



FCC RADIO TEST REPORT

FCC ID : 2AEUPBHART001
Equipment : INTERCOM
Brand Name : ring
Model Name : 5F34E9
Applicant : Ring LLC
12515 Cerise Ave, Hawthorne, CA 90250, USA
Manufacturer : Ring LLC
12515 Cerise Ave, Hawthorne, CA 90250, USA
Standard : FCC Part 15 Subpart C §15.247

The product was received on May 17, 2022 and testing was performed from May 20, 2022 to Aug. 09, 2022. We, Sporton International (USA) Inc., would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

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

Approved by: Neil Kao

Sporton International (USA) Inc.
1175 Montague Expressway, Milpitas, CA 95035



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History of this test report

Report No.	Version	Description	Issue Date
FR220509002D	01	Initial issue of report	Jul. 27, 2022
FR220509002D	02	1. Revise 99% Bandwidth test result 2. Add Duty cycle Plots, and Uncertainty of Evaluation for Conducted test measurement	Aug. 10, 2022

Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)	Remark
3.1	15.247(a)(2)	6dB Bandwidth	Pass	-
3.1	2.1049	99% Occupied Bandwidth	Reporting only	-
3.2	15.247(b)(3)	Power Output Measurement	Pass	-
3.3	15.247(e)	Power Spectral Density	Pass	-
3.4	15.247(d)	Conducted Band Edges	Pass	-
		Conducted Spurious Emission	Pass	-
3.5	15.247(d)	Radiated Band Edges and Radiated Spurious Emission	Pass	7.38 dB under the limit at 32.910 MHz
-	15.207	AC Conducted Emission	Not Required	-
3.6	15.203 & 15.247(b)	Antenna Requirement	Pass	-

Note:

1. Not required means after assessing, test items are not necessary to carry out.
2. The EUT is powered by batteries which is deemed DC power source, it does not operate from the AC power lines or contain provisions for operation while connected to the AC power lines, according to 47 CFR §15.207(c), the conducted emission limits are not applicable to the device hence the test is not performed.

Conformity Assessment Condition:

1. The test results (PASS/FAIL) with all measurement uncertainty excluded are presented against the regulation limits or in accordance with the requirements stipulated by the applicant/manufacture who shall bear all the risks of non-compliance that may potentially occur if measurement uncertainty is taken into account.
2. Please refer to the section "Uncertainty of Evaluation" for measurement uncertainty..

Comments and Explanations:

The product specifications of the EUT presented in the report are declared by the manufacturer who shall take full responsibility for the authenticity.



1 General Description

1.1 Product Feature of Equipment Under Test

Bluetooth – LE, Wi-Fi 2.4GHz 802.11b/g/n and LoRa/FSK.

Product Feature	
Antenna Type	WLAN: PCB-ILA Antenna Bluetooth - LE: PCB-ILA Antenna LoRa/FSK: PCB-ILA Antenna

Antenna information		
902 MHz ~ 928 MHz	Peak Gain (dBi)	2.5

Remark: The above EUT's information was declared by manufacturer. Please refer to Comments and Explanations in report summary.

1.2 Modification of EUT

No modifications made to the EUT during the testing.

1.3 Testing Location

Test Site	Sporton International (USA) Inc.
Test Site Location	1175 Montague Expressway, Milpitas, CA 95035 TEL : 408 9043300
Test Site No.	Sporton Site No.
	TH01-CA, 03CH02-CA

Note: The test site complies with ANSI C63.4 2014 requirement.

1.4 Applicable Standards

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

- ♦ FCC Part 15 Subpart C §15.247
- ♦ FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05r02
- ♦ FCC KDB 414788 D01 Radiated Test Site v01r01.
- ♦ ANSI C63.10-2013

Remark:

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

2 Test Configuration of Equipment Under Test

- a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated: radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, the measured emission level of the EUT was maximized by rotating the EUT on a turntable, adjusting the orientation of the EUT and EUT antenna in three orthogonal axis (X: flat, Y: portrait, Z: landscape), and adjusting the measurement antenna orientation, following C63.10 exploratory test procedures and find Y plane as worst plane.

2.1 Carrier Frequency and Channel

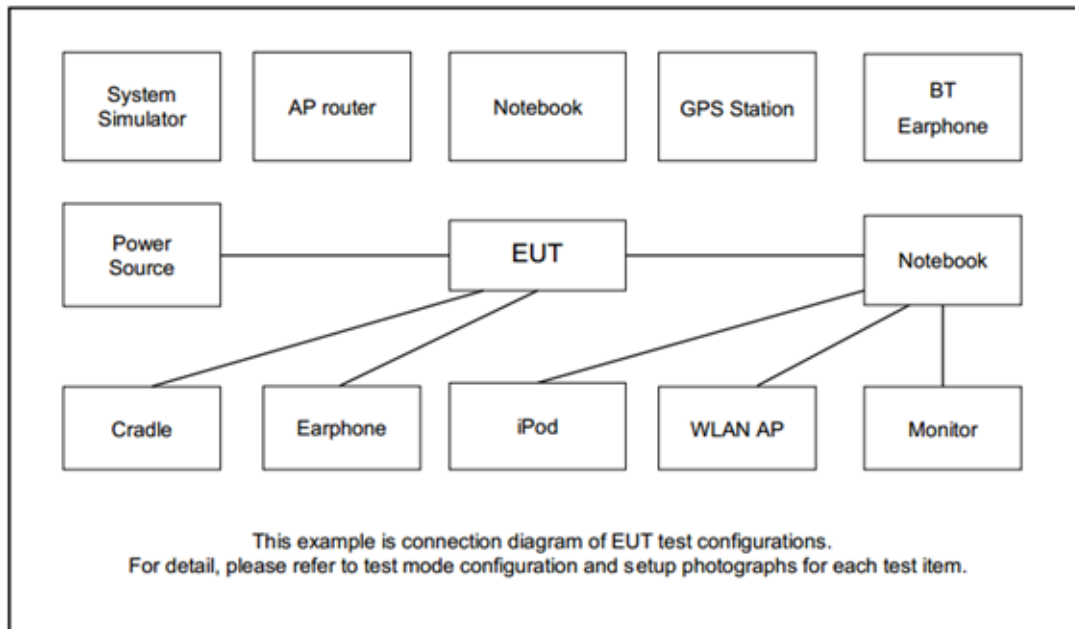
Frequency Band	Channel	Freq. (MHz)	Channel	Freq. (MHz)
902 – 928 MHz	1	902.5	17	915.3
	2	903.3	18	916.1
	3	904.1	19	916.9
	4	904.9	20	917.7
	5	905.7	21	918.5
	6	906.5	22	919.3
	7	907.3	23	920.1
	8	908.1	24	920.9
	9	908.9	25	921.7
	10	909.7	26	922.5
	11	910.5	27	923.3
	12	911.3	28	924.1
	13	912.1	29	924.9
	14	912.9	30	925.7
	15	913.7	31	926.5
	16	914.5		

2.2 Test Mode

Summary table of Test Cases		
Test Item	Feature	LoRa
Conducted Test Cases	LoRa 500 KHz DTS SF11	Mode 1: CH01 Tx_902.50 MHz Mode 2: CH16 Tx_914.50 MHz Mode 3: CH31 Tx_926.50 MHz
Radiated Test Cases	LoRa 500 KHz DTS SF11	Mode 1: CH01 Tx_902.50 MHz Mode 2: CH16 Tx_914.50 MHz Mode 3: CH31 Tx_926.50 MHz

Remark: After pretest, the spread factor (SF) which has maximum conducted power was selected as final test mode.

2.3 Connection Diagram of Test System



2.4 Support Unit used in test configuration and system

Item	Equipment	Brand Name	Model Name	FCC ID	Data Cable	Power Cord
1.	Notebook	ACER	Altos PS548-G1	N/A	N/A	AC I/P: Unshielded, 1.2 m DC O/P: Shielded, 1.8 m

2.5 EUT Operation Test Setup

The RF test items, utility "Spyder v5.1.5" was installed in Notebook which was programmed in order to make the EUT get into the engineering modes to provide channel selection, power level, data rate and the application type and for continuous transmitting signals.

2.6 Measurement Results Explanation Example

For all conducted test items:

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

Example:

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

Offset = RF cable loss + attenuator factor.

Following shows an offset computation example with cable loss 4.2 dB and 10 dB attenuator.

$$\begin{aligned}\text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)} \\ &= 4.2 + 10 = 14.2 \text{ (dB)}\end{aligned}$$

3 Test Result

3.1 6dB and 99% Bandwidth Measurement

3.1.1 Limit of 6dB and 99% Bandwidth

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

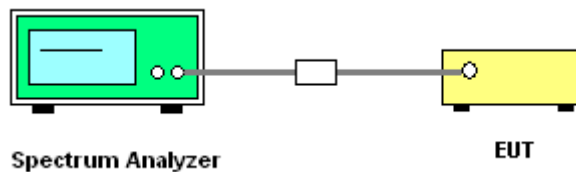
3.1.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

3.1.3 Test Procedures

1. The testing follows the ANSI C63.10 Section 6.9.3 (OBW) and 11.8.1 (6dB BW).
2. The RF output of EUT is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to 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 1-5% of the emission bandwidth and set the Video bandwidth (VBW) $\geq 3 * RBW$.
6. Measure and record the results in the test report.

3.1.4 Test Setup

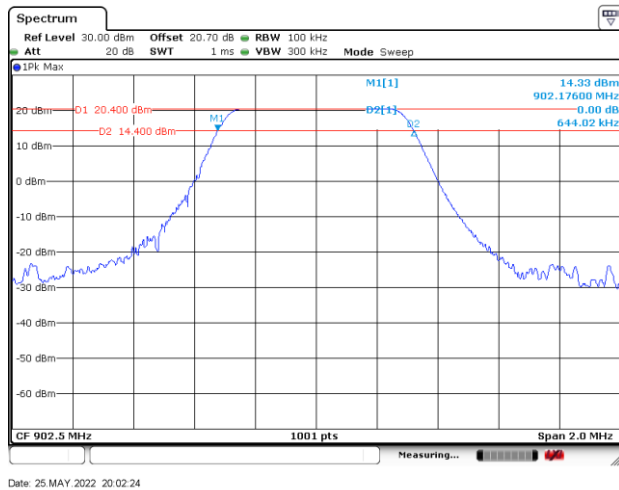




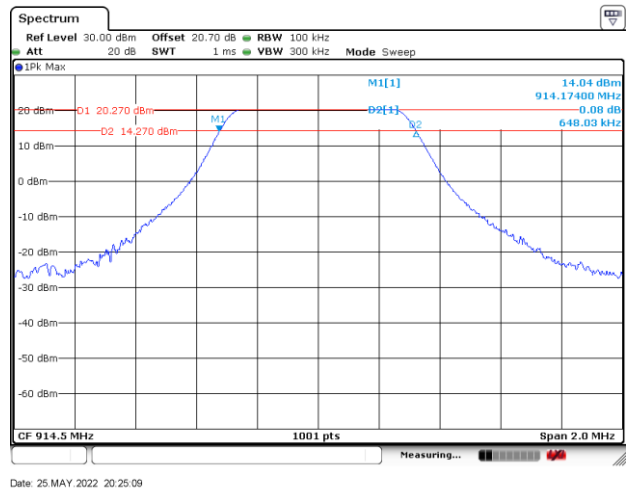
3.1.5 Test Result of 6dB and 99% Occupied Bandwidth

Please refer to Appendix A.

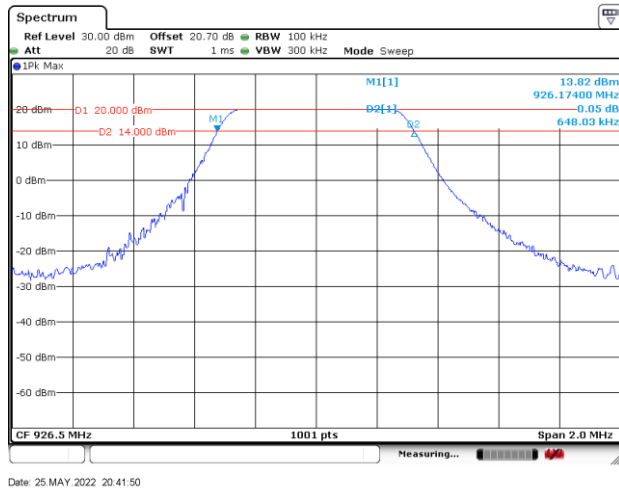
6 dB Bandwidth Plot on Channel 1



6 dB Bandwidth Plot on Channel 16



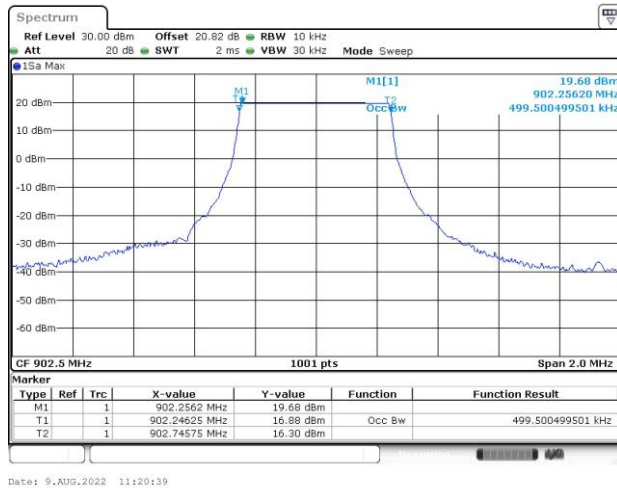
6 dB Bandwidth Plot on Channel 31



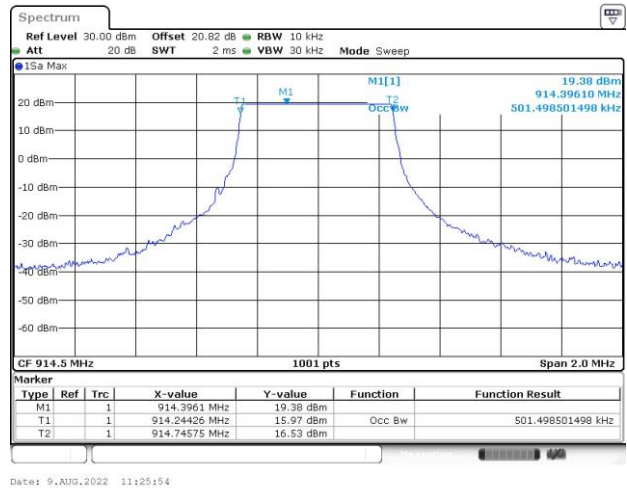
N/A



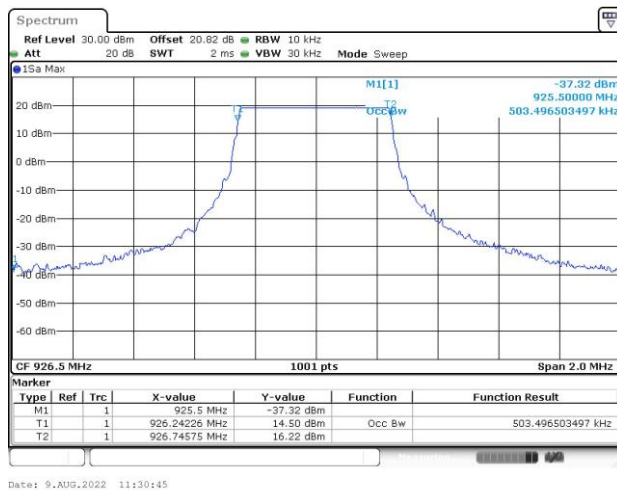
99% Occupied Bandwidth Plot on Channel 1



99% Occupied Plot Bandwidth on Channel 16



99% Occupied Bandwidth Plot on Channel 31



N/A

Note: The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

3.2 Output Power Measurement

3.2.1 Limit of Output Power

Section 15.247(b)(3) For systems using digital modulation in the 902-928 MHz, the limit for peak output power is 1 watt.

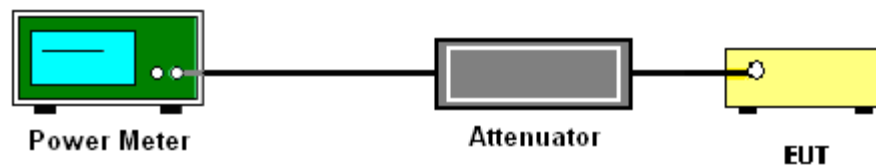
3.2.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

3.2.3 Test Procedures

1. For Average Power, the testing follows ANSI C63.10 Section 11.9.2.3.2 Method AVGPM-G
2. The RF output of EUT is connected to the power meter by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. Measure the conducted output power and record the results in the test report.

3.2.4 Test Setup



3.2.5 Test Result of Average Output Power

Please refer to Appendix A.

3.3 Power Spectral Density Measurement

3.3.1 Limit of Power Spectral Density

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

3.3.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

3.3.3 Test Procedures

1. The testing follows the ANSI C63.10 Section 11.10.2 Method PKPSD.
2. The RF output of EUT is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 3 kHz. Video bandwidth VBW = 10 kHz In order to make an accurate measurement, set the span to 1.5 times DTS Channel Bandwidth. (6dB BW)
5. Detector = peak, Sweep time = auto couple, Trace mode = max hold, Allow trace to fully stabilize. Use the peak marker function to determine the maximum power level.
6. Measure and record the results in the test report.

3.3.4 Test Setup

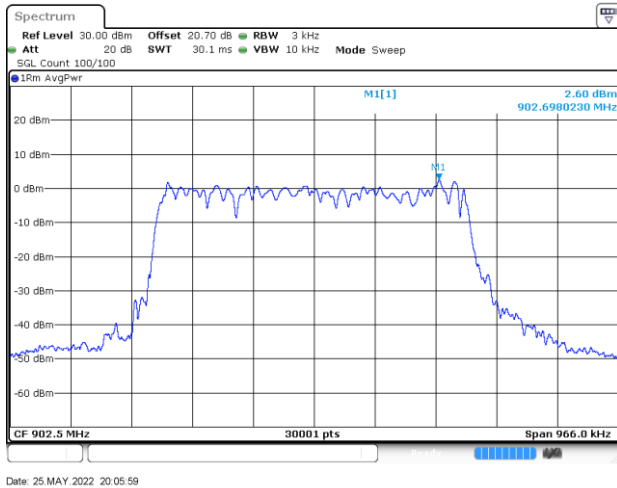




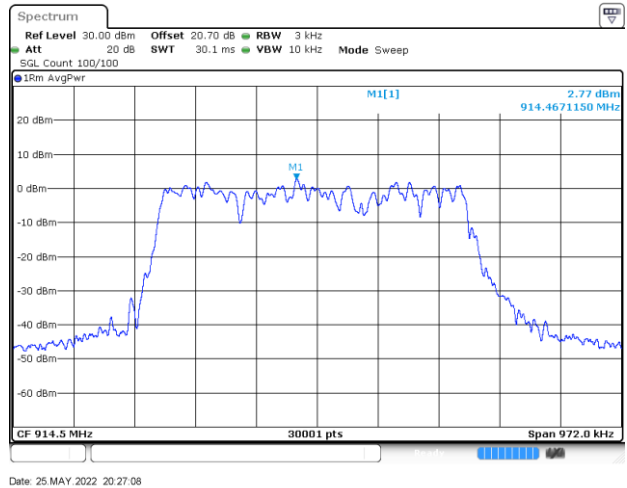
3.3.5 Test Result of Power Spectral Density

Please refer to Appendix A.

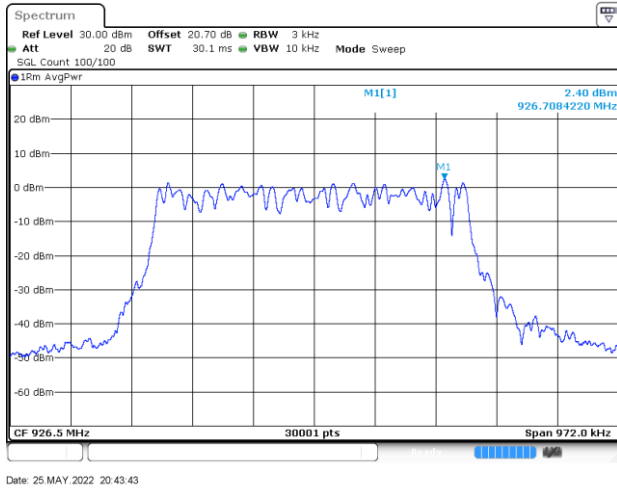
Power Density (dBm/3kHz) Plot Channel 1



Power Density (dBm/3kHz) Plot Channel 16



Power Density (dBm/3kHz) Plot Channel 31



N/A

3.4 Conducted Band Edges and Spurious Emission Measurement

3.4.1 Limit of Conducted Band Edges and Spurious Emission Measurement

In any 100 kHz bandwidth outside of the authorized frequency band, the emissions which fall in the non-restricted bands shall be attenuated at least 20 dB / 30dB relative to the maximum PSD level in 100 kHz by RF conducted measurement.

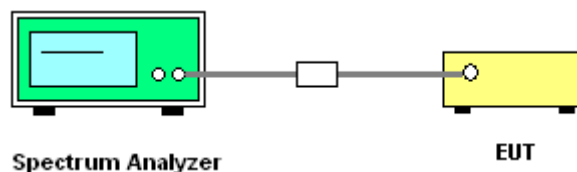
3.4.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

3.4.3 Test Procedures

1. The testing follows the ANSI C63.10 Section 11.11.3 Emission level measurement.
2. The RF output of EUT is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. Set RBW = 100 kHz, VBW=300 kHz, Peak Detector. Unwanted Emissions measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz when maximum peak conducted output power procedure is used. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB per 15.247(d).
5. Measure and record the results in the test report.
6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

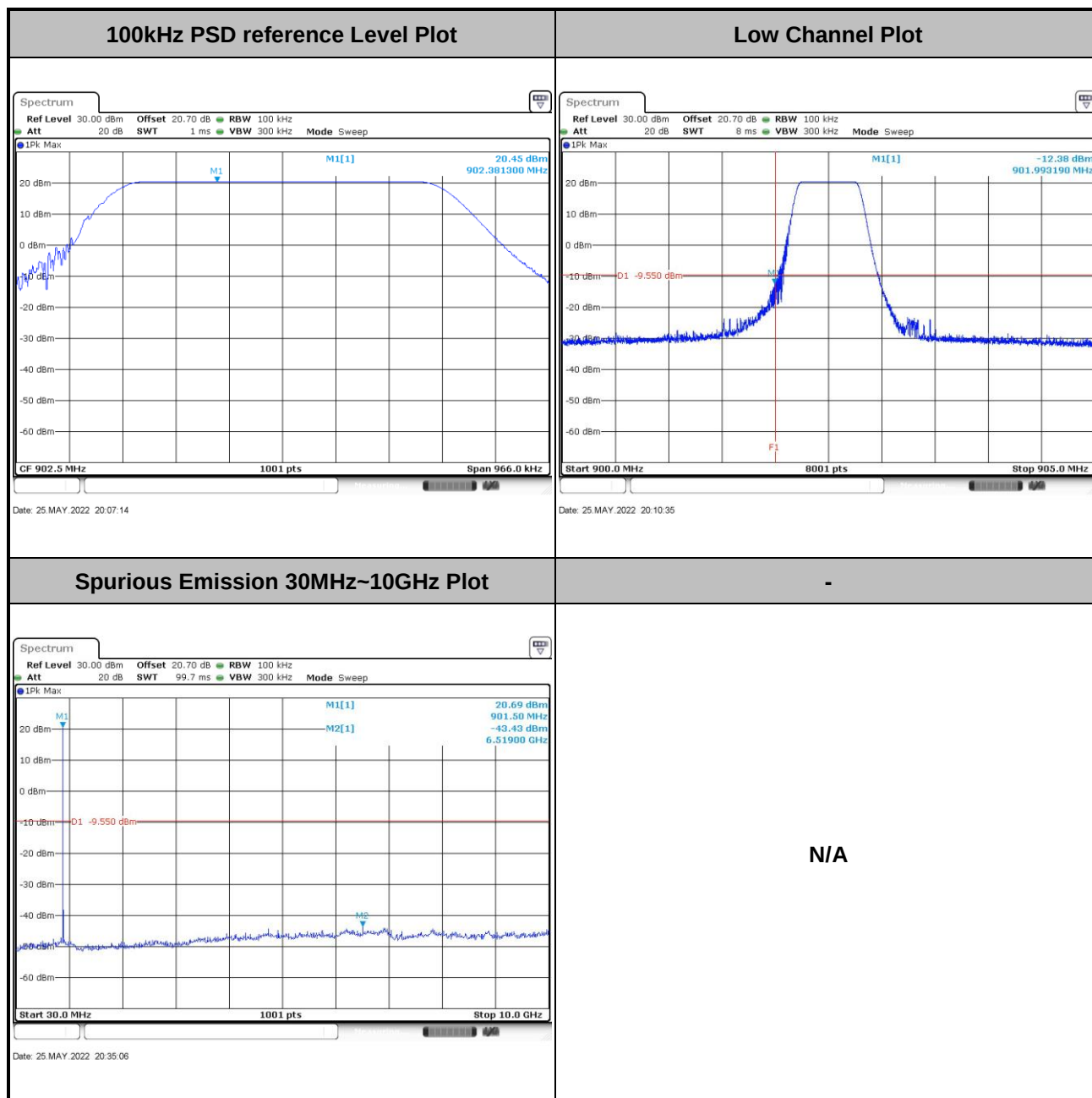
3.4.4 Test Setup





3.4.5 Test Result of Conducted Band Edges and Spurious Emission

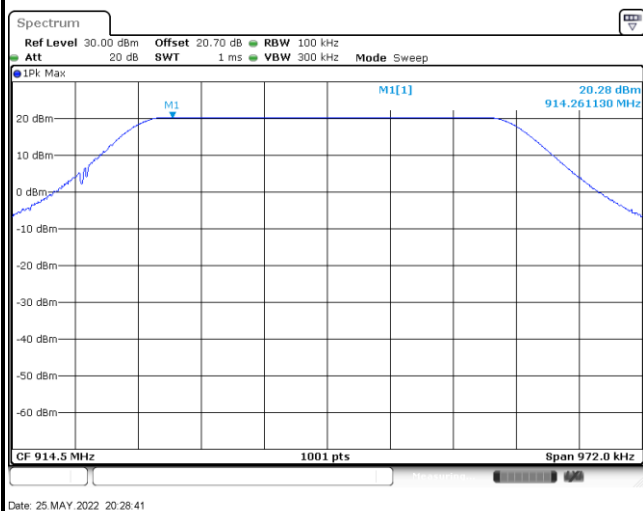
Test Mode :	LoRa 500kHz	Test Channel :	01
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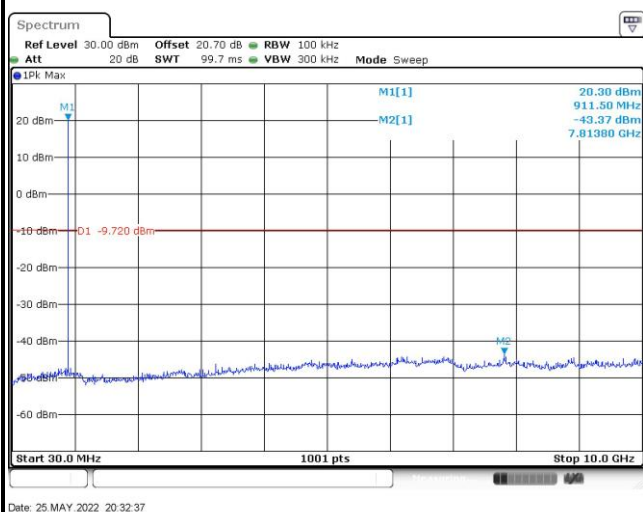
Test Mode :	LoRa 500kHz	Test Channel :	16
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100kHz PSD reference Level Plot



Middle Channel Plot

Spurious Emission 30MHz~10GHz Plot

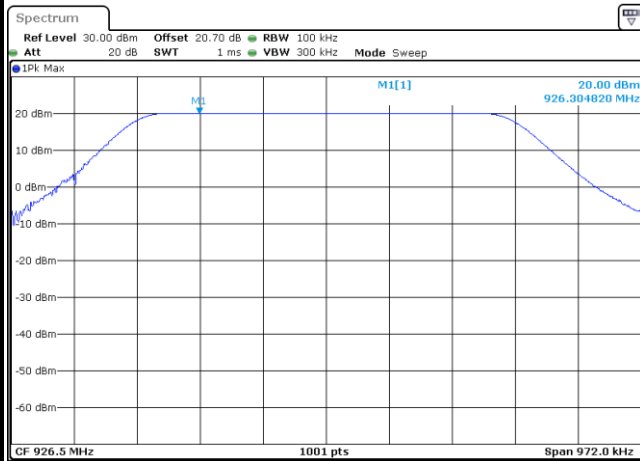


N/A



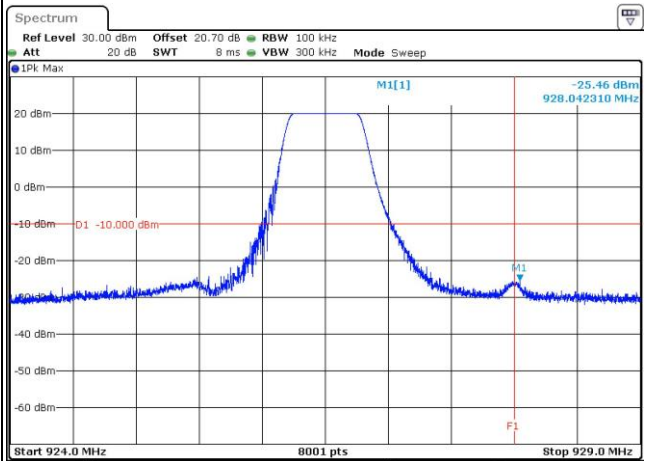
Test Mode :	LoRa 500kHz	Test Channel :	31
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100kHz PSD reference Level Plot



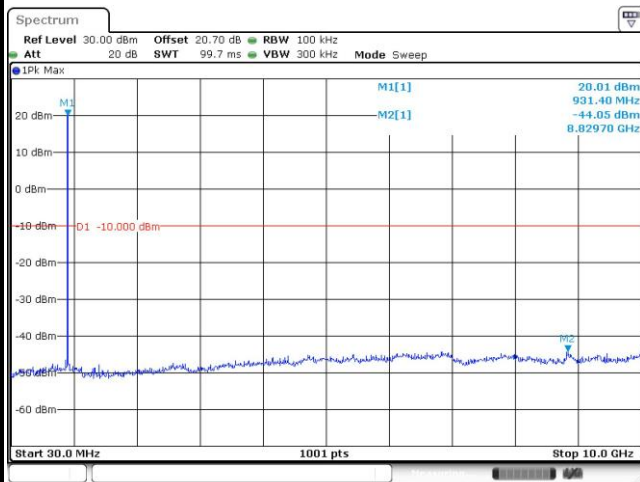
Date: 25 MAY 2022 20:45:13

High Channel Plot



Date: 25 MAY 2022 20:47:44

Spurious Emission 30MHz~10GHz Plot



Date: 25 MAY 2022 20:50:32

N/A

3.5 Radiated Band Edges and Spurious Emission Measurement

3.5.1 Limit of Radiated band edge and Spurious Emission Measurement

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. If the output power of this device is measured by spectrum analyzer, the attenuation under this paragraph shall be 30 dB instead of 20 dB. In addition, radiated emissions which fall in the restricted bands must also comply with the limits as below.

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

3.5.2 Measuring Instruments

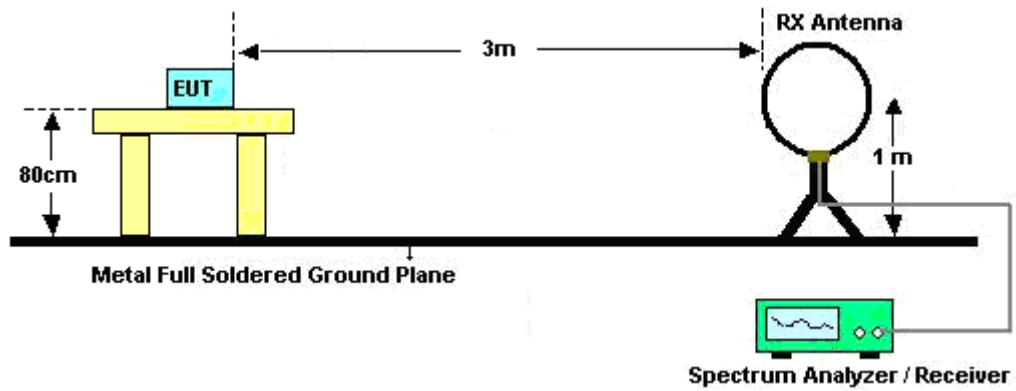
Please refer to the measuring equipment list in this test report.

3.5.3 Test Procedures

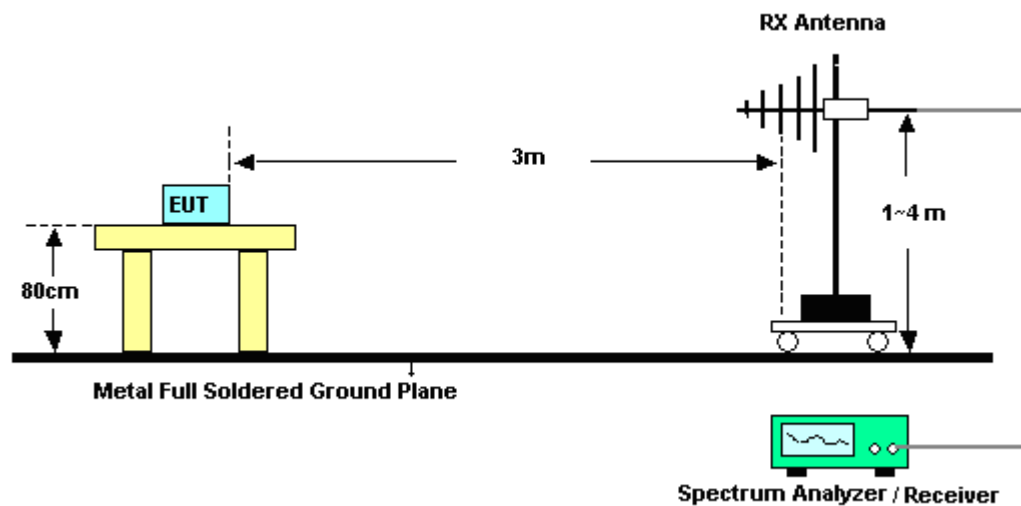
1. The testing follows the ANSI C63.10 Section 11.12.1 Radiated emission measurements.
2. The EUT is arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level.
3. The EUT is placed on a turntable with 0.8 meter for frequency below 1 GHz and 1.5 meter for frequency above 1 GHz respectively above ground.
4. The EUT is set 3 meters away from the receiving antenna, which is mounted on the top of a variable height antenna tower.
5. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
6. Radiated testing below 1 GHz is performed by adjusting the antenna tower from 1 m to 4 m and by rotating the turn table from 0 degree to 360 degrees to find the peak maximum hold reading. When there is no suspected emission found and the emission level is with at least 6 dB margin against QP limit line, the position is marked as “-”.
7. Radiated testing above 1 GHz is performed by adjusting the antenna tower from 1 m to 4 m and by rotating the turn table from 0 degree to 360 degrees to find the peak maximum hold reading for scanning all frequencies. When there is no suspected emission found and the harmonic emission level is with at least 6 dB margin against average limit line, the position is marked as “-”.
8. Use the following spectrum analyzer settings:
 - (1) Span shall wide enough to fully capture the emission being measured;
 - (2) Set RBW = 100 kHz for $f < 1$ GHz; VBW $\geq$ RBW; Sweep = auto; Detector function = peak; Trace = max hold;
 - (3) Set RBW = 1 MHz, VBW= 3 MHz for $f \geq 1$ GHz for peak measurement.For average measurement:
 - VBW = 10 Hz, when duty cycle is no less than 98 percent.
 - VBW $\geq 1/T$, when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.

3.5.4 Test Setup

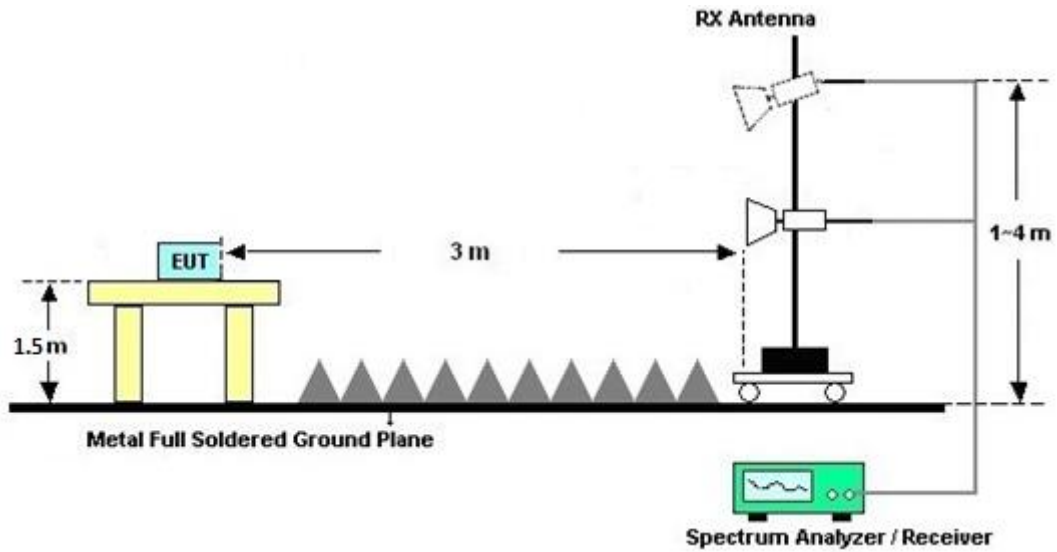
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated test above 1GHz



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

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

There is adequate comparison measurement of both open-field test site and alternative test site - semi-Anechoic chamber according to 414788 D01 Radiated Test Site v01r01, and the result comes out very similar.

3.5.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix B and C.

3.5.7 Duty Cycle

Please refer to Appendix D.

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

Please refer to Appendix B and C.



3.6 Antenna Requirements

3.6.1 Standard Applicable

If directional gain of transmitting Antennas is greater than 6 dBi, the power shall be reduced by the same level in dB comparing to gain minus 6 dBi. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the rule.

3.6.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.6.3 Antenna Gain

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



4 List of Measuring Equipment

Instrument	Brand Name	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Loop Antenna	R&S	HFH2-Z2E	100840	9kHz~30MHz	Jun. 21, 2021	May 20, 2022~ Jun. 01, 2022	Jun. 20, 2022	Radiation (03CH02-CA)
Bilog Antenna	TESEQ	6111D	54683	30MHz~1GHz	Oct. 15, 2021	May 20, 2022~ Jun. 01, 2022	Oct. 14, 2022	Radiation (03CH02-CA)
Horn Antenna	SCHWARZBECK	BBHA 9120D	01895	1GHz~18GHz	Aug. 25, 2021	May 20, 2022~ Jun. 01, 2022	Aug. 24, 2022	Radiation (03CH02-CA)
Amplifier	SONOMA	310N	372240	N/A	Aug. 09, 2021	May 20, 2022~ Jun. 01, 2022	Aug. 08, 2022	Radiation (03CH02-CA)
Preamplifier	E-instrument	ERA-100M-1 8G-56-01-A7 0	EC1900251	1GHz~18GHz	May 10, 2022	May 20, 2022~ Jun. 01, 2022	May 09, 2023	Radiation (03CH02-CA)
Spectrum Analyzer	Keysight	N9010A	MY57420221	10Hz~44GHz	Sep. 22, 2021	May 20, 2022~ Jun. 01, 2022	Sep. 21, 2022	Radiation (03CH02-CA)
Filter	Wainwright	WLK12-1200 -1272-11000- 40SS	SN1	1.2G Low Pass	Jul. 23, 2021	May 20, 2022~ Jun. 01, 2022	Jul. 22, 2022	Radiation (03CH02-CA)
Hygrometer	TESEO	608-H1	45142602	N/A	Aug. 04, 2021	May 20, 2022~ Jun. 01, 2022	Aug. 03, 2022	Radiation (03CH02-CA)
Controller	ChainTek	EM-1000	060876	NA	N/A	May 20, 2022~ Jun. 01, 2022	N/A	Radiation (03CH02-CA)
Antenna Mast	ChainTek	MBS-520-1	N/A	1m~4m	N/A	May 20, 2022~ Jun. 01, 2022	N/A	Radiation (03CH02-CA)
Turn Table	ChainTek	T-200-S-1	N/A	0~360 Degree	N/A	May 20, 2022~ Jun. 01, 2022	N/A	Radiation (03CH02-CA)
Software	Audix	E3	N/A	N/A	N/A	May 20, 2022~ Jun. 01, 2022	N/A	Radiation (03CH02-CA)
Hygrometer	Testo	608-H1	45142595	N/A	Aug. 30, 2021	May 25, 2022~ Aug. 09, 2022	Aug. 29, 2022	Conducted (TH01-CA)
Power Sensor	EM Electronics Corporation	RPR3006W	RPR6W-1901 026	10MHz-6GHz	May 10, 2022	May 25, 2022~ Aug. 09, 2022	May 09, 2023	Conducted (TH01-CA)
Power Meter	Anritsu	ML2495A	1804004	N/A	May 10, 2022	May 25, 2022~ Aug. 09, 2022	May 09, 2023	Conducted (TH01-CA)
Power Sensor	Anritsu	MA2411B	1726149	300MHz-40GHz	May 10, 2022	May 25, 2022~ Aug. 09, 2022	May 09, 2023	Conducted (TH01-CA)
Switch Box & RF Cable	EM Electronics	EMSW26	1090304	N/A	Mar. 30, 2022	May 25, 2022~ Aug. 09, 2022	Mar. 29, 2023	Conducted (TH01-CA)
Spectrum Analyzer	Rohde & Schwarz	FSV40	101089	10Hz-40GHz	Jun. 02, 2021	May 25, 2022	Jun. 01, 2022	Conducted (TH01-CA)
Spectrum Analyzer	Rohde & Schwarz	FSV40	101545	10Hz-40GHz	May 31, 2022	Aug. 09, 2022	May 30, 2023	Conducted (TH01-CA)

5 Uncertainty of Evaluation

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

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	4.7 dB
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Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	6.2 dB
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Uncertainty of 6dB Bandwidth Measurement

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	0.1 MHz
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Uncertainty of 99% Occupied Bandwidth Measurement

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	3.3×10^{-7} MHz
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Uncertainty of Maximum Conducted Output Power Measurement

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	± 0.7 dB
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Uncertainty of Power Spectral Density Measurement

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	± 0.61 dB
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Uncertainty of Conducted Band Edges and Spurious Emission Measurement (30MHz~1000MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	± 0.69 dB
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Uncertainty of Conducted Band Edges and Spurious Emission Measurement (Above 1000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	± 0.63 dB
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Appendix A. Test Result of Conducted Test Items

Test Engineer:	Liliana Gonzalez	Temperature:	23~24.1	°C
Test Date:	2022/05/25 ~ 2022/08/09	Relative Humidity:	32.6~35.1	%

TEST RESULTS DATA
6dB and 99% Occupied Bandwidth

Mod.	NTX	CH.	Freq. (MHz)	99% Occupied BW (MHz)	6dB BW (MHz)	6dB BW Limit (MHz)	Pass/Fail
Lora	1	1	902.5	0.500	0.644	0.50	Pass
Lora	1	16	914.5	0.501	0.648	0.50	Pass
Lora	1	31	926.5	0.503	0.648	0.50	Pass

TEST RESULTS DATA
Average Power Table

Mod.	NTX	CH.	Freq. (MHz)	Average Conducted Power (dBm)	Conducted Power Limit (dBm)	DG (dBi)	EIRP Power (dBm)	EIRP Power Limit (dBm)	Pass /Fail
Lora	1	1	902.5	20.45	30.00	2.50	22.95	36.00	Pass
Lora	1	16	914.5	20.20	30.00	2.50	22.70	36.00	Pass
Lora	1	31	926.5	19.86	30.00	2.50	22.36	36.00	Pass

TEST RESULTS DATA
Average Power Density

Mod.	NTX	CH.	Freq. (MHz)	Peak PSD (dBm /100kHz)	Average PSD (dBm /3kHz)	DG (dBi)	Average PSD Limit (dBm /3kHz)	Pass/Fail
Lora	1	1	902.5	20.45	2.60	2.50	8.00	Pass
Lora	1	16	914.5	20.28	2.77	2.50	8.00	Pass
Lora	1	31	926.5	20.00	2.40	2.50	8.00	Pass

Note: PSD (dBm/ 100kHz) is a reference level used for Conducted Band Edges and Conducted Spurious Emission 30dBc limit.



Appendix B. Radiated Spurious Emission

Test Engineer :	Michael Bui and Daniel Lee	Temperature :	22~24.5°C
		Relative Humidity :	43~46.1%

Lora 902~928MHz
Lora DTS 500k (LF @ 3m)

Loa	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Path Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
Lora DTS 500k CH 01 902.5MHz		30.97	32.48	-7.52	40	29.35	24.71	10.85	32.43	-	-	P	H
		115.36	26.3	-17.2	43.5	29.64	17.4	11.66	32.4	-	-	P	H
		259.89	29.59	-16.41	46	29.3	20.18	12.52	32.41	-	-	P	H
		367.56	30.81	-15.19	46	29.26	21.05	12.98	32.48	-	-	P	H
		515.97	35.42	-10.58	46	30.31	24.1	13.6	32.59	-	-	P	H
		597.45	36.75	-9.25	46	29.53	26	13.84	32.62	-	-	P	H
		870.02	46.99	-39.91	86.9	34.8	29.3	14.72	31.83	-	-	P	H
	*	902.5	116.9	-	-	104.34	29.35	14.81	31.6	-	-	P	H
		934.04	47.25	-39.65	86.9	33.27	30.44	14.89	31.35	-	-	P	H
													H
		30	32.42	-7.58	40	28.91	25.1	10.84	32.43	-	-	P	V
		114.39	26.5	-17	43.5	29.83	17.4	11.67	32.4	-	-	P	V
		262.8	29.31	-16.69	46	29	20.2	12.53	32.42	-	-	P	V
		358.83	30.91	-15.09	46	29.49	20.95	12.95	32.48	-	-	P	V
		543.13	34.61	-11.39	46	29.01	24.55	13.66	32.61	-	-	P	V
		598.42	36.84	-9.16	46	29.63	26	13.84	32.63	-	-	P	V
		870.99	45.18	-41.72	86.9	33	29.28	14.72	31.82	-	-	P	V
	*	902.5	114.67	-	-	102.11	29.35	14.81	31.6	-	-	P	V
		934.04	45.98	-40.92	86.9	32	30.44	14.89	31.35	-	-	P	V
													V
Remark	1. No other spurious found. 2. All results are PASS against limit line. 3. Emission in non-restricted band should be 20dB lower than fundamental emission level 4. The emission position marked as "-" means no suspected emission found and emission level has at least 6dB margin against limit or emission is noise floor only												

[illegible]

Lora	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Path Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
Lora DTS 500k CH 31 926.5MHz		32.91	32.62	-7.38	40	30.44	23.75	10.87	32.44	-	-	P	H
		129.91	29.07	-14.43	43.5	32.16	17.59	11.72	32.4	-	-	P	H
		262.8	30.44	-15.56	46	30.13	20.2	12.53	32.42	-	-	P	H
		556.71	36.55	-9.45	46	29.5	25.97	13.7	32.62	-	-	P	H
		644.98	38.04	-7.96	46	30.1	26.6	13.94	32.6	-	-	P	H
		894.27	44.4	-41.55	85.95	31.99	29.29	14.78	31.66	-	-	P	H
	*	926.5	115.95	-	-	102.38	30.13	14.86	31.42	-	-	P	H
													H
													H
													H
													H
													H
		31.94	32.22	-7.78	40	29.56	24.23	10.86	32.43	-	-	P	V
		115.36	29.17	-14.33	43.5	32.51	17.4	11.66	32.4	-	-	P	V
		189.08	32.8	-10.7	43.5	38.11	15	12.09	32.4	-	-	P	V
		259.89	32.13	-13.87	46	31.84	20.18	12.52	32.41	-	-	P	V
		564.47	36.96	-9.04	46	29.66	26.19	13.73	32.62	-	-	P	V
		660.5	37.5	-8.5	46	29.48	26.59	14.01	32.58	-	-	P	V
		894.27	44.01	-41.94	85.95	31.6	29.29	14.78	31.66	-	-	P	V
	*	926.5	114.58	-	-	101.01	30.13	14.86	31.42	-	-	P	V
													V
													V
												V	
												V	
Remark	1. No other spurious found.												
	2. All results are PASS against limit line.												
	3. Emission in non-restricted band should be 20dB lower than fundamental emission level												
	4. The emission position marked as “-” means no suspected emission found and emission level has at least 6dB margin against limit or emission is noise floor only												



Lora DTS 500k (Harmonic @ 3m)

Lora	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Path Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
Lora DTS 500k CH 01 902.5MHz		1805	42.07	-44.83	86.9	78.32	25.4	7.09	68.74	-	-	P	H
		2707.5	46.28	-27.72	74	78.34	27.95	8.23	68.24	-	-	P	H
		3610	38.52	-35.48	74	67.69	29.19	9.69	68.05	-	-	P	H
		4512.5	39.05	-34.95	74	66.22	30.81	10.53	68.51	-	-	P	H
		5415	39.97	-34.03	74	63.89	31.76	11.78	67.46	-	-	P	H
		6317.5	44.9	-42	86.9	64.26	33.35	12.53	65.24	-	-	P	H
		1805	42.72	-44.18	86.9	78.78	25.59	7.09	68.74	-	-	P	V
		2707.5	38.48	-35.52	74	70.71	27.78	8.23	68.24	-	-	P	V
		3610	37.96	-36.04	74	67.11	29.21	9.69	68.05	-	-	P	V
		4512.5	39.08	-34.92	74	66.33	30.73	10.53	68.51	-	-	P	V
		5415	44.63	-29.37	74	68.6	31.71	11.78	67.46	-	-	P	V
		6317.5	47.81	-39.09	86.9	67.09	33.43	12.53	65.24	-	-	P	V
Lora DTS 500k CH 16 914.5MHz		1829	40.16	-46.69	86.85	76.15	25.52	7.11	68.62	-	-	P	H
		2743.5	44.01	-29.99	74	75.74	28.1	8.27	68.1	-	-	P	H
		3658	38.15	-35.85	74	67.26	29.21	9.69	68.01	-	-	P	H
		4572.5	38.79	-35.21	74	65.76	30.92	10.6	68.49	-	-	P	H
		5487	40.92	-45.93	86.85	64.64	31.91	11.84	67.47	-	-	P	H
		6401.5	44.73	-42.12	86.85	64.16	33.72	12.64	65.79	-	-	P	H
		1829	42.16	-44.69	86.85	78.05	25.62	7.11	68.62	-	-	P	V
		2743.5	38.01	-35.99	74	69.88	27.96	8.27	68.1	-	-	P	V
		3658	37.96	-36.04	74	66.98	29.3	9.69	68.01	-	-	P	V
		4572.5	39.81	-34.19	74	66.77	30.93	10.6	68.49	-	-	P	V
		5487	43.01	-43.84	86.85	66.72	31.92	11.84	67.47	-	-	P	V
		6401.5	45.18	-41.67	86.85	64.64	33.69	12.64	65.79	-	-	P	V



Lora DTS 500k CH 31 926.5MHz		1853	39.41	-46.54	85.95	75.14	25.64	7.13	68.5	-	-	P	H
		2779.5	43.05	-30.95	74	74.49	28.19	8.31	67.94	-	-	P	H
		3706	37.52	-36.48	74	66.35	29.39	9.69	67.91	-	-	P	H
		4632.5	38.43	-35.57	74	65.1	31.06	10.65	68.38	-	-	P	H
		5559	40.34	-45.61	85.95	63.83	31.92	11.91	67.32	-	-	P	H
		6485.5	43.85	-42.1	85.95	63.16	34.11	12.76	66.18	-	-	P	H
		1853	38.43	-47.52	85.95	74.15	25.65	7.13	68.5	-	-	P	V
		2779.5	38.56	-35.44	74	70.02	28.17	8.31	67.94	-	-	P	V
		3706	36.87	-37.13	74	65.7	29.39	9.69	67.91	-	-	P	V
		4632.5	41.6	-32.4	74	68.27	31.06	10.65	68.38	-	-	P	V
		5559	42.4	-43.55	85.95	65.87	31.94	11.91	67.32	-	-	P	V
		6485.5	44.96	-40.99	85.95	64.25	34.13	12.76	66.18	-	-	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Emission in non-restricted band should be 20dB lower than fundamental emission level 4. The emission position marked as “-” means no suspected emission found and emission level has at least 6dB margin against limit or emission is noise floor only												



Note symbol

*	Fundamental Frequency which can be ignored. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
!	Test result is over limit line.
P/A	Peak or Average
H/V	Horizontal or Vertical

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

LoRa	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
LoRa CH 01 902.2MHz		910	55.45	-18.55	74	54.51	32.22	4.58	35.86	103	308	P	H
		910	43.54	-10.46	54	42.6	32.22	4.58	35.86	103	308	A	H

1. Path Loss(dB) = Cable loss(dB) + Filter loss(dB) + Attenuator loss(dB)
2. Level(dBμV/m) =
Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
3. Over Limit(dB) = Level(dBμV/m) – Limit Line(dBμV/m)

For Peak Limit @ 910MHz:

1. Level(dBμV/m)
= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
= 32.22(dB/m) + 4.58(dB) + 54.51(dBμV) – 35.86 (dB)
= 55.45 (dBμV/m)
2. Over Limit(dB)
= Level(dBμV/m) – Limit Line(dBμV/m)
= 55.45(dBμV/m) – 74(dBμV/m)
= -18.55(dB)

For Average Limit @ 910MHz:

1. Level(dBμV/m)
= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
= 32.22(dB/m) + 4.58(dB) + 42.6(dBμV) – 35.86 (dB)
= 43.54 (dBμV/m)
2. Over Limit(dB)
= Level(dBμV/m) – Limit Line(dBμV/m)
= 43.54(dBμV/m) – 54(dBμV/m)
= -10.46(dB)

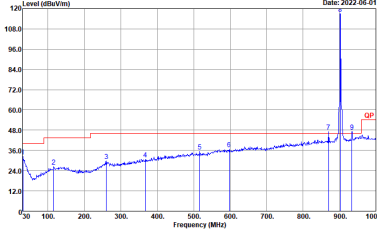
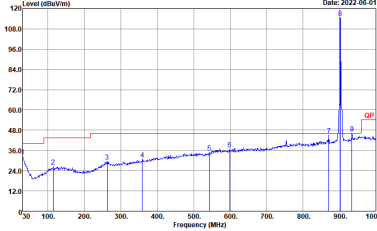
Both peak and average measured complies with the limit line, so test result is “PASS”.



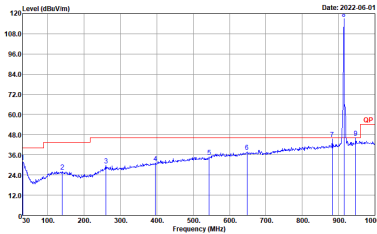
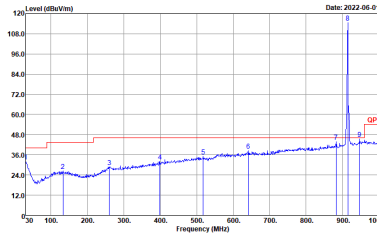
Appendix C. Radiated Spurious Emission Plots

Test Engineer :	Michael Bui and Daniel Lee	Temperature :	22~24.5°C
		Relative Humidity :	43~46.1%

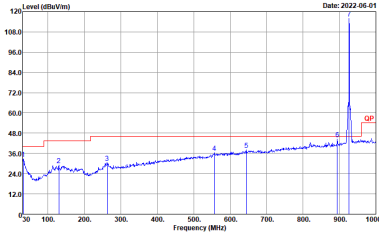
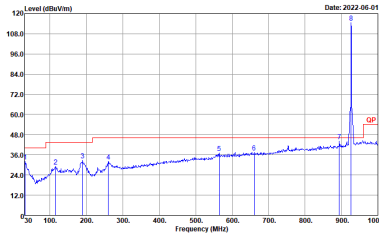
Lora 902~928MHz Lora DTS 500k (LF @ 3m)

Lora	Lora 902~928MHz	
	Lora DTS 500k Ch01 902.5Mhz	
	Horizontal	Vertical
QP / Peak		



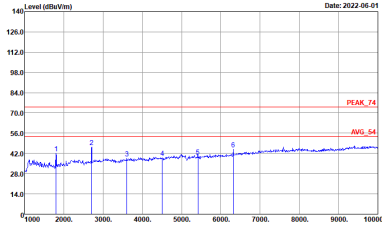
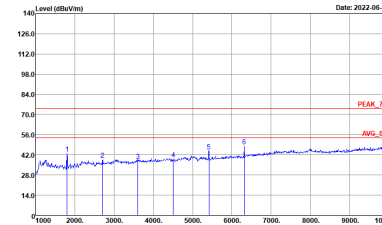
Lora	Lora 920~928MHz	
	Lora DTS 500k Ch16 914.5MHz	
	Horizontal	Vertical
QP / Peak	 Site : 03CH02-CA Condition : QP 3m BIL06_54683_2021 HORIZONTAL	 Site : 03CH02-CA Condition : QP 3m BIL06_54683_2021 VERTICAL



Lora	Lora 902~928MHz	
	Lora DTS 500k Ch31 926.5MHz	
	Horizontal	Vertical
Peak Avg.	 Site : 03CH02-CA Condition : QP 3m B1LOG_54683_2021 HORIZONTAL	 Site : 03CH02-CA Condition : QP 3m B1LOG_54683_2021 VERTICAL



Lora 902~928MHz
Lora DTS 500k (Harmonic @ 3m)

Lora	Lora 902~928MHz	
	Lora DTS 500k Ch01 902.5Mhz	
	Horizontal	Vertical
Peak Avg.	Level (dBuV/m) Date: 2022-06-01  Site : 03CH02-CA Condition : PEAK_74 3m HORN-HF_01895_2021 HORIZONTAL	Level (dBuV/m) Date: 2022-06-01  Site : 03CH02-CA Condition : PEAK_74 3m HORN-HF_01895_2021 VERTICAL



Lora	Lora 902~928MHz	
	Lora DTS 500k Ch16 914.5MHz	
	Horizontal	Vertical
Peak Avg.	Level (dBm/100) Date: 2022-06-01 Site : 03CH02-CA Condition : PEAK_74 3m HORN-HF_01895_2021 HORIZONTAL	Level (dBm/100) Date: 2022-06-01 Site : 03CH02-CA Condition : PEAK_74 3m HORN-HF_01895_2021 VERTICAL



Lora	Lora 902~928MHz	
	Lora DTS 500k Ch31 926.5MHz	
	Horizontal	Vertical
Peak Avg.	Level (dBμV/m) Date: 2022-06-01 Site : 03CH02-CA Condition : PEAK_74 3m HORN-HF_01895_2021 HORIZONTAL	Level (dBμV/m) Date: 2022-06-01 Site : 03CH02-CA Condition : PEAK_74 3m HORN-HF_01895_2021 VERTICAL



Appendix D. Duty Cycle Plots

Band	Duty Cycle(%)	T(us)	1/T(kHz)	VBW Setting
Lora DTS 500kHz	100.00	-	-	10Hz

