

FCC RF Test Report

For

Ring LLC

Test Standards:	<u>Part 15C Subpart C §15.247</u>
Product Description:	<u>Pathlight</u>
Tested Model:	<u>5LP1Y8</u>
Additional Model No.:	<u>N/A</u>
Brand Name:	<u>Ring</u>
FCC ID:	2AEUPBHAPB001
ISED:	20271-BHAPB001
Classification	(DTS) Digital Transmission System
Report No.:	<u>EC1903031F02</u>
Tested Date:	<u>2019-03-16 to 2019-04-02</u>
Issued Date:	<u>2019-04-02</u>
Prepared By:	 Damon Zhang/ Engineer
Approved By:	 Bacon Wu / RF Manager

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Note: The test results in this report apply exclusively to the tested model / sample. Without written approval of Hunan Ecloud Testing Technology Co., Ltd., the test report shall not be reproduced except in full.

Report Revise Record

Report Version	Revise Time	Issued Date	Valid Version	Notes
V1.0	/	2019.04.02	Valid	Original Report

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Summary of Test RESULT

FCC Rule	IC Rule	Description	Limit	Result	Remark
15.247(a)(2)	RSS-247 5.2(1)	6dB Bandwidth	$\geq 0.5\text{MHz}$	Pass	-
-	RSS-Gen 6.6	99% Bandwidth	-	Pass	-
15.247(b)(1)	RSS-247 A5.4(4)	Peak Output Power	$\leq 30\text{dBm}$	Pass	-
15.247(e)	RSS-247 5.2(2)	Power Spectral Density	$\leq 8\text{dBm}/3\text{kHz}$	Note	-
15.247(d)	RSS-247 5.5	Conducted Band Edges and Spurious Emission	$\leq 20\text{dBc}$	Note	-
15.247(d)	RSS-247 5.5	Radiated Band Edges and Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit 1.28 dB at 75.590 MH
15.203 & 15.247(b)	N/A	Antenna Requirement	N/A	Note	-

Note:

Because only the capacitance of the two capacitors has been changed, some items do not need to be tested. Please refer to the original report EC1811005F02.

1. Test Laboratory

1.1 Test facility

CNAS (accreditation number: L11138)

Hunan Ecloud Testing Technology Co., Ltd. has obtained the accreditation of China National Accreditation Service for Conformity Assessment (CNAS).

FCC (Designation number: CN1244 , Test Firm Registration Number: 793308)

Hunan Ecloud Testing Technology Co., Ltd. has been listed on the US Federal Communications Commission list of test facilities recognized to perform electromagnetic emissions measurements.

ISED(CAB identifier: CN0012, ISED#: 24347)

Hunan Ecloud Testing Technology Co., Ltd. has been listed on the Wireless Device Testing Laboratories list of innovation, Science and Economic Development Canada to test to Canadian radio equipment requirements.

A2LA (Certificate Code: 4895.01)

Hunan Ecloud Testing Technology Co., Ltd. has been listed by American Association for Laboratory Accreditation to perform electromagnetic emission measurement.

2. General Description

2.1 Applicant

Ring LLC
1523 26th St, Santa Monica, CA 90404

2.2 Manufacturer

Guangdong Bestek Technology Co., Ltd
No.1, B Road, Longling industrial Zone, YuanCheng District, HeYuan City. China

2.3 General Description Of EUT

Product	Pathlight
Model No.	5LP1Y8
Additional No.	N/A
Difference Description	N/A
FCC ID	2AEUPBHAPB001
IC ID	20271-BHAPB001
Power Supply	6Vdc (4*D Batteries)
Modulation Technology	BLE / LoRa
Modulation Type	GFSK/ LoRa 500KHz DTS
Operating Frequency	2402MHz ~ 2480MHz - BLE 902.5MHz ~ 927.0MHz – DTS
Max. Output Power	16.172 dBm (41.42 mW)
Antenna Type	BLE: PCB Antenna type with 1dBi gain Lora: Monopole Antenna type with 3dBi gain
I/O Ports	Refer to user's manual

NOTE:

1. For a more detailed features description, please refer to the manufacturer's specifications or the user's manual.
2. For the test results, the EUT had been tested with all conditions. But only the worst case was shown in test report.

2.4 Modification of EUT

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

2.5 ApplicaLora Standards

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

- ♦ FCC Part 15 Subpart C §15.247
- ♦ ANSI C63.10-2013
- ♦ IC RSS-247 Issue 2
- ♦ IC RSS-Gen Issue 5
- ♦ FCC KDB Publication No. 558074 D01 15.247 Meas Guidance v05r01

Remark:

1. This EUT has also been tested and complied with the requirements of FCC Part 15, Subpart B, ICES-005 recorded in a separate test report.

3. Test Configuration of Equipment Under Test

3.1 Descriptions of Test Mode

The transmitter has a maximum peak conducted output power as follows:

Channel	Frequency	Lora RF Output Power
Low	902.5MHz	16.036
Middle	913.7MHz	16.172
High	927.0MHz	15.847

- a. Radiated emission was performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

3.2 Test Mode

3.2.1 Antenna Port Conducted Measurement

Summary taLora of Test Cases	
Test Item	Data Rate / Modulation
	Lora 500KHz DTS
Conducted Test Cases	Mode 1: 902.5 MHz
	Mode 2: 913.7 MHz
	Mode 3: 927.0 MHz

3.2.2 Radiated Emission Test (Below 1GHz)

Radiated Test Cases	Lora 500KHz DTS	
	Transmitting	Mode 1: 902.5 MHz Mode 2: 913.7 MHz Mode 3: 927.0 MHz

Note : 1. Pre-Scan has been conducted to determine the worst-case mode from all possiLora combinations between availaLora modulations, antenna ports (if EUT with antenna diversity architecture) and packet type.

2. All above modes were tested, but only the worst case test mode 1 was reported .

3.2.3 Radiated Emission Test (Above 1GHz)

Radiated Test Cases	Lora 500KHz DTS	
	Transmitting	Mode 1: 902.5 MHz Mode 2: 913.7 MHz Mode 3: 927.0 MHz

Note : 1. Pre-Scan has been conducted to determine the worst-case mode from all possiLora combinations between availaLora modulations, antenna ports (if EUT with antenna diversity architecture) and packet type.

2. Following channel(s) was (were) selected for the final test as listed above

3. This is a validation report which mainly verifies the conduction power and radiation spurious.

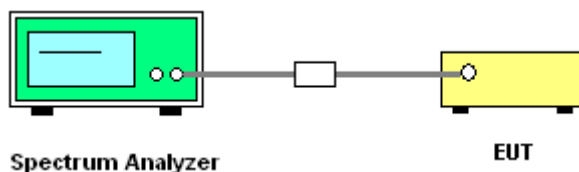
3.3 Support Equipment

Item	Equipment	Trade Name	Model Name	FCC ID	Data CaLora	Power Cord
1.	Notebook	Lenovo	E470C	FCC DoC	N/A	shielded caLora DC O/P 1.8 m unshielded AC I/P caLora1.2 m

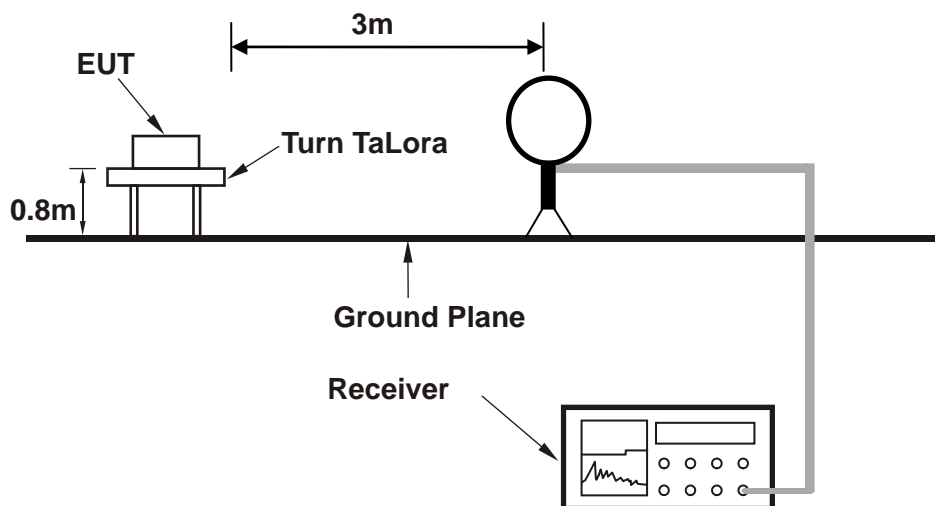
3.4 Test Setup

The software provided by client to enaLora the EUT under transmission condition continuously at specific channel frequencies individually.

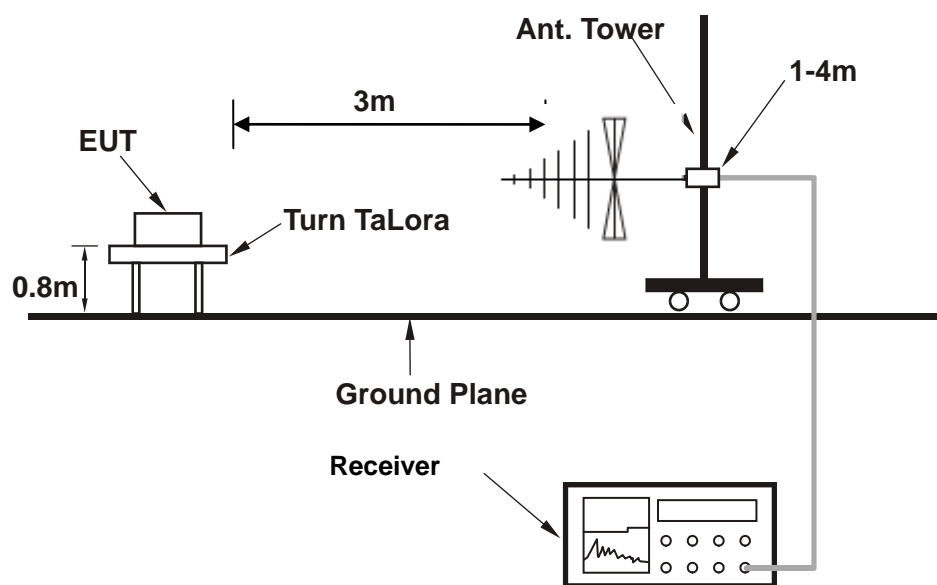
Setup diagram for Conducted Test



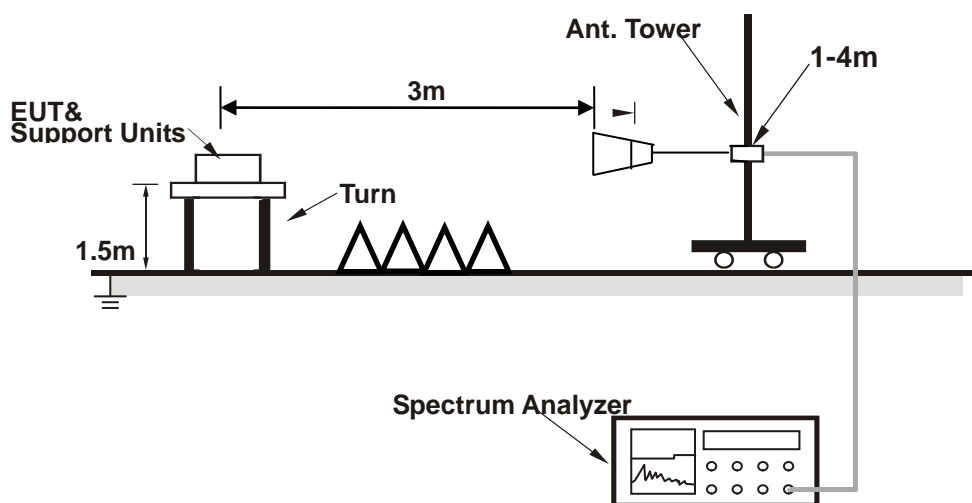
Setup diagram for Raidation(9KHz~30MHz) Test



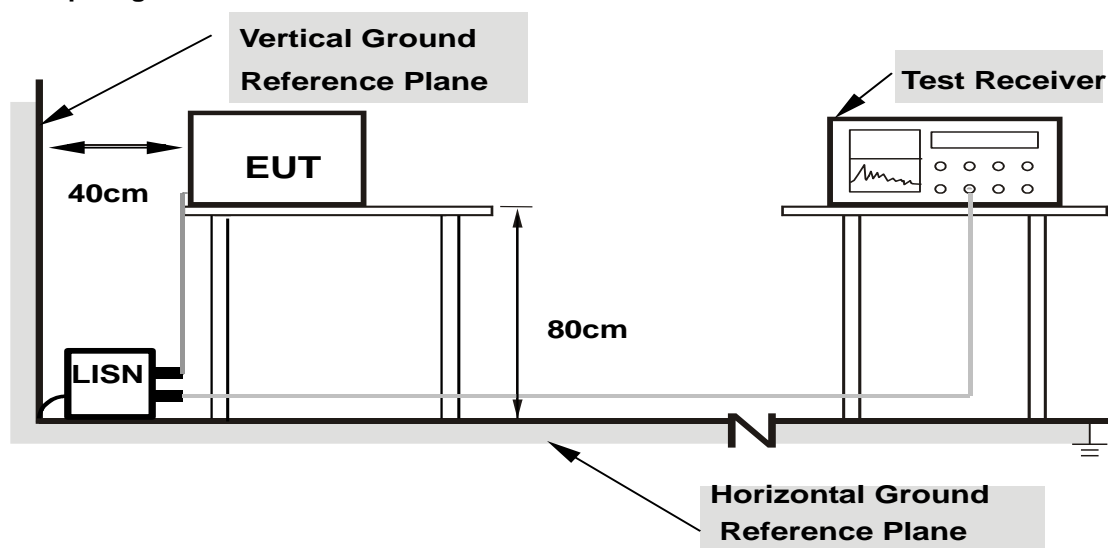
Setup diagram for Raidation(Below 1G) Test



Setup diagram for Raidation(Above1G) Test



Setup diagram for AC Conducted Emission Test



Note: 1.Support units were connected to second LISN.

2.Both of LISNs (AMN) are 80 cm from EUT and at least 80 from other units and other metal planes

3.5 Measurement Results Explanation Example

For all conducted test items:

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

Example:

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

Offset = RF caLora loss + attenuator factor.

Following shows an offset computation example with caLora loss 5 dB and 10dB attenuator.

$$\begin{aligned} \text{Offset(dB)} &= \text{RF caLora loss(dB)} + \text{attenuator factor(dB)}. \\ &= 5 + 10 = 15 \text{ (dB)} \end{aligned}$$

4. Test Result

4.1 6dB and 99% Bandwidth Measurement

4.1.1 Limit of 6dB and 99% Bandwidth

FCC §15.247 (a) (2)

IC RSS-247 5.2(1)

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

4.1.2 Test Procedures

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. Set to the maximum power setting and enable the EUT transmit continuously
4. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. Set the Video bandwidth (VBW) = 300 kHz. In order to make an accurate measurement. The 6 dB bandwidth must be greater than 500 kHz.
5. For 99% Bandwidth Measurement, the spectrum analyzer's resolution bandwidth (RBW) is set 30kHz and set the Video bandwidth (VBW) = 100kHz.

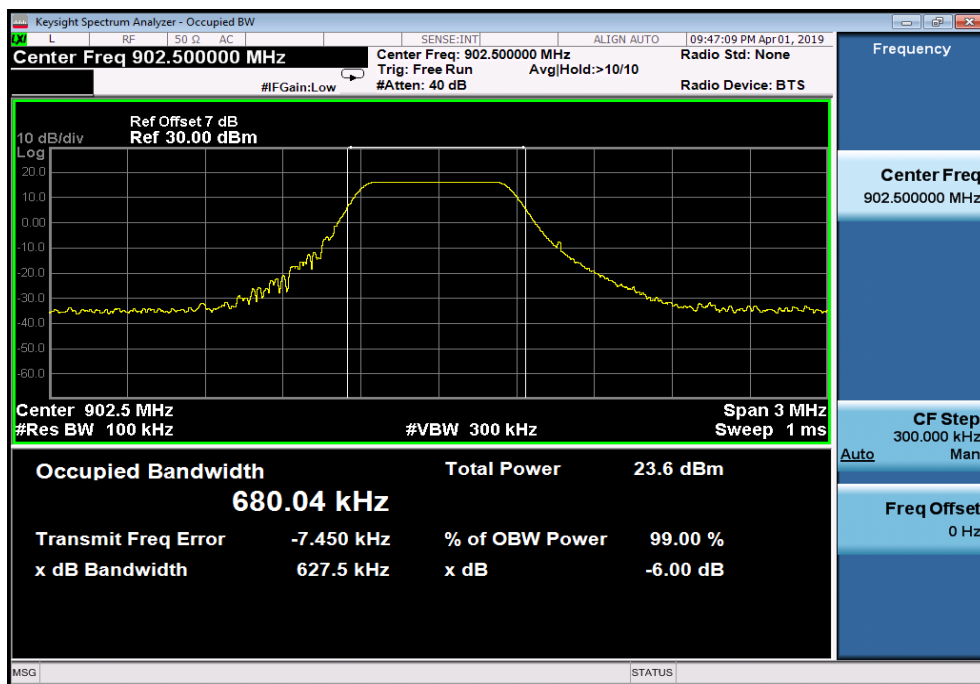
4.1.3 Test Result of 6dB and 99% Bandwidth

Test Mode :		Transmitting	Temperature :	21~24℃	
Test Engineer :		Damon Zhang	Relative Humidity :	60~63%	
Channel	Frequency [MHz]	6dB Bandwidth [MHz]	99% OBW[MHz]	Limit 6dB OBW	Verdict
LCH	902.5	0.6275	0.68004	≥500KHz	PASS
MCH	913.7	0.6267	0.67706	≥500KHz	PASS
HCH	927.0	0.6181	0.66799	≥500KHz	PASS

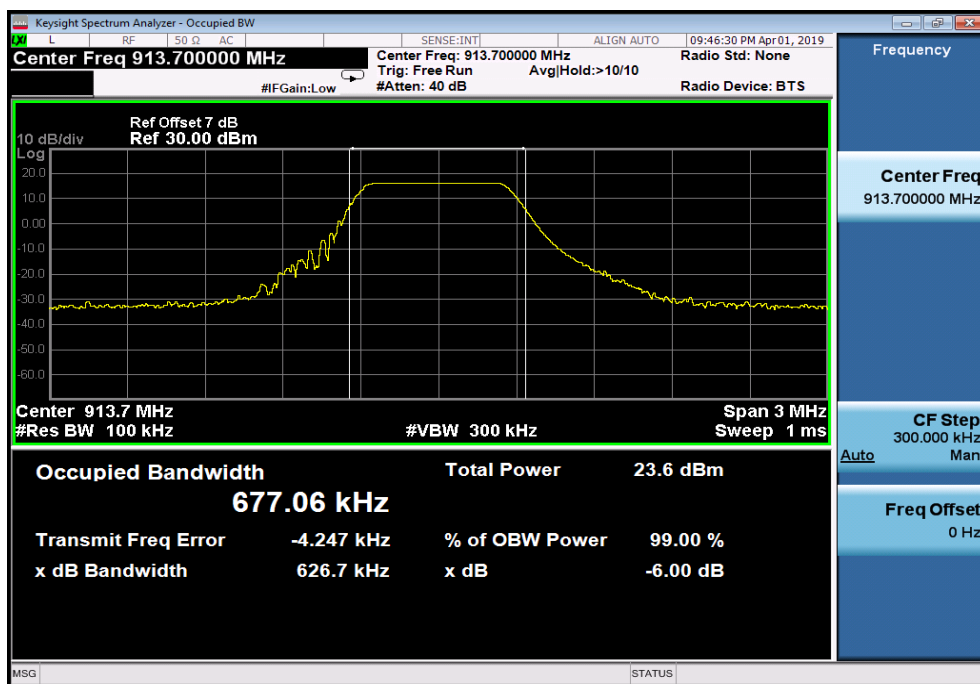
6dB and 99% Bandwidth Plot

Graphs

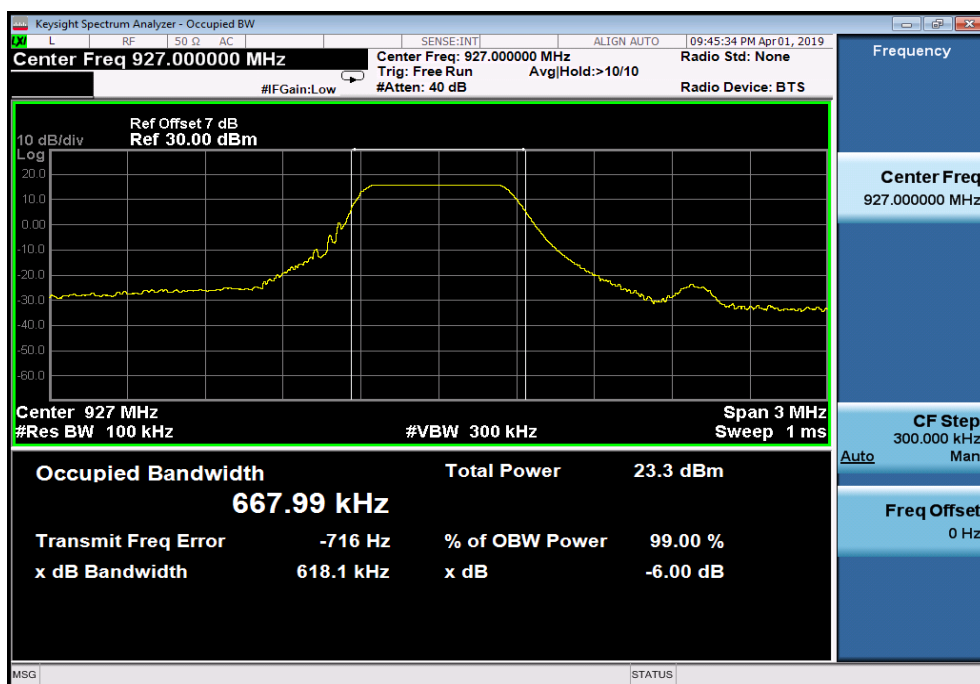
LCH



MCH



HCH



4.2 Peak Output Power Measurement

4.2.1 Limit of Peak Output Power

FCC §15.247 (b)(3)

IC RSS-247 A5.4(4)

For systems using digital modulation in the 2400-2483.5MHz, the limit for peak output power is 30dBm. If transmitting antenna of directional gain greater than 6dBi is used, the peak output power from the intentional radiator shall be reduced below the above stated value by the amount in dB that the directional gain of the antenna exceeds 6 dBi. In case of point-to-point operation, the limit has to be reduced by 1dB for every 3dB that the directional gain of the antenna exceeds 6dBi.

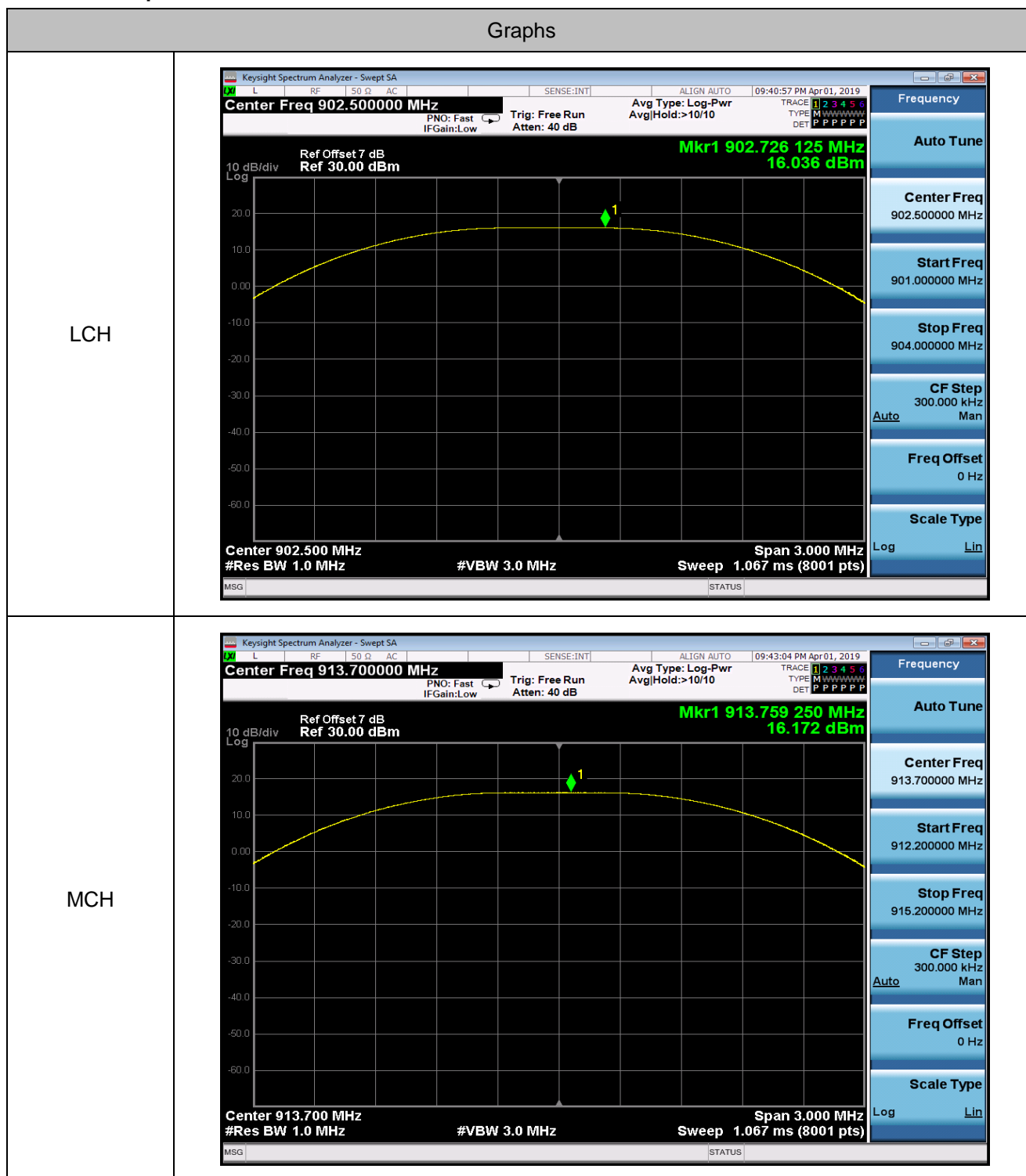
4.2.2 Test Procedures

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to spectrum analyzer.
3. Set to the maximum power setting and enable the EUT transmit continuously
4. Set the RBW \geq DTS Bandwidth, VBW \geq 3*RBW, Span \geq 3*RBW, Detector=Peak, Sweep time=auto couple, Trace mode=max hold.
5. Allow trace to fully stabilize, Use peak marker function to determine the peak amplitude level.
6. Measure the conducted output power

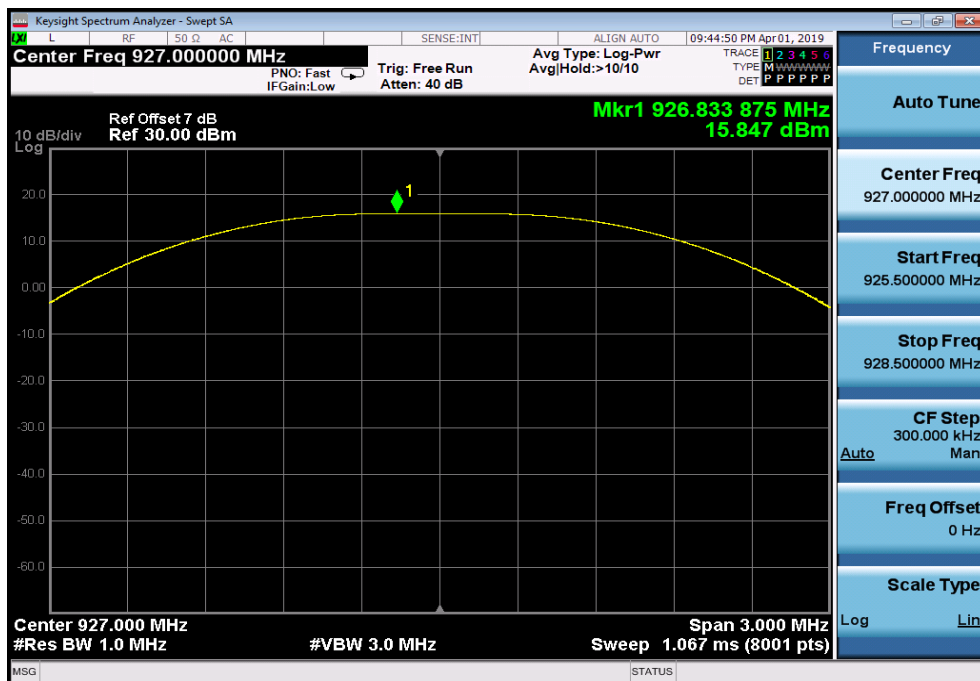
4.2.3 Test Result of Peak Output Power

Test Mode :	Transmitting	Temperature :	21~24℃
Test Engineer :	Damon Zhang	Relative Humidity :	60~63%
Channel	Frequency	Conduct Peak Power[dBm]	Verdict
LCH	902.5	16.036	PASS
MCH	913.7	16.172	PASS
HCH	927.0	15.847	PASS

Peak Output Power Plot



HCH



4.3 Radiated Spurious Emission Measurement

4.3.1 Limit of Radiated Spurious Emission

FCC §15.247 (d)

IC RSS-247 5.5

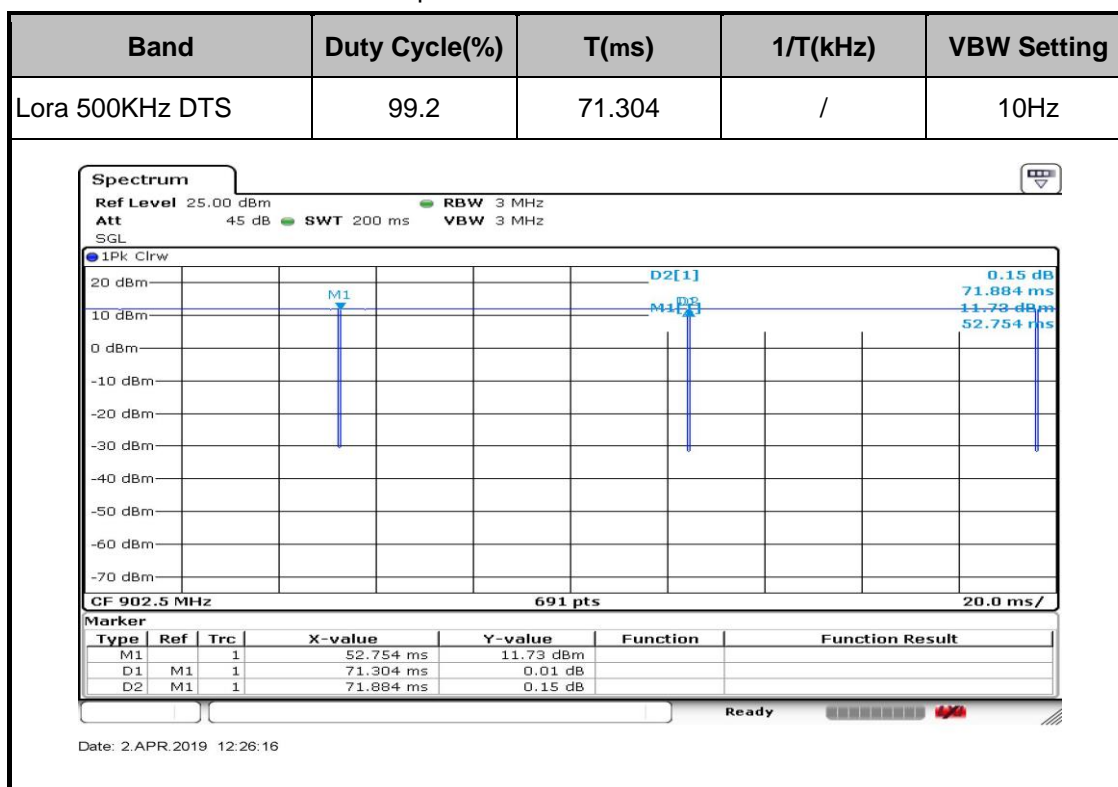
In any 100 kHz bandwidth outside the intentional radiator frequency band, all harmonics/spurious must be at least 20 dB below the highest emission level within the authorized band. In addition, radiated emissions which fall in the restricted bands must also comply with the FCC section 15.209 limits as below.

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 - 960	200	3
Above 960	500	3

Note: The frequency range from 9KHz to 10th harmonic (25GHz) are checked, and no any emissions were found from 18GHz to 25GHz, So the radiated emissions from 18GHz to 25GHz were not record.

4.3.2 Test Procedures

1. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
2. The measurement distance is 3 meter.
3. For each suspected emission, the EUT was arranged to its worst case and then tune the Antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level to comply with the guidelines.
4. Set to the maximum power setting and enable the EUT transmit continuously.
5. Use the following spectrum analyzer settings:
 - (1) Span shall wide enough to fully capture the emission being measured;
 - (2) Set RBW=100 kHz for $f < 1$ GHz, RBW=1MHz for $f > 1$ GHz ; VBW \geq RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak
 - (3) For average measurement:
 VBW = 10 Hz, when duty cycle is no less than 98 percent.
 VBW $\geq 1/T$, when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.



6. Corrected Reading: Antenna Factor + CaLora Loss + Read Level - Preamp Factor = Level

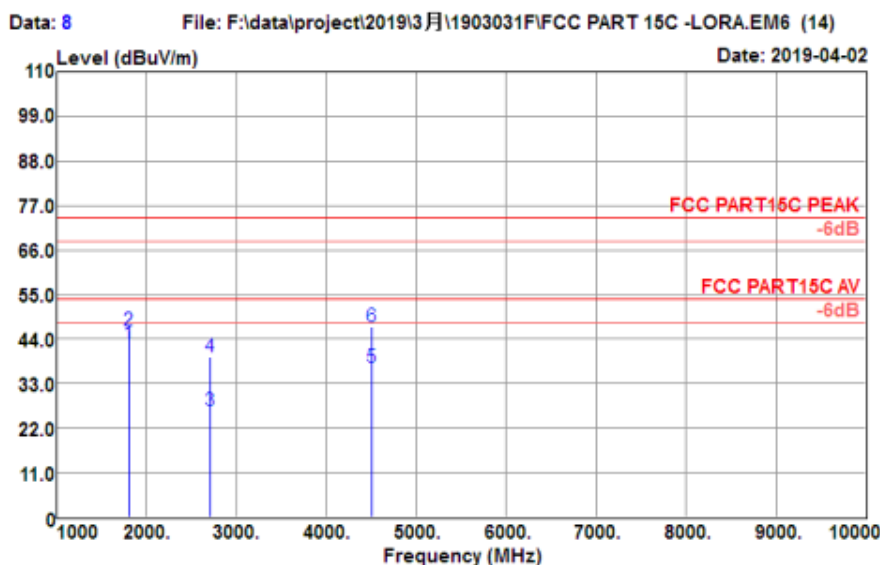
4.3.3 Test Results of Radiated Spurious Emissions (9 kHz ~ 30 MHz)

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line per 15.31(o) was not reported.

4.3.4 Test Result of Radiated Spurious Emission (1GHz ~ 10th Harmonic)

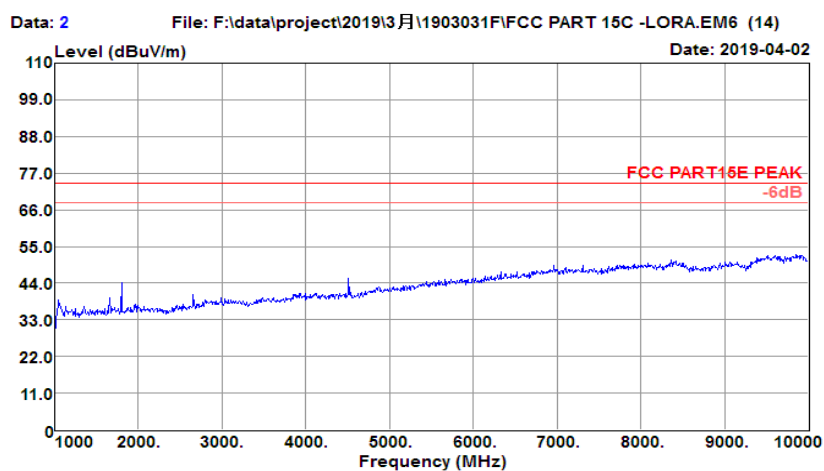
Low Channel Horizontal:

Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating:	DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: HORIZONTAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 902.5MHz		



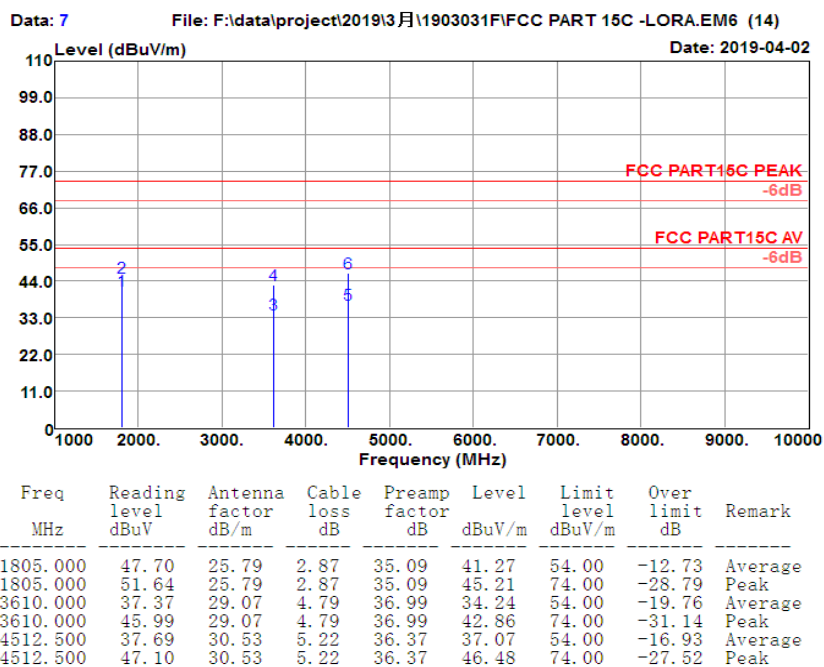
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	Level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
1805.000	49.37	25.79	2.87	35.09	42.94	54.00	-11.06	Average
1805.000	52.51	25.79	2.87	35.09	46.08	74.00	-27.92	Peak
2707.500	31.45	27.94	3.70	36.92	26.17	54.00	-27.83	Average
2707.500	44.73	27.94	3.70	36.92	39.45	74.00	-34.55	Peak
4512.500	37.60	30.53	5.22	36.37	36.98	54.00	-17.02	Average
4512.500	47.80	30.53	5.22	36.37	47.18	74.00	-26.82	Peak

Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating	: DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: HORIZONTAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 902.5MHz		

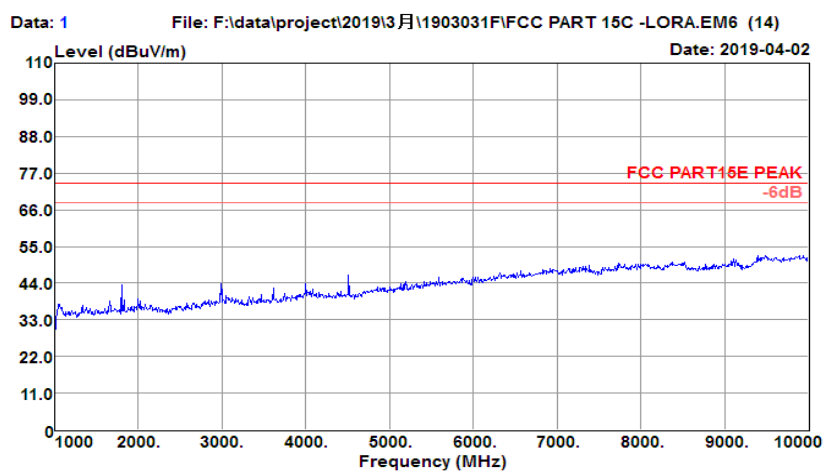


Low Channel Vertical:

Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating:	DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: VERTICAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 902.5MHz		

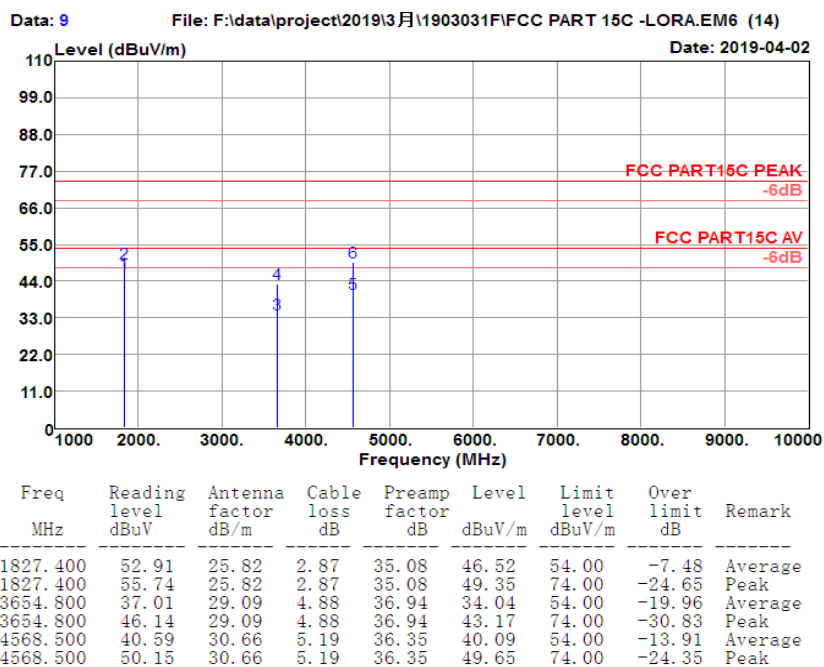


Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating	: DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: VERTICAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 902.5MHz		

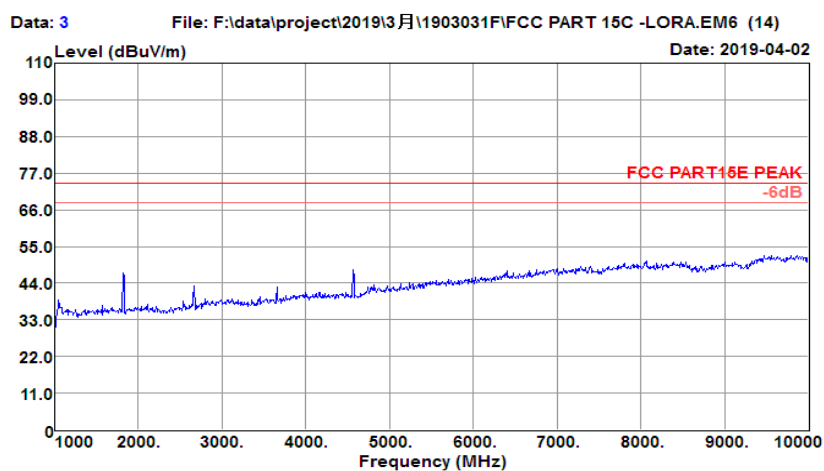


Middle Channel Horizontal:

Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating:	DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: HORIZONTAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 913.7MHz		

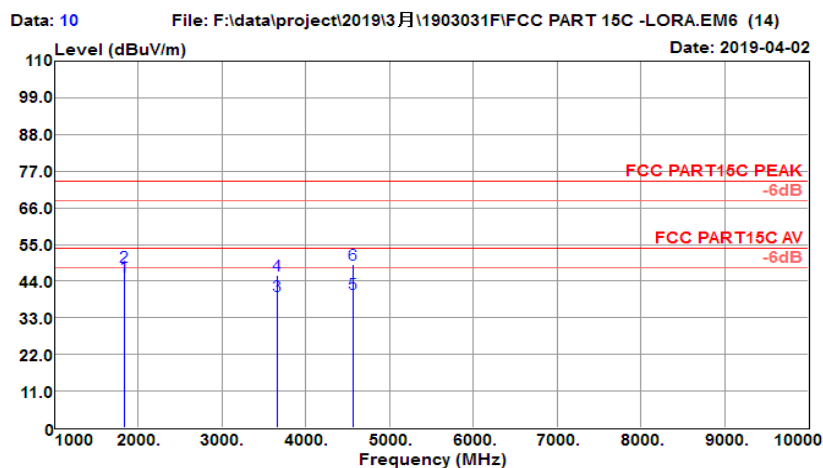


Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating	: DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: HORIZONTAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 913.7MHz		



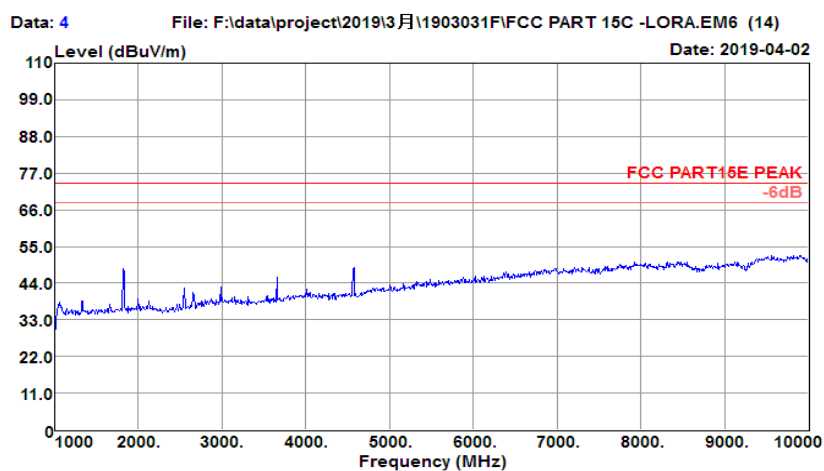
Middle Channel Vertical:

Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating:	DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: VERTICAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 913.7MHz		



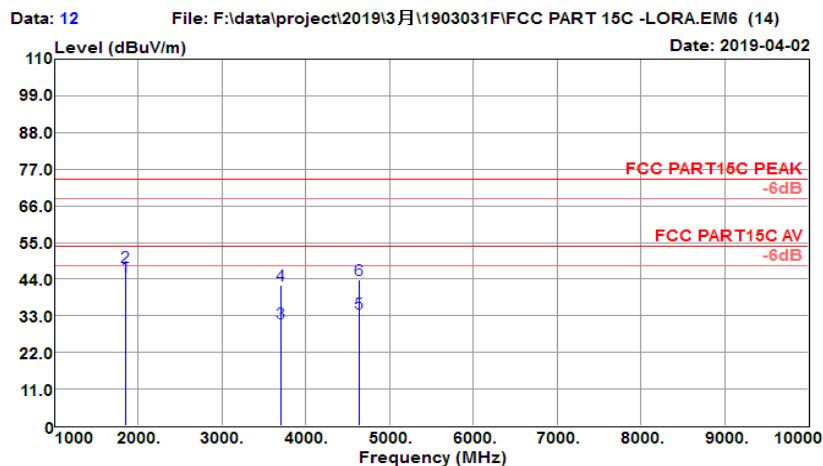
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	Level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
1827.400	51.90	25.82	2.87	35.08	45.51	54.00	-8.49	Average
1827.400	54.85	25.82	2.87	35.08	48.46	74.00	-25.54	Peak
3654.800	42.47	29.09	4.88	36.94	39.50	54.00	-14.50	Average
3654.800	48.89	29.09	4.88	36.94	45.92	74.00	-28.08	Peak
4568.500	40.85	30.66	5.19	36.35	40.35	54.00	-13.65	Average
4568.500	49.36	30.66	5.19	36.35	48.86	74.00	-25.14	Peak

Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating	: DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: VERTICAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 913.7MHz		



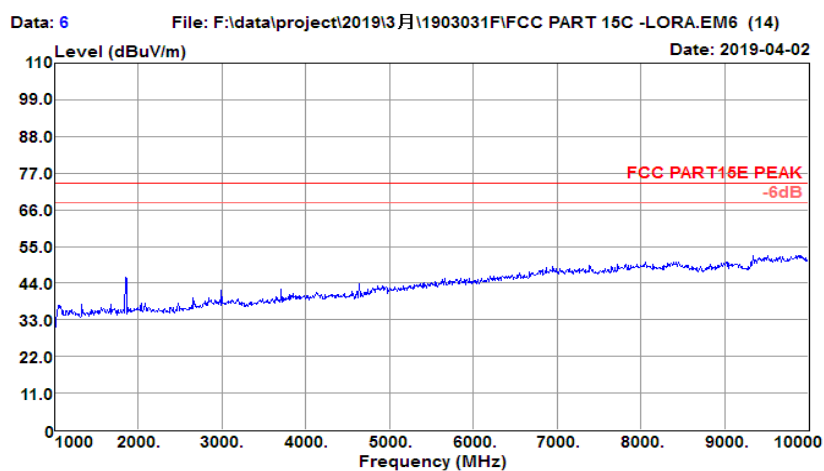
High Channel Horizontal:

Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating:	DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: HORIZONTAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 927MHz		



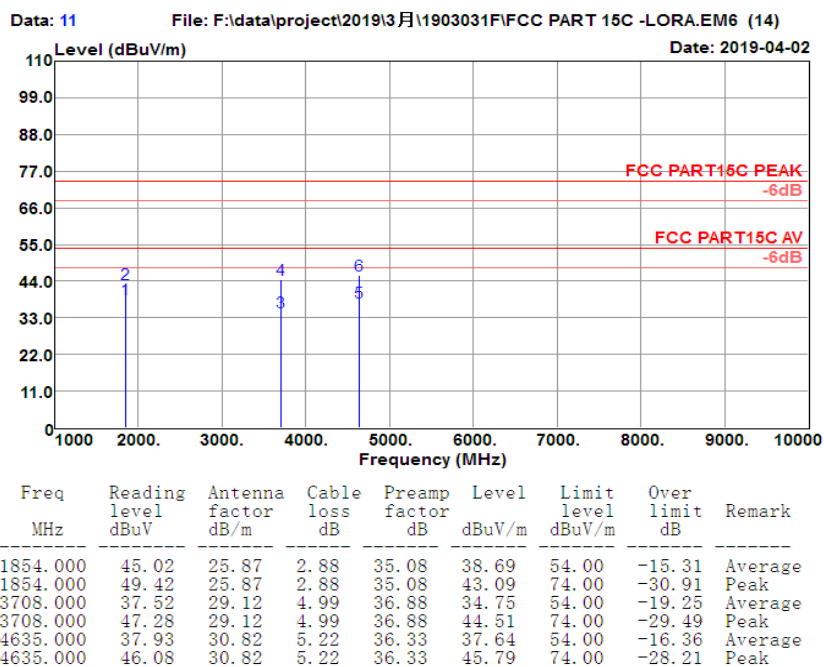
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	Level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
1846.000	51.10	25.85	2.87	35.08	44.74	54.00	-9.26	Average
1846.000	54.19	25.85	2.87	35.08	47.83	74.00	-26.17	Peak
3708.000	33.67	29.12	4.99	36.88	30.90	54.00	-23.10	Average
3708.000	44.92	29.12	4.99	36.88	42.15	74.00	-31.85	Peak
4635.000	34.16	30.82	5.22	36.33	33.87	54.00	-20.13	Average
4635.000	43.96	30.82	5.22	36.33	43.67	74.00	-30.33	Peak

Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating	: DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: HORIZONTAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 927MHz		

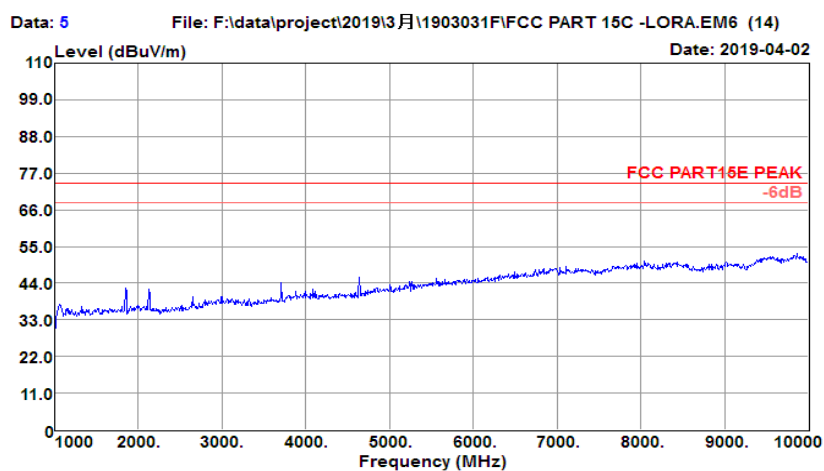


High Channel Vertical:

Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating:	DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: VERTICAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 927MHz		



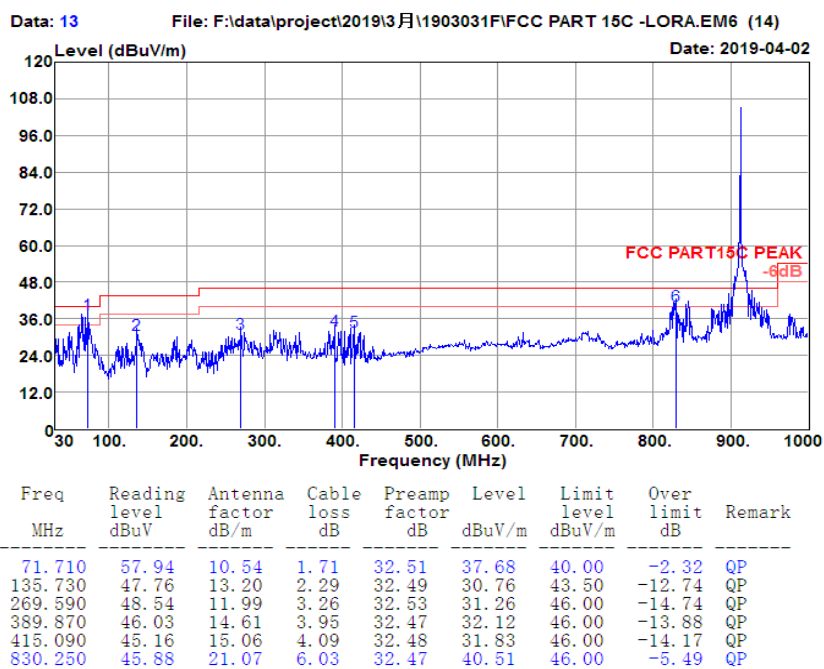
Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating	: DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: VERTICAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 927MHz		



4.3.5 Test Result of Radiated Spurious Emission (30MHz ~ 1GHz)

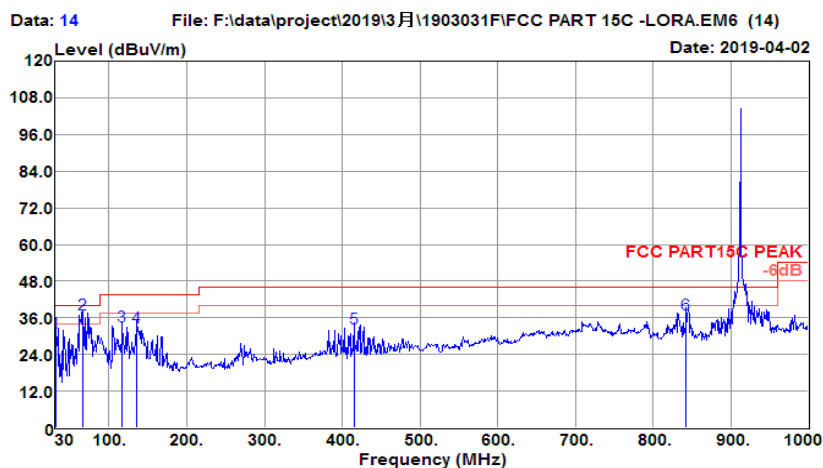
Horizontal:

Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating	: DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: HORIZONTAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 913.7MHz		



Vertical:

Test Site	: 3m Chamber	Temp/Humi	: 18°C/61%
Tested by	: Damon	Power rating	: DC 6V
Model No.	: 5LP1Y8	Pol/Phase	: VERTICAL
EUT	: Pathlight		
Test Mode	: LoRa 500KHz DTS 913.7MHz		



Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	Level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
30.970	49.32	13.24	0.96	32.52	31.00	40.00	-9.00	QP
66.860	56.70	11.40	1.63	32.53	37.20	40.00	-2.80	QP
117.300	51.78	11.93	2.10	32.47	33.34	43.50	-10.16	QP
135.730	50.10	13.20	2.29	32.49	33.10	43.50	-10.40	QP
415.090	45.74	15.06	4.09	32.48	32.41	46.00	-13.59	QP
842.860	42.46	21.19	5.99	32.40	37.24	46.00	-8.76	QP

5. List of Measuring Equipment

Instrument	Manufacturer	Model No.	Serial No.	Calibration Date	Due Date	Remark
Spectrum Analyzer	Keysight	N9010A	MY56070788	2019/1/23	2020/1/22	Conducted
Power Sensor	Keysight	U2021XA	MY56510025	2019/1/23	2020/1/22	Conducted
Power Sensor	Keysight	U2021XA	MY57030005	2019/1/23	2020/1/22	Conducted
Power Sensor	Keysight	U2021XA	MY56510018	2019/1/23	2020/1/22	Conducted
Power Sensor	Keysight	U2021XA	MY56480002	2019/1/23	2020/1/22	Conducted
Thermal Chamber	Sanmtest	SMC-408-CD	2435	2018/7/5	2019/7/4	Conducted
Base Station	R&S	CMW 270	101231	2019/1/23	2020/1/22	Conducted
Signal Generator (Blocker)	Keysight	N5171B	MY56200661	2019/1/23	2020/1/22	Conducted

Instrument	Manufacturer	Model No.	Serial No.	Calibration Date	Due Date	Remark
Spectrum Analyzer	R&S	FSV 40	101433	2019/2/18	2020/2/17	Radiation
Amplifier	Sonoma	310	363917	2019/1/22	2020/1/21	Radiation
Amplifier	Schwarzbeck	BBV 9718	327	2019/1/22	2020/1/21	Radiation
Amplifier	Narda	TTA1840-35-HG	2034380	2018/7/18	2019/7/17	Radiation
Broadband Antenna	Schwarzbeck	VULB 9168	9168-757	2017-03-03	2020-03-02	Radiation
Horn Antenna	Schwarzbeck	BBHA 9120 D	1677	2017-03-03	2020-03-02	Radiation
Horn Antenna	COM-POWER	AH-1840	101117	2018-06-20	2021-06-19	Radiation
Test Software	Auidx	E3	6.111221a	N/A	N/A	Radiation
Filter	Micro-Tronics	BRM 50702	G266	N/A	N/A	Radiation

N/A: No Calibration Required

6. Uncertainty of Evaluation

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

MEASUREMENT	FREQUENCY	UNCERTAINTY
Conducted emissions	9kHz~30MHz	2.64dB
Radiated emission	30MHz ~ 1GMHz	5.05dB
	1GHz ~ 18GHz	5.06 dB
	18GHz ~ 40GHz	3.65dB

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

-----End of the report-----