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TEST REPORT

FCC LoRa Test for LGW
Certification

APPLICANT
MUSMA Co.,Ltd

REPORT NO.
HCT-RF-2402-FC024

DATE OF ISSUE
February 15, 2024

Tested by
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TEST REPORT

REPORT NO.
HCT-RF-2402-FC024

DATE OF ISSUE
January 15, 2024

Applicant	**MUSMA Co.,Ltd** 1~4th Floor, 3, Mangmibeonyeong-ro 52beon-gil, Suyeong-gu, Busan, Republic of Korea
Product Name Model Name	LoRa Gateway LGW
FCC ID	2BEXVLGW
RF Peak Output Power	14.654 dBm (29.20 mW)
FCC Classification	FCC Part 15 Spread Spectrum Transmitter
Test Standard Used	FCC Rule Part15 subpart C 15.247
Test Results	PASS
Date of Test	December 01, 2023 ~ January 31, 2024
Location of Test	■ Permanent Testing Lab ☐ On Site Testing Lab (Address: 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, Republic of Korea)

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REVISION HISTORY

The revision history for this test report is shown in table.

Revision No.	Date of Issue	Description
0	January 15, 2024	Initial Release

Notice

Content
Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules under normal use and maintenance. The results shown in this test report only apply to the sample(s), as received, provided by the applicant, unless otherwise stated. The test results have only been applied with the test methods required by the standard(s). The laboratory is not accredited for the test results marked *. Information provided by the applicant is marked **. Test results provided by external providers are marked ***. When confirmation of authenticity of this test report is required, please contact www.hct.co.kr The test results in this test report are not associated with the ((KS Q) ISO/IEC 17025) accreditation by KOLAS (Korea Laboratory Accreditation Scheme) / A2LA (American Association for Laboratory Accreditation) that are under the ILAC (International Laboratory Accreditation Cooperation) Mutual Recognition Agreement (MRA).

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1. EUT DESCRIPTION

Model	LGW
EUT Type	LoRa Gateway
Voltage (V)	AC 220 V
Frequency Range	902 MHz – 928 MHz (TX/RX 125 kHz : 902.3 ~ 914.9)
Max. RF Output Power	14.654 dBm (29.20 mW)
Modulation Type	CSS
Number of Channels (125 kHz)	64 Channels uplink 64 Channels downlink
Antenna Specification	Antenna type: LoRa Dipole Antenna Peak Gain : 3.5 dBi
EUT serial numbers	Conducted : L0008 Radiated : L0008

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2. Requirements for Frequency Hopping Device(FHSS) transmitter(15.247)

This LoRa module has been tested by a LoRa Qualification Lab, and we confirm the following:

1) This system is hopping pseudo-randomly.
2) Each frequency is used equally on the average by each transmitter.
3) The receiver input bandwidths that match the hopping channel bandwidths of their corresponding transmitters
4) The receiver shifts frequencies in synchronization with the transmitted signals.

- 15.247(g): The system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this Section 15.247 should the transmitter be presented with a continuous data (or information) stream.

- 15.247(h): The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

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3. TEST METHODOLOGY

The measurement procedure described in the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Device (ANSI C63.10-2013, KDB 558074) is used in the measurement of the test device.

EUT CONFIGURATION

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

EUT EXERCISE

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. According to its specifications, the EUT must comply with the requirements of the Section 15.207, 15.209 and 15.247 under the FCC Rules Part 15 Subpart C.

GENERAL TEST PROCEDURES

Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2 of ANSI C63.10. (Version :2013) Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30 MHz using CISPR Quasi-peak and average detector modes.

Radiated Emissions

The EUT is placed on a turn table, which is 0.8 m above ground plane below 1 GHz. Above 1 GHz with 1.5 m using absorbers between the EUT and receive antenna. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3 m away from the receiving antenna, which varied from 1 m to 4 m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. emission, the relative positions of this hand-held transmitter (EUT) was rotated through three orthogonal axes according to the requirements in Section 6.6.5 of ANSI C63.10. (Version: 2013). To record the final measurements, the analyzer detector function was set to CISPR quasi-peak mode and the bandwidth of the spectrum analyzer was set to 120 kHz for frequencies below 1 GHz or 1 MHz for frequencies above 1 GHz. For average measurements above 1 GHz, the analyzer was set to peak detector with a reduced VBW setting(RBW = 1 MHz, VBW = 1/T Hz, where T = Pulse width).

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DESCRIPTION OF TEST MODES

The EUT has been tested under operating condition. Test program used to control the EUT for staying in continuous transmitting and receiving mode is programmed.

4. INSTRUMENT CALIBRATION

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipment's, which is traceable to recognized national standards.
Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5 (Version : 2017).

5. FACILITIES AND ACCREDITATIONS

FACILITIES

The SAC(Semi-Anechoic Chamber) and conducted measurement facility used to collect the radiated data are located at the 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, 17383, Rep. of KOREA. The site is constructed in conformance with the requirements of ANSI C63.4. (Version :2014) and CISPR Publication 22.
Detailed description of test facility was submitted to the Commission and accepted dated March 31, 2022 (Registration Number: KR0032).

EQUIPMENT

Radiated emissions are measured with one or more of the following types of Linearly polarized antennas: tuned dipole, bi-conical, log periodic, bi-log, and/or ridged waveguide, horn. Spectrum analyzers with pre-selectors and quasi-peak detectors are used to perform radiated measurements. Conducted emissions are measured with Line Impedance Stabilization Networks and EMI Test Receivers. Calibrated wideband preamplifiers, coaxial cables, and coaxial attenuators are also used for making measurements.
All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

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6. ANTENNA REQUIREMENTS

According to FCC 47 CFR § 15.203:

"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section."

This device has a standard antenna connector but, it is professionally installed in specific location, so § 15.203 Antenna requirements does not be applied to.

7. MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of $k = 2$ to indicate a 95 % level of confidence. The measurement data shown herein meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded Uncertainty (dB)
Conducted Disturbance (150 kHz ~ 30 MHz)	1.98 (Confidence level about 95 %, k=2)
Radiated Disturbance (9 kHz ~ 30 MHz)	4.36 (Confidence level about 95 %, k=2)
Radiated Disturbance (30 MHz ~ 1 GHz)	5.70 (Confidence level about 95 %, k=2)
Radiated Disturbance (1 GHz ~ 18 GHz)	5.52 (Confidence level about 95 %, k=2)
Radiated Disturbance (18 GHz ~ 40 GHz)	5.66 (Confidence level about 95 %, k=2)
Radiated Disturbance (Above 40 GHz)	5.58 (Confidence level about 95 %, k=2)

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8. DESCRIPTION OF TESTS

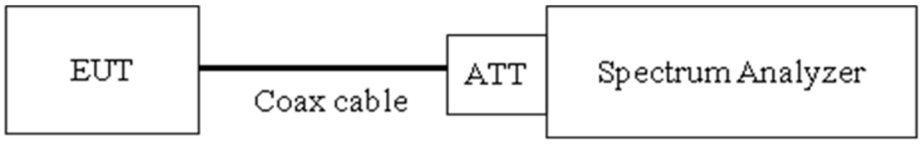
8.1. Conducted Maximum Peak Output Power

Limit

The maximum peak output power of the intentional radiator shall not exceed the following:

1. 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
2. The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer. The Spectrum Analyzer is set to the peak detector mode. This test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.5 in ANSI 63.10-2013 & Procedure 9(b) in KDB 558074 v05r02)

1) Span: approximately 5 times the 20 dB bandwidth, centered on a hopping channel
2) RBW > the 20 dB bandwidth of the emission being measured
3) VBW ≥ RBW
4) Sweep = Auto
5) Detector = Peak
6) Trace = Max hold

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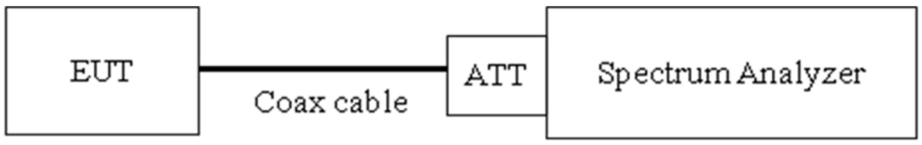
8.2. Conducted Band Edge(Out of Band Emissions)

Limit

According to § 15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

Test Configuration



Test Procedure

This test is performed with hopping off and hopping on.

The Spectrum Analyzer is set to (6.10.4 in ANSI 63.10-2013 & Procedure 8.5 and 8.6 in KDB 558074 v05r02)

1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation
2) Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level.
3) Attenuation: Auto (at least 10 dB preferred).
4) Sweep time: Coupled.
5) RBW: 100 kHz
6) VBW: 300 kHz
7) Detector: Peak
8) Trace: Max hold

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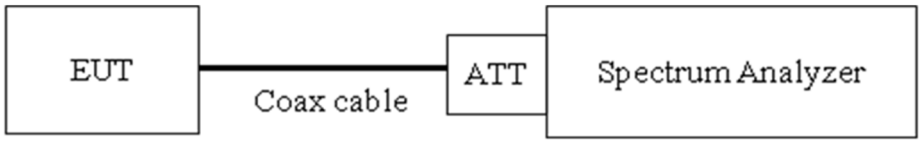
8.3. Frequency Separation & 20 dB Bandwidth

Limit

According to § 15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Test Configuration



Test Procedure(Frequency Separation)

The Channel Separation test is performed with hopping on.
And the 20 dB Bandwidth test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.2 in ANSI 63.10-2013 & Procedure 9(b) in KDB 558074 v05r02)

1) Span: Wide enough to capture the peaks of two adjacent channels
2) RBW: Start with the RBW set to approximately 30 % of the channel spacing; adjust as necessary to best identify the center of each individual channel.
3) VBW ≥ RBW
4) Sweep: Auto
5) Detector: Peak
6) Trace: Max hold
7) All the trace to stabilize.
8) Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.

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Test Procedure (20 dB Bandwidth)

And the 20 dB Bandwidth test is performed with hopping off.

The Spectrum Analyzer is set to (6.9.2 in ANSI 63.10-2013)

1) Span: Set between two times and five times the OBW
2) RBW: 1 % to 5 % of the OBW.
3) VBW ≥ 3 x RBW
4) Sweep: Auto
5) Detector: Peak
6) Trace: Max hold
7) All the trace to stabilize.

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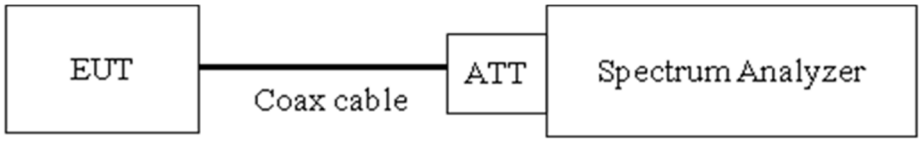
8.4. Number of Hopping Frequencies

Limit

According to § 15.247(a)(1)(i), 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

Test Configuration



Test Procedure

The Bluetooth frequency hopping function of the EUT was enabled.

The Spectrum Analyzer is set to (7.8.3 in ANSI 63.10-2013 & Procedure 9(b) in KDB 558074 v05r02)

1) Span: the frequency band of operation
2) RBW: To identify clearly the individual channels, set the RBW to less than 30 % of the channel spacing or the 20 dB bandwidth, whichever is smaller.
3) VBW ≥ RBW
4) Sweep: Auto
5) Detector: Peak
6) Trace: Max hold
7) Allow the trace to stabilize.

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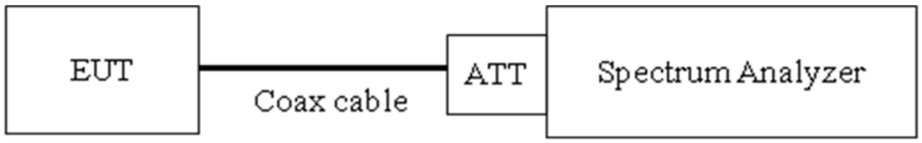
8.5. Time of Occupancy

Limit

According to § 15.247(a)(1)(i), 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 average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period

Test Configuration



Test Procedure

This test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.4 in ANSI 63.10-2013 & Procedure 9(b) in KDB 558074 v05r02)

1) Span: Zero span, centered on a hopping channel
2) RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
3) Sweep = as necessary to capture the entire dwell time per hopping channel
4) Detector: Peak
5) Trace: Max hold

The marker-delta function was used to determine the dwell time.

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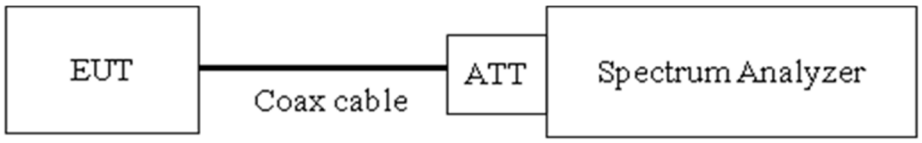
8.6. Conducted Spurious Emissions

Limit

Conducted > 20 dBc

Test Configuration



Test Procedure

Conducted RF measurements of the transmitter output were made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer.

The Spectrum Analyzer is set to (7.8.8 in ANSI 63.10-2013 & Procedure 8.5 and 8.6 in KDB 558074 v05r02)

1) Span: 30 MHz to 10 times the operating frequency in GHz.
2) RBW: 100 kHz
3) VBW: 300 kHz
4) Sweep: Coupled
5) Detector: Peak

Measurements are made over the 30 MHz to 10 GHz range with the transmitter set to the lowest, middle, and highest channels.

This test is performed with hopping off.

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Factors for frequency

Freq(MHz)	Factor(dB)
30	10.03
100	10.10
200	10.14
300	10.16
400	10.18
500	10.24
600	10.22
700	10.27
800	10.28
902	10.30
928	10.30
1 000	10.49
2 000	10.51
2 400	10.60
2 500	10.60
3 000	10.60
4 000	10.71
5 000	10.73
6 000	10.80
7 000	10.85
8 000	10.91
9 000	10.97
10 000	11.02
11 000	11.10
12 000	11.19
13 000	11.16
14 000	11.21
15 000	11.22
16 000	11.25
17 000	11.30
18 000	11.32
19 000	11.36
20 000	11.48
21 000	11.55
22 000	11.55
23 000	11.59
24 000	11.68

Note :
1. 902 ~ 928 MHz is fundamental frequency range.
2. Factor = Cable loss + Attenuator

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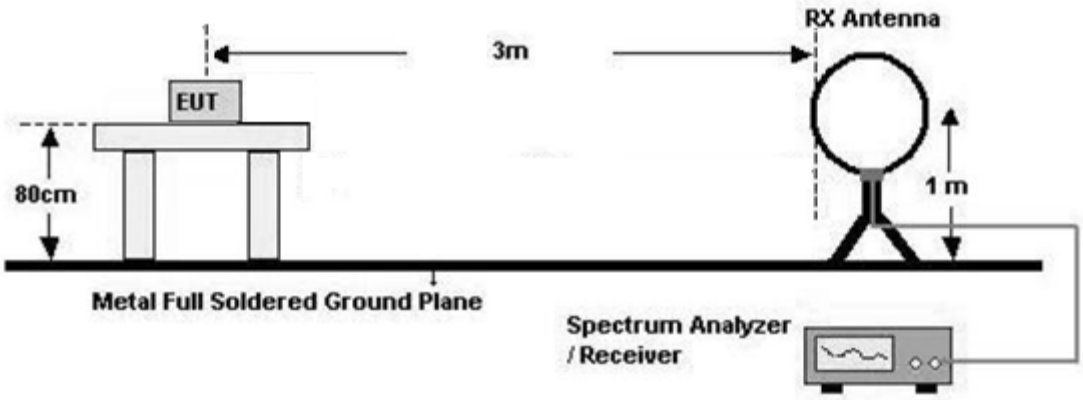
8.7. Radiated Test

Limit

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

Test Configuration

Below 30 MHz



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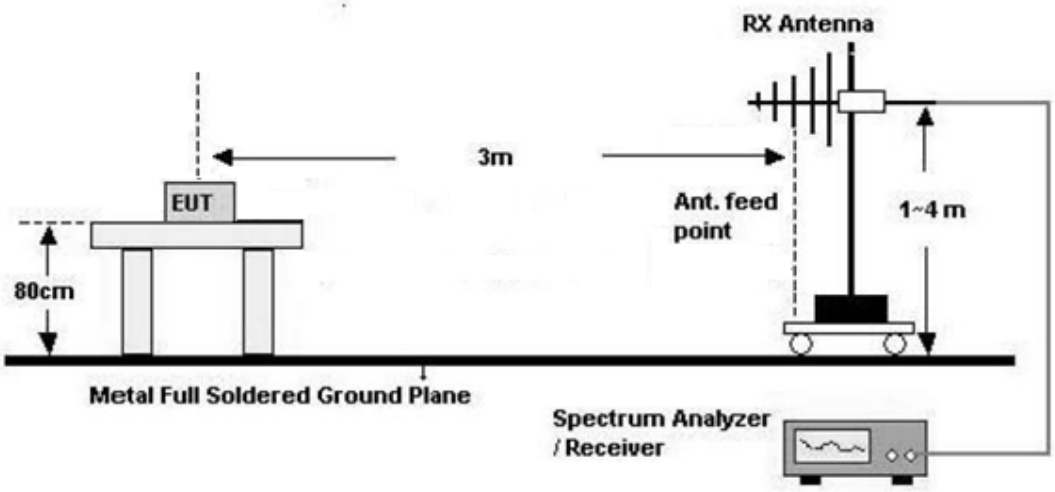
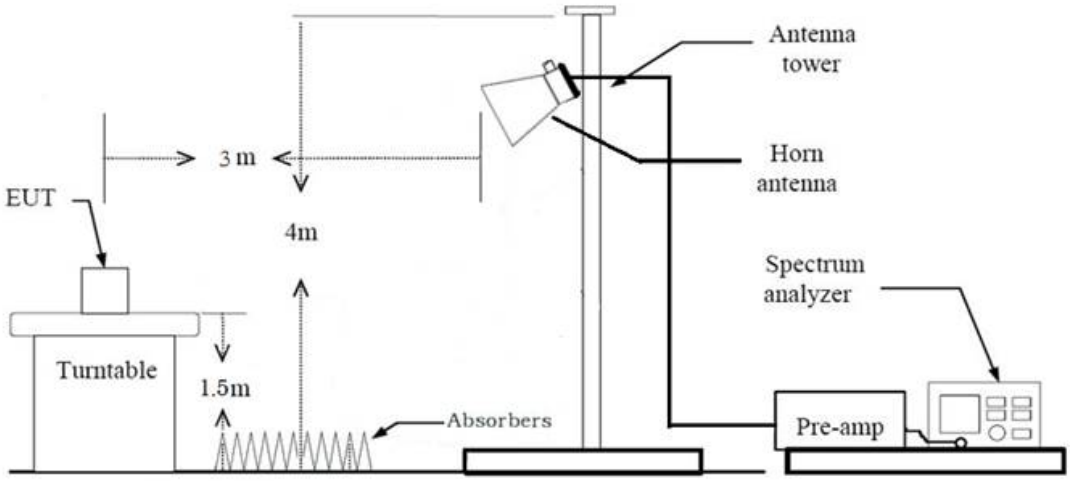
30 MHz - 1 GHz



Above 1 GHz



Test Procedure of Radiated spurious emissions(Below 30 MHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The loop antenna was placed at a location 3 m from the EUT
3. The EUT is placed on a turntable, which is 0.8 m above ground plane.
4. We have done x, y, z planes in EUT and horizontal and vertical polarization and Parallel to the ground plane in detecting antenna.
5. The turntable shall be rotated for 360 degrees to determine the position of maximum emission

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level.

6. Distance Correction Factor(0.009 MHz – 0.490 MHz) = 40log(3 m/300 m) = - 80 dB
   Measurement Distance : 3 m
7. Distance Correction Factor(0.490 MHz – 30 MHz) = 40log(3 m/30 m) = - 40 dB
   Measurement Distance : 3 m
8. Spectrum Setting
   - Frequency Range = 9 kHz ~ 30 MHz
   - Detector = Peak
   - Trace = Maxhold
   - RBW = 9 kHz
   - VBW ≥ 3 x RBW
9. Total = Measured Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)
10. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.

KDB 414788 OFS 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.

OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

Test Procedure of Radiated spurious emissions(Below 1 GHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The EUT is placed on a turntable, which is 0.8 m above ground plane.
3. The Hybrid antenna was placed at a location 3 m from the EUT, which is varied from 1 m to 4 m to find out the highest emissions.
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
5. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
6. Spectrum Setting
   (1) Measurement Type(Peak):
      - Measured Frequency Range : 30 MHz – 1 GHz
      - Detector = Peak

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- Trace = Maxhold
- RBW = 100 kHz
- VBW ≥ 3 x RBW

(2) Measurement Type(Quasi-peak):

- Measured Frequency Range : 30 MHz – 1 GHz
- Detector = Quasi-Peak
- RBW = 120 kHz

※In general, (1) is used mainly

7. Total = Measured Value + Antenna Factor(A.F) + Cable Loss(C.L)
8. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.

Test Procedure of Radiated spurious emissions (Above 1 GHz)

1. Radiated test is performed with hopping off.
2. The EUT is placed on a turntable, which is 1.5 m above ground plane.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
5. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
6. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
7. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
8. Spectrum Setting

(1) Measurement Type(Peak):

- Measured Frequency Range 1 GHz – 10th Harmonics
- Detector = Peak
- Trace = Maxhold
- RBW = 1 MHz
- VBW ≥ 3 x RBW

(2) Measurement Type(Average):

- We performed using a reduced video BW method was done with the analyzer in linear mode
- Measured Frequency Range : 1 GHz – 10th Harmonics
- Detector = Peak

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- Trace = Maxhold
- RBW = 1 MHz
- VBW ≥ 1/τ Hz, where τ = pulse width in seconds

  The actual setting value of VBW = 1 kHz

9. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.
10. Distance extrapolation factor = 20log (test distance / specific distance) (dB)
11. Total = Measured Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(A.G) + Distance Factor(D.F)

Test Procedure of Radiated Restricted Band Edge

1. Radiated test is performed with hopping off.
2. The EUT is placed on a turntable, which is 1.5 m above ground plane.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
5. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
6. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
7. Spectrum Setting

   (1) Measurement Type(Peak):

   - Measured Frequency Range : 1 GHz – 10th Harmonics
   - Detector = Peak
   - Trace = Maxhold
   - RBW = 1 MHz
   - VBW ≥ 3 x RBW

   (2) Measurement Type(Average):

   - We performed using a reduced video BW method was done with the analyzer in linear mode
   - Measured Frequency Range : 1 GHz – 10th Harmonics
   - Detector = Peak
   - Trace = Maxhold
   - RBW = 1 MHz
   - VBW ≥ 1/τ Hz, where τ = pulse width in seconds

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The actual setting value of VBW = 1 kHz

8. Distance extrapolation factor = 20log (test distance / specific distance) (dB)
9. Total(Measurement Type : Peak, Average)
   = Measured Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F) – Amp Gain(A.G)
10. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.

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8.8. AC Power line Conducted Emissions

Limit

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN).

Frequency Range (MHz)	Limits (dBμV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56[a]	56 to 46[a]
0.50 to 5	56	46
5 to 30	60	50

[a]Decreases with the logarithm of the frequency.

Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line (LINE and NEUTRAL) and ground at the power terminals.

Test Configuration

See test photographs attached in Annex A for the actual connections between EUT and support equipment.

Test Procedure

1. The EUT is placed on a wooden table 80 cm above the reference ground plane.
2. The EUT is connected via LISN to a test power supply.
3. The measurement results are obtained as described below:
4. Detectors : Quasi Peak and Average Detector.
5. The EUT is the device operating below 30 MHz.
   - For unterminated the Antenna, the AC line conducted tests are performed with the antenna connected
   - For terminated the Antenna, the AC line conducted tests are performed with a dummy load connected to the EUT antenna output terminal.

Sample Calculation

Quasi-peak(Final Result) = Measured Value + Correction Factor

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8.9. Worst case configuration and mode

Radiated test

1. All modes of operation were investigated and the worst case configuration results are reported.
   - Mode : Stand alone
2. EUT Axis
   - Radiated Spurious Emissions : Z
   - Radiated Restricted Band Edge : Z
3. All data rate of operation were investigated and the test results are worst case of each mode.
   - 125 kHz (SF 7, 9)
   - Worst case : 125 kHz SF 9
4. All position of loop antenna were investigated and the test result is a no critical peak found at all positions.
   - Position : Horizontal, Vertical, Parallel to the ground plane

AC Power line Conducted Emissions

1. All modes of operation were investigated and the worst case configuration results are reported.

Conducted test

1. All modes of operation were investigated and the worst case configuration results are reported.
   - 125 kHz (SF 7, 9)
   - Worst case : 125 kHz SF 7

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9. SUMMARY OF TEST RESULTS

Test Description	FCC Part Section(s)	Test Limit	Test Condition	Test Result
20 dB Bandwidth	§ 15.247(a)(1)(i)	< 250 kHz	Conducted	PASS
Occupied Bandwidth	N/A	N/A		N/A
Conducted Maximum Peak Output Power	§ 15.247(b)(2)	< 1 W		PASS
Carrier Frequency Separation	§ 15.247(a)(1)	> 25 kHz or > 20 dB BW of hopping channel, whichever is greater.		PASS
Number of Hopping Frequencies	§ 15.247(a)(1)(i)	≥ 50		PASS
Time of Occupancy	§ 15.247(a)(1)(i)	< 400 ms (20s)		PASS
Conducted Spurious Emissions	§ 15.247(d)	> 20 dB for all out-of band emissions		PASS
Band Edge (Out of Band Emissions)	§ 15.247(d)	> 20 dB for all out-of band emissions		PASS
AC Power line Conducted Emissions	§ 15.207(a)	cf. Section 8.8		PASS
Radiated Spurious Emissions	§ 15.247(d), 15.205, 15.209	cf. Section 8.7	Radiated	PASS
Radiated Restricted Band Edge	§ 15.247(d), 15.205, 15.209	cf. Section 8.7		PASS

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10. TEST RESULT

10.1 PEAK POWER

Test Data (LoRa 125k)

Channel	Frequency (MHz)	Output Power (SF7)		Limit (mW)	Result
		(dBm)	(mW)		
Low	902.3	14.654	29.20	1000	PASS
Mid	908.5	14.379	27.41		PASS
High	914.9	14.470	27.99		PASS

Channel	Frequency (MHz)	Output Power (SF9)		Limit (mW)	Result
		(dBm)	(mW)		
Low	902.3	14.011	25.18	1000	PASS
Mid	908.5	14.191	26.25		PASS
High	914.9	14.242	26.56		PASS

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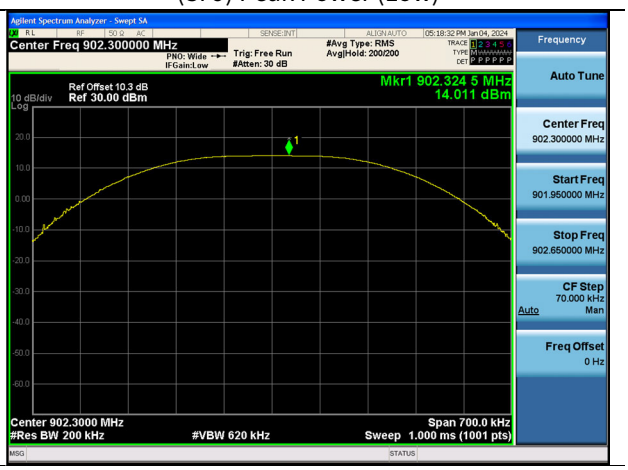
Test Plots **-LoRa 125k -**

(SF7) Peak Power (Low)

(SF9) Peak Power (Low)



(SF7) Peak Power (Mid)

(SF9) Peak Power (Mid)

(SF7) Peak Power (High)

(SF9) Peak Power (High)

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10.2 BAND EDGES

Test Data (LoRa 125k)

- Without hopping

Channel	Frequency (MHz)	Position	SF7	Limit (dBc)	Margin (dBc)	Result
Low	902.3	Lower	27.458	20	7.458	Pass
High	914.9	Upper	68.108		48.108	Pass

Channel	Frequency (MHz)	Position	SF9	Limit (dBc)	Margin (dBc)	Result
Low	902.3	Lower	30.629	20	20.074	Pass
High	914.9	Upper	68.663		48.663	Pass

- With hopping

Channel	Frequency (MHz)	Position	SF7	Limit (dBc)	Margin (dBc)	Result
Low	902.3	Lower	43.859	20	23.859	Pass
High	914.9	Upper	67.560		47.560	Pass

Channel	Frequency (MHz)	Position	SF9	Limit (dBc)	Margin (dBc)	Result
Low	902.3	Lower	44.751	20	24.751	Pass
High	914.9	Upper	68.181		48.181	Pass

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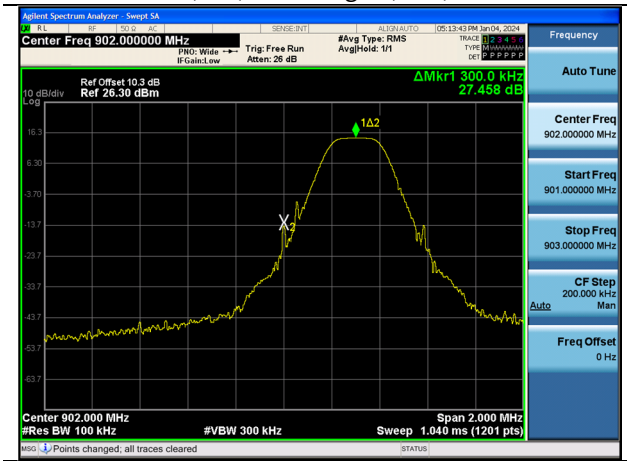
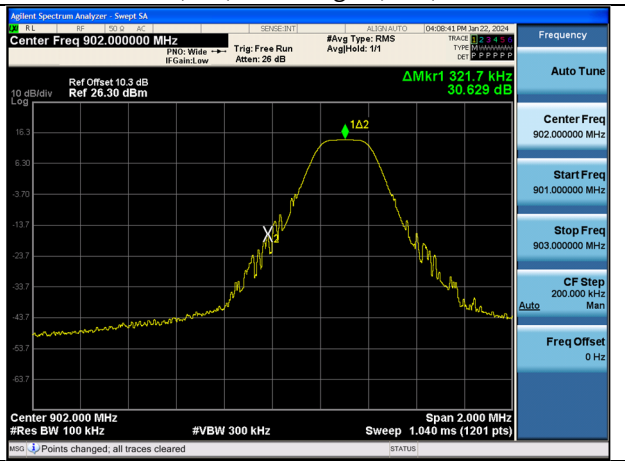
Test Plots without hopping -**LoRa 125k -**

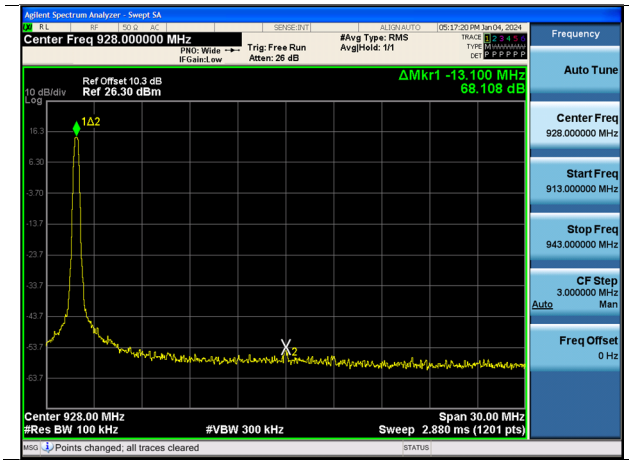
(SF7) Band Edges (Low)



(SF9) Band Edges (Low)



(SF7) Band Edges (High)



(SF9) Band Edges (High)

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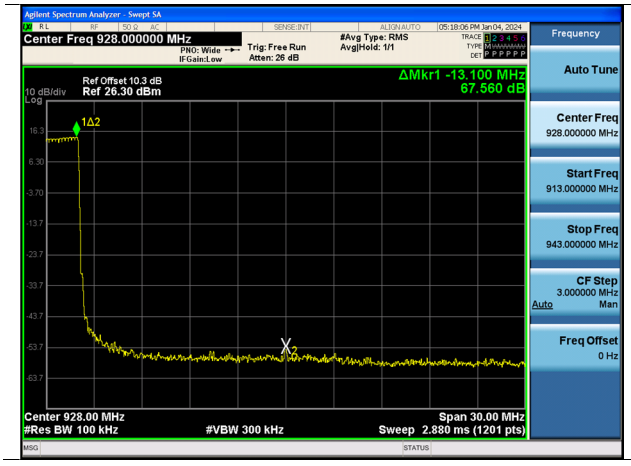
Test Plots with hopping -**LoRa 125k -**

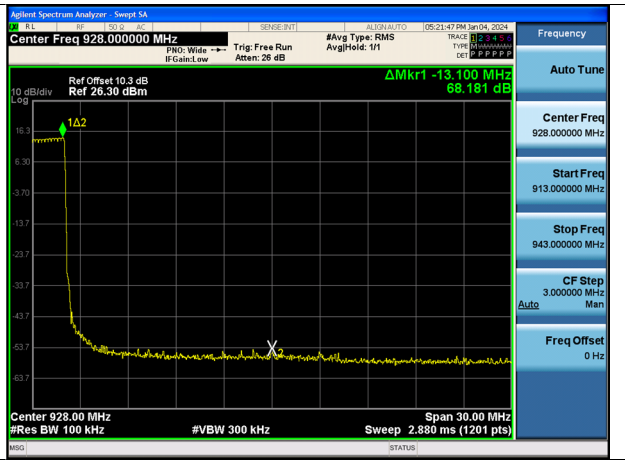
(SF7) Band Edges (Low)

(SF9) Band Edges (Low)

(SF7) Band Edges (High)



(SF9) Band Edges (High)



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10.3 FREQUENCY SEPARATION / OCCUPIED BANDWIDTH (99 % BW)

Test Data (LoRa 125k)

20dB Bandwidth (kHz)			Channel Separation (kHz)	Limit (kHz)	Limit (kHz)	Result
Channel	Freq(MHz)	SF7				
Low	902.3	150.3	200.0	150.3	>25 or > 20 dB BW of hopping channel, Whichever is greater	Pass
Mid	908.5	149.1				
High	914.9	150.0				

20dB Bandwidth (kHz)			Channel Separation (kHz)	Limit (kHz)	Limit (kHz)	Result
Channel	Freq(MHz)	SF9				
Low	902.3	142.8	200.0	143.2	>25 or > 20 dB BW of hopping channel, Whichever is greater	Pass
Mid	908.5	143.2				
High	914.9	139.6				

Occupied Bandwidth (99 % BW)

Channel	Frequency (MHz)	99% BW (kHz)	
		SF7	SF9
Low	902.3	130.32	125.81
Mid	908.5	131.22	125.61
High	914.9	130.59	125.64

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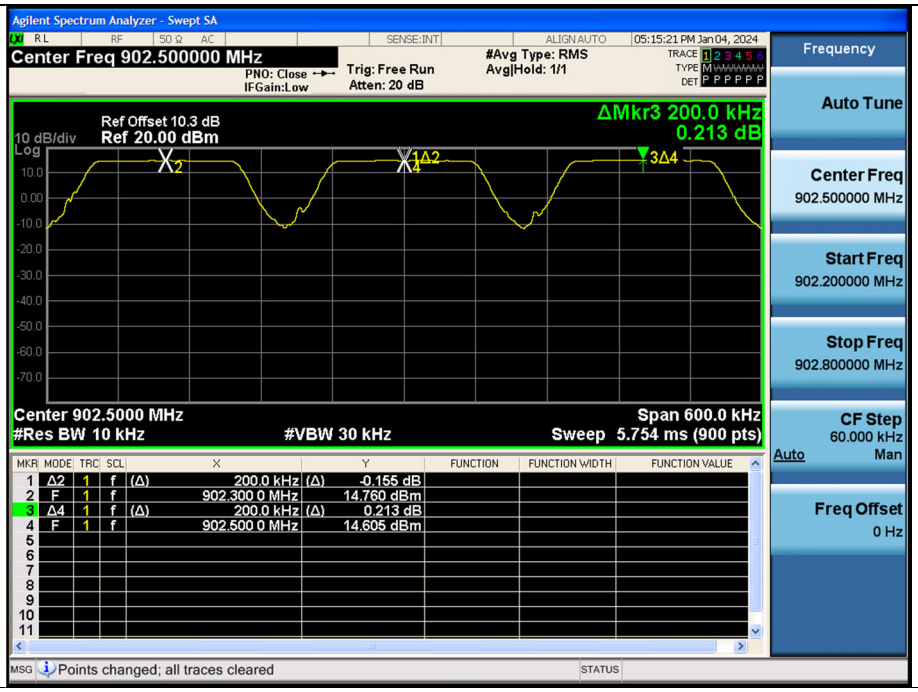
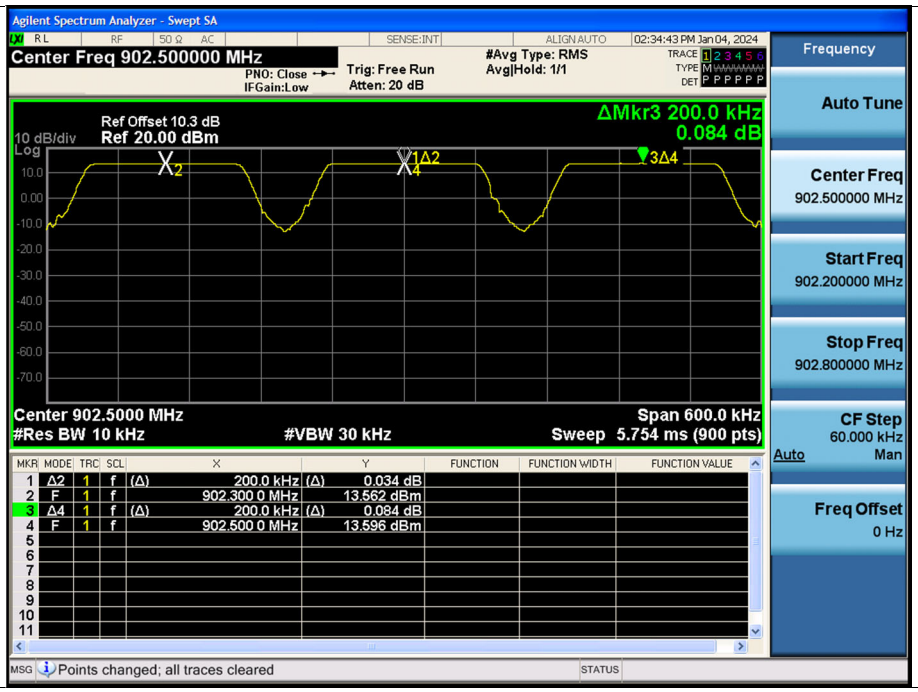
Test Plots(Channel Separation) -**LoRa 125k** -

(SF7) Channel Separation



(SF9) Channel Separation



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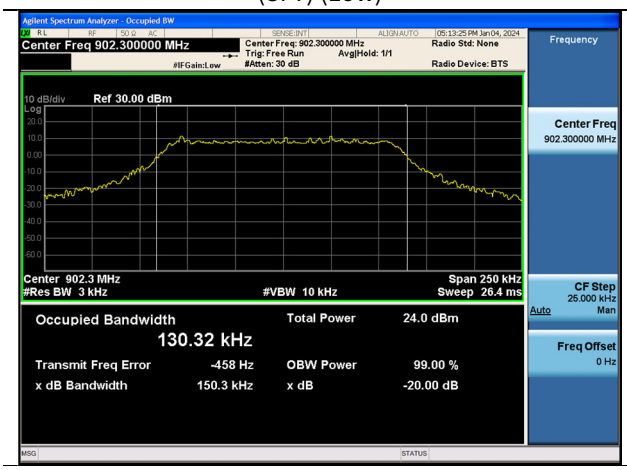
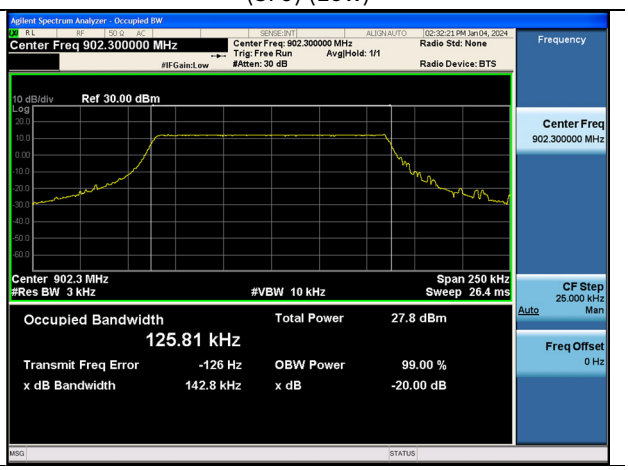
Test Plots (20 dB Bandwidth & Occupied Bandwidth) **-LoRa 125k -**

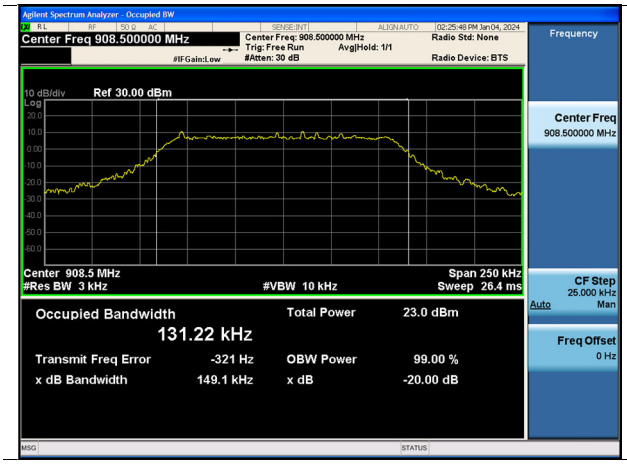
(SF7) (Low)



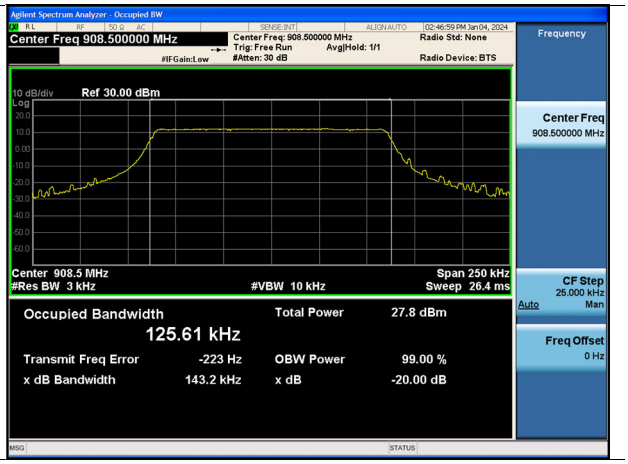
(SF9) (Low)



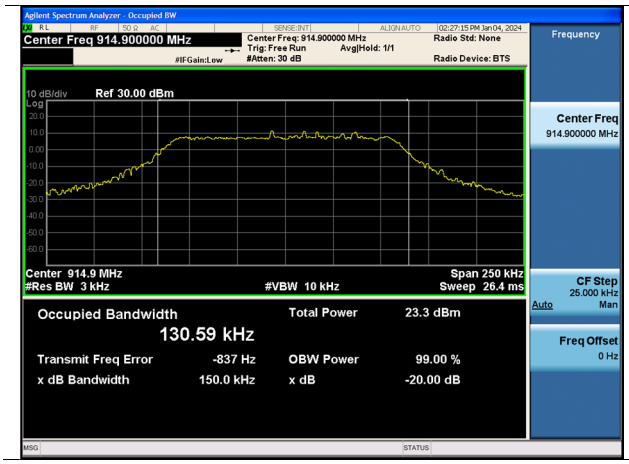
(SF7) (Mid)



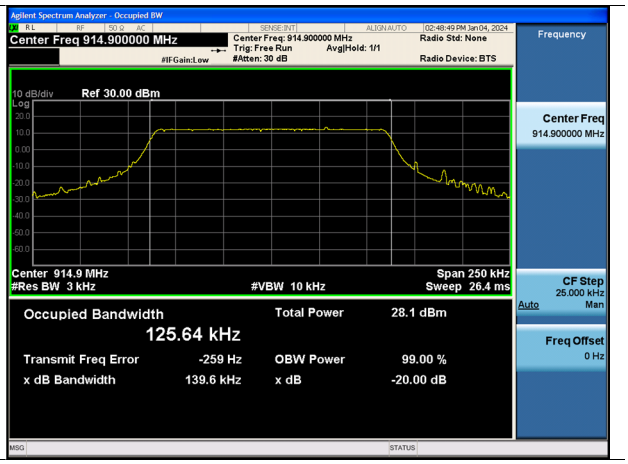
(SF9) (Mid)



(SF7) (High)



(SF9) (High)



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10.4 NUMBER OF HOPPING FREQUENCY

Result (No. of CH)		Limit
SF7	SF9	
64	64	> 50

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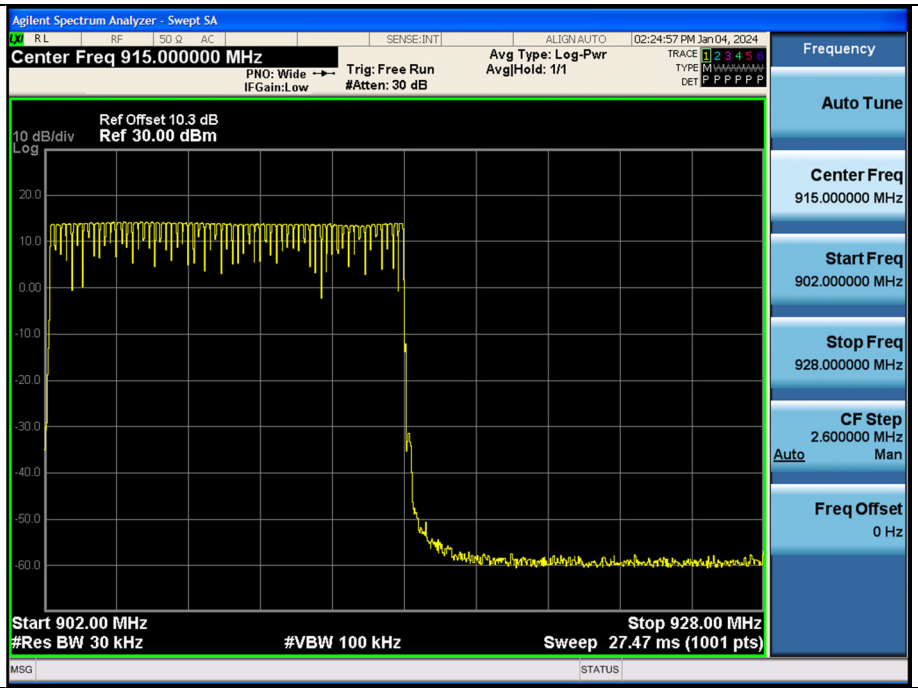
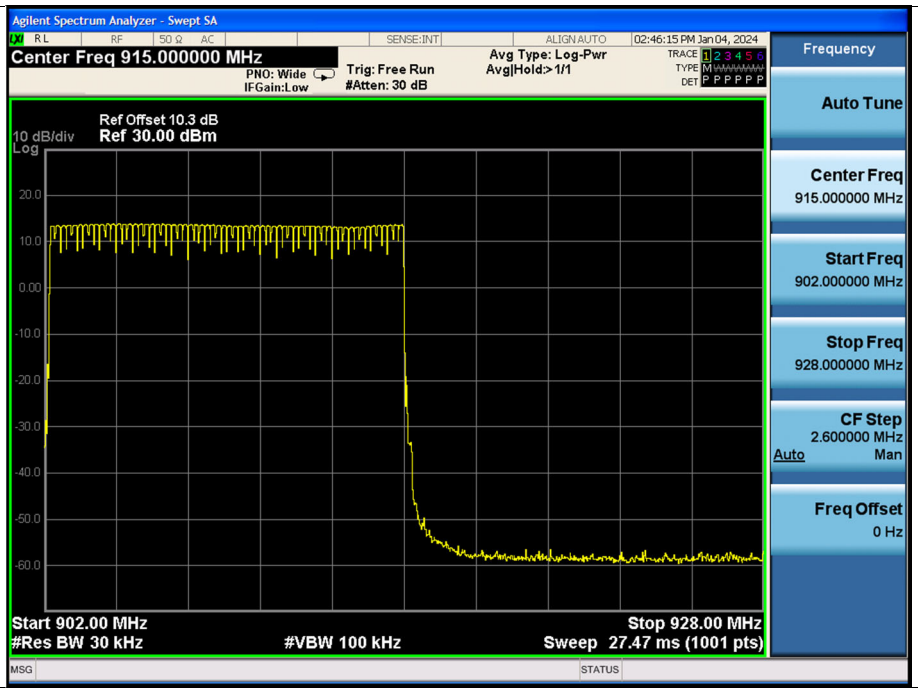
Test Plots(Number of Channels) -**LoRa 125k -**

(SF7) Number of Channels



(SF9) Number of Channels



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10.5 TIME OF OCCUPANCY (DWELL TIME)

TEST RESULTS (LoRa 125k)

See the table.

	Channel	SF7	SF9	Limit (ms)	Result
Dwell Time (ms)	Low	102.6	329.0	400 ms (20s)	Pass
	Mid	102.6	329.0		Pass
	High	102.8	329.0		Pass

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