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FCC/ISED DXX Part 15.225
Test Report

Prepared for: Garmin International Inc.

Address: 1200 E. 151st Street
Olathe, Kansas, 66062, USA

Product: A03645

Test Report No: R20181219-20-15B

Approved By:

Nic S. Johnson, NCE
Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: 14 August 2019

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ilac-MRA A2LA ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

Revision Page

Rev. No.	Date	Description
Original	21 June 2019	Original – Prepared by KVepuri Approved by NJohnson
A	15 July 2019	Includes NCEE Labs report R20181219-20-15 and its amendment in full. -NJ
B	14 August 2019	Includes NCEE Labs report R20181219-20-12A and its amendment in full. -NJ

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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-210 Issue 9

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-210 Issue 5, Sec 4.3	Complies
Frequency Error	FCC Part 15.225 (e) RSS-210 Issue 5, Annex D	Complies
Conducted Emissions	FCC Part 15.207 RSS-Gen Issue 5, Sec 8.8	Complies

2 EUT Description

The Equipment Under Test (EUT) was a portable transceiver from Garmin.

2.1 Equipment under Test (EUT)

Table 2 – Equipment under Test (EUT)

Model	A03645
EUT Received	16 April 2019
EUT Tested	16 April 2019 - 21 June 2019
Serial No.	3991631270 (radiated unit)
Operating Band	13.56 MHz
Device Type	Low-power
Antenna	Trace Antenna
Power Supply	Internal Battery/ Charger: Garmin (Phi Hong) MN: PSAI10R-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)		
Test Specifications:	Class A		
Test Result:	Complies	**Date:**	6/5/2019- 6/21/2019

3.1.1 Test Description

Radiated emissions measurements were made from 30MHz to 1GHz at a distance of 3m (Radiated Emissions) and 1m (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. 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 running in parallel 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° 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.
1647	EMCO	3142B	Bicon Antenna	02 Aug 2017*
00024936	EMCO	6512	Loop Antenna	30 Jan 2018*
100037	Rohde & Schwarz	ES126	EMI Test Receiver	30 Jan 2018*
2575	Rohde & Schwarz	ES-K1	Software v.1.60	N/A

*Two Year Calibration Cycle

3.1.6 Test Pictures and/or Figures

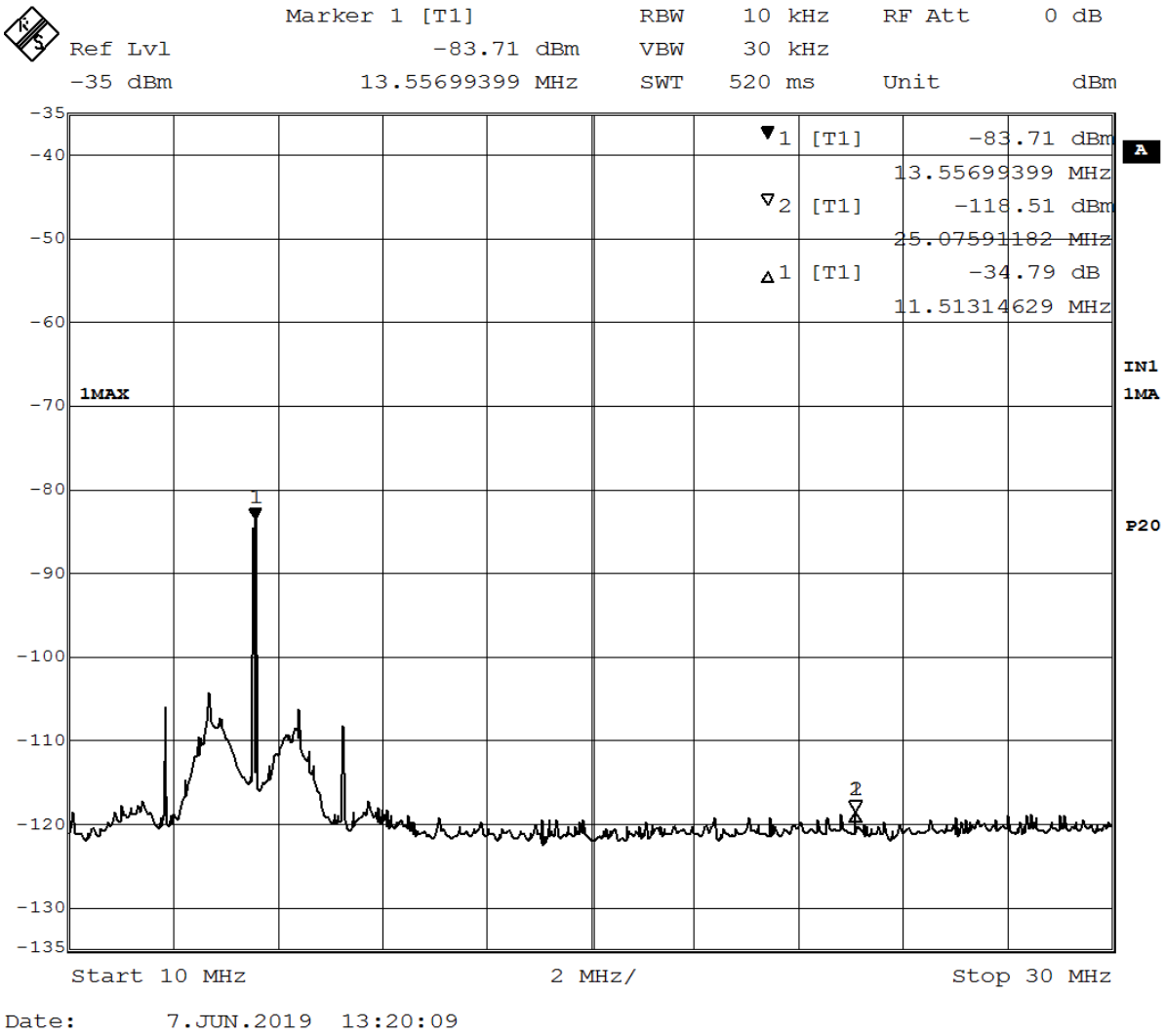

Figure 1 – Radiated Emissions Peak Plot, Horizontal Polarization, 10 MHz- 30 MHz

Limit: 30 µV/m at 30m = 29.54 dBµV/m = 59.08 dBµV/m at 1m

Maximum Spurious = 107 – FS(dBm) + CL + AF = 107 – 118.51 + 0.9 + 35 = 24.39 dBuV/m @ 1m

CL = cable loss = 0.90 dB
AF = antenna factor = 35.00 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system

Loop antenna was used in all three axis, worst axis is reported.

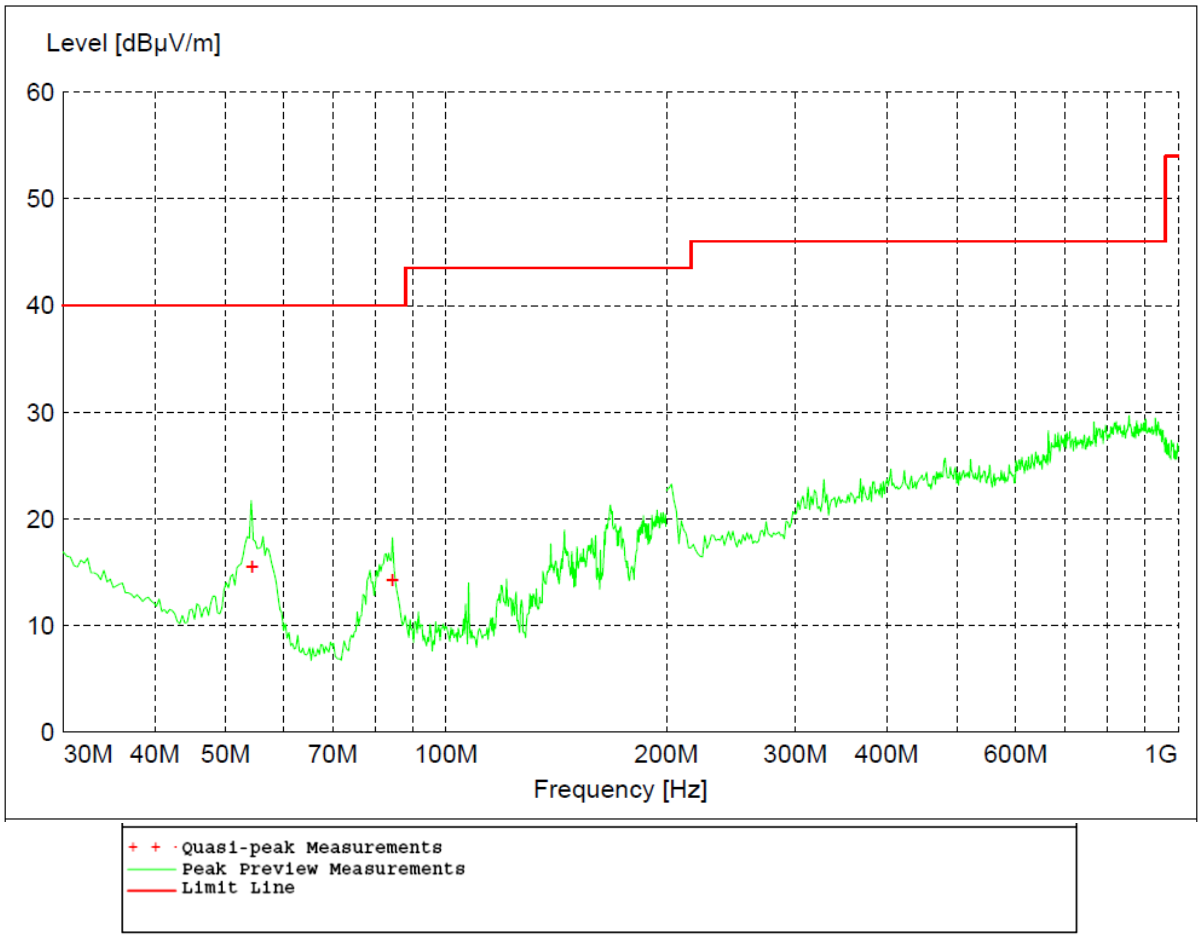

Figure 2 – Radiated Emissions Peak Plot, 30 MHz- 1 GHz

Table 3 – Radiated Emissions QP Data

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg	
54.360000	15.60	40.00	24.40	100	60	VERT
84.540000	14.27	40.00	25.70	156	330	VERT

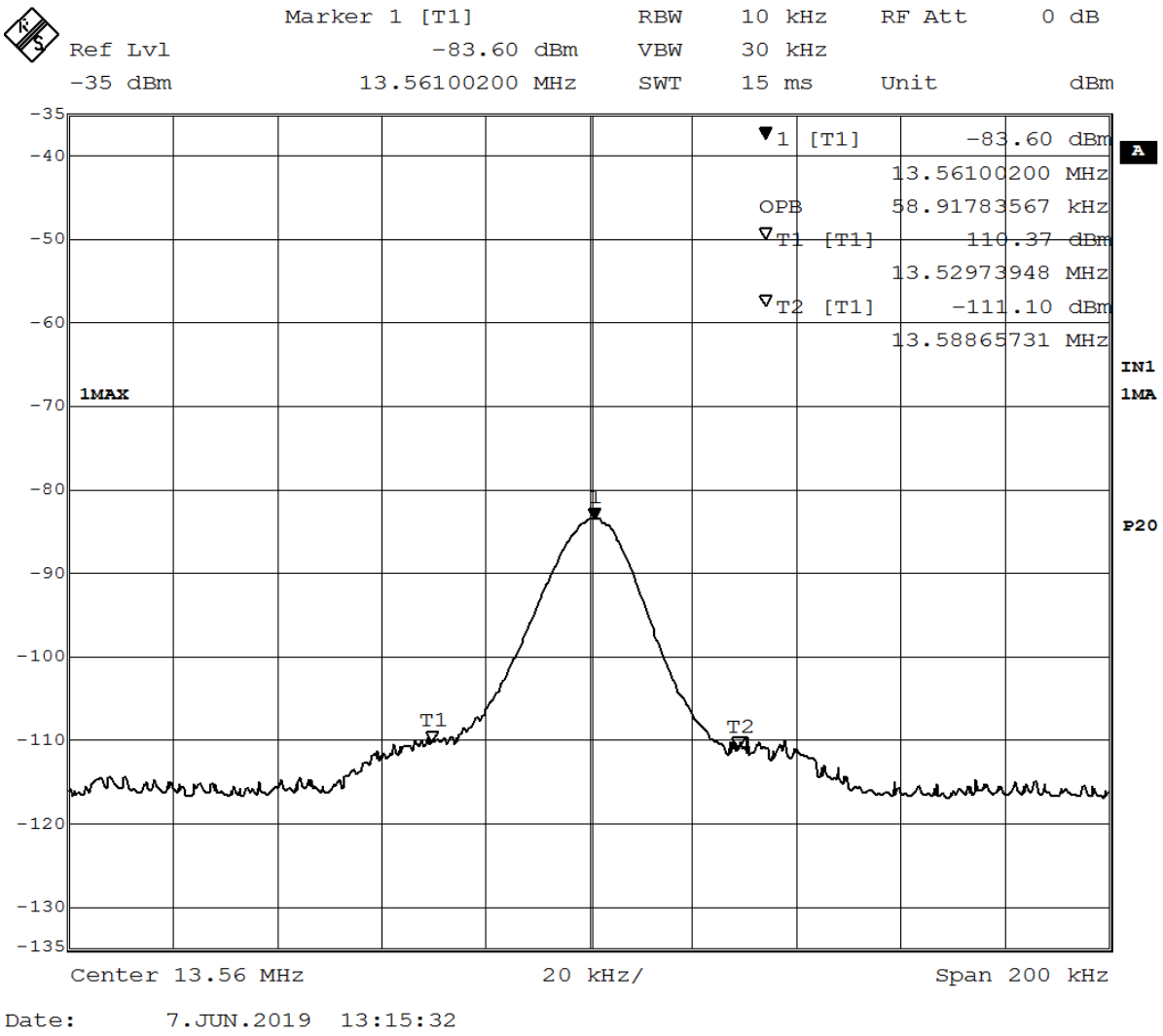

Figure 3 - 99% Occupied Bandwidth, NFC

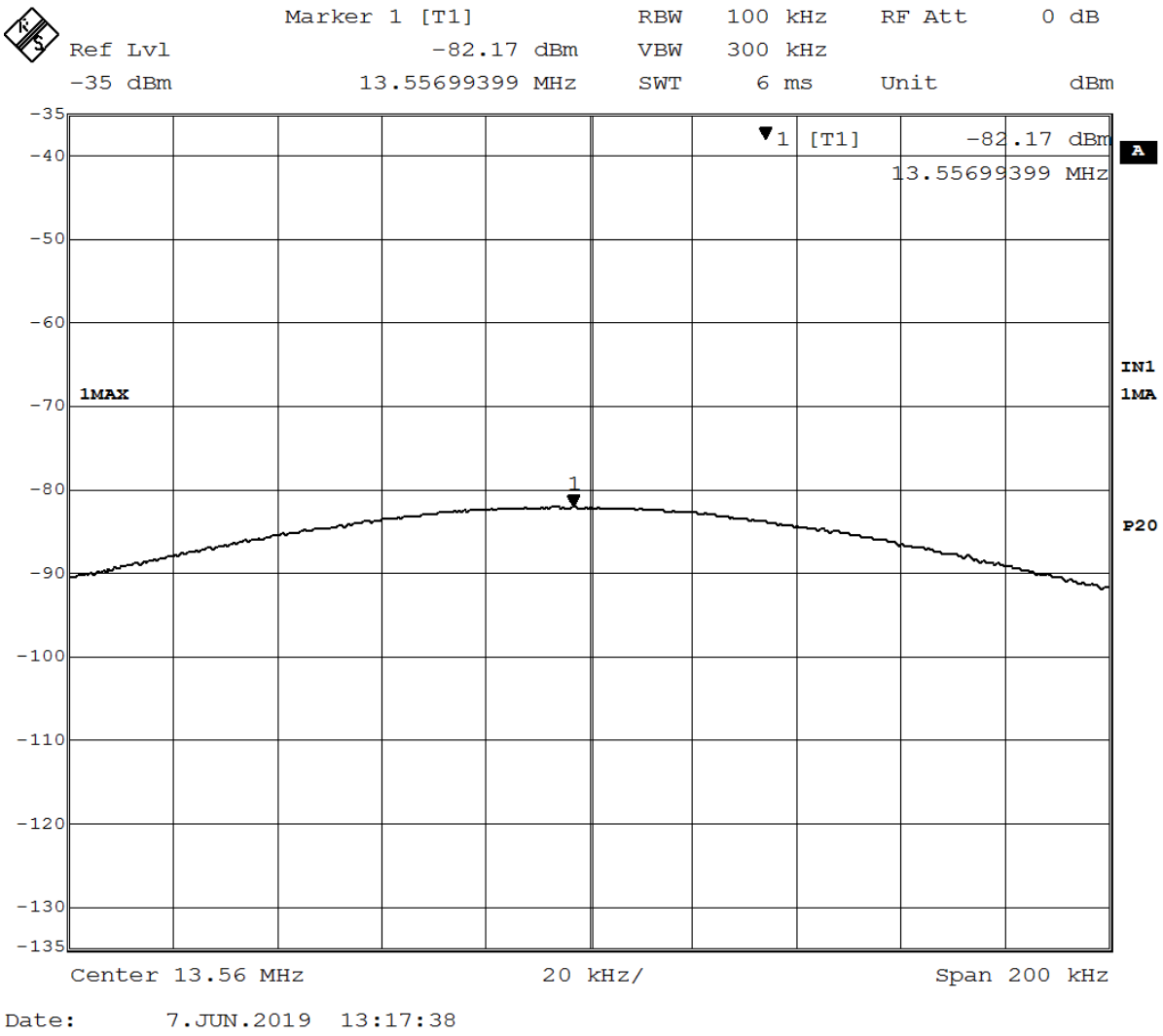

Figure 4 – Output Power, NFC

Figure 5 – Output Power

Raw band level dBm	Corrected band level dBµV/m	Limit	Margin	Result
-82.17	60.73	113.54*	52.81	PASS

Maximum power = 107 – 82.17 + 0.9 + 35 = 60.73 dBuV/m @ 1m
CL = cable loss = 0.90 dB
AF = antenna factor = 35.00 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system

* Extrapolated limit from 30 m to 1 m; Measurement performed at 1m distance.

Band Edge Measurements:

Band edge /Measurement Frequency (MHz)	Uncorrected band level dBµV	Corrected band level dBµV/m @ 1m	Limit	Margin	Result
13.11-13.41	-3.25	32.65	70.51*	37.86	PASS
13.41-13.553	17.25	53.15	80.02*	26.87	PASS
13.71-14.01	17.61	53.51	70.51*	17.00	PASS
13.567-13.71	-4.39	31.51	80.02*	48.51	PASS

* Extrapolated limit from 30 m to 1 m. Corrected band level = uncorrected band level + cable loss + antenna facor

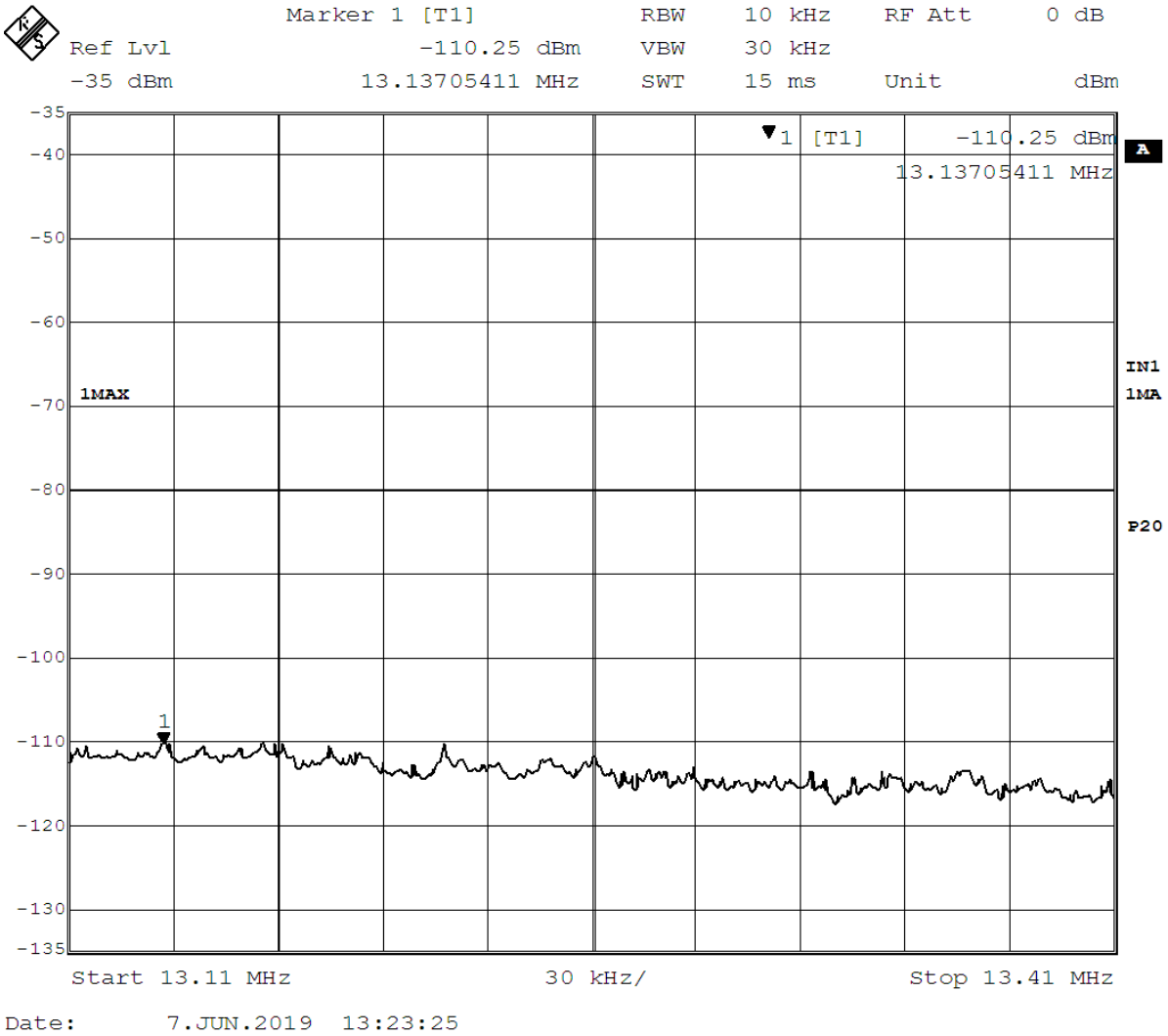

Figure 6 – Lower Bandedge

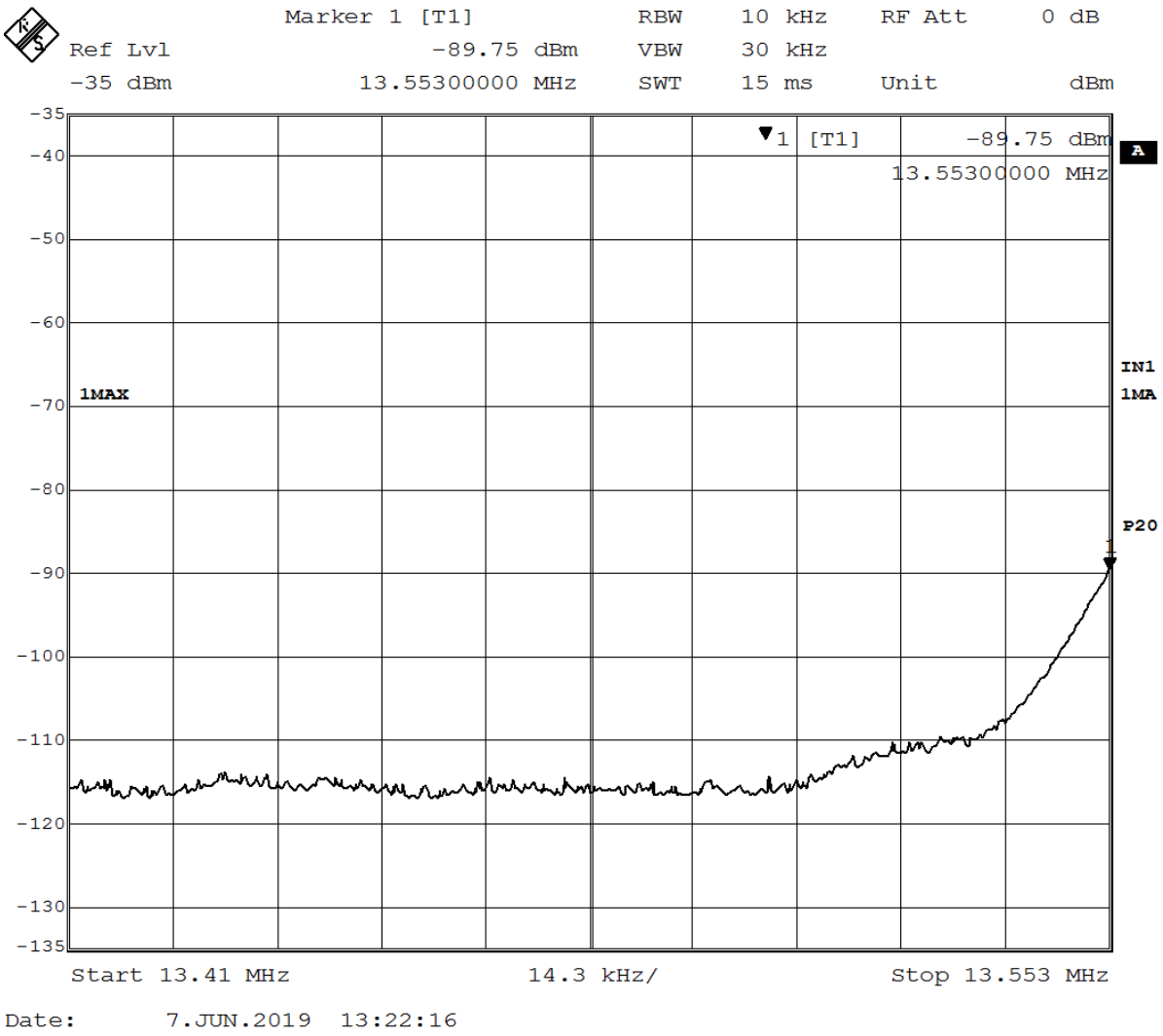

Figure 7 – Lower Bandedge

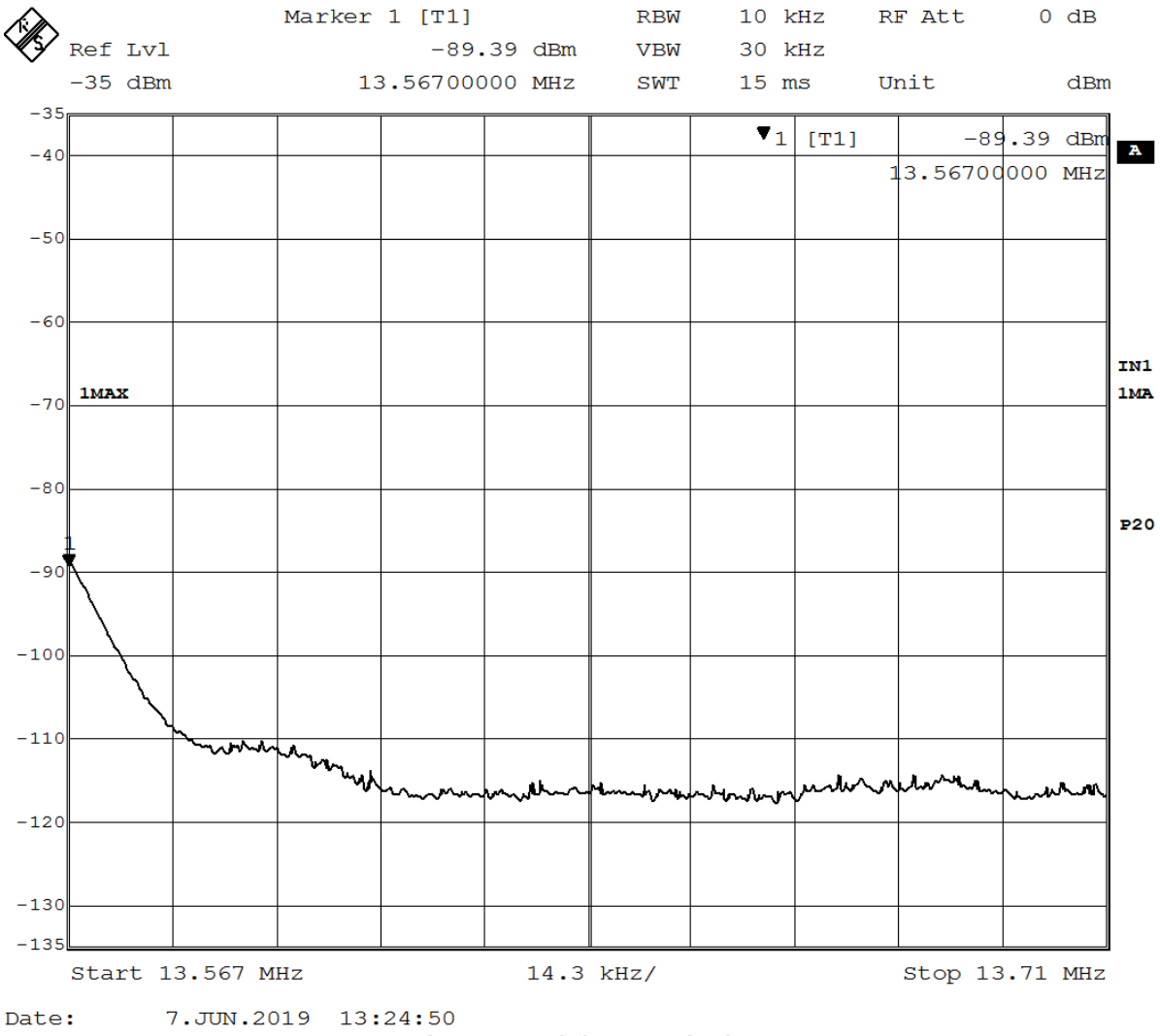

Figure 8 – Higher Band edge

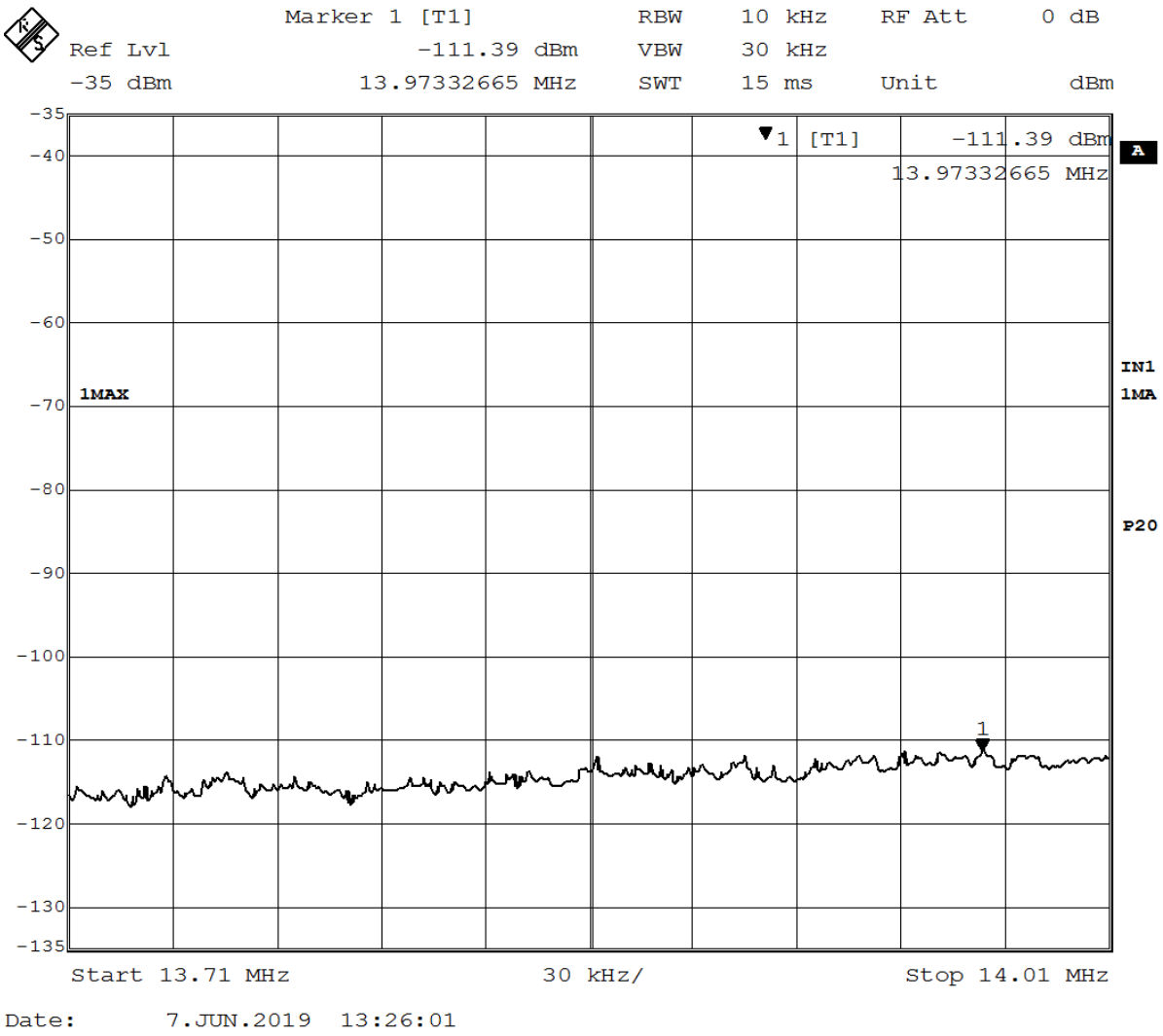

Figure 9 – Higher Band edge

3.2 Frequency Error

Test:	FCC Part 15.225 (e)		
Test Result:	Complies	**Date:**	6/21/2019

3.2.1 Test Description

Radiated power was measured on a spectrum analyzer with resolution bandwidth and video bandwidth set to 3 kHz and 10 kHz respectively. The center frequency was found by measuring the frequency of the signal 10dB below the peak on the high and low end of the signal. The frequency half way in between these frequencies was recorded as the center 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
100007	Rohde & Schwarz	ESIB7	EMI Test Receiver	2018 Jul 31
00024936	EMCO	6512	Loop Antenna	2018 Jan 30*
ID # 2130155	Omega	iTHX-SD	3m Temp. Humidity Meter	2018 Jan 31

*Two Year Calibration Cycle

3.2.6 Test results

Table 4 - Frequency Range Measurements

Temperature (°C)	Channel (MHz)
	13.56000 Nom.
-20°C	13.559970
-10°C	13.560000
0°C	13.560000
10°C	13.560000
20°C	13.560039
30°C	13.559970
40°C	13.560000
50°C	13.560000

Limit: 100 PPM

Table 5 - Voltage Range Measurements

Temperature (°C)	Voltage (VDC)	Channel (MHz)
		13.56000
20°C	3.20	13.55990982
20°C	3.90	13.55996994
20°C	4.75	13.56003900

Voltage ranges provided by the manufacturer, Limit: 100 PPM

3.3 Conducted Emissions

Test Method:	ANSI C63.10-2013, Section(s) 6.2		
Test Result:	Complies	**Date:**	6/7/2019

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^{o} C

3.3.4 Test Setup

To produce the highest possible emissions, the WiFi mode that produced the highest output power was set to transmit simultaneously. 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	26 Jul 2018
100037	Rohde & Schwarz	ES126	EMI Test Receiver	30 Jan 2018*
2575	Rohde & Schwarz	ES-K1	Software v.1.60	N/A

*Two Year Calibration Cycle

3.3.6 Test Pictures and/or Figures

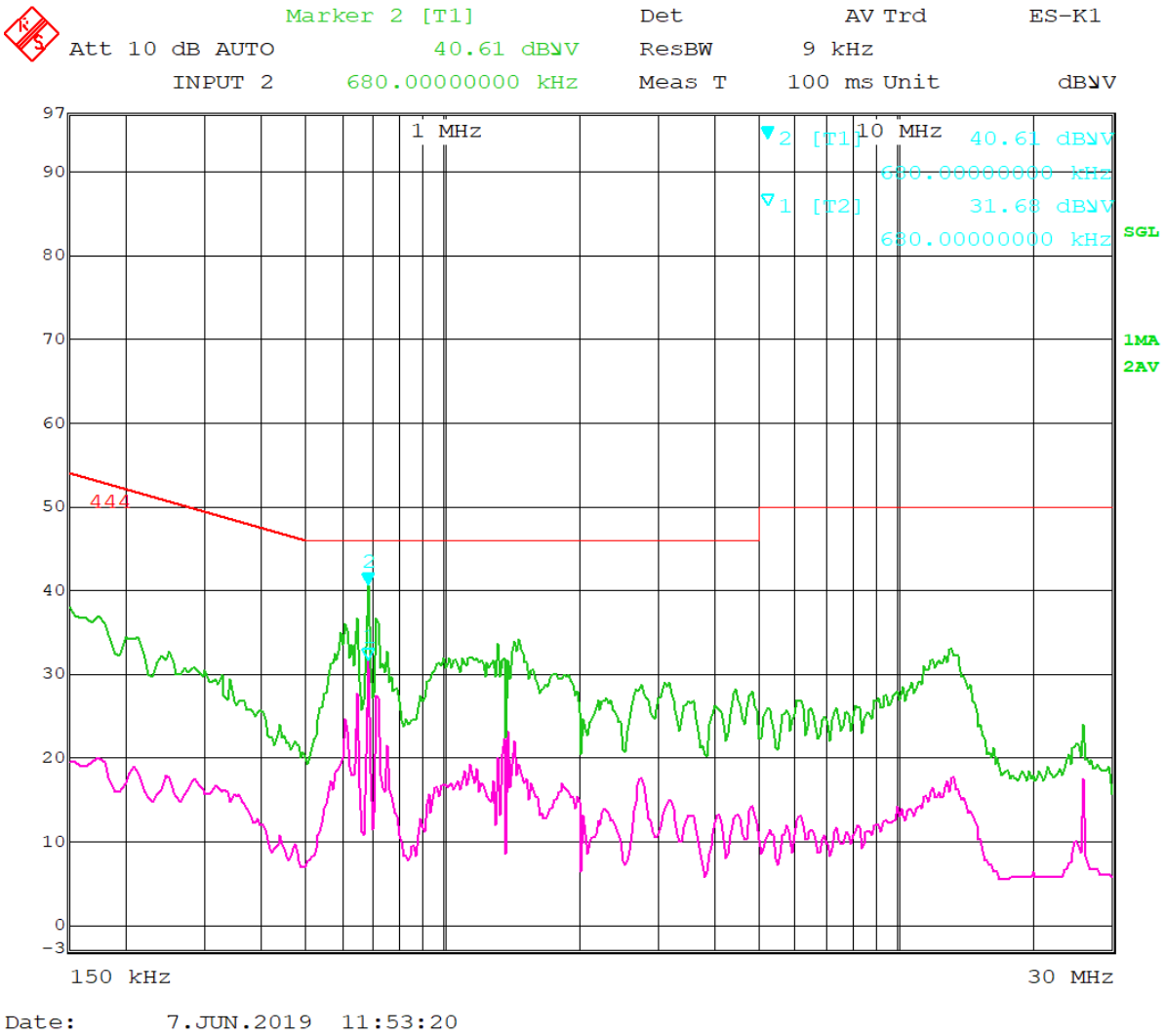

Figure 10 - Conducted Emissions, Line

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

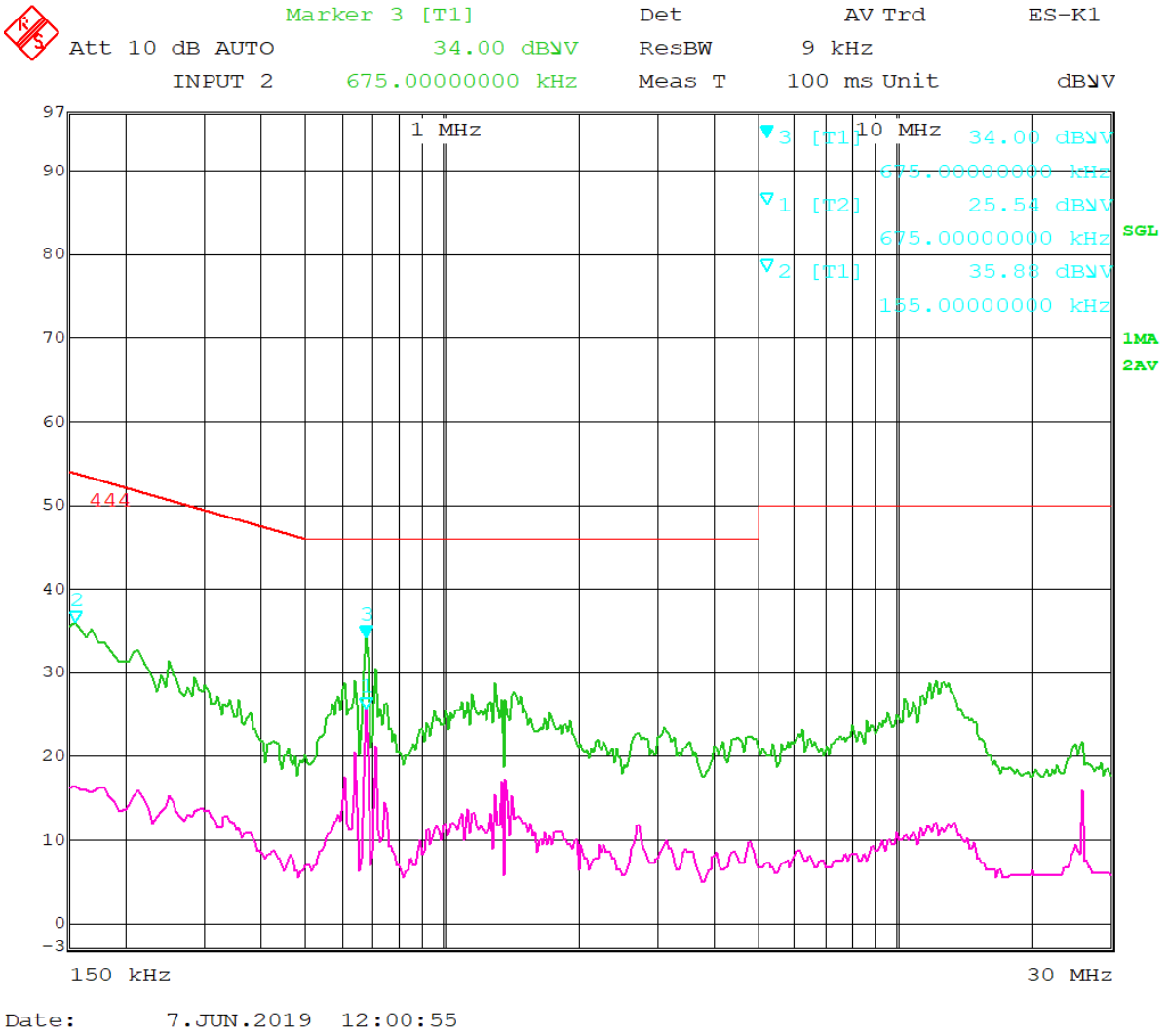

Figure 11 - Conducted Emissions, Neutral

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