RADIO TEST REPORT

Product	:	Antenna Transceiver Module
Model Name	:	RYLR998
FCC ID	:	QLYRYLR998
Test Regulation	:	FCC 47 CFR Part 15 Subpart C (Section 15.247)
Received Date	:	2022/4/14
Test Date	:	2022/5/10 ~ 2022/5/20
Issued Date	:	2022/7/26
Applicant	:	REYAX TECHNOLOGY CO.,LTD. 4F.-15, No.26, Ln. 321, Yangguang St., Neihu Dist.Taipei City Taiwan
Issued By	:	Underwriters Laboratories Taiwan Co., Ltd. Building B and Building E, No. 372-7, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County, Taiwan

Testing Laboratory
3398

The results reported herein have been performed in accordance with the laboratory's terms of accreditation. This report shall not be reproduced except in full without the written approval of the Laboratory. The results in this report are responsible of the test sample(s) provided by the client only and are not to be used to indicate applicability to other similar products.

REVISION HISTORY

Original Test Report No.: 4790363992-US-R0-V0

Rev.	Test report No.	Date	Page revised	Contents
Original	4790363992-US-R0-V0	2022/7/26	-	Initial issue

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1. Attestation of Test Results

APPLICANT:	REYAX TECHNOLOGY CO.,LTD. 4F.-15, No.26, Ln. 321, Yangguang St., Neihu Dist.Taipei City Taiwan
MANUFACTURER:	REYAX TECHNOLOGY CO.,LTD. Rm. 1, 6F., No. 5, Ln. 345, Yangguang St., Neihu Dist., Taipei City, Taiwan (R.O.C.)
EUT DESCRIPTION:	Antenna Transceiver Module
BRAND:	REYAX
MODEL:	RYLR998
SAMPLE STAGE:	Mass-Production
DATE of TESTED:	2022/5/10 ~ 2022/5/20

APPLICABLE STANDARDS

STANDARD	Test Results
FCC 47 CFR PART 15 Subpart C (Section 15.247)	PASS

Underwriters Laboratories Taiwan Co., Ltd. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by Underwriters Laboratories Taiwan Co., Ltd. based on interpretations and/or observations of test results. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by Underwriters Laboratories Taiwan Co., Ltd. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by Underwriters Laboratories Taiwan Co., Ltd. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

Prepared By:

Cindy Hsin Date : 2022/7/26
Project Handler

Approved and Authorized By:

Kent Liu Date : 2022/7/26
Senior Laboratory Engineer

2. Summary of Test Results

Summary of Test Results		
FCC Clause	**Test Items**	**Result**
15.247(a)(1) (iii)	Number of Hopping Frequency Used	PASS
15.247(a)(1) (iii)	Dwell Time on Each Channel	PASS
15.247(a)(1)	1. Hopping Channel Separation 2. Spectrum Bandwidth of a Frequency Hopping Sequence Spread Spectrum System	PASS
15.247(b)	Conducted Output Power	PASS
15.247(d)	Antenna Port Emission	PASS
15.205 / 15.209 / 15.247(d)	Radiated Emissions and Band Edge Measurement	PASS
15.207	AC Power Conducted Emission	PASS
15.203	Antenna Requirement	PASS

3. Test Methodology and Reference Procedures

The tests documented in this report were performed in accordance with 47 CFR FCC Part 2, KDB558074 D01 Meas Guidance v05r02, KDB414788 D01 Radiated Test Site v01r01, ANSI C63.10-2013.

4. Facilities and Accreditation

Test Location	Underwriters Laboratories Taiwan Co., Ltd.
Address	Building B and Building E, No. 372-7, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County, Taiwan
Accreditation Certificate	Underwriters Laboratories Taiwan Co., Ltd. is accredited by TAF, Laboratory Code 3398.

5. Measurement Uncertainty

For statement of conformity, accuracy method (Section 8.2.4 and 8.2.5 of ISO Guide 98-4) was applied as decision rule for measurement in this test report.

The following uncertainties have been calculated to provide a confidence level of 95 % using a coverage factor k=2.

Measurement	Frequency	Uncertainty
Conducted disturbance at mains terminals ports	150kHz ~ 30MHz	±2.9 dB
RF Conducted	9 kHz - 40GHz	±2.4 dB
Radiated disturbance below 30MHz	9 kHz - 30 MHz	±1.9 dB
Radiated disturbance below 1 GHz	30MHz ~ 1GHz	±5.8 dB
Radiated disturbance above 1 GHz	1GHz ~ 40GHz	±4.8 dB

6. Equipment under Test

6.1. Description of EUT

Product	Antenna Transceiver Module
Brand Name	REYAX
Model Name	RYLR998
Operating Frequency	902.3MHz ~ 927.9MHz
Modulation	CSS
Transfer Rate	Up to 50 kbps
Number of Channel	129
Maximum Output Power	20.84 dBm
Normal Voltage	3.3Vdc
Sample ID	Conducted Test: 4862516 Radiated Test: 4862518

Note:

1. The above EUT information is declared by manufacturer and for more detailed features description, please refer the manufacturer's or user's manual.

6.2. Channel List

129 channels are provided for LoRa mode:

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	902.3	34	909.1	68	915.9	102	922.7
1	902.5	35	909.3	69	916.1	103	922.9
2	902.7	36	909.5	70	916.3	104	923.1
3	902.9	37	909.7	71	916.5	105	923.3
4	903.1	38	909.9	72	916.7	106	923.5
5	903.3	39	910.1	73	916.9	107	923.7
6	903.5	40	910.3	74	917.1	108	923.9
7	903.7	41	910.5	75	917.3	109	924.1
8	903.9	42	910.7	76	917.5	110	924.3
9	904.1	43	910.9	77	917.7	111	924.5
10	904.3	44	911.1	78	917.9	112	924.7
11	904.5	45	911.3	79	918.1	113	924.9
12	904.7	46	911.5	80	918.3	114	925.1
13	904.9	47	911.7	81	918.5	115	925.3
14	905.1	48	911.9	82	918.7	116	925.5
15	905.3	49	912.1	83	918.9	117	925.7
16	905.5	50	912.3	84	919.1	118	925.9
17	905.7	51	912.5	85	919.3	119	926.1
18	905.9	52	912.7	86	919.5	120	926.3
19	906.1	53	912.9	87	919.7	121	926.5
20	906.3	54	913.1	88	919.9	122	926.7
21	906.5	55	913.3	89	920.1	123	926.9
22	906.7	56	913.5	90	920.3	124	927.1
23	906.9	57	913.7	91	920.5	125	927.3
24	907.1	58	913.9	92	920.7	126	927.5
25	907.3	59	914.1	93	920.9	127	927.7
26	907.5	60	914.3	94	921.1	128	927.9
27	907.7	61	914.5	95	921.3		
28	907.9	62	914.7	96	921.5	-	-
29	908.1	63	914.9	97	921.7	-	-
30	908.3	64	915.1	98	921.9	-	-
31	908.5	65	915.3	99	922.1	-	-
32	908.7	66	915.5	100	922.3	-	-
33	908.9	67	915.7	101	922.5	-	-

6.3. Test Condition

Test Item	Test Site No.	Environmental Condition	Input Power	Test Date	Tested by
Antenna Port Conducted Measurement	SR4	22~24°C/ 65~69%RH	3.3Vdc from Test Tool	2022/05/10~ 2022/05/20	WaterNil Guan
Radiated Spurious Emission	966-2	22~26°C/ 62~68%RH	3.3Vdc from Test Tool	2022/05/17~ 2022/05/20	WaterNil Guan
AC power Line Conducted Emission	SR1	23.2~26°C/ 66.8~68%RH	120Vac/ 60Hz	2022/05/20~ 2022/05/20	WaterNil Guan

FCC Test Firm Registration Number: 498077

6.4. Description of Available Antennas

Ant. No.	Brand Name	Model Name	Ant. Type	Maximum Gain (dBi)
1	REYAX	RYAI915	Spring	2

Note: The above antenna information was provided from customer and for more detailed features description, please refer the manufacturer's specification or user's manual.

6.5. Test Mode Applicability and Tested Channel Detail

- The fundamental of the EUT was investigated in three orthogonal axes X-Y/Y-Z/X-Z, it was determined that X-Y plane was worst-case. Therefore, all final radiated testing was performed with the EUT in X-Y plane.
- For below 1 GHz radiated emission and AC power line conducted emission have performed all modes of operation were investigated and the worst-case emissions are reported.
- Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

Test item	Modulation Type	Available Channel	Test Channel	Packet Type
Radiated Emissions (Above 1GHz)	LoRa	0 to 128	0,64,128	LoRa
Radiated Emissions (Below 1GHz)	LoRa	0 to 128	0,64,128	LoRa
AC Power Line Conducted Emission	LoRa	0 to 128	0	LoRa
Antenna Port Conducted Measurement	LoRa	0 to 128	0,64,128	LoRa

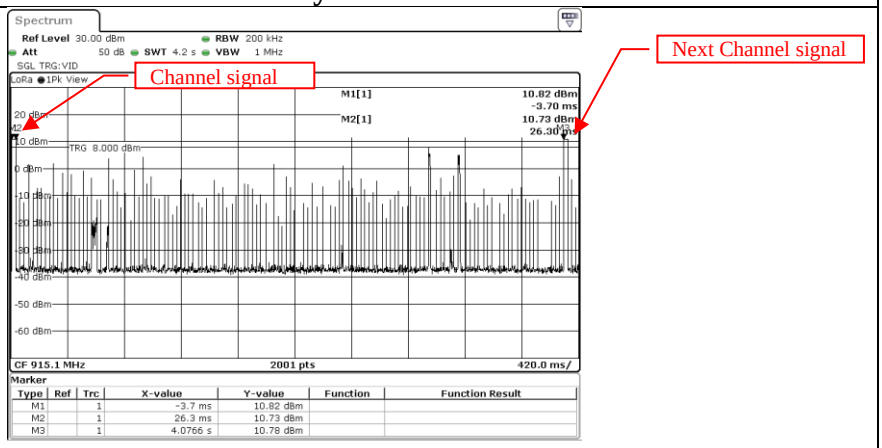
6.6. Duty cycle

Mode	On Time (ms)	On+Off Time (ms)	Duty Cycle
LoRa	30.000	4080.300	0.01

Duty Cycle Correction Factor for radiated spurious emission average value is
= 20 Log*[1/ (Ton/Ton+Toff)]
= 20 Log*[1/ (30/100)]
= 10.46 dB

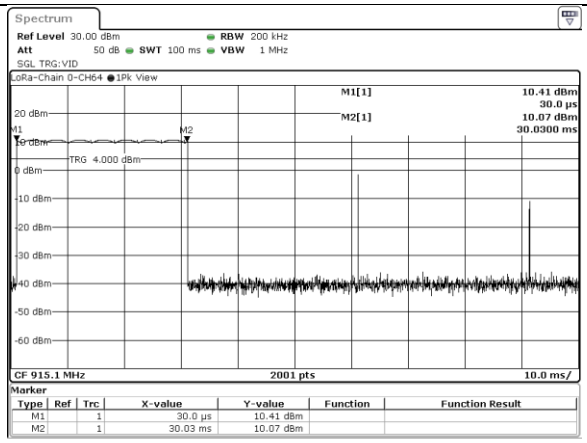
Note: Maximum Ton+Toff should less than 100ms.

Duty



*Others are adjacent channels signals

on time



7. Test Equipment

Test Equipment List					
Equipment	**Manufacturer**	**Model No.**	**Serial No.**	**Cal. Date**	**Expired date**
Radiated Spurious Emission					
Spectrum Analyzer	Keysight	N9010A	MY56070827	2021/11/9	2022/11/8
EMI Test Receiver	Rohde & Schwarz	ESR7	101754	2021/12/10	2022/12/9
Loop Antenna	ETS lindgren	6502	00213440	2021/12/23	2022/12/22
Trilog-Broadband Antenna with 5dB Attenuator	Schwarzbeck & EMCI	VULB 9168 & N-6-05	774 & AT-N0538	2022/2/8	2023/2/7
Horn Antenna (1-18 GHz)	Schwarzbeck	BBHA 9120 D	01690	2021/12/13	2022/12/12
Horn Antenna (18-40 GHz)	Schwarzbeck	BBHA 9170	781	2021/12/17	2022/12/16
Preamplifier (30-1000 MHz)	EMCI	EMC330E	980405	2021/6/8	2022/6/7
Preamplifier (1-18 GHz)	EMCI	EMC051835BE	980406	2022/2/16	2023/2/15
Preamplifier (18-40GHz)	EMCI	EMC184045SE	980408	2022/3/9	2023/3/8
Cables	Hanyitek	K1K50-UP0264-K1K50-2500	170214-4 & 170425-2	2021/12/3	2022/12/2
Cables	Hanyitek	K1K50-UP0264-K1K50-2500	170214-1 & 170214-2	2021/12/3	2022/12/2

Test Equipment List					
Equipment	**Manufacturer**	**Model No.**	**Serial No.**	**Cal. Date**	**Expired date**
Antenna Port Conducted Measurement					
Spectrum Analyzer	Rohde & Schwarz	FSV40	101490	2021/9/7	2022/9/6
Pulse Power Sensor	Anritsu	MA2411B	1531202	2021/12/22	2022/12/21
Power Meter	Anritsu	ML2495A	1645002	2021/12/22	2022/12/21
AC power Line Conducted Emission					
EMI Test Receiver	Rohde & Schwarz	ESR7	101753	2021/11/15	2022/11/14
Two-Line V-Network	Rohde & Schwarz	ENV216	102136	2021/8/30	2022/8/29
Impuls-Begrenzer Pulse Limiter	Rohde & Schwarz	ESH3-Z2	102219-Qt	2021/8/26	2022/8/25
Cables	TITAN	CFD200	T0732ACFD20020A300-1	2022/3/16	2023/3/15

UL Software		
Description	**Name**	**Version**
Radiated measurement	e3	6.191211 (V6)
Conducted measurement	RF Conducted Test Tools	ver 2.4.0.620b
AC power Line Conducted Emission	EZ_EMC	UL-3A1.2

8. Description of Test Setup

Support Equipment

ID	Equipment	Brand Name	Model Name	S/N	Remark
A	Laptop	DELL	Latitude E5470	5M2MWF2	Provided by Lab
B	CP2102 USB to TTL USB (Test Tool)	SiLab	CP2102	NA	Supplied by client

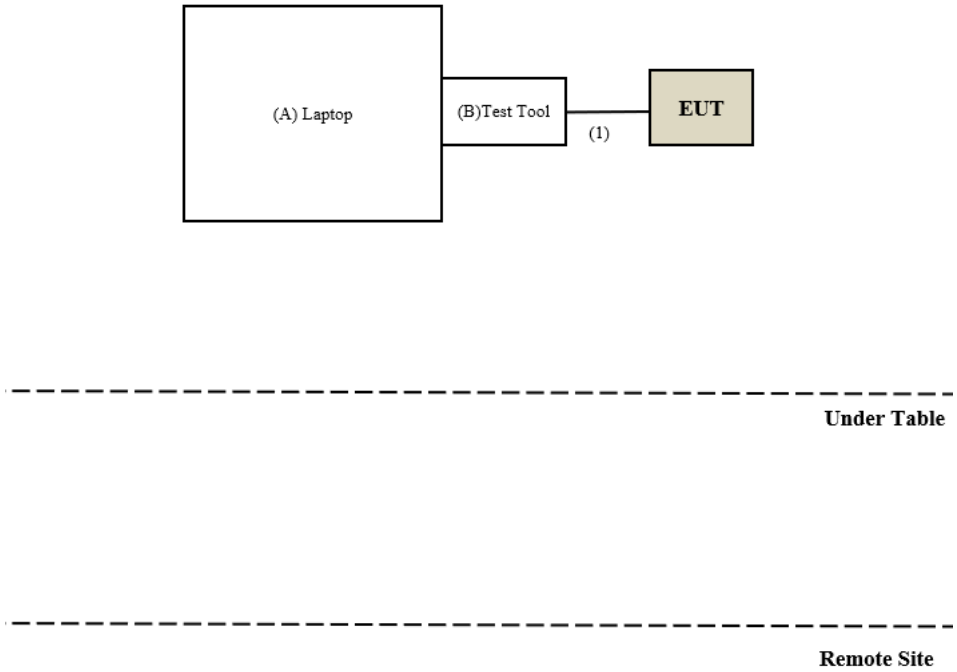
I/O Cables

ID	Equipment	Brand Name	Model Name	Length (m)	Remark
1	Dupont Line	Yi Yang	1046C-10	0.2	Supplied by client

Test Setup

Controlled using a bespoke application (QCOM_V1.6(15.01.16.10.00) & XCOM_V2.2) on a test Notebook. The application was used to enable a continuous transmission mode and to select the test channels, data rates, modulation schemes and power setting as required.

Setup Diagram for Test



9. Test Results

9.1. Channel Bandwidth

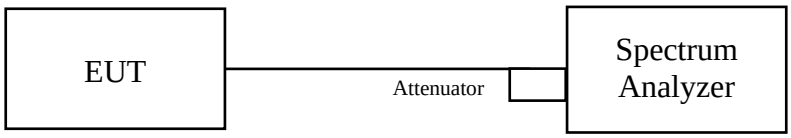
Requirements

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Test procedure

a. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
c. Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.
d. Repeat above procedures until all frequencies measured were complete.

Test Setup

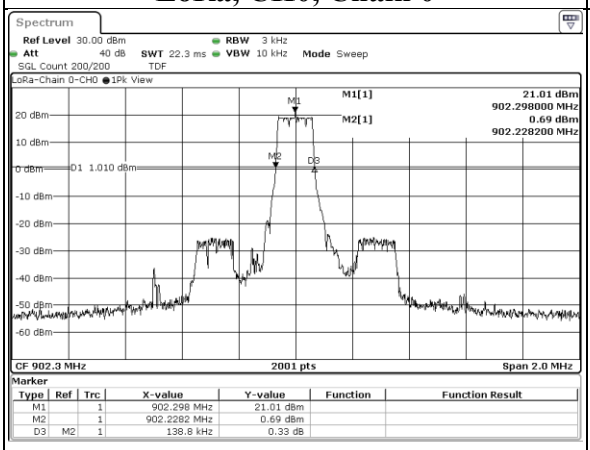


The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

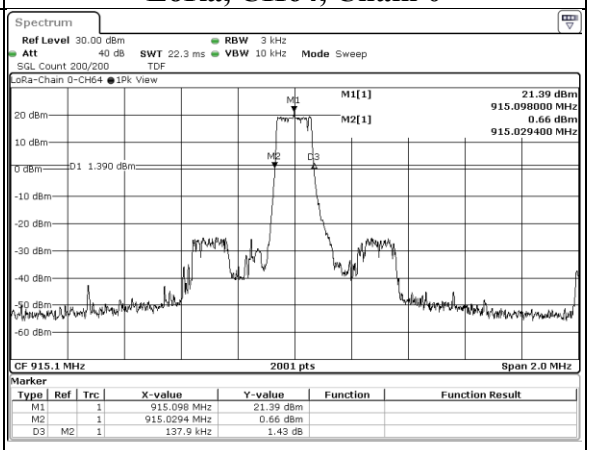
Test Data

Mode	CH	Freq (MHz)	20dB BW (MHz)	Limit (MHz)	Result
LoRa	0	902.3	0.139	N/A	Pass
LoRa	64	915.1	0.138	N/A	Pass
LoRa	128	927.9	0.170	N/A	Pass

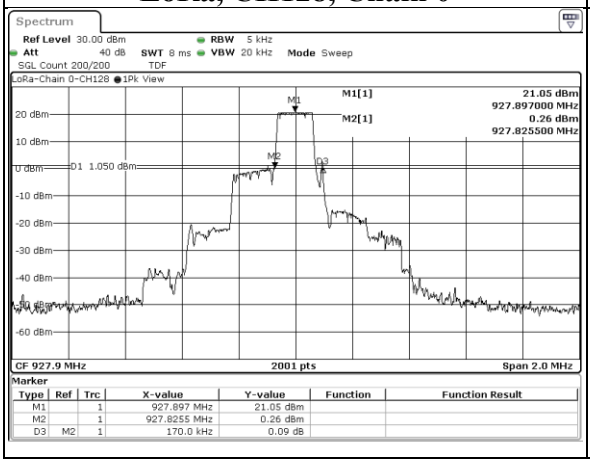
LoRa, CH0, Chain 0



LoRa, CH64, Chain 0



LoRa, CH128, Chain 0



9.2. Conducted Output Power

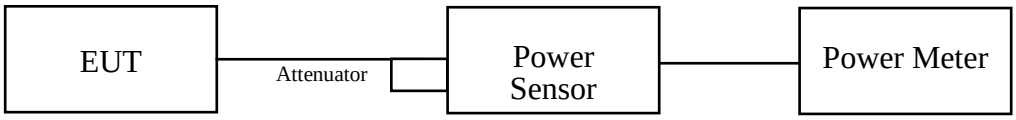
Requirements

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels.

Test Procedure

A peak power sensor was used on the output port of the EUT. A power meter was used to read the response of the peak power sensor. Record the power level.

Test Setup



The loss between RF output port of the EUT and the input port of the Power Meter has been taken into consideration.

Test Data

Peak Power

LoRa

Channel	Frequency (MHz)	Peak Power (mW)	Peak Power (dBm)	Limit (dBm)	Pass/Fail
0	902.3	121.339	20.84	30	PASS
64	915.1	118.032	20.72	30	PASS
128	927.9	113.24	20.54	30	PASS

Average Power (Reference Only)

LoRa

Channel	Frequency (MHz)	Average Power (mW)	Average Power (dBm)
0	902.3	119.674	20.78
64	915.1	116.681	20.67
128	927.9	111.173	20.46

9.3. Hopping Channel Separation

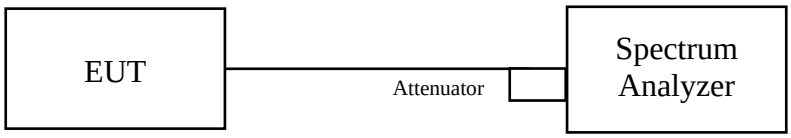
Requirements

At least 25kHz or 20dB hopping channel bandwidth (whichever is greater).

Test procedure

a. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range.
c. By using the MaxHold function record the separation of two adjacent channels.
d. Measure the frequency difference of these two adjacent channels by SA MARK function. And then plot the result on SA screen.

Test Setup

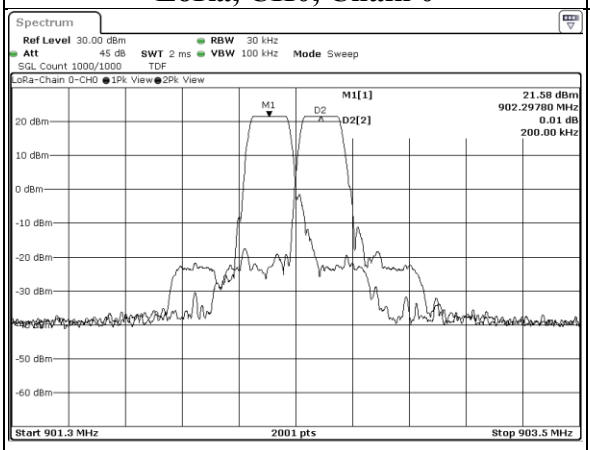


The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

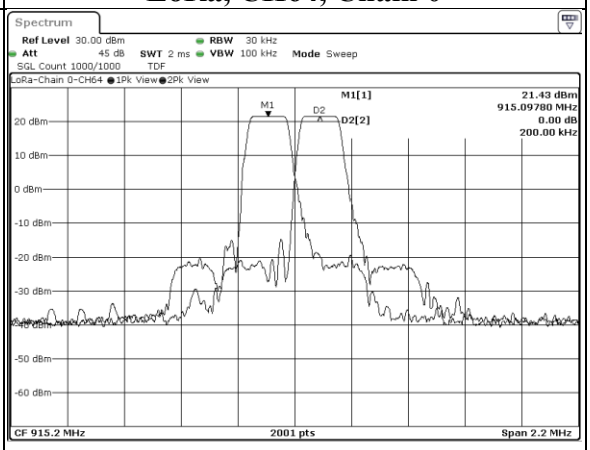
Test Data

Mode	CH	Freq (MHz)	Channel Separation (MHz)	> Limit (MHz)
LoRa	0	902.3	0.2	0.139
LoRa	64	915.1	0.2	0.138
LoRa	128	927.9	0.2	0.170

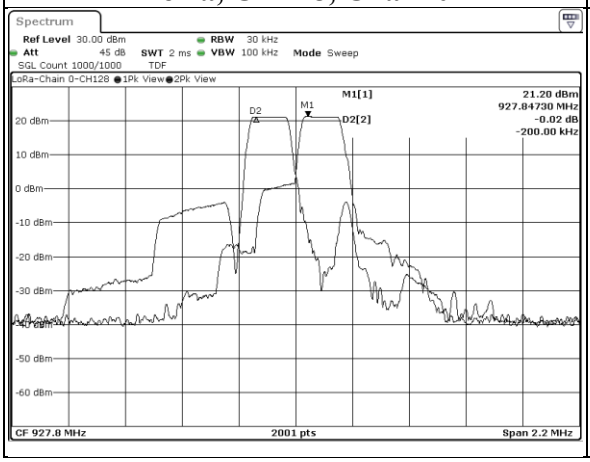
LoRa, CH0, Chain 0



LoRa, CH64, Chain 0



LoRa, CH128, Chain 0



9.4. Number of Hopping Frequency Used

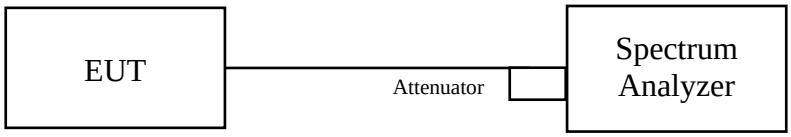
Requirements

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Test procedure

a. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
b. Turn on the EUT and connect its antenna terminal to measurement via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
c. Set the SA on MaxHold Mode, and then keep the EUT in hopping mode. Record all the signals from each channel until each one has been recorded.
d. Set the SA on View mode and then plot the result on SA screen.
e. Repeat above procedures until all frequencies measured were complete.

Test Setup

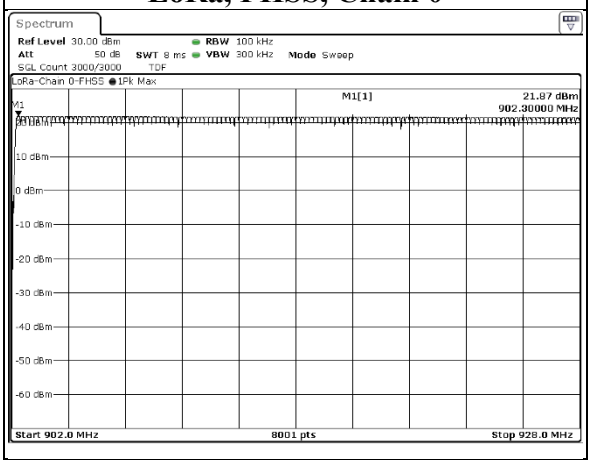


The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

Test Data

There are 129 hopping frequencies in the hopping mode. On the plots, it shows that the hopping frequencies are equally spaced.

LoRa, FHSS, Chain 0



9.5. Dwell Time on Each Channel

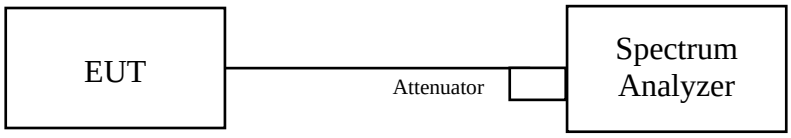
Requirements

The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period.

Test procedure

a. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
b. Turn on the EUT and connect its antenna terminal to measurement via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
c. Adjust the center frequency of SA on any frequency be measured and set SA to zero span mode. And then, set RBW and VBW of spectrum analyzer to proper value.
d. Measure the time duration of one transmission on the measured frequency. And then plot the result with time difference of this time duration.
e. Repeat above procedures until all different time-slot modes have been completed.
f. Measure the maximum time duration of one single pulse.

Test Setup



The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

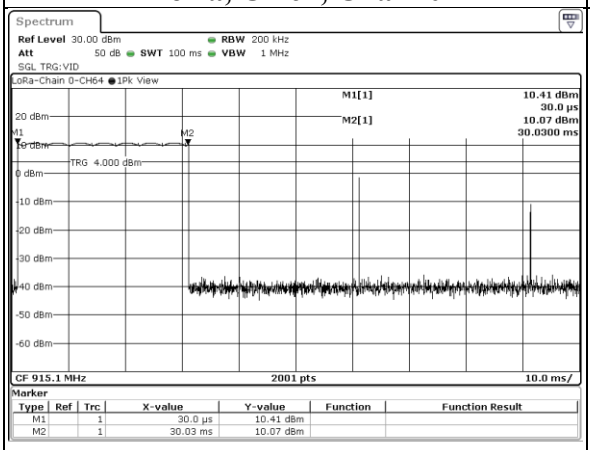
Test Data

Mode	Freq (MHz)	Length of transmission time (ms)	Dwell Time in 20s (ms)	Limit (ms)	Result
LoRa	915.1	30.000	150.000	400	Pass

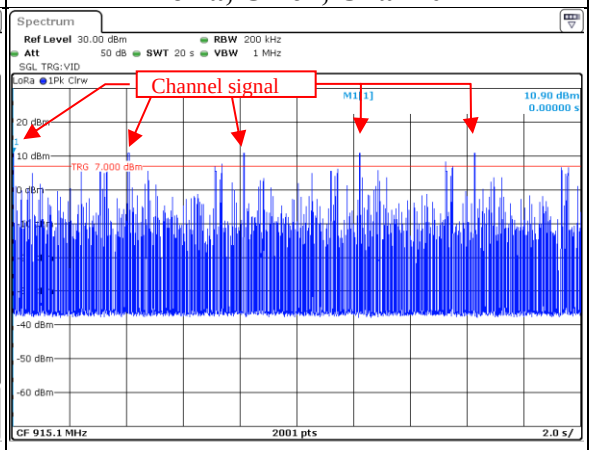
For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period;

Number of burst in 20 second period = 5
One burst time = 30ms
Dwell Time = 5 x 30 = 150 ms

LoRa, CH64, Chain 0



LoRa, CH64, Chain 0



*Others are adjacent channels signals

9.6. Conducted Out of Band Emission

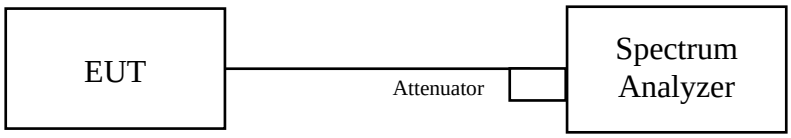
Requirements

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.

Test procedure

The transmitter output was connected to the spectrum analyzer via a low lose cable. Set both RBW and VBW of spectrum analyzer to 100 kHz and 300 kHz with suitable frequency span including 100 MHz bandwidth from band edge. The band edges was measured and recorded.

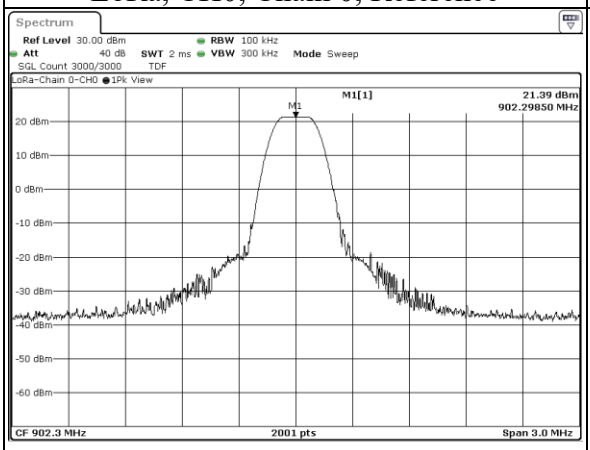
Test Setup



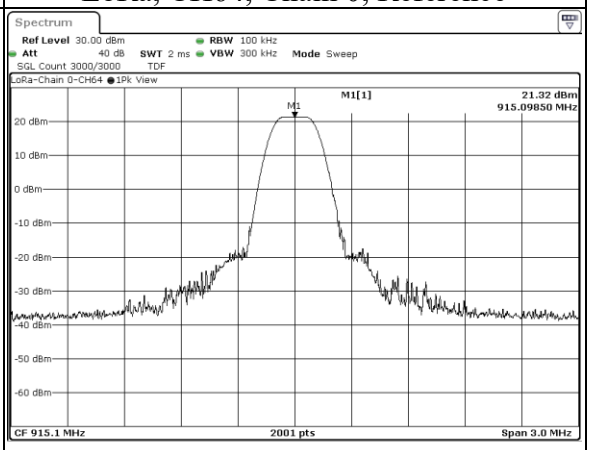
The loss between RF output port of the EUT and the input port of the Spectrum Analyzer has been taken into consideration.

Test Data

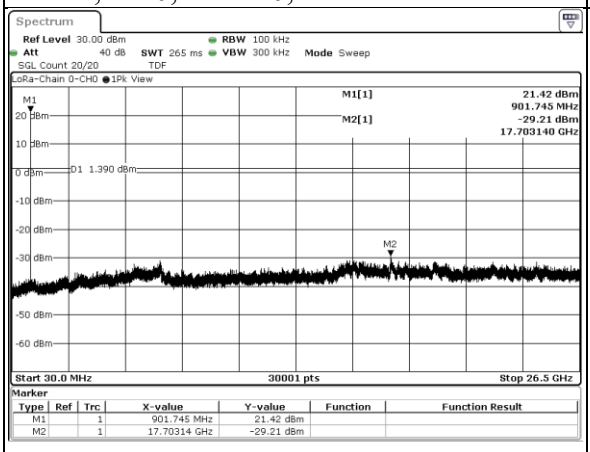
LoRa, CH0, Chain 0, Reference



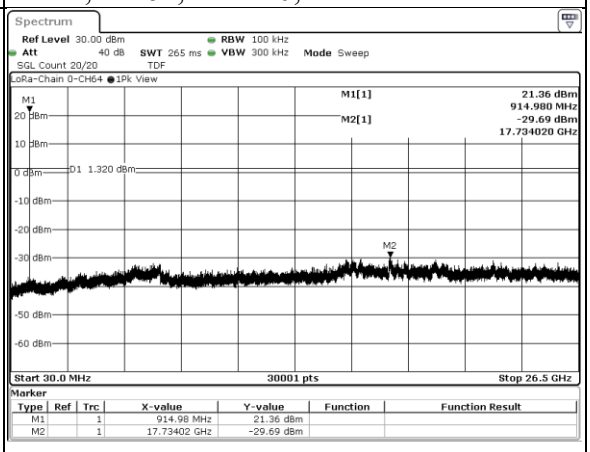
LoRa, CH64, Chain 0, Reference



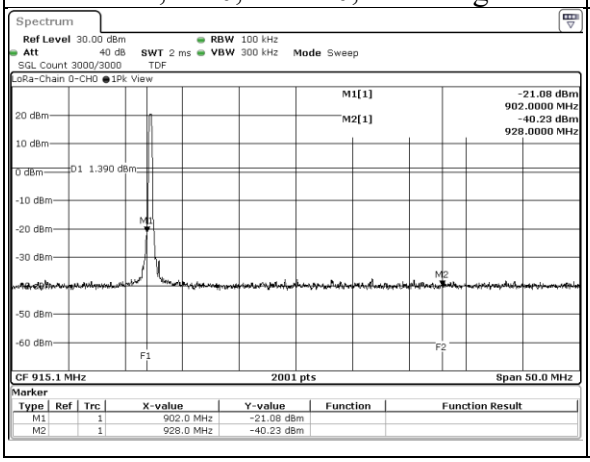
LoRa, CH0, Chain 0, Conducted Emission



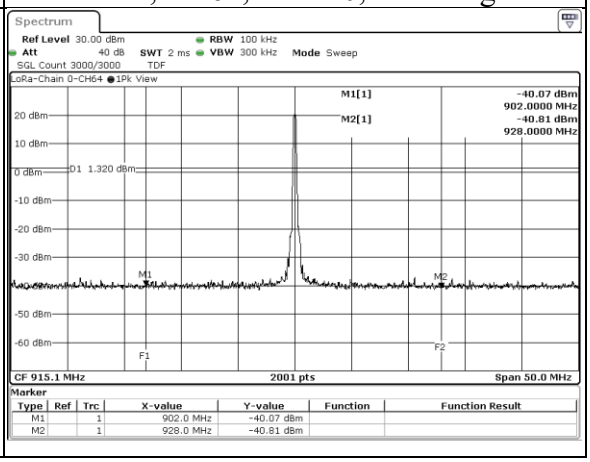
LoRa, CH64, Chain 0, Conducted Emission



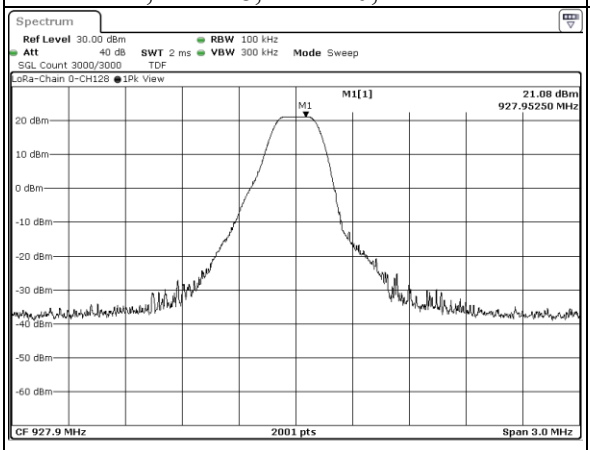
LoRa, CH0, Chain 0, Band edge



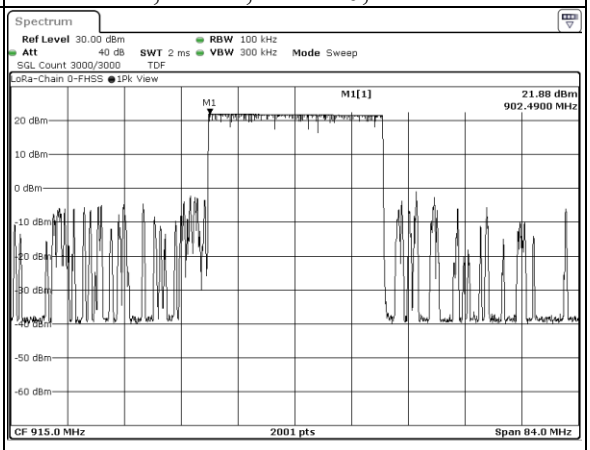
LoRa, CH64, Chain 0, Band edge



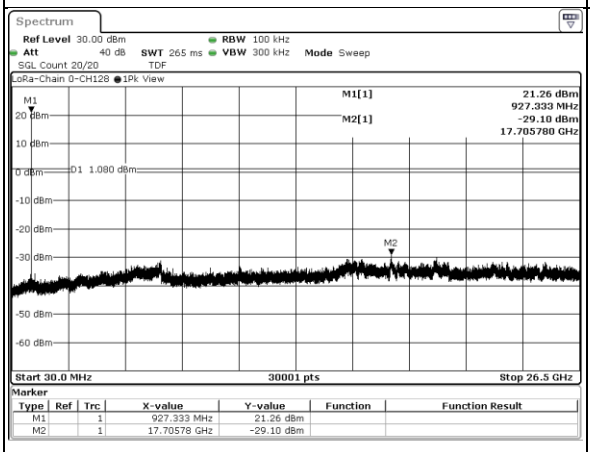
LoRa, CH128, Chain 0, Reference



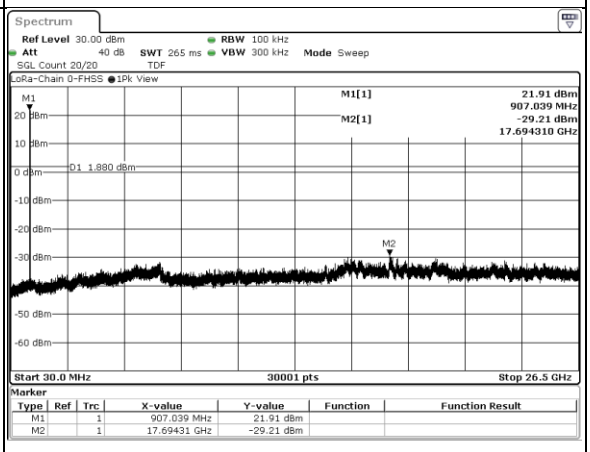
LoRa, FHSS, Chain 0, Reference



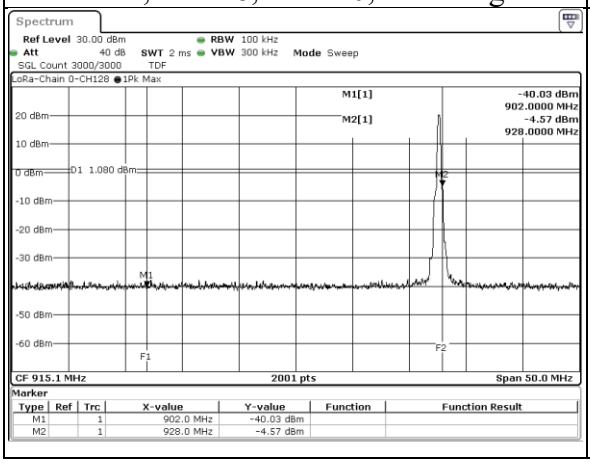
LoRa, CH128, Chain 0, Conducted Emission



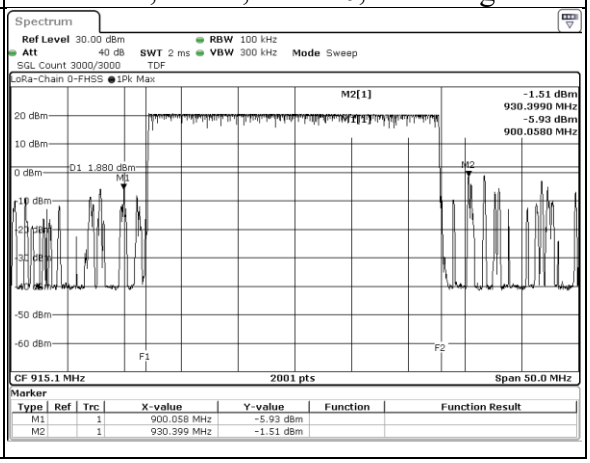
LoRa, FHSS, Chain 0, Conducted Emission



LoRa, CH128, Chain 0, Band edge



LoRa, FHSS, Chain 0, Band edge



9.7. Radiated Spurious Emission

Requirements

Radiated emissions which fall in the restricted bands must comply with the radiated emission limits specified as below table. Other emissions shall be at least 20dB below the highest level of the desired power:

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:
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. For frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition of modulation.

Test Procedures

[For 9 kHz ~ 30 MHz]

a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter chamber room. The table was rotated 360 degrees to determine the position of the highest radiation.
b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
c. Parallel, perpendicular, and ground-parallel orientations of the antenna are set to make the measurement.
d. For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
e. For measurement below 30MHz, the initial step in collecting conducted emission data is a spectrum analyzer peak detector mode pre-scanning the measurement frequency range. Significant peaks are then marked and then Quasi Peak detector mode re-measured. If the emission level of the EUT measured by the peak detector is lower than the applicable limit, the peak emission level will be reported. Otherwise, the emission measurement will be repeated using the quasi-peak detector and reported.

NOTE:
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 9kHz at frequency below 30MHz.

[For above 30 MHz]

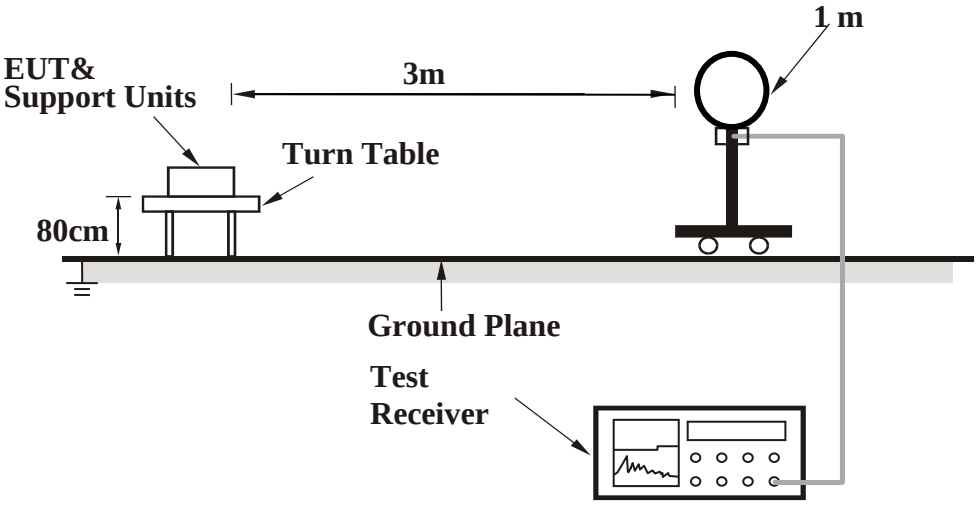
a. The EUT was placed on the top of a rotating table 0.8 meters (for 30MHz ~ 1GHz) / 1.5 meters (for above 1GHz) above the ground at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.
b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
c. The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
e. For measurement below 1GHz, the initial step in collecting conducted emission data is a spectrum analyzer peak detector mode pre-scanning the measurement frequency range. Significant peaks are then marked and then Quasi Peak detector mode re-measured. If the emission level of the EUT measured by the peak detector is lower than the applicable limit, the peak emission level will be reported. Otherwise, the emission measurement will be repeated using the quasi-peak detector and reported.
f. The test-receiver system was set to peak and average detects function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets average limit, measurement with the average detector is unnecessary.

Note:

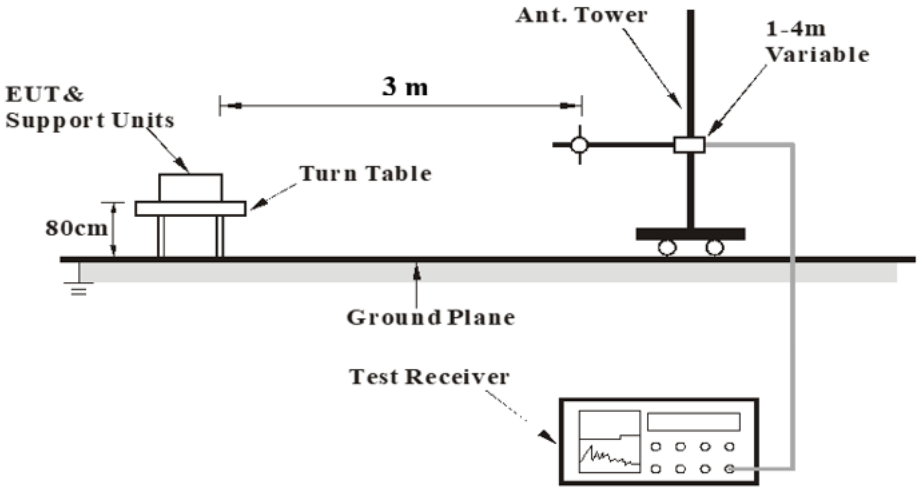
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Quasi-peak detection (QP) at frequency below 1GHz.
2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1GHz.
3. The average value of fundamental and harmonic frequency is:
   Average = Peak value - 20 log(1/ Duty cycle) , DCCF refer to section 6.6 for duty cycle.
4. All modes of operation were investigated (includes all external accessories) and the worst-case emissions are reported, the other emission levels were low against the limit.
5. Test data of Result value (dBuV/m) = Reading value (dBuV/m) + Correction Factor (dB/m).
6. Test data of Margin(dB) = Result value (dBuV/m) - Limit value (dBuV/m).
7. Test data of Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Loss (dB) - Preamp Factor (dB).
8. Test data of Notation "@" = Fundamental Frequency
9. Test data of Notation " * " = The peak result under 20 dB above and complies with AVG limit, AVG result is deemed to comply with AVG limit.

Test Setup

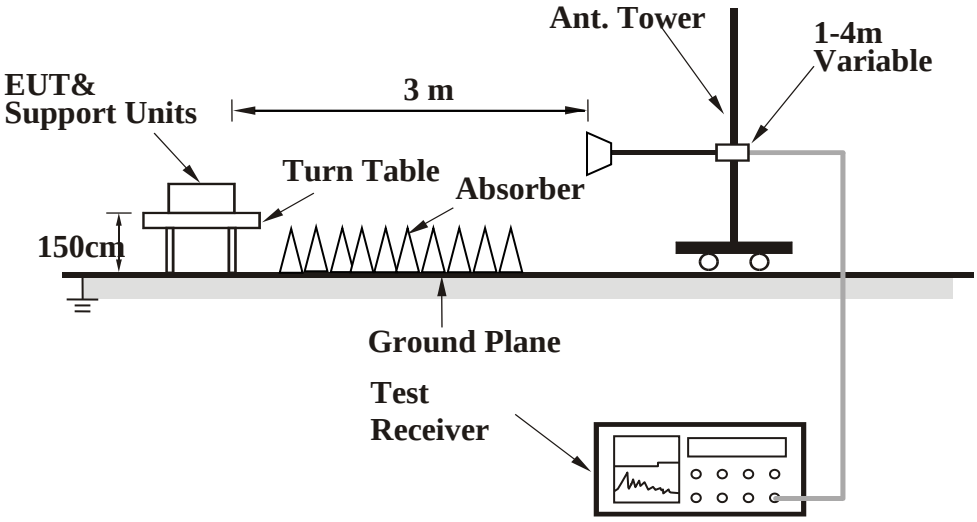
<Frequency Range 9 kHz ~ 30 MHz>



<Frequency Range 30 MHz ~ 1 GHz >



<Frequency Range above 1 GHz>



For the actual test configuration, please refer to the Setup Configurations.

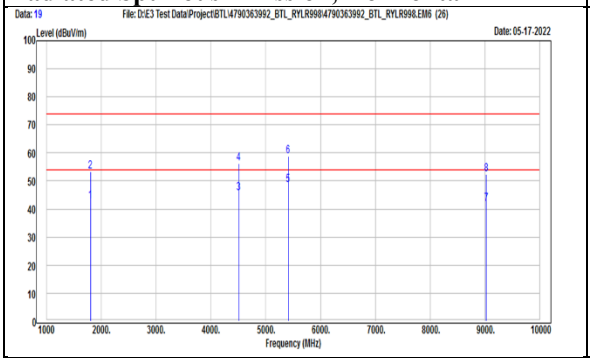
Test Data

Above 1 GHz

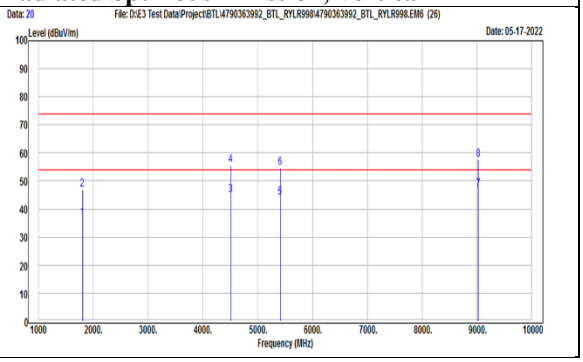
Mode	LoRa	Channel	0

Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	DCCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		1804.6	60.63	-7.36	N/A	53.27	74	-20.73	PK
		1804.6	60.63	-7.36	-10.46	42.81	54	-11.19	AVG
		4511.5	54.9	1.34	N/A	56.24	74	-17.76	PK
		4511.5	54.9	1.34	-10.46	45.78	54	-8.22	AVG
		5413.8	55.55	3.34	N/A	58.89	74	-15.11	PK
		5413.8	55.55	3.34	-10.46	48.43	54	-5.57	AVG
		9023	38.42	13.99	N/A	52.41	74	-21.59	PK
		9023	38.42	13.99	-10.46	41.95	54	-12.05	AVG
Vertical		1804.6	54.43	-7.36	N/A	47.07	74	-26.93	PK
		1804.6	54.43	-7.36	-10.46	36.61	54	-17.39	AVG
		4511.5	54.18	1.34	N/A	55.52	74	-18.48	PK
		4511.5	54.18	1.34	-10.46	45.06	54	-8.94	AVG
		5413.8	51.27	3.34	N/A	54.61	74	-19.39	PK
		5413.8	51.27	3.34	-10.46	44.15	54	-9.85	AVG
		9023	43.44	13.99	N/A	57.43	74	-16.57	PK
		9023	43.44	13.99	-10.46	46.97	54	-7.03	AVG

TX, LoRa (Ch 0)
Radiated Spurious Emission, Horizontal



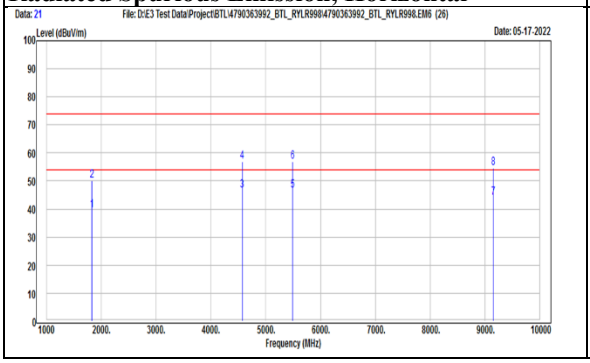
TX, LoRa (Ch 0)
Radiated Spurious Emission, Vertical



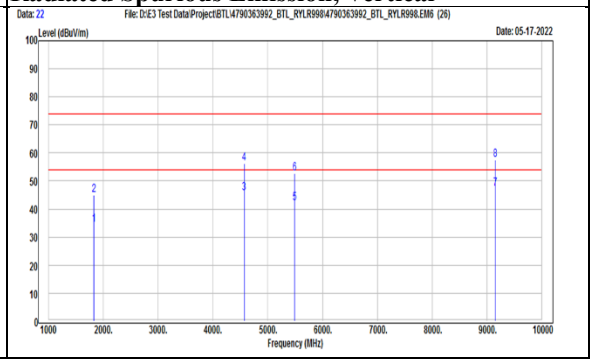
Mode	LoRa	Channel	64

Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	DCCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		1830.2	57.27	-7.22	N/A	50.05	74	-23.95	PK
		1830.2	57.27	-7.22	-10.46	39.59	54	-14.41	AVG
		4575.5	55.34	1.64	N/A	56.98	74	-17.02	PK
		4575.5	55.34	1.64	-10.46	46.52	54	-7.48	AVG
		5490.6	53.35	3.72	N/A	57.07	74	-16.93	PK
		5490.6	53.35	3.72	-10.46	46.61	54	-7.39	AVG
		9151	39.85	14.71	N/A	54.56	74	-19.44	PK
		9151	39.85	14.71	-10.46	44.1	54	-9.9	AVG
Vertical		1830.2	52.16	-7.22	N/A	44.94	74	-29.06	PK
		1830.2	52.16	-7.22	-10.46	34.48	54	-19.52	AVG
		4575.5	54.53	1.64	N/A	56.17	74	-17.83	PK
		4575.5	54.53	1.64	-10.46	45.71	54	-8.29	AVG
		5490.6	48.98	3.72	N/A	52.7	74	-21.3	PK
		5490.6	48.98	3.72	-10.46	42.24	54	-11.76	AVG
		9151	42.97	14.71	N/A	57.68	74	-16.32	PK
		9151	42.97	14.71	-10.46	47.22	54	-6.78	AVG

TX, LoRa (Ch 64)
Radiated Spurious Emission, Horizontal



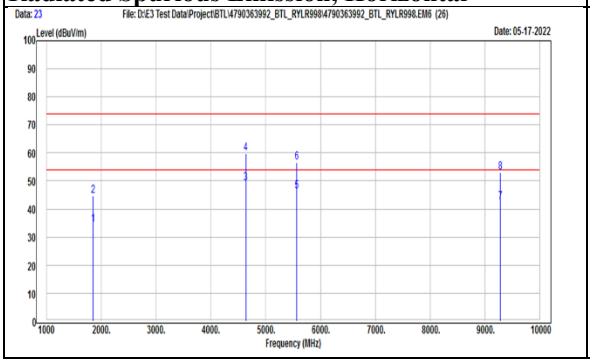
TX, LoRa (Ch 64)
Radiated Spurious Emission, Vertical



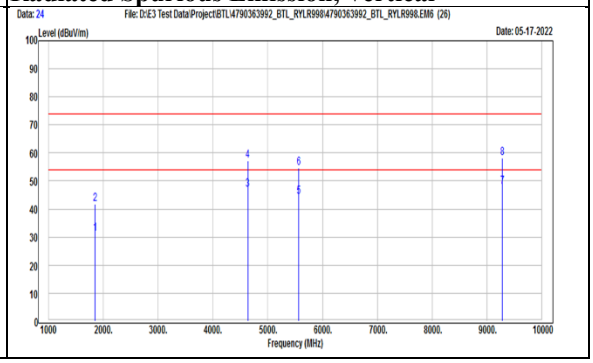
Mode	LoRa	Channel	128

Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	DCCF (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		1855.8	51.93	-7.09	N/A	44.84	74	-29.16	PK
		1855.8	51.93	-7.09	-10.46	34.38	54	-19.62	AVG
		4639.5	57.8	1.85	N/A	59.65	74	-14.35	PK
		4639.5	57.8	1.85	-10.46	49.19	54	-4.81	AVG
		5567.4	52.86	3.79	N/A	56.65	74	-17.35	PK
		5567.4	52.86	3.79	-10.46	46.19	54	-7.81	AVG
		9279	37.61	15.35	N/A	52.96	74	-21.04	PK
		9279	37.61	15.35	-10.46	42.5	54	-11.5	AVG
Vertical		1855.8	48.74	-7.09	N/A	41.65	74	-32.35	PK
		1855.8	48.74	-7.09	-10.46	31.19	54	-22.81	AVG
		4639.5	55.52	1.85	N/A	57.37	74	-16.63	PK
		4639.5	55.52	1.85	-10.46	46.91	54	-7.09	AVG
		5567.4	50.89	3.79	N/A	54.68	74	-19.32	PK
		5567.4	50.89	3.79	-10.46	44.22	54	-9.78	AVG
		9279	42.95	15.35	N/A	58.3	74	-15.7	PK
		9279	42.95	15.35	-10.46	47.84	54	-6.16	AVG

TX, LoRa (Ch 128)
Radiated Spurious Emission, Horizontal



TX, LoRa (Ch 128)
Radiated Spurious Emission, Vertical

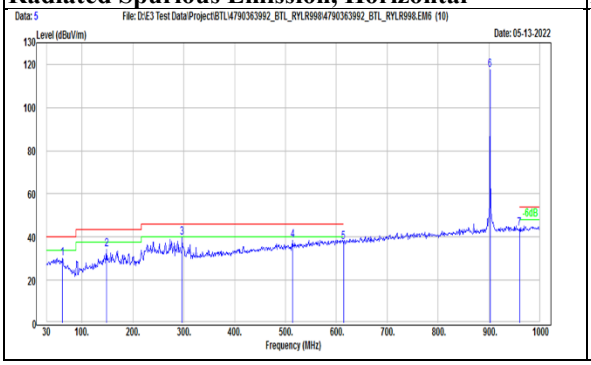


Below 1 GHz

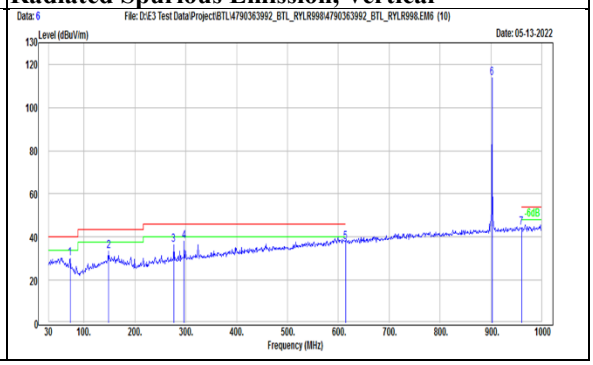
Mode	LoRa	Channel	0

Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		62.01	32.43	-2.3	30.13	40	-9.87	PK
		148.34	36.04	-1.57	34.47	43.5	-9.03	PK
		296.75	39.92	-0.13	39.79	46	-6.21	PK
		514.03	32.69	5.6	38.29	46	-7.71	PK
		614	29.76	8.05	37.81	46	-8.19	PK
	@	902.3	104.56	12.95	117.51	N/A	N/A	PK
		960	30.15	13.83	43.98	54	-10.02	PK
Vertical		72.68	34.72	-4.62	30.1	40	-9.9	PK
		148.34	35	-1.57	33.43	43.5	-10.07	PK
		276.38	37.16	-0.75	36.41	46	-9.59	PK
		296.75	38.01	-0.13	37.88	46	-8.12	PK
		614	29.47	8.05	37.52	46	-8.48	PK
	@	902.3	100.6	12.95	113.55	N/A	N/A	PK
		960	30.32	13.83	44.15	54	-9.85	PK

TX, LoRa (Ch 0)
Radiated Spurious Emission, Horizontal



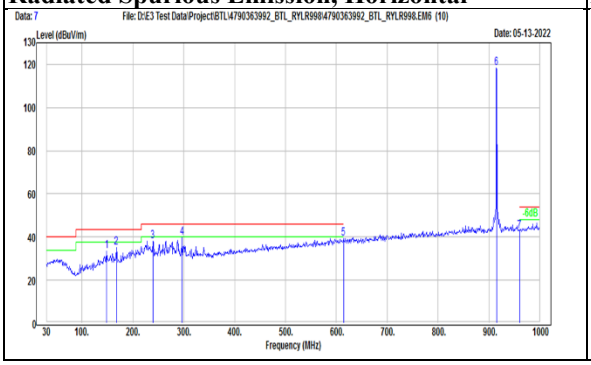
TX, LoRa (Ch 0)
Radiated Spurious Emission, Vertical



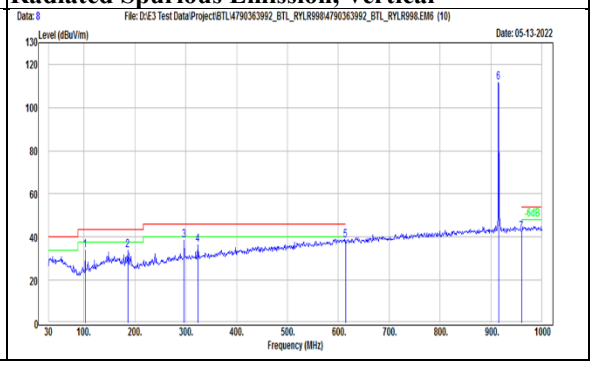
Mode	LoRa	Channel	64

Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		148.34	34.85	-1.57	33.28	43.5	-10.22	PK
		167.74	36.49	-1.22	35.27	43.5	-8.23	PK
		239.52	40.14	-2.16	37.98	46	-8.02	PK
		296.75	39.86	-0.13	39.73	46	-6.27	PK
		614	31.23	8.05	39.28	46	-6.72	PK
	@	915.1	105.3	13.17	118.47	N/A	N/A	PK
		960	28.96	13.83	42.79	54	-11.21	PK
Vertical		102.75	39.79	-5.97	33.82	43.5	-9.68	PK
		186.17	36.67	-2.92	33.75	43.5	-9.75	PK
		296.75	38.46	-0.13	38.33	46	-7.67	PK
		323.91	35.63	0.77	36.4	46	-9.6	PK
		614	30.31	8.05	38.36	46	-7.64	PK
	@	915.1	98.38	13.17	111.55	N/A	N/A	PK
		960	28.58	13.83	42.41	54	-11.59	PK

TX, LoRa (Ch 64)
Radiated Spurious Emission, Horizontal



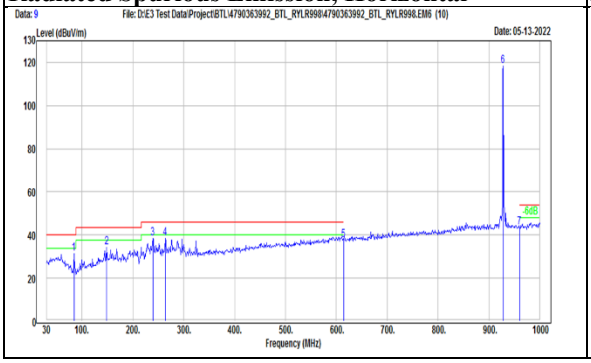
TX, LoRa (Ch 64)
Radiated Spurious Emission, Vertical



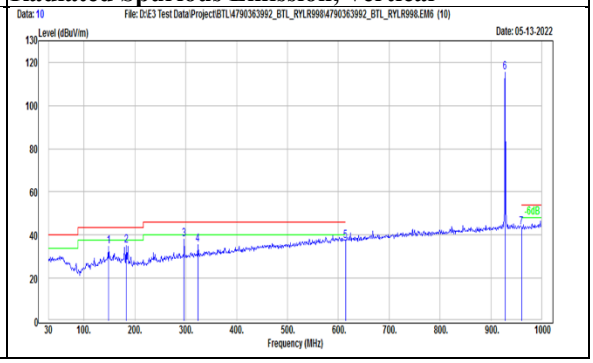
Mode	LoRa	Channel	128

Polarization	Notation	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
Horizontal		84.32	38.5	-7.33	31.17	40	-8.83	PK
		148.34	35.77	-1.57	34.2	43.5	-9.3	PK
		239.52	40.75	-2.16	38.59	46	-7.41	PK
		263.77	39.56	-1.27	38.29	46	-7.71	PK
		614	29.75	8.05	37.8	46	-8.2	PK
	@	927.9	104.74	13.45	118.19	N/A	N/A	PK
		960	29.77	13.83	43.6	54	-10.4	PK
Vertical		148.34	36.25	-1.57	34.68	43.5	-8.82	PK
		183.26	37.8	-2.68	35.12	43.5	-8.38	PK
		296.75	38.05	-0.13	37.92	46	-8.08	PK
		323.91	34.9	0.77	35.67	46	-10.33	PK
		614	29.13	8.05	37.18	46	-8.82	PK
	@	927.9	101.87	13.45	115.32	N/A	N/A	PK
		960	29.56	13.83	43.39	54	-10.61	PK

TX, LoRa (Ch 128)
Radiated Spurious Emission, Horizontal



TX, LoRa (Ch 128)
Radiated Spurious Emission, Vertical



9 kHz ~ 30 MHz Data:

For 9 kHz to 30 MHz radiated emission have performed all modes of operation were investigated. The amplitude of spurious emissions attenuated more than 20 dB below the permissible value is not required to be report.

No non-compliance noted:

KDB 414788 D01 OATS and Chamber Correlation Justification

- Base on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

- OATs and chamber correlation testing had been performed and chamber measured test results is the worst case test result.

Although these tests were performed other than open area test site, adequate comparison measurements were confirmed against 30m open area test site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 414788.

9.8. AC Power Line Conducted Emission

Requirements

Frequency (MHz)	Conducted limit (dBμV)	
	Quasi-peak	Average
0.15 - 0.5	66 - 56	56 - 46
0.50 - 5.0	56	46
5.0 - 30	60	50

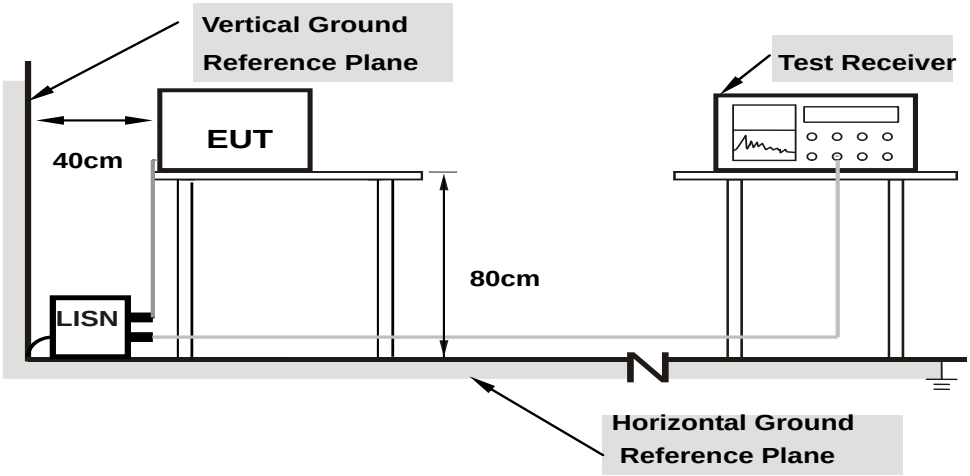
Note:
1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

Test Procedures

a. The EUT was placed 0.4 meters from the conducting wall of the shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). Other support units were connected to the power mains through another LISN. The two LISNs provide 50 ohm/ 50uH of coupling impedance for the measuring instrument.
b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference.
c. The frequency range from 150kHz to 30MHz was searched. Emission levels under (Limit - 20dB) was not recorded.

NOTE:
1. The resolution bandwidth and video bandwidth of test receiver is 9kHz for quasi-peak detection (QP) and average detection (AV) at frequency 0.15MHz-30MHz.
2. All modes of operation were investigated (includes all external accessories) and the worst-case emissions are reported, the other emission levels were low against the limit.
3. Test data of Result value (dBuV) = Reading value (dBuV) + Correction Factor (dB).
4. Test data of Margin(dB) = Result value (dBuV) - Limit value (dBuV).
5. Test data of Correction Factor (dB) = Insertion loss(dB) + Cable loss(dB).

Test Setup



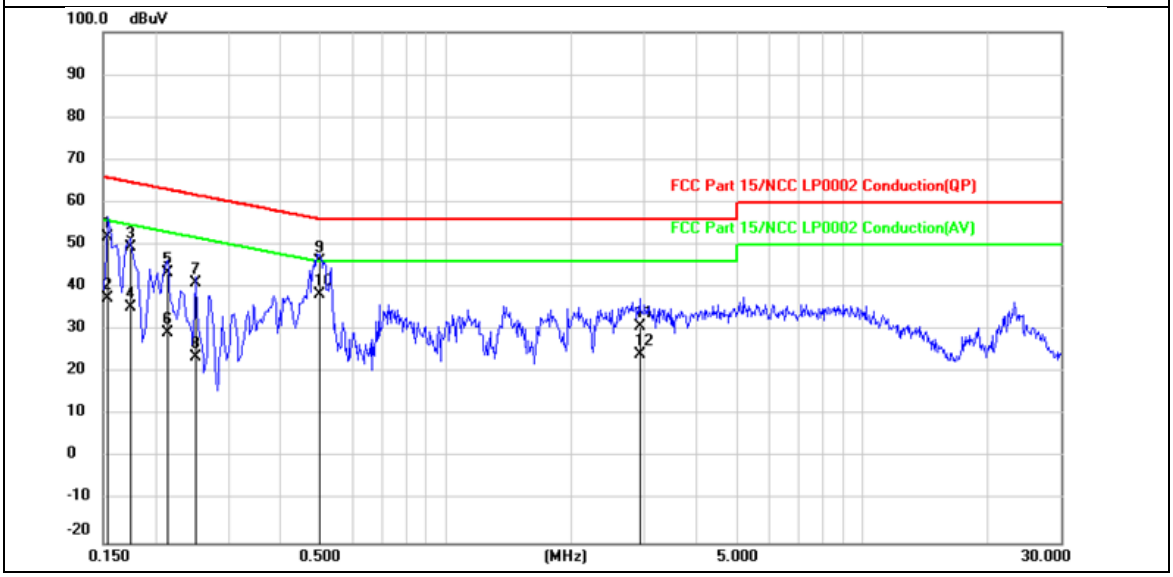
Note: 1.Support units were connected to second LISN.

For the actual test configuration, please refer to the Setup Configurations.

Test Data

Mode	LoRa_TX902.3	Channel	0

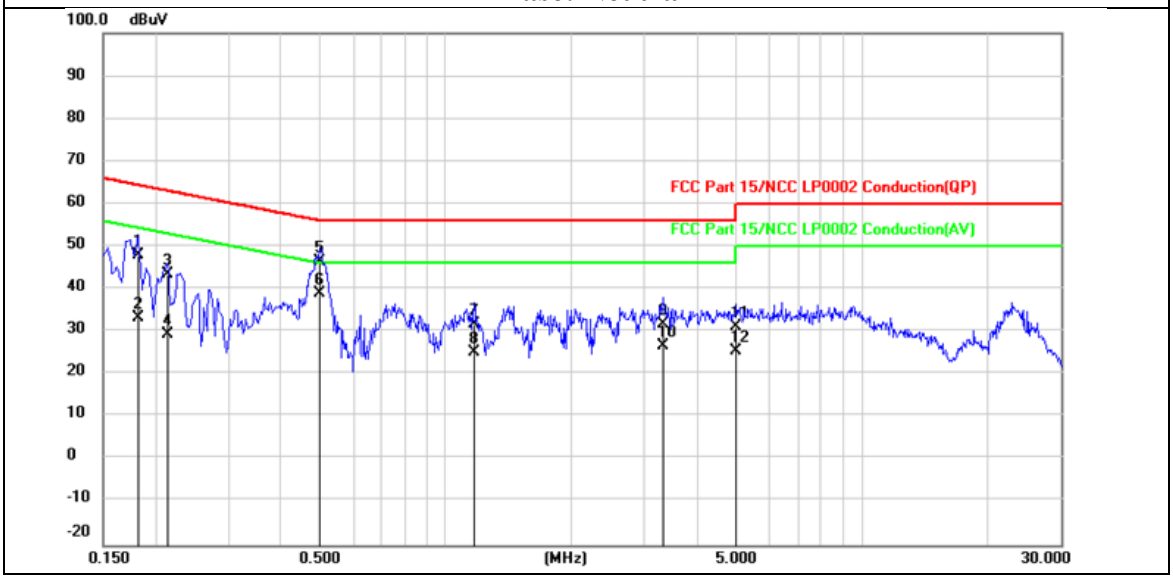
Phase: Line



No.	Frequency (MHz)	Reading (dBuV)	Correct (dB)	Result (dBuV)	Limit (dBuV)	Margin (dB)	Remark
1	0.1539	41.88	9.96	51.84	65.79	-13.95	QP
2	0.1539	27.39	9.96	37.35	55.79	-18.44	AVG
3	0.1740	39.40	9.96	49.36	64.77	-15.41	QP
4	0.1740	25.25	9.96	35.21	54.77	-19.56	AVG
5	0.2140	33.50	9.95	43.45	63.05	-19.60	QP
6	0.2140	19.32	9.95	29.27	53.05	-23.78	AVG
7	0.2500	31.10	9.95	41.05	61.76	-20.71	QP
8	0.2500	13.56	9.95	23.51	51.76	-28.25	AVG
9	0.4980	36.35	9.95	46.30	56.03	-9.73	QP
10	0.4980	28.46	9.95	38.41	46.03	-7.62	AVG
11	2.9300	20.92	10.02	30.94	56.00	-25.06	QP
12	2.9300	14.33	10.02	24.35	46.00	-21.65	AVG

Mode	LoRa_TX902.3	Channel	0

Phase: Neutral



No.	Frequency (MHz)	Reading (dBuV)	Correct (dB)	Result (dBuV)	Limit (dBuV)	Margin (dB)	Remark
1	0.1819	37.98	9.98	47.96	64.40	-16.44	QP
2	0.1819	23.23	9.98	33.21	54.40	-21.19	AVG
3	0.2140	33.57	9.98	43.55	63.05	-19.50	QP
4	0.2140	19.23	9.98	29.21	53.05	-23.84	AVG
5	0.4980	36.36	9.97	46.33	56.03	-9.70	QP
6	0.4980	28.89	9.97	38.86	46.03	-7.17	AVG
7	1.1700	21.65	10.00	31.65	56.00	-24.35	QP
8	1.1700	15.25	10.00	25.25	46.00	-20.75	AVG
9	3.3180	21.71	10.05	31.76	56.00	-24.24	QP
10	3.3180	16.49	10.05	26.54	46.00	-19.46	AVG
11	4.9860	21.00	10.11	31.11	56.00	-24.89	QP
12	4.9860	15.23	10.11	25.34	46.00	-20.66	AVG

END OF REPORT