Report on the Testing of the

Underground Magnetics Inc.
GL2RF9

FCC ID: 2A3JY2RF9
IC: 28818-2RF9

In accordance with:
FCC 47 CFR Part 15.247
ISED RSS-247 Issue 2, February 2017

America

Add value.
Inspire trust.

Prepared for: Underground Magnetics Inc.
5501 NW Beaver Dr
Johnston, IA 50131

COMMERCIAL-IN-CONFIDENCE

Document Number: NC72174575.1 | Issue: 1

SIGNATURE			
Sean Sellergren			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Sean Sellergren	Sr EMC Engineer	**Authorized Signatory**	07 February 2022

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD America, Inc. document control rules.

FCC Accreditation Designation Number US1148 New Brighton, MN Test Laboratory	Innovation, Science, and Economic Development Canada Accreditation Site Number 4512A New Brighton, MN Test Laboratory

EXECUTIVE SUMMARY
A sample of this product was tested and found to be compliant with the standards listed above and the tests shown in Table 1.3.1 of this report.

A2LA Cert. No. 2955.11

ACCREDITATION
Our A2LA Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our A2LA Accreditation.

TÜV SÜD America Inc
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New Brighton, MN 55112

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Contents

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Table 1.1-1 – Modification Record

Issue	Description of Change	Date of Issue
1	First Issue	07 February 2022

1.2 Introduction

Applicant	Underground Magnetics Inc.
Manufacturer	Underground Magnetics Inc.
Applicant's Email Address	Keith.lloyd@umaghdd.com
Model Number(s)	GL2RF9
Serial Number(s)	57055AE1
Number of Samples Tested	1
PMN	GL2RF9
HVIN	201030
FVIN	n/a
HMN	201030
Test Specification/Issue/Date	FCC 47 CFR Part 15.247 ISED RSS-247 Issue 2, February 2017
Order Number	72174575
Date of Receipt of EUT	13 December 2021
Start of Test	13 December 2021
Finish of Test	15 December 2021
Related Document(s)	KDB 558074 D01

1.3 Scope of Testing

To perform certification testing to confirm that the wireless device(s) meet the requirements of the applicable standards and guidance documents (KDB 558074 D01).

1.4 Summary of Results

A summary of the tests carried out in accordance with the specifications shown below.

Table 1.4-1 – Summary of Results

Report Section	Specification Clause		Test Description	Accreditation	Base Standard
2.1	15.203	RSS-GEN	Antenna Requirements	A2LA	FCC Part 15.203
2.2	15.247(a)(1)(i)	RSS-247 (5.1a)	20dB / 99% Bandwidth	A2LA	ANSI C63.10:2013
2.3	15.247(a)(1)	RSS-247 (5.1b)	Hopping Channel Separation	A2LA	ANSI C63.10:2013
2.4	15.247(a)(1)(i)	RSS-247 (5.1c)	Number of Hopping Channels	A2LA	ANSI C63.10:2013
2.5	15.247(a)(1)(i)	RSS-247 (5.1d)	Average Occupancy Period	A2LA	ANSI C63.10:2013
2.6	15.247(b)(2)	RSS-247 (5.4d)	Peak Conducted Output Power	A2LA	ANSI C63.10:2013
2.7	15.247(d)	RSS-247 (5.5)	Conducted Spurious Emissions	A2LA	ANSI C63.10:2013
2.8	15.247(d)	RSS-247 (5.5)	Conducted Band-Edge	A2LA	ANSI C63.10:2013
2.9	15.207	RSS-GEN	Conducted Emissions	A2LA	ANSI C63.4:2013
2.10	15.247(d)	RSS-GEN	Radiated Spurious Emissions	A2LA	ANSI C63.10:2013
2.11	15.205	RSS-GEN	Radiated Restricted Bands of Emissions	A2LA	ANSI C63.10:2013

Table 1.4-2 – Test Accreditation

Test Name	Name of Tester(s)	Results / Comments
Antenna Requirements	Franklin Rose	Pass
20dB / 99% Bandwidth	Franklin Rose	Pass
Hopping Channel Separation	Franklin Rose	Pass
Number of Hopping Channels	Franklin Rose	Pass
Average Occupancy Period	Franklin Rose	Pass
Peak Conducted Output Power	Franklin Rose	Pass
Conducted Spurious Emissions	Franklin Rose	Pass
Conducted Band-Edge	Franklin Rose	Pass
Conducted Emissions	Franklin Rose	N/A
Radiated Spurious Emissions	Franklin Rose	Pass
Radiated Restricted Bands of Emissions	Franklin Rose	Pass

Note: Tests marked with N/A were not tested due to EUT not meeting the full requirements for test applicability and therefore are not required.

1.5 Product Information

1.5.1 Technical Description

The Equipment Under Test (EUT) is a frequency hopping radio.

Table 1.5-1 – Wireless Module Technical Information

Detail	Description
FCC ID	2A3JY2RF9
IC	28818-2RF9
Transceiver Model #	GL2RF9
Operating Frequency	902.5-927.5 MHz
Modulation Format	GFSK
Antenna 1 Type / Gain:	½ wave dipole, 2.5 dBi
Antenna 2 Type / Gain:	Yagi, 9 dBi

A full description and detailed product specification details are available from the manufacturer.

Table 1.5-2 – Cable Descriptions

Cable/Port	Description
USB to Serial	~10 cm cable adapter
Optical Fiber	> 3m optical fiber cable

Table 1.5-3 – Support Equipment Descriptions

Make/Model	Description
Notepad PC	A PC used to program the EUT for testing supplied by client
USB to Serial to Optical Convertor	Custom signal conversion to control EUT supplied by client
Test Fixture	Custom housing with antenna connector for EUT supplied by client

1.5.2 Modes of Operation

Table 1.5-4 – Test Frequencies & Modes of Operation

Channel	Frequency (MHz)	Mode(s)
Low End	902.5	Modulated; Unmodulated (CW)
Middle	915.0	Modulated; Unmodulated (CW)
High End	927.5	Modulated; Unmodulated (CW)

1.6 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.7 EUT Modification Record

The table below details modifications made to the EUT during the test program. The modifications incorporated during each test are recorded on the appropriate test pages.

Table 1.7-1 – Modification Record

Modification State	Description of Modification fitted to EUT	Modification Fitted By	Date Modification Fitted
0	Initial State		

1.8 Test Location

TÜV SÜD conducted the following tests at our New Brighton, MN Test Laboratory.
Office address:

TÜV SÜD America
141 14th Street NW
New Brighton, MN 55112 USA

2 Test Details

2.1 Antenna Requirements

2.1.1 Specification Reference

FCC 47 CFR Part 15 Subpart C, 15.203
RSS-GEN Issue 5

2.1.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.1.3 Antenna Requirement

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall 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. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of §§15.211, 15.213, 15.217, 15.219, 15.221, or §15.236. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

Note: Above statement is taken from FCC Part 15 Subpart C §15.203

Table 2.1-1 – Antenna Used In EUT

Antenna Type	Connection Type	Antenna Gain
½ Wave Dipole	Reverse-polarity SMA	2.5 dBi
Yagi	Reverse-polarity SMA	9.0 dBi

2.2 20dB / 99% Bandwidth

2.2.1 Specification Reference

FCC 47 CFR Part 15.247(a)(2)
RSS-247 5.2(a)

2.2.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.2.3 Date of Test

13 December 2021

2.2.4 Test Method

The 20dB bandwidth was measured in accordance with the FCC KDB 558074 D01 15.247 Meas Guidance. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 100 kHz and the Video Bandwidth (VBW) was set to ≥ 3 times the RBW. The trace was set to max hold using a peak detector. The marker-delta function of the spectrum analyzer was utilized to determine the 20dB bandwidth of the emission.

The occupied bandwidth measurement function of the spectrum analyzer was used to measure the 99% bandwidth value. The span of the analyzer was set to capture all products of the modulation process, including the emission sidebands. The RBW to 1-5% of the occupied bandwidth and the VBW set to ≥ 3 times the RBW.

2.2.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.2.6 Test Results

Table 2.2-1 – 20dB Bandwidth Results

Frequency (MHz)	20dB Bandwidth (kHz)	99% Bandwidth (kHz)
902.5	65.93	60.37
915.0	66.93	60.38
927.5	66.53	60.27

Test Summary: The EUT operated as intended before, during, and after testing.

Test Result: Pass

See data below for detailed results.

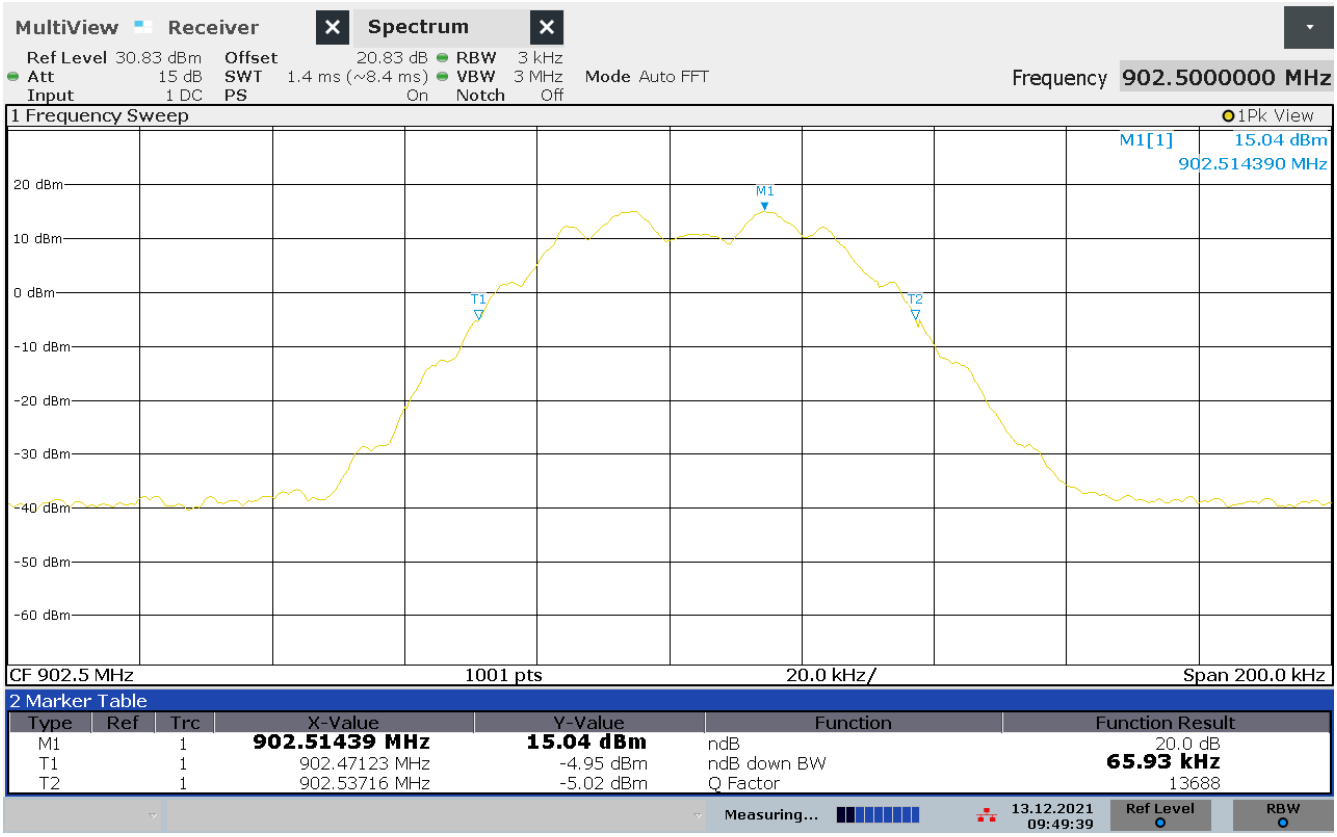

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Figure 2-1 – 20dB Bandwidth – Low Channel

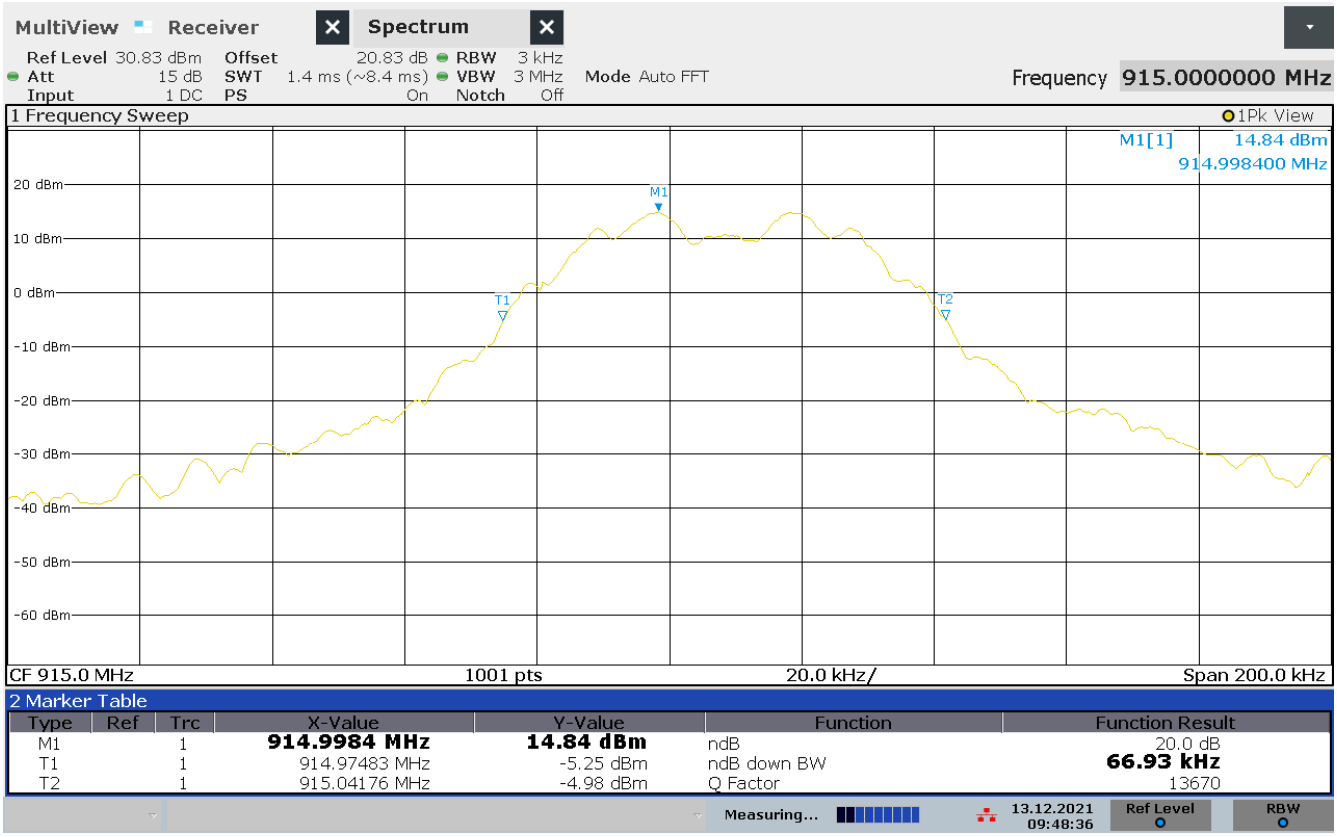

Figure 2-2 – 20dB Bandwidth – Middle Channel

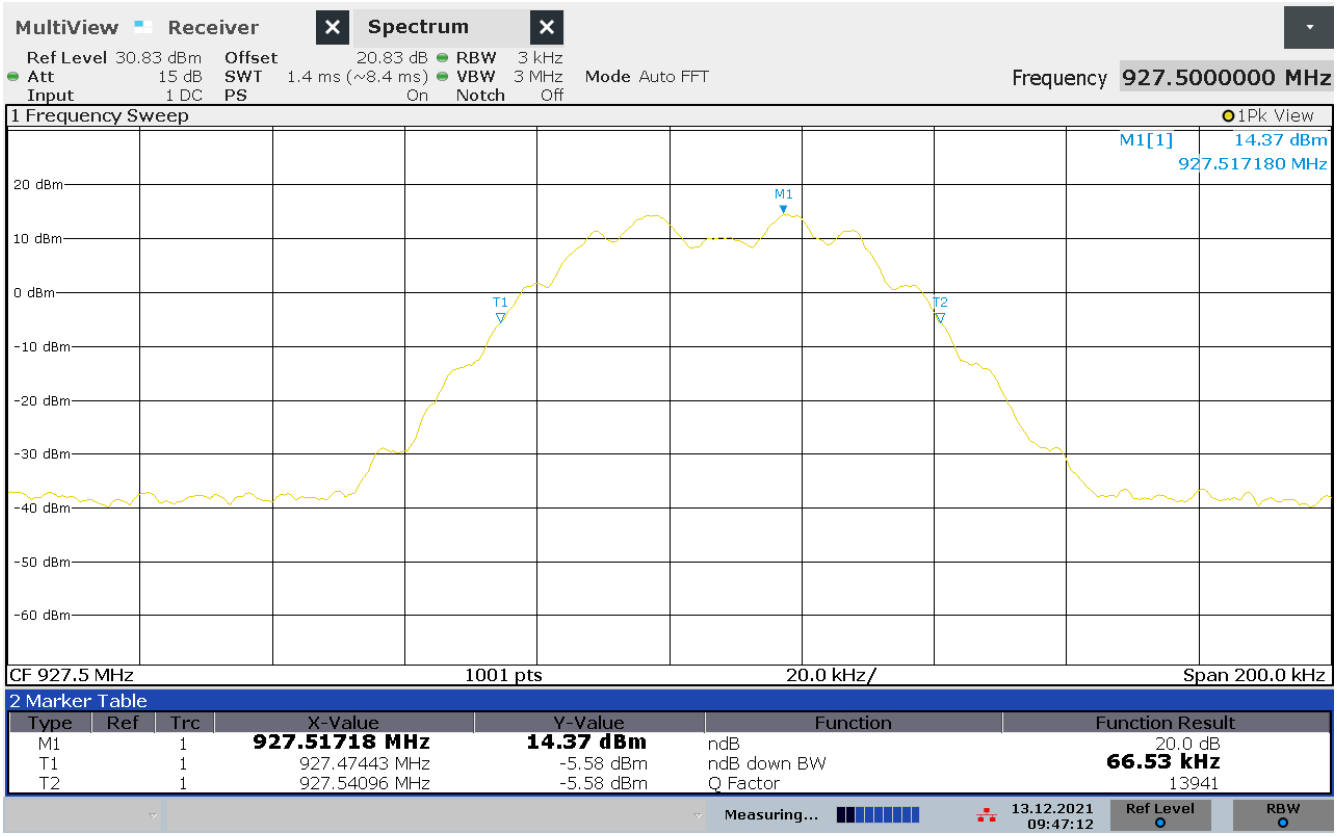

Figure 2-3 – 20dB Bandwidth – High Channel

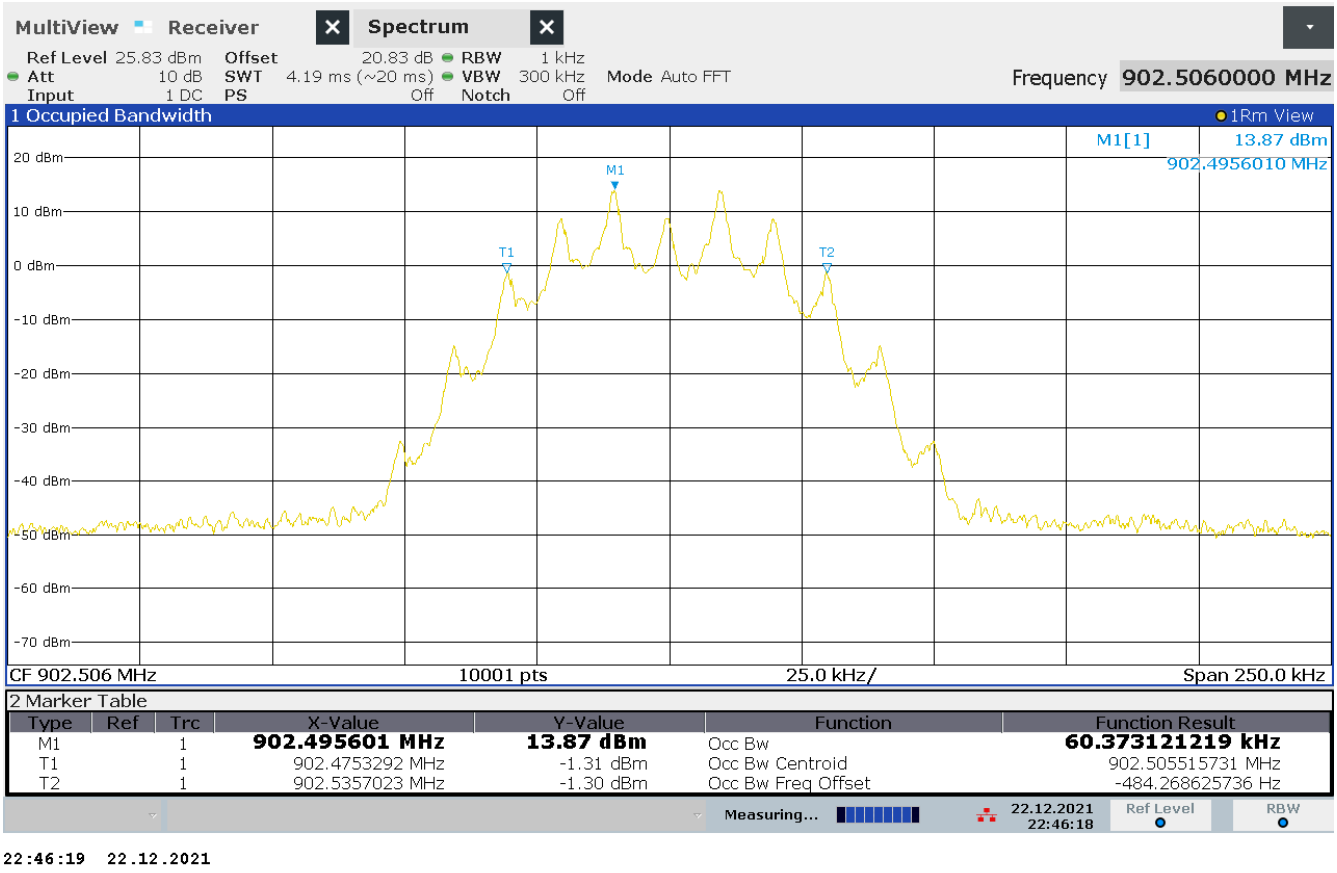

Figure 2-4 – 99% Bandwidth – Low Channel

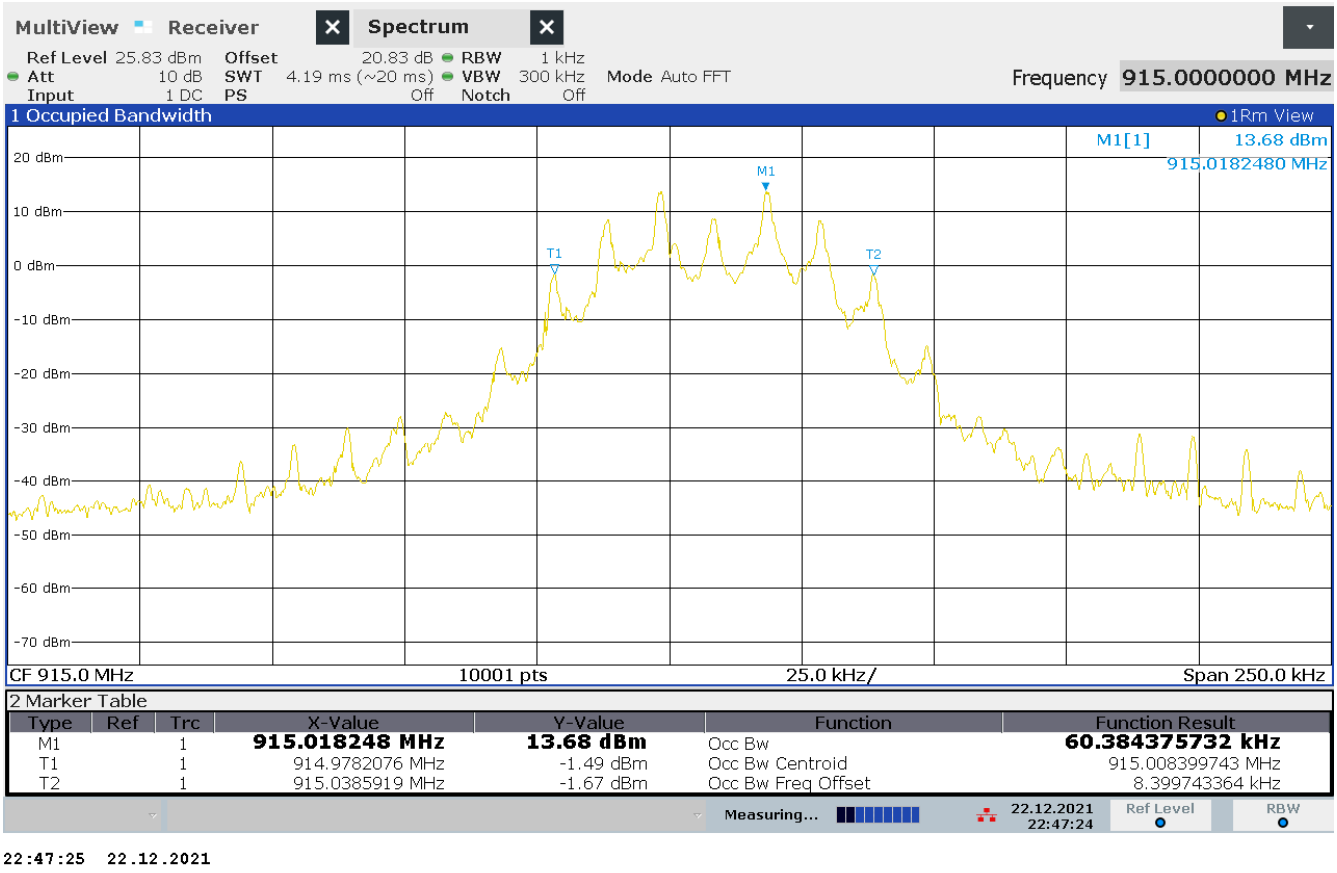

Figure 2-5 – 99% Bandwidth – Middle Channel

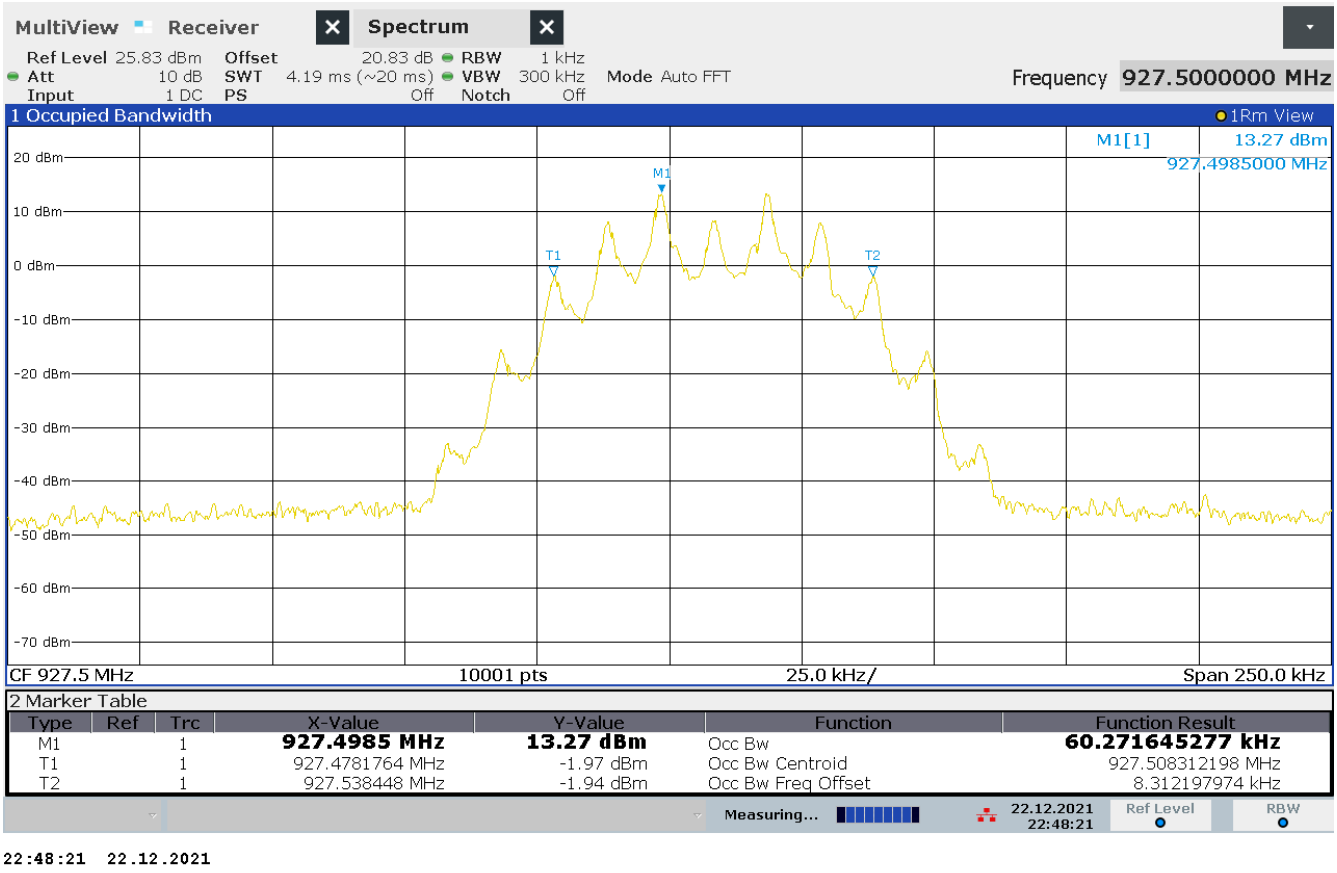

Figure 2-6 – 99% Bandwidth – High Channel

2.2.7 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: CSAC1

Table 2.2-2 – Conducted Emissions Test Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
WRLE11397	Meca	Attenuator, 20 dB	603-20-1F18	11397	B	12/02/2021	12/02/2022
NBLE03509	Florida RF Labs	Cable, SMA 6ft	FL200	6ft-4	B	03/21/2021	03/21/2022
NBLE11555	Rohde & Schwarz	Receiver, 2 Hz-44 GHz	ESW44	101537	G	12/31/2020	12/31/2021

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.3 Hopping Channel Separation

2.3.1 Specification Reference

FCC 47 CFR Part 15.247(a)(1)
RSS-247 5.1(b)

2.3.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.3.3 Date of Test

13 December 2021

2.3.4 Test Method

The Hopping Channel Separation was measured in accordance with ANSI C63.10-2013 Section 7.8.2. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to 30% of the channel spacing and the Video Bandwidth (VBW) was set to ≥ 3 times the RBW. The trace was set to max hold using a peak detector. The marker-delta function of the spectrum analyzer was utilized to determine the channel separation of the adjacent channels.

2.3.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.3.6 Test Results

Table 2.3-1 – Hopping Channel Separation Results

Hopping Separation (MHz)	20dB Bandwidth (MHz)
0.500	0.067

Test Summary: The EUT operated as intended before, during, and after testing.

Test Result: Pass

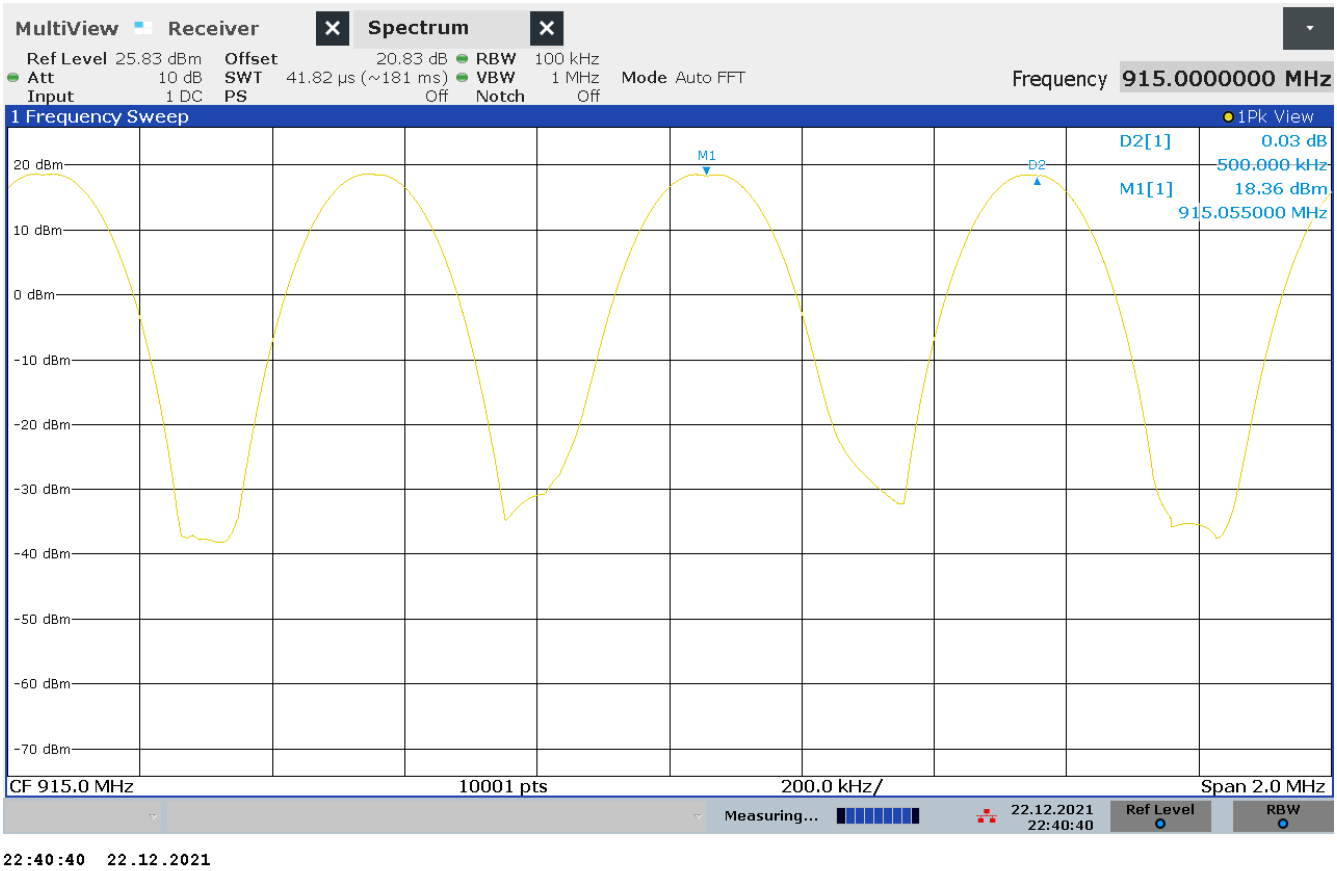

Figure 2-7 – Hopping Channel Separation

2.3.7 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: CSAC1

Table 2.3-2 – Conducted Emissions Test Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
WRLE11397	Meca	Attenuator, 20 dB	603-20-1F18	11397	B	12/02/2021	12/02/2022
NBLE03509	Florida RF Labs	Cable, SMA 6ft	FL200	6ft-4	B	03/21/2021	03/21/2022
NBLE11555	Rohde & Schwarz	Receiver, 2 Hz-44 GHz	ESW44	101537	G	12/31/2020	12/31/2021

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.4 Number of Hopping Channels

2.4.1 Specification Reference

FCC 47 CFR Part 15.247(a)(1)(i)
RSS-247 5.1(c)

2.4.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.4.3 Date of Test

13 December 2021

2.4.4 Test Method

The Number of Hopping Channels was measured in accordance with ANSI C63.10-2013 Section 7.8.3. The Resolution Bandwidth (RBW) of the spectrum analyzer was set to ≤ 30% of the channel spacing or the 20dB Bandwidth, and the Video Bandwidth (VBW) was set to ≥ 3 times the RBW. The trace was set to max hold using a peak detector. The spectrum analyzer automatic peak list function was utilized to determine the number of channels.

2.4.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.4.6 Test Results

Table 2.4-1 – Number of Hopping Channel Results

Number of Hopping Channels
50

Test Summary: The EUT operated as intended before, during, and after testing.

Test Result: Pass

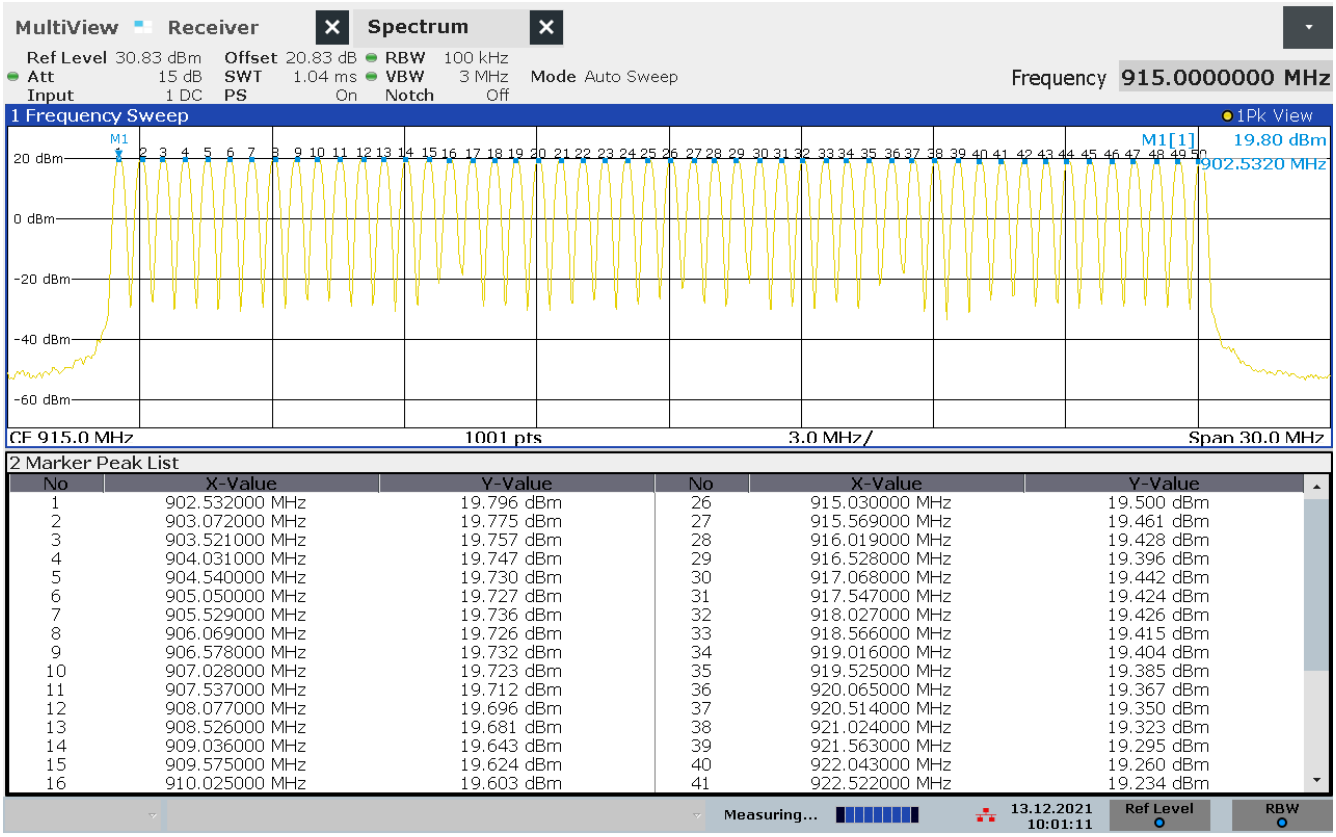

Figure 2-8 – Number of Hopping Channels

2.4.7 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: CSAC1

Table 2.4-2 – Conducted Emissions Test Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
WRLE11397	Meca	Attenuator, 20 dB	603-20-1F18	11397	B	12/02/2021	12/02/2022
NBLE03509	Florida RF Labs	Cable, SMA 6ft	FL200	6ft-4	B	03/21/2021	03/21/2022
NBLE11555	Rohde & Schwarz	Receiver, 2 Hz-44 GHz	ESW44	101537	G	12/31/2020	12/31/2021

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.5 Average Occupancy Period

2.5.1 Specification Reference

FCC 47 CFR Part 15.247(a)(1)(i)
RSS-247 5.1(d)

2.5.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.5.3 Date of Test

13 December 2021

2.5.4 Test Method

The Average Occupancy Period (Dwell Time) was measured in accordance with ANSI C63.10-2013 Section 7.8.4. The spectrum analyzer was put into a 0 Hz Span (time domain) measurement mode, and the Resolution Bandwidth (RBW) of the spectrum analyzer was set less than or equal to the channel spacing and where possible was set > 1/T, where T is the dwell time. The sweep time was set high enough to encompass the entire time on the channel. Triggering was set to video trigger at a level high enough to negate interference from adjacent channels. The trace was set to max hold using a peak detector. The marker-delta function of the spectrum analyzer was utilized to determine the occupancy time on the channel. The test was then repeated (if necessary) to measure the period until returning to the channel.

The Average Occupancy Period is calculated with the following formula:

*(Number of Hops within the Requirement Period) = (Number of Observed Hops) * (Requirement Period / Analyzer Sweep Time)*

2.5.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.5.6 Test Results

Table 2.5-1 – Average Occupancy Period Results

Frequency (MHz)	Number of Hops Observed	Requirement Time Period (s)	Dwell Time per Hop (ms)	Average Occupancy Period (ms)	Occupancy Limit (ms)	Margin (ms)
915.0	1	20	128.4	128.4	0.4	-271.6

Test Summary: The EUT operated as intended before, during, and after testing.

Test Result: Pass

See data below for detailed results.

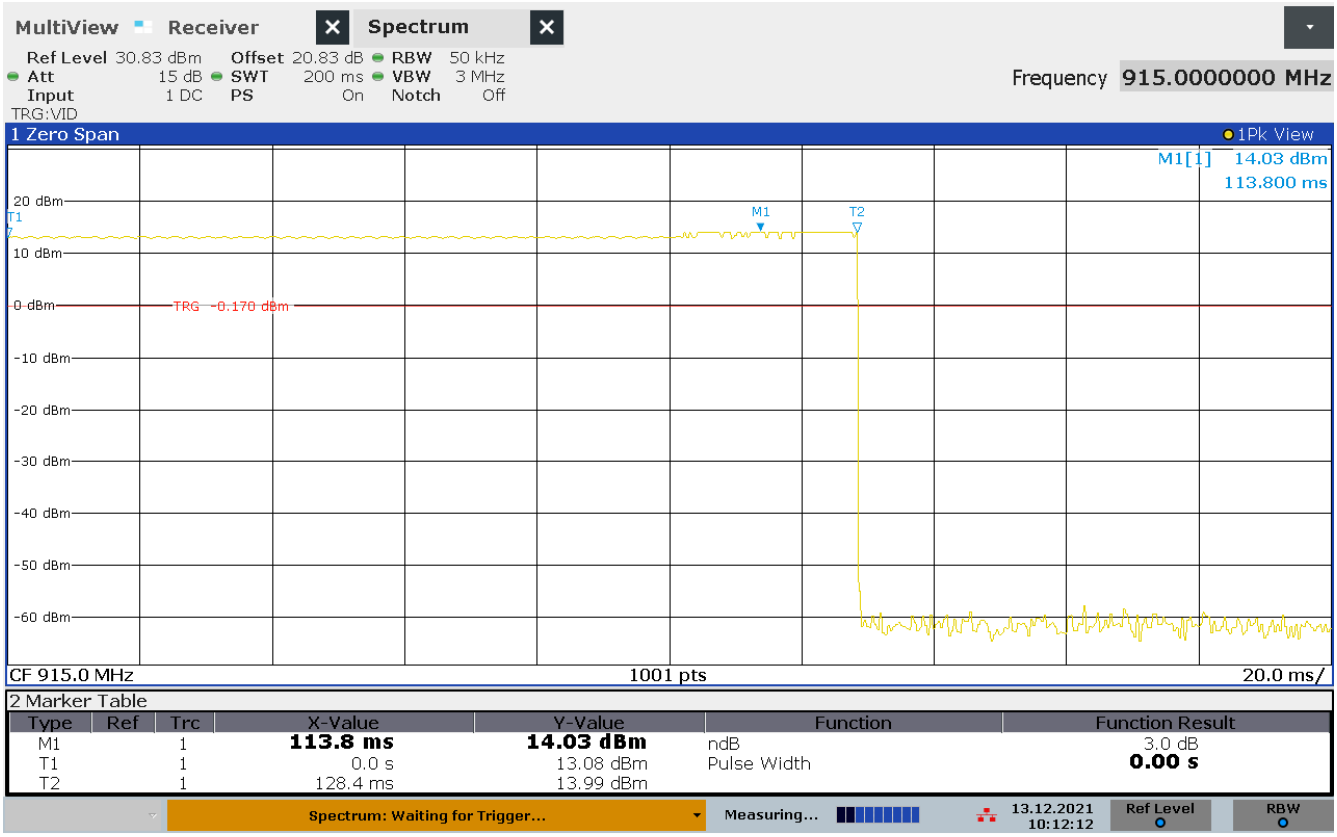

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Figure 2-9 – Dwell Time of Hop

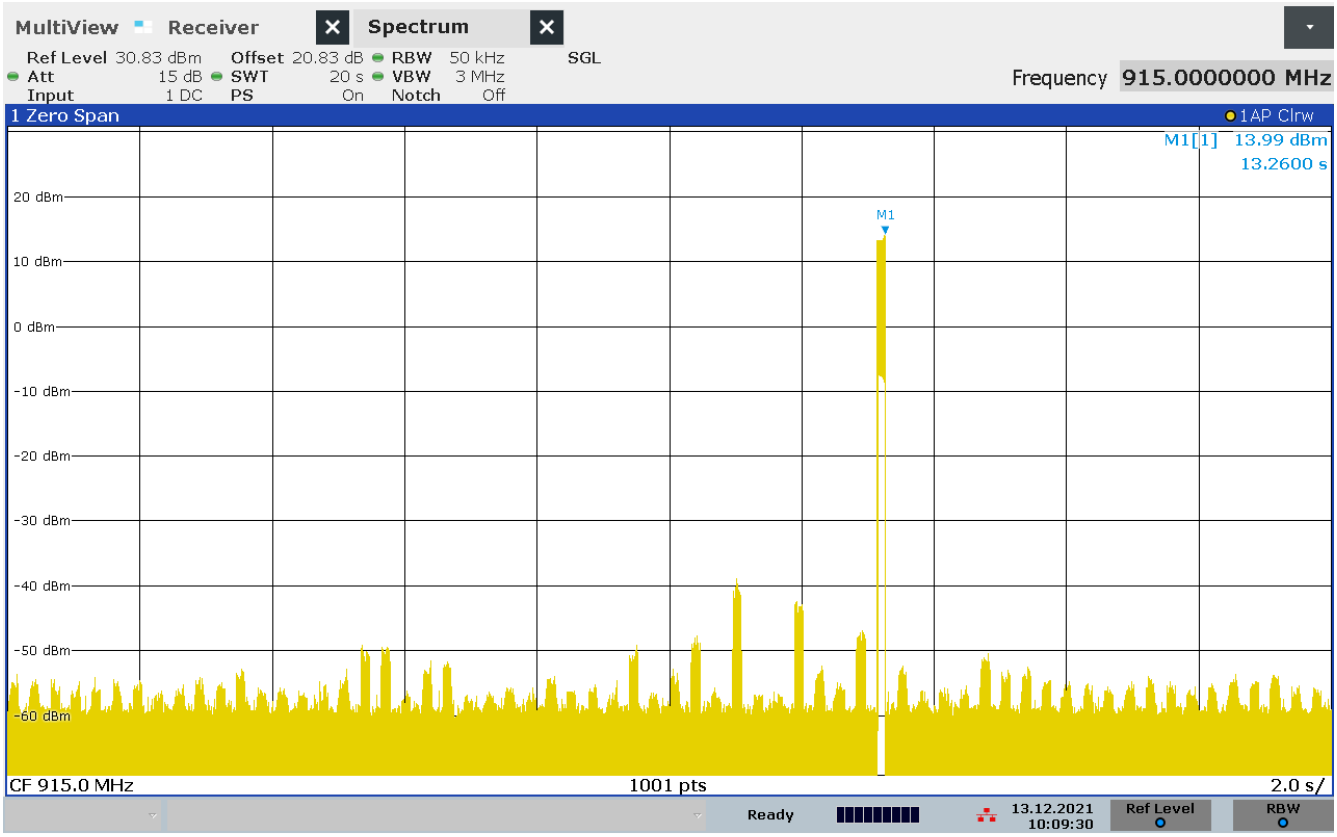


Figure 2-10 – Number of Hops in 20 s

2.5.7 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: CSAC1

Table 2.5-2 – Conducted Emissions Test Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
WRLE11397	Meca	Attenuator, 20 dB	603-20-1F18	11397	B	12/02/2021	12/02/2022
NBLE03509	Florida RF Labs	Cable, SMA 6ft	FL200	6ft-4	B	03/21/2021	03/21/2022
NBLE11555	Rohde & Schwarz	Receiver, 2 Hz-44 GHz	ESW44	101537	G	12/31/2020	12/31/2021

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.6 Peak Conducted Output Power

2.6.1 Specification Reference

FCC 47 CFR Part 15.247(b)(2)
RSS-247 5.2(d)

2.6.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.6.3 Date of Test

13 December 2021

2.6.4 Test Method

The maximum peak conducted output power was measured in accordance with ANSI C63.10-2013 Section 7.8.5. The RF output of the EUT was directly connected to the input of the spectrum analyzer along with a suitable external attenuator. The Resolution Bandwidth (RBW) was > 20dB of the emission and the VBW was set to ≥ 3 times the RBW. The trace was set to max hold using a peak detector. The marker-to-peak function of the spectrum analyzer was utilized to determine the peak level of the emission.

2.6.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.6.6 Test Results

Table 2.6-1 – Peak Conducted Output Power Results, ½ Wave Dipole Antenna Limit

Frequency (MHz)	Measured Output Power (dBm)	Output Power Limit (dBm)	Margin (dB)
902.5	19.85	30.00	-10.15
915.0	19.60	30.00	-10.40
927.5	19.10	30.00	-10.90

Table 2.6-2 – Peak Conducted Output Power Results, Yagi Antenna Limit

Frequency (MHz)	Measured Output Power (dBm)	Output Power Limit (dBm)	Margin (dB)
902.5	19.85	27.00	-7.15
915.0	19.60	27.00	-7.40
927.5	19.10	27.00	-7.90

Note: The output power limit clause found in 15.247(b)(4) states that antenna array gains greater than 6 dBi are subject to decreased power output limits (more stringent) by the amount in which they exceed 6 dBi.

Test Summary: The EUT operated as intended before, during, and after testing.

Test Result: Pass

See data below for detailed results.

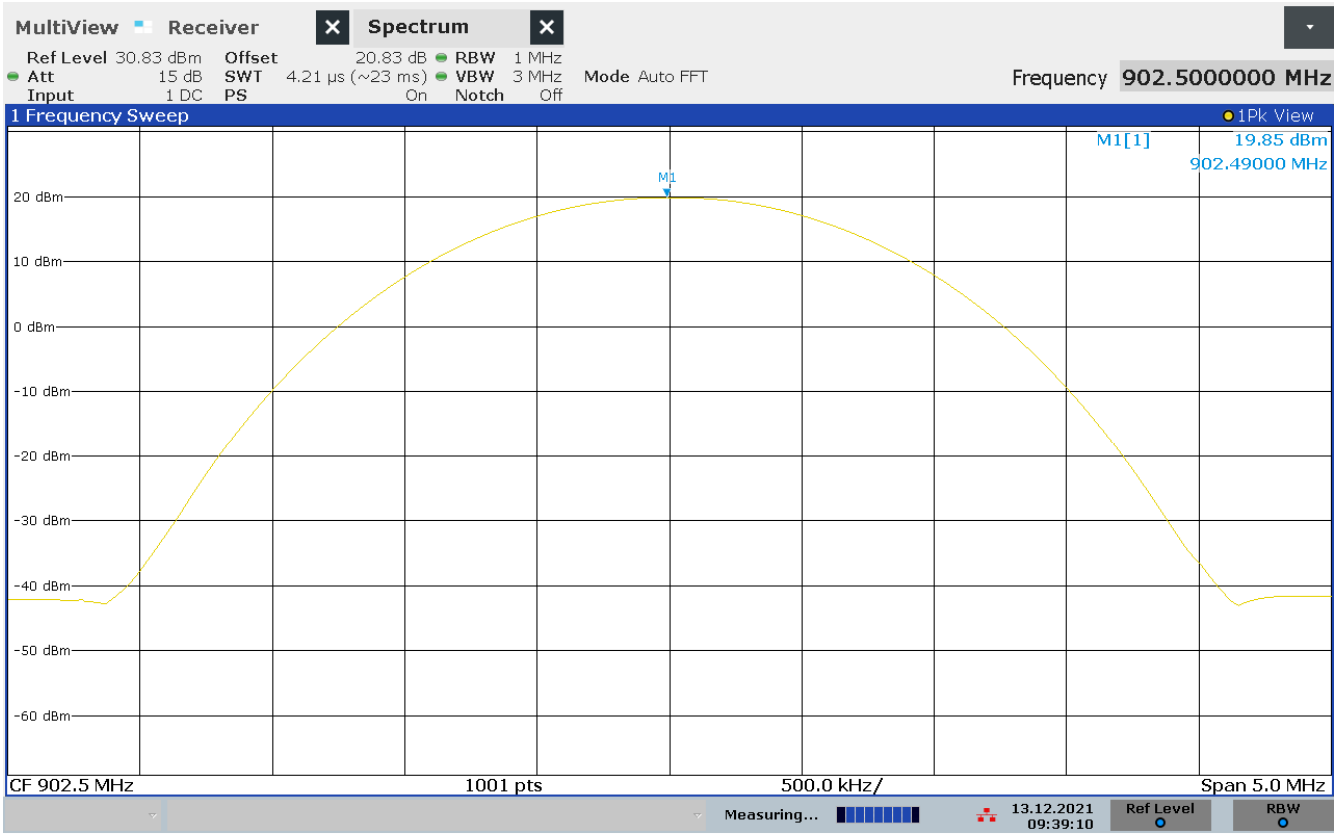


Figure 2-11 – Peak Conducted Output Power – Low Channel

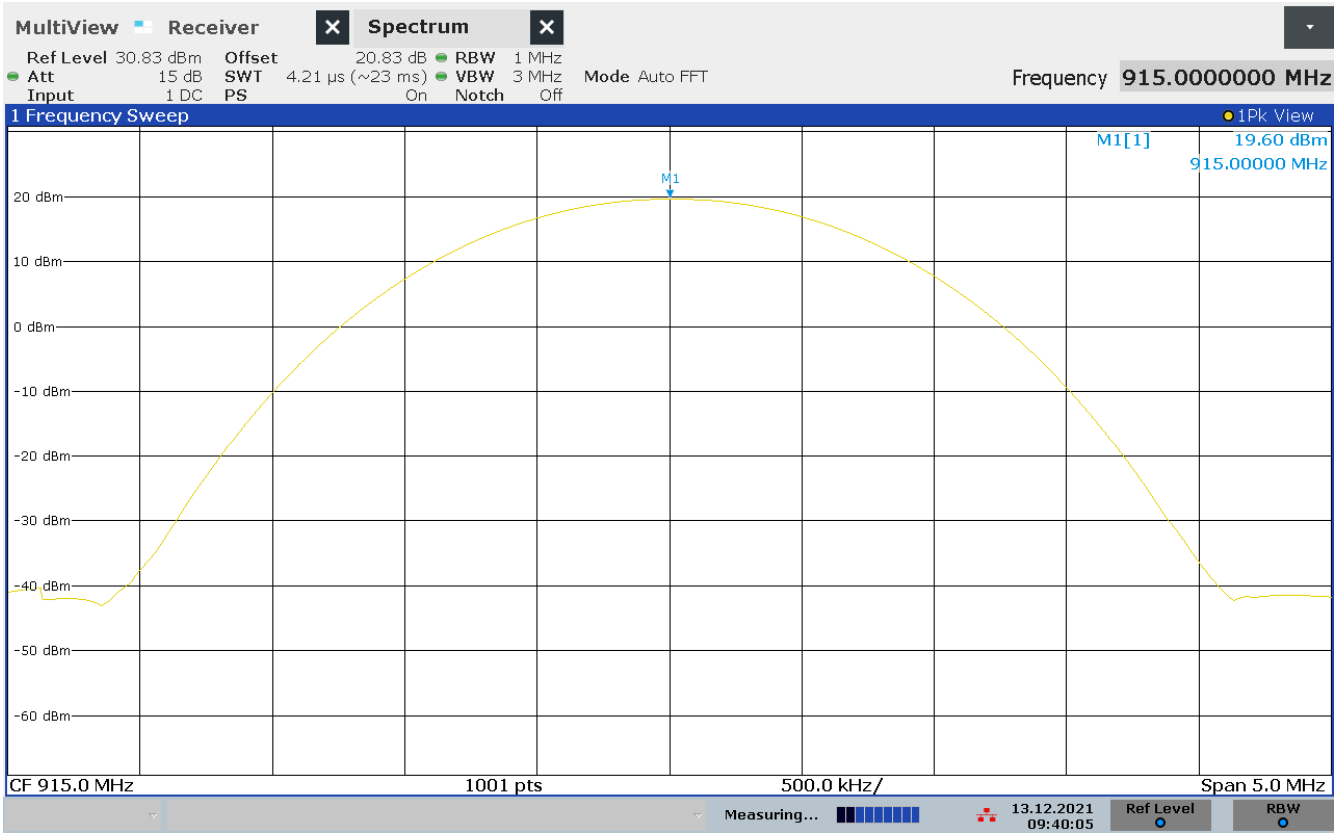


Figure 2-12 – Peak Conducted Output Power – Middle Channel

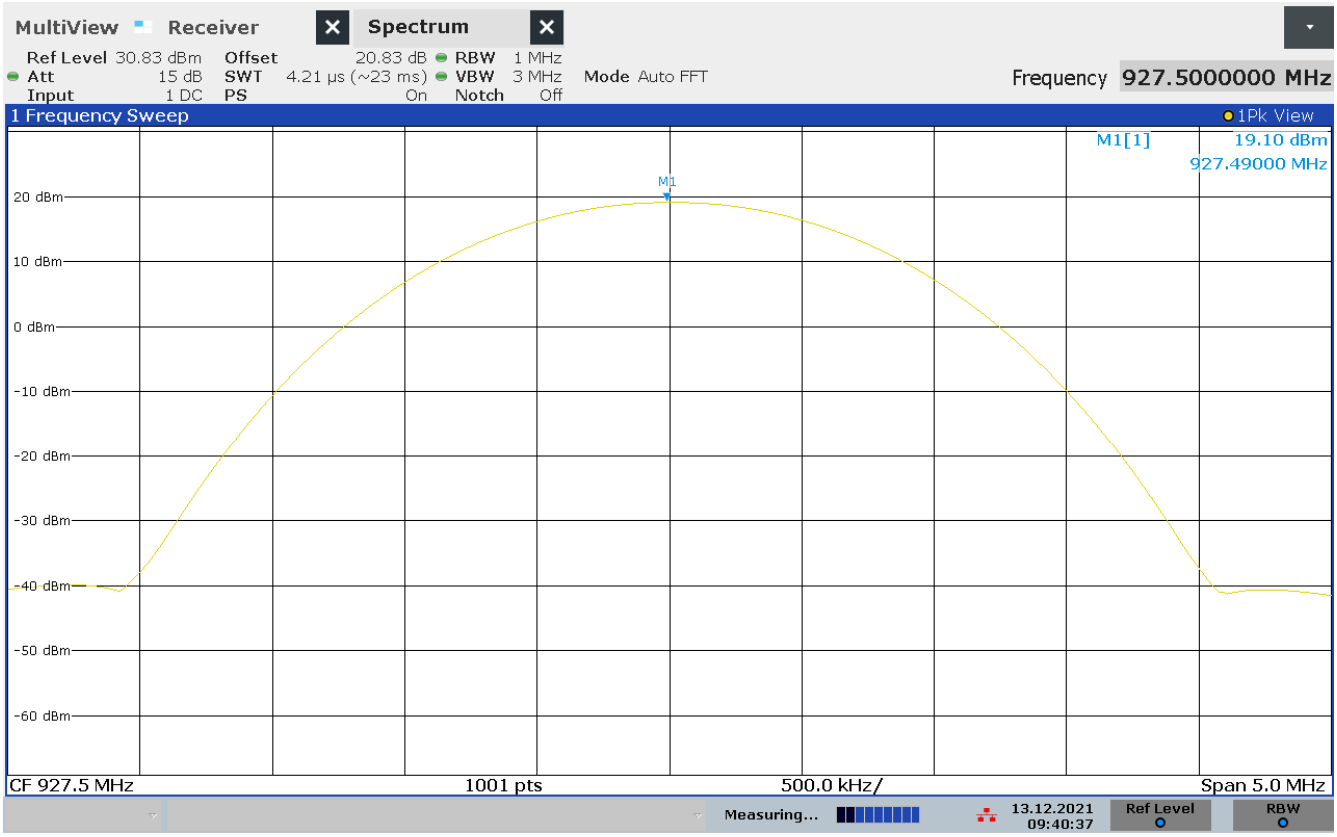


Figure 2-13 – Peak Conducted Output Power – High Channel

2.6.7 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: TRN1

Table 2.6-3 – Conducted Emissions Test Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
WRLE11397	Meca	Attenuator, 20 dB	603-20-1F18	11397	B	12/02/2021	12/02/2022
NBLE03509	Florida RF Labs	Cable, SMA 6ft	FL200	6ft-4	B	03/21/2021	03/21/2022
NBLE11555	Rohde & Schwarz	Receiver, 2 Hz-44 GHz	ESW44	101537	G	12/31/2020	12/31/2021

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.7 Conducted Spurious Emissions

2.7.1 Specification Reference

FCC 47 CFR Part 15.247(d)
RSS-247 5.2(5.5)

2.7.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.7.3 Date of Test

13 December 2021

2.7.4 Test Method

The maximum peak conducted output power was measured in accordance with ANSI C63.10-2013 Section 7.8.8. The RF output of the EUT was directly connected to the input of the spectrum analyzer along with a suitable external attenuator. The RBW of the spectrum analyzer was set to 100kHz and the VBW was set to ≥ 3 times the RBW. The spectrum analyzer span was set to cover the entire frequency range of 30MHz to 5 times the highest intentional radiator and the trace was set to max hold using the peak detector.

2.7.5 Environmental Conditions

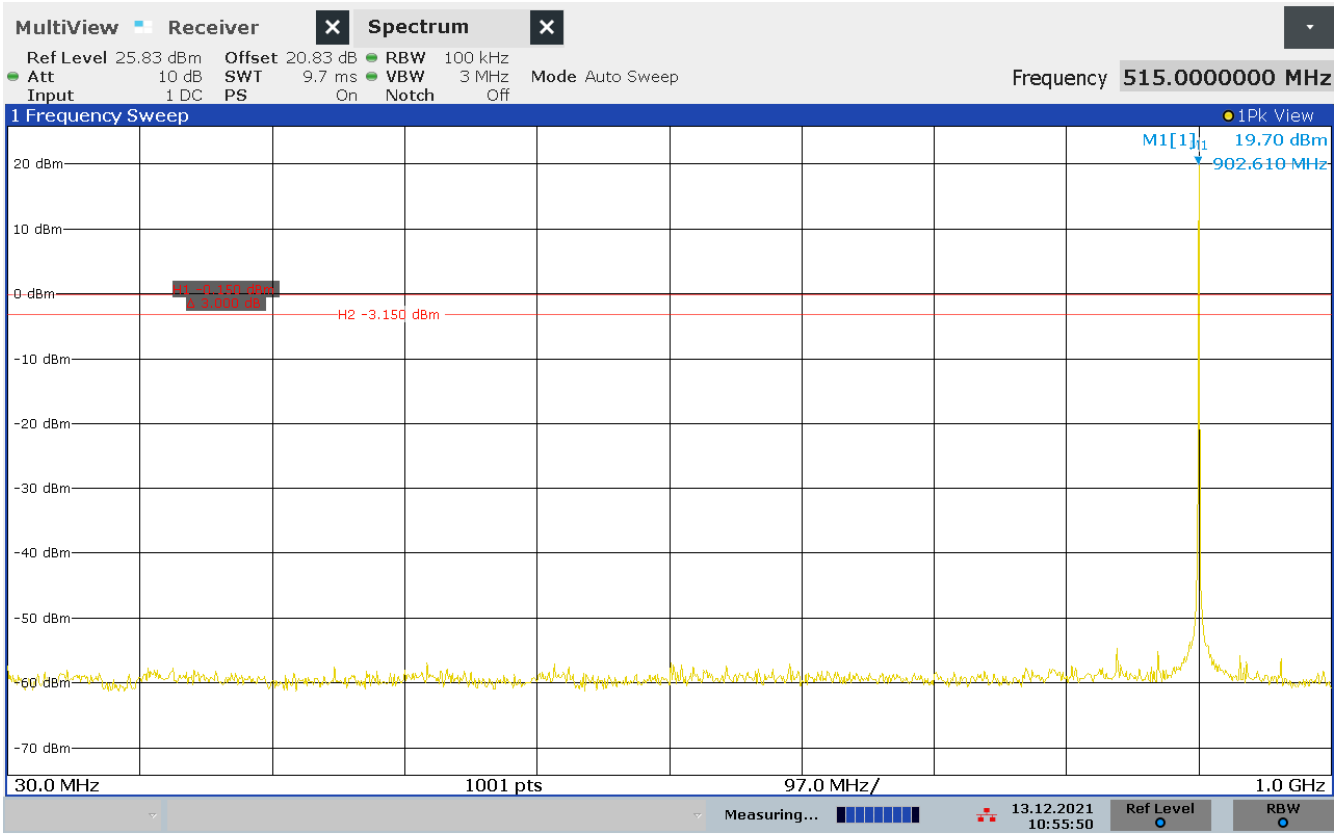
The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.7.6 Test Results

Test Summary: The EUT operated as intended before, during, and after testing.

Test Result: Pass

See data below for detailed results.



10:55:51 13.12.2021

Figure 2-14 – Conducted Spurious Emissions 30 MHz – 1GHz – Low Channel

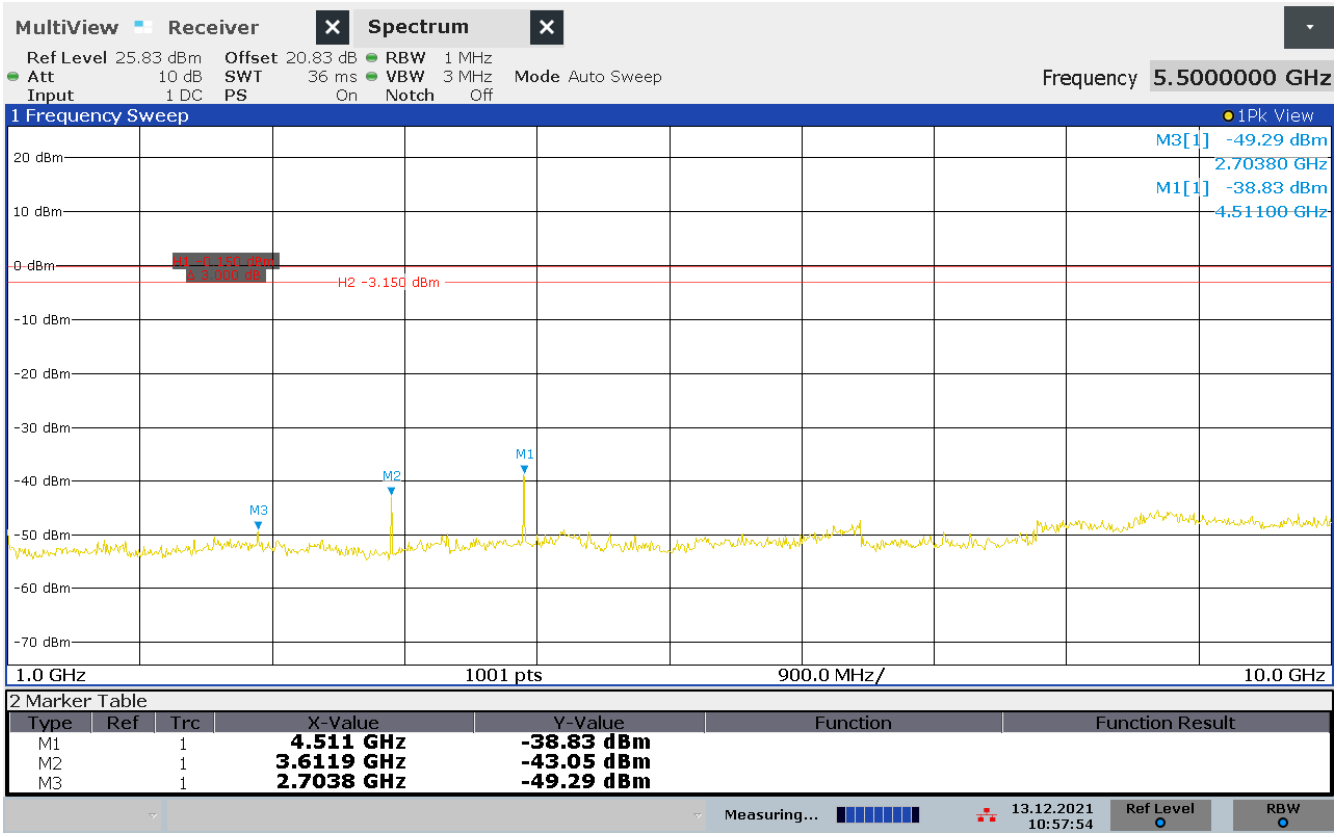
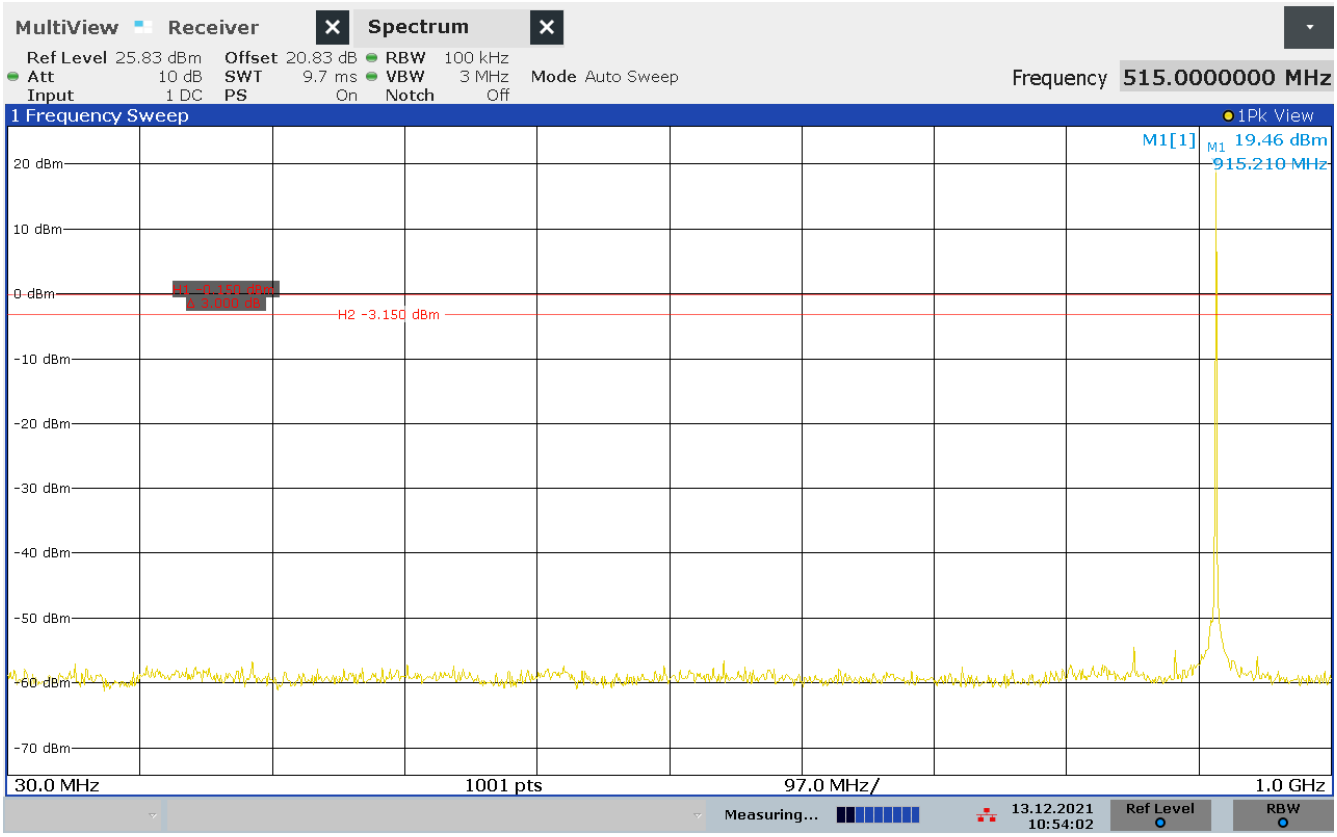


Figure 2-15 – Conducted Spurious Emissions Above 1GHz – Low Channel

Table 2.7-1 – Conducted Spurious Emissions Results – Low Channel

Marker/Plot	Frequency	Measured Level (dBm)	Limit (dBm)	Margin (dBm)
Marker 1, Plot 2	4.511 GHz	-38.83	-3.15	-35.68
Marker 2, Plot 2	3.612 GHz	-43.05	-3.15	-39.90
Marker 3, Plot 2	2.704 GHz	-49.29	-3.15	-46.14

Note: The limit was lowered in reference to the highest gain antenna.



10:54:03 13.12.2021

Figure 2-16 – Conducted Spurious Emissions 30 MHz – 1GHz – Middle Channel

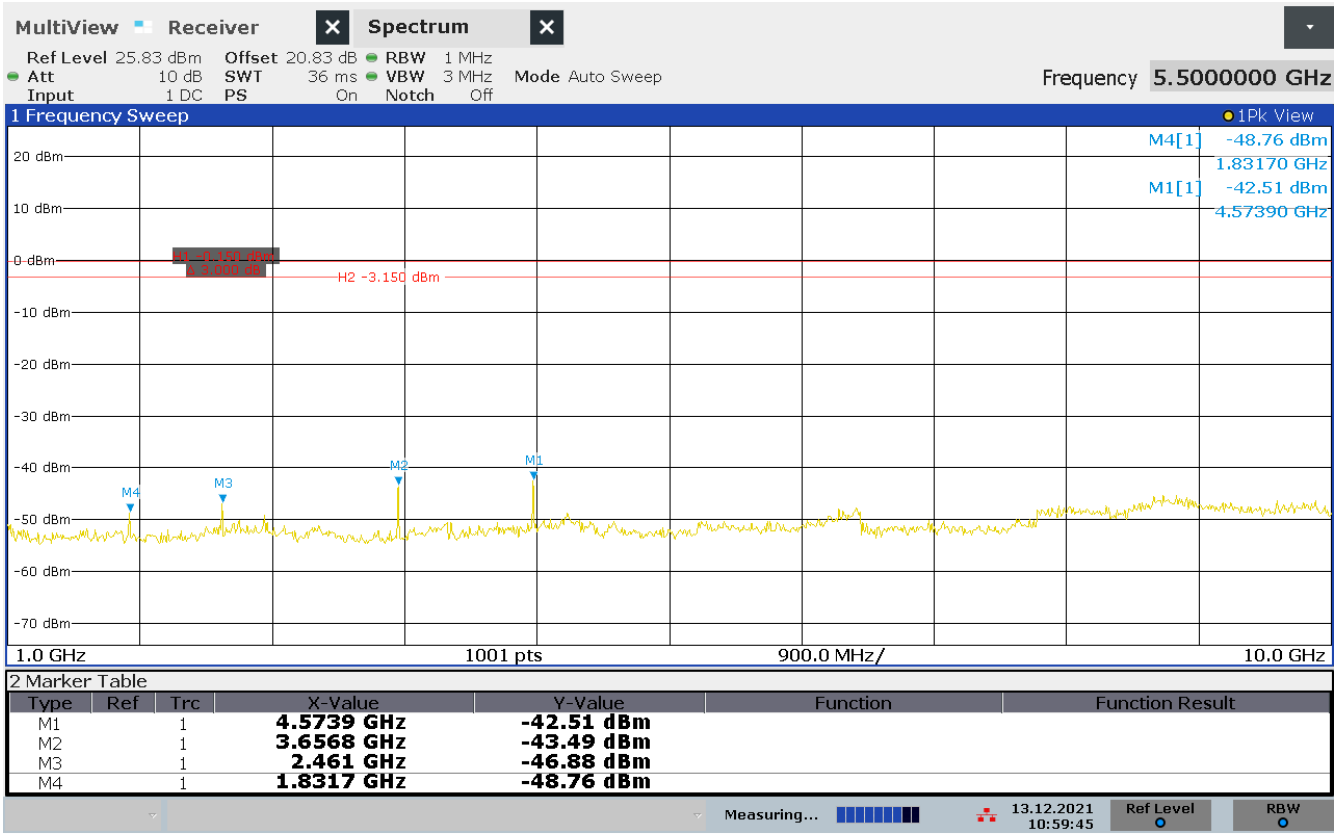
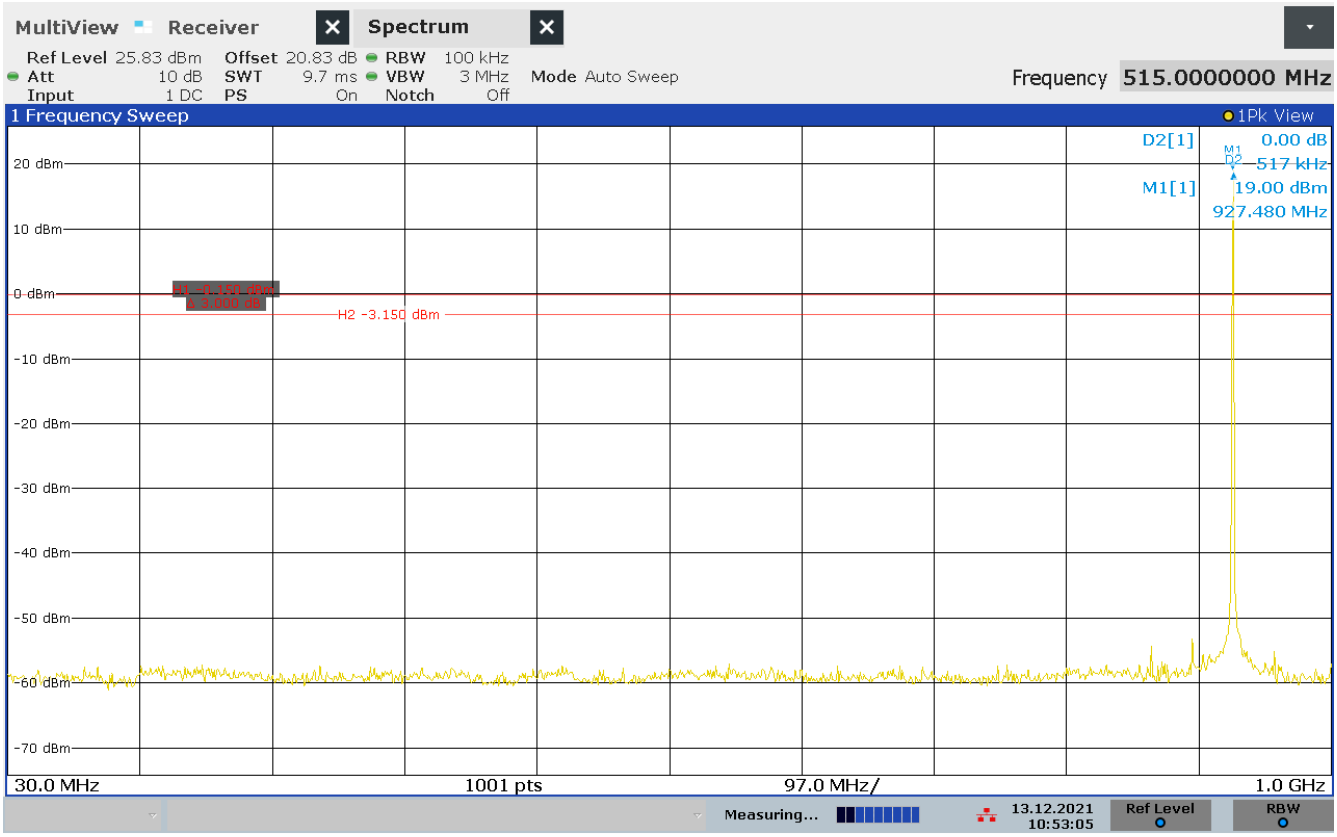


Figure 2-17 – Conducted Spurious Emissions Above 1GHz – Middle Channel

Table 2.7-2 – Conducted Spurious Emissions Results – Middle Channel

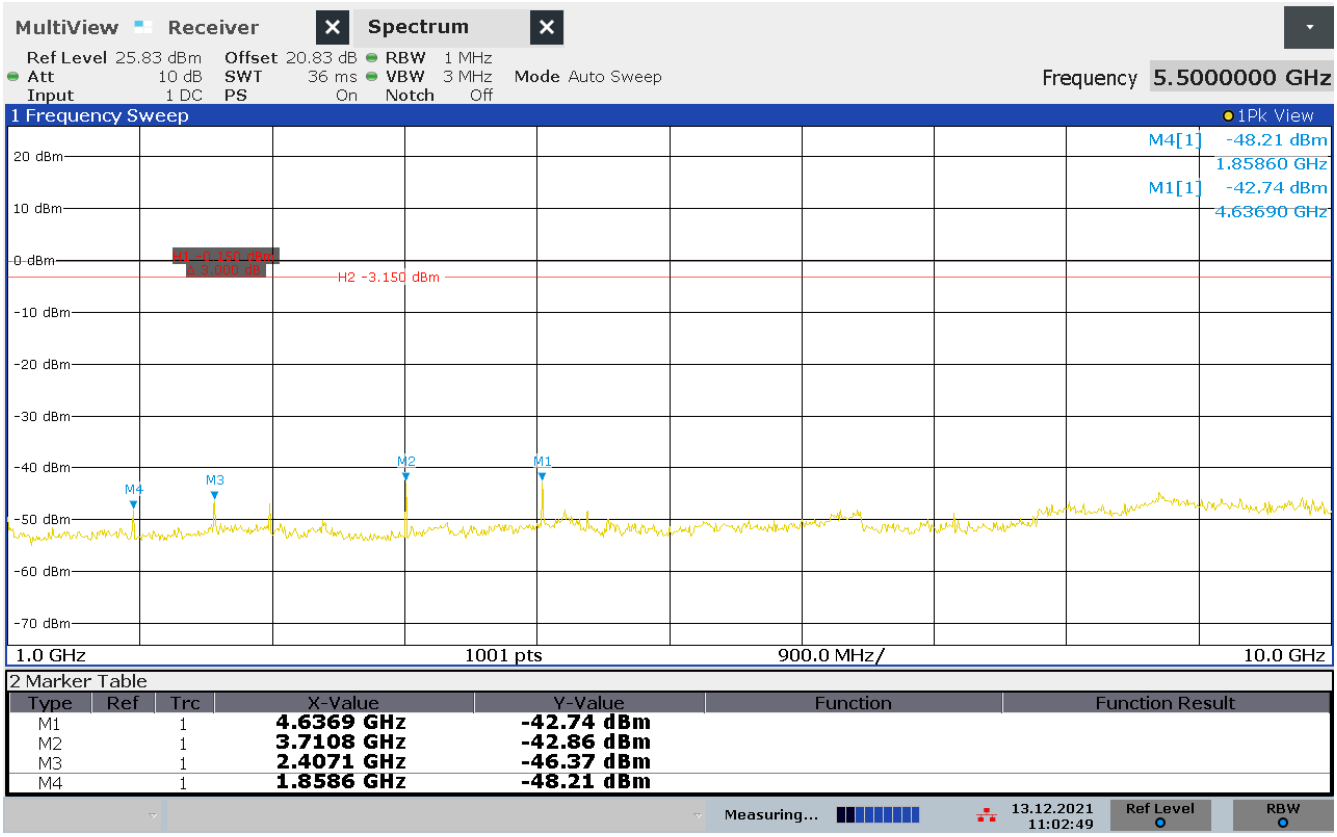
Marker/Plot	Frequency	Measured Level (dBm)	Limit (dBm)	Margin (dBm)
Marker 1, Plot 2	4.574 GHz	-42.51	-3.15	-39.36
Marker 2, Plot 2	3.657 GHz	-43.49	-3.15	-40.34
Marker 3, Plot 2	2.461 GHz	-46.88	-3.15	-43.73
Marker 4, Plot 2	1.832 GHz	-48.76	-3.15	-45.61

Note: The limit was lowered in reference to the highest gain antenna.



10:53:05 13.12.2021

Figure 2-18 – Conducted Spurious Emissions 30 MHz – 1GHz – High Channel



11:02:49 13.12.2021

Figure 2-19 – Conducted Spurious Emissions Above 1GHz – High Channel

Table 2.7-3 – Conducted Spurious Emissions Results – High Channel

Marker/Plot	Frequency	Measured Level (dBm)	Limit (dBm)	Margin (dBm)
Marker 1, Plot 2	4.637 GHz	-42.74	-3.15	-39.59
Marker 2, Plot 2	3.711 GHz	-42.86	-3.15	-39.71
Marker 3, Plot 2	2.407 GHz	-46.37	-3.15	-43.22
Marker 4, Plot 2	1.859 GHz	-48.21	-3.15	-45.06

2.7.7 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: TRN1

Table 2.7-4 – Conducted Emissions Test Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
WRLE11397	Meca	Attenuator, 20 dB	603-20-1F18	11397	B	12/02/2021	12/02/2022
NBLE03509	Florida RF Labs	Cable, SMA 6ft	FL200	6ft-4	B	03/21/2021	03/21/2022
NBLE11555	Rohde & Schwarz	Receiver, 2 Hz-44 GHz	ESW44	101537	G	12/31/2020	12/31/2021

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.8 Conducted Band-Edge

2.8.1 Specification Reference

FCC 47 CFR Part 15.247(d)
RSS-247 5.2(5.5)

2.8.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.8.3 Date of Test

13 December 2021

2.8.4 Test Method

The maximum peak conducted output power was measured in accordance with ANSI C63.10-2013 Section 7.8.8. The RF output of the EUT was directly connected to the input of the spectrum analyzer along with a suitable external attenuator. The RBW of the spectrum analyzer was set to 100kHz and the VBW was set to ≥ 3 times the RBW. The spectrum analyzer span was set to cover the entire frequency range of 30MHz to 5 times the highest intentional radiator and the trace was set to max hold using the peak detector, and was repeated using an average detector.

2.8.5 Environmental Conditions

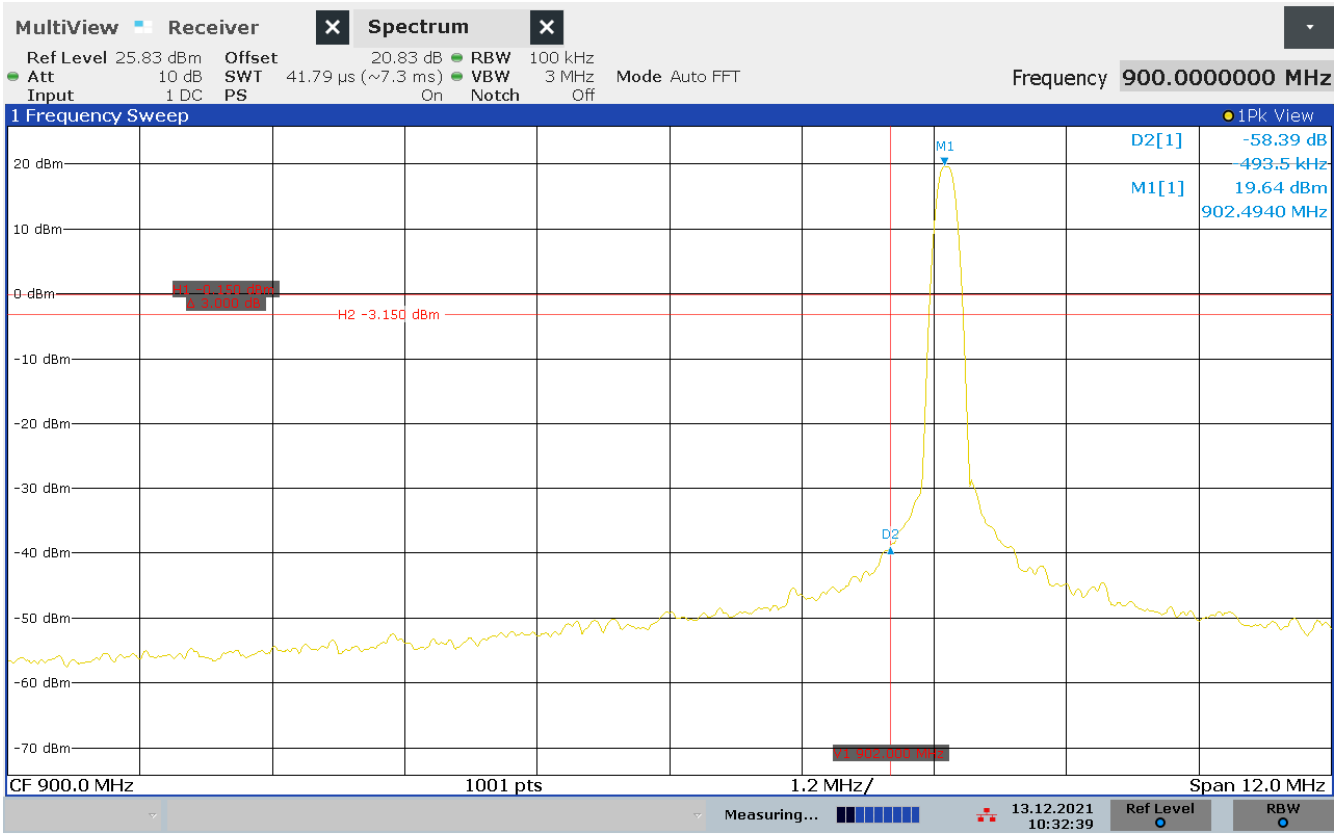
The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.8.6 Test Results

Test Summary: The EUT operated as intended before, during, and after testing.

Test Result: Pass

See data below for detailed results.

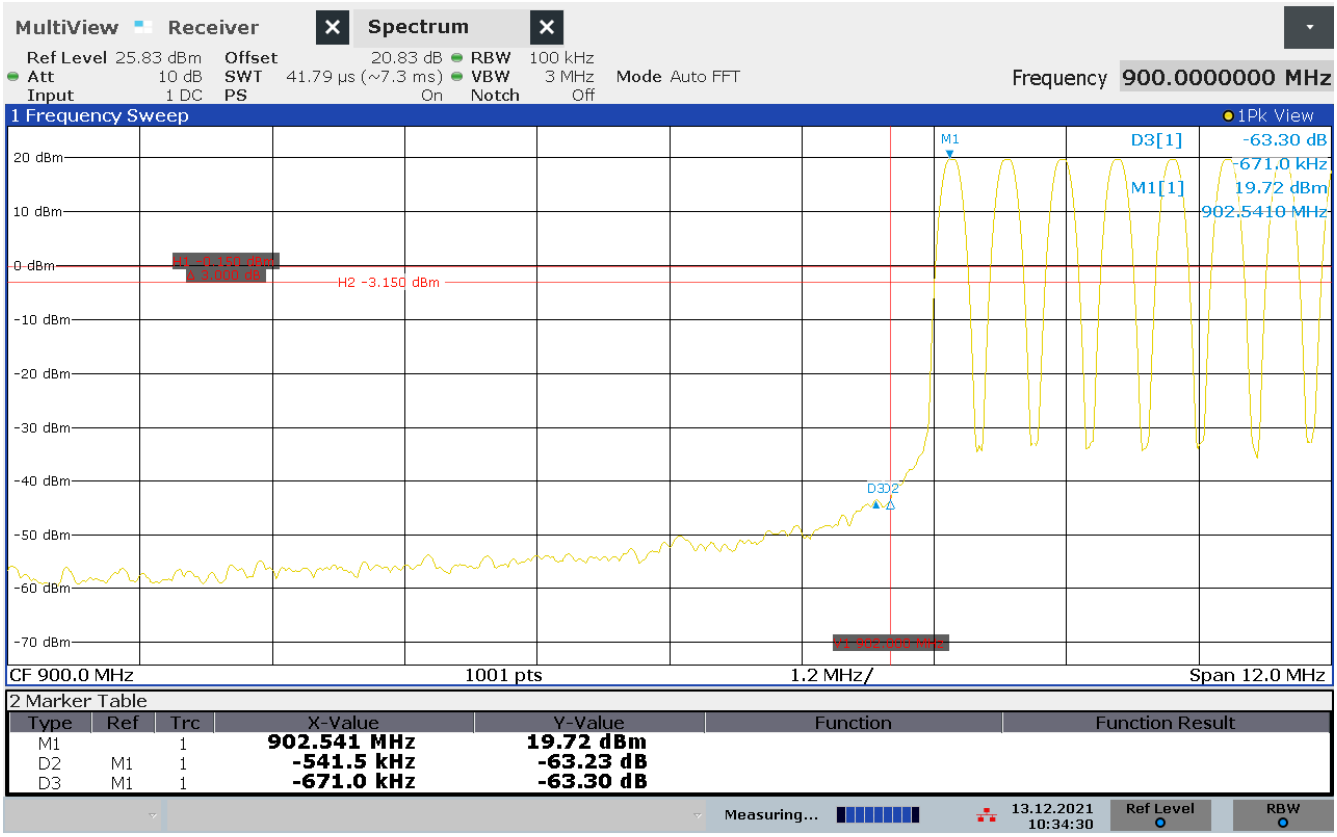


10:32:39 13.12.2021

Figure 2-20 – Conducted Band-Edge – Low Channel, Stopped

Table 2.8-1 – Conducted Band-Edge Results

Frequency (MHz)	Measured Level (dBm)	Limit (dBm)	Margin (dBm)
902 MHz	-38.75	-3.15	-35.6

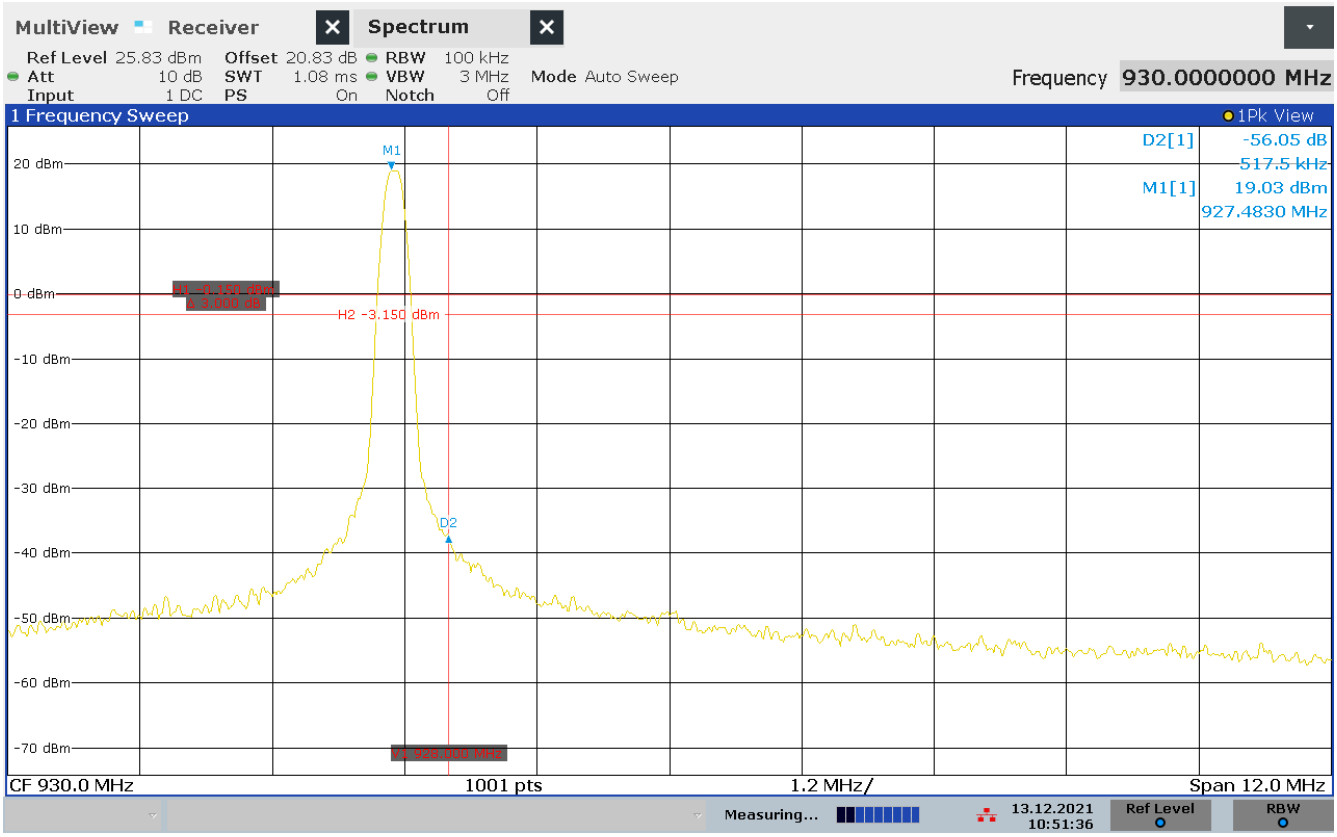


10:34:31 13.12.2021

Figure 2-21 – Conducted Band-Edge – Low Channel, Hopping

Table 2.8-2 – Conducted Band-Edge Results

Frequency (MHz)	Measured Level (dBm)	Limit (dBm)	Margin (dBm)
901.829 MHz	-43.58	-3.15	-40.43
902.000 MHz	-43.51	-3.15	-40.36

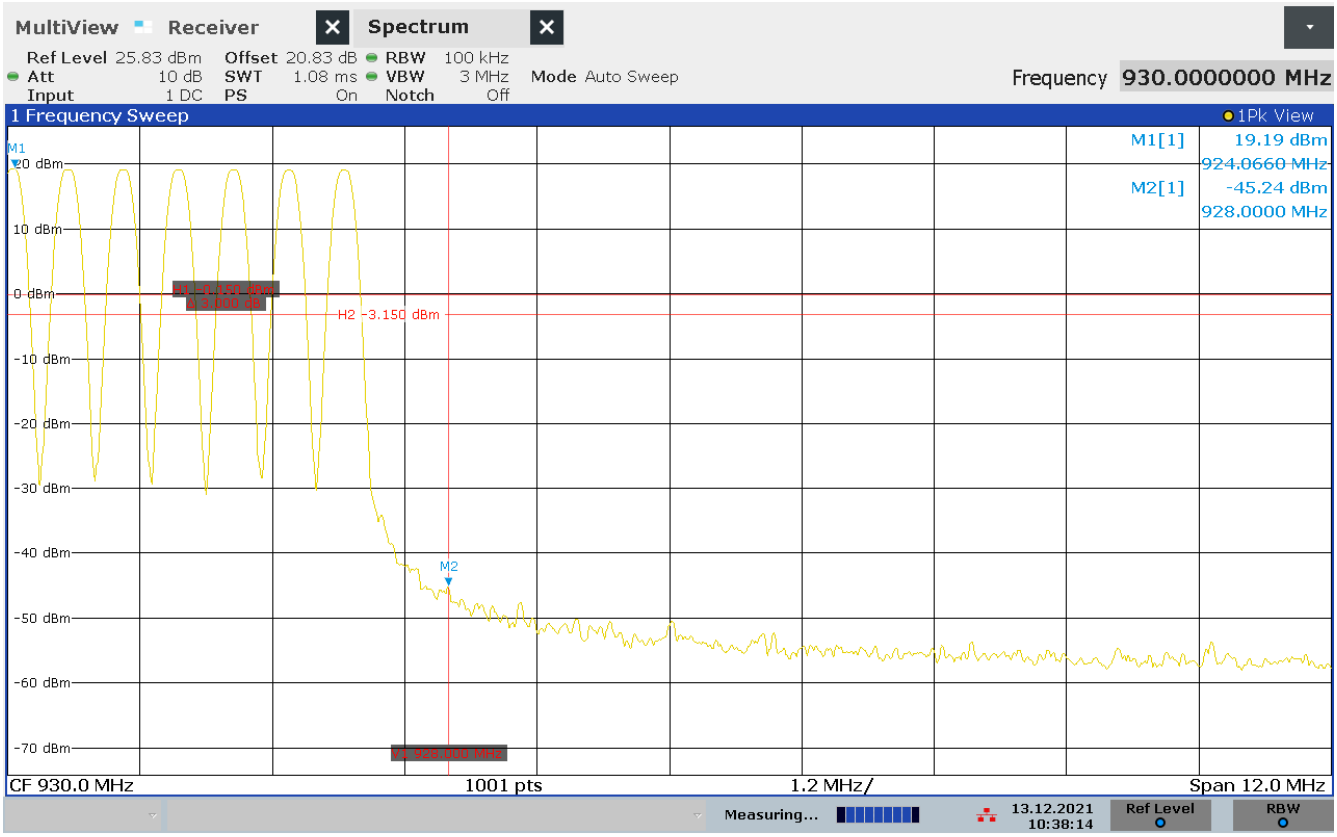


10:51:37 13.12.2021

Figure 2-22 – Conducted Band-Edge – High Channel, Stopped

Table 2.8-3 – Conducted Band-Edge Results

Frequency (MHz)	Measured Level (dBm)	Limit (dBm)	Margin (dBm)
928 MHz	-37.02	-3.15	-33.87



10:38:14 13.12.2021

Figure 2-23 – Conducted Band-Edge – High Channel, Hopping

Table 2.8-4 – Conducted Band-Edge Results

Frequency (MHz)	Measured Level (dBm)	Limit (dBm)	Margin (dBm)
928 MHz	-45.24	-3.15	-42.09

2.8.7 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: TRN1

Table 2.8-5 – Conducted Emissions Test Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
WRLE11397	Meca	Attenuator, 20 dB	603-20-1F18	11397	B	12/02/2021	12/02/2022
NBLE03509	Florida RF Labs	Cable, SMA 6ft	FL200	6ft-4	B	03/21/2021	03/21/2022
NBLE11555	Rohde & Schwarz	Receiver, 2 Hz-44 GHz	ESW44	101537	G	12/31/2020	12/31/2021

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.9 Conducted Emissions 15.207

2.9.1 Specification Reference

FCC 47 CFR Part 15 Subpart C, 15.207
RSS-GEN Issue 5

2.9.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.9.3 Date of Test

N/A

2.9.4 Test Method

The EUT was placed on a non-conductive table 0.8 m above a reference ground plane and 0.4 m away from a vertical coupling plane.

All power was connected to the EUT through an Artificial Mains Network (AMN). Conducted emissions measurements on mains lines were made at the output of the AMN. The AMN was placed 0.8m from the boundary of the EUT and bonded to the reference ground plane.

The EUT was tested with each transmitter operating in the worst-case channel and mode as determined in the original FCC report. Transmitters were tested individually.

The EUT was assessed against the limits of FCC 15.207.

2.9.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.9.6 Additional Observations

Measurements were performed using BAT-EMC (v3.18) automated software. The reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only.

2.9.7 Sample Computation (Conducted Emission)

Measuring equipment raw measurement (dBµV) @ 150 kHz			30.0
Correction Factor (dB)	TEMC00002 - LISN	0.03	10.53
	Cable 1	10.50	
Reported Quasi-peak Final Measurement (dBµV) @ 150 kHz			40.53

2.9.8 Test Results

Test Result: N/A

EUT does not provide a way to connect to AC Mains.

2.10 Radiated Spurious Emissions

2.10.1 Specification Reference

FCC 47 CFR Part 15 Subpart C, 15.247
RSS-247 Issue 2

2.10.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.10.3 Date of Test

13-15 December 2021

2.10.4 Test Method

The EUT was set up in a semi-anechoic chamber on a remotely controlled turntable and placed on a non-conductive table 0.8 m above a reference ground plane for 30-1000 MHz and 1.5m above the ground plane for above 1 GHz.

For 30-1000 MHz a pre-scan of the EUT emissions profile was made while varying the antenna-to-EUT azimuth and antenna-to-EUT polarization using a peak detector; measurements were taken at a 3m distance.

For above 1 GHz a pre-scan of the EUT emissions profile was made while varying the antenna-to-EUT azimuth and antenna-to-EUT polarization using peak and average detectors; measurements were taken at a 3m distance.

For all frequency ranges the final readings were maximized by adjusting the antenna height, polarization and turntable azimuth, in accordance with the specification. For final measurements below 1 GHz a quasi-peak detector was used and above 1 GHz final measurements were re-measured with peak and average detectors.

The EUT was assessed against the limits specified in FCC 47 CFR Part 15C §15.209.

2.10.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.10.6 Additional Observations

The highest frequency to which the DUT was measured in accordance with §15.33(a)(1).

Automated measurements used BAT-EMC (v3.18) software. Measurements were done at a 3m distance. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only.

2.10.7 Sample Computation (Radiated Emissions)

Measuring equipment raw measurement (dBµV) @ 30 MHz			20.0
Correction Factor (dB)	Cable 2	0.24	18.94
	TEMC00011 (antenna)	18.70	
Reported Quasi-peak Final Measurement (dBµV/m) @ 30 MHz			38.94

2.10.8 Test Results

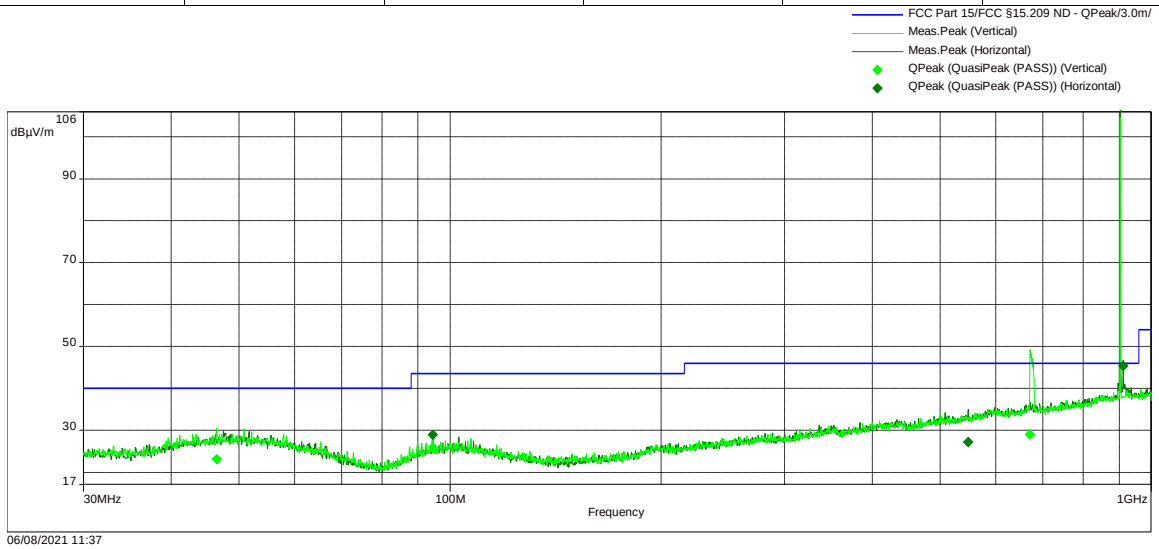
Test Summary: Measurements between 1-18 GHz were taken with a 902-928 MHz notch filter in front of the pre-amp to prevent overloading. EUT operated as intended before, during, and after testing.

Test Result: Pass

See data below for detailed results.

Spurious Emissions 30M-1GHz; 902.5 M (Yagi)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
30MHz- 1GHz	Vertical	3m	100kHz	18001Pts	Auto
30MHz- 1GHz	Horizontal	3m	100kHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Note: The emission measured at 902.5 MHz is the fundamental frequency and is not subject to this limit.

Figure 2-24 – RE Spurious Emissions 30-1000 MHz – Low Channel

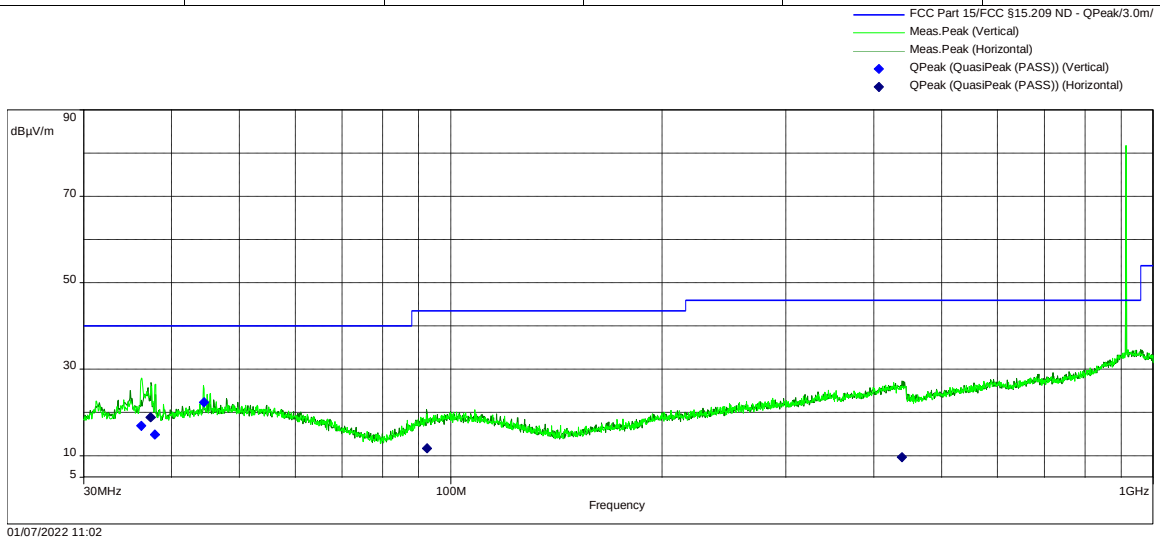
Table 2.10-1 – RE Spurious Emissions 30-1000 MHz – Low Channel

Spurious Emissions 30M-1GHz; 902.5 M (Yagi)

Frequency	Quasi-Peak Level (dBuV/m)	Quasi-Peak Limit (dBuV/m)	Quasi-Peak Margin (dB)	Azimuth (º)	Height (m)	Polarity	Quasi-Peak Result
36.989387MHz	20.54	40.00	-19.46	248.00	1.00	Horizontal	PASS
37.480124MHz	4.67	40.00	-35.33	204.00	1.70	Vertical	PASS
44.491905MHz	17.52	40.00	-22.48	112.00	1.65	Horizontal	PASS
44.967683MHz	15.22	40.00	-24.78	127.00	3.98	Vertical	PASS
92.501956MHz	14.09	43.50	-29.41	174.00	3.68	Horizontal	PASS
410.84657MHz	8.87	46.00	-37.13	72.00	2.82	Vertical	PASS

Spurious Emissions 30M-1GHz; 915 M (Yagi)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
30MHz- 1GHz	Vertical	3m	100kHz	18001Pts	Auto
30MHz- 1GHz	Horizontal	3m	100kHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Note: The emission measured at 915 MHz is the fundamental frequency and is not subject to this limit.

Figure 2-25 – RE Spurious Emissions 30-1000 MHz – Mid Channel

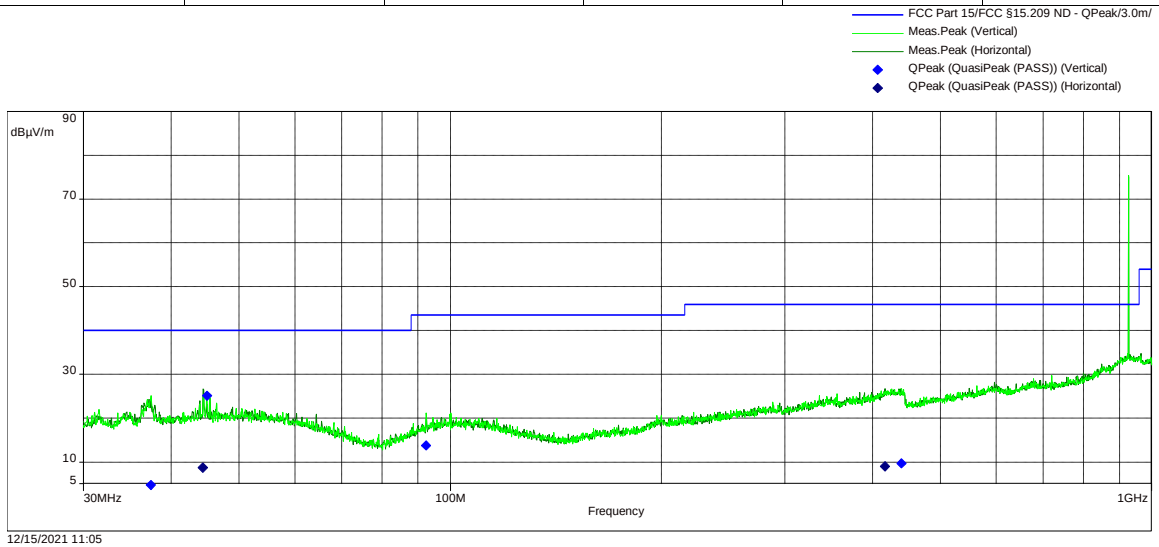
Table 2.10-2 – RE Spurious Emissions 30-1000 MHz – Mid Channel

Spurious Emissions 30M-1GHz; 915 M (Yagi)

Frequency	Quasi-Peak Level (dBuV/m)	Quasi-Peak Limit (dBuV/m)	Quasi-Peak Margin (dB)	Azimuth (º)	Height (m)	Polarity	Quasi-Peak Result
36.264595MHz	16.96	40.00	-23.04	189.00	1.00	Vertical	PASS
37.390402MHz	18.87	40.00	-21.13	318.00	1.00	Horizontal	PASS
37.937714MHz	14.87	40.00	-25.13	149.00	1.00	Vertical	PASS
44.491294MHz	22.39	40.00	-17.61	233.00	2.21	Vertical	PASS
92.432508MHz	11.73	43.50	-31.77	318.00	1.14	Horizontal	PASS
439.068MHz	9.67	46.00	-36.33	157.00	1.80	Horizontal	PASS

Spurious Emissions 30M-1GHz; 927.5 M (Yagi)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
30MHz- 1GHz	Vertical	3m	100kHz	18001Pts	Auto
30MHz- 1GHz	Horizontal	3m	100kHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Note: The emission measured at 927.5 MHz is the fundamental frequency and is not subject to this limit.

Figure 2-26 – RE Spurious Emissions 30-1000 MHz – High Channel

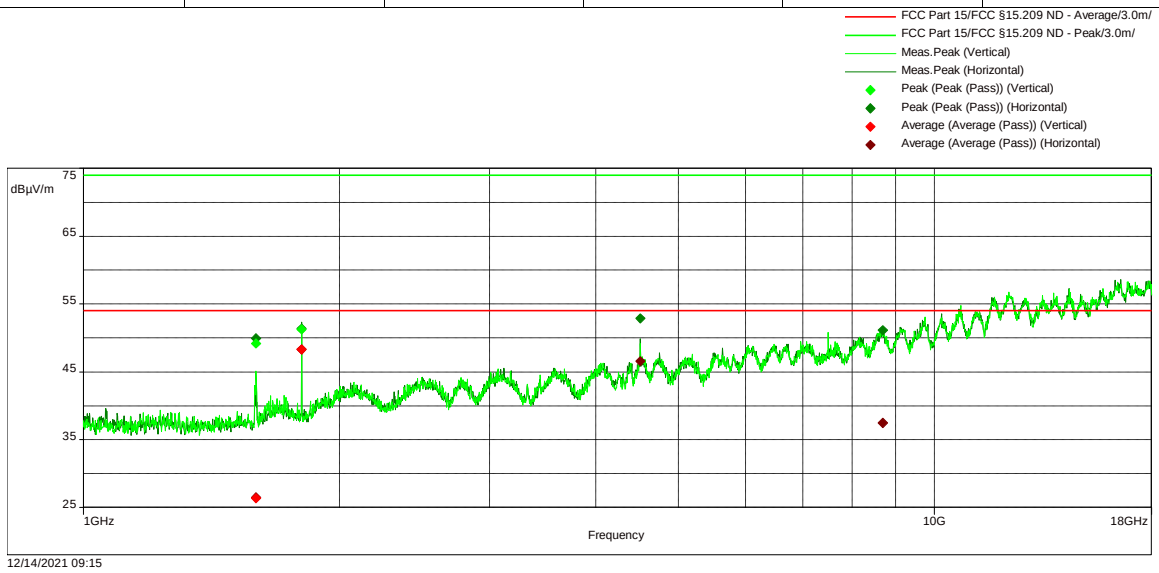
Table 2.10-3 – RE Spurious Emissions 30-1000 MHz – High Channel

Spurious Emissions 30M-1GHz; 927.5 M (Yagi)

Frequency	Quasi-Peak Level (dBuV/m)	Quasi-Peak Limit (dBuV/m)	Quasi-Peak Margin (dB)	Azimuth (º)	Height (m)	Polarity	Quasi-Peak Result
37.419211MHz	4.35	40.00	-35.65	262.00	1.85	Vertical	PASS
44.408775MHz	8.73	40.00	-31.27	54.00	1.85	Horizontal	PASS
44.964387MHz	25.10	40.00	-14.90	281.00	2.82	Vertical	PASS
92.428357MHz	13.77	43.50	-29.73	274.00	1.19	Vertical	PASS
416.75897MHz	9.01	46.00	-36.99	306.00	1.65	Horizontal	PASS
439.86973MHz	9.69	46.00	-36.31	208.00	3.78	Vertical	PASS

Spurious Emissions 1-18GHz; 902.5 M (Yagi)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
1GHz- 18GHz	Vertical	3m	1MHz	18001Pts	Auto
1GHz- 18GHz	Horizontal	3m	1MHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Figure 2-27 – RE Spurious Emissions 1-18 GHz – Low Channel

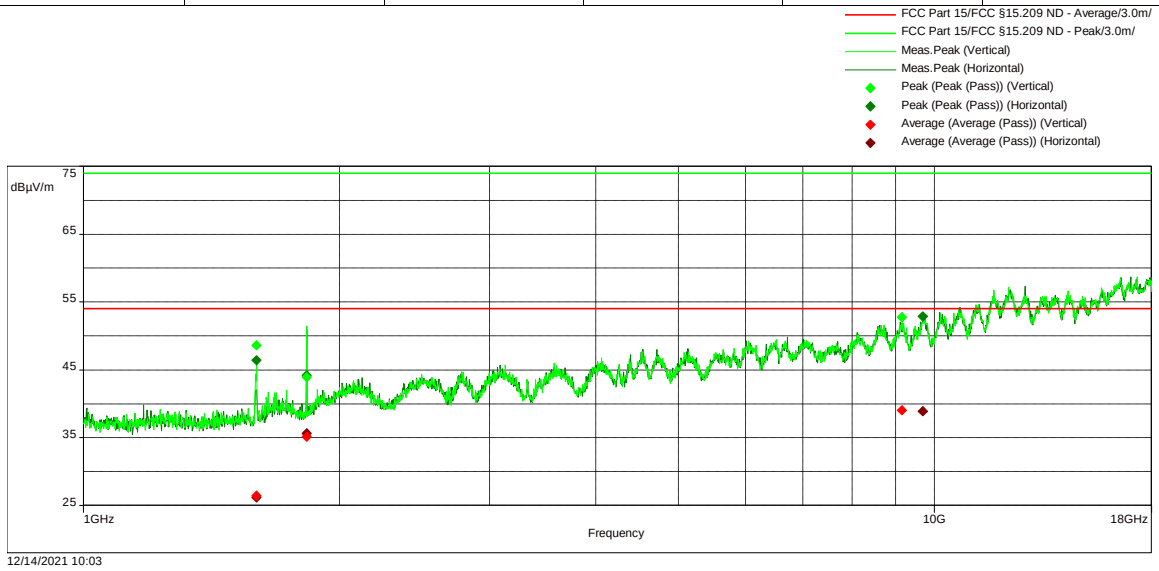
Table 2.10-4 – RE Spurious Emissions 1-18 GHz – Low Channel

Spurious Emissions 1-18GHz; 902.5 M (Yagi)

Frequency	Peak Level (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Average Level (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	Azimuth (º)	Height (m)	Polarity	Peak Result	Average Result
1.595GHz	49.21	74.00	-24.79	26.40	54.00	-27.60	240.00	1.95	Vertical	PASS	PASS
1.5959444GHz	49.91	74.00	-24.09	26.50	54.00	-27.50	105.00	2.26	Horizontal	PASS	PASS
1.8046667GHz	51.29	74.00	-22.71	48.30	54.00	-5.70	215.00	1.09	Vertical	PASS	PASS
4.5123889GHz	52.92	74.00	-21.08	46.53	54.00	-7.47	164.00	3.73	Horizontal	PASS	PASS
8.6934444GHz	51.14	74.00	-22.86	37.45	54.00	-16.55	182.00	1.29	Horizontal	PASS	PASS

Spurious Emissions 1-18GHz; 915 M (Yagi)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
1GHz- 18GHz	Vertical	3m	1MHz	18001Pts	Auto
1GHz- 18GHz	Horizontal	3m	1MHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Figure 2-28 – RE Spurious Emissions 1-18 GHz – Mid Channel

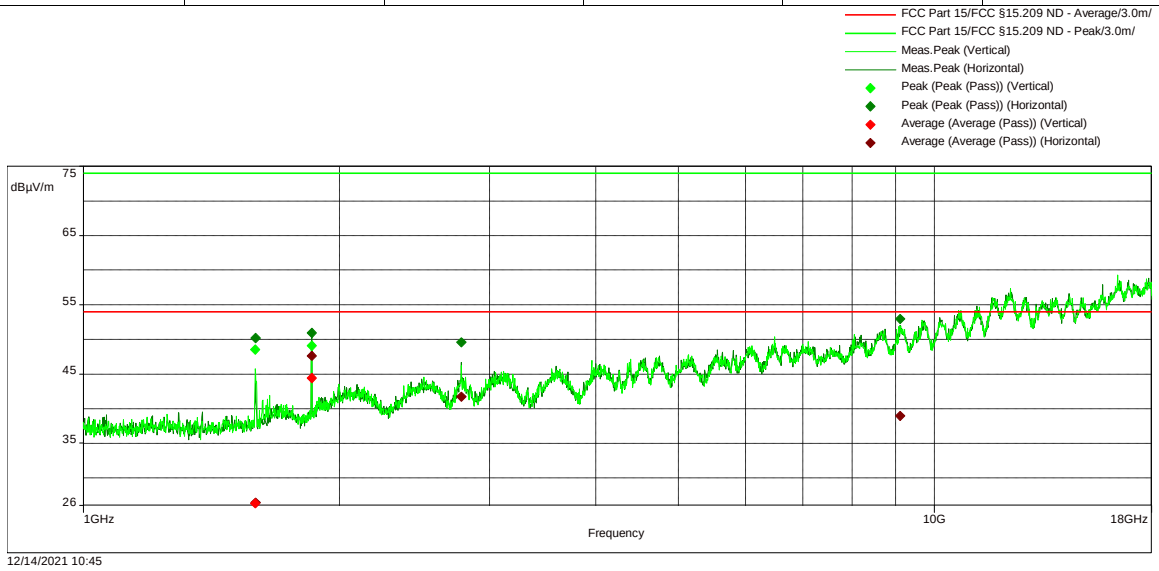
Table 2.10-5 – RE Spurious Emissions 1-18 GHz – Mid Channel

Spurious Emissions 1-18GHz; 915 M (Yagi)

Frequency	Peak Level (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Average Level (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	Azimuth (º)	Height (m)	Polarity	Peak Result	Average Result
1.5968889GHz	46.42	74.00	-27.58	26.21	54.00	-27.79	351.00	3.02	Horizontal	PASS	PASS
1.5978333GHz	48.64	74.00	-25.36	26.43	54.00	-27.57	240.00	2.00	Vertical	PASS	PASS
1.8292222GHz	43.90	74.00	-30.10	35.18	54.00	-18.82	222.00	1.00	Vertical	PASS	PASS
9.1609444GHz	52.76	74.00	-21.24	39.04	54.00	-14.96	178.00	3.12	Vertical	PASS	PASS
9.6964444GHz	52.86	74.00	-21.14	38.92	54.00	-15.08	200.00	3.83	Horizontal	PASS	PASS

Spurious Emissions 1-18GHz; 927.5 M (Yagi)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
1GHz- 18GHz	Vertical	3m	1MHz	18001Pts	Auto
1GHz- 18GHz	Horizontal	3m	1MHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Figure 2-29 – RE Spurious Emissions 1-18 GHz – High Channel

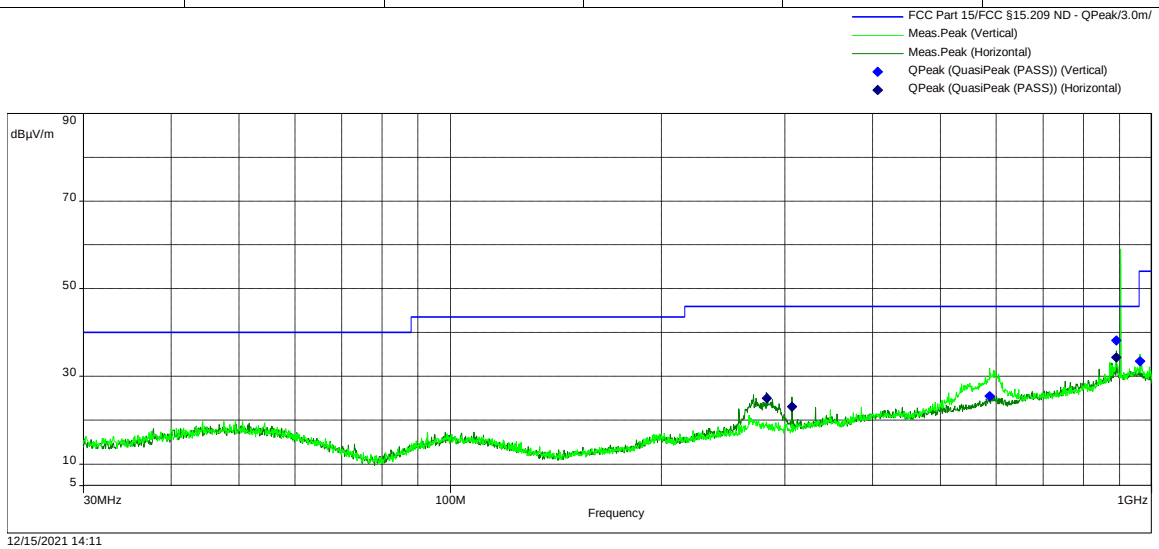
Table 2.10-6 – RE Spurious Emissions 1-18 GHz – High Channel

Spurious Emissions 1-18GHz; 927.5 M (Yagi)

Frequency	Peak Level (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Average Level (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	Azimuth (º)	Height (m)	Polarity	Peak Result	Average Result
1.5921667GHz	48.52	74.00	-25.48	26.31	54.00	-27.69	292.00	2.10	Vertical	PASS	PASS
1.5931111GHz	50.21	74.00	-23.79	26.45	54.00	-27.55	105.00	2.21	Horizontal	PASS	PASS
1.8547222GHz	49.11	74.00	-24.89	44.45	54.00	-9.55	274.00	2.31	Vertical	PASS	PASS
2.7821667GHz	49.59	74.00	-24.41	41.72	54.00	-12.28	340.00	3.78	Horizontal	PASS	PASS
9.1222222GHz	52.94	74.00	-21.06	38.96	54.00	-15.04	259.00	1.09	Horizontal	PASS	PASS

Spurious Emissions 30M-1GHz; 902.5 M (1/2 Wave Dipole)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
30MHz- 1GHz	Vertical	3m	100kHz	18001Pts	Auto
30MHz- 1GHz	Horizontal	3m	100kHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Note: The emission measured at 902.5 MHz is the fundamental frequency and is not subject to this limit.

Figure 2-30 – RE Spurious Emissions 30-1000 MHz – Low Channel

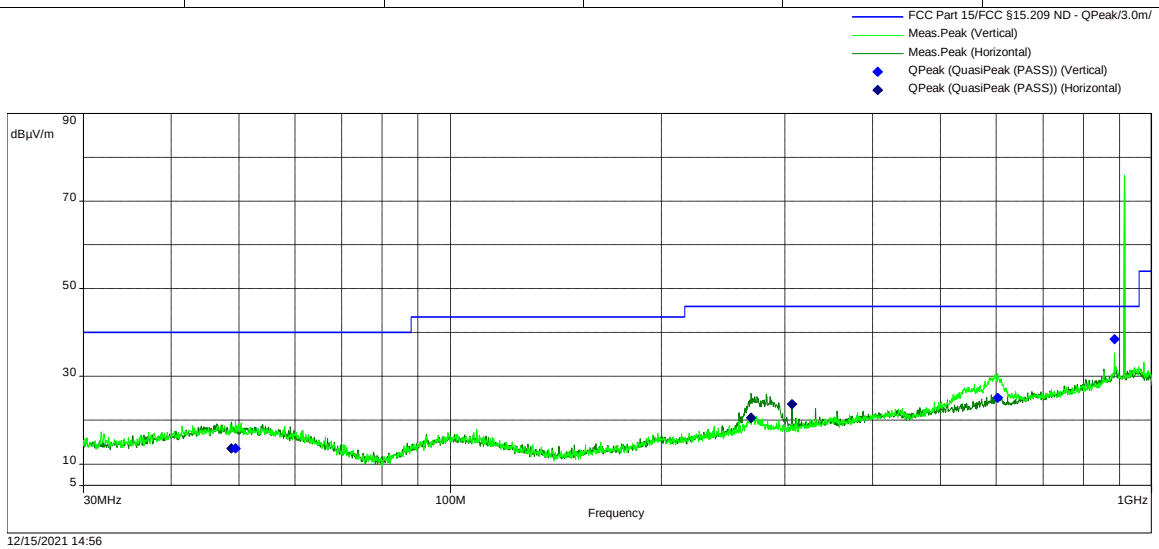
Table 2.10-7 – RE Spurious Emissions 30-1000 MHz – Low Channel

Spurious Emissions 30M-1GHz; 902.5 M (1/2 Wave Dipole)

Frequency	Quasi-Peak Level (dBuV/m)	Quasi-Peak Limit (dBuV/m)	Quasi-Peak Margin (dB)	Azimuth (º)	Height (m)	Polarity	Quasi-Peak Result
282.62532MHz	24.95	46.00	-21.05	226.00	1.09	Horizontal	PASS
307.17839MHz	23.01	46.00	-22.99	222.00	1.00	Horizontal	PASS
587.71082MHz	25.51	46.00	-20.49	299.00	1.03	Vertical	PASS
890.20654MHz	38.17	46.00	-7.83	46.00	1.34	Vertical	PASS
890.22638MHz	34.29	46.00	-11.71	85.00	1.00	Horizontal	PASS
962.49492MHz	33.45	53.97	-20.52	167.00	1.24	Vertical	PASS

Spurious Emissions 30M-1GHz; 915 M (1/2 Wave Dipole)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
30MHz- 1GHz	Vertical	3m	100kHz	18001Pts	Auto
30MHz- 1GHz	Horizontal	3m	100kHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Note: The emission measured at 915 MHz is the fundamental frequency and is not subject to this limit.

Figure 2-31 – RE Spurious Emissions 30-1000 MHz – Mid Channel

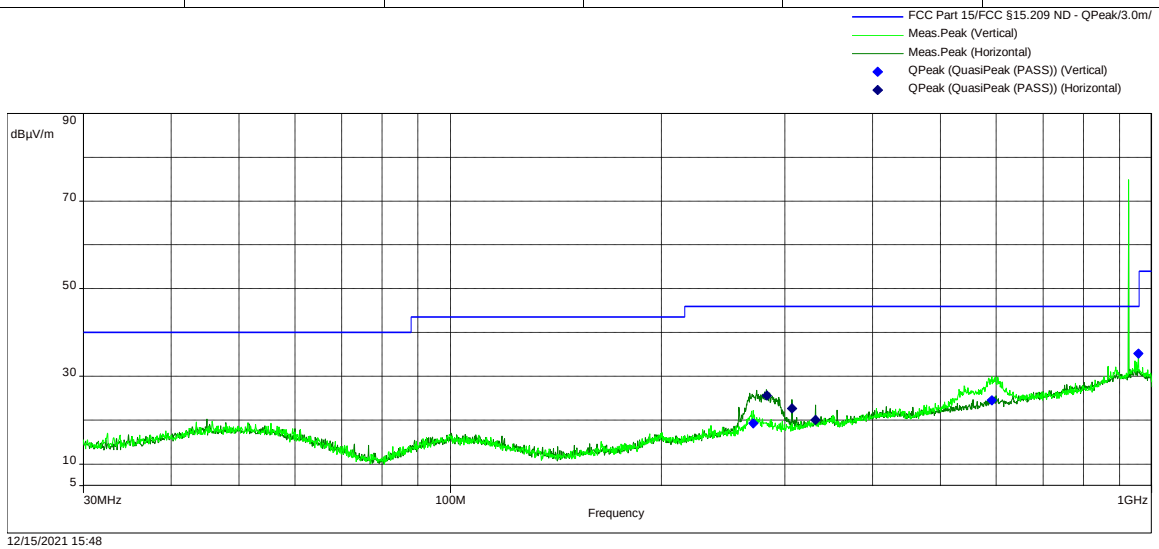
Table 2.10-8 – RE Spurious Emissions 30-1000 MHz – Mid Channel

Spurious Emissions 30M-1GHz; 915 M (1/2 Wave Dipole)

Frequency	Quasi-Peak Level (dBuV/m)	Quasi-Peak Limit (dBuV/m)	Quasi-Peak Margin (dB)	Azimuth (º)	Height (m)	Polarity	Quasi-Peak Result
48.7717MHz	13.57	40.00	-26.43	196.00	1.90	Horizontal	PASS
49.469392MHz	13.55	40.00	-26.45	226.00	1.95	Vertical	PASS
268.38381MHz	20.58	46.00	-25.42	208.00	1.00	Horizontal	PASS
307.20127MHz	23.59	46.00	-22.41	244.00	1.00	Horizontal	PASS
603.86943MHz	25.14	46.00	-20.86	69.00	1.00	Vertical	PASS
885.01716MHz	38.49	46.00	-7.51	20.00	1.34	Vertical	PASS

Spurious Emissions 30M-1GHz; 927.5 M (1/2 Wave Dipole)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
30MHz- 1GHz	Vertical	3m	100kHz	18001Pts	Auto
30MHz- 1GHz	Horizontal	3m	100kHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Note: The emission measured at 927.5 MHz is the fundamental frequency and is not subject to this limit.

Figure 2-32 – RE Spurious Emissions 30-1000 MHz – High Channel

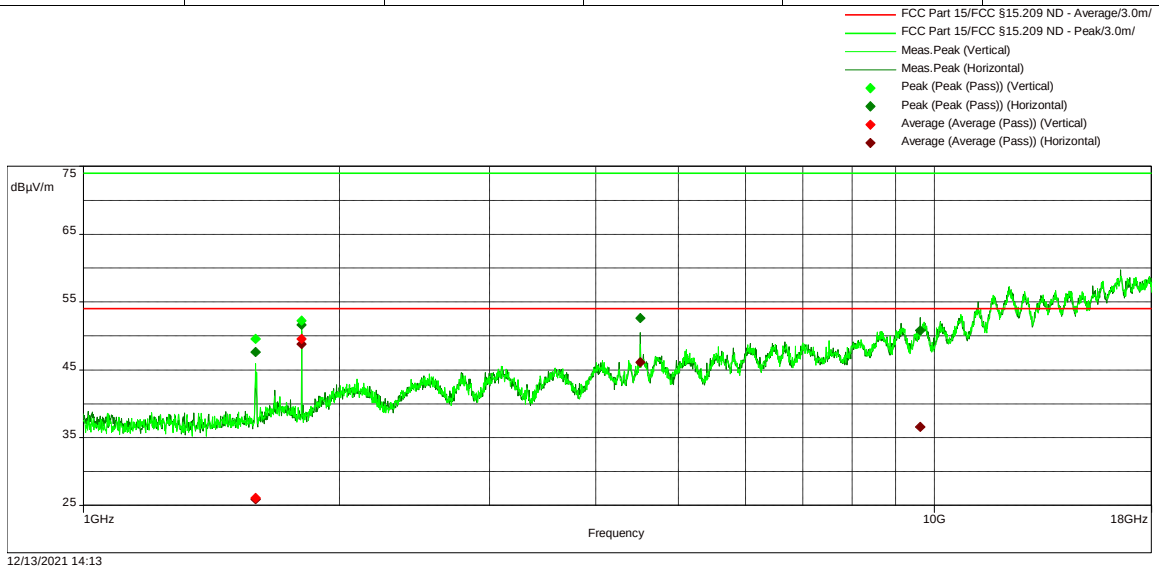
Table 2.10-9 – RE Spurious Emissions 30-1000 MHz – High Channel

Spurious Emissions 30M-1GHz; 927.5 M (1/2 Wave Dipole)

Frequency	Quasi-Peak Level (dBuV/m)	Quasi-Peak Limit (dBuV/m)	Quasi-Peak Margin (dB)	Azimuth (º)	Height (m)	Polarity	Quasi-Peak Result
270.33724MHz	19.28	46.00	-26.72	160.00	1.60	Vertical	PASS
282.62519MHz	25.56	46.00	-20.44	61.00	1.09	Horizontal	PASS
307.18425MHz	22.69	46.00	-23.31	240.00	1.14	Horizontal	PASS
331.74501MHz	20.06	46.00	-25.94	54.00	1.04	Horizontal	PASS
591.80363MHz	24.52	46.00	-21.48	270.00	1.00	Vertical	PASS
957.49747MHz	35.19	46.00	-10.81	325.00	1.19	Vertical	PASS

Spurious Emissions 1-18GHz; 902.5 M (1/2 Wave Dipole)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
1GHz- 18GHz	Vertical	3m	1MHz	18001Pts	Auto
1GHz- 18GHz	Horizontal	3m	1MHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Figure 2-33 – RE Spurious Emissions 1-18 GHz – Low Channel

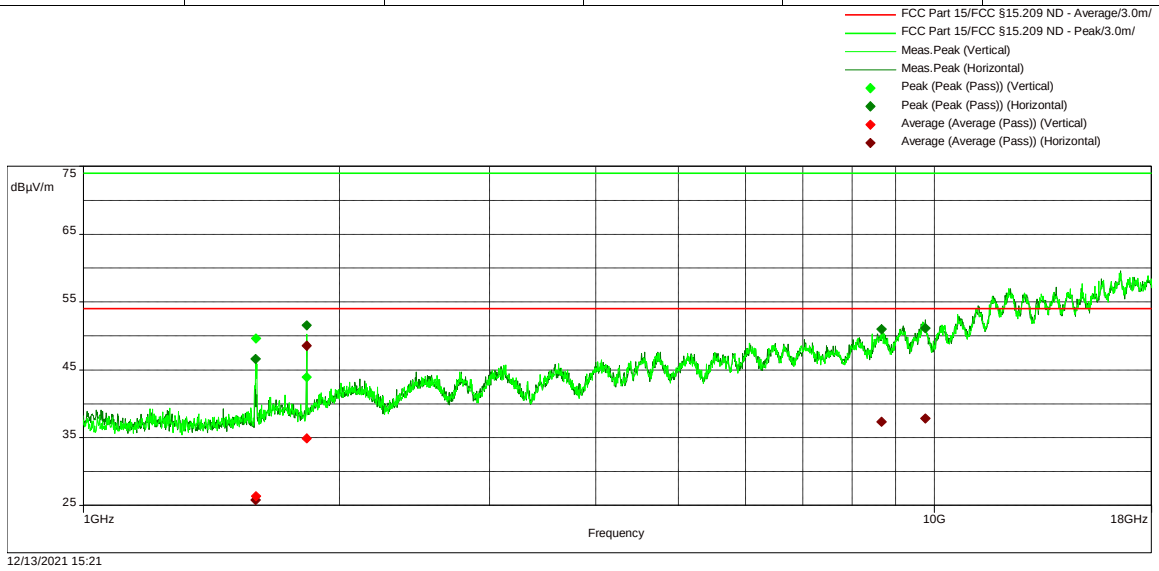
Table 2.10-10 – RE Spurious Emissions 1-18 GHz – Low Channel

Spurious Emissions 1-18GHz; 902.5 M (1/2 Wave Dipole)

Frequency	Peak Level (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Average Level (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	Azimuth (º)	Height (m)	Polarity	Peak Result	Average Result
1.5931111GHz	49.54	74.00	-24.46	26.16	54.00	-27.84	245.00	1.80	Vertical	PASS	PASS
1.5940556GHz	47.59	74.00	-26.41	25.93	54.00	-28.07	6.00	3.12	Horizontal	PASS	PASS
1.8046667GHz	52.24	74.00	-21.76	49.57	54.00	-4.43	112.00	1.90	Vertical	PASS	PASS
4.5123889GHz	52.64	74.00	-21.36	46.15	54.00	-7.85	237.00	1.19	Horizontal	PASS	PASS
9.6199444GHz	50.84	74.00	-23.16	36.58	54.00	-17.42	229.00	3.78	Horizontal	PASS	PASS

Spurious Emissions 1-18GHz; 915 M (1/2 Wave Dipole)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
1GHz- 18GHz	Vertical	3m	1MHz	18001Pts	Auto
1GHz- 18GHz	Horizontal	3m	1MHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Figure 2-34 – RE Spurious Emissions 1-18 GHz – Mid Channel

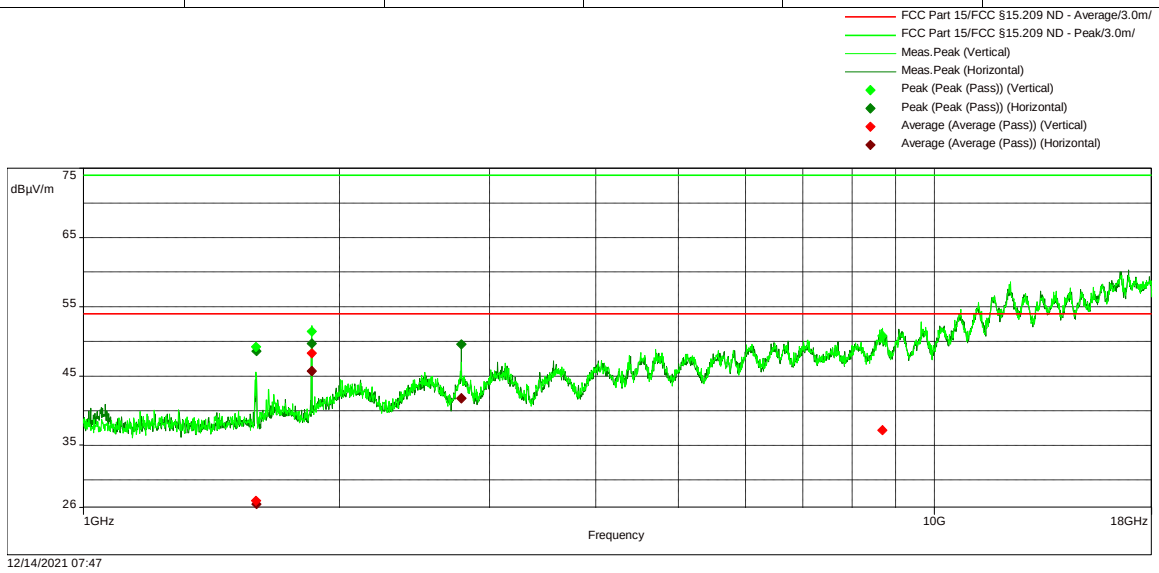
Table 2.10-11 – RE Spurious Emissions 1-18 GHz – Mid Channel

Spurious Emissions 1-18GHz; 915 M (1/2 Wave Dipole)

Frequency	Peak Level (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Average Level (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	Azimuth (º)	Height (m)	Polarity	Peak Result	Average Result
1.5931111GHz	46.64	74.00	-27.36	25.84	54.00	-28.16	0.00	1.09	Horizontal	PASS	PASS
1.5959444GHz	49.62	74.00	-24.38	26.38	54.00	-27.62	247.00	1.95	Vertical	PASS	PASS
1.8292222GHz	43.91	74.00	-30.09	34.89	54.00	-19.11	97.00	2.92	Vertical	PASS	PASS
1.8301667GHz	51.54	74.00	-22.46	48.54	54.00	-5.46	241.00	1.44	Horizontal	PASS	PASS
8.6707778GHz	51.00	74.00	-23.00	37.38	54.00	-16.62	97.00	3.17	Horizontal	PASS	PASS
9.7540556GHz	51.14	74.00	-22.86	37.87	54.00	-16.13	292.00	2.20	Horizontal	PASS	PASS

Spurious Emissions 1-18GHz; 927.5 M (1/2 Wave Dipole)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
1GHz- 18GHz	Vertical	3m	1MHz	18001Pts	Auto
1GHz- 18GHz	Horizontal	3m	1MHz	18001Pts	Auto



Limit: FCC §15.209

Test Results: Pass

Figure 2-35 – RE Spurious Emissions 1-18 GHz – High Channel

Table 2.10-12 – RE Spurious Emissions 1-18 GHz – High Channel

Spurious Emissions 1-18GHz; 927.5 M (1/2 Wave Dipole)

Frequency	Peak Level (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Average Level (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	Azimuth (º)	Height (m)	Polarity	Peak Result	Average Result
1.5959444GHz	49.22	74.00	-24.78	26.99	54.00	-27.01	240.00	1.75	Vertical	PASS	PASS
1.5968889GHz	48.62	74.00	-25.38	26.52	54.00	-27.48	197.00	2.51	Horizontal	PASS	PASS
1.8547222GHz	49.68	74.00	-24.32	45.73	54.00	-8.27	75.00	1.80	Horizontal	PASS	PASS
2.7821667GHz	49.59	74.00	-24.41	41.76	54.00	-12.24	175.00	2.92	Horizontal	PASS	PASS
8.6849444GHz	50.78	74.00	-23.22	37.20	54.00	-16.80	94.00	3.93	Vertical	PASS	PASS

2.10.9 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: 3mSAC

Table 2.10-13 – Radiated Emissions Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE10985	Agilent Technologies	Pre Amplifier, 0.1-1300 MHz	8447D	2443A04180	B	04/07/2021	04/07/2022
WRLE11519	Com-Power Corp.	Preamp, 500 MHz-18 GHz	PAM-118A	18040002	B	01/08/2021	01/08/2022
NBLE11555	Rohde & Schwarz	Receiver, 2 Hz-44 GHz	ESW44	101537	G	12/31/2020	12/31/2021
NBLE11578	ETS-Lindgren	Antenna, BiConiLog	3142C	00079889	G	09/14/2020	09/14/2022
NBLE11630	ETS-Lindgren	Antenna, 1-18 GHz	3117	00218816	G	09/04/2020	09/04/2022
NBLE11699	Mini-Circuits Lab	Filter, 900-950 MHz Notch	N03915M1	138901	B	03/31/2021	03/31/2022

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.11 Radiated Band-Edge

2.11.1 Specification Reference

FCC 47 CFR Part 15 Subpart C, 15.247
RSS-GEN Issue 5

2.11.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.11.3 Date of Test

15 December 2021

2.11.4 Test Method

The EUT was set up in a semi-anechoic chamber on a remotely controlled turntable and placed on a non-conductive table 1.5 m above a reference ground plane. Measurements were taken at a 3m distance. The fundamental signal was maximized while varying the antenna-to-EUT azimuth and antenna-to-EUT polarization using a peak detector. Band-edge measurements were made with the device in its maximized position using a peak and average detector as described in ANSI C63.10.

The EUT was assessed against the limits specified in FCC 47 CFR Part 15C §15.209.

2.11.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

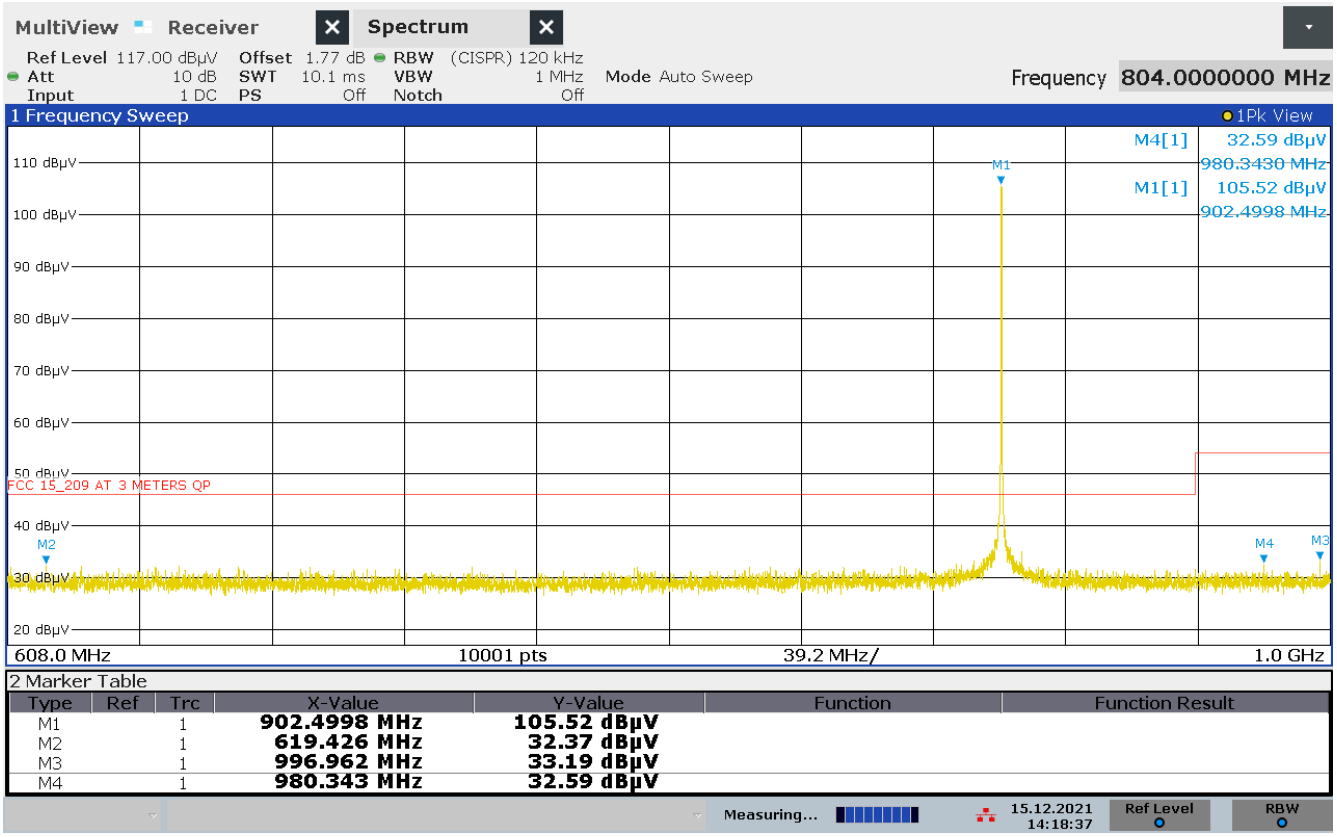
2.11.6 Test Results

Test Summary: EUT operated as intended before, during, and after testing. Both stopped and hopping operation were evaluated, and the worst-case was chosen for final evaluation of radiated band-edge emissions.

Test Result: Pass

See data below for detailed results.

Bandedge Emissions; 902.5 M (1/2 Wave Dipole)



14:18:37 15.12.2021

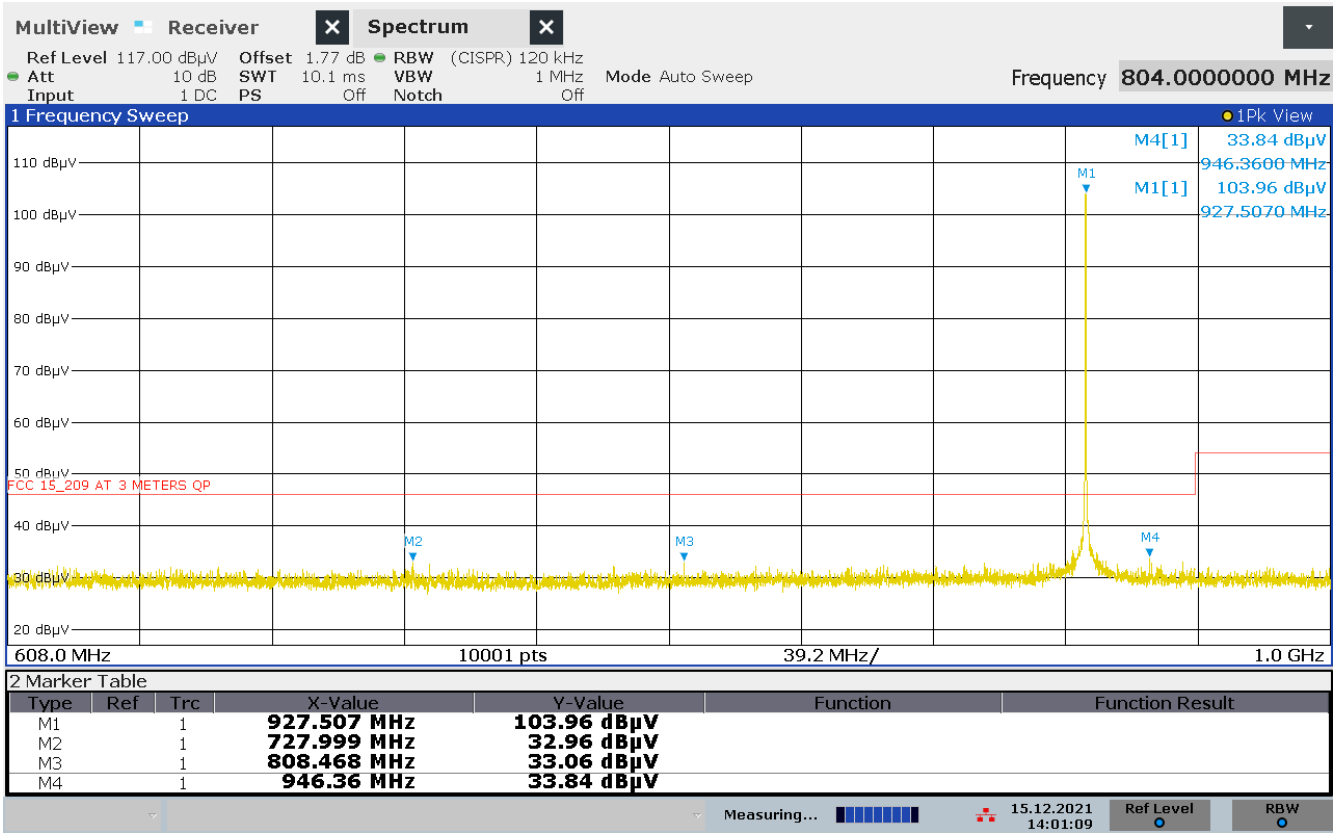
Figure 2-36 – Radiated Band-Edge, Low Channel – Peak

Table 2.11-1 – Radiated Band Edge – Low Channel – Peak

Frequency (MHz)	Peak Level (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Result
619.43	32.37	46.02	-13.65	PASS
996.96	33.19	53.98	-20.79	PASS
980.34	32.59	53.98	-21.39	PASS

Note: Margin Calculation: Margin = Peak Level – Average Limit.
Note: Average measurement was not taken where Peak measurement complies with Average limits.

Bandedge Emissions; 927.5 M (1/2 Wave Dipole)



14:01:10 15.12.2021

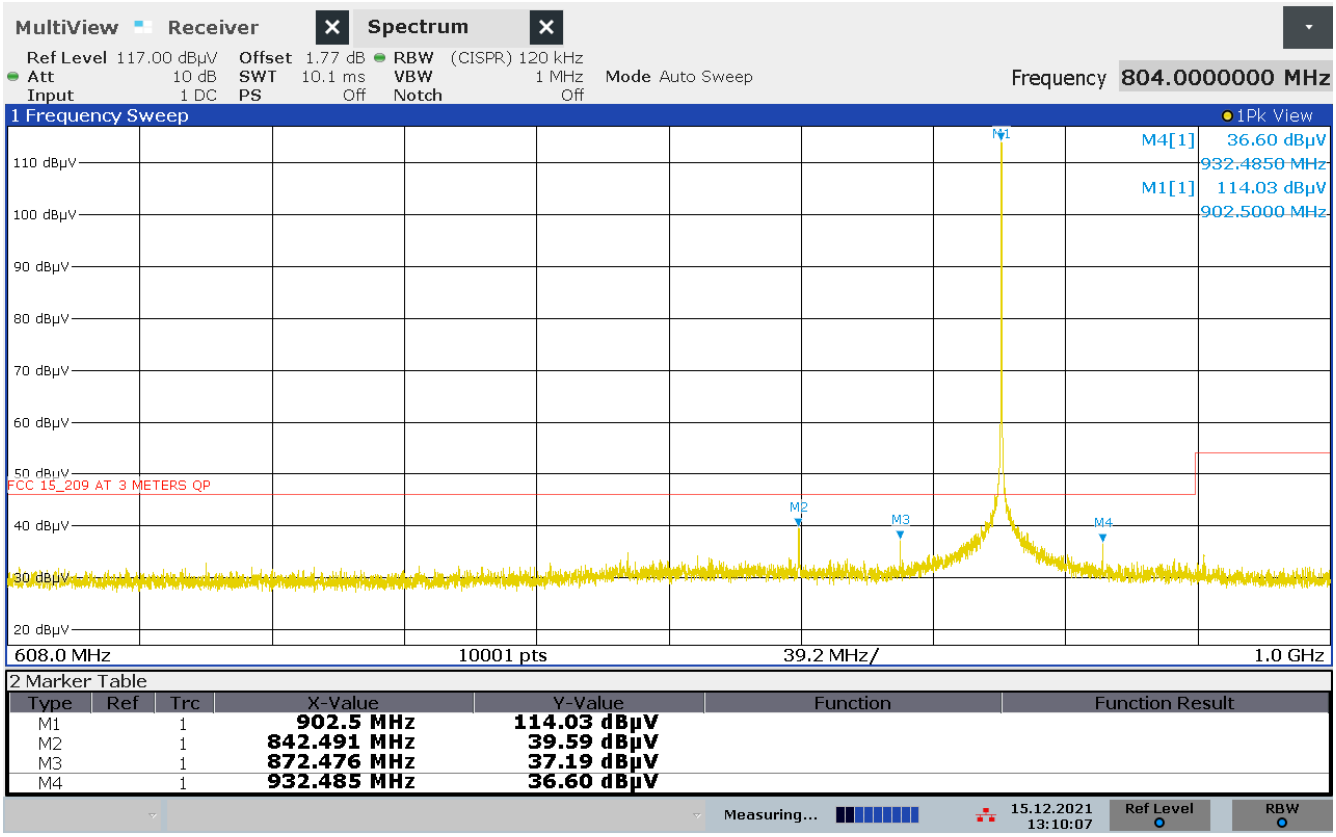
Figure 2-37 – Radiated Band-Edge, High Channel – Peak

Table 2.11-2 – Radiated Band Edge – High Channel – Peak

Frequency (MHz)	Peak Level (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Result
728.00	32.96	46.02	-13.06	PASS
808.47	33.06	46.02	-12.96	PASS
946.36	33.84	46.02	-12.18	PASS

Note: Margin Calculation: Margin = Peak Level – Average Limit.
Note: Average measurement was not taken where Peak measurement complies with Average limits.

Bandedge Emissions; 902.5 M (Yagi)



13:10:08 15.12.2021

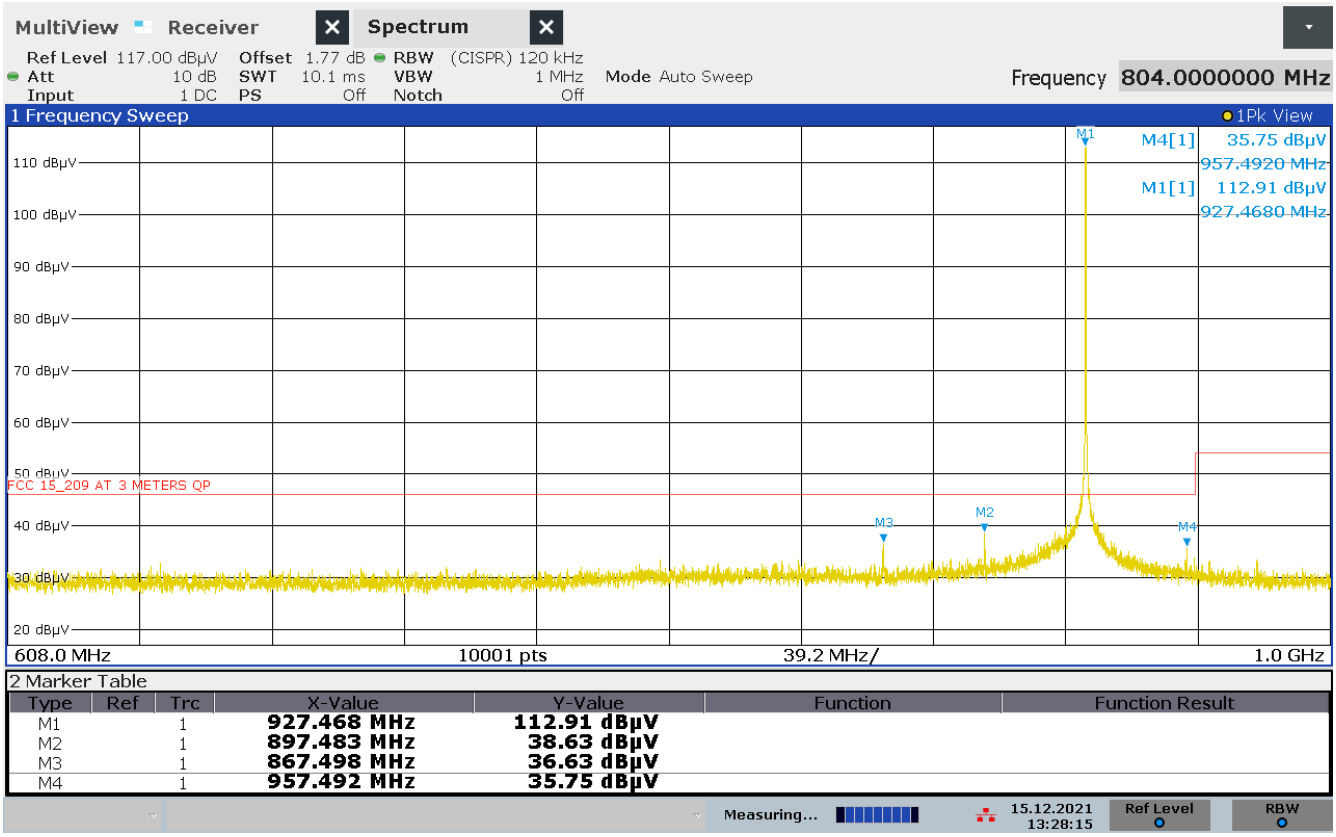
Figure 2-38 – Radiated Band-Edge, Low Channel – Peak

Table 2.11-3 – Radiated Band Edge – Low Channel – Peak

Frequency (MHz)	Peak Level (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Result
842.49	39.59	46.02	-6.43	PASS
872.48	37.19	46.02	-8.83	PASS
932.49	36.60	46.02	-9.42	PASS

Note: Margin Calculation: Margin = Peak Level – Average Limit.
Note: Average measurement was not taken where Peak measurement complies with Average limits.

Bandedge Emissions; 927.5 M (Yagi)



13:28:16 15.12.2021

Figure 2-39 – Radiated Band-Edge, High Channel – Peak

Table 2.11-4 – Radiated Band Edge – High Channel – Peak

Frequency (MHz)	Peak Level (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)	Peak Result
897.48	38.63	46.02	-7.39	PASS
867.50	36.63	46.02	-9.39	PASS
957.49	35.75	46.02	-10.27	PASS

Note: Margin Calculation: Peak Margin = Peak Level – Peak Limit.

Note: Average measurement was not taken where Peak measurement complies with Average limits.

2.11.7 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: 3mSAC

Table 2.11-5 – Restricted Band Edge Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE10985	Agilent Technologies	Pre Amplifier, 0.1-1300 MHz	8447D	2443A04180	B	04/07/2021	04/07/2022
WRLE11519	Com-Power Corp.	Preamp, 500 MHz-18 GHz	PAM-118A	18040002	B	01/08/2021	01/08/2022
NBLE11555	Rohde & Schwarz	Receiver, 2 Hz-44 GHz	ESW44	101537	G	12/31/2020	12/31/2021
NBLE11578	ETS-Lindgren	Antenna, BiConiLog	3142C	00079889	G	09/14/2020	09/14/2022
NBLE11630	ETS-Lindgren	Antenna, 1-18 GHz	3117	00218816	G	09/04/2020	09/04/2022
NBLE11699	Mini-Circuits Lab	Filter, 900-950 MHz Notch	N03915M1	138901	B	03/31/2021	03/31/2022

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

3 Diagram of Test Setups

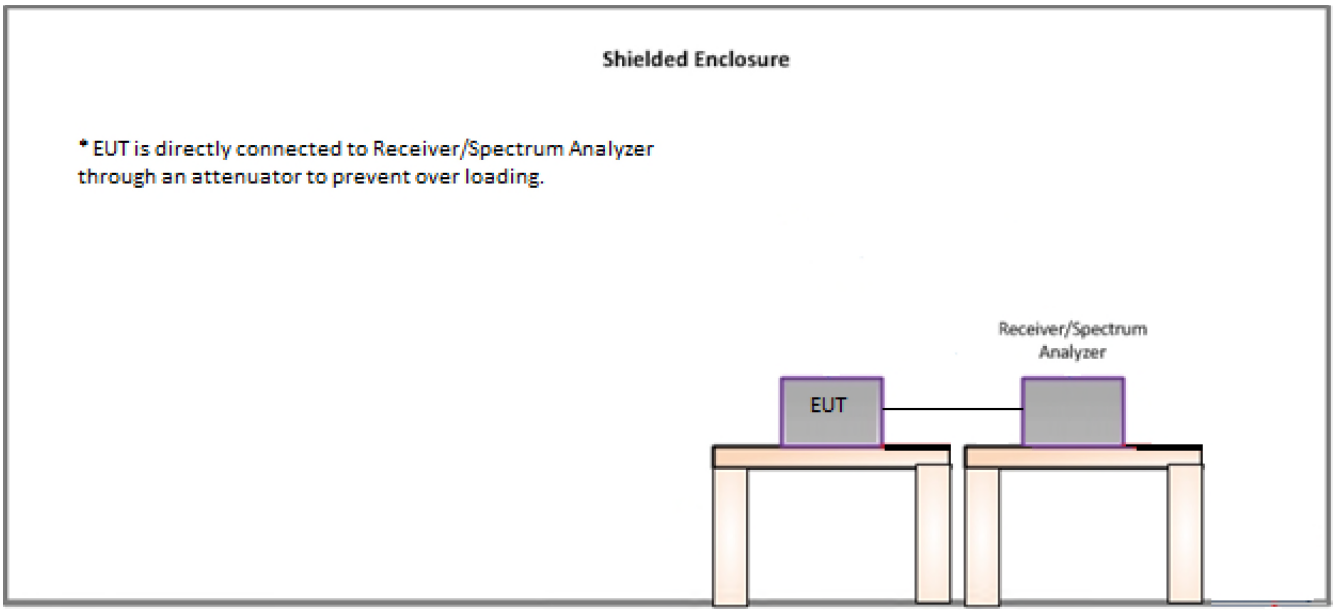


Figure 3-1 – Conducted Test Setup

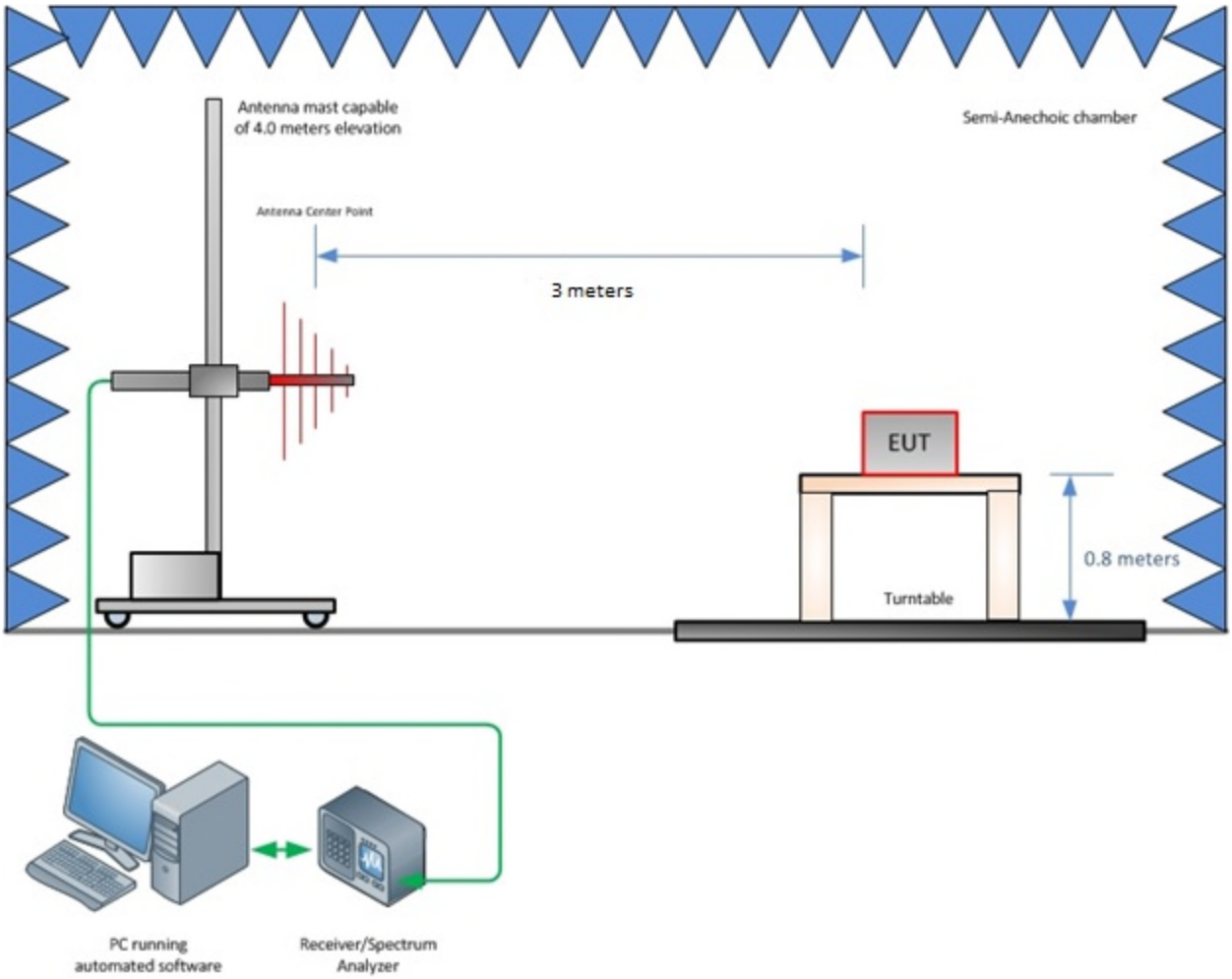


Figure 3-2 – Radiated Emissions Test Setup up to 1 GHz

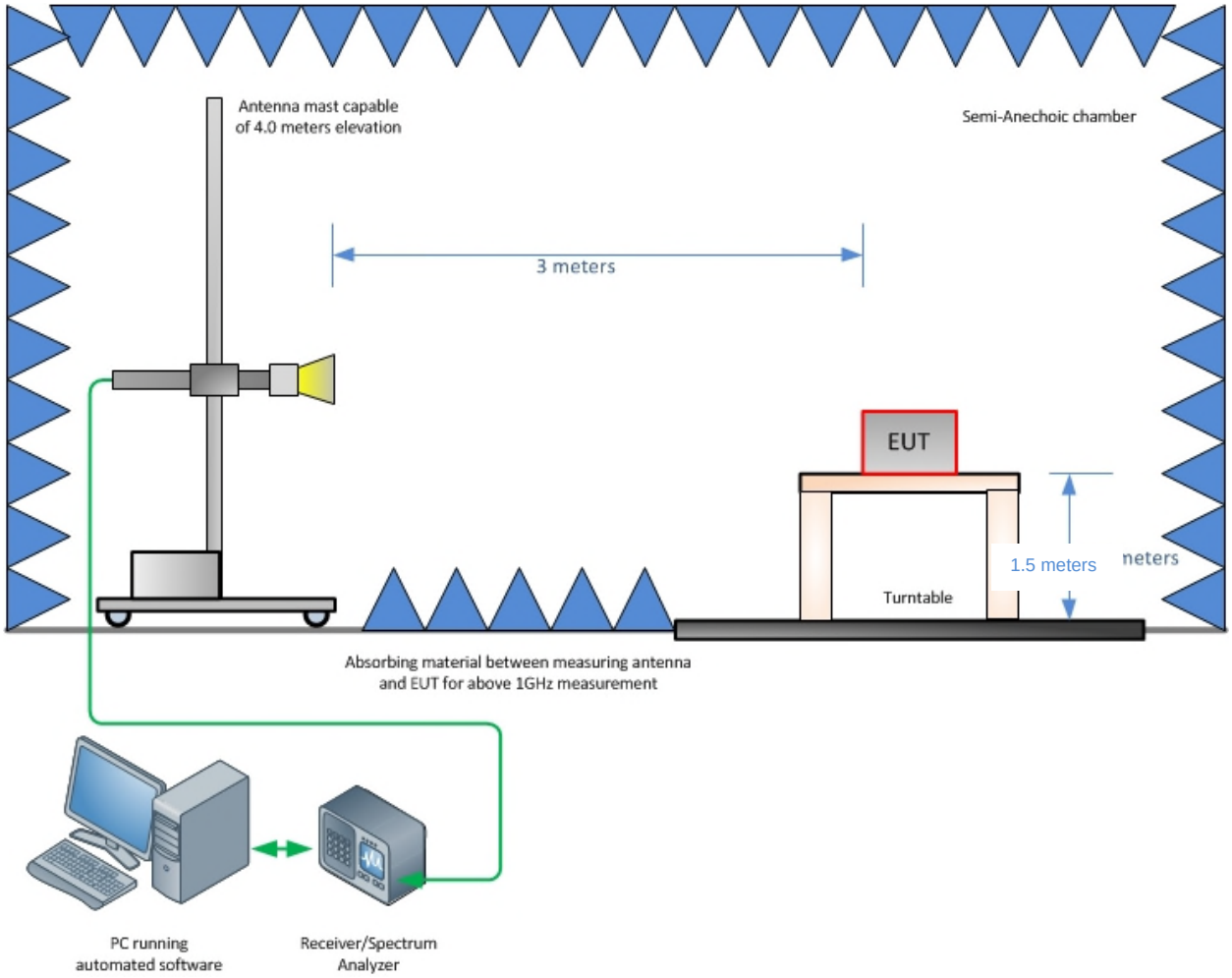


Figure 3-3 – Radiated Emissions Test Setup above 1 GHz

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STATEMENT OF MEASUREMENT UNCERTAINTY – Emissions

The test system for conducted emissions is defined as the LISN, tuned receiver or spectrum analyzer, and coaxial cable. This test system has a measurement uncertainty of ±3.30 dB. The test system for radiated emissions is defined as the antenna, the pre-amplifier, the spectrum analyzer and the coaxial cable. This test system for 30 MHz-1000 MHz has a measurement uncertainty of ±5.88 dB and above 1 GHz a measurement uncertainty of ±4.47 dB. The measurement uncertainty values for conducted and radiated emissions meet the requirements as expressed in CISPR 16-4-2. The equipment comprising the test systems is calibrated on an annual basis.

TEST EQUIPMENT

All measurement instrumentation is traceable to the National Institute of Standards and Technology and is calibrated to meet test method standard requirements and/or manufacturer's specifications