded	Notes
1	/	/	/	/	/	/	/

3.4. Block Diagram/Schematics

Please refer to the related document

3.5. Equipment Modifications

Shenzhen HUAKE Testing Technology 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	Result
§15.247(b)	Maximum Conducted Output Power	Compliant
§15.247(e)	Power Spectral Density	Compliant
§15.247(a)(2)	6dB Bandwidth	Compliant
§15.247(a)	Occupied Bandwidth	Compliant
§15.209, §15.247(d)	Radiated and Conducted Spurious Emissions	Compliant
§15.205	Emissions at Restricted Band	Compliant
§15.207(a)	Conducted Emissions	Compliant
§15.203	Antenna Requirements	Compliant
§15.247(i)§2.1093	RF Exposure	Compliant

5. TEST RESULT

5.1. On Time and Duty Cycle

5.1.1. Standard Applicable

None; for reporting purpose only.

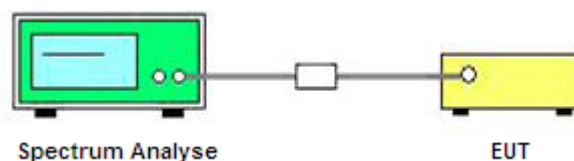
5.1.2. Measuring Instruments and Setting

Please refer to section 6 of 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 Points	Total Sweep points	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (KHz)
LoRa-DTS	4827	8001	60.33	2.2	0.01

Remark:

1. Please refer to Appendix A.8;



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. Test Procedures

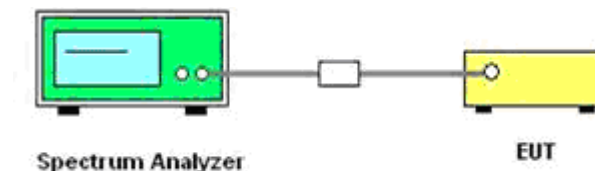
The transmitter output (antenna port) was connected to the spectrum analyzer.

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.

- Set the RBW \geq DTS bandwidth.
- Set VBW $\geq 3 \times$ RBW.
- Set span $\geq 3 \times$ RBW
- Sweep time = auto couple.
- Detector = peak.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use peak marker function to determine the peak amplitude level.

5.2.3. Test Setup Layout



5.2.4. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

5.2.5. Test Result of Maximum Conducted Output Power

Temperature	24.5°C	Humidity	60°C
Test Engineer	Gary Qian	Configurations	LoRa-DTS

Remark:

- Test results including cable loss;*
- please refer to following plots;*
- Please refer to Appendix A.3;*

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.

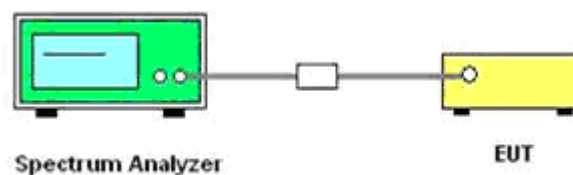
5.3.2. Measuring Instruments and Setting

Please refer to section 6 of 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 = 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.

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

Temperature	24.5°C	Humidity	60°C
Test Engineer	Gary Qian	Configurations	LoRa-DTS

Remark:

1. *Test results including cable loss;*
2. *Please refer to following plots;*
3. *Please refer to Appendix A.4;*



5.4. 6 dB 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

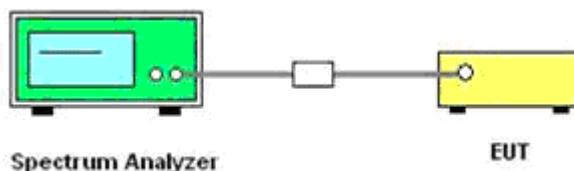
Please refer to section 6 of equipment list in this report. The following table is the setting of the Spectrum Analyzer.

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 Spectrum Bandwidth

Temperature	24.5°C	Humidity	60°C
Test Engineer	Gary Qian	Configurations	LoRa-DTS

Remark:

1. Test results including cable loss;
2. please refer to following plots;
3. Please refer to Appendix A.1;



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 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



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 ($\pm 45^\circ$) 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 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 ($\pm 45^\circ$) 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.



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.

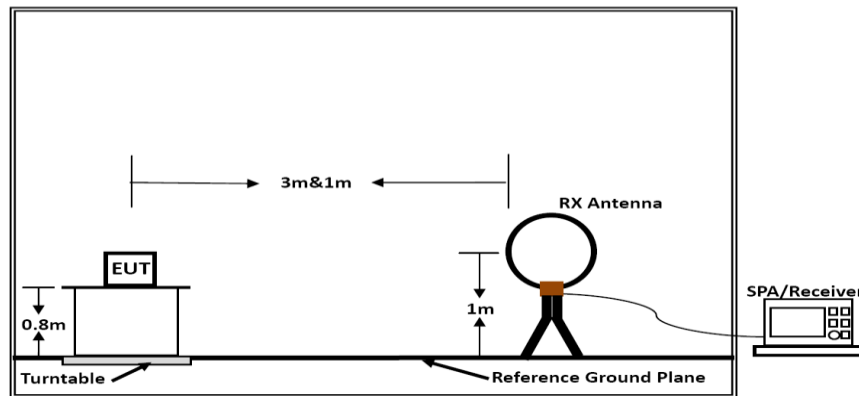
Premeasurement:

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

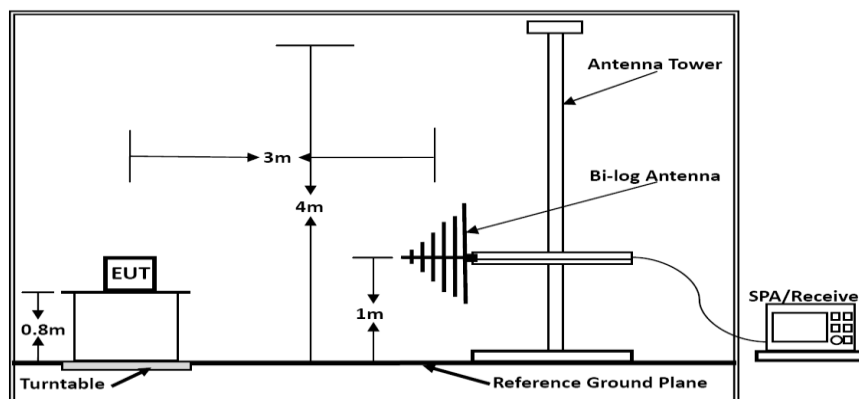
Final measurement:

- 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.

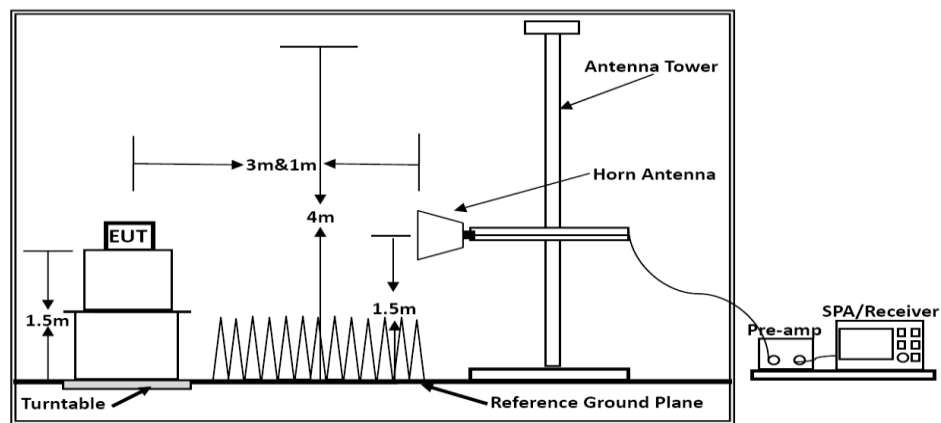
5.5.4. Test Setup Layout



Below 30MHz



Below 1GHz



Above 1GHz

Above 10 GHz shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade from 3m to 1.5m.

Distance extrapolation factor = $20 \log (\text{specific distance [3m]} / \text{test distance [1.5m]})$ (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	24.5℃	Humidity	60℃
Test Engineer	Gary Qian	Configurations	LoRa-DTS

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);

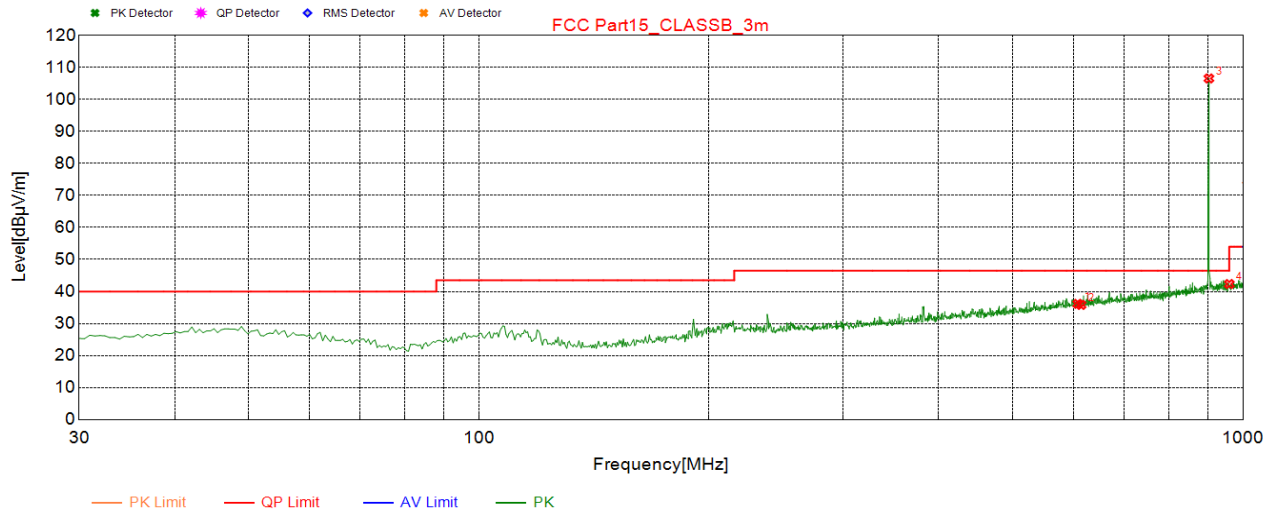
Limit line = specific limits (dBuV) + distance extrapolation factor.

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

Temperature	24.5℃	Humidity	60℃
Test Engineer	Gary Qian	Configurations	LoRa-DTS



Vertical:



NO.	Freq. [MHz]	Result Level [dBuV/m]	Factor [dB/m]	Limit [dBuV/m]	Margin [dB]	Height [cm]	Angle[°]	Polarity
1	608.12	36.16	0.5	46.5	10.34	100	305	Vertical
2	614.425	35.8	0.59	46.5	10.7	100	23	Vertical
3*	903	106.57	5	46.5	-60.07	100	360	Vertical
4	960.23	42.35	5.66	54	11.65	100	357	Vertical

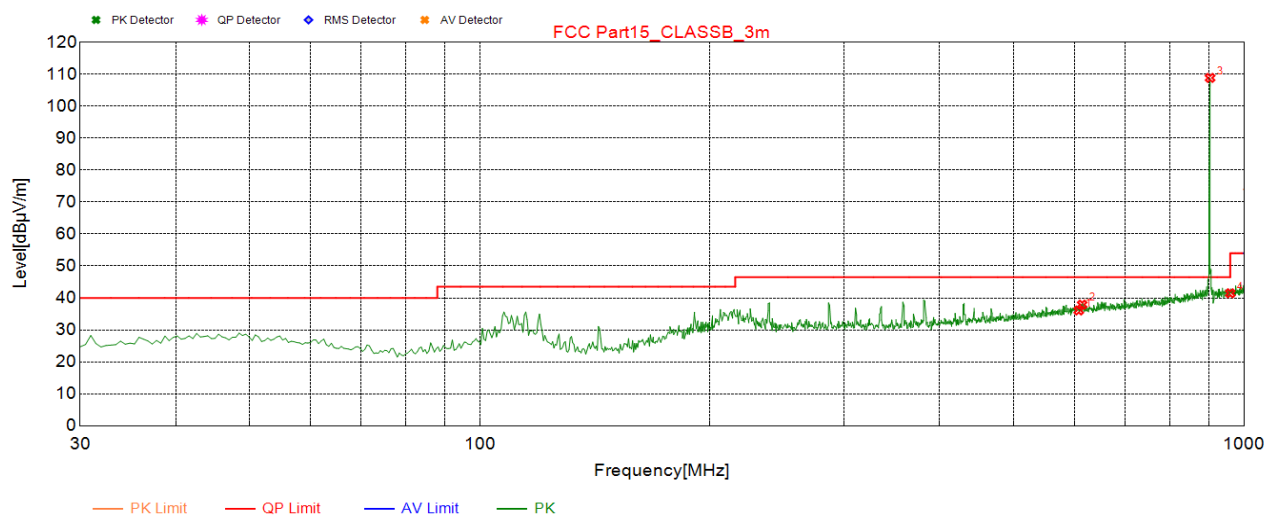
Note:

*: Fundamental

 $Emission\ level\ (dBuV/m) = 20\ log\ Emission\ level\ (uV/m).$ $Margin\ [dB] = Limit\ [dBuV/m] - Result\ Level[dBuV/m]$



Horizontal:



NO.	Freq. [MHz]	Result Level [dBμV/m]	Factor [dB/m]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	608.12	36.07	0.5	46.5	10.43	100	50	Horizontal
2	614.425	37.91	0.59	46.5	8.59	100	58	Horizontal
3*	903.485	108.88	5	46.5	-62.38	100	130	Horizontal
4	960.23	41.46	5.66	54	12.54	100	201	Horizontal

Note:

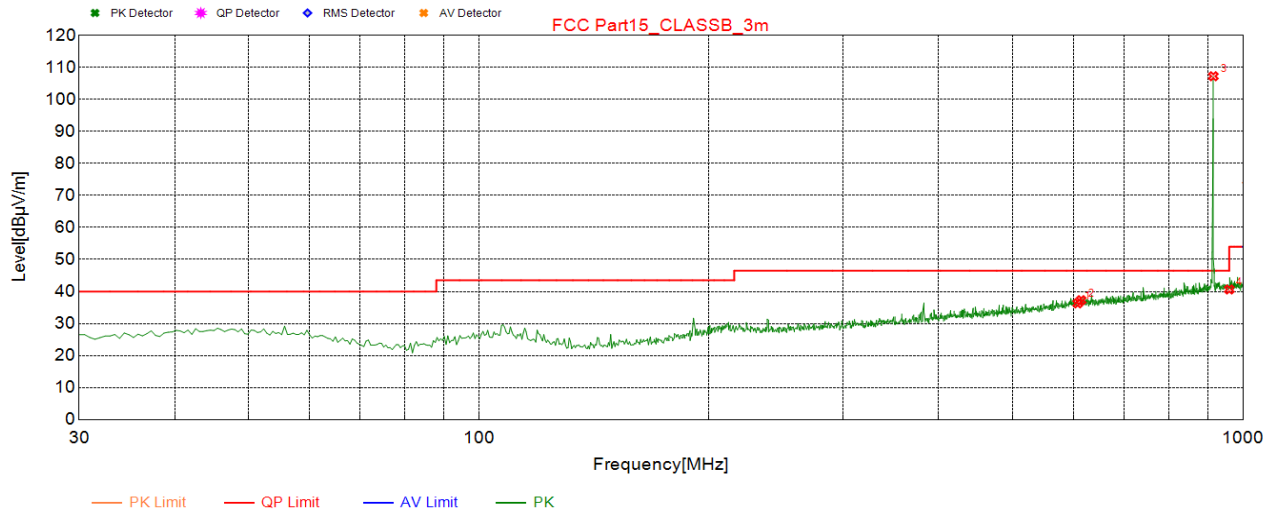
*: Fundamental

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

Margin [dB] = Limit [dBμV/m] - Result Level [dBμV/m]



Vertical:



NO.	Freq. [MHz]	Result Level [dBμV/m]	Factor [dB/m]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle[°]	Polarity
1	608.12	36.29	0.5	46.5	10.21	100	293	Vertical
2	614.425	37.29	0.59	46.5	9.21	100	49	Vertical
3*	915.125	107.26	5.14	46.5	-60.76	100	0	Vertical
4	960.23	40.64	5.66	54	13.36	100	237	Vertical

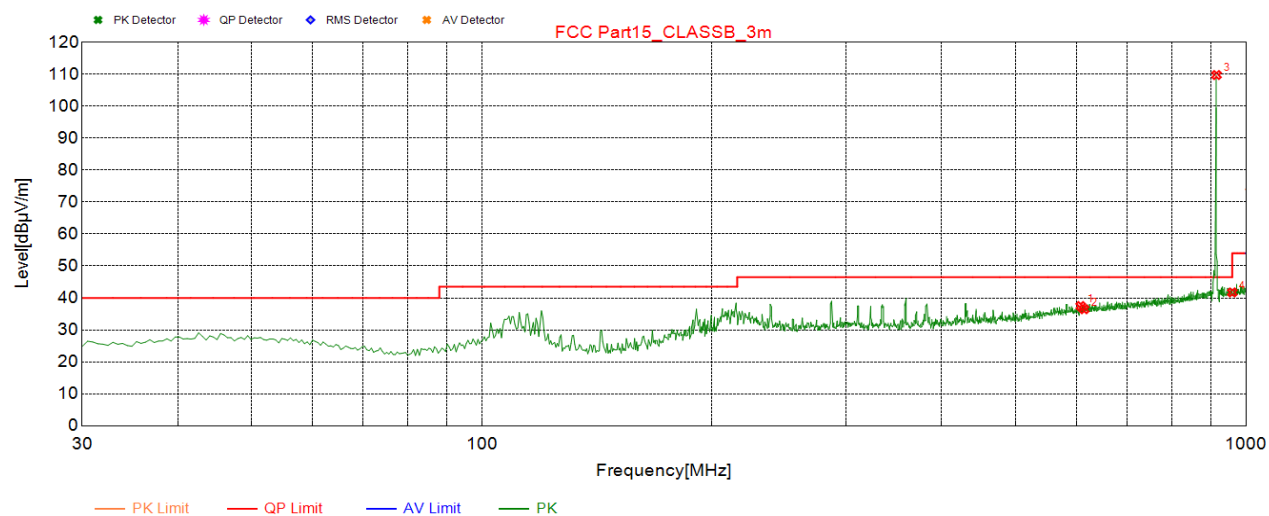
Note:

*: Fundamental

 $Emission\ level\ (dBuV/m) = 20\ log\ Emission\ level\ (uV/m).$ $Margin\ [dB] = Limit\ [dBuV/m] - Result\ Level[dBuV/m]$



Horizontal:



NO.	Freq. [MHz]	Result Level [dBμV/m]	Factor [dB/m]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle[°]	Polarity
1	608.12	37.46	0.5	46.5	9.04	100	114	Horizontal
2	614.425	36.46	0.59	46.5	10.04	100	13	Horizontal
3*	915.61	109.77	5.14	46.5	-63.27	100	131	Horizontal
4	960.23	41.73	5.66	54	12.27	100	359	Horizontal

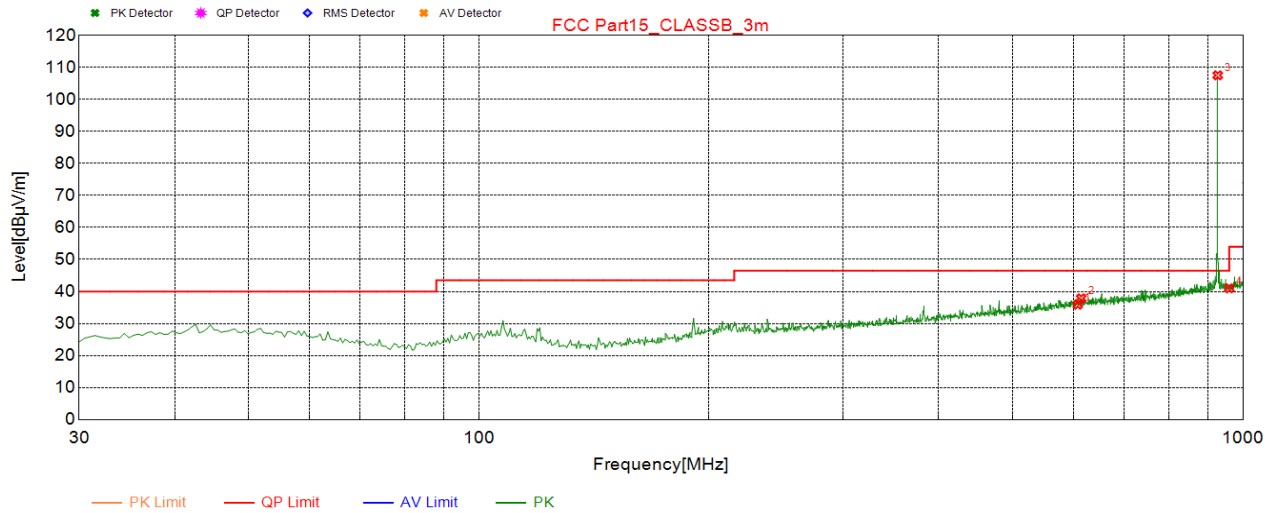
Note:

*: Fundamental

$$\text{Emission level (dBuV/m)} = 20 \log \text{Emission level (uV/m)}.$$
$$\text{Margin [dB]} = \text{Limit [dBμV/m]} - \text{Result Level[dBμV/m]}$$



Vertical:



NO.	Freq. [MHz]	Result Level [dBμV/m]	Factor [dB/m]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle[°]	Polarity
1	608.12	35.9	0.5	46.5	10.6	100	325	Vertical
2	614.425	37.86	0.59	46.5	8.64	100	22	Vertical
3*	927.25	107.55	5.28	46.5	-61.05	100	4	Vertical
4	960.23	41	5.66	54	13	100	24	Vertical

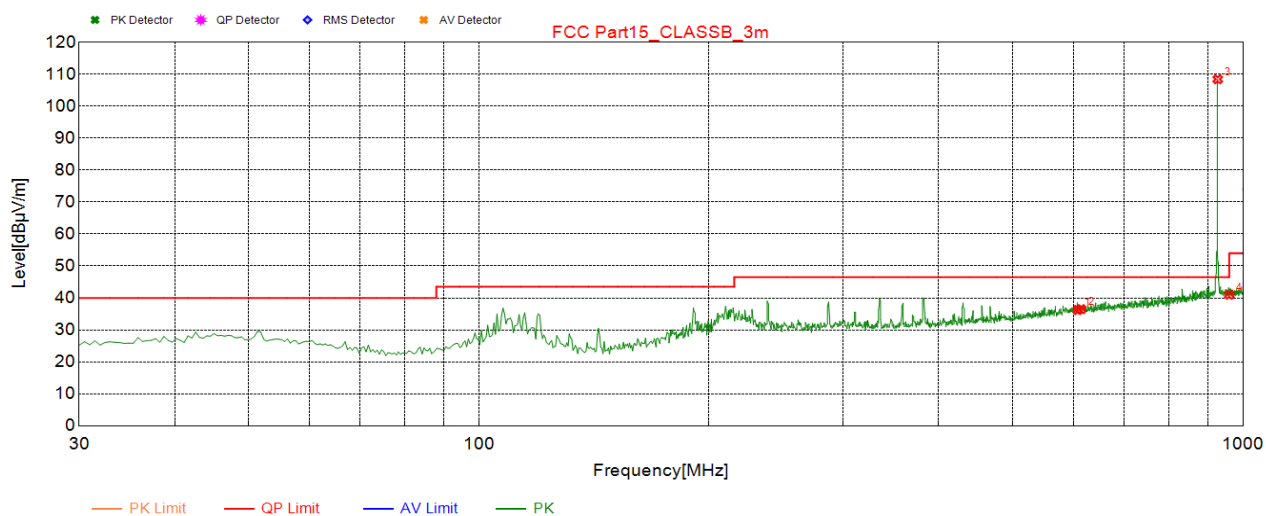
Note:

*: Fundamental

 $Emission\ level\ (dBuV/m) = 20\ log\ Emission\ level\ (uV/m).$ $Margin\ [dB] = Limit\ [dBuV/m] - Result\ Level[dBμV/m]$



Horizontal:



NO.	Freq. [MHz]	Result Level [dBμV/m]	Factor [dB/m]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle[°]	Polarity
1	608.12	36.2	0.5	46.5	10.3	100	93	Horizontal
2	614.425	36.48	0.59	46.5	10.02	100	105	Horizontal
3*	927.25	108.46	5.28	46.5	-61.96	100	155	Horizontal
4	960.23	40.99	5.66	54	13.01	100	319	Horizontal

Note:

*: Fundamental

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

Margin [dB] = Limit [dBμV/m] - Result Level[dBμV/m]



5.5.8. Results for Radiated Emissions (Above 1GHz)

Channel 0 / 903 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.
1806.37	44.72	33.06	35.04	3.94	46.68	74.00	27.32	Peak	Horizontal
1806.32	44.79	33.06	35.04	3.94	46.75	74.00	27.25	Peak	Vertical
2709.46	47.12	33.06	35.04	3.94	49.08	74.00	24.92	Peak	Horizontal
2709.26	49.15	33.06	35.04	3.94	51.11	74.00	22.89	Peak	Vertical

Channel 19 / 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.
1830.30	49.86	33.16	35.15	3.96	51.83	74.00	22.17	Peak	Horizontal
1830.60	44.62	33.16	35.15	3.96	46.59	74.00	27.41	Peak	Vertical
2745.79	47.42	33.16	35.15	3.96	49.39	74.00	24.61	Peak	Horizontal
2745.36	48.11	33.16	35.15	3.96	50.08	74.00	23.92	Peak	Vertical

Channel 39 / 927 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.
1854.61	48.49	33.26	35.14	3.98	50.59	74.00	23.41	Peak	Horizontal
1854.46	48.43	33.26	35.14	3.98	50.53	74.00	23.47	Peak	Vertical
2781.68	48.00	33.26	35.14	3.98	50.10	74.00	23.90	Peak	Horizontal
2781.66	48.48	33.26	35.14	3.98	50.58	74.00	23.42	Peak	Vertical

Notes:

- 1). Measuring frequencies from 9k~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 9k~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.



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 section 6 of 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 26.5GHz 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	24.5°C	Humidity	60°C
Test Engineer	Gary Qian	Configurations	LoRa-DTS

Test Mode	Channel	Frequency (MHz)	Measured Frequency Range	Spurious RF Conducted Emission (dBc)	Limits (dBc)	Verdict
Lora-DTS	0	903	9 KHz – 26.5 GHz	<-20	-20	PASS
	19	915	9 KHz – 26.5 GHz	<-20		
	39	927	9 KHz – 26.5 GHz	<-20		

Remark:

1. Test results including cable loss;
2. “---“means that the fundamental frequency not for 15.209 limits requirement.
3. Not recorded values as emission level lower than limit at least 20 dBc;
4. Please refer to Appendix A.6 for Conducted Spurious Emissions;
5. Please refer to Appendix A.5 for Conducted Band Edges.

5.7. AC Power line conducted emissions

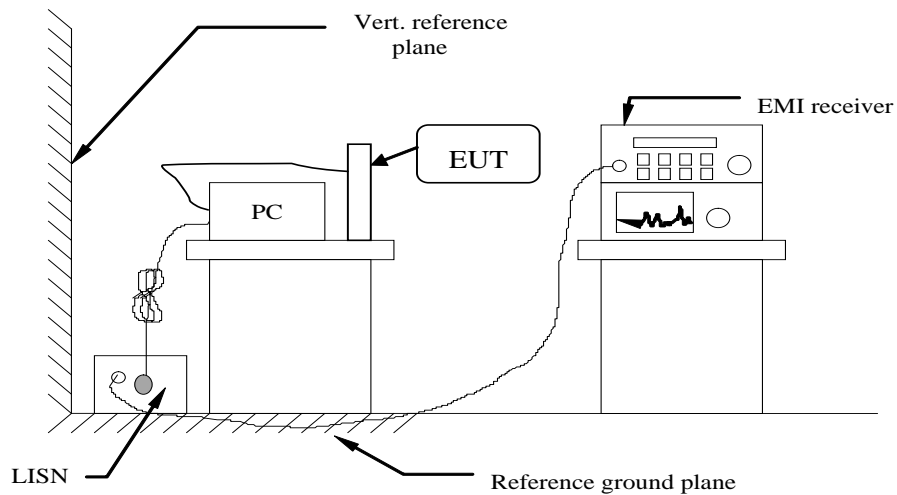
5.7.1 Standard Applicable

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 (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

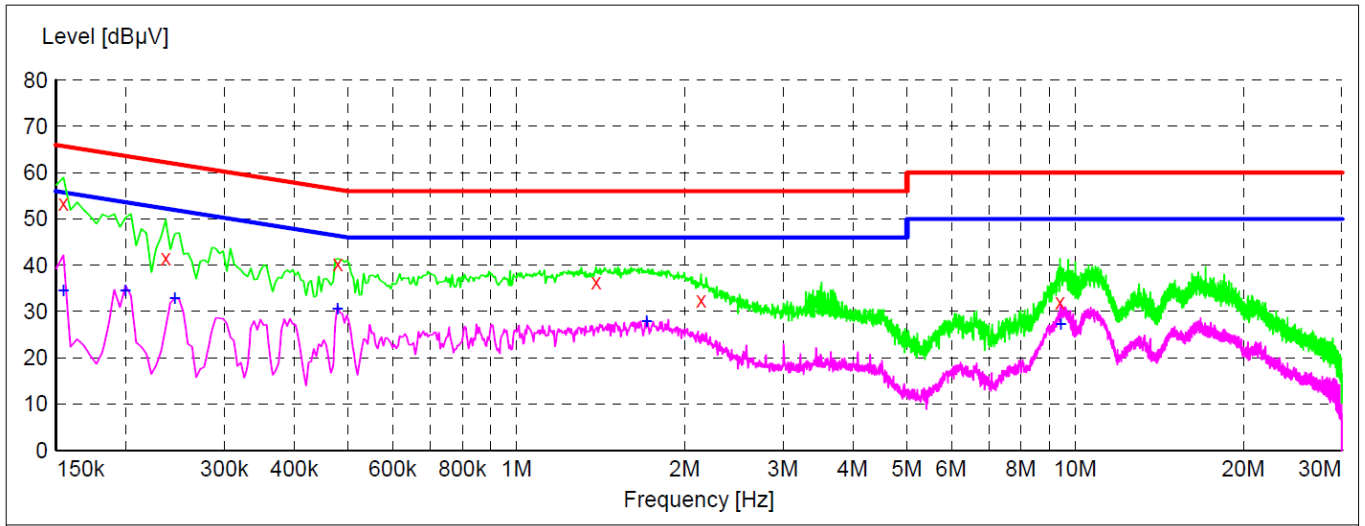
5.7.2 Block Diagram of Test Setup



5.7.3 Test Results

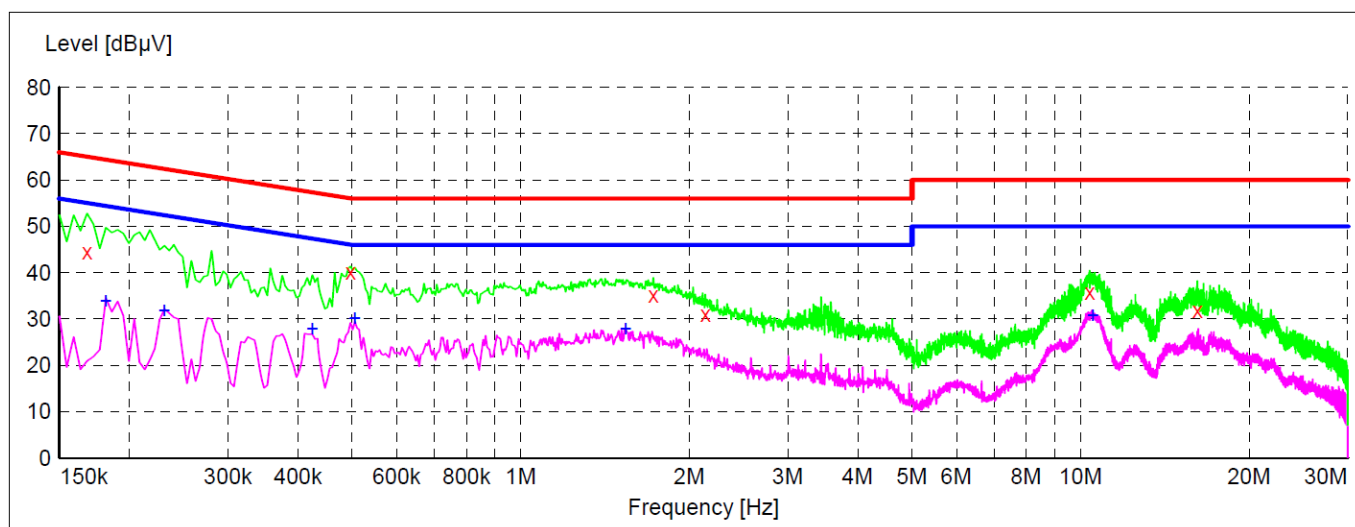
Pass

Note: Present the worst case(Low Channel) in this item



Frequency MHz	Level dBμV	Transd dB	Limit dBμV	Margin dB	Detector	Line	PE
0.154500	53.40	9.9	66	12.4	QP	N	GND
0.235500	41.60	10.5	62	20.7	QP	N	GND
0.478500	40.30	10.0	56	16.1	QP	N	GND
1.387500	36.30	9.7	56	19.7	QP	N	GND
2.139000	32.50	9.7	56	23.5	QP	N	GND
9.393000	32.00	9.8	60	28.0	QP	N	GND

Frequency MHz	Level dBμV	Transd dB	Limit dBμV	Margin dB	Detector	Line	PE
0.154500	34.50	9.9	56	21.3	AV	N	GND
0.199500	34.60	10.6	54	19.0	AV	N	GND
0.244500	32.80	10.4	52	19.1	AV	N	GND
0.478500	30.50	10.0	46	15.9	AV	N	GND
1.711500	27.90	9.7	46	18.1	AV	N	GND
9.429000	27.20	9.8	50	22.8	AV	N	GND



Frequency MHz	Level dBμV	Transd dB	Limit dBμV	Margin dB	Detector	Line	PE
0.168000	44.40	10.1	65	20.7	QP	L1	GND
0.496500	40.20	9.9	56	15.9	QP	L1	GND
1.725000	35.20	9.7	56	20.8	QP	L1	GND
2.134500	31.00	9.7	56	25.0	QP	L1	GND
10.378500	35.80	9.8	60	24.2	QP	L1	GND
16.156500	31.80	10.0	60	28.2	QP	L1	GND

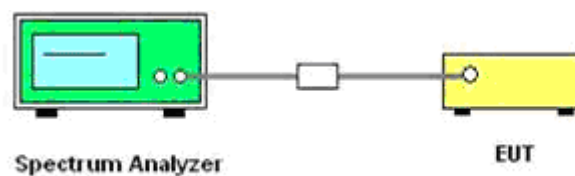
Frequency MHz	Level dBμV	Transd dB	Limit dBμV	Margin dB	Detector	Line	PE
0.181500	33.90	10.3	54	20.5	AV	L1	GND
0.231000	31.90	10.5	52	20.5	AV	L1	GND
0.424500	27.80	10.0	47	19.6	AV	L1	GND
0.505500	30.10	9.9	46	15.9	AV	L1	GND
1.540500	27.80	9.7	46	18.2	AV	L1	GND
10.518000	30.80	9.8	50	19.2	AV	L1	GND

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



5.8.3. Measuring Instruments and Setting

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

5.8.4. Test Procedures

According to KDB 558074 D01 V04 for Antenna-port conducted measurement. Antenna-port conducted measurements may also be used as an alternative to radiated measurements for demonstrating compliance in the restricted frequency bands. If conducted measurements are performed, then proper impedance matching must be ensured and an additional radiated test for cabinet/case spurious emissions is required.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set both RBW and VBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100kHz bandwidth from band edge, for Radiated emissions restricted band RBW=1MHz, VBW=3MHz for peak detector and RBW=1MHz, VBW=1/B for Peak detector.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.
6. Measure the conducted output power (in dBm) using the detector specified by the appropriate regulatory agency (see 12.2.2, 12.2.3, and 12.2.4 for guidance regarding measurement procedures for determining quasi-peak, peak, and average conducted output power, respectively).
7. Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP level (see 12.2.5 for guidance on determining the applicable antenna gain)
8. Add the appropriate maximum ground reflection factor to the EIRP level (6 dB for frequencies ≤ 30 MHz, 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive and 0 dB for frequencies > 1000 MHz).



9. For devices with multiple antenna-ports, measure the power of each individual chain and sum the EIRP of all chains in linear terms (e.g., Watts, mW).
10. Convert the resultant EIRP level to an equivalent electric field strength using the following relationship:
$$E = \text{EIRP} - 20\log D + 104.8$$

Where:

E = electric field strength in dB μ V/m,

EIRP = equivalent isotropic radiated power in dBm

D = specified measurement distance in meters.

11. Since the out-of-band characteristics of the EUT transmit antenna will often be unknown, the use of a conservative antenna gain value is necessary. Thus, when determining the EIRP based on the measured conducted power, the upper bound on antenna gain for a device with a single RF output shall be selected as the maximum in-band gain of the antenna across all operating bands, or 2 dBi, whichever is greater. However, for devices that operate in multiple frequency bands while using the same transmit antenna, the highest gain of the antenna within the operating band nearest in frequency to the restricted band emission being measured may be used in lieu of the overall highest gain when the emission is at a frequency that is within 20 percent of the nearest band edge frequency, but in no case shall a value less than 2 dBi be used.
12. Compare the resultant electric field strength level to the applicable regulatory limit.
13. Perform radiated spurious emission test duress until all measured frequencies were complete.

5.8.5 Test Results

PASS.

Remark:

1. *Test results including cable loss;*
2. *“---“means that the fundamental frequency not for 15.209 limits requirement.*
3. *Average Values = Average Reading Values - Duty Cycle Factor*
4. *Please refer to Appendix A.7;*



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 is 3.0 dBi, and the antenna is an Internal antenna connect to PCB board and no consideration of replacement. Please see EUT photo for details.

5.9.2.3. Results: Compliance.



6. LIST OF MEASURING EQUIPMENTS

Item	Equipment	Manufacturer	Model No.	Serial No.	Last Cal.	Cal. Interval
1.	L.I.S.N. Artificial Mains Network	R&S	ENV216	HKE-002	Dec. 26, 2019	1 Year
2.	Receiver	R&S	ESCI 7	HKE-010	Dec. 26, 2019	1 Year
3.	RF automatic control unit	Tonscend	JS0806-2	HKE-060	Dec. 26, 2019	1 Year
4.	Spectrum analyzer	R&S	FSP40	HKE-025	Dec. 26, 2019	1 Year
5.	Spectrum analyzer	Agilent	N9020A	HKE-048	Dec. 26, 2019	1 Year
6.	Preamplifier	Schwarzbeck	BBV 9743	HKE-006	Dec. 26, 2019	1 Year
7.	EMI Test Receiver	Rohde & Schwarz	ESCI 7	HKE-010	Dec. 26, 2019	1 Year
8.	Bilog Broadband Antenna	Schwarzbeck	VULB9163	HKE-012	Dec. 26, 2019	1 Year
9.	Loop Antenna	Schwarzbeck	FMZB 1519 B	HKE-014	Dec. 26, 2019	1 Year
10.	Horn Antenna	Schewarzbeck	9120D	HKE-013	Dec. 26, 2019	1 Year
11.	Broadband Horn Antenna	Schewarzbeck	BBHA 9170	HKE-017	Dec. 26, 2019	1 Year
12.	Pre-amplifier	EMCI	EMC051845 SE	HKE-015	Dec. 26, 2019	1 Year
13.	Pre-amplifier	Agilent	83051A	HKE-016	Dec. 26, 2019	1 Year
14.	EMI Test Software EZ-EMC	Tonscend	JS1120-B	HKE-083	Dec. 26, 2019	N/A
15.	Power Sensor	Agilent	E9300A	HKE-086	Dec. 26, 2019	1 Year
16.	Signal generator	Agilent	N5182A	HKE-029	Dec. 26, 2019	1 Year
17.	Signal Generator	Agilent	83630A	HKE-028	Dec. 26, 2019	1 Year
18.	Shielded room	Shiel Hong	4*3*3	HKE-039	Dec. 26, 2019	3 Year
19.	Horn Antenna	ETS	3117	HKE-040	Dec. 26, 2019	1 Year
20.	RF Cable(below 1GHz)	HUBER+SUHNER	RG214	HKE-055	Dec. 26, 2019	1 Year
21.	RF Cable(above 1GHz)	HUBER+SUHNER	RG214	HKE-056	Dec. 26, 2019	1 Year



7. TEST SETUP PHOTOGRAPHS OF EUT

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

8. PHOTOGRAPHS OF THE EUT

Please refer to separated files for Photos of the EUT.

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