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Amended

FCC/ISED DXX Part 15.225
Test Report

Prepared for:	**Garmin International Inc.**
Address:	**1200 E. 151st Street** **Olathe, Kansas, 66062, USA**
Product:	**C03561**
Test Report No:	**R20200110-20-E13C**
Approved By:	 **Nic S. Johnson, NCE** **Technical Manager** **iNARTE Certified EMC Engineer #EMC-003337-NE**
DATE:	**13 May 2020**
Total Pages:	**24**

ilac-MRA A2LA ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

Revision Page

Rev. No.	Date	Description
Original	21 April 2020	Original – Prepared by CFarrington Approved by NJohnson
A	8 May 2020	1. Table in section 2.1 was updated to show the correct antenna type 2. Section 3.1.6 was updated with the statement regarding the harmonic measurements and the output power table was updated to show the 3m measurements. 3. Radiated Emissions limit from RSS-Gen Issue 5 was added. 4. Output power table was updated 5. Contains the report R20200110-20-E13 and its amendments in full. -KV
B	12 May 2020	1. Added the radiated emissions plot to show compliance for RSS Gen in section 3.1 2. Contains the report R20200110-20-E13A and its amendments in full.
C	13 May 2020	Update Section 3.1.1 to specify intermodulation testing was done with transmitters both operating. Contains the report R20200110-20-E2B and its amendments in full

TABLE OF CONTENTS

1 Summary of Test Results

The EUT was tested for compliance to the following standards and/or regulations;

1.1 Emissions Test Results

The EUT was tested for compliance to:

US CFR Title 47 FCC Part 15.225
RSS-Gen Issue 5

Below is a summary of the test results. Complete results of testing can be found in Section 3.

Table 1 – Emissions Test Results

Emissions Tests	Test Method and Limits	Result
Radiated Emissions	FCC Part 15.225 (a), (b), (c), (d) RSS-Gen, Sec 8.9	Complies
Frequency Error	FCC Part 15.225 (e) RSS-Gen, Sec 6.11	Complies
Conducted Emissions	FCC Part 15.207 RSS-Gen, Sec 8.8	Complies

2 EUT Description

2.1 Equipment under Test (EUT)

Table 2 – Equipment under Test (EUT)

Model	C03561
EUT Received	13 January 2020
EUT Tested	20 March 2020
Serial No.	3319808469 (Radiated Measurements) 3319808431 (Radiated Measurements)
Operating Band	13.56 MHz
Device Type	NFC
Antenna	Coil Antenna
Power Supply	Internal Battery/ 5VDC Charger: Garmin (Phi Hong) MN: PSAF10R-050Q (Representative Power Supply)

2.2 Laboratory Description

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of 28 ± 4%
Temperature of 22 ± 3° C

2.3 EUT Setup

The EUT was powered by 120 VAC / 60Hz (5 VDC Output) for all tests.

3 Test Results

3.1 Radiated Emissions, Band Width, Output Power and Band edge

Test:	FCC Part 15.225 (a), (b), (c), (d) RSS-Gen, Sec 8.9
Test Specifications:	Class A
Test Result:	Complies

3.1.1 Test Description

Radiated emissions measurements were made from 30MHz to 1GHz at a distance of 3m (Radiated Emissions) and 0.5m (Band width, Output Power and Band edges) inside a semi-anechoic chamber. The EUT was rotated 360°, the antenna height varied from 1-4 meters and both the vertical and horizontal antenna polarizations examined. For measurements below 30 MHz, the loop antenna was used to measure in all 3 axis. The results were compared against the limits. Measurements were made by first using a spectrum analyzer to acquire the signal spectrum; individual frequencies were then measured using a CISPR 16.1 compliant receiver with the following bandwidth setting:

30MHz – 1GHz:120kHz IF bandwidth, 60kHz steps
10 – 30MHz, 9kHz RBW, 5 kHz steps

Intermodulation products were investigated by measuring spurious emissions with each of the two 2.4 GHz radios were transmitting simultaneously with the NFC radio. No intermodulation products were found above the labs system sensitivity.

3.1.2 Test Results

No radiated emissions measurements were found in excess of the limits. Test result data can be seen below.

3.1.3 Test Environment

Testing was performed at the NCEE Labs Lincoln facility in the 10m semi-anechoic chamber. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 30 ± 5%
Temperature of 23 ±2^{o} C

3.1.4 Test Setup

See Section 2.3 for further details.

3.1.5 Test Equipment Used

Serial No.	Manufacturer	Model	Description	Last Cal.
A082918-1	SunAR RF Motion	JB1	Bicon Antenna	15 Oct 2018*
00024936	EMCO	6512	Loop Antenna	11 Feb 2019*
MY59050109	Keysight	N9038A	MXE Signal Analyzer	23 Apr 2019
700307	TDK	TDK Emissions lab	Software V.11.25	Not Required

*Two Year Calibration Cycle

3.1.6 Test Pictures and/or Figures

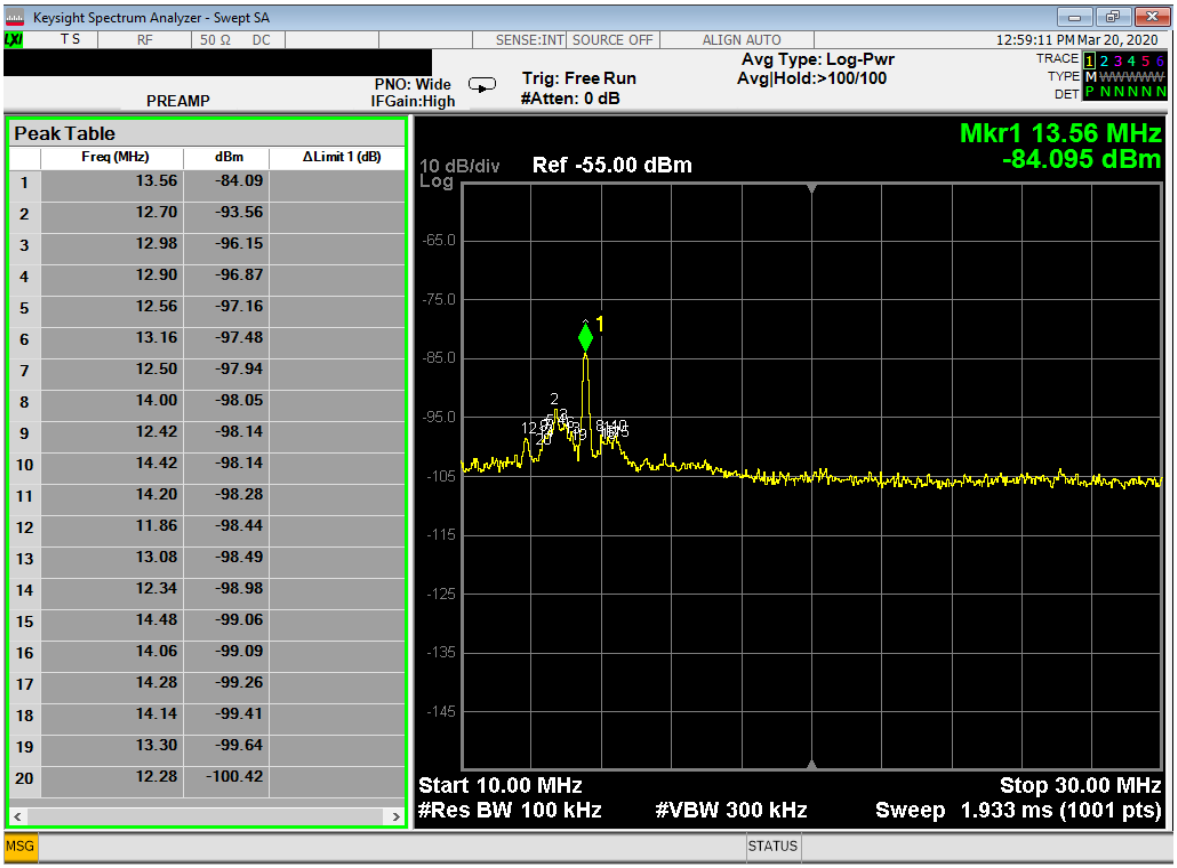


Figure 1 – Radiated Emissions Peak Plot, Horizontal Polarization, 10 MHz- 30 MHz

*The field strength of any emissions appearing outside of the 13.110-14.010 MHz band shall not exceed the general radiated emission limits in §15.209. Note that the Harmonic measurements were investigated and found to be below the applicable limits by at least 6 dB so the tabular data was not provided. In order to show compliance between 12 MHz and 15 MHz band refer to figure 2.

A loop antenna was used to test all three axis, worst axis is reported. Note that the measurements were done with 100 kHz RBW and compared to the limit which specified 9 kHz to show compliance.

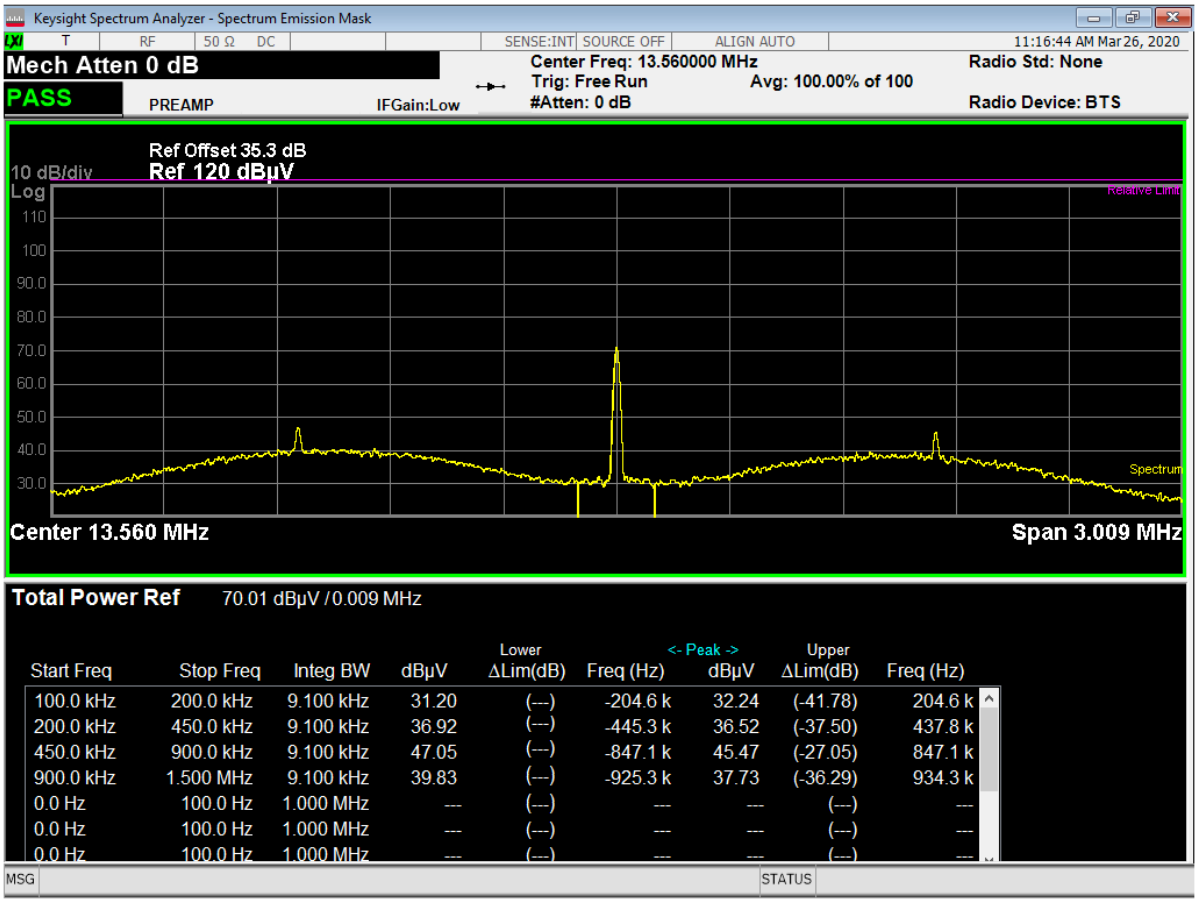


Figure 2 – Radiated Emissions Peak Plot, Horizontal Polarization, 12 MHz- 15 MHz

FCC Limit: 30 µV/m at 30m = 29.54 dBµV/m = 65.10 dBµV/m at 0.5m

RSS-Gen Limit:
0.08 uA/m at 30m = -21.938 dBuA/m = 13.625 dBuA/m at 0.5m = 47.60 dBuV/m at 0.5m

Maximum Spurious = 47.05 dBuV/m @ 0.5m; Worst-case margin=0.55 dB
*The graph in figure 2 shows the corrected values

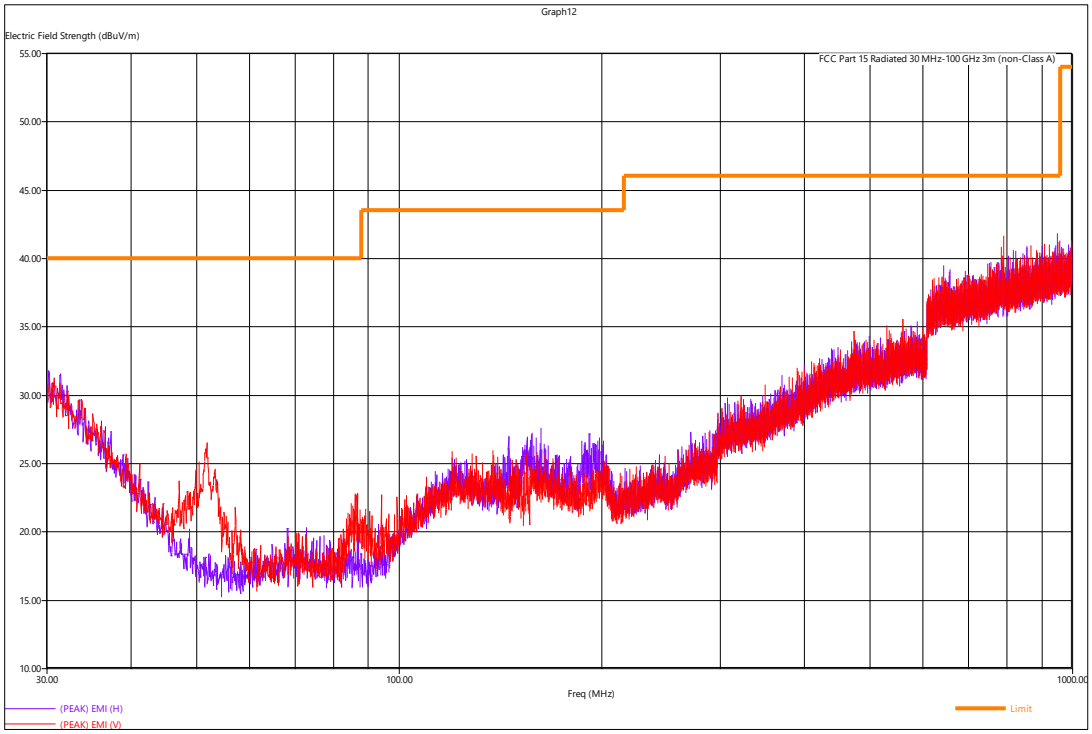


Figure 3 – Radiated Emissions Peak Plot, 30 MHz- 1 GHz
All emissions were found to be at least 10dB below the limit.

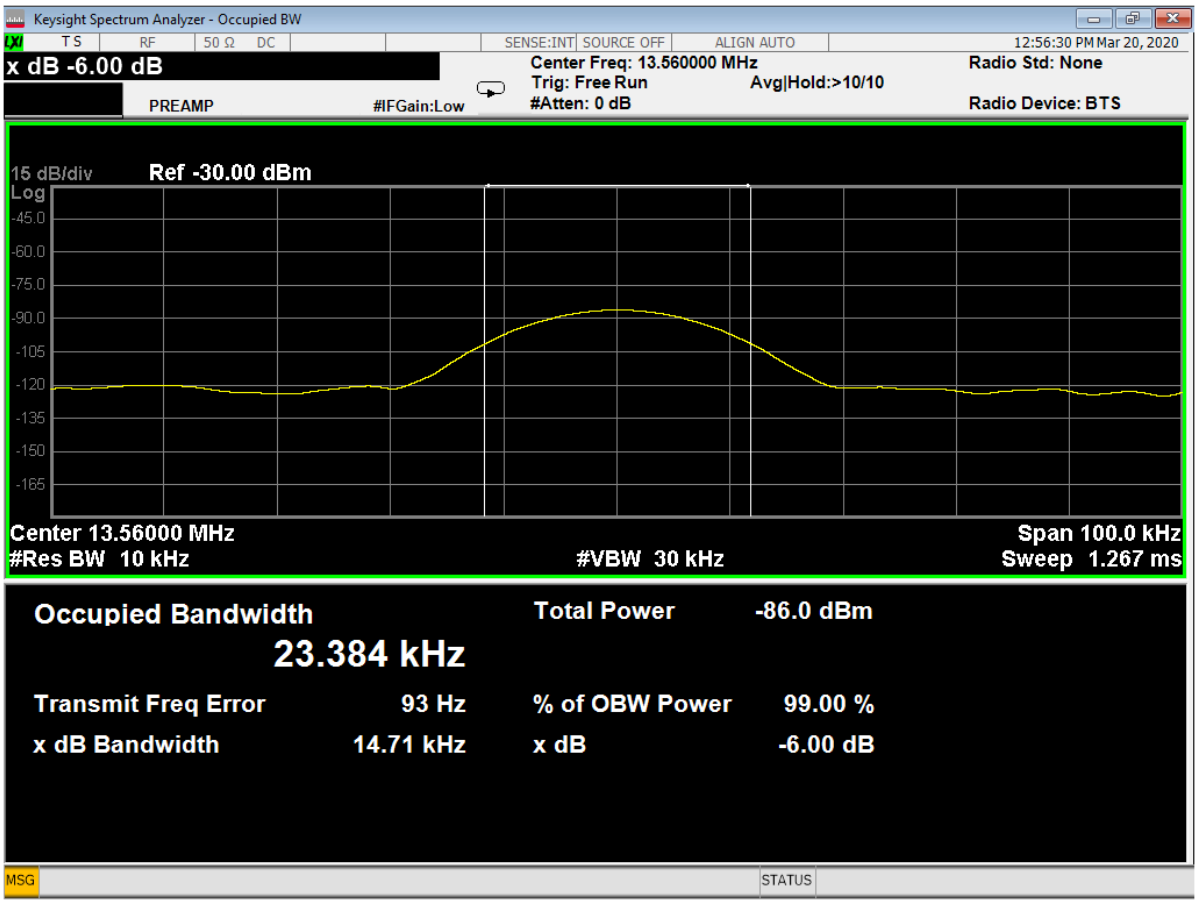


Figure 4 - 99% Occupied Bandwidth, NFC

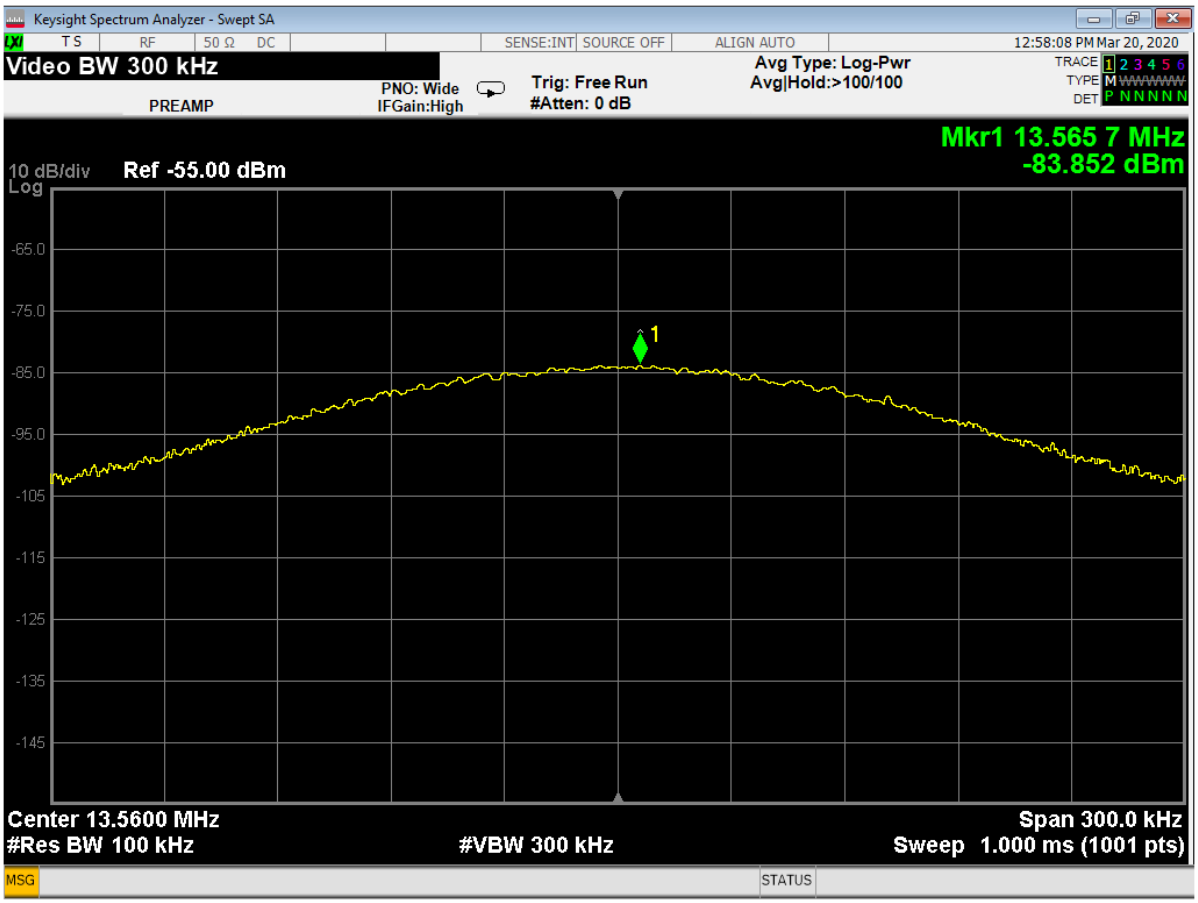


Figure 5 – Output Power

Raw band level dBm	Corrected band level @0.5m dBµV/m	Corrected band level @3m dBµV/m	Limit @ 0.5 m	Limit @ 3m	Margin	Result
-83.852	58.448	42.885	119.560	103.999	61.112	Pass

Maximum power = 107 – 83.852 + 0.9 + 34.4 = 58.448 dBuV/m @ 0.5m
CL = cable loss = 0.90 dB
AF = antenna factor = 34.4 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system

* Extrapolated limit from 30 m to 0.5 m

Measurement performed at 0.5m distance.

Band Edge Measurements:

Band edge /Measurement Frequency (MHz)	Uncorrected band level dBm	Corrected band level dBµV/m @ 0.5m	Limit* dBµV	Margin	Result
13.11-13.41	-109.425	33.475	76.531	43.056	PASS
13.41-13.553	-97.143	45.757	86.041	40.284	PASS
13.71-14.01	-110.136	32.764	76.531	43.767	PASS
13.567-13.71	-85.453	57.447	86.041	28.594	PASS

* Extrapolated limit from 30 m to 0.5 m.
Corrected band level = 107 + uncorrected band level + cable loss + antenna factor

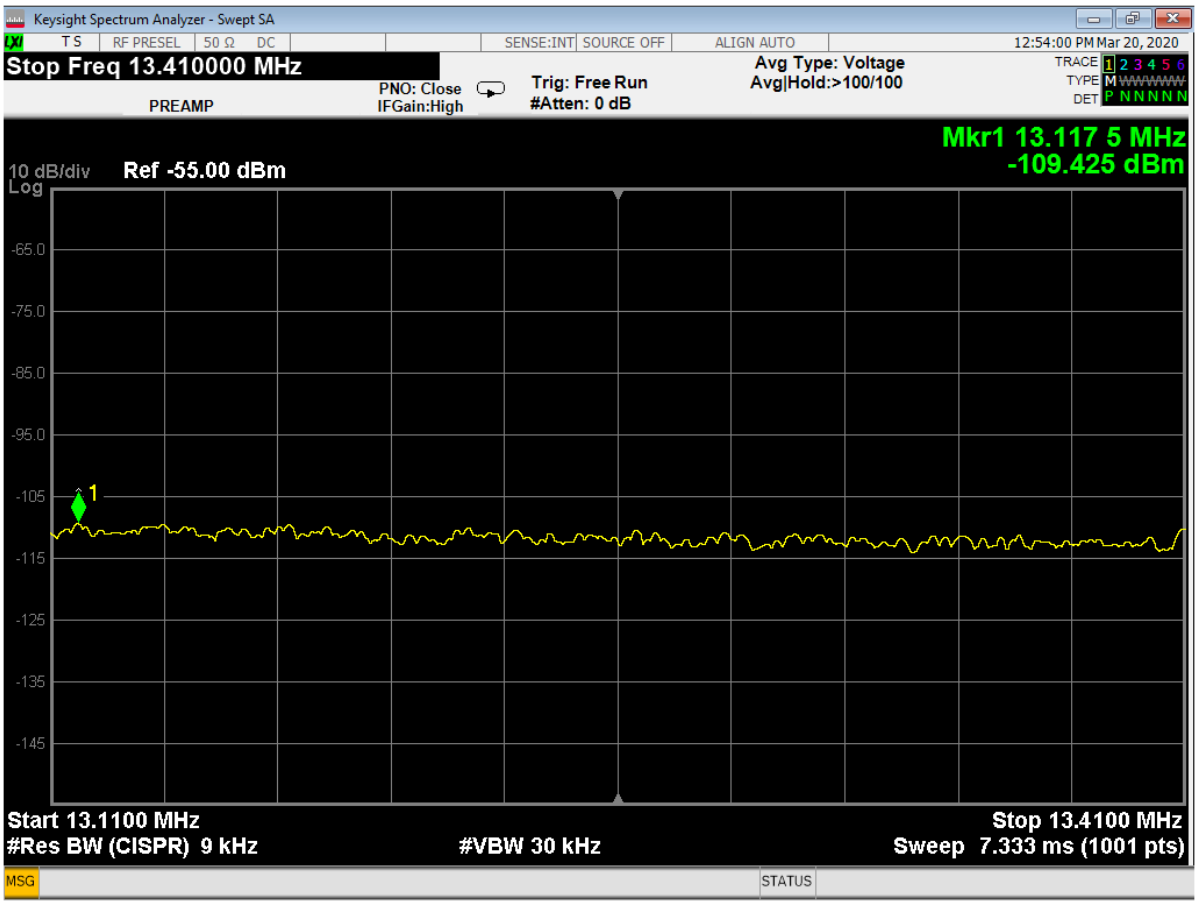


Figure 6 – Lower Band-edge

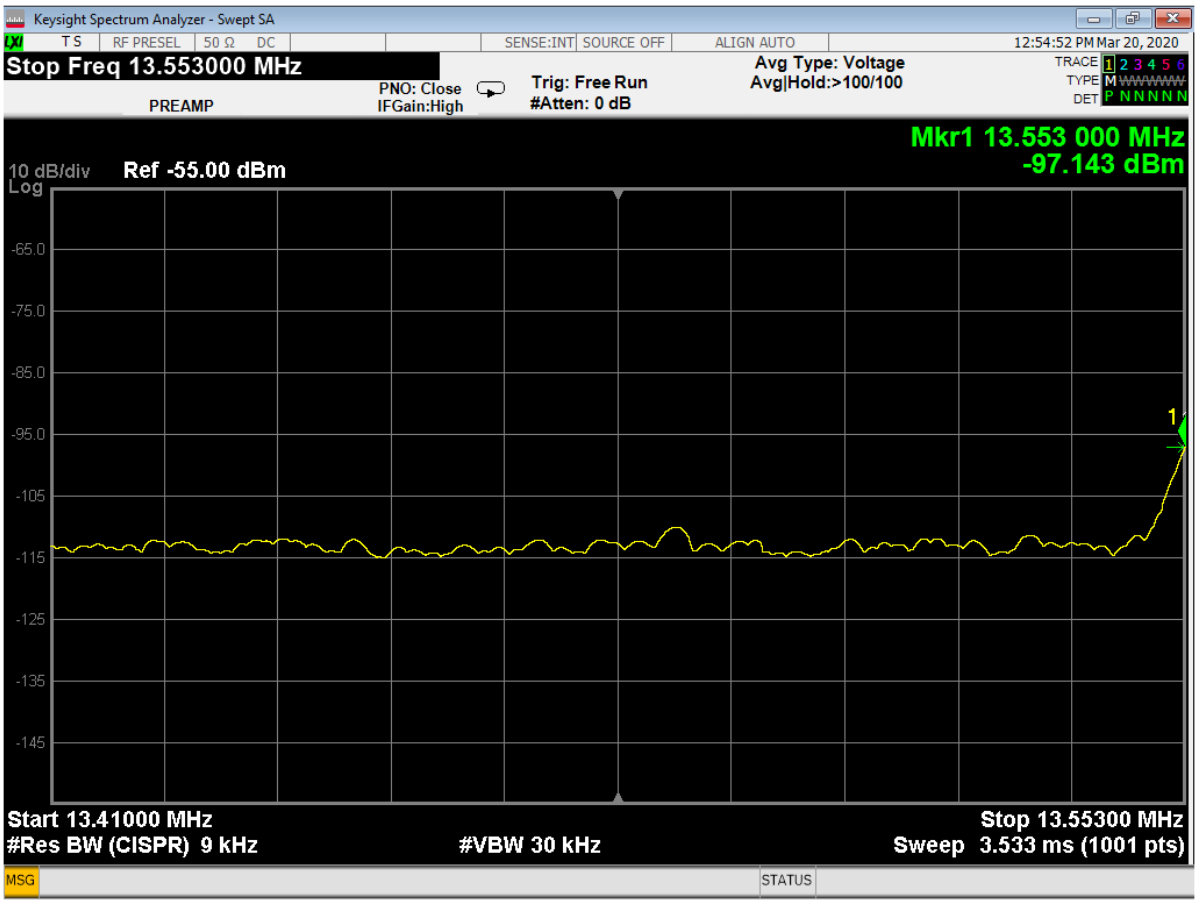


Figure 7 – Lower Band-edge

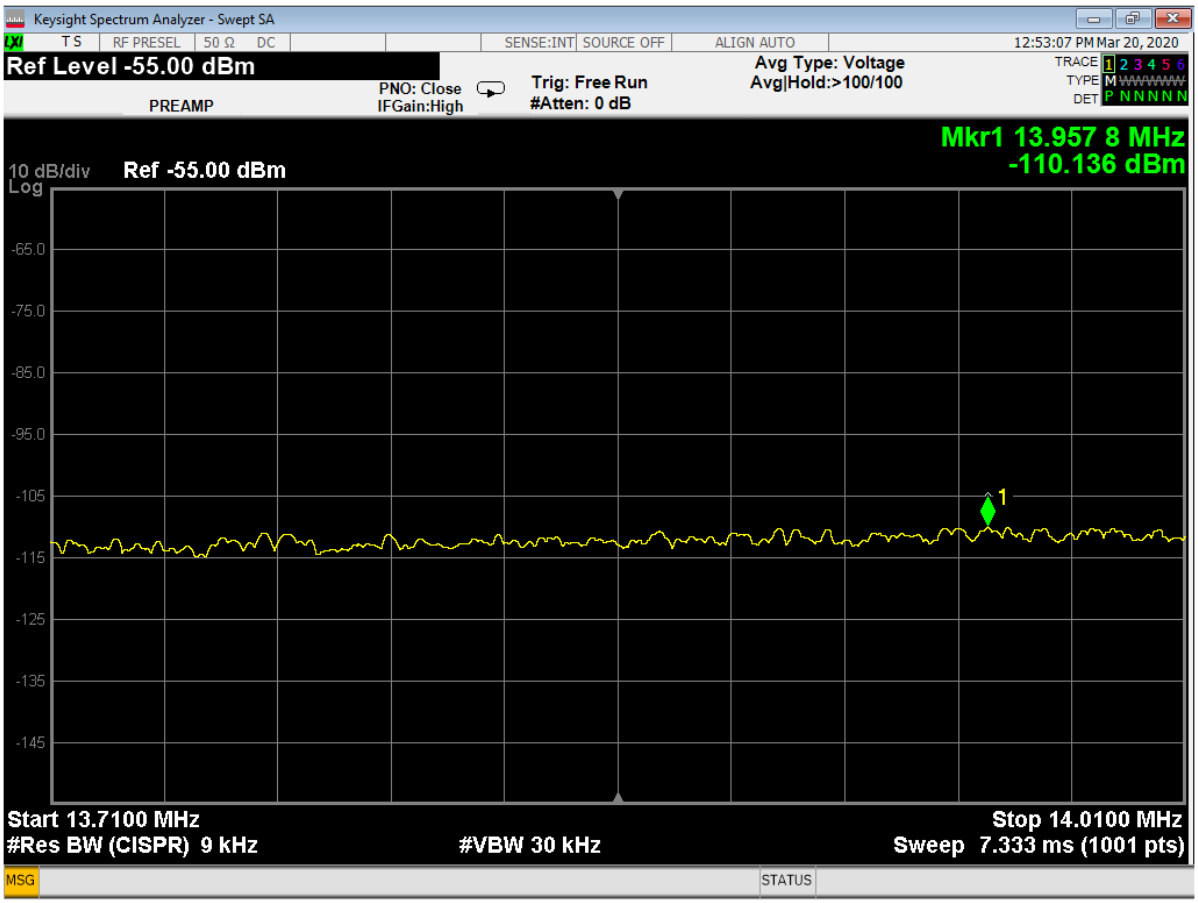


Figure 8 – Higher Band-edge

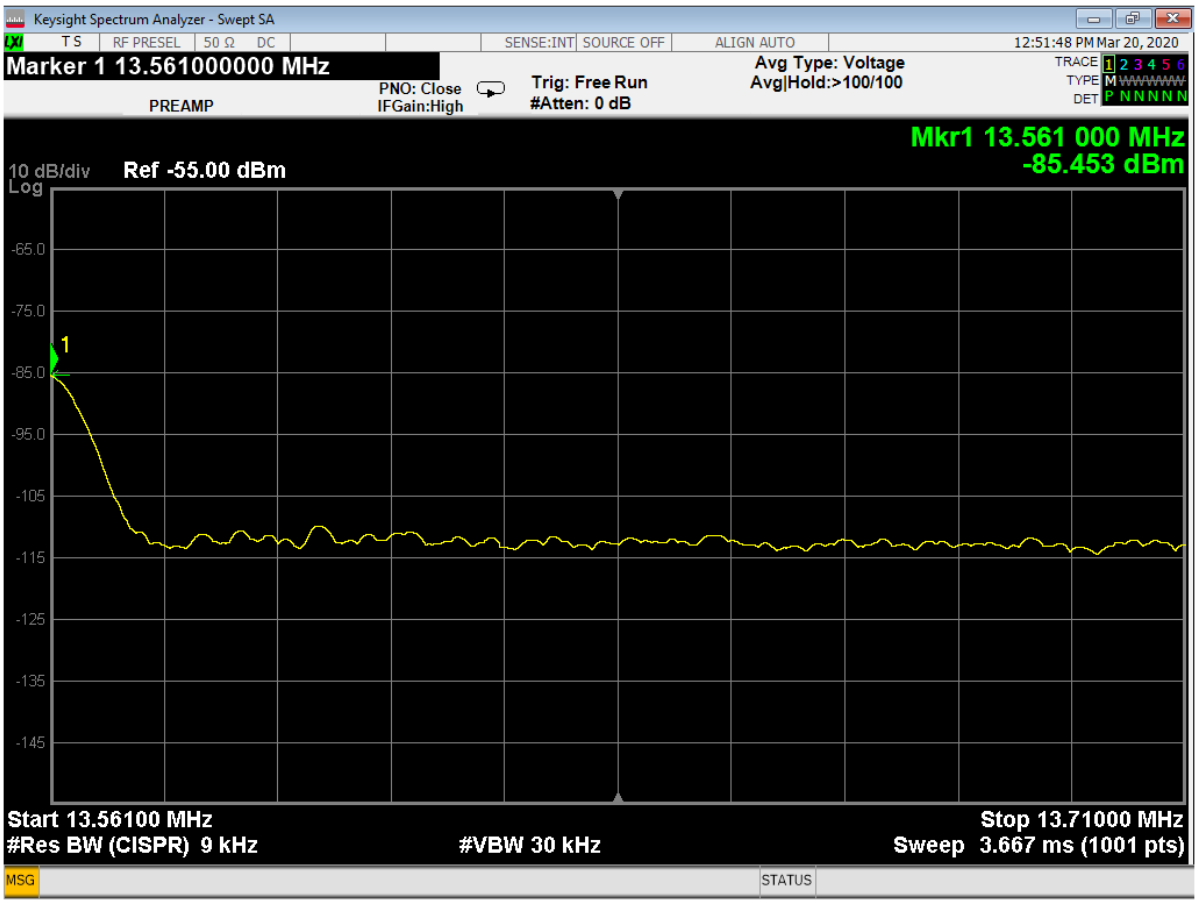


Figure 9 – Higher Band-edge

3.2 Frequency Error

Test:	FCC Part 15.225 (e) RSS-Gen 6.11
Test Result:	Complies

3.2.1 Test Description

Frequency error was determined using the build in frequency error function of the spectrum analyzer. The analyzer finds the occupied bandwidth, calculates the center of the given band then returns the deviation with respect to the given transmit frequency. The temperature was varied from -20°C to -50°C. Limit: 100 PPM

3.2.2 Test Results

No results were found to be in excess of the limits. A plot of the results can be seen below.

3.2.3 Test Environment

Testing was performed at the NCEE Labs Lincoln facility on the 10-meter chamber ground plane. Laboratory environmental conditions varied slightly throughout the test:
Relative humidity of 30 ± 5%
Temperature of 23 ±2° C

3.2.4 Test Setup

See Section 2.3 for further details.

3.2.5 Test Equipment Used

Serial No.	Manufacturer	Model	Description	Last Cal.
31373	Thermotron	SE1000-5-5	Temp chamber	NA
MY59050109	Keysight	N9038A	MXE Signal Analyzer	23 Apr 2019
00024936	EMCO	6512	Loop Antenna	11 Feb 2019*
ID # 2130155	Omega	iTHX-SD	3m Temp. Humidity Meter	2018 Jan 31

3.2.6 Test results

Table 3 - Frequency Range Measurements

Temperature (°C)	Channel (MHz)
	13.56000 Nom.
-20°C	28
-10°C	33
0°C	38
10°C	19
20°C	48
30°C	65
40°C	48
50°C	76

Limit: 100 PPM

Table 4 - Voltage Range Measurements

Temperature (°C)	Voltage (VDC)	Channel (MHz)
		13.56000
20°C	3.20	73
20°C	3.90	48
20°C	4.75	64

Voltage ranges provided by the manufacturer, Limit: 100 PPM

3.3 Conducted Emissions

Test Method:	ANSI C63.10-2013, Section(s) 6.2 RSS-Gen 8.8
Test Result:	Complies

3.3.1 Test Description

Conducted emissions measurements were made from 150kHz to 30MHz via a 50µH Line Impedance Stabilization Network (LISN). The results were compared against the limits. Measurements were made on both the line and neutral conductors by first using a spectrum analyzer to acquire the signal spectrum; individual frequencies were then measured using a CISPR 16.1 compliant receiver with the following bandwidth setting:

150kHz – 30MHz: 9kHz IF bandwidth, 5kHz steps

3.3.2 Test Results

No results were found to be in excess of the limits. A plot of the results can be seen below.

3.3.3 Test Environment

Testing was performed at the NCEE Labs Lincoln facility. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 30 ± 5%

Temperature of 23 ±2° C

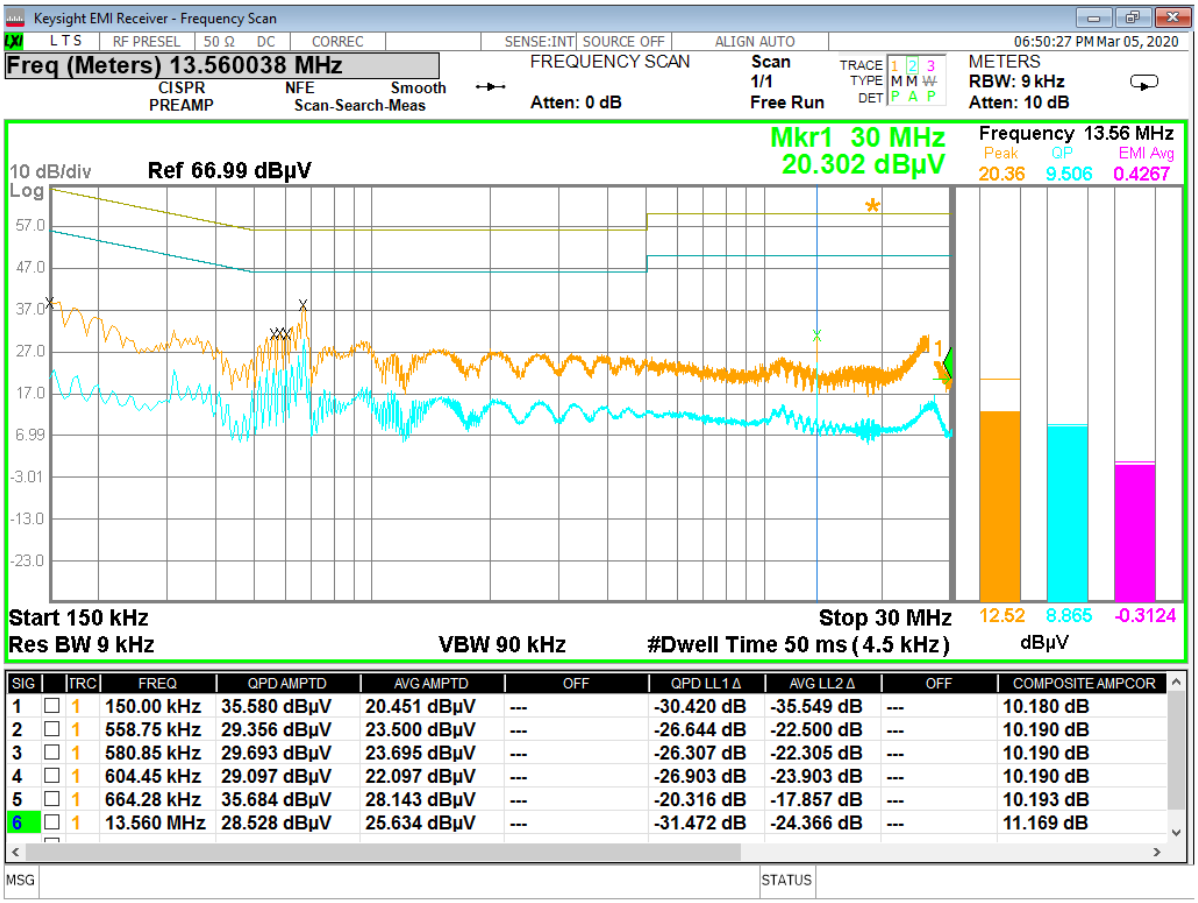
3.3.4 Test Setup

See Section 2.3 for further details.

3.3.5 Test Equipment Used

Serial No.	Manufacturer	Model	Description	Last Cal.
836679/010	Rohde & Schwarz	ESH3-Z5	Artificial Mains	25 Jul 2019
MY59050109	Keysight	N9038A	MXE Signal Analyzer	23 Apr 2019
700307	TDK	TDK Emissions lab	Software V.11.25	Not Required

3.3.6 Test Pictures and/or Figures



SIG		TRC	FREQ	QPD AMPTD	AVG AMPTD	OFF	QPD LL1 Δ	AVG LL2 Δ	OFF	COMPOSITE AMPCOR
1	☐	1	150.00 kHz	35.580 dBµV	20.451 dBµV	---	-30.420 dB	-35.549 dB	---	10.180 dB
2	☐	1	558.75 kHz	29.356 dBµV	23.500 dBµV	---	-26.644 dB	-22.500 dB	---	10.190 dB
3	☐	1	580.85 kHz	29.693 dBµV	23.695 dBµV	---	-26.307 dB	-22.305 dB	---	10.190 dB
4	☐	1	604.45 kHz	29.097 dBµV	22.097 dBµV	---	-26.903 dB	-23.903 dB	---	10.190 dB
5	☐	1	664.28 kHz	35.684 dBµV	28.143 dBµV	---	-20.316 dB	-17.857 dB	---	10.193 dB
6	☐	1	13.560 MHz	28.528 dBµV	25.634 dBµV	---	-31.472 dB	-24.366 dB	---	11.169 dB

Figure 10 - Conducted Emissions, Line

All Measurements were found to be at least 10 dB below the limits.

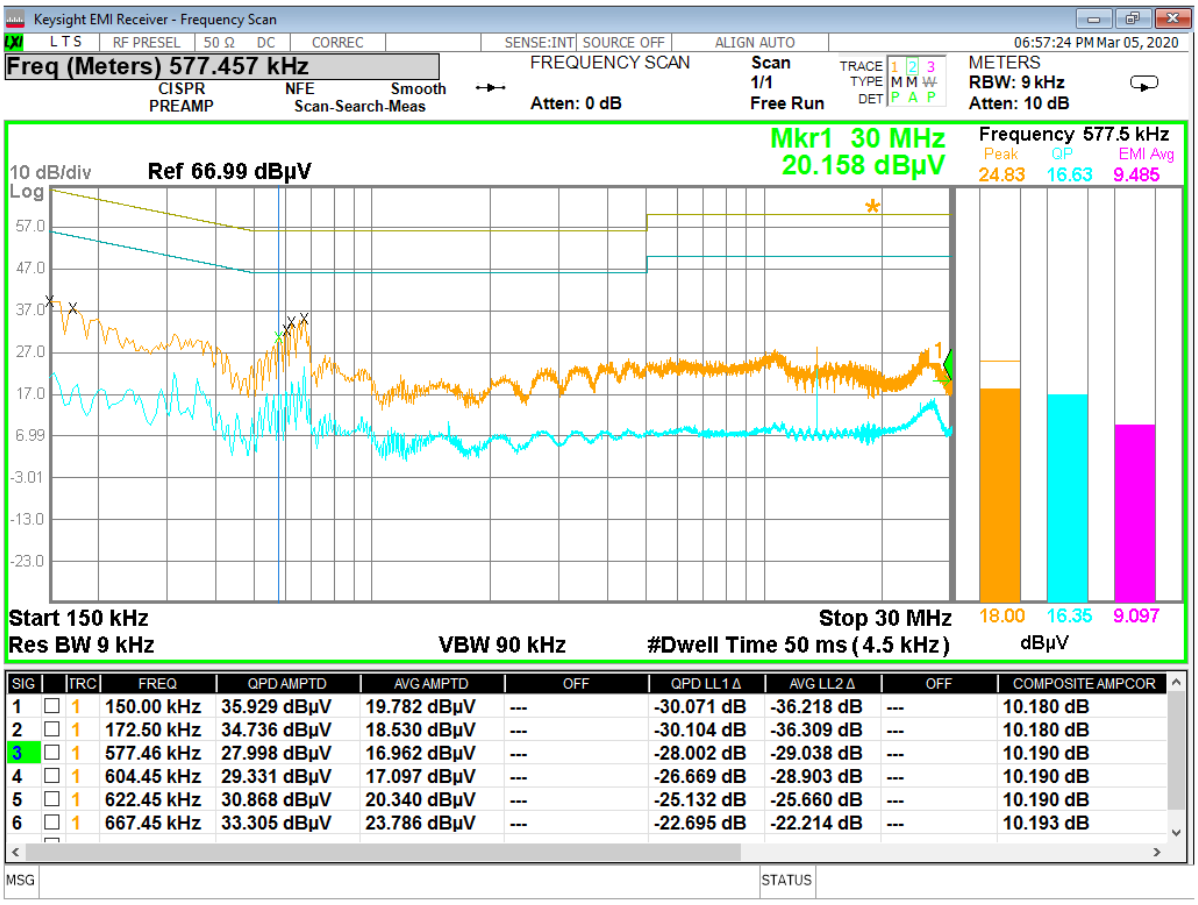


Figure 11 - Conducted Emissions, Neutral

All Measurements were found to be at least 10 dB below the limits.

Annex A: Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±3.82 dB
Radiated Emissions, 3m	1GHz - 18GHz	±4.44 dB
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB
Antenna port conducted	9 kHz – 25 GHz	±0.50 dB

Values were calculated per CISPR 16-4-2:2011

Expanded uncertainty values are calculated to a confidence level of 95%.

Annex B: Sample Field Strength Calculation

Radiated Emissions

The field strength is calculated in decibels (dB) by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = R + AF – (-CF + AG)

where FS = Field Strength

R = Receiver Amplitude Receiver reading in dBμV

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Preamplifier Amplifier Gain

Assume a receiver reading of 55.00 dBμV is obtained. The Antenna Factor of 12.00 and a Cable Factor of 1.10 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.10 dBμV/m.

FS = 55.00 + 12.00 – (-1.10 + 20.00) = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

Conducted Emissions

Receiver readings are compared directly to the conducted emissions limits in decibels (dB) by adding the cable loss and LISN insertion loss to the receiver reading. The basic equations with a sample calculation is as follows;

FS = R + IL – (-CF)

where V = Conducted Emissions Voltage Measurement

R = Receiver reading in dBμV

IL = LISN Insertion Loss

CF = Cable Attenuation Factor

Assume a receiver reading of 52.00 dBμV is obtained. The LISN insertion loss of 0.80 dB and a Cable Factor of 1.10 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

V = 52.00 + 0.80 – (-1.10) = 53.90 dBμV/m

The 53.90 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 495.45 μV/m

*Note: NCEE Labs uses the Rohde and Schwarz ES-K1 software package. In this software, all cable losses are listed as negative. This is why cable loss is subtracting in the preceding equations.

Margin is calculated by taking the limit and subtracting the Field

REPORT END