TEST REPORT

FCC/ISED LoRa Test for LORU
Certification

APPLICANT
Mueller Systems, LLC

REPORT NO.
HCT-RF-2312-FI012-R1

DATE OF ISSUE
January 25, 2024

Tested by
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Technical Manager
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Accredited by KOLAS, Republic of KOREA

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Applicant	**Mueller Systems, LLC** 1200 Abernathy Road, NE, Suite 1200. Atlanta, GA, USA, 30328
Eut Type Model Name	Water Meter Universal Node (LoRa) LORU
FCC ID IC	SM6-LORU 9235A-LORU
RF Peak Output Power	8.229 dBm (6.65 mW)
FCC Classification	FCC Part 15 Spread Spectrum Transmitter (DSS)
FCC Rule Part(s)	Part 15.247
ISED Rule Part(s)	RSS-247 Issue 3 (August 2023) RSS-Gen Issue 5_Amendment 2 (February 2021)
Location of Test	■ Permanent Testing Lab ☐ On Site Testing (Address: 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, Republic of Korea)

REVISION HISTORY

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

Revision No.	Date of Issue	Description
0	December 27, 2023	Initial Release
1	January 25, 2024	Revised the Page 6.

Notice

Content
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 / ISED 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).
When confirmation of authenticity of this test report is required, please contact www.hct.co.kr
This test report provides test result(s) under the scope accredited by the Korea Laboratory Accreditation Scheme (KOLAS), which signed the ILAC-MRA. (KOLAS (KS Q ISO/IEC 17025) Accreditation No. KT197)

CONTENTS

1. EUT DESCRIPTION

Model	LORU
Additional Model	-
EUT Type	Water Meter Universal Node (LoRa)
Battery Capacity	19 000 mAh
Rated Voltage (V)	3.60 V
Frequency Range	902 MHz – 928 MHz (TX 125 kHz : 902.3 ~ 914.9) – FHSS/DTS Signal (RX 500 kHz : 923.3 ~ 927.5) – DTS Signal
Max. RF Output Power	8.229 dBm (6.65 mW)
Modulation Type	CSS
Number of Channels (125 kHz)	64 Channels uplink 8 Channels downlink
Antenna Specification	Antenna type: PCB Antenna Peak Gain : 0.95 dBi
Date(s) of Tests	December 08, 2023 ~ December 27, 2023
PMN (Product Marketing Number)	Water Meter Universal Node (LoRa)
HVIN (Hardware Version Identification Number)	LORU
FVIN (Firmware Version Identification Number)	1.0
HMN (Host Marketing Name)	N/A
EUT serial numbers	Conducted : 180A58FC Radiated : C7D912E5

2. Requirements for Hybrid System 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 shifts frequencies in synchronization with the transmitted signals.
4) In Hybrid mode, FHSS operates only during the transmission of the signal, and not while receiving the signal.

- 15.247(f), RSS-247 5.3 : hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques.

- 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.

- RSS-247 5.1 (a): 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.

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. / RSS-Gen issue 5, RSS-247 issue 3.

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)

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 (CAB identifier: KR0032).
For ISED, test facility was accepted dated April 06, 2022 (CAB identifier: 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."

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."

(1) The antennas of this E.U.T are permanently attached.

(2) The E.U.T Complies with the requirement of § 15.203

According to RSS-GEN(Issue 5) Section 6.8:

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.

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)	1.90 (Confidence level about 95 %, k=2)
Radiated Disturbance (9 kHz ~ 30 MHz)	4.14 (Confidence level about 95 %, k=2)
Radiated Disturbance (30 MHz ~ 1 GHz)	5.82 (Confidence level about 95 %, k=2)
Radiated Disturbance (1 GHz ~ 18 GHz)	5.74 (Confidence level about 95 %, k=2)
Radiated Disturbance (18 GHz ~ 40 GHz)	5.76 (Confidence level about 95 %, k=2)
Radiated Disturbance (Above 40 GHz)	5.52 (Confidence level about 95 %, k=2)

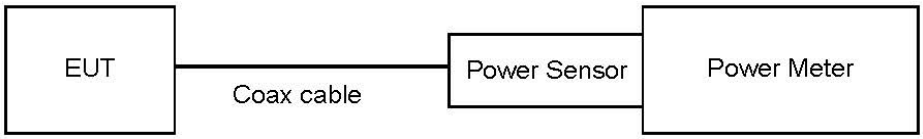
8. DESCRIPTION OF TESTS

8.1. Conducted Maximum Peak Output Power

Limit

The maximum permissible conducted output power is 1 Watt.

Test Configuration



The transmitter output is connected to the Power Meter.

- Peak Power (Procedure 11.9.1.3 in ANSI 63.10-2013)

  : Measure the peak power of the transmitter.

Sample Calculation

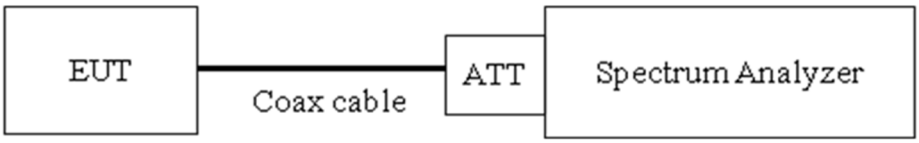
- Conducted Output Power(Peak) = Measured Value + ATT loss + Cable loss

8.2. Power Spectral Density

Limit

The transmitter power density average over 1-second interval shall not be greater than 8 dBm in any 3 kHz BW.

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

We tested according to Procedure 8.4 in KDB 558074 v05r02, Procedure 11.10 in ANSI 63.10-2013.

The spectrum analyzer is set to :

1) Set analyzer center frequency to DTS channel center frequency.
2) Set span to at least 1.5 times the OBW.
3) RBW = 3 kHz ≤ RBW ≤ 100 kHz.
4) VBW ≥ 3 x RBW.
5) Sweep = auto couple
6) Detector = Peak
7) Trace mode = Max hold
8) Allow trace to fully stabilize.
9) Use the peak marker function to determine the maximum amplitude level.
10) Use the peak marker function to determine the maximum amplitude level within the RBW.
    If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

Sample Calculation

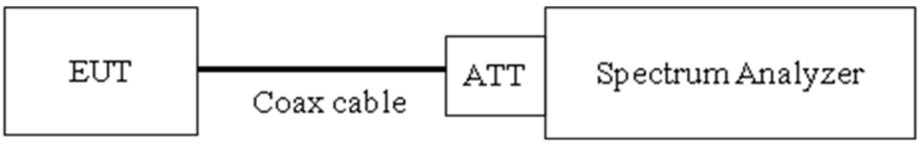
- Power Spectral Density = Measured Level + ATT loss + Cable loss

8.3. 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)

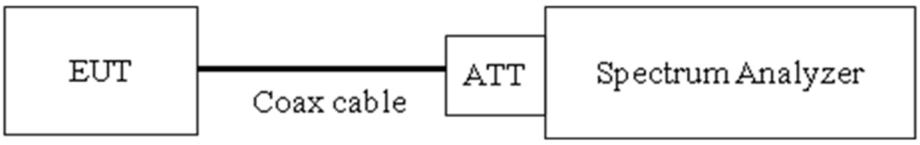
1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation
2) Reference level: As required to keep the signal from exceeding the maximum instrument input mixer 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

8.4. 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 10(b)(6)(iii) 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.

Test Procedure (20 dB Bandwidth)

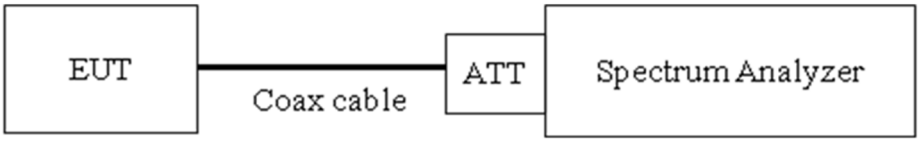
And the 20 dB Bandwidth test is performed with hopping off.

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.

8.5. Number of 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 10(b)(4) in KDB 558074 v05r02)

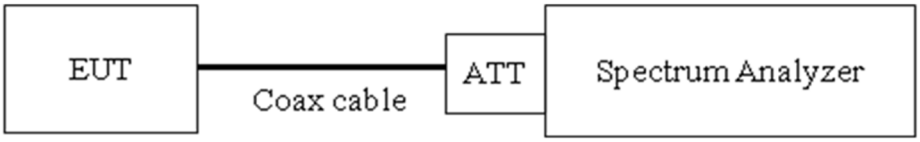
1) Span: the frequency band of operation
2) RBW: To identify clearly the individual channels, set the RBW to less than 30 % of the channel spacing or the 20 dB bandwidth, whichever is smaller.
3) VBW ≥ RBW
4) Sweep: Auto
5) Detector: Peak
6) Trace: Max hold
7) Allow the trace to stabilize.

8.6. Time of Occupancy

Limit

According to § 15.247(f), The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4.

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 10(b)(6)(iv) 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

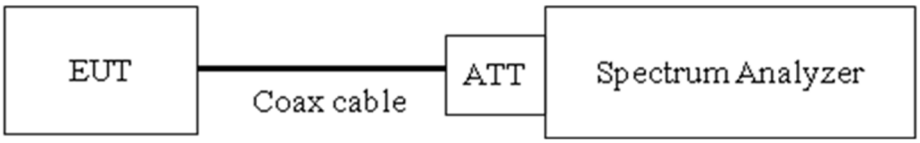
The marker-delta function was used to determine the dwell time.

8.7. 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.

Factors for frequency

Freq(MHz)	Factor(dB)
30	20.10
100	20.15
200	20.19
300	20.24
400	20.30
500	20.30
600	20.31
700	20.32
800	20.33
900	20.35
902	20.35
928	20.35
1 000	20.40
2 000	20.65
2 400	20.74
2 500	20.74
3 000	20.89
4 000	21.13
5 000	21.65
5 700	21.74
5 800	21.74
6 000	21.83
7 000	21.96
8 000	21.96
9 000	22.04
10 000	22.14
11 000	22.23
12 000	22.32
13 000	22.33
14 000	22.36
15 000	22.46
16 000	22.54
17 000	22.75
18 000	22.88
19 000	22.80
20 000	22.47
21 000	22.60
22 000	22.59
23 000	22.60
24 000	22.61
25 000	22.71

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

8.8. Radiated Test

Limit

FCC

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

ISED

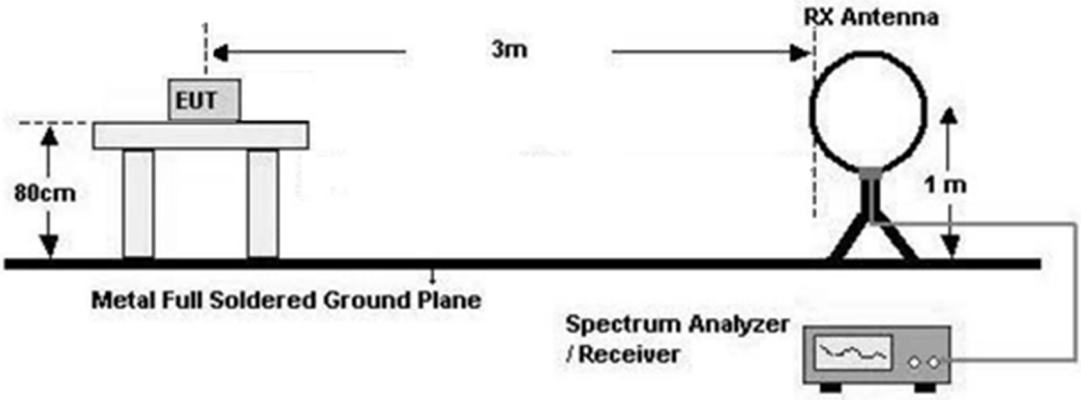
Frequency (MHz)	Field Strength (μA/m)	Measurement Distance (m)
0.009 – 0.490	6.37/F(kHz)	300
0.490 – 1.705	63.7/F(kHz)	30
1.705 – 30	0.08	30

FCC&ISED

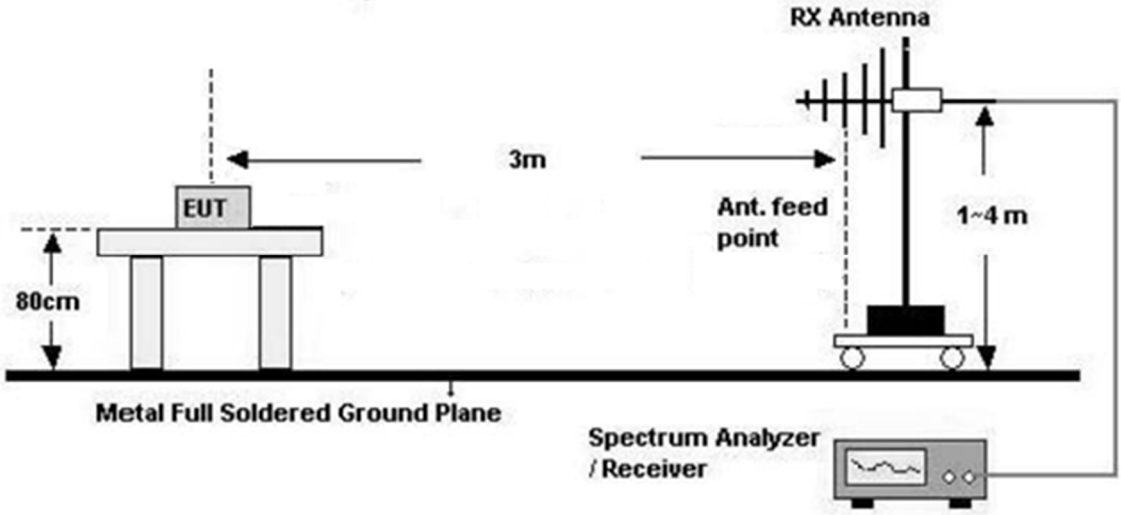
Frequency (MHz)	Field Strength (μV/m)	Measurement Distance (m)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Test Configuration

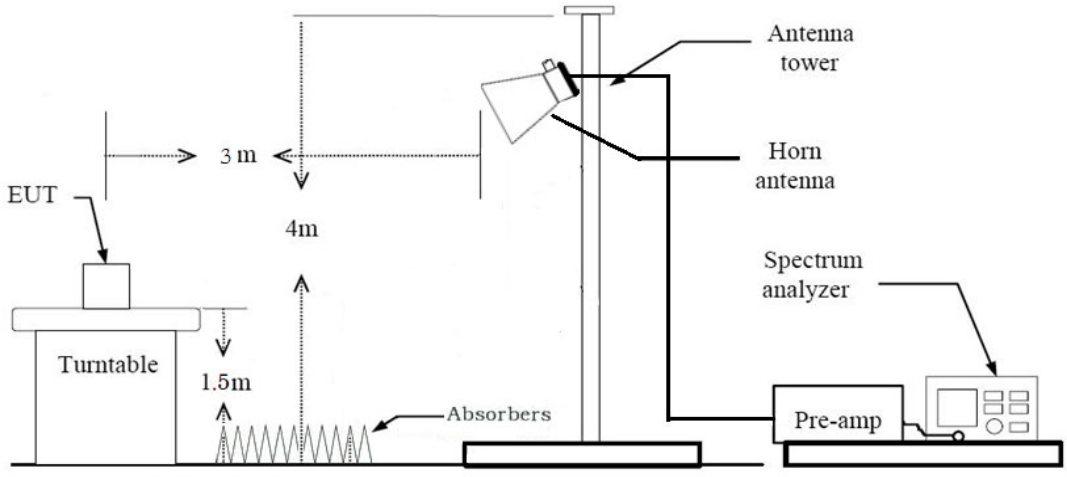
Below 30 MHz



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 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 Level + 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
      - 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 Level + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)
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 – 10^{th} 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 – 10^{th} Harmonics
      - Detector = Peak
      - 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(Measurement Type : Peak
    = Peak Measured Value

    Total(Measurement Type : Average)
    = Average Measured Value

    - We apply to the offset in range 1 GHz - 18 GHz
    - The offset = Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F) - Amp.Gain(A.G)

8.9. 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.

Sample Calculation

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

8.10. Receiver Spurious Emissions

Limit

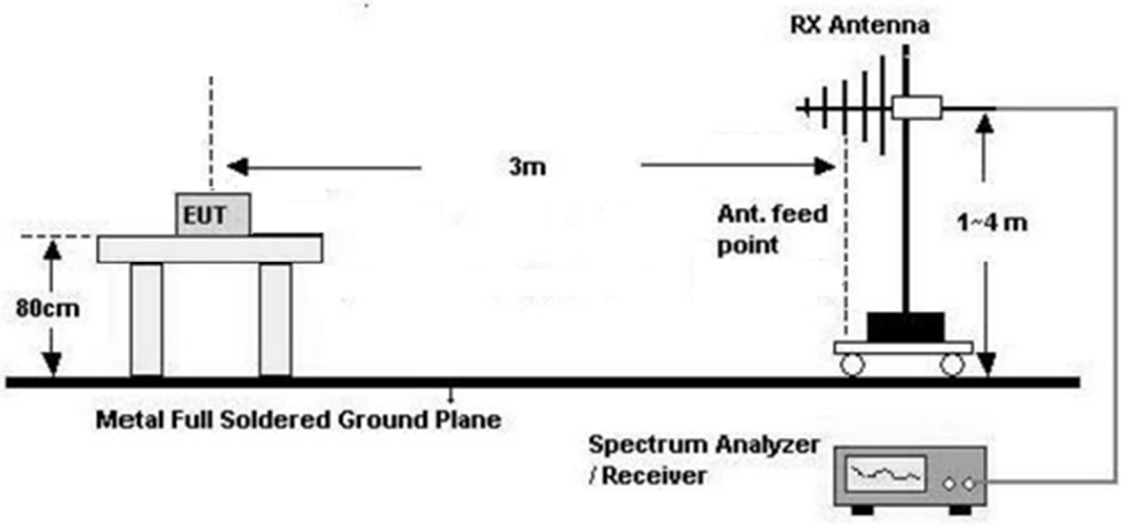
Frequency (MHz)	Field Strength (μV/m)	Measurement Distance (m)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Note:

Measurements for compliance with the limits in table may be performed at distances other than 3 metres.

Test Configuration

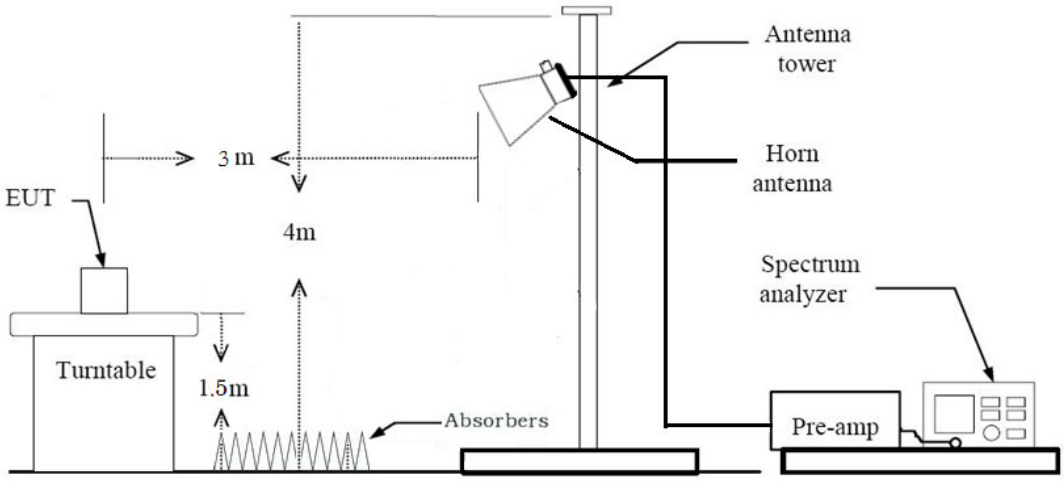
30 MHz - 1 GHz



Test Procedure of Receiver Spurious Emissions (Below 1GHz)

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
      - 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
7. Total = Measured Level + Antenna Factor(A.F) + Cable Loss(C.L)

Above 1 GHz



Test Procedure of Radiated spurious emissions (Above 1 GHz)

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
3. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
4. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
5. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
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 – 25 GHz
      - Detector = Peak
      - Trace = Maxhold
      - RBW = 1 MHz
      - VBW ≥ 3 x RBW
   (2) Measurement Type(Average):
      - Duty cycle < 98%, duty cycle variations are less than ±2%
      - Measured Frequency Range : 1 GHz – 25 GHz
      - Detector = RMS
      - Averaging type = power (*i.e.*, RMS)

- RBW = 1 MHz
- VBW ≥ 3 x RBW
- Sweep time = auto.

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.
9. Total = Measured Level + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(A.G) + Distance Factor(D.F)

8.11. 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 : X
3. All data rate of operation were investigated and the test results are worst case of each mode.
   - 125 kHz (SF 7, 8, 9, 10)
   - Worst case : 125 kHz SF 10
4. All Packet length of operation were investigated and the test results are worst case of each mode.
   - 125k SF 7, 8, 9 (1 to 36)
   - 125k SF 10 (1 to 24)
   - Worst case : Packet length 24
5. 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. We don’t perform powerline conducted emission test. Because EUT is used DC.

Conducted test

1. All modes of operation were investigated and the worst case configuration results are reported.
   - Mode : 125kHz (SF 7, 8, 9, 10)
   - Worst case : 125 kHz SF7, 10
2. All Packet length of operation were investigated and the test results are worst case of each mode.
   - 125k SF 7, 8, 9 (1 to 36)
   - 125k SF 10 (1 to 24)
   - Worst case : Packet length 1 & 36 (SF7), 1 &24 (SF10)

9. SUMMARY OF TEST RESULTS

Test Description	FCC Part Section(s)	ISED Part Section(s)	Test Limit	Test Condition	Test Result
20 dB Bandwidth	§ 15.247(a)(1)(i)	RSS-247, 5.1 c)	< 250 kHz	Conducted	PASS
Occupied Bandwidth	N/A	RSS-GEN, 6.7	N/A		N/A
Conducted Maximum Peak Output Power	§ 15.247(b)(3)	RSS-247, 5.4 a)	< 1 W		PASS
Power Spectral Density	§ 15.247(f)	RSS-247, 5.3 b)	< 8 dBm / 3 kHz Band		PASS
Carrier Frequency Separation	§ 15.247(a)(1)	RSS-247, 5.1 b)	> 25 kHz or > 20 dB BW of hopping channel, whichever is greater.		PASS
Number of Hopping Frequencies	-	-	-		N/A
Time of Occupancy	§ 15.247(f)	RSS-247, 5.3 a)	< 400 ms (0.4xNumber of Hopping Frequencies)		PASS
Conducted Spurious Emissions	§ 15.247(d)	RSS-247, 5.5	> 20 dB for all out-of band emissions		PASS
Band Edge (Out of Band Emissions)	§ 15.247(d)	RSS-247, 5.5	> 20 dB for all out-of band emissions		PASS
AC Power line Conducted Emissions	§ 15.207(a)	RSS-GEN, 8.8	cf. Section 8.9		N/A (Note.1)
Radiated Spurious Emissions	§ 15.247(d), 15.205, 15.209	RSS-GEN, 8.9	cf. Section 8.8	Radiated	PASS
Radiated Restricted Band Edge	§ 15.247(d), 15.205, 15.209	RSS-GEN, 8.9 RSS-GEN, 8.10	cf. Section 8.8		PASS
Receiver Spurious Emissions	N/A	RSS-GEN, 7	cf. Section 8.10		PASS

Note:

1. Not Tested

10. TEST RESULT

10.1 PEAK POWER

-SF7

Channel	Frequency (MHz)	Output Power (Length 1)		Output Power (Length 36)		Limit (mW)	Result
		(dBm)	(mW)	(dBm)	(mW)		
0	902.3	8.127	6.50	8.131	6.50	1000	Pass
31	908.5	8.183	6.58	8.173	6.57		Pass
63	914.9	8.208	6.62	8.214	6.63		Pass

-SF8

Channel	Frequency (MHz)	Output Power (Length 1)		Output Power (Length 36)		Limit (mW)	Result
		(dBm)	(mW)	(dBm)	(mW)		
0	902.3	8.122	6.49	8.125	6.49	1000	Pass
31	908.5	8.177	6.57	8.182	6.58		Pass
63	914.9	8.209	6.62	8.211	6.62		Pass

-SF9

Channel	Frequency (MHz)	Output Power (Lentgh 1)		Output Power (Lentgh 36)		Limit (mW)	Result
		(dBm)	(mW)	(dBm)	(mW)		
0	902.3	8.124	6.49	8.126	6.50	1000	Pass
31	908.5	8.179	6.58	8.171	6.56		Pass
63	914.9	8.216	6.63	8.204	6.61		Pass

-SF10

Channel	Frequency (MHz)	Output Power (Lentgh 1)		Output Power (Lentgh 24)		Limit (mW)	Result
		(dBm)	(mW)	(dBm)	(mW)		
0	902.3	8.141	6.52	8.168	6.56	1000	Pass
31	908.5	8.191	6.59	8.194	6.60		Pass
63	914.9	8.217	6.63	8.229	6.65		Pass

10.2 POWER SPECTRAL DENSITY

Note:

1. In order to simplify the report, The table was recorded at the highest power.

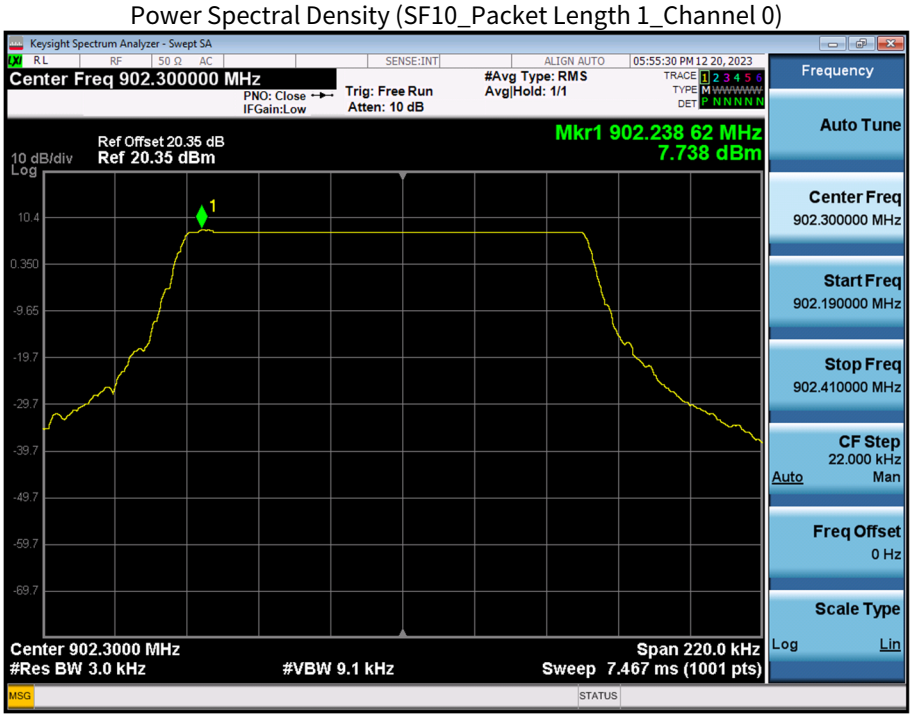
-SF10-

Channel	Frequency (MHz)	PSD (Lengh 1) (dBm / 3 kHz)	PSD (Lengh 24) (dBm/ 3 kHz)	Limit (dBm/ 3 kHz)	Result
0	902.3	7.738	7.424	8	Pass
31	908.5	7.762	7.457		Pass
63	914.9	7.852	7.484		Pass

▣ Test Plots

Note:
In order to simplify the report, Attached Plots were only the worst case.
Worst case : SF 10_Length 1, 24

Power Spectral Density (SF10_Packet Length 1_Channel 0)



Power Spectral Density (SF10_Packet Lenth 1_Channel 31)

Power Spectral Density (SF10_Packet Lenth 1_Channel 63)

Power Spectral Density (SF10_Packet Lenth 24_Channel 0)

Power Spectral Density (SF10_Packet Lenth 24_Channel 31)

Power Spectral Density (SF10_Packet Lenth 24_Channel 63)

10.3 BAND EDGES

- Without hopping

Frequency (MHz)	Channel	Position	SF7 (dB)	Limit (dBc)	Margin (dBc)	Result
902.3	0	Lower	30.739	20	10.739	Pass
914.9	63	Upper	60.551		40.551	Pass

Frequency (MHz)	Channel	Position	SF10 (dB)	Limit (dBc)	Margin (dBc)	Result
902.3	0	Lower	30.699	20	10.699	Pass
914.9	63	Upper	60.260		40.260	Pass

- With hopping

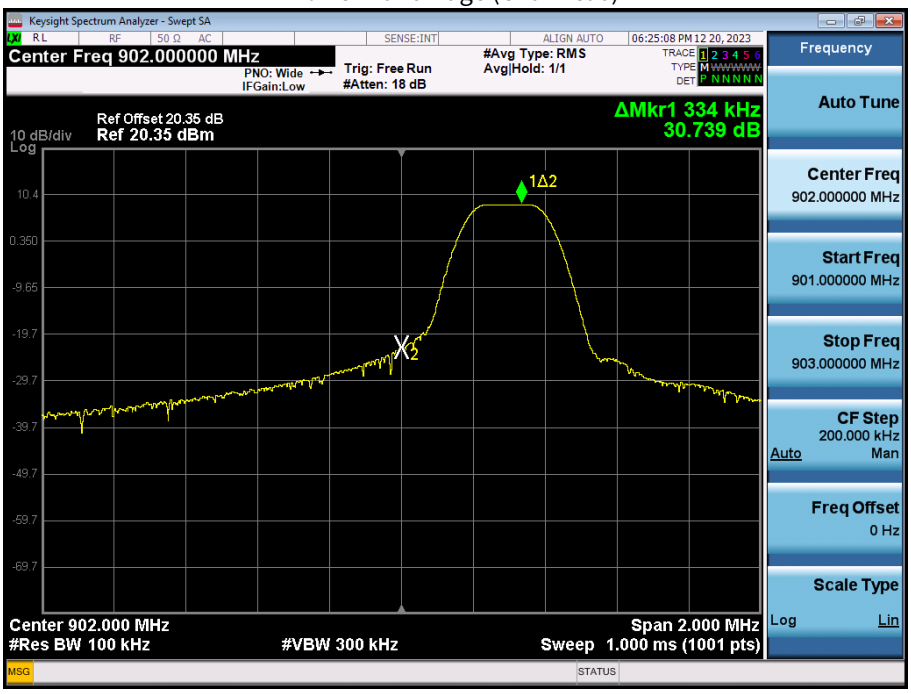
Frequency (MHz)	Channel	Position	SF7 (dB)	Limit (dBc)	Margin (dBc)	Result
902.3	0	Lower	32.032	20	12.032	Pass
914.9	63	Upper	59.360		39.360	Pass

Frequency (MHz)	Channel	Position	SF10 (dB)	Limit (dBc)	Margin (dBc)	Result
902.3	0	Lower	32.146	20	12.146	Pass
914.9	63	Upper	59.697		39.697	Pass

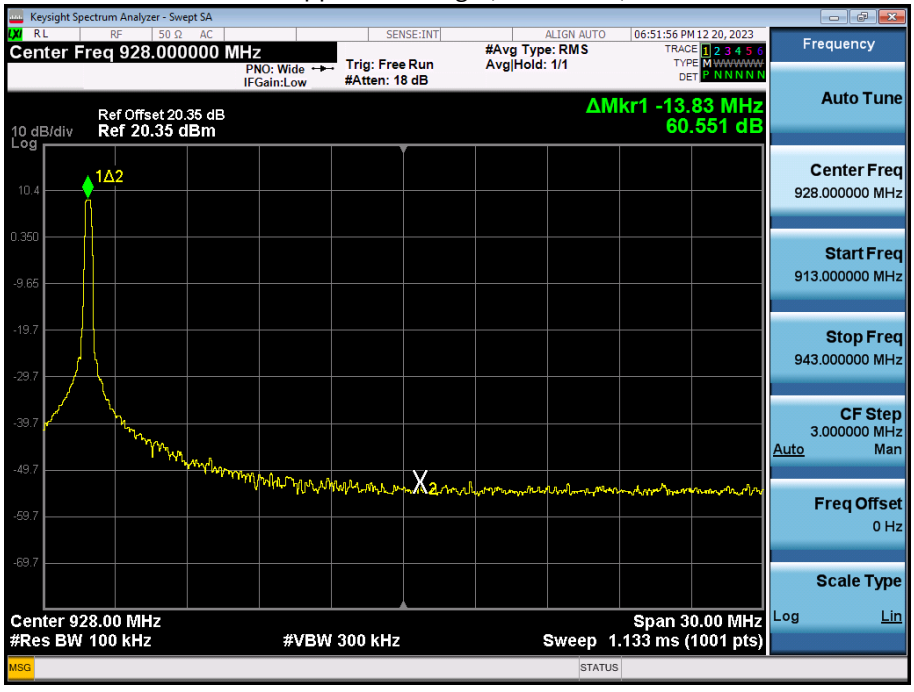
▣ Test Plots

Without Hopping (SF7)

Lower Band Edge (Channel 0)

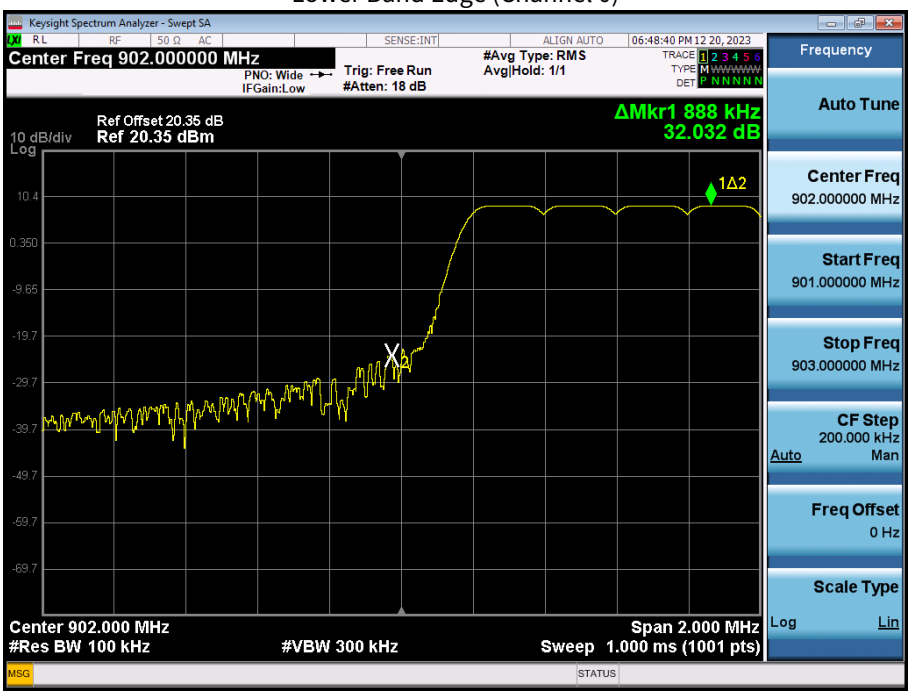


Upper Band Edge (Channel 63)

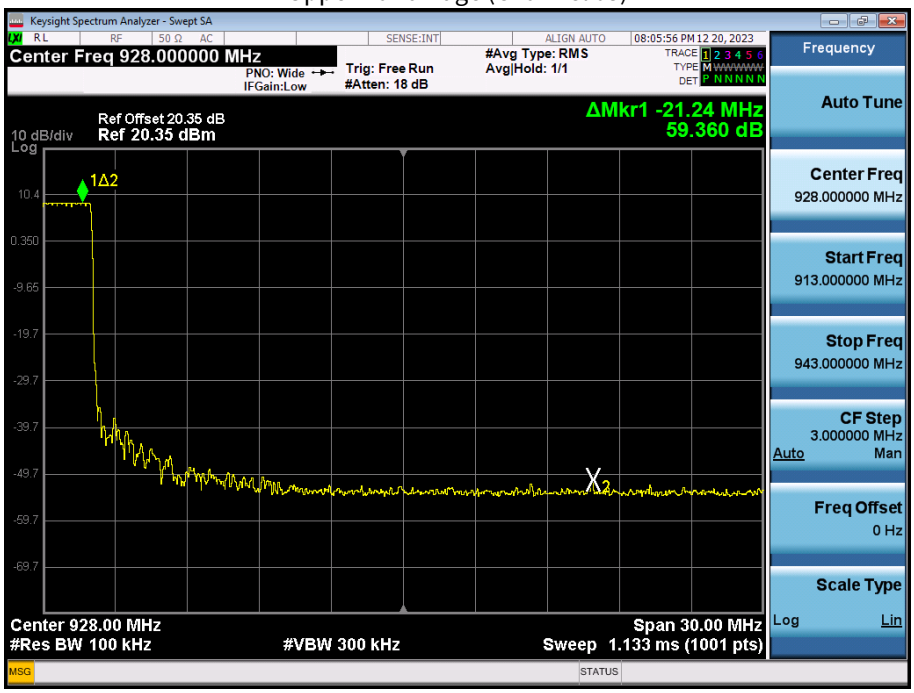


With Hopping (SF7)

Lower Band Edge (Channel 0)



Upper Band Edge (Channel 63)



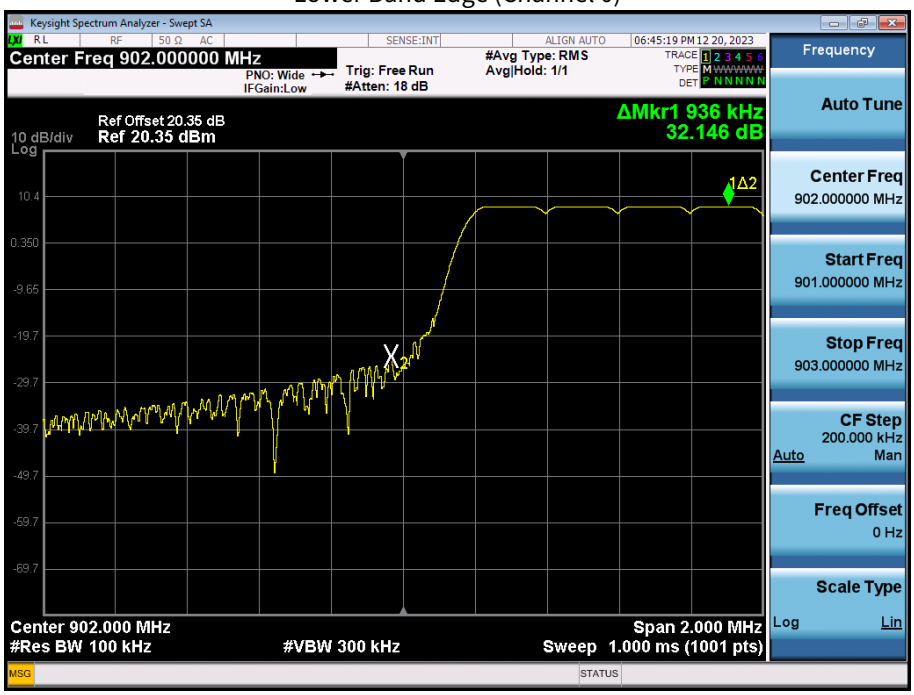
Without Hopping (SF10)

Lower Band Edge (Channel 0)

Upper Band Edge (Channel 63)

With Hopping (SF10)

Lower Band Edge (Channel 0)



Upper Band Edge (Channel 63)

10.4 FREQUENCY SEPARATION / OCCUPIED BANDWIDTH (99 % BW)

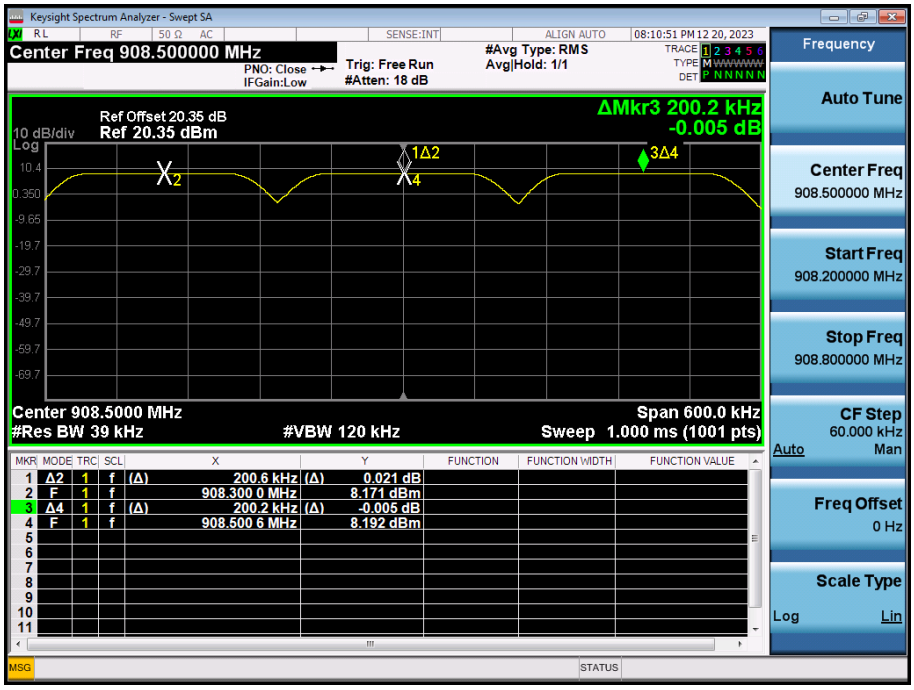
Channel Separation (kHz)		20 dB Bandwidth (kHz)					Limit (kHz)	Result
SF7	SF10	Channel	SF 7	Limit (kHz)	SF 10	Limit (kHz)		
200.2	200.0	0	149.2	149.2	139.1	139.1	>25 or > 20 dB BW of hopping channel, Whichever is greater	Pass
		31	148.6		138.4			
		63	147.4		138.8			

Occupied Bandwidth (99 % BW)

	99 % BW (kHz)			
Channel	SF	Channel 0	Channel 31	Channel 63
	SF7	127.78	127.25	127.01
	SF10	126.61	126.02	126.17

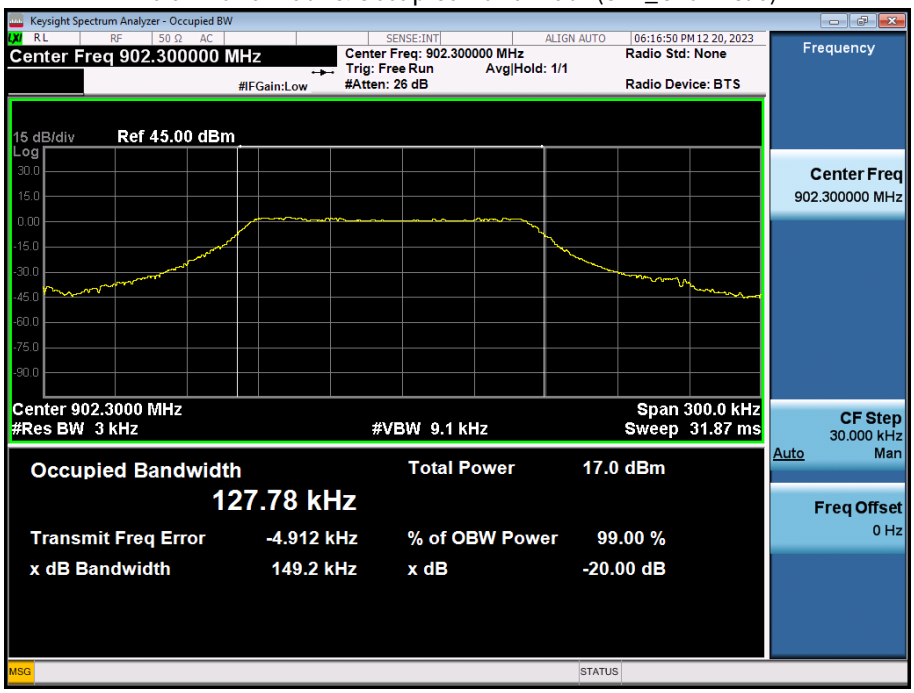
▣ Test Plots

Channel Separation(SF 7)

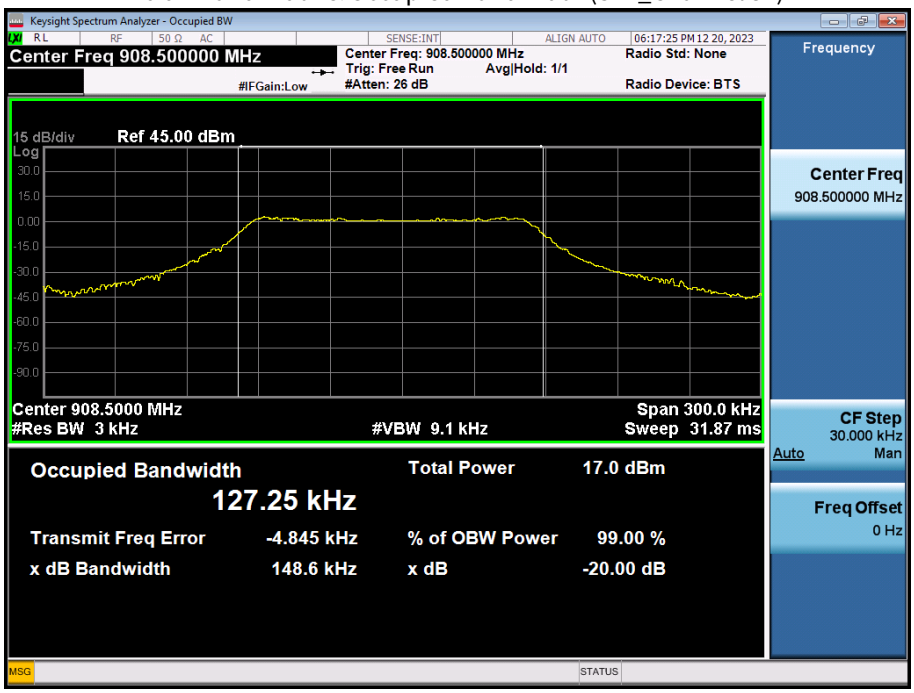


Channel Separation(SF 10)

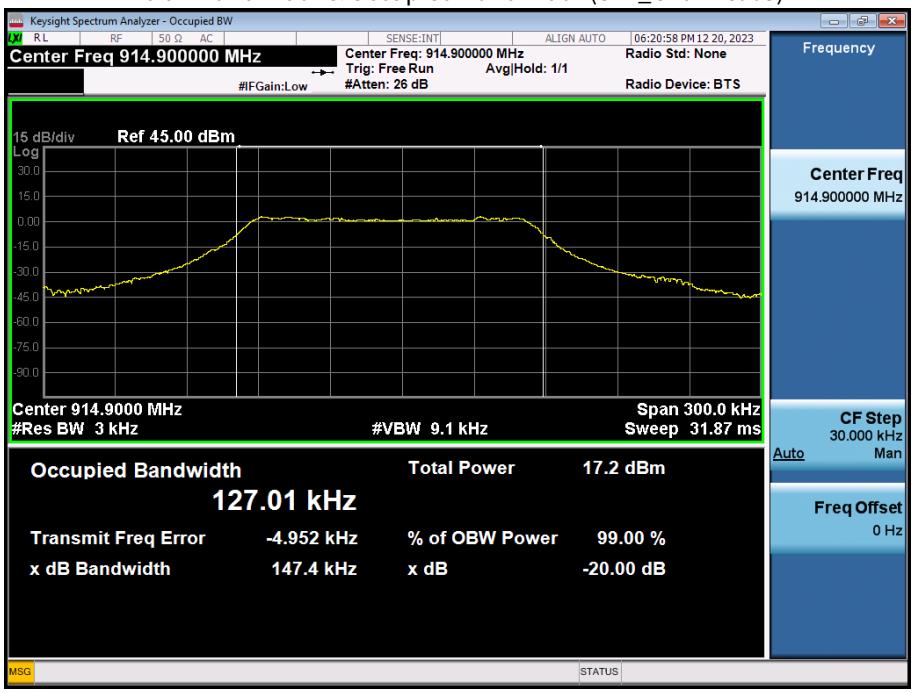
20 dB Bandwidth & Occupied Bandwidth (SF7_Channel 0)



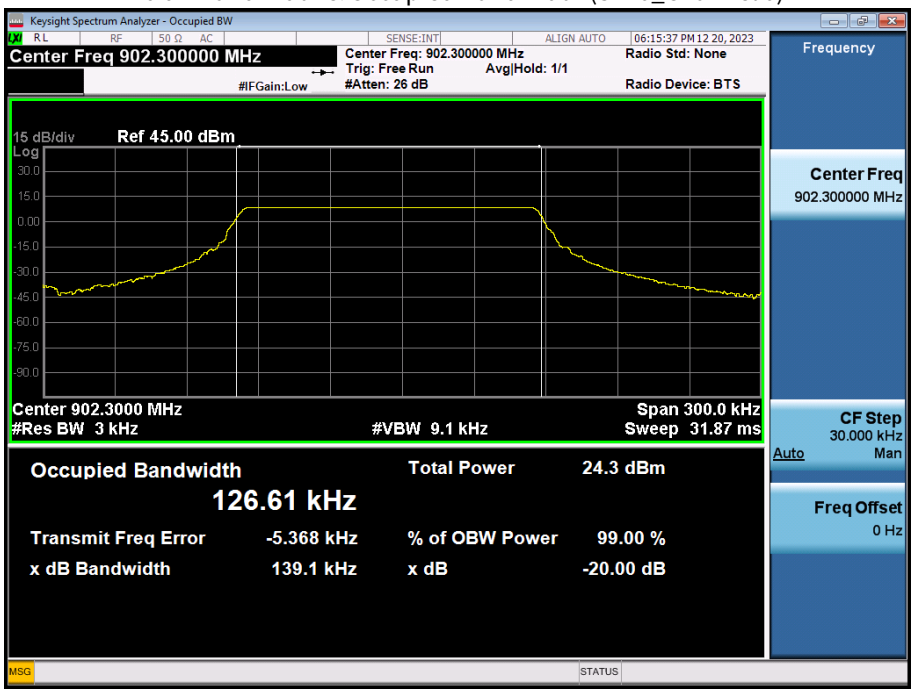
20 dB Bandwidth & Occupied Bandwidth (SF7_Channel 31)



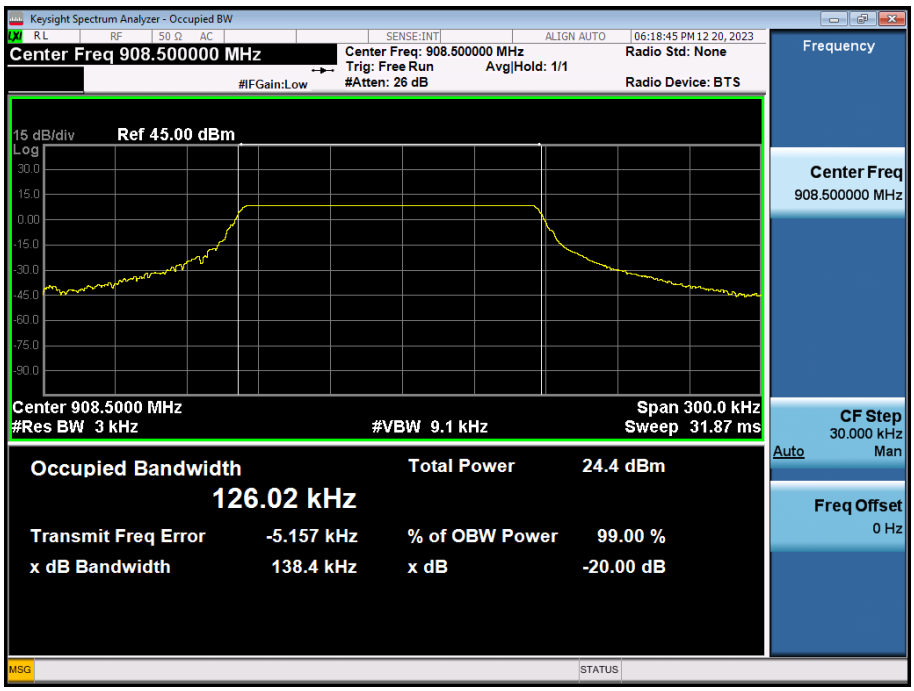
20 dB Bandwidth & Occupied Bandwidth (SF7_Channel 63)



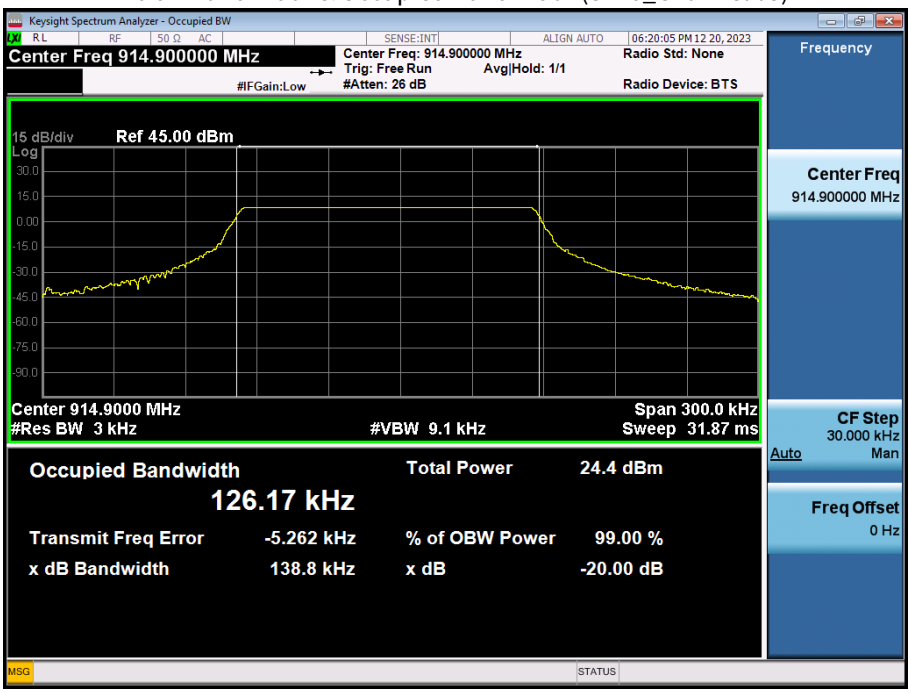
20 dB Bandwidth & Occupied Bandwidth (SF10_Channel 0)



20 dB Bandwidth & Occupied Bandwidth (SF10_Channel 31)



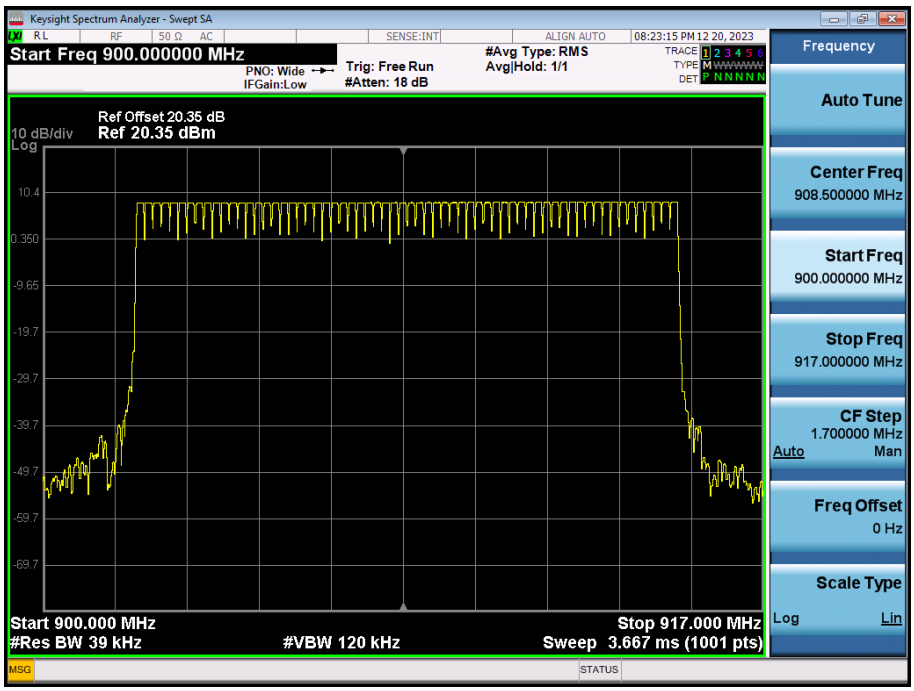
20 dB Bandwidth & Occupied Bandwidth (SF10_Channel 63)



10.5 NUMBER OF HOPPING FREQUENCY

Result (No. of CH)	Limit
64	-

▣ Test Plots



10.6 TIME OF OCCUPANCY (DWELL TIME)

Note :

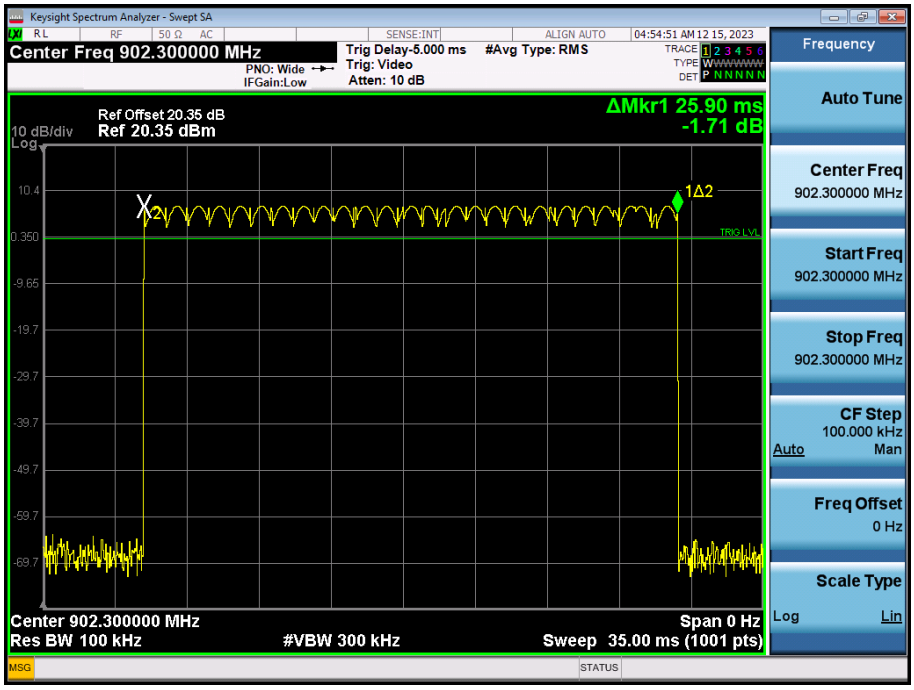
Time Period = 0.4s x 64(The number of Hopping Frequencies)

= 25.6 s

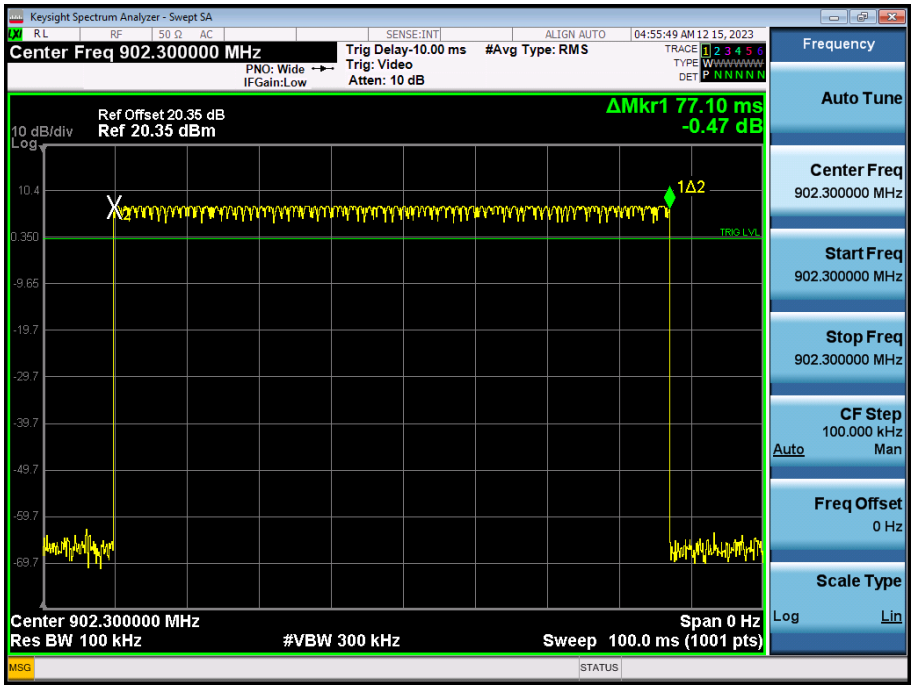
Spreading Factor	Length	Dwell Time (ms)	Hops in 25.6s	The average time of occupancy (ms)	Limit (ms)
SF7	1	25.90	6	155.40	400
	36	77.10	4	308.40	
SF8	1	51.68	5	258.40	
	36	143.70	1	143.70	
SF9	1	103.50	3	310.50	
	36	267.30	1	267.30	
SF10	1	206.80	1	206.80	
	24	370.40	1	370.40	

▣ Test Plots

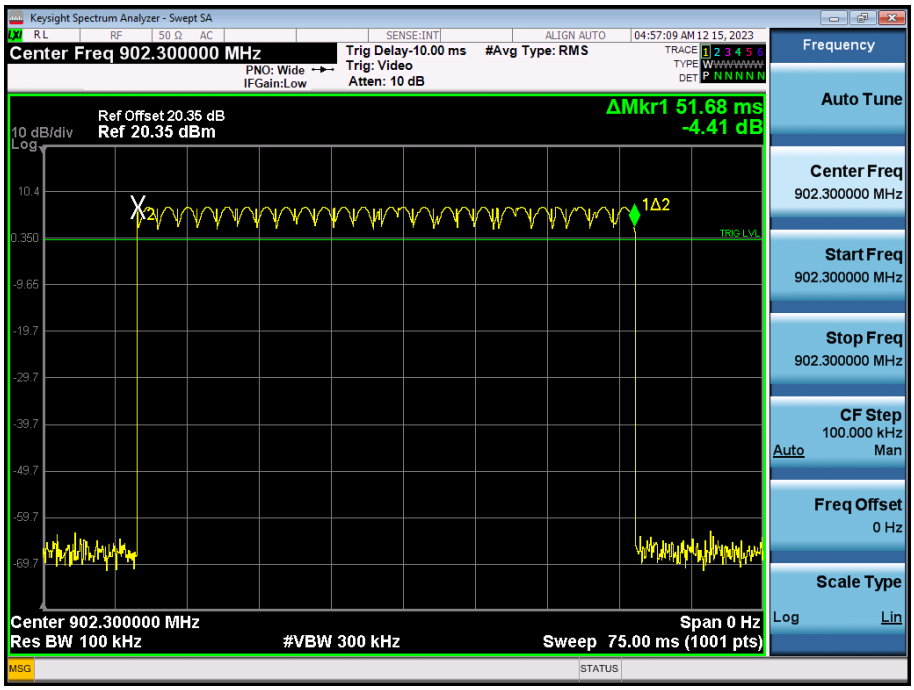
SF7_ Packet Length 1



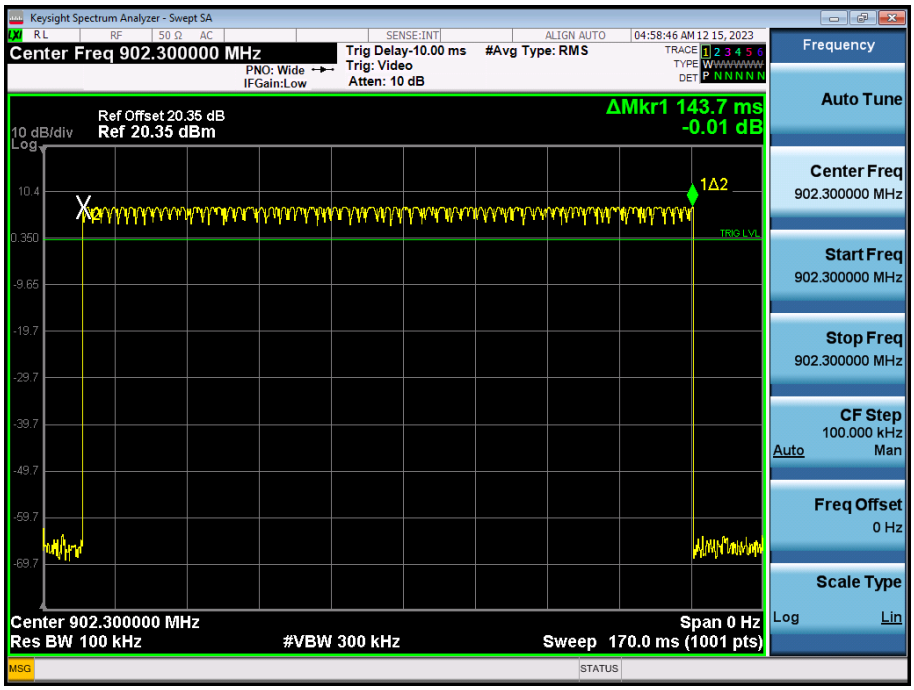
SF7_ Packet Length 36



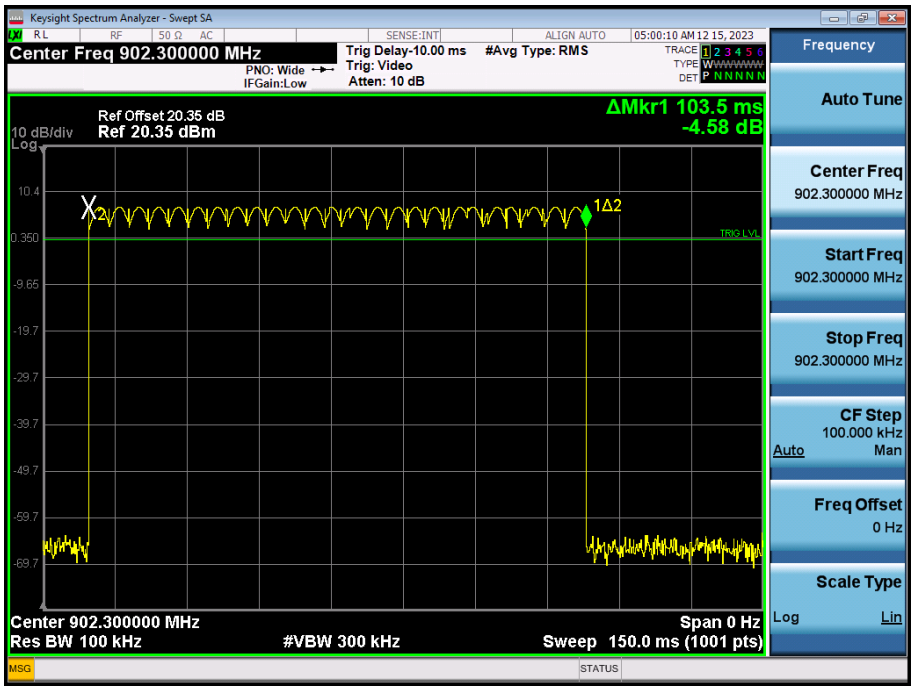
SF8_ Packet Length 1



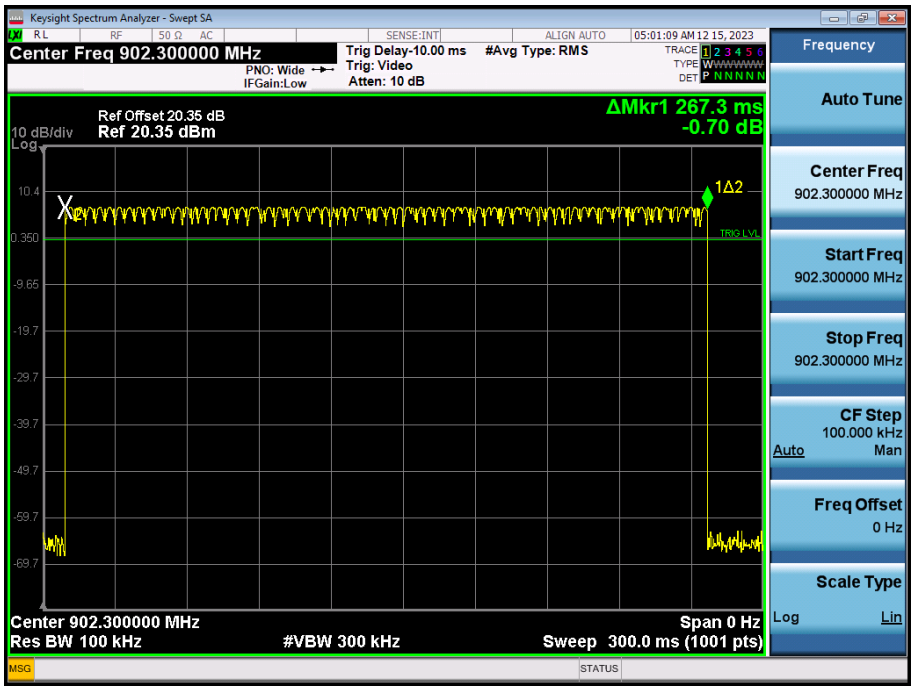
SF8_ Packet Length 36



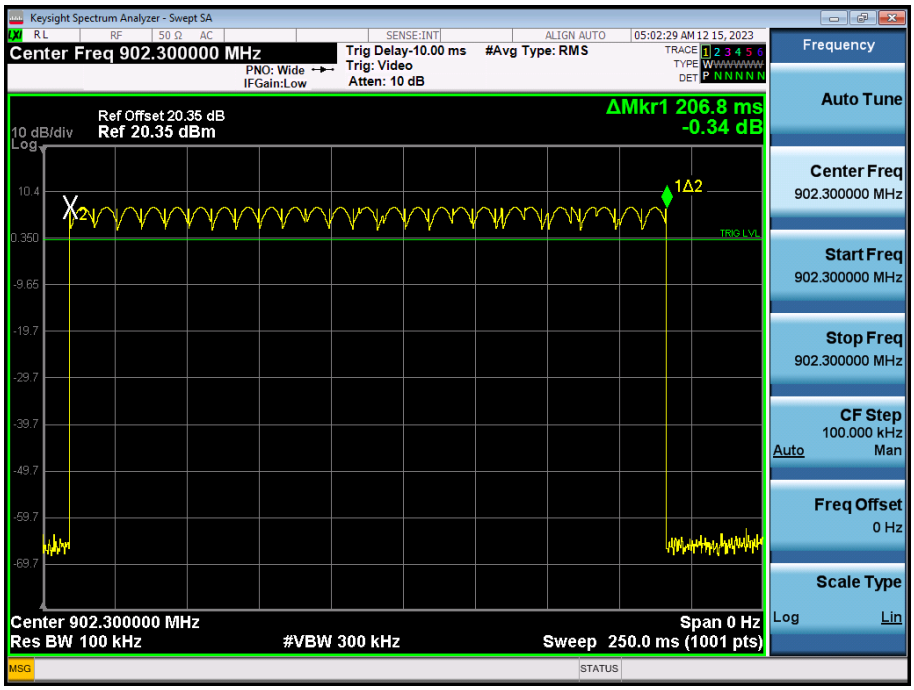
SF9_ Packet Length 1



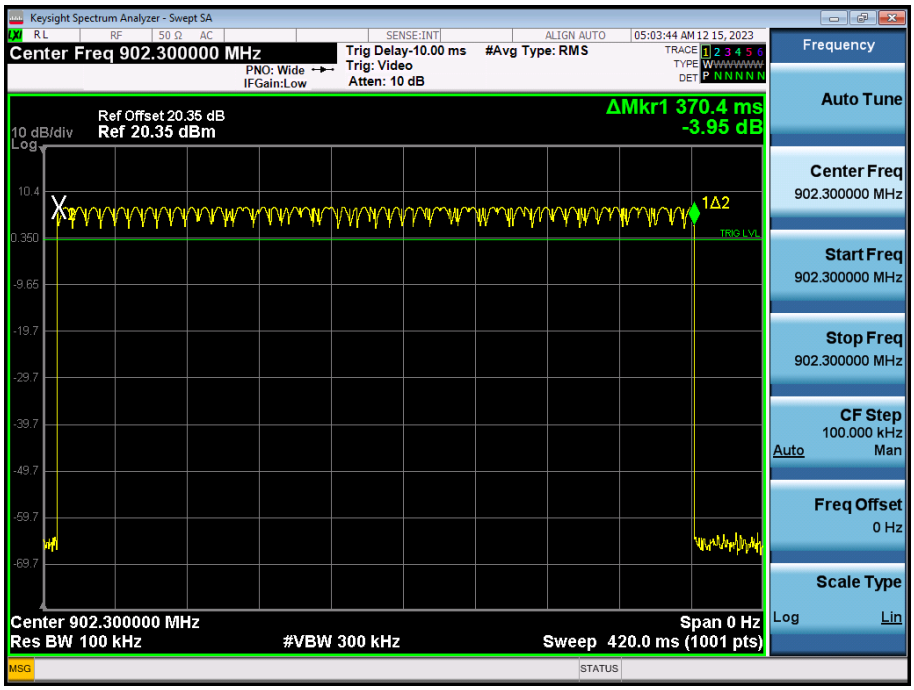
SF9_ Packet Length 36



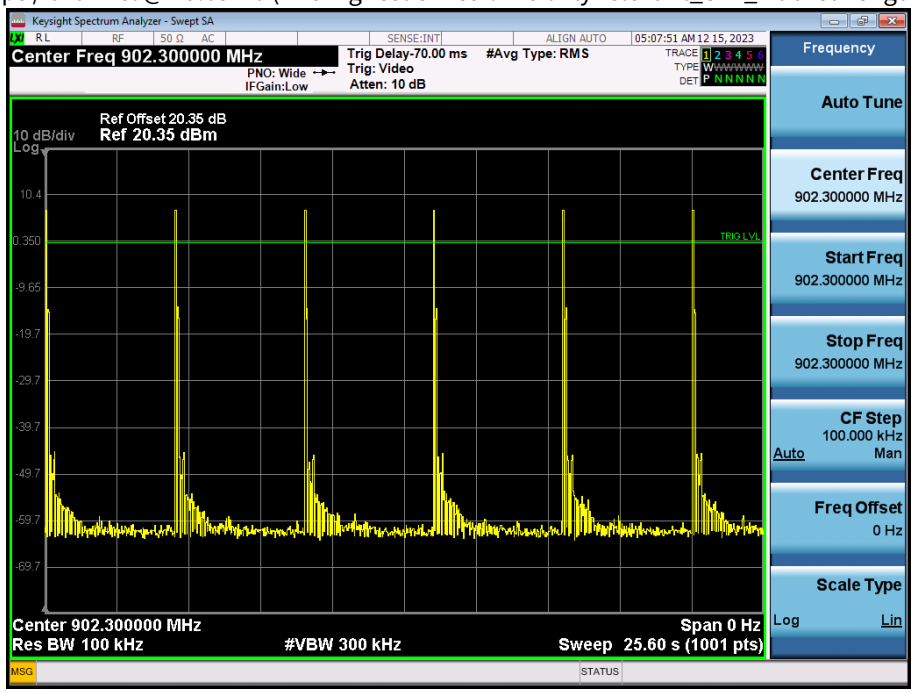
SF10_ Packet Length 1



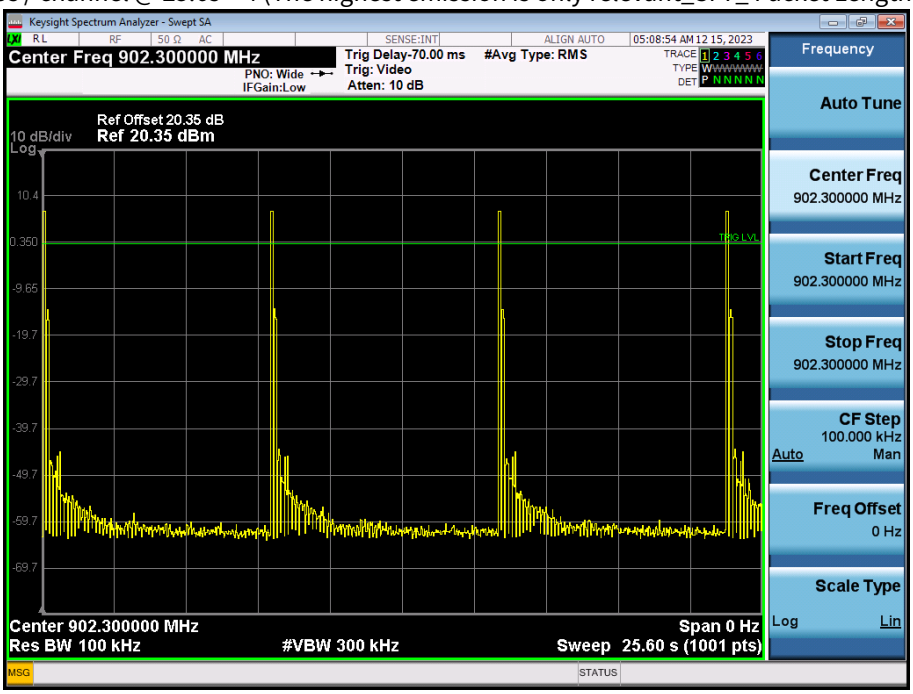
SF10_ Packet Length 24



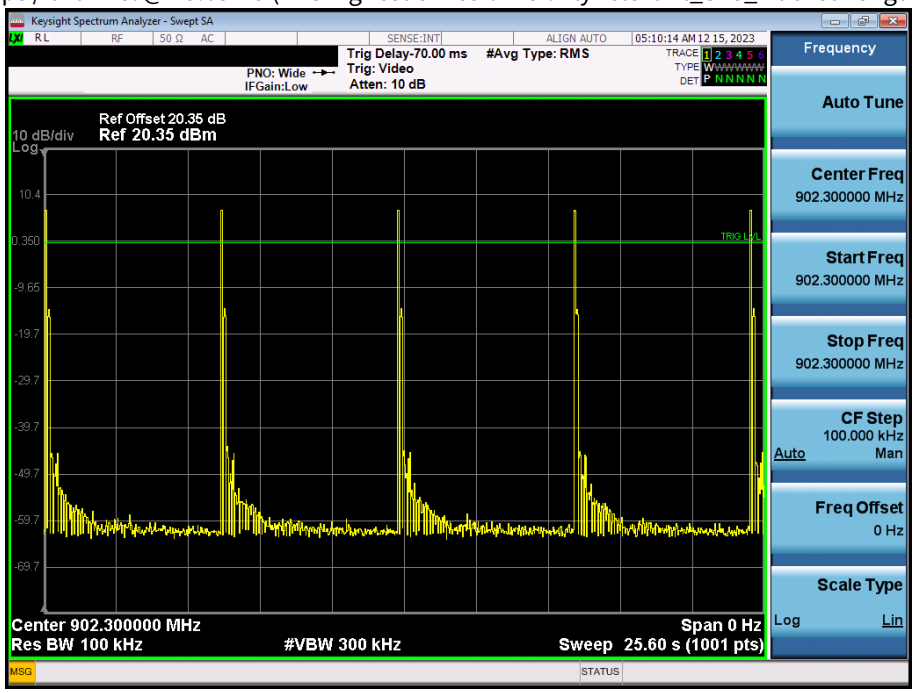
Hops / channel @ 25.6s = 6 (The highest emission is only relevant_SF7_ Packet Length 1)



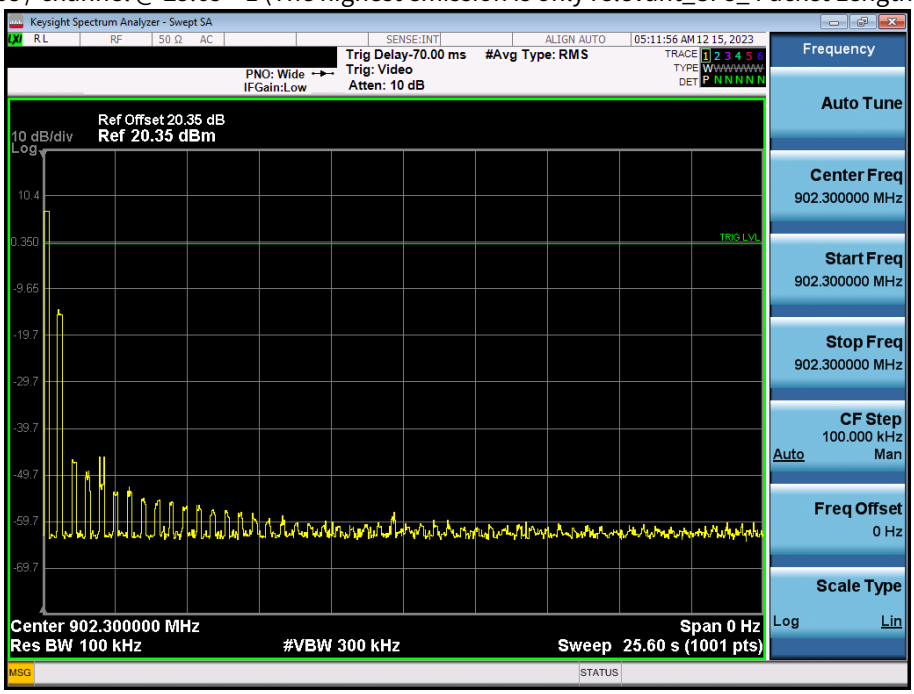
Hops / channel @ 25.6s = 4 (The highest emission is only relevant_SF7_ Packet Length 36)



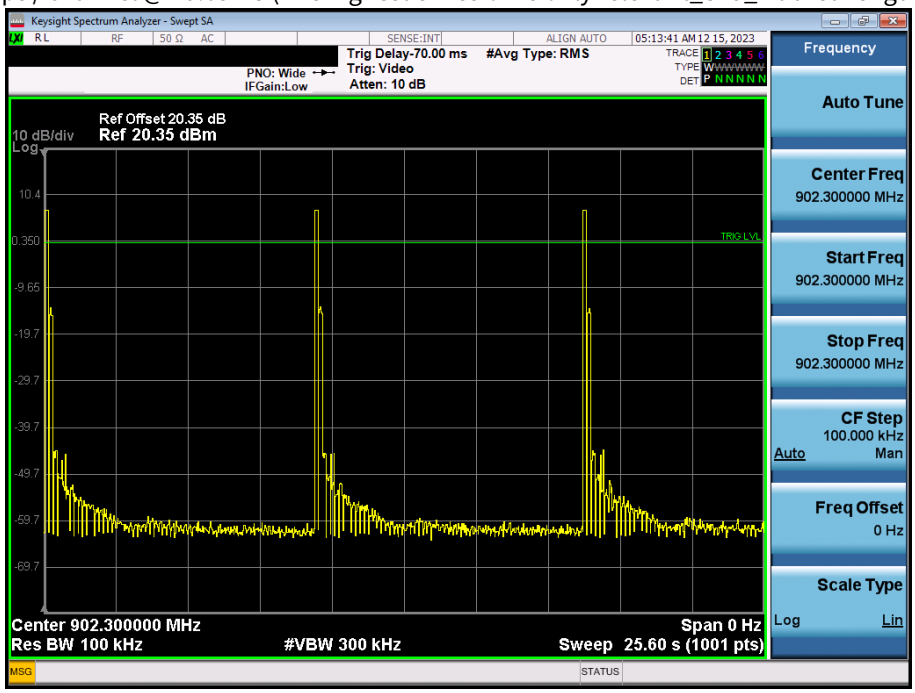
Hops / channel @ 25.6s = 5 (The highest emission is only relevant_SF8_ Packet Length 1)



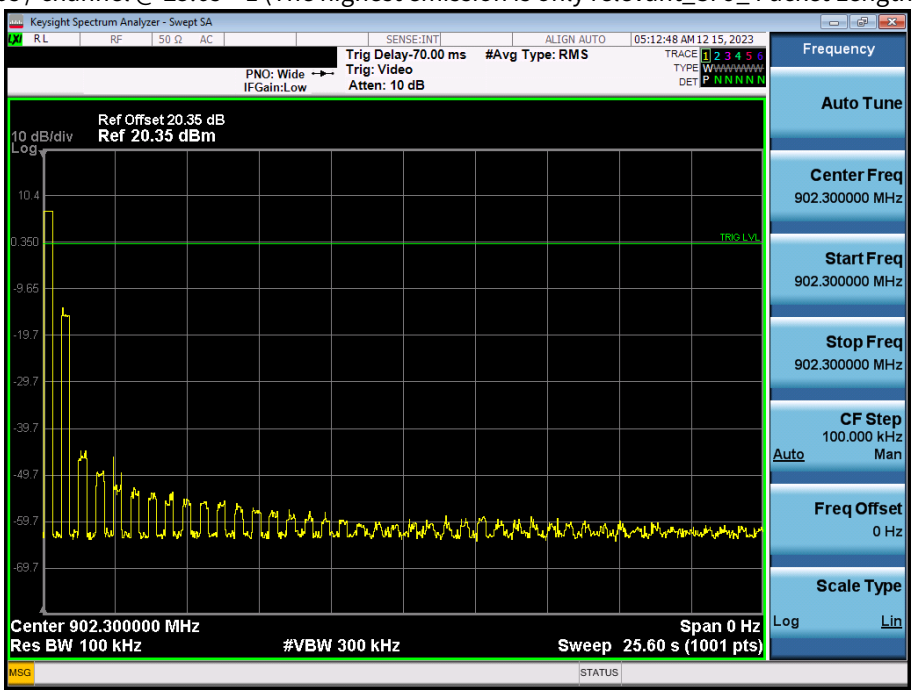
Hops / channel @ 25.6s = 1 (The highest emission is only relevant_SF8_ Packet Length 36)



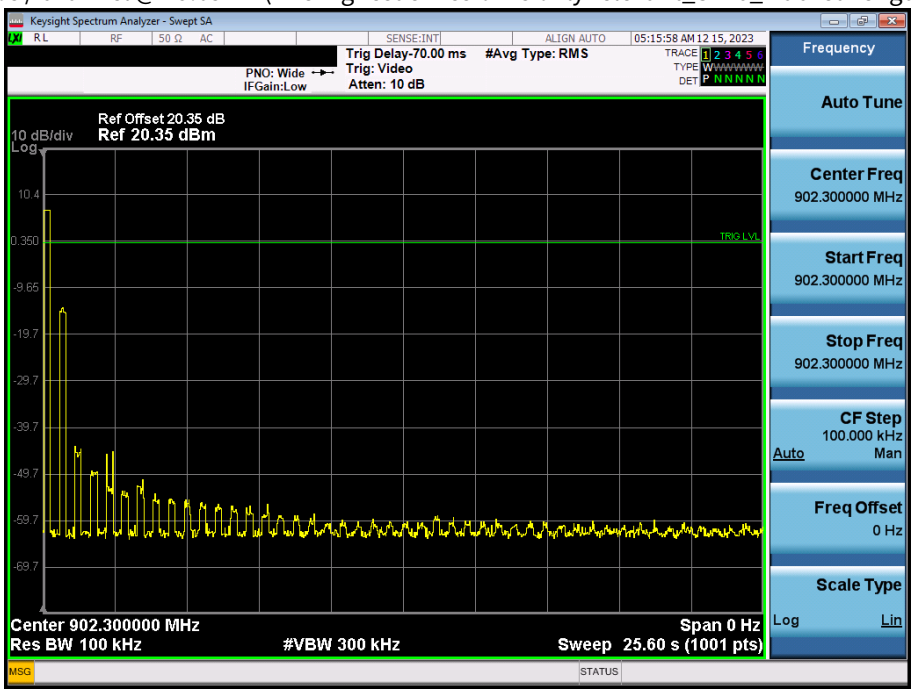
Hops / channel @ 25.6s = 3 (The highest emission is only relevant_SF9_ Packet Length 1)



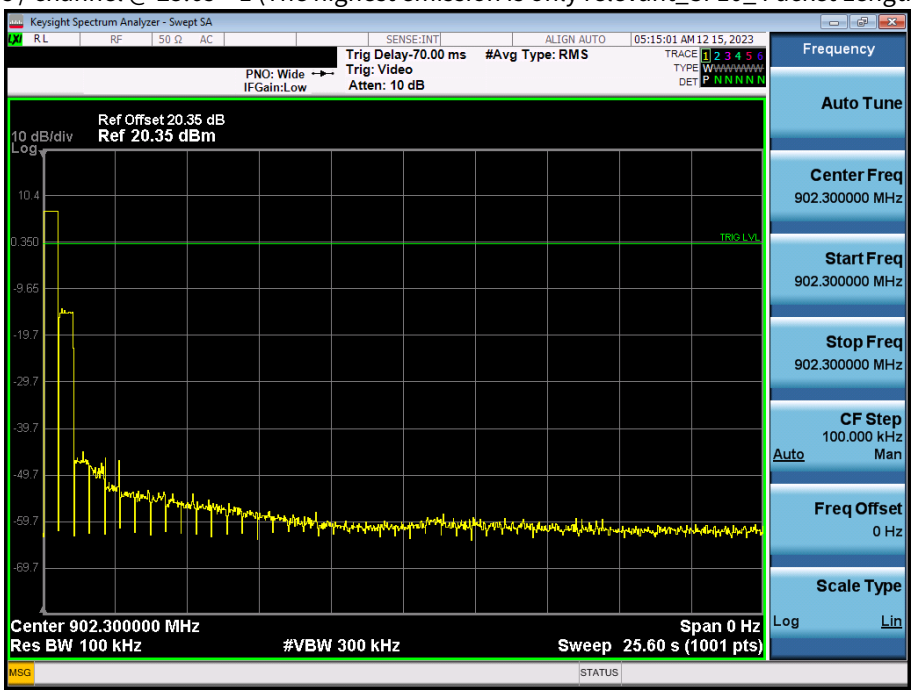
Hops / channel @ 25.6s = 1 (The highest emission is only relevant_SF9_ Packet Length 36)



Hops / channel @ 25.6s = 1 (The highest emission is only relevant_SF10_ Packet Length 1)



Hops / channel @ 25.6s = 1 (The highest emission is only relevant_SF10_ Packet Length 24)



10.7 SPURIOUS EMISSIONS

10.7.1 CONDUCTED SPURIOUS EMISSIONS

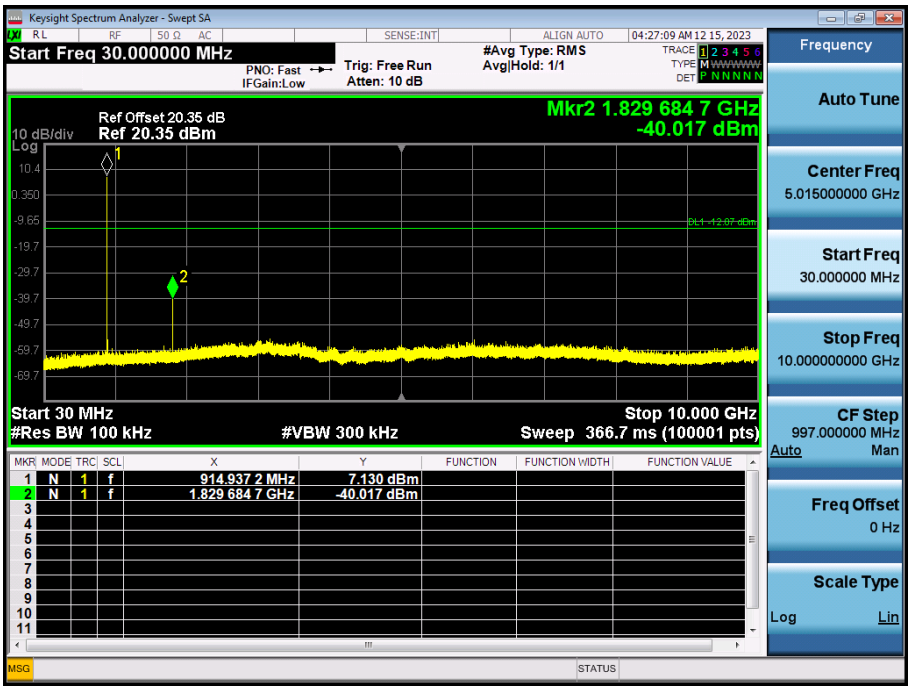
Note:

In order to simplify the report, attached plots were only the worst case mode and channel.

Worst case Mode : Channel 0_SF10_Length 24

▣ Test Plots

30 MHz ~ 10 GHz



Note :

Limit : -12.87 dBm

10.7.2 RADIATED SPURIOUS EMISSIONS

Frequency Range : 9 kHz – 30 MHz

Frequency	Measured Level	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
[MHz]	[dBμV/m]	[dB/m]	[dB]	[H/V]	[dBμV/m]	[dBμV/m]	[dB]
No Critical peaks found							

Note:

1. The Measured Level of emissions are attenuated more than 20 dB below the permissible limits or the field strength is too small to be measured.
2. Distance extrapolation factor = 40log (specific distance / test distance) (dB)
3. Limit line = specific Limits (dBμV) + Distance extrapolation factor

Frequency Range : Below 1 GHz

Frequency	Measured Level	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
[MHz]	[dBμV/m]	[dB/m]	[dB]	[H/V]	[dBμV/m]	[dBμV/m]	[dB]
No Critical peaks found							

Note:

1. Radiated emissions measured in frequency range from 30 MHz to 1000 MHz were made with an instrument using Quasi peak detector mode.

Frequency Range : Above 1 GHz

Channel : 0(902.3 MHz)

Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 706.90	51.13	H	51.13	73.98	22.85	PK
2 706.90	37.70	H	37.70	53.98	16.28	AV
3 609.20	43.32	H	43.32	73.98	30.66	PK
3 609.20	30.09	H	30.09	53.98	23.89	AV
4 511.50	46.12	H	46.12	73.98	27.86	PK
4 511.50	32.30	H	32.30	53.98	21.68	AV
5 413.80	47.20	H	47.20	73.98	26.78	PK
5 413.80	33.88	H	33.88	53.98	20.10	AV
8 120.70	51.77	H	51.77	73.98	22.21	PK
8 120.70	38.12	H	38.12	53.98	15.86	AV
9 023.00	52.35	H	52.35	73.98	21.63	PK
9 023.00	38.88	H	38.88	53.98	15.10	AV

Note :

1. Non Restricted Band refer to Conducted Spurious emission test result (20 dBc)

Channel : 0(902.3 MHz)

Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 706.90	51.08	V	51.08	73.98	22.90	PK
2 706.90	37.68	V	37.68	53.98	16.30	AV
3 609.20	43.22	V	43.22	73.98	30.76	PK
3 609.20	30.02	V	30.02	53.98	23.96	AV
4 511.50	46.05	V	46.05	73.98	27.93	PK
4 511.50	32.18	V	32.18	53.98	21.80	AV
5 413.80	46.92	V	46.92	73.98	27.06	PK
5 413.80	33.79	V	33.79	53.98	20.19	AV
8 120.70	51.75	V	51.75	73.98	22.23	PK
8 120.70	38.02	V	38.02	53.98	15.96	AV
9 023.00	52.28	V	52.28	73.98	21.70	PK
9 023.00	38.40	V	38.40	53.98	15.58	AV

Note :

1. Non Restricted Band refer to Conducted Spurious emission test result (20 dBc)

Channel : 31(908.5 MHz)

Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 725.50	50.64	H	50.64	73.98	23.34	PK
2 725.50	37.72	H	37.72	53.98	16.26	AV
3 634.00	44.59	H	44.59	73.98	29.39	PK
3 634.00	30.74	H	30.74	53.98	23.24	AV
4 542.50	45.99	H	45.99	73.98	27.99	PK
4 542.50	32.43	H	32.43	53.98	21.55	AV
5 451.00	47.26	H	47.26	73.98	26.72	PK
5 451.00	33.40	H	33.40	53.98	20.58	AV
7 268.00	51.49	H	51.49	73.98	22.49	PK
7 268.00	37.33	H	37.33	53.98	16.65	AV
8 176.50	52.49	H	52.49	73.98	21.49	PK
8 176.50	38.77	H	38.77	53.98	15.21	AV
9 085.00	52.65	H	52.65	73.98	21.33	PK
9 085.00	39.48	H	39.48	53.98	14.50	AV

Note :

1. Non Restricted Band refer to Conducted Spurious emission test result (20 dBc)

Channel : 31(908.5 MHz)

Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 725.50	50.97	V	50.97	73.98	23.01	PK
2 725.50	37.79	V	37.79	53.98	16.19	AV
3 634.00	44.27	V	44.27	73.98	29.71	PK
3 634.00	30.62	V	30.62	53.98	23.36	AV
4 542.50	45.61	V	45.61	73.98	28.37	PK
4 542.50	32.38	V	32.38	53.98	21.60	AV
5 451.00	47.12	V	47.12	73.98	26.86	PK
5 451.00	33.30	V	33.30	53.98	20.68	AV
7 268.00	51.32	V	51.32	73.98	22.66	PK
7 268.00	37.28	V	37.28	53.98	16.70	AV
8 176.50	51.97	V	51.97	73.98	22.01	PK
8 176.50	33.56	V	33.56	53.98	20.42	AV
9 085.00	52.44	V	52.44	73.98	21.54	PK
9 085.00	39.27	V	39.27	53.98	14.71	AV

Note :

1. Non Restricted Band refer to Conducted Spurious emission test result (20 dBc)

Channel : 63(914.9 MHz)

Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 744.70	51.49	H	51.49	73.98	22.49	PK
2 744.70	38.31	H	38.31	53.98	15.67	AV
3 659.60	44.30	H	44.30	73.98	29.68	PK
3 659.60	30.99	H	30.99	53.98	22.99	AV
4 574.50	45.67	H	45.67	73.98	28.31	PK
4 574.50	32.20	H	32.20	53.98	21.78	AV
7 319.20	51.99	H	51.99	73.98	21.99	PK
7 319.20	38.29	H	38.29	53.98	15.69	AV
8 234.10	51.56	H	51.56	73.98	22.42	PK
8 234.10	39.31	H	39.31	53.98	14.67	AV
9 149.00	53.81	H	53.81	73.98	20.17	PK
9 149.00	40.22	H	40.22	53.98	13.76	AV

Note :

1. Non Restricted Band refer to Conducted Spurious emission test result (20 dBc)

Channel : 63(914.9 MHz)

Frequency	Measured Level	ANT. POL	Total	Limit	Margin	Detect
[MHz]	[dBµV]	[H/V]	[dBµV/m]	[dBµV/m]	[dB]	
2 744.70	51.36	V	51.36	73.98	22.62	PK
2 744.70	38.28	V	38.28	53.98	15.70	AV
3 659.60	44.21	V	44.21	73.98	29.77	PK
3 659.60	30.87	V	30.87	53.98	23.11	AV
4 574.50	45.51	V	45.51	73.98	28.47	PK
4 574.50	32.18	V	32.18	53.98	21.80	AV
7 319.20	51.57	V	51.57	73.98	22.41	PK
7 319.20	38.21	V	38.21	53.98	15.77	AV
8 234.10	51.42	V	51.42	73.98	22.56	PK
8 234.10	39.28	V	39.28	53.98	14.70	AV
9 149.00	53.77	V	53.77	73.98	20.21	PK
9 149.00	40.21	V	40.21	53.98	13.77	AV

Note :

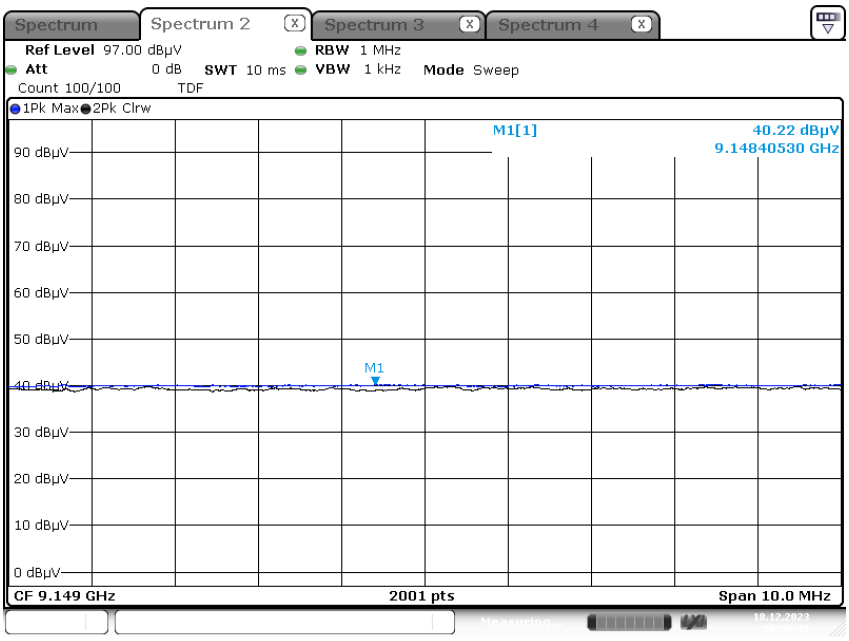
1. Non Restricted Band refer to Conducted Spurious emission test result (20 dBc)

RESULT PLOTS

Note:

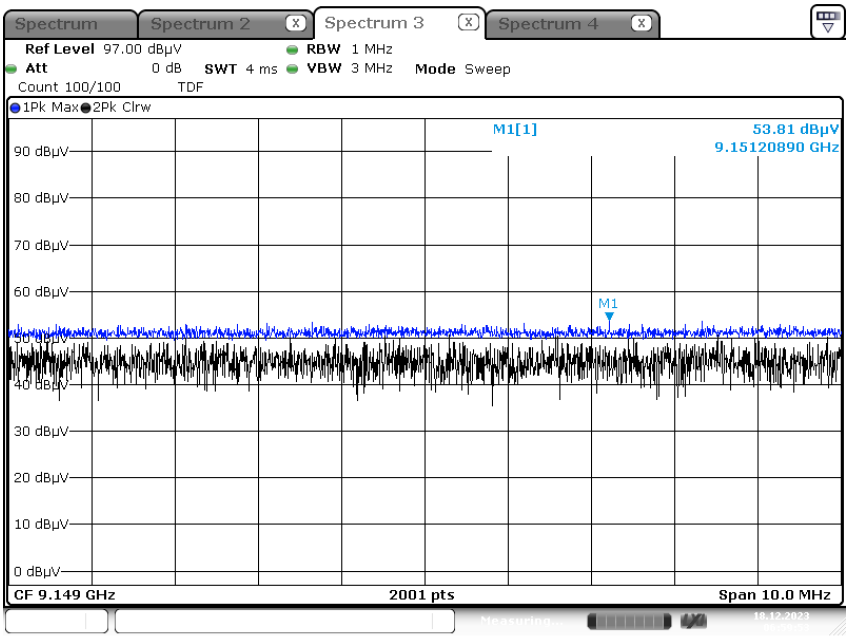
In order to simplify the report, Only the worst case plots were attached.

Radiated Spurious Emissions plot – Average Result (SF10 10th Harmonic)



Date: 18.DEC.2023 06:59:38

Radiated Spurious Emissions plot – Peak Result (SF10 10th Harmonic)



Date: 18.DEC.2023 06:59:54

10.8 RECEIVER SPURIOUS EMISSIONS

Frequency Range : Below 1 GHz

Frequency	Measured Level	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
[MHz]	[dBμV/m]	[dB/m]	[dB]	[H/V]	[dBμV/m]	[dBμV/m]	[dB]
No Critical peaks found							

Note:

1. Radiated emissions measured in frequency range from 30 MHz to 1000 MHz were made with an instrument using Quasi peak detector mode.

Frequency Range : Above 1 GHz

Frequency	Measured Level	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
[MHz]	[dBμV/m]	[dB/m]	[dB]	[H/V]	[dBμV/m]	[dBμV/m]	[dB]
No Critical peaks found							

11. LIST OF TEST EQUIPMENT

Conducted Test

Equipment	Model	Manufacturer	Serial No.	Due to Calibration	Calibration Interval
LISN	ENV216	Rohde & Schwarz	102245	08/02/2024	Annual
EMI Test Receiver	ESR	Rohde & Schwarz	101910	05/26/2024	Annual
Temperature Chamber	SU-642	ESPEC	93008124	02/22/2024	Annual
Signal Analyzer	N9030A	Keysight	MY55410508	09/04/2024	Annual
Power Meter	N1911A	Agilent	MY45100523	03/06/2024	Annual
Power Sensor	N1921A	Agilent	MY57820067	03/06/2024	Annual
Directional Coupler	87300B	Agilent	3116A03621	10/30/2024	Annual
Power Splitter	11667B	Hewlett Packard	10545	02/06/2024	Annual
DC Power Supply	E3632A	Agilent	KR75305528	01/03/2024	Annual
Attenuator(10 dB)(DC-26.5 GHz)	8493C-010	Agilent	08285	06/02/2024	Annual
Attenuator(20 dB)	18N-20dB	Rohde & Schwarz	8	03/08/2024	Annual
Software	EMC32	Rohde & Schwarz	N/A	N/A	N/A
FCC WLAN&BT&BLE Conducted Test Software v3.0	N/A	HCT CO., LTD.	N/A	N/A	N/A
Bluetooth Tester	CBT	Rohde & Schwarz	100808	02/16/2024	Annual

Note:

1. Equipment listed above that calibrated during the testing period was set for test after the calibration.
2. Equipment listed above that has a calibration due date during the testing period, the testing is completed before equipment expiration date.

Radiated Test

Equipment	Model	Manufacturer	Serial No.	Due to Calibration	Calibration Interval
Controller(Antenna mast)	CO3000	Innco system	CO3000-4p	N/A	N/A
Antenna Position Tower	MA4640/800-XP-EP	Innco system	S3AM	08/03/2025	Biennial
Controller	EM2090	Emco	060520	N/A	N/A
Turn Table	N/A	Ets	N/A	N/A	N/A
Loop Antenna	FMZB 1513	Rohde & Schwarz	1513-333	03/17/2024	Biennial
Hybrid Antenna	VULB 9168	Schwarzbeck	9168-0895	08/16/2024	Biennial
Horn Antenna	BBHA 9120D	Schwarzbeck	9120D-1191	11/07/2025	Biennial
Horn Antenna(15 GHz ~ 40 GHz)	BBHA9170	Schwarzbeck	BBHA9170124	03/28/2025	Biennial
Amp & Filter Bank Switch Controller	FBSM-01A	TNM system	0	N/A	N/A
Band Reject Filter	WRCJV2400/2483.5-2370/2520-60/12SS	Wainwright Instruments	2	01/05/2024	Annual
Band Reject Filter	WRCJV12-4900-5100-5900-6100-50SS	Wainwright Instruments	5	06/12/2024	Annual
Band Reject Filter	WRCJV12-4900-5100-5900-6100-50SS	Wainwright Instruments	6	06/12/2024	Annual
Band Reject Filter	WRCJV5100/5850-40/50-8EEK	Wainwright Instruments	1	02/09/2024	Annual
RF Switching System	FBSR-03A (3G HPF+LNA)	T&M SYSTEM	S3L1	11/17/2024	Annual
RF Switching System	FBSR-03A (10dB ATT+LNA)	T&M SYSTEM	S3L2	11/17/2024	Annual
RF Switching System	FBSR-03A (7G HPF+LNA)	T&M SYSTEM	S3L3	11/17/2024	Annual
RF Switching System	FBSR-03A (3dB ATT+LNA)	T&M SYSTEM	S3L4	11/17/2024	Annual
Power Amplifier	CBL18265035	CERNEX	22966	11/17/2024	Annual
Power Amplifier	CBL26405040	CERNEX	25956	03/02/2024	Annual
Bluetooth Tester	TC-3000C	TESCOM	3000C000175	03/28/2024	Annual
Spectrum Analyzer	FSVA40 (10 Hz ~ 40 GHz)	Rohde & Schwarz	101502	03/17/2024	Annual
Spectrum Analyzer	FSV40 (10 Hz ~ 40 GHz)	Rohde & Schwarz	100900	12/06/2024	Annual

Note:

1. Equipment listed above that calibrated during the testing period was set for test after the calibration.
2. Equipment listed above that has a calibration due date during the testing period, the testing is completed before equipment expiration date.
3. Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5(Version : 2017).

12. ANNEX A_TEST SETUP PHOTO

Please refer to test setup photo file no. as follows;

No.	Description
1	HCT-RF-2312-FI012-P