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Cubic Transportation Systems Ltd.
TEST REPORT

SCOPE OF WORK
EMC TESTING FCC PART 15B, FCC PART 15.215, FCC PART 1 5.225, RSS-210: TR4

REPORT NUMBER
104085447LEX-002

ISSUE DATE

12/9/2019

PAGES
40

DOCUMENT CONTROL NUMBER
Non-Specific EMC Report Shell Rev. December 2017

EMC TEST REPORT

(FULL COMPLIANCE)

Report Number: 104085447LEX-002
Project Number: G104085447

Report Issue Date: 12/9/2019

Model(s) Tested: TR4

Standards: FCC Part 15.225
FCC Part 15.215
RSS-210 Issue 9
ICES-003 Issue 6

Tested by:
Intertek Testing Services NA, Inc.
731 Enterprise Dr.
Lexington, KY 40510
USA

Client:
Cubic Transportation Systems Ltd.
AFC House, Honeycrock Lane
Salfords, Redhill,
RH1 6LA, UK

Report prepared by

Carmen Davis, Project Engineer

Report reviewed by

Bryan Taylor, Team Lead-Engineering

Table of Contents

1 Introduction and Conclusion

The tests indicated in section 2.0 were performed on the product constructed as described in section 4.0. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test Method, a list of the actual Test Equipment Used, documentation Photos, Results and raw Data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested **complies** with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

2 Test Summary

Section	Test full name	Result
6	Radiated Emissions (Transmitters Idle) (ANSI C63.4:2014)	Pass
7	Radiated Spurious Emissions (Transmitters Active) (ANSI C63.10:2013, RSS-210 Issue 9)	Pass
8	Conducted Emissions (ANSI C63.10:2013, ANSI C63.4:2014)	Pass
9	Frequency Stability (ANSI C63.10:2013, RSS-210-Issue 9)	Pass
10	Occupied Bandwidth (ANSI C63.10:2013, RSS-Gen Issue 5)	Pass
11	Antenna Requirement (FCC Part 15.203, RSS-Gen Issue 5)	Pass

3 Client Information

This product was tested at the request of the following:

Client Information	
Client Name:	Cubic Transportation Systems Ltd.
Address:	AFC House, Honeycrock Lane Salfords, Redhill, RH1 6LA, UK
Contact:	Chris Curtin
Email:	Chris.Curtin@cubic.com
Manufacturer Information	
Manufacturer Name:	Cubic Transportation Systems Inc.
Manufacturer Address:	1308 South Washington Street, Tullahoma, TN 37388 USA

4 Description of Equipment under Test and Variant Models

Equipment Under Test	
Product Name	TR4
Model Number	4400-10006-21
Serial Number	PF0003
Receive Date	9/30/2019
Test Start Date	10/16/2019
Test End Date	10/24/2019
Device Received Condition	Good
Test Sample Type	Production
Power Ratings	24VDC
Transmit Frequency	13.56MHz

Description of Equipment Under Test (provided by client)

The TR4 (the equipment under test) is a contactless reader designed and developed by Cubic Transportation Systems. It is intended to read ISO/IEC 14443 compliant contactless media from a patron intending to use and pay for public transport. The information read is processed on the device for use in an open or closed loop payment system connected to the transit operator's transportation network.

4.1 Variant Models:

Customer states that Model No: 4400-10006-11 is equivalent to the sample tested. The variation is with color of the sample and test software used to operate the sample.

5 System Setup and Method

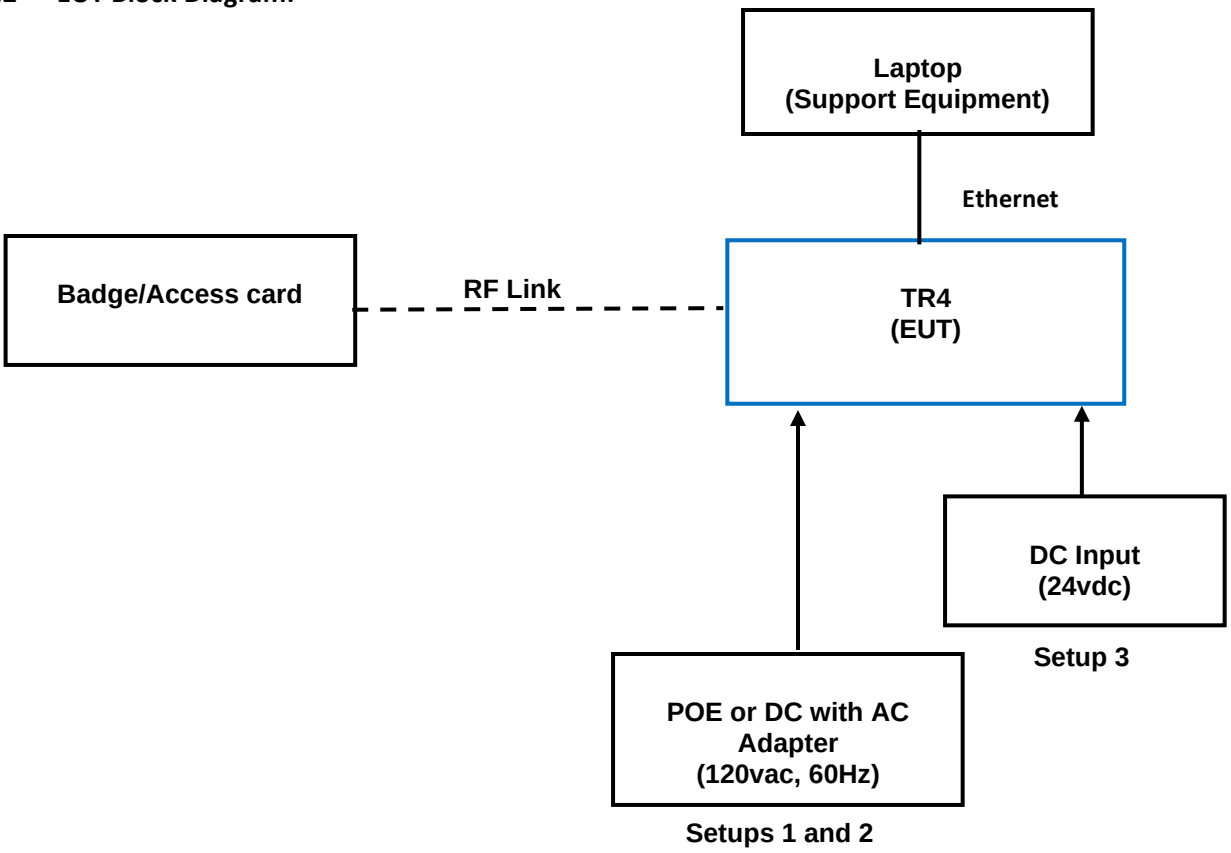
5.1 Method:

Configuration as required by ANSI C63.4:2014 and ANSI C63.10:2013.

No.	Descriptions of EUT Exercising
1	During the testing the TR4 was transmitting a 13.56MHz RFID signal with a tag present.
2	Idle mode with the RFID radio not transmitting.

Cables					
ID	Description	Length (m)	Shielding	Ferrites	Termination
1	24vDC	0.5	None	None	DC power supply
2	Power over Ethernet (POE)	2	None	None	AC Mains and Ethernet 1 and 2
3	Ethernet 1	2	None	None	POE to Laptop
4	Ethernet 2	2	None	None	POE to EUT
5	Ethernet 3	2	None	None	EUT to Laptop

5.2 EUT Block Diagram:



6 Radiated Emissions

6.1 Method

Tests are performed in accordance with ANSI C63.4:2014.

TEST SITE: 10m ALSE

Site Designation: 10m Chamber

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 10m	30-1000 MHz	3.9dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	4.0dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.7dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	4.7dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	4.7dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	4.7dB	5.5 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required.

6.2 Sample Calculation

The field strength is calculated 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 = RA + AF + CF - AG

Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
$UF = 10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

6.3 Test Equipment Used:

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
EMI Test Receiver	3900	Rohde & Schwarz	ESU40	9/18/2019	9/18/2020
Bilog Antenna	7088	SunAR	JB6	8/8/2019	8/8/2020
System Controller	3957	Sunol Sciences	SC99V	Verify at Time of Use	Verify at Time of Use
Coaxial Cable	3339			11/26/2018	11/26/2019
Coaxial Cable	2593			11/26/2018	11/26/2019
Coaxial Cable	2592			11/26/2018	11/26/2019

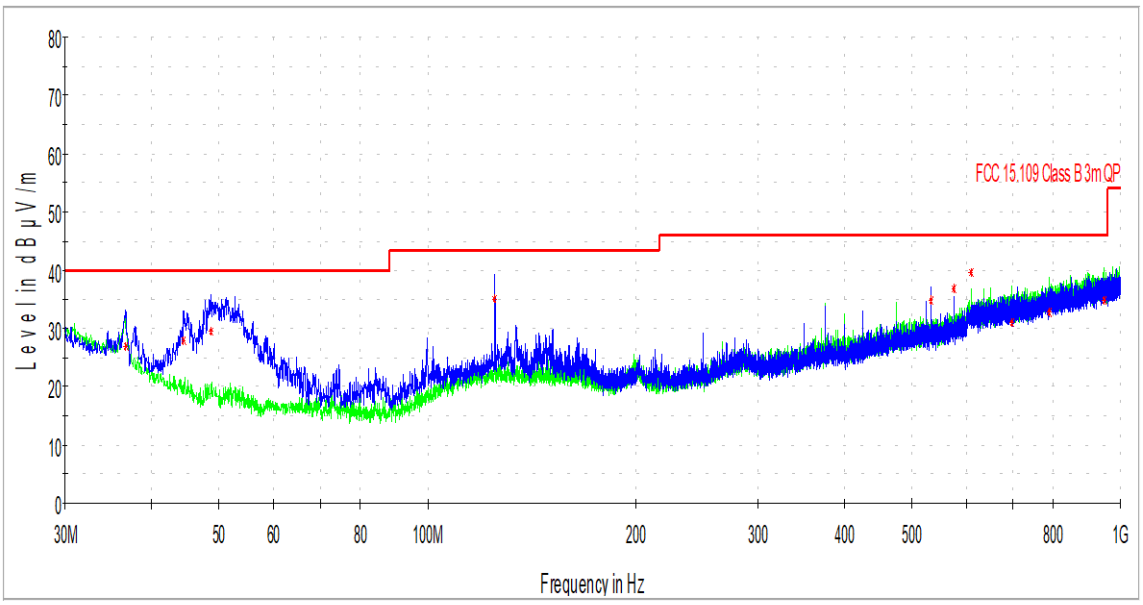
6.4 Software Utilized:

Name	Manufacturer	Version
EMC32	Rohde & Schwarz	Version 9.15.02

6.5 Results:

The sample tested was found to Comply.

6.6 Plots/Data: Radiated Emissions, 30MHz – 1GHz (Transmitter Idle_ POE)

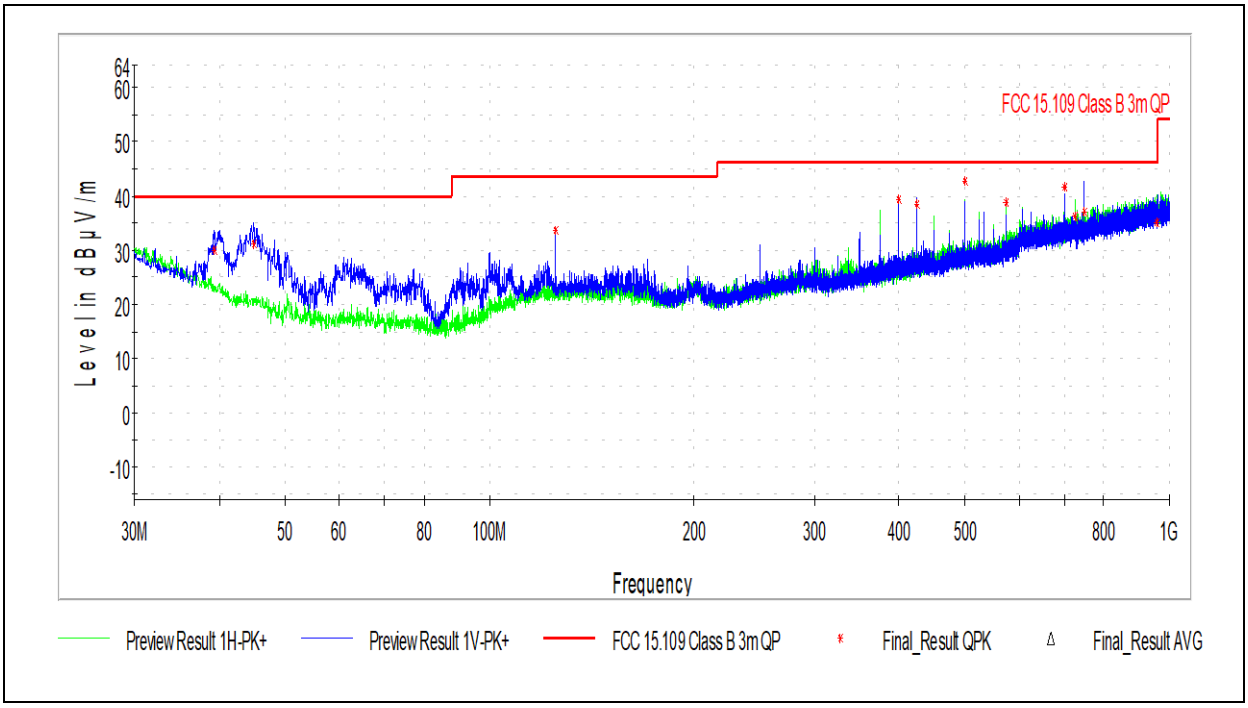


Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
36.736111	26.95	40.00	13.05	120.000	165.6	V	176.0	22.8
44.496111	27.99	40.00	12.01	120.000	99.9	V	-1.0	17.7
48.699445	29.55	40.00	10.45	120.000	100.3	V	35.0	15.9
125.006111	34.95	43.52	8.57	120.000	100.4	V	83.0	22.0
532.998889	34.76	46.02	11.26	120.000	107.1	V	329.0	28.1
574.978333	36.70	46.02	9.32	120.000	106.5	V	285.0	28.9
608.012222	39.55	46.02	6.47	120.000	100.3	H	219.0	30.2
697.306111	31.04	46.02	14.98	120.000	285.2	H	228.0	31.3
790.641667	32.65	46.02	13.37	120.000	399.9	H	274.0	33.0
946.865556	34.68	46.02	11.34	120.000	142.5	H	275.0	34.7

Test Personnel:	Carmen Davis	Test Date:	10/04/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	FCC Part 15.109
Product Standard:	FCC Part 15B, ICES-003 Issue 6	Ambient Temperature:	25°C
Input Voltage:	Power Over Ethernet (POE)	Relative Humidity:	37.3%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	990.1mbar

Deviations, Additions, or Exclusions: None

6.7 Plots/Data: Radiated Emissions, 30MHz – 1GHz (Transmitter Idle_24VDC Input)



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
39.376667	30.01	40.00	9.99	120.000	105.3	V	5.0	21.0
44.927222	31.03	40.00	8.97	120.000	105.0	V	290.0	17.5
125.006111	33.73	43.52	9.79	120.000	100.2	V	35.0	22.0
400.001111	39.19	46.02	6.83	120.000	100.1	V	248.0	25.4
425.005556	38.43	46.02	7.59	120.000	165.6	V	264.0	25.9
500.018889	42.73	46.02	3.29	120.000	190.0	H	319.0	28.0
574.978333	38.87	46.02	7.15	120.000	166.3	H	100.0	29.5
700.000556	41.50	46.02	4.52	120.000	104.7	V	292.0	30.9
724.951111	36.12	46.02	9.90	120.000	249.4	H	251.0	31.7
750.063333	36.97	46.02	9.05	120.000	99.6	V	303.0	31.3
957.158333	34.98	46.02	11.04	120.000	153.9	H	45.0	34.9

Test Personnel:	Carmen Davis	Test Date:	10/09/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	FCC Part 15.109
Product Standard:	FCC Part 15B, ICES-003 Issue 6	Ambient Temperature:	25°C
Input Voltage:	24VDC	Relative Humidity:	37.3%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	990.1mbar

Deviations, Additions, or Exclusions: None

7 Radiated Emissions (RFID)

7.1 Method

Tests are performed in accordance with ANSI C63.10:2013.

TEST SITE: 10m ALSE

Site Designation: 10m Chamber

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 10m	30-1000 MHz	3.9dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	4.0dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.7dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	4.7dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	4.7dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	4.7dB	5.5 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required.

7.2 Sample Calculation

The field strength is calculated 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 = RA + AF + CF - AG

Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
$UF = 10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

7.3 Test Equipment Used:

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
EMI Test Receiver	3900	Rohde & Schwarz	ESU40	9/18/2019	9/18/2020
Magnetic Loop Antenna	2366	ETS	6502	6/11/2019	6/11/2020
Bilog Antenna	7088	SunAR	JB6	8/8/2019	8/8/2020
System Controller	3957	Sunol Sciences	SC99V	Verify at Time of Use	Verify at Time of Use
Coaxial Cable	3339			11/26/2018	11/26/2019
Coaxial Cable	2593			11/26/2018	11/26/2019
Coaxial Cable	2592			11/26/2018	11/26/2019

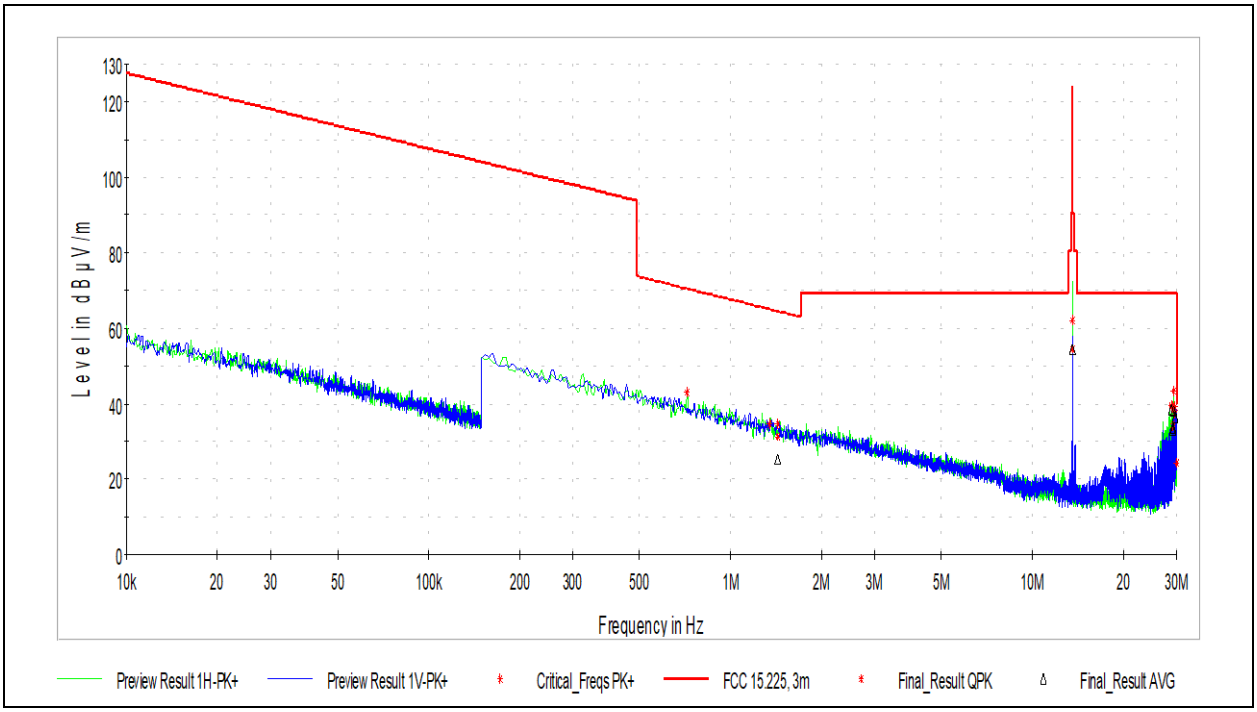
7.4 Software Utilized:

Name	Manufacturer	Version
EMC32	Rohde & Schwarz	Version 9.15.02

7.5 Results:

The sample tested was found to Comply.

7.6 Radiated Spurious Emissions (Below 30MHz_24V DC Input)



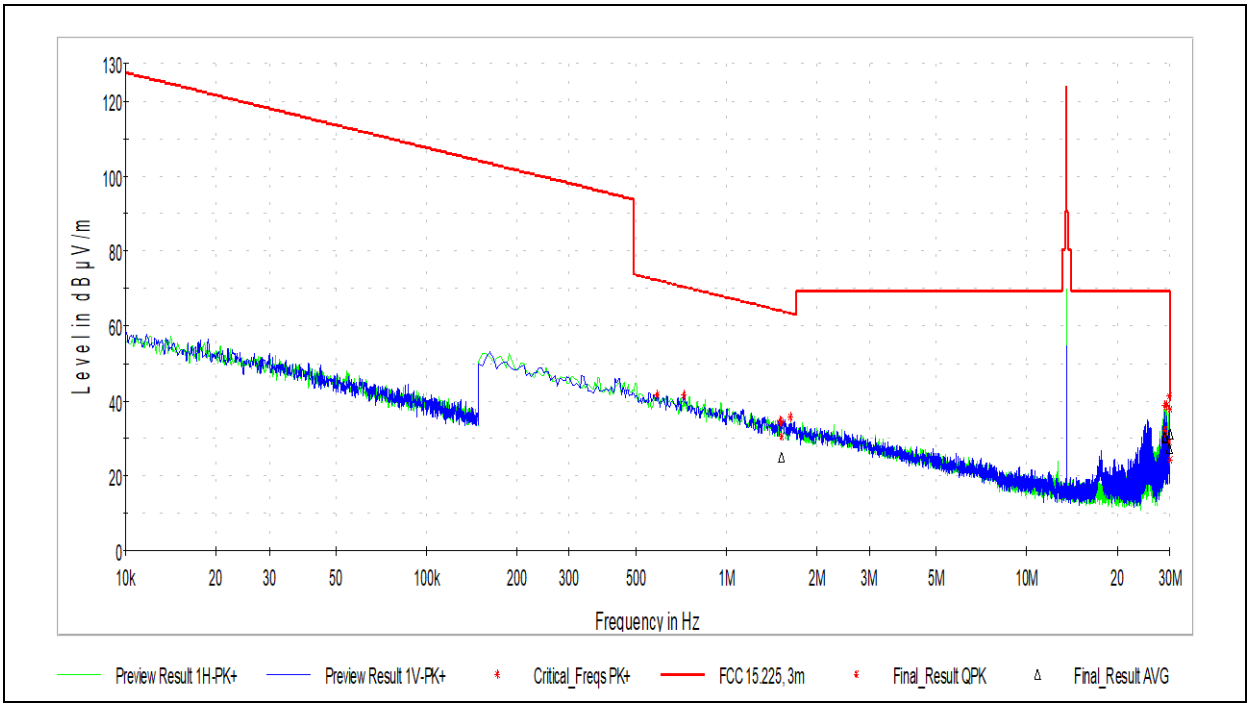
Frequency (MHz)	Peak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Azimuth (deg)	Corr. (dB)
1.431794	31.09	64.51	33.42	9.000	92.0	12.6
13.551772	54.42	90.50	36.08	9.000	8.0	11.5
28.792831	39.06	69.50	30.44	9.000	77.0	9.3
29.130838	34.60	69.50	34.90	9.000	41.0	9.2
29.223022	33.68	69.50	35.82	9.000	40.0	9.2
29.284478	38.30	69.50	31.20	9.000	93.0	9.2
29.587368	37.10	69.50	32.40	9.000	42.0	9.1

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Azimuth (deg)	Corr. (dB)
1.431794	25.41	64.51	39.10	9.000	92.0	12.6
13.551772	54.45	90.50	36.05	9.000	8.0	11.5
28.792831	38.47	69.50	31.03	9.000	77.0	9.3
29.130838	33.78	69.50	35.72	9.000	41.0	9.2
29.223022	32.97	69.50	36.53	9.000	40.0	9.2
29.284478	38.03	69.50	31.47	9.000	93.0	9.2
29.587368	36.40	69.50	33.10	9.000	42.0	9.1

Test Personnel:	Carmen Davis	Test Date:	10/9/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	FCC Part 15.225
Product Standard:	FCC Part 15C RSS-210 Issue 9	Ambient Temperature:	26.3°C
Input Voltage:	24VDC	Relative Humidity:	48.2%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	987.5mbar

Deviations, Additions, or Exclusions: None

7.7 Radiated Spurious Emissions (Below 30MHz_POE)



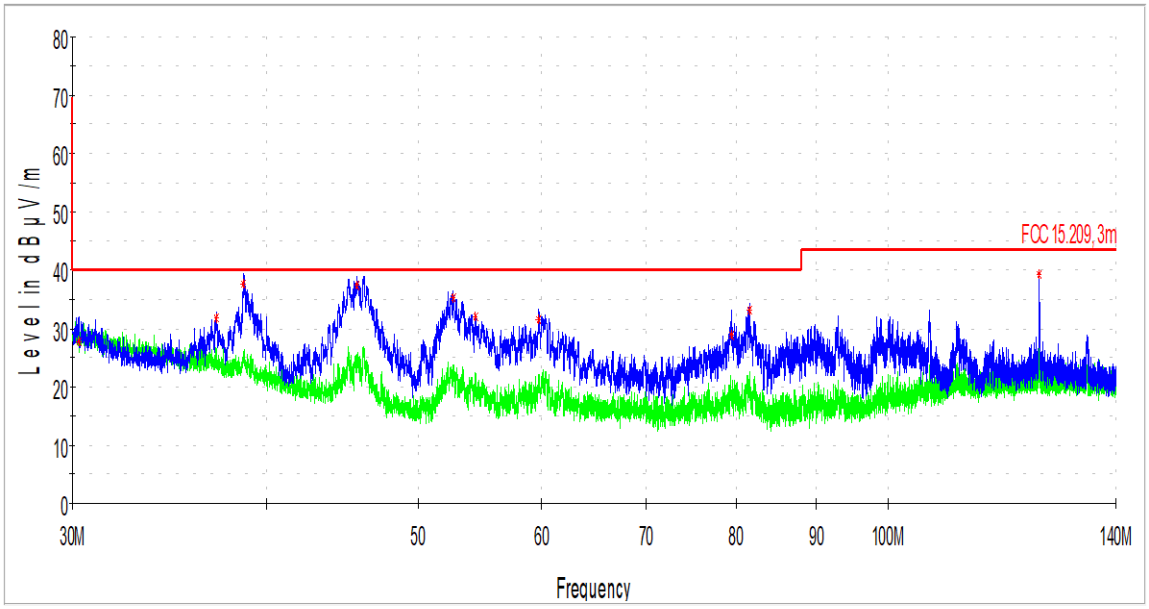
Frequency (MHz)	Peak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Azimuth (deg)	Corr. (dB)
1.523978	30.64	63.97	33.33	9.000	132.0	12.5
13.551772	54.42	90.50	36.08	9.000	8.0	11.5
28.792831	32.15	69.50	37.35	9.000	72.0	9.3
28.854287	31.06	69.50	38.44	9.000	92.0	9.3
29.894647	29.09	69.50	40.41	9.000	0.0	9.0
30.000000	37.72	40.00	2.28	120.000	1.0	9.0

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Azimuth (deg)	Corr. (dB)
1.523978	24.79	63.97	39.18	9.000	132.0	12.5
13.551772	54.45	90.50	36.05	9.000	8.0	11.5
28.792831	30.35	69.50	39.15	9.000	72.0	9.3
28.854287	30.05	69.50	39.45	9.000	92.0	9.3
29.894647	27.39	69.50	42.11	9.000	0.0	9.0
30.000000	31.10	69.50	38.40	120.000	1.0	9.0

Test Personnel:	Carmen Davis	Test Date:	10/9/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	FCC Part 15.225
Product Standard:	FCC Part 15C RSS-210 Issue 9	Ambient Temperature:	26.3°C
Input Voltage:	24VDC	Relative Humidity:	48.2%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	987.5mbar

Deviations, Additions, or Exclusions: None

7.8 Radiated Spurious Emissions (30MHz – 140MHz_POE)

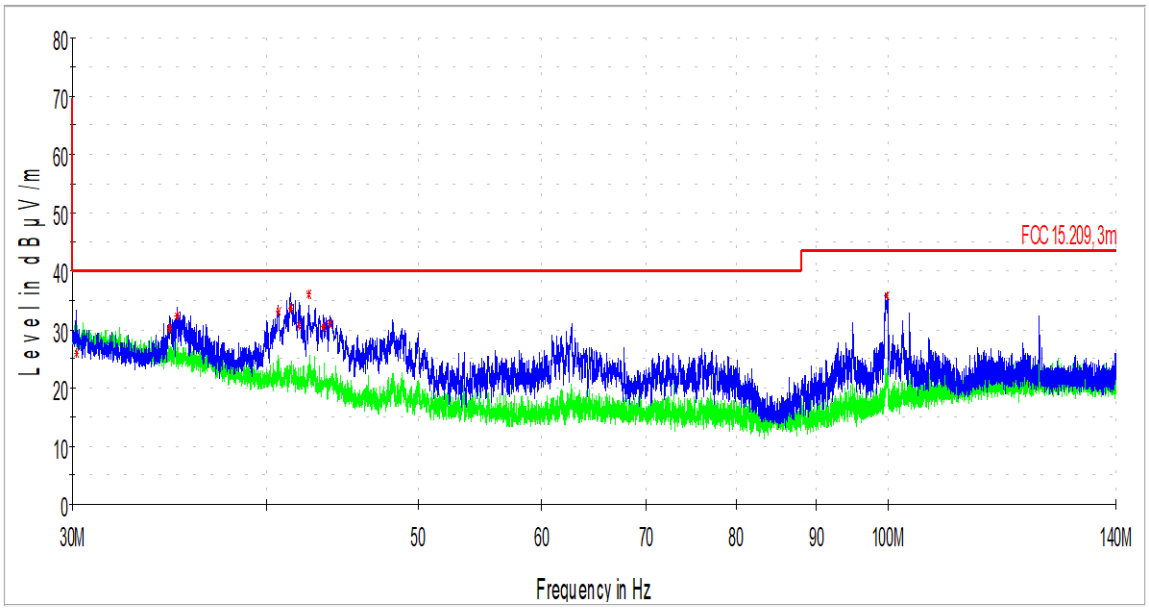


Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
30.275000	27.77	40.00	12.23	120.000	106.5	V	81.0	27.3
37.095000	31.81	40.00	8.19	120.000	100.2	V	28.0	22.6
38.628889	37.73	40.00	2.27	120.000	100.4	V	81.0	21.5
45.675000	37.34	40.00	2.66	120.000	100.4	V	136.0	17.1
52.678333	35.23	40.00	4.77	120.000	100.3	V	99.0	14.8
54.413889	32.03	40.00	7.97	120.000	100.1	V	72.0	14.8
59.730556	31.51	40.00	8.49	120.000	100.1	V	90.0	14.1
79.335000	28.82	40.00	11.18	120.000	105.4	V	201.0	15.1
81.480000	33.09	40.00	6.91	120.000	104.8	V	230.0	15.4
125.003333	39.25	43.52	4.27	120.000	100.1	V	26.0	22.0

Test Personnel:	Bryan Taylor	Test Date:	9/9/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	FCC Part 15.209
Product Standard:	FCC Part 15C RSS-210 Issue 9	Ambient Temperature:	26.9°C
Input Voltage:	POE	Relative Humidity:	41.3 %
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	987.3 mbar

Deviations, Additions, or Exclusions: None

7.9 Radiated Spurious Emissions (30MHz – 140MHz_24V DC Input)



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
30.165000	25.93	40.00	14.07	120.000	100.4	V	0.0	27.4
34.644445	30.19	40.00	9.81	120.000	104.7	V	0.0	24.1
34.992778	32.38	40.00	7.62	120.000	100.4	V	0.0	23.9
40.651667	33.07	40.00	6.93	120.000	104.9	V	294.0	20.2
41.397222	33.66	40.00	6.34	120.000	110.0	V	44.0	19.6
41.898333	30.61	40.00	9.39	120.000	99.8	V	0.0	19.3
42.527778	35.95	40.00	4.05	120.000	100.3	V	90.0	18.8
43.456667	30.40	40.00	9.60	120.000	99.5	V	0.0	18.2
43.878333	30.91	40.00	9.09	120.000	105.0	V	254.0	18.0
99.886667	35.62	43.52	7.90	120.000	100.3	V	17.0	19.2

Test Personnel:	Bryan Taylor	Test Date:	9/9/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	FCC Part 15.209
Product Standard:	FCC Part 15C RSS-210 Issue 9	Ambient Temperature:	26.9°C
Input Voltage:	24VDC	Relative Humidity:	41.3 %
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	987.3 mbar

Deviations, Additions, or Exclusions: None

8 Conducted Emissions

8.1 Method

Tests are performed in accordance with ANSI C63.4:2014 and ANSI C63.10: 2013.

TEST SITE: Ground Plane

Site Designation: Ground Plane

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
AC Line Conducted Emissions	150 kHz - 30 MHz	3.1dB	3.4dB

As shown in the table above our conducted emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required.

8.2 Sample Calculations

The following is how net line-conducted readings were determined:

NF = RF + LF + CF + AF
Where NF = Net Reading in dBμV
RF = Reading from receiver in dBμV
LF = LISN or ISN Correction Factor in dB
CF = Cable Correction Factor in dB
AF = Attenuator Loss Factor in dB

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

NF = RF + LF + CF + AF = 28.5 + 0.2 + 0.4 + 20.0 = 49.1 dBμV
$UF = 10^{(49.1\ dB\mu V / 20)}$ = 285.1 μV/m

8.3 Test Equipment Used:

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
EMI Test Receiver	3900	Rohde & Schwarz	ESU40	9/18/2019	9/18/2020
LISN	3333	Teseq	NNB52	4/16/2019	4/16/2020
Coaxial Cable (COND 3)	7024			11/26/2018	11/26/2019

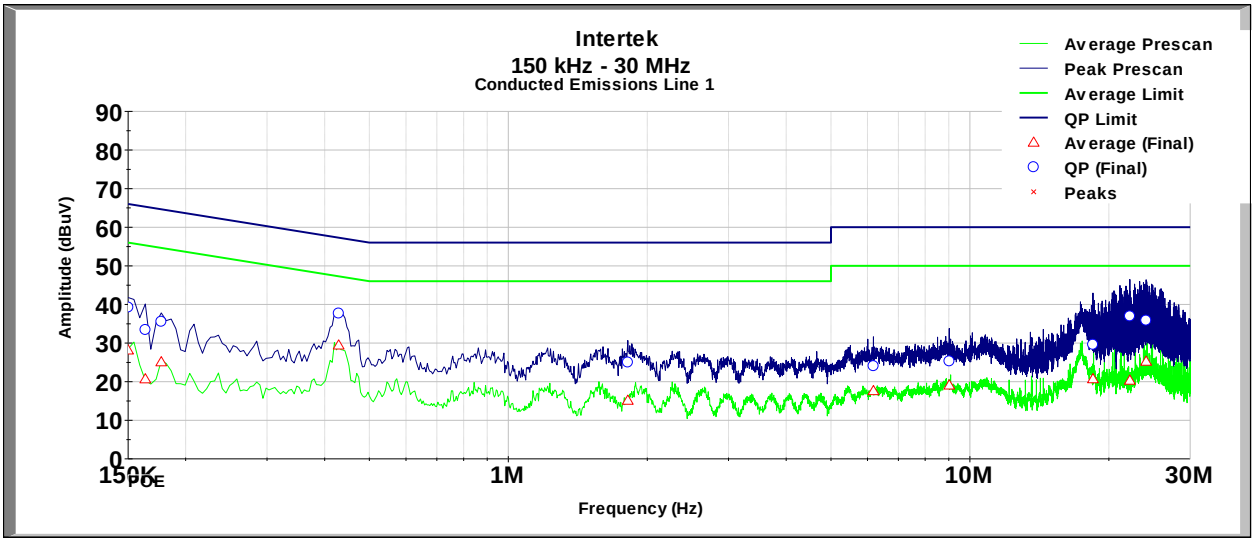
8.4 Software Utilized:

Name	Manufacturer	Version
TILE	ETS Lindgren	V7.0.6.545

8.5 Results:

The sample tested was found to Comply.

8.6 Plots/Data: Conducted Emissions (Line, Idle) POE

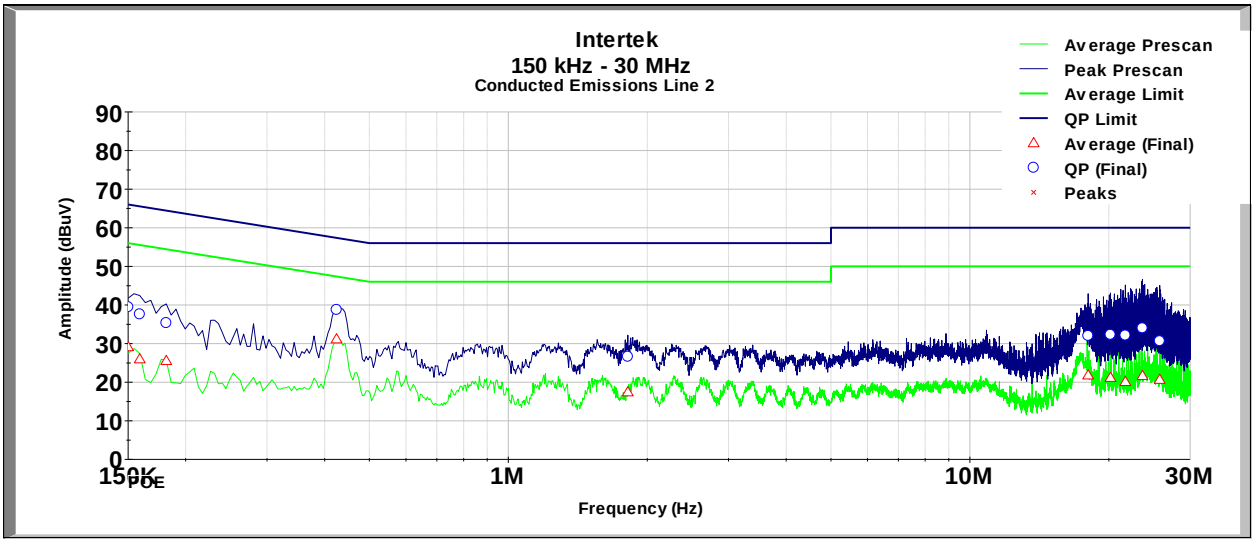


Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.150	39.243	66.000	26.757	28.142	56.000	27.858
0.164	33.417	65.614	32.197	20.669	55.614	34.945
0.177	35.543	65.229	29.685	25.091	55.229	30.138
0.429	37.665	58.029	20.363	29.437	48.029	18.591
1.815	24.997	56.000	31.003	15.132	46.000	30.868
6.180	24.055	60.000	35.945	17.609	50.000	32.391
9.025	25.278	60.000	34.722	19.080	50.000	30.920
18.477	29.576	60.000	30.424	20.700	50.000	29.300
22.212	36.939	60.000	23.061	20.320	50.000	29.680
24.090	35.841	60.000	24.159	25.232	50.000	24.768

Test Personnel:	Carmen Davis	Test Date:	10/10/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207
Product Standard:	FCC Part 15B ICES-003 Issue 6	Ambient Temperature:	23.4°C
Input Voltage:	Power Over Ethernet (POE)	Relative Humidity:	44.9%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	985mbar

Deviations, Additions, or Exclusions: None

8.7 Plots/Data: Conducted Emissions (Neutral, Idle) POE

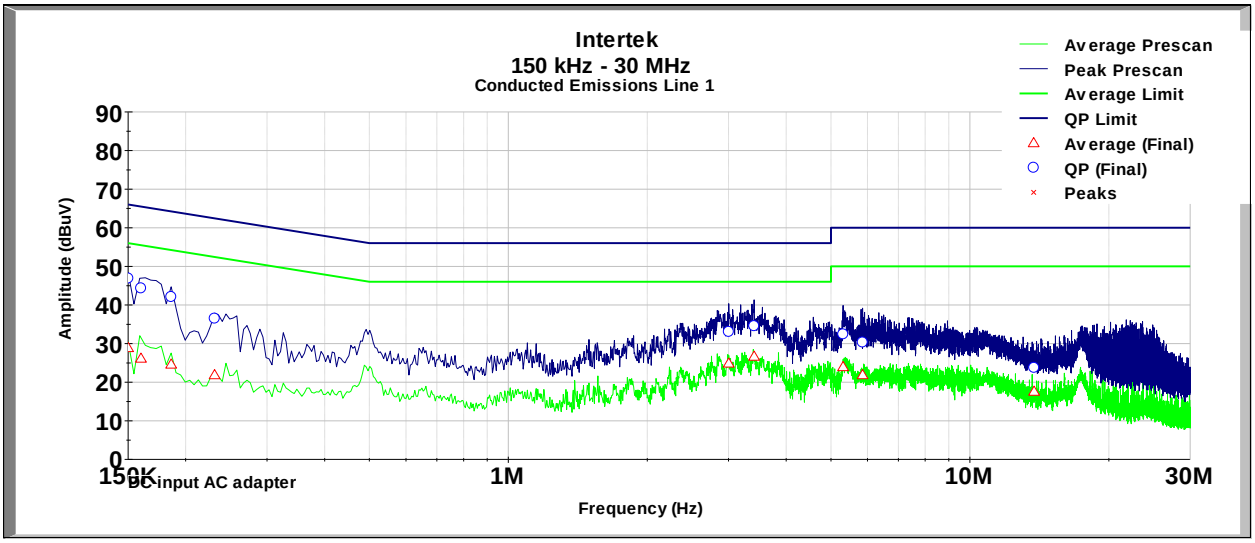


Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.150	39.468	66.000	26.532	29.146	56.000	26.854
0.159	37.596	65.743	28.147	26.003	55.743	29.739
0.181	35.337	65.100	29.763	25.554	55.100	29.546
0.424	38.736	58.157	19.421	31.172	48.157	16.985
1.815	26.617	56.000	29.383	17.444	46.000	28.556
18.045	32.008	60.000	27.992	21.815	50.000	28.185
20.169	32.280	60.000	27.720	21.184	50.000	28.816
21.717	32.104	60.000	27.896	20.114	50.000	29.886
23.654	33.989	60.000	26.011	21.669	50.000	28.331
25.773	30.655	60.000	29.345	20.675	50.000	29.325

Test Personnel:	Carmen Davis	Test Date:	10/10/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207
Product Standard:	FCC Part 15B ICES-003 Issue 6	Ambient Temperature:	23.4°C
Input Voltage:	120VAC / 60Hz into power adapter powering the device	Relative Humidity:	44.9%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	985mbar

Deviations, Additions, or Exclusions: None

8.8 Plots/Data: Conducted Emissions (Line, Idle) DC Input with AC Adapter

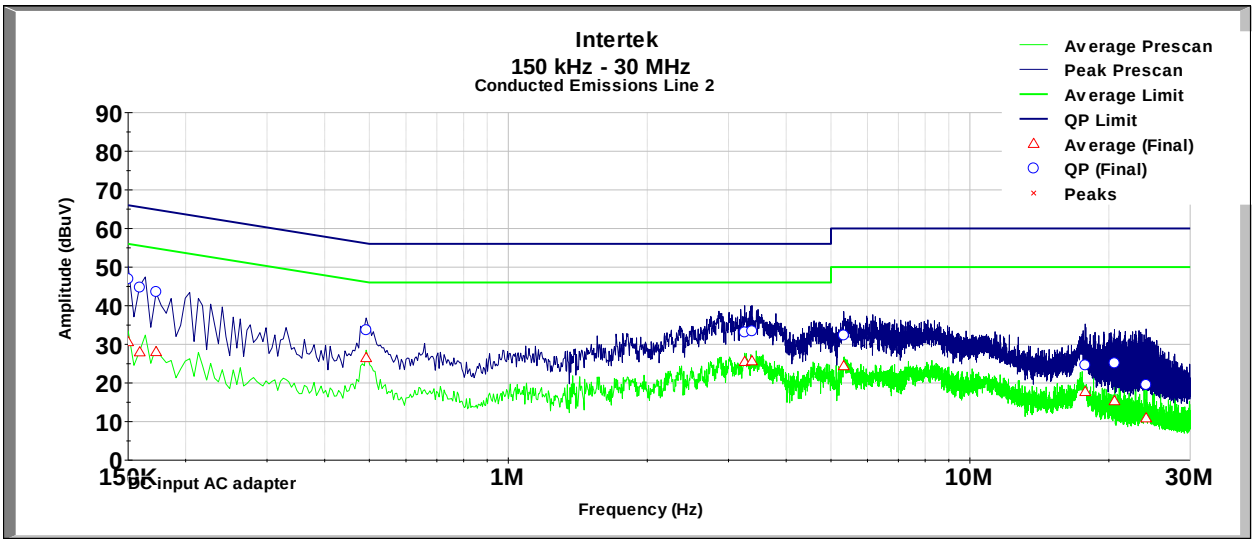


Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.150	46.883	66.000	19.117	28.917	56.000	27.083
0.160	44.318	65.714	21.397	26.156	55.714	29.558
0.186	42.104	64.971	22.868	24.628	54.971	30.343
0.231	36.483	63.686	27.203	21.897	53.686	31.788
3.003	33.060	56.000	22.940	24.898	46.000	21.102
3.408	34.530	56.000	21.470	26.675	46.000	19.325
5.311	32.411	60.000	27.589	23.980	50.000	26.020
5.856	30.312	60.000	29.688	21.890	50.000	28.110
13.773	23.754	60.000	36.246	17.584	50.000	32.416

Test Personnel:	Carmen Davis	Test Date:	10/10/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207
Product Standard:	FCC Part 15B ICES-003 Issue 6	Ambient Temperature:	23.4°C
Input Voltage:	DC with AC Adapter	Relative Humidity:	44.9%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	985mbar

Deviations, Additions, or Exclusions: None

8.9 Plots/Data: Conducted Emissions (Neutral, Idle) DC Input with AC Adapter

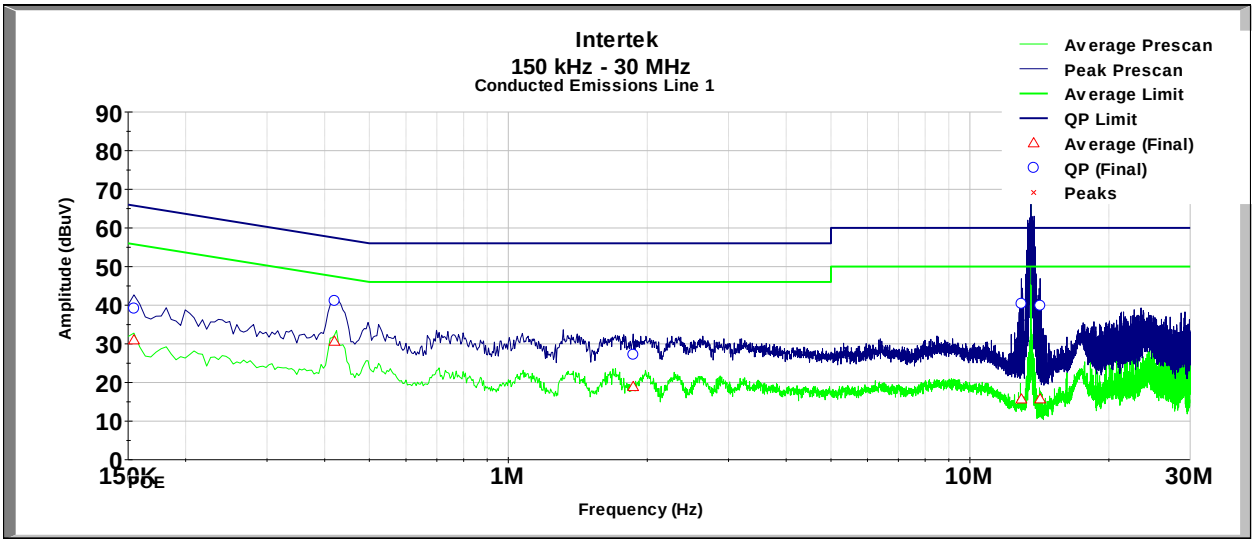


Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.150	46.919	66.000	19.081	30.661	56.000	25.339
0.159	44.730	65.743	21.013	27.985	55.743	27.758
0.172	43.589	65.357	21.769	28.080	55.357	27.278
0.492	33.673	56.229	22.555	26.497	46.229	19.731
3.251	33.100	56.000	22.900	25.505	46.000	20.495
3.372	33.393	56.000	22.607	25.680	46.000	20.320
5.330	32.339	60.000	27.661	24.418	50.000	25.582
17.775	24.604	60.000	35.396	17.719	50.000	32.281
20.578	25.085	60.000	34.915	15.334	50.000	34.666
24.095	19.508	60.000	40.492	10.914	50.000	39.086

Test Personnel:	Carmen Davis	Test Date:	10/10/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207
Product Standard:	FCC Part 15B ICES-003 Issue 6	Ambient Temperature:	23.4°C
Input Voltage:	DC with AC Adapter	Relative Humidity:	44.9%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	985mbar

Deviations, Additions, or Exclusions: None

8.10 Plots/Data: Conducted Emissions (Line, Transmitting) POE

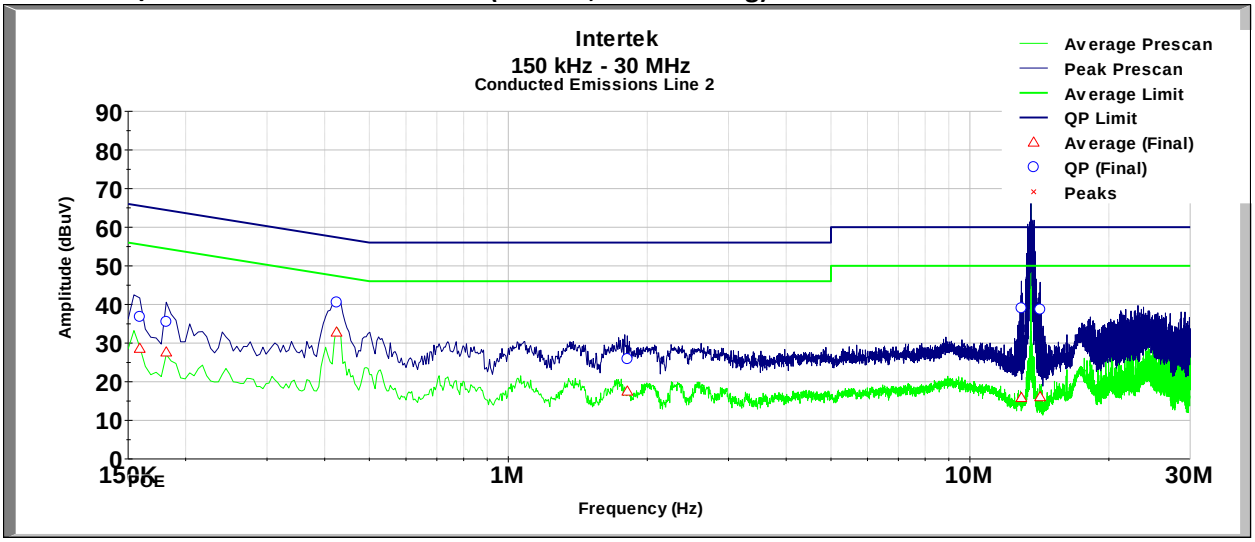


Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.155	39.171	65.871	26.700	30.979	55.871	24.893
0.420	41.130	58.286	17.156	30.617	48.286	17.669
1.865	27.187	56.000	28.813	18.893	46.000	27.107
12.927	40.372	60.000	19.628	15.686	50.000	34.314
13.562	84.688	60.000	-24.688	84.651	50.000	-34.651
14.196	39.876	60.000	20.124	15.709	50.000	34.291

Test Personnel:	Carmen Davis	Test Date:	10/10/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207
Product Standard:	FCC Part 15C RSS-Gen Issue 5	Ambient Temperature:	23.4°C
Input Voltage:	POE	Relative Humidity:	44.9%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	985mbar

Deviations, Additions, or Exclusions: None

8.11 Plots/Data: Conducted Emissions (Neutral, Transmitting) POE

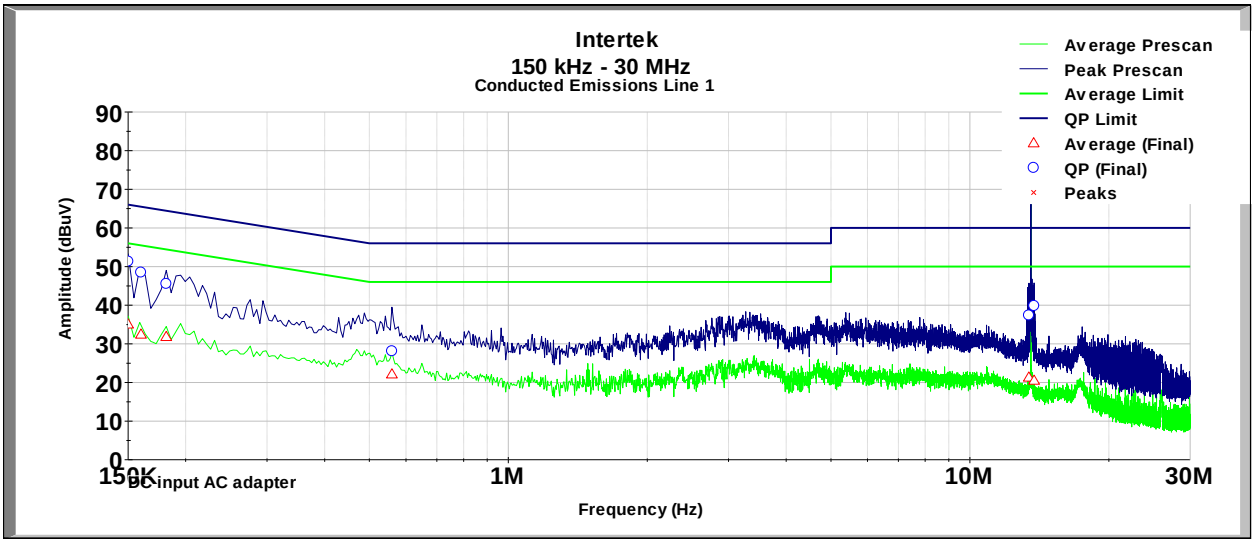


Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.159	36.796	65.743	28.947	28.579	55.743	27.164
0.181	35.515	65.100	29.585	27.652	55.100	27.448
0.424	40.553	58.157	17.604	32.793	48.157	15.364
1.811	25.876	56.000	30.124	17.518	46.000	28.482
12.927	39.053	60.000	20.947	15.853	50.000	34.147
13.562	83.562	60.000	-23.562	83.530	50.000	-33.530
14.196	38.692	60.000	21.308	16.057	50.000	33.943

Test Personnel:	Carmen Davis	Test Date:	10/11/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207
Product Standard:	FCC Part 15C RSS-Gen Issue 5	Ambient Temperature:	24.1°C
Input Voltage:	POE	Relative Humidity:	46.1%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	985mbar

Deviations, Additions, or Exclusions: None

8.12 Plots/Data: Conducted Emissions (Line, Transmitting) DC Input with AC Adapter



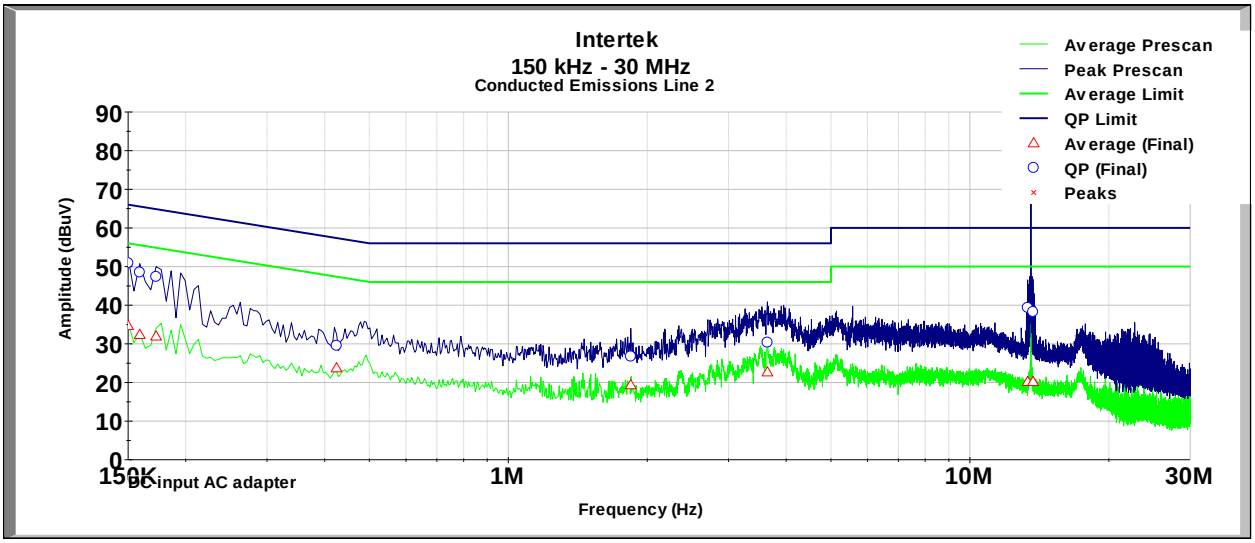
Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.150	51.302	66.000	14.698	35.069	56.000	20.931
0.160	48.488	65.714	17.226	32.462	55.714	23.252
0.181	45.552	65.100	19.548	31.845	55.100	23.255
0.560	28.117	56.000	27.883	22.158	46.000	23.842
13.422	37.380	60.000	22.620	21.329	50.000	28.671
*13.562	69.440	60.000	-9.440	68.596	50.000	-18.596
13.773	39.821	60.000	20.179	20.517	50.000	29.483

*__Note__: This is the fundamental transmission. Compliance at this frequency is determined with the radiating antenna replaced by a 50Ohm load.

Test Personnel:	Carmen Davis	Test Date:	10/11/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207 FCC Part 15C
Product Standard:	RSS-Gen Issue 5	Ambient Temperature:	24.1°C
Input Voltage:	DC with AC Adapter	Relative Humidity:	46.1%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	985mbar

Deviations, Additions, or Exclusions: None

8.13 Plots/Data: Conducted Emissions (Neutral, Transmitting) DC Input with AC Adapter



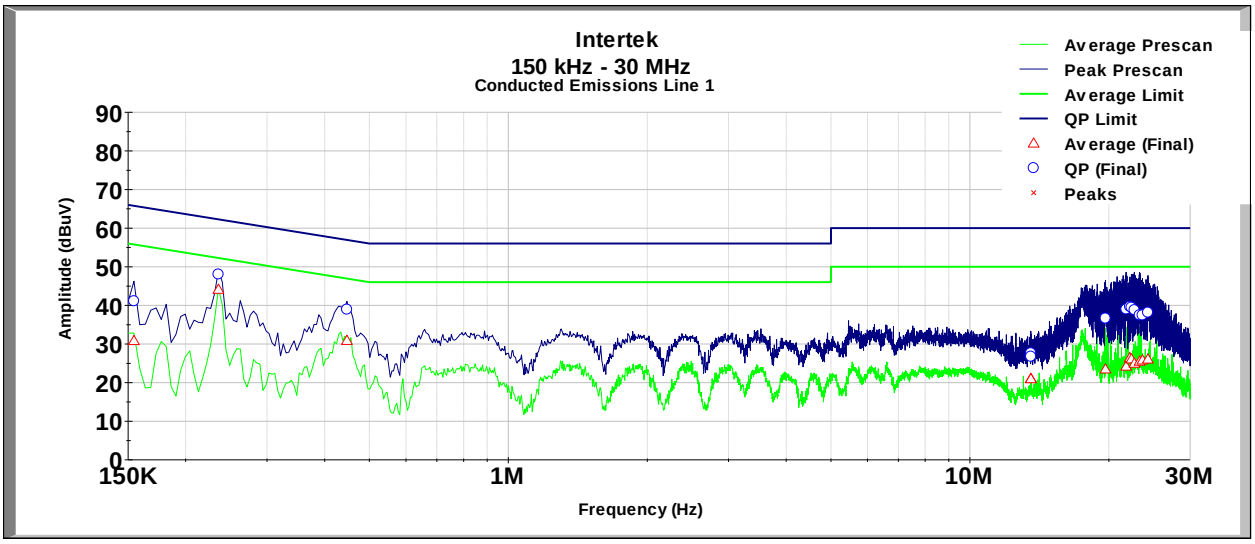
Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.150	50.904	66.000	15.096	34.708	56.000	21.292
0.159	48.489	65.743	17.254	32.356	55.743	23.387
0.172	47.364	65.357	17.993	31.956	55.357	23.401
0.424	29.531	58.157	28.626	23.753	48.157	24.404
1.842	26.753	56.000	29.247	19.362	46.000	26.638
3.642	30.354	56.000	25.646	22.672	46.000	23.328
13.345	39.368	60.000	20.632	20.198	50.000	29.802
*13.562	69.470	60.000	-9.470	68.613	50.000	-18.613
13.701	38.277	60.000	21.723	20.205	50.000	29.795

* **Note**: This is the fundamental transmission. Compliance at this frequency is determined with the radiating antenna replaced by a 50Ohm load.

Test Personnel:	Carmen Davis	Test Date:	10/11/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207
Product Standard:	FCC Part 15C RSS-Gen Issue 5	Ambient Temperature:	24.1°C
Input Voltage:	DC Input with AC Adapter	Relative Humidity:	46.1%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	985mbar

Deviations, Additions, or Exclusions: None

8.14 Plots/Data: Conducted Emissions (Line, Transmitting) POE with Dummy Load (50Ω)

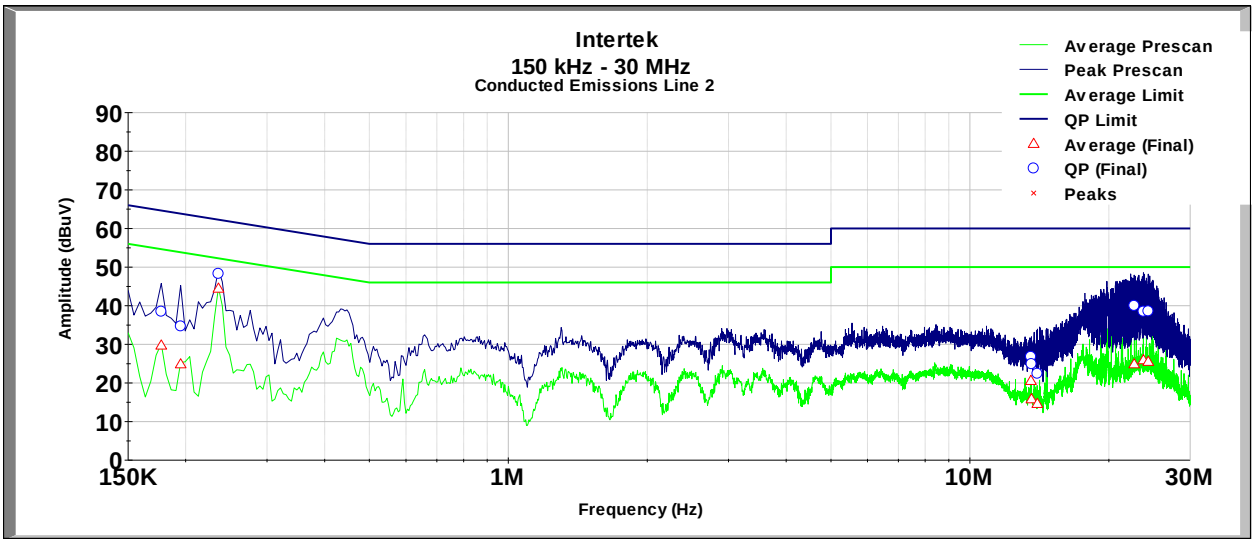


Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.155	41.108	65.871	24.764	30.817	55.871	25.055
0.235	48.035	63.557	15.522	44.108	53.557	9.449
0.447	38.933	57.514	18.581	30.870	47.514	16.645
13.560	27.618	60.000	32.382	21.046	50.000	28.954
13.560	26.746	60.000	33.254	20.952	50.000	29.048
19.665	36.635	60.000	23.365	23.469	50.000	26.531
21.802	38.961	60.000	21.039	24.192	50.000	25.808
22.217	39.664	60.000	20.336	26.406	50.000	23.594
22.387	39.438	60.000	20.562	26.084	50.000	23.916
22.727	38.801	60.000	21.199	24.961	50.000	25.039
23.316	37.442	60.000	22.558	25.491	50.000	24.509
23.658	37.425	60.000	22.575	25.813	50.000	24.187
24.315	38.139	60.000	21.861	26.027	50.000	23.973

Test Personnel:	Carmen Davis	Test Date:	11/08/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207
Product Standard:	FCC Part 15C RSS-Gen Issue 5	Ambient Temperature:	23.4°C
Input Voltage:	POE	Relative Humidity:	19.8%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	988mbar

Deviations, Additions, or Exclusions: None

8.15 Plots/Data: Conducted Emissions (Neutral, Transmitting) POE with Dummy Load (50Ω)

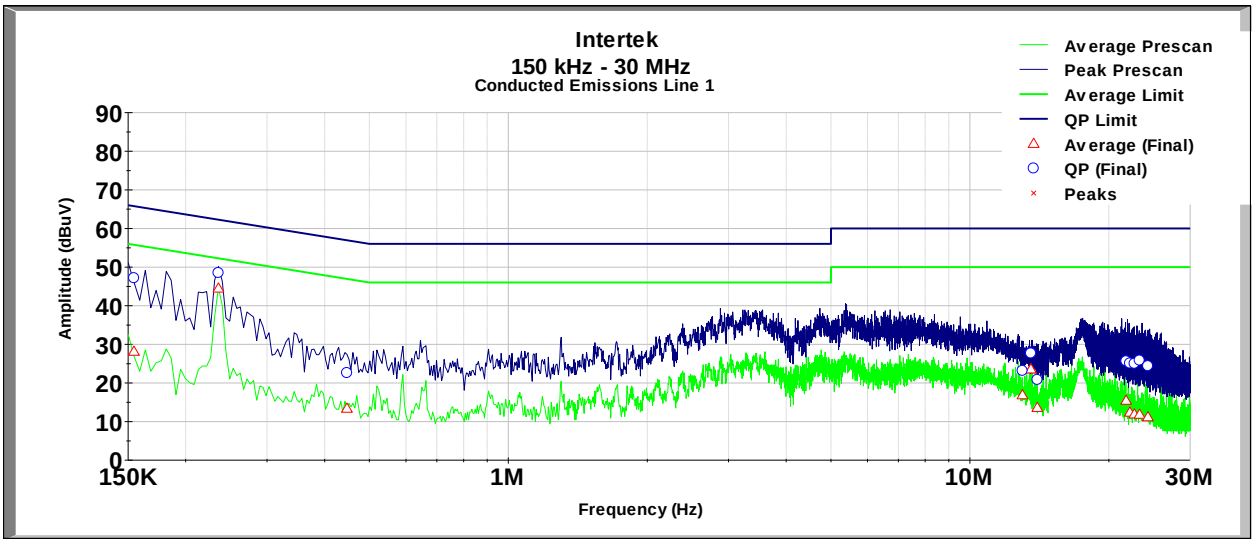


Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.177	38.502	65.229	26.726	29.766	55.229	25.463
0.195	34.670	64.714	30.044	24.900	54.714	29.814
0.235	48.287	63.557	15.271	44.486	53.557	9.071
13.560	26.781	60.000	33.219	20.592	50.000	29.408
13.596	24.923	60.000	35.077	15.858	50.000	34.142
14.000	22.402	60.000	37.598	14.648	50.000	35.352
22.700	39.988	60.000	20.012	24.898	50.000	25.102
23.766	38.486	60.000	21.514	25.964	50.000	24.036
24.351	38.566	60.000	21.434	25.525	50.000	24.475

Test Personnel:	Carmen Davis	Test Date:	11/08/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207
Product Standard:	FCC Part 15C RSS-Gen Issue 5	Ambient Temperature:	23.4°C
Input Voltage:	POE	Relative Humidity:	19.8%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	988mbar

Deviations, Additions, or Exclusions: None

8.16 Plots/Data: Conducted Emissions (Line, Transmitting) DC_AC Adapter with Dummy Load (50Ω)

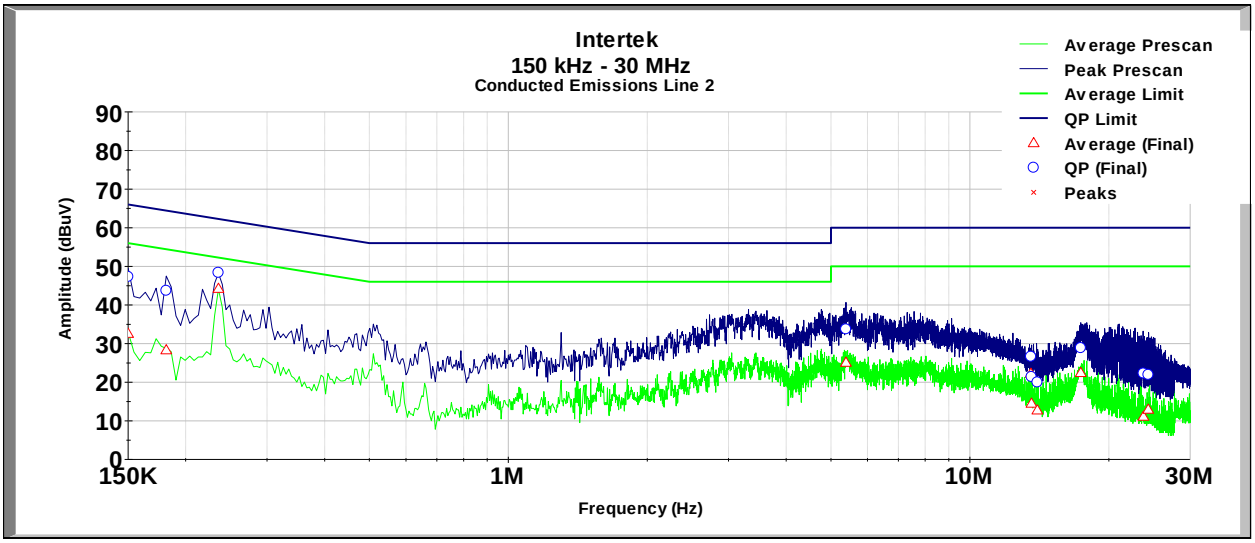


Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.155	47.149	65.871	18.723	28.144	55.871	27.727
0.235	48.501	63.557	15.056	44.500	53.557	9.057
0.447	22.597	57.514	34.917	13.397	47.514	34.117
13.000	23.144	60.000	36.856	16.883	50.000	33.117
13.560	27.745	60.000	32.255	23.609	50.000	26.391
13.560	27.682	60.000	32.318	23.579	50.000	26.421
14.000	20.825	60.000	39.175	13.617	50.000	36.383
21.802	25.645	60.000	34.355	15.460	50.000	34.540
22.217	25.058	60.000	34.942	12.380	50.000	37.620
22.727	24.983	60.000	35.017	11.936	50.000	38.064
23.316	25.834	60.000	34.166	11.828	50.000	38.172
24.315	24.372	60.000	35.628	11.191	50.000	38.809

Test Personnel:	Carmen Davis	Test Date:	11/08/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207
Product Standard:	FCC Part 15C RSS-Gen Issue 5	Ambient Temperature:	23.4°C
Input Voltage:	DC Input with AC Adapter	Relative Humidity:	19.8%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	988mbar

Deviations, Additions, or Exclusions: None

8.17 Plots/Data: Conducted Emissions (Neutral, Transmitting) DC_AC Adapter with Dummy Load (50Ω)



Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
0.150	47.304	66.000	18.696	32.609	56.000	23.391
0.181	43.704	65.100	21.396	28.346	55.100	26.754
0.235	48.386	63.557	15.171	44.249	53.557	9.309
5.388	33.723	60.000	26.277	25.111	50.000	24.889
13.560	26.639	60.000	33.361	22.249	50.000	27.751
13.596	21.401	60.000	38.599	14.500	50.000	35.500
14.000	19.981	60.000	40.019	12.784	50.000	37.216
17.388	28.866	60.000	31.134	22.452	50.000	27.548
23.766	22.275	60.000	37.725	11.130	50.000	38.870
24.351	21.923	60.000	38.077	12.946	50.000	37.054

Test Personnel:	Carmen Davis	Test Date:	11/08/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.207
Product Standard:	FCC Part 15C RSS-Gen Issue 5	Ambient Temperature:	23.4°C
Input Voltage:	DC Input with AC Adapter	Relative Humidity:	19.8%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	988mbar

Deviations, Additions, or Exclusions: None

9 Frequency Stability

9.1 Test Limits

FCC Part 15.225:

(e) The frequency tolerance of the carrier signal shall be maintained within ±0.01% of the operating frequency over a temperature variation of −20 degrees to + 50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

RSS-210 Issue 9 § B.6:

Carrier frequency stability shall be maintained to ±0.01% (±100 ppm).

9.2 Test Method

Tests are performed in accordance with ANSI C63.10:2013.

9.3 Test Equipment Used

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
Spectrum Analyzer	3099	Rohde & Schwarz	FSP7	9/20/2019	9/20/2020
Environmental Chamber	7077	Gentherm	CSZ	2/28/2019	2/28/2020

9.4 Test Results

The sample tested was found to be **compliant**.

9.5 Test Data

Fundamental Frequency: 13,559,722 Hz
Voltage: 24VDC
Limit: 0.01%

Input: 24vdc power supply
Date: 10/17/2019

Voltage (VDC)	Temp (°C)	Measured Frequency (Hz)	Frequency Error (Hz)	Deviation (%)	Limit (%)
24	-20	13,559,802	80	0.0006	0.01
24	-10	13,559,802	80	0.0006	0.01
24	0	13,559,782	60	0.0004	0.01
24	10	13,559,782	60	0.0004	0.01
24	20	13,559,722	0	0.0000	0.01
24	30	13,559,702	-20	-0.0001	0.01
24	40	13,559,702	-20	-0.0001	0.01
24	50	13,559,712	-10	-0.0001	0.01
27.6	20	13,559,732	10	0.0001	0.01
20.4	20	13,559,722	0	0.0000	0.01

Fundamental Frequency: 13,559,742 Hz
Voltage: 110VAC
Limit: 0.01%

Input: Power Over Ethernet
Date: 10/18/2019

Voltage (VAC)	Temp (°C)	Measured Frequency (Hz)	Frequency Error (Hz)	Deviation (%)	Limit (%)
110	-20	13,559,792	50	0.0004	0.01
110	-10	13,559,792	50	0.0004	0.01
110	0	13,559,762	20	0.0001	0.01
110	10	13,559,732	-10	-0.0001	0.01
110	20	13,559,742	0	0.0000	0.01
110	30	13,559,702	-40	-0.0003	0.01
110	40	13,559,712	-30	-0.0002	0.01
110	50	13,559,722	-20	-0.0001	0.01
126.5	20	13,559,732	-10	-0.0001	0.01
93.5	20	13,559,722	-20	-0.0001	0.01

Test Personnel:	Carmen Davis	Test Date:	10/16/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	See Above
Product Standard:	FCC Part 15.225 RSS-210 Issue 9	Ambient Temperature:	20°C
Input Voltage:	24VDC and POE	Relative Humidity:	25%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	982mbar

Deviations, Additions, or Exclusions: None

10 Occupied Bandwidth

10.1 Test Limits

15.215(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

10.2 Test Method

Tests are performed in accordance with ANSI C63.10:2013.

10.3 Test Equipment Used

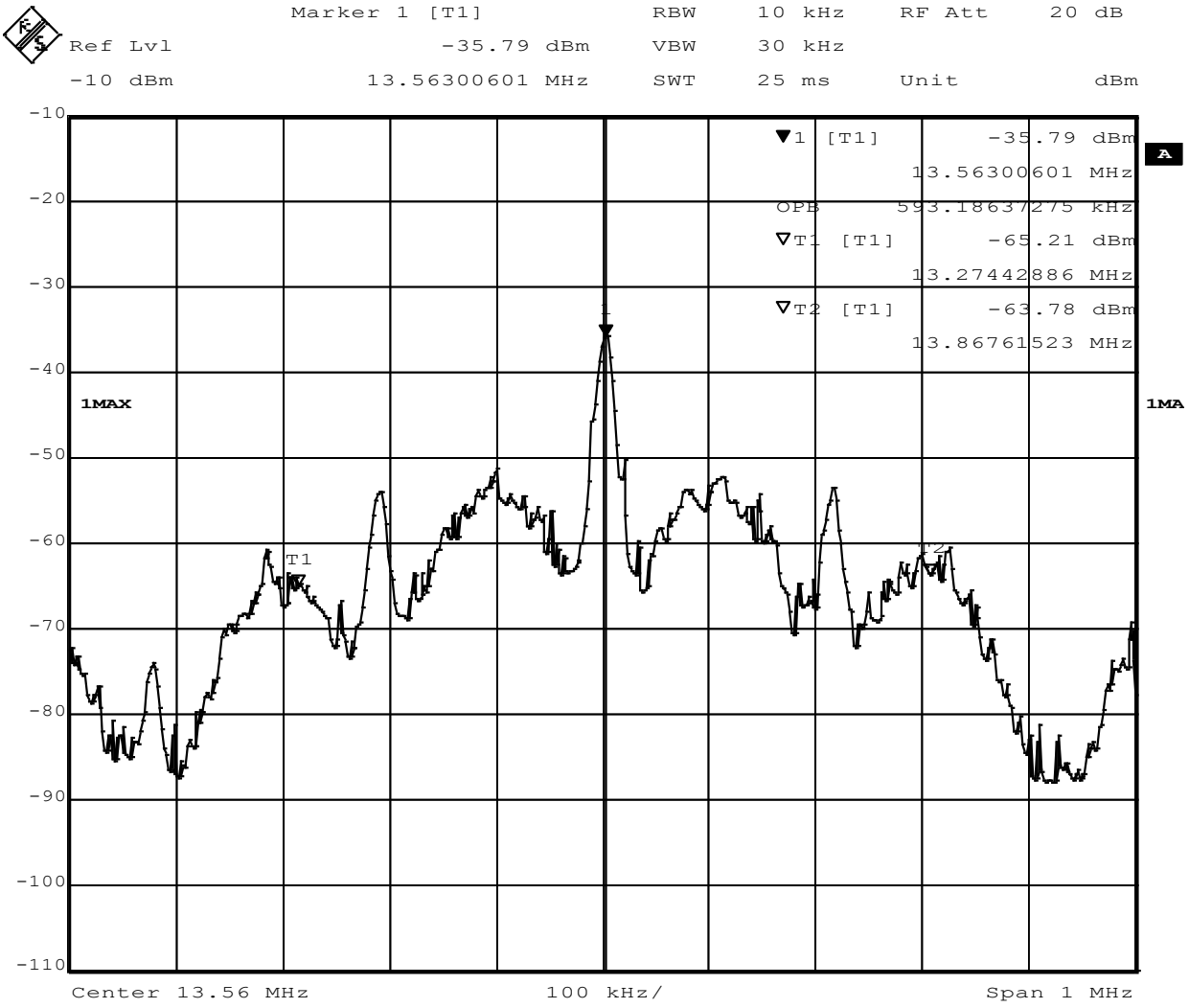
Description	Asset	Manufacturer	Model	Cal Date	Cal Due
Spectrum Analyzer	3720	Rohde & Schwarz	FSEK	9/20/2018	9/20/2019

10.4 Test Results

The sample tested was found to be **compliant**. The 99% power bandwidth was measured as was the 20dB down bandwidth. The 20dB bandwidth was entirely within the transmit band 13.11MHz – 14.01MHz as required by FCC Part 15.215.

10.5 Test Data

RBW	VBW	99% BW
10kHz	30kHz	593.18kHz

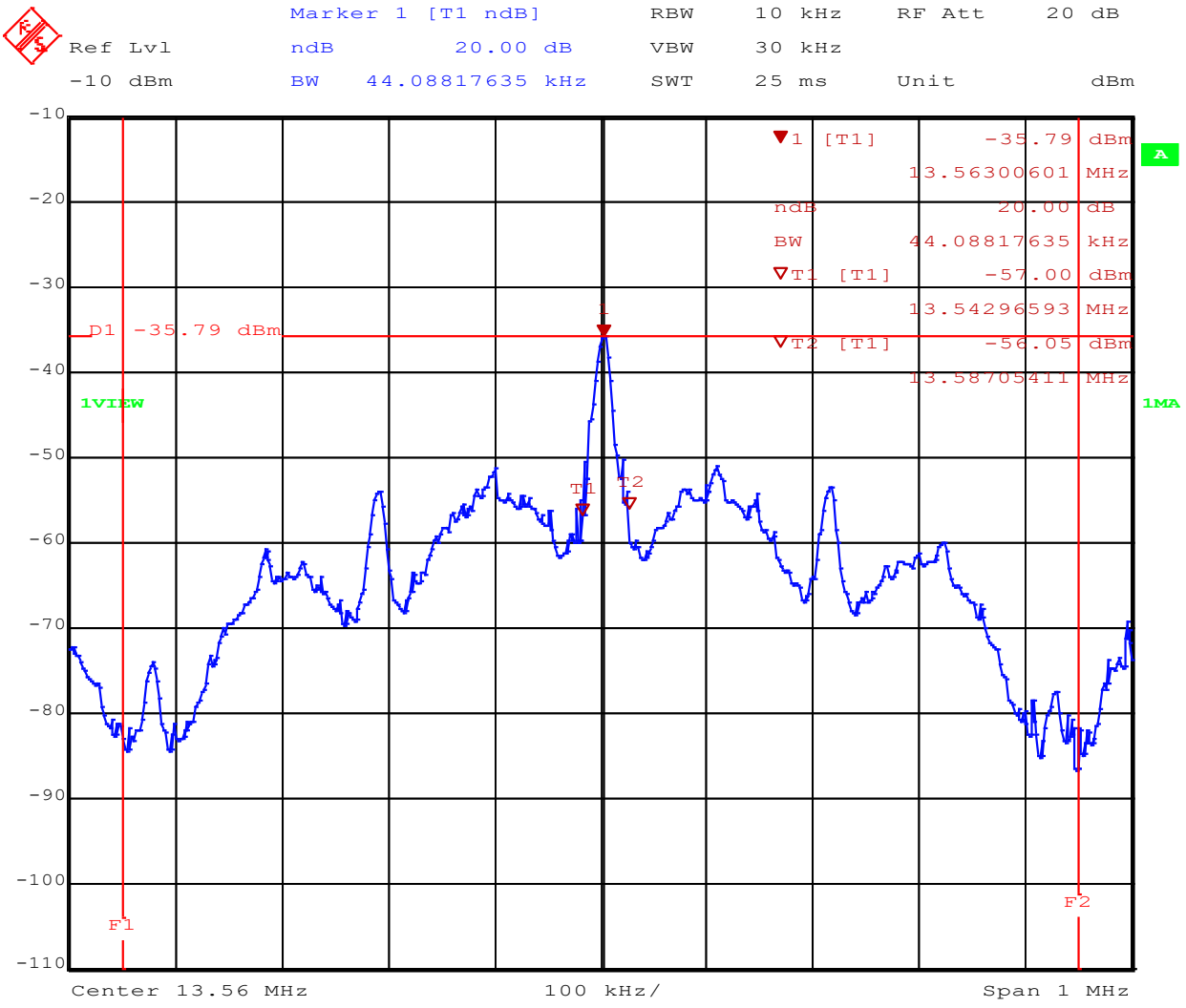


99% Occupied Bandwidth

Test Personnel:	Bryan Taylor	Test Date:	9/12/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	See Above
Product Standard:	RSS-210 Issue 9	Ambient Temperature:	24.7°C
Input Voltage:	24VDC and POE	Relative Humidity:	45.9 %
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	978.6 mbar

Deviations, Additions, or Exclusions: None

RBW	VBW	20dB BW
10kHz	30kHz	44.08kHz



20dB Bandwidth

Test Personnel:	Bryan Taylor	Test Date:	9/12/2019
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	See Above
Product Standard:	FCC Part 15.215c	Ambient Temperature:	24.7°C
Input Voltage:	24VDC and POE	Relative Humidity:	45.9 %
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	978.6 mbar

Deviations, Additions, or Exclusions: None

11 Antenna Requirement

11.1 Test Limits

FCC Part 15.203:

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.

RSS-Gen Issue 5 § 6.8:

The applicant for equipment certification, as per RSP-100, must provide a list of all antenna types that may be used with the license-exempt transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna.

License-exempt transmitters that have received equipment certification may operate with different types of antennas. However, it is not permissible to exceed the maximum equivalent isotropically radiated power (e.i.r.p.) limits specified in the applicable standard (RSS) for the license-exempt apparatus.

Testing shall be performed using the highest gain antenna of each combination of license-exempt transmitter and antenna type, with the transmitter output power set at the maximum level. When a measurement at the antenna connector is used to determine RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna manufacturer.

User manuals for transmitters equipped with detachable antennas shall also contain the following notice in a conspicuous location:

This radio transmitter (identify the device by certification number) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Immediately following the above notice, the manufacturer shall provide a list of all antenna types approved for use with the transmitter, indicating the maximum permissible antenna gain (in dBi).

11.2 Test Results

The device was found to be **compliant**. The device has permanent antenna designed into the PCB.

12 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	12/09/2019	104085447LEX-002	CO	BCT	Original Issue