

## TEST REPORT

**Report Number: 103436674MPK-001**  
**Project Numbers: G103436674, G103442604**  
**April 05, 2018**

**Testing performed on**  
**Repeaters**  
**Model: FAST-60-601-000003**  
**FCC ID: 2APK7-9705080V1-0**  
**IC: 23979-9705080V10**

to

**FCC Part 15 Subpart C (15.247)**  
**Industry Canada RSS-247 Issue 2**  
**FCC Part 15, Subpart B**  
**Industry Canada ICES-003**

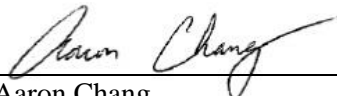
For

**Fastenal Company**

Test Performed by:  
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1365 Adams Court  
Menlo Park, CA 94025 USA

Test Authorized by:  
Fastenal Company  
2001 Theurer Blvd.  
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Prepared by:

  
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**Date:** April 05, 2018

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Krishna K Vemuri

**Date:** April 05, 2018

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## Report No. 103436674MPK-001

**Equipment Under Test:**

**Trade Name:**

**Model Number:**

Repeaters

Fastenal Company

FAST-60-601-000003

**Applicant:**

**Contact:**

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**Applicable Regulation:**

FCC Part 15 Subpart C (15.247)

Industry Canada RSS-247 Issue 2


FCC Part 15, Subpart B

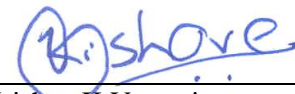
Industry Canada ICES-003 Issue 6

**Date of Test:**

March 5-27, 2018

*We attest to the accuracy of this report:*

  
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## 1.0 Summary of Tests

Test	Reference FCC	Reference Industry Canada	Result
<b>RF Output Power</b>	15.247(b)(3)	RSS-247, 5.4.4	Complies
<b>6 dB Bandwidth</b>	15.247(a)(2)	RSS-247, 5.2.1	Complies
<b>Power Density</b>	15.247(e)	RSS-247, 5.2.2	Complies
<b>Out of Band Antenna Conducted Emission</b>	15.247(d)	RSS-247, 5.5	Complies
<b>Transmitter Radiated Emissions</b>	15.247(d), 15.209, 15.205	RSS-247, 5.5	Complies
<b>AC Line Conducted Emission</b>	15.207	RSS-GEN	Complies
<b>Antenna Requirement</b>	15.203	RSS-GEN	Complies (Internal Antenna)
<b>RF Exposure</b>	15.247(i), 2.1093(d)	RSS-102	Complies
<b>Radiated Emissions</b>	15.109	ICES-003	Complies
<b>AC Line Conducted Emission</b>	15.107	ICES-003	Complies

**EUT receive date:** March 05, 2018

**EUT receive condition:** The pre-production version of the EUT was received in good condition with no apparent damage. As declared by the Applicant, it is identical to the production units.

**Test start date:** March 5, 2018

**Test completion date:** March 27, 2018

The test results in this report pertain only to the item tested.

## 2.0 General Information

### 2.1 Product Description

Fastenal Company supplied the following description of the EUT:

Device that receives messages from in-range BLE Bins and forwards this data to an in-range Controller via LoRa.

Information about the LoRa radio is presented below:

For more information, refer to the following product specification, declared by the manufacturer.

Information about the 900 MHz radio is presented below:

<b>Applicant</b>	Fastenal Company
<b>Model No.</b>	FAST-60-601-000003
<b>FCC Identifier</b>	2APK7-9705080V1-0
<b>IC Identifier</b>	23979-9705080V10
<b>Type of transmission</b>	Digital Transmission System (DTS)
<b>Rated RF Output</b>	18.35 dBm
<b>Antenna(s) &amp; Gain</b>	PCB Antenna, Gain: 5.1 dBi
<b>Frequency Range</b>	903 – 914.2 MHz (Tx); 923.3 – 927.5 MHz (Rx)
<b>Type of modulation</b>	LoRa® Technology
<b>Data Rate</b>	1760 bps
<b>Number of Channel(s)</b>	16 Total (8 Tx and 8 Rx)
<b>Applicant Name &amp; Address</b>	Fastenal Company 2001 Theurer Blvd Winona, MN 55987 USA

## 2.2 Related Submittal(s) Grants

None.

## 2.3 Test Facility

The test site used to collect the radiated data is site 1 (10-m semi-anechoic chamber). This test facility and site measurement data have been fully placed on file with the FCC, IC and A2LA accredited.

## 2.4 Test Methodology

Antenna conducted measurements were performed according to the FCC documents “Guidance for Performing Compliance Measurement on Digital Transmission Systems (DTS) Operating under §15.247” (KDB 558074 D01 DTS Meas Guidance v04), and RSS-247, RSS-GEN Issue 4.

Radiated emissions and AC mains conducted emissions measurements were performed according to the procedures in ANSI C63.10: 2013. Radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the "Data Sheet" of this report.

## 2.5 Measurement Uncertainty

Compliance with the limits was based on the results of the measurements and doesn't take into account the measurement uncertainty.

Estimated Measurement Uncertainty

Measurement	Expanded Uncertainty (k=2)		
	0.15 MHz – 1 GHz	1 GHz – 2.5 GHz	> 2.5 GHz
RF Power and Power Density – antenna conducted	-	0.7 dB	-
Unwanted emissions - antenna conducted	1.1 dB	1.3 dB	1.9 dB
Bandwidth – antenna conducted	-	30 Hz	-

Measurement	Expanded Uncertainty (k=2)			
	0.15 MHz – 30MHz	30 – 200 MHz	200 MHz – 1 GHz	1 GHz – 18 GHz
Radiated emissions	-	4.7	4.6	5.1 dB
AC mains conducted emissions	2.1 dB	-	-	-

### 3.0 System Test Configuration

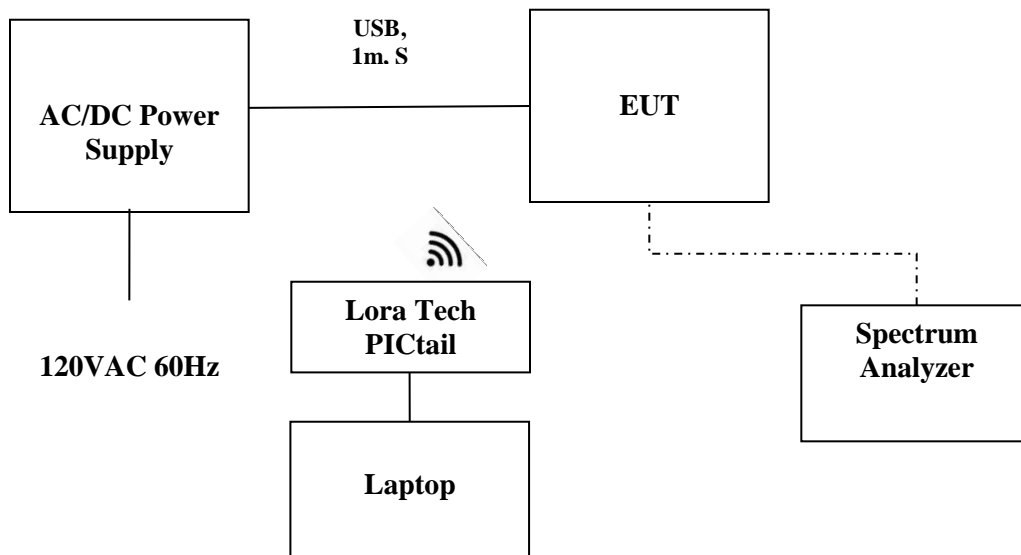
#### 3.1 Support Equipment

Description	Manufacturer	Model Number
Laptop	HP	ProBook 430
LoRa Tech PICtail	MicroChip	MTI160581148

#### 3.2 Block Diagram of Test Setup

Equipment Under Test			
Description	Manufacturer	Model Number	Serial Number
Repeaters	Fastenal Company	FAST-60-601-000003	Rt-0000071
AC/DC Power Supply	CUI Inc	SWI12-5-N	No markings

Antenna was removed and co-axial connector with a cable was installed for Conducted Measurements.



<b>S</b> = Shielded	<b>F</b> = With Ferrite
<b>U</b> = Unshielded	<b>m</b> = Length in Meters



### 3.3 Justification

For radiated emission measurements the EUT is placed on a non-conductive table.

### 3.4 Software Exercise Program

The EUT exercise program used during radiated and conducted testing was provided by Fastenal Company

### 3.5 Mode of Operation during Test

During transmitter testing, the transmitter was setup to transmit at maximum RF power on low, middle and high frequencies/channels.

### 3.5 Modifications Required for Compliance

No modifications were made by the manufacturer or Intertek to the EUT in order to bring the EUT into compliance.

### 3.6 Additions, Deviations and Exclusions from Standards

No additions, deviations or exclusions from the standard were made.

#### 4.0 Measurement Results

##### 4.1 6-dB Bandwidth and 99% Occupied Bandwidth FCC Rule: 15.247(a)(2); RSS-247 A8.2 and RSS-GEN;

###### 4.1.1 Requirement

The minimum 6-dB bandwidth shall be at least 500 kHz

###### 4.1.2 Procedure

A spectrum analyzer was connected to the antenna port of the transmitter.

For FCC 6dB Channel Bandwidth the Procedure described in the FCC Publication 558074 D01 DTS Meas Guidance v04 was used to determine the DTS occupied bandwidth. Section 8.1 Option 1 was used.

1. Set RBW = 100 kHz.
2. Set the video bandwidth (VBW)  $\geq 3 \times$  RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize.
7. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

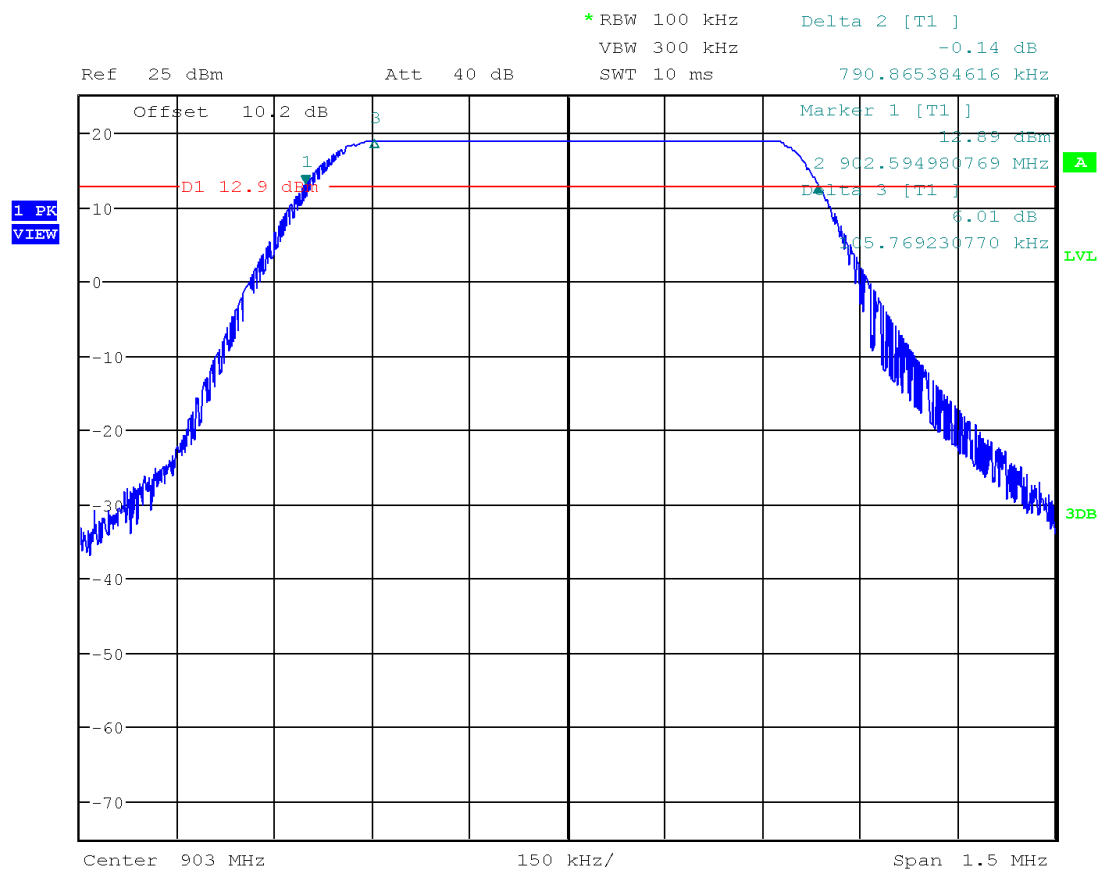
For 99% power bandwidth measurement, the bandwidth was determined by using the built-in 99% occupied bandwidth function of the spectrum analyzer. The resolution bandwidth is set to 1% of the selected span as is without being below 1%. The video bandwidth shall be set to 3 times the resolution bandwidth.

###### 4.1.3 Test Result

Frequency (MHz)	6-dB bandwidth FCC 15.247 & RSS-GEN, kHz	Occupied bandwidth, RSS-GEN, kHz	Plot
903	790.865	--	1.1
	--	586.538	1.4
907.8	771.635	--	1.2
	--	628.205	1.5
914.2	786.058	--	1.3
	--	634.615	1.6

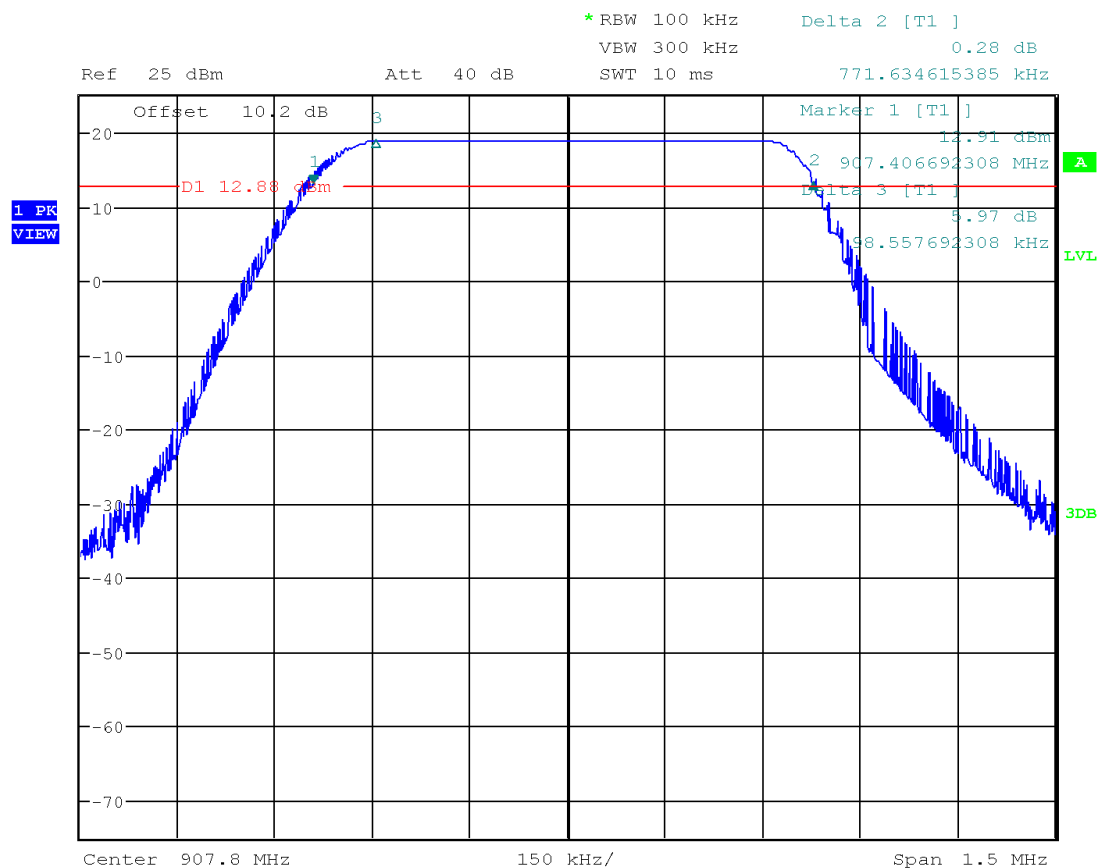
<b>Date of Test:</b>	March 6, 2018
<b>Results</b>	<b>Complies</b>

Plot 1. 1



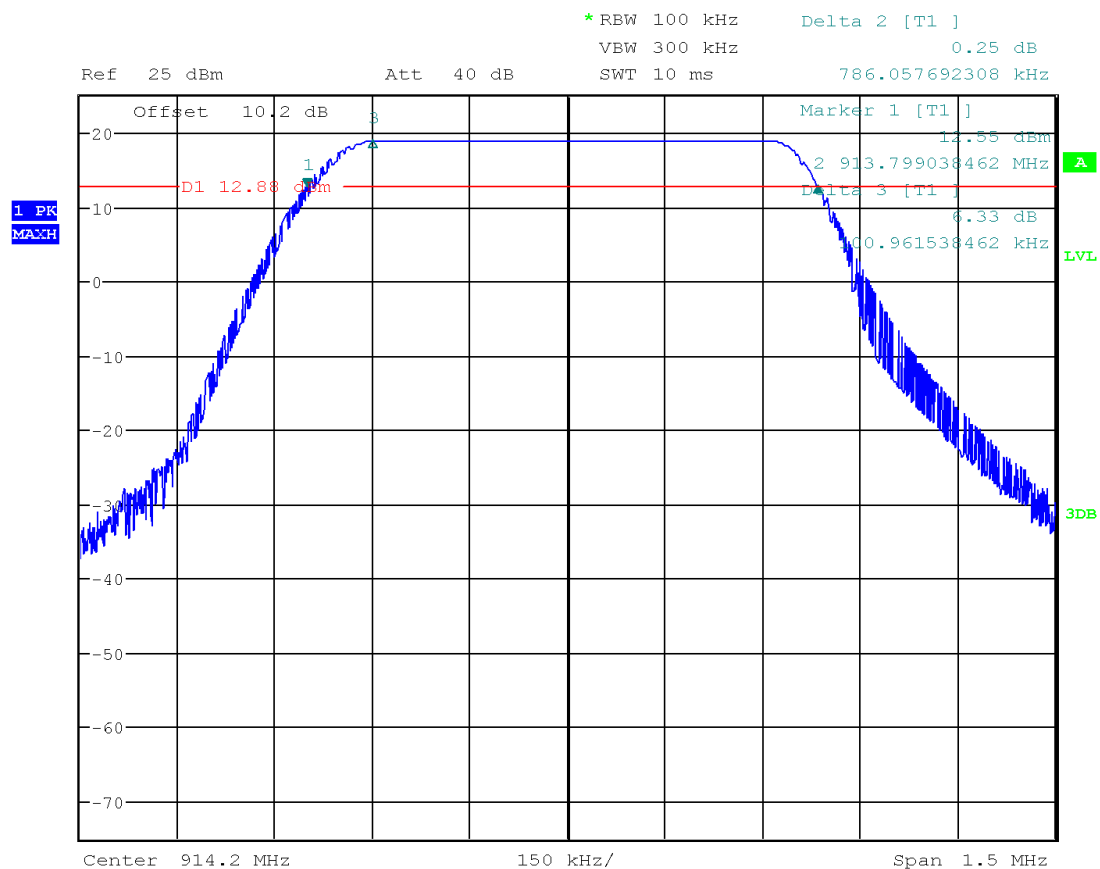
Date: 6.MAR.2018 17:41:46

Plot 1.2



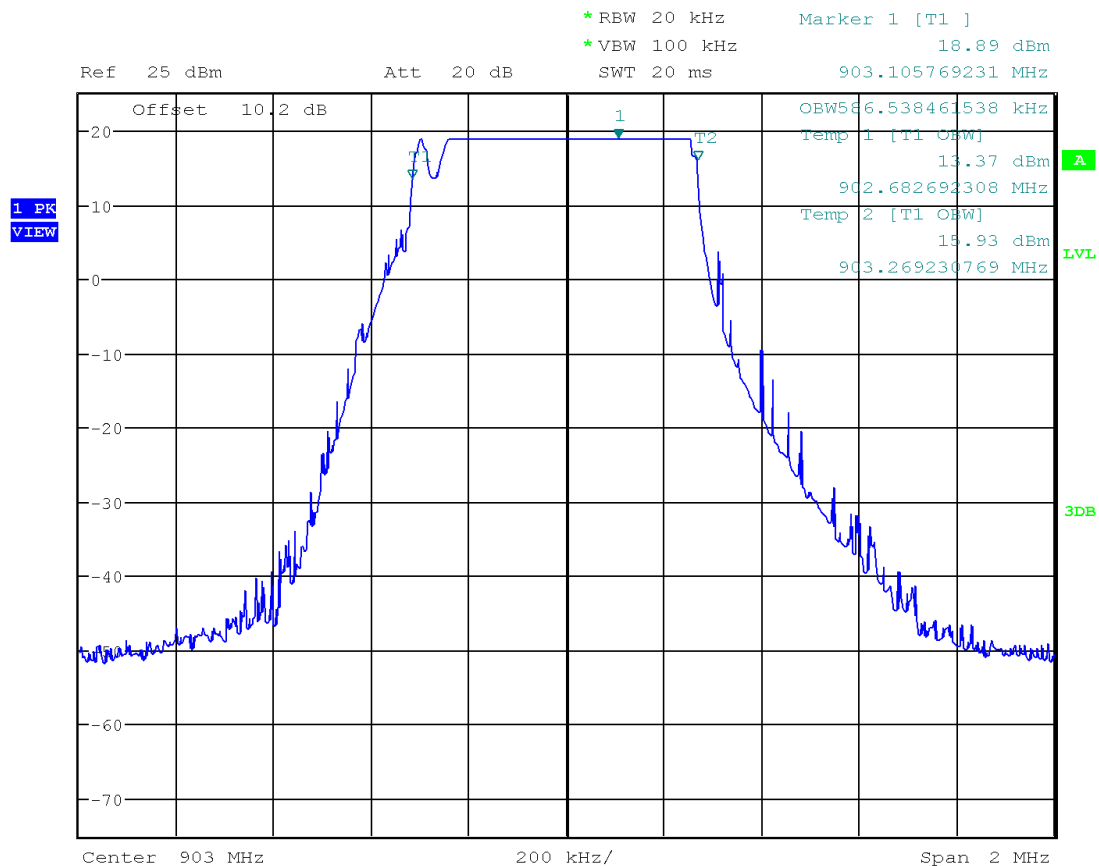
Date: 6.MAR.2018 17:04:36

Plot 1.3



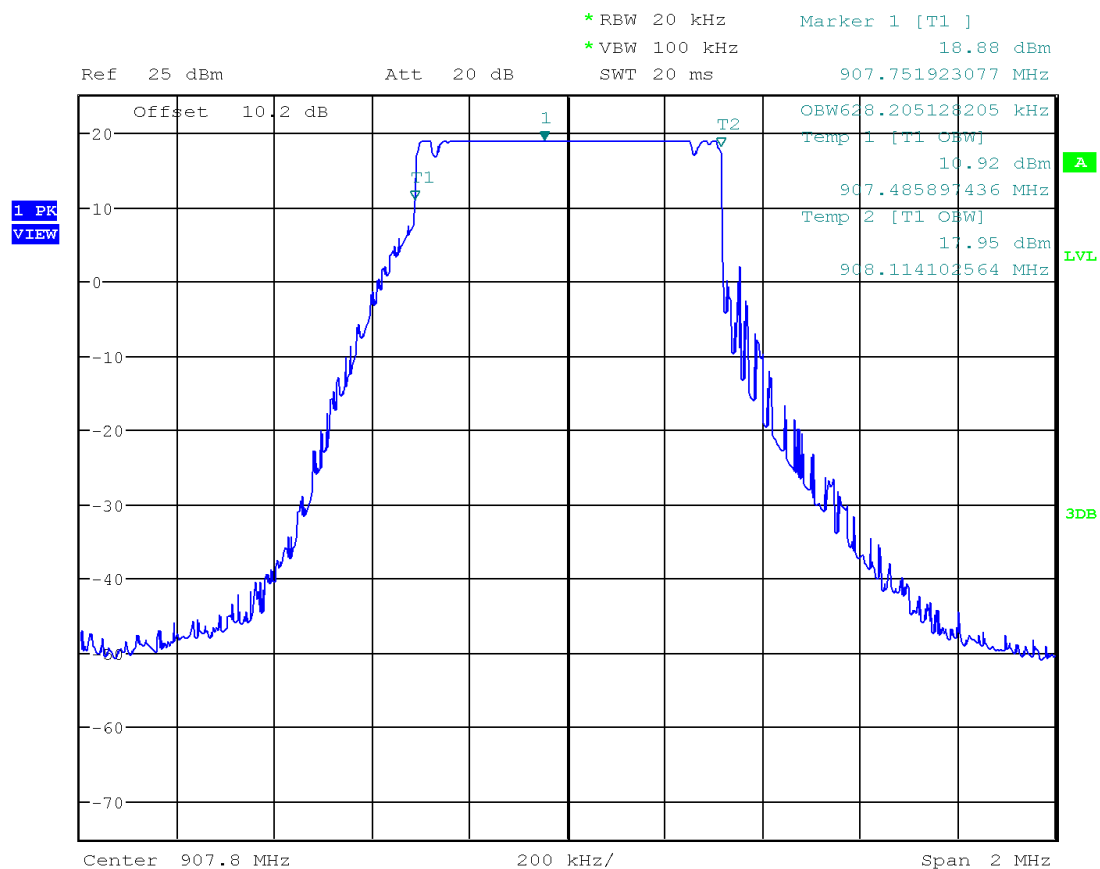
Date: 6.MAR.2018 16:57:20

Plot 1.4



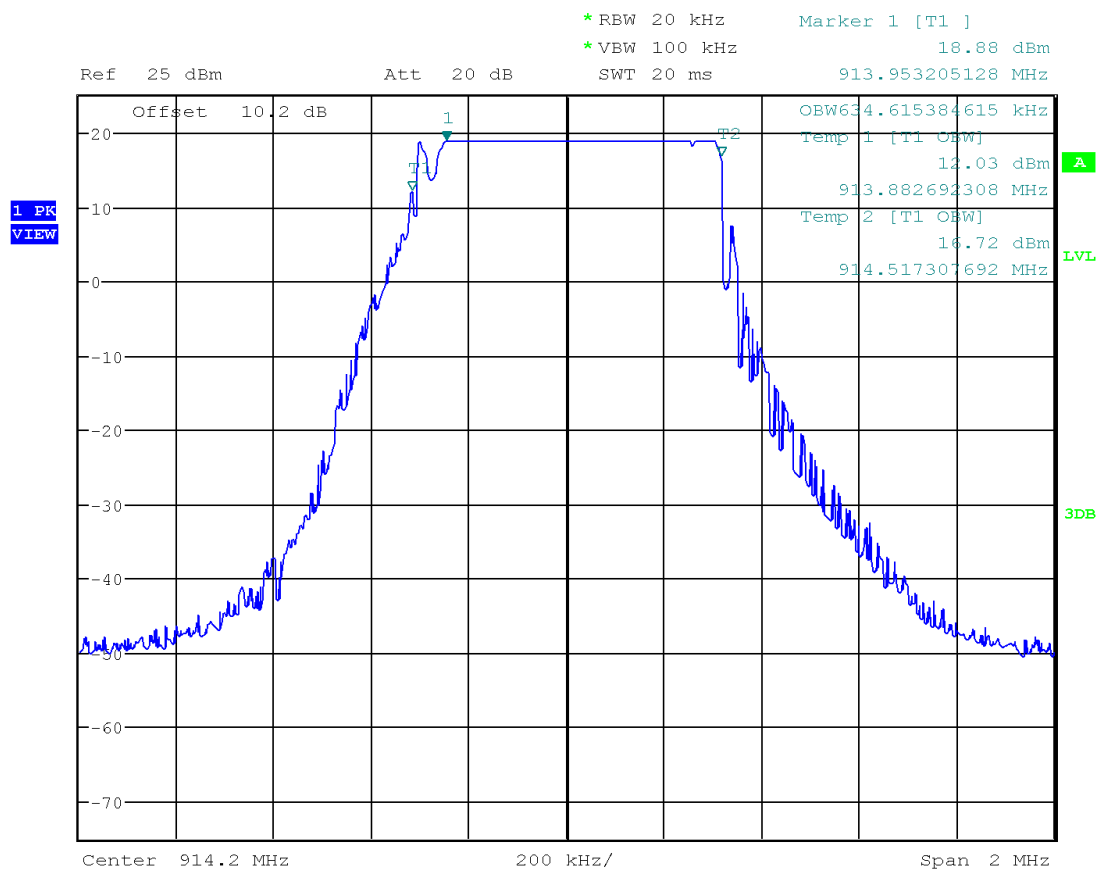
Date: 6.MAR.2018 17:53:51

Plot 1.5



Date: 6.MAR.2018 17:50:31

Plot 1.6



Date: 6.MAR.2018 17:52:45



#### 4.2 Maximum Peak Conducted Output Power at Antenna Terminals FCC Rule: 15.247(b)(3); RSS-247 A8.4;

##### 4.2.1 Requirement

For antennas with gains of 6 dBi or less, maximum allowed transmitter output is 1 watt or 30 dBm.  
For antennas with gains greater than 6 dBi, transmitter output level must be decreased appropriately, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

##### 4.2.2 Procedure

The procedure described in FCC Publication 558074 D01 DTS Meas Guidance v04 was used.  
Specifically, section 9.2.2.3 Method AVGSA-1 Alternative (RMS detection with slow sweep and EUT transmitting continuously at full power) was utilized.

1. Set span to at least 1.5 x OBW.
2. Set RBW = 1 % to 5 % of the OBW, not to exceed 1 MHz.
3. Set VBW  $\geq 3 \times$  RBW.
4. Number of points in sweep  $\geq 2 \times$  span / RBW.
5. Manually set sweep time  $\geq 10 \times$  (number of points in sweep) x (transmission symbol period), but not less than the automatic default sweep time.
6. Detector = RMS
7. The EUT shall be operated at  $\geq 98$  % duty cycle or sweep triggering/signal gating shall be employed such that the sweep time is less than or equal to the transmission duration T.
8. Perform a single sweep.
9. Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function, with band limits set equal to the OBW band edges. If the instrument does not have a band power function, sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.

A spectrum analyzer was connected to the antenna port of the transmitter.

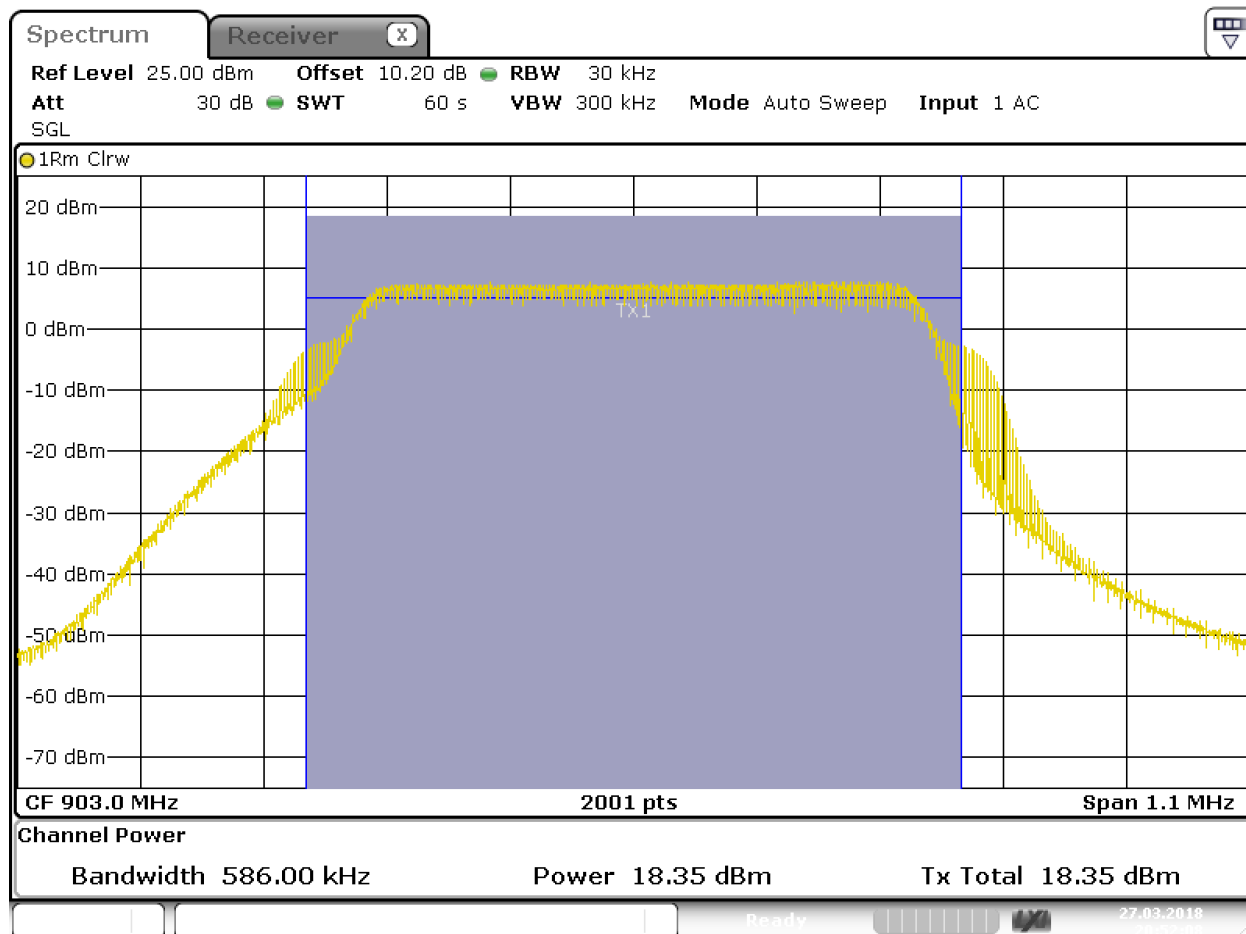
##### 4.3.3 Test Result

Refer to the following plots 2.1 – 2.3 for the test details.

Frequency, MHz	Conducted Power (peak), dBm	Conducted Power (peak), mW	Plot
903	18.35	68.39	2.1
907.8	18.25	66.83	2.2
914.2	18.21	66.22	2.3

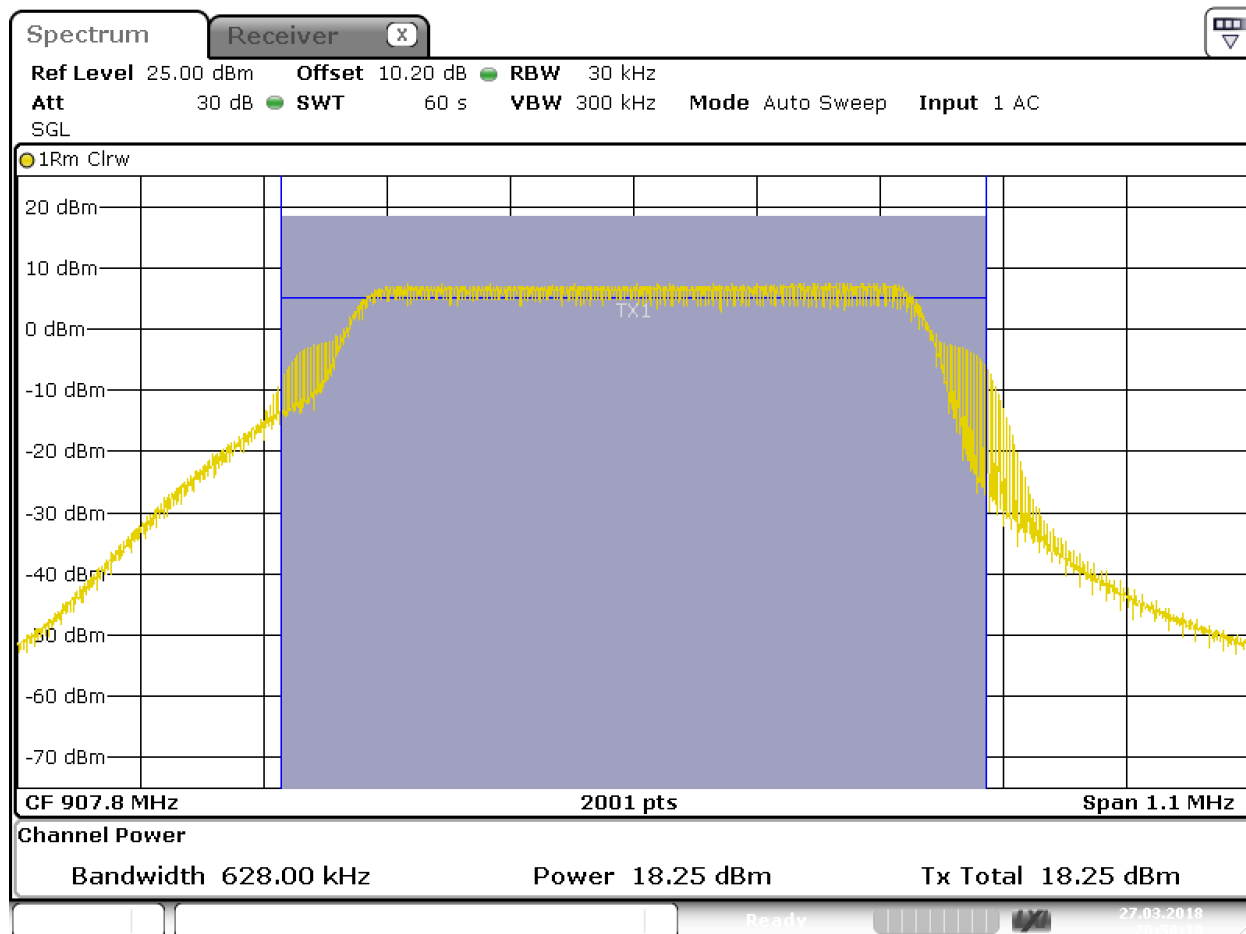
<b>Date of Test:</b>	March 27, 2018
<b>Results</b>	<b>Complies</b>

Plot 2. 1



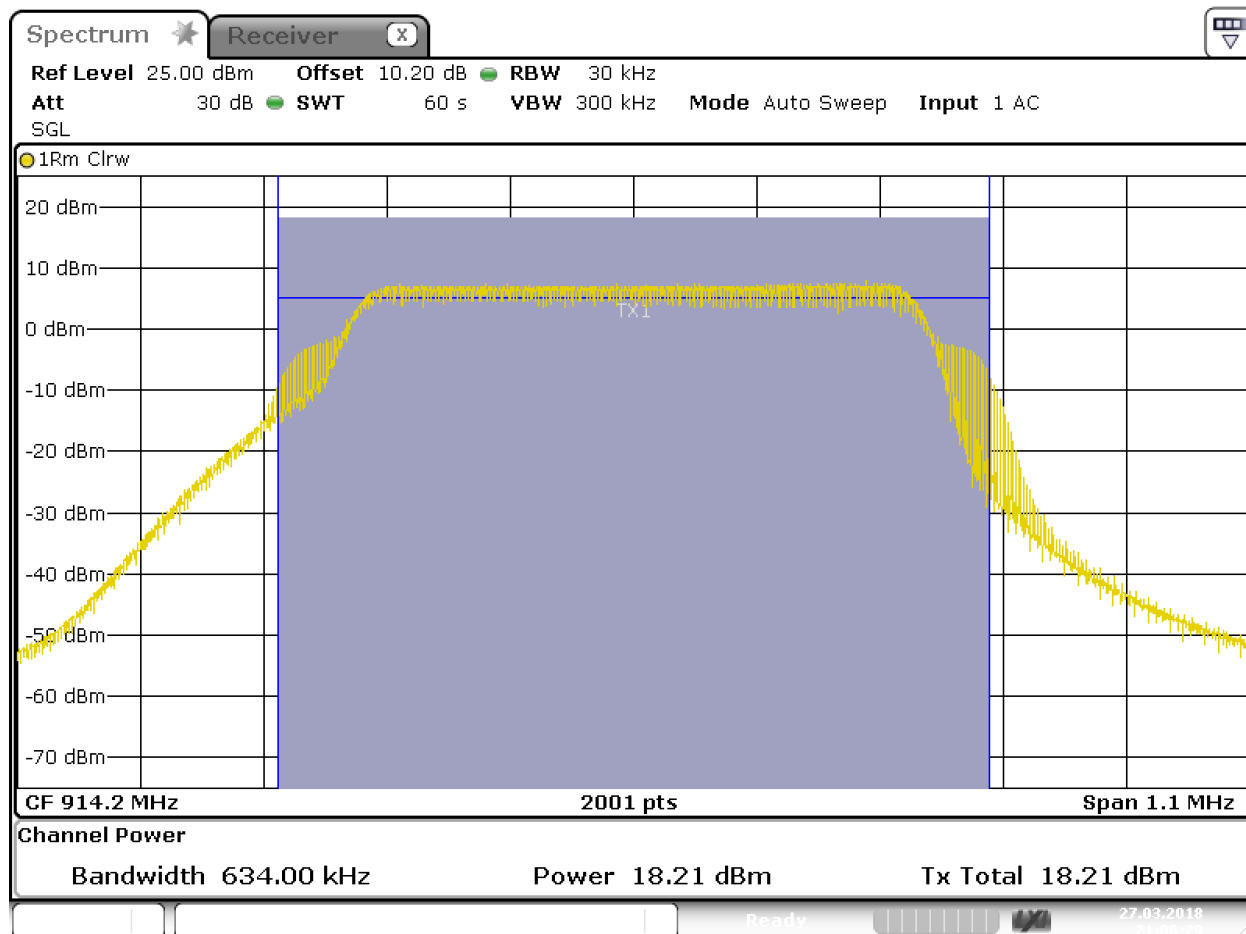
Date: 27.MAR.2018 20:52:08

Plot 2. 2



Date: 27.MAR.2018 20:58:17

Plot 2.3



Date: 27.MAR.2018 21:00:29

#### 4.3 Maximum Power Spectral Density FCC: 15.247 (e); RSS-247 A8.2b;

##### 4.3.1 Requirement

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna should not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

##### 4.3.2 Procedure

A spectrum analyzer was connected to the antenna port of the transmitter.

The procedure described in FCC Publication 558074 D01 DTS Meas Guidance v04, specifically section 10.3 Method AVGPS-1 (trace averaging with EUT transmitting at full power throughout each sweep).

1. Set instrument center frequency to DTS channel center frequency.
2. Set the span to at least  $1.5 \times \text{OBW}$ .
3. Set the RBW to:  $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$ .
4. Set the VBW  $\geq 3 \times \text{RBW}$ .
5. Detector = power averaging (RMS) or sample detector (when RMS not available).
6. Ensure that the number of measurement points in the sweep  $\geq 2 \times \text{span/RBW}$ .
7. Sweep time = auto couple.
8. Employ trace averaging (RMS) mode over a minimum of 100 traces.
9. Use the peak marker function to determine the maximum amplitude level.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span in order to meet the minimum measurement point requirement as the RBW is reduced).

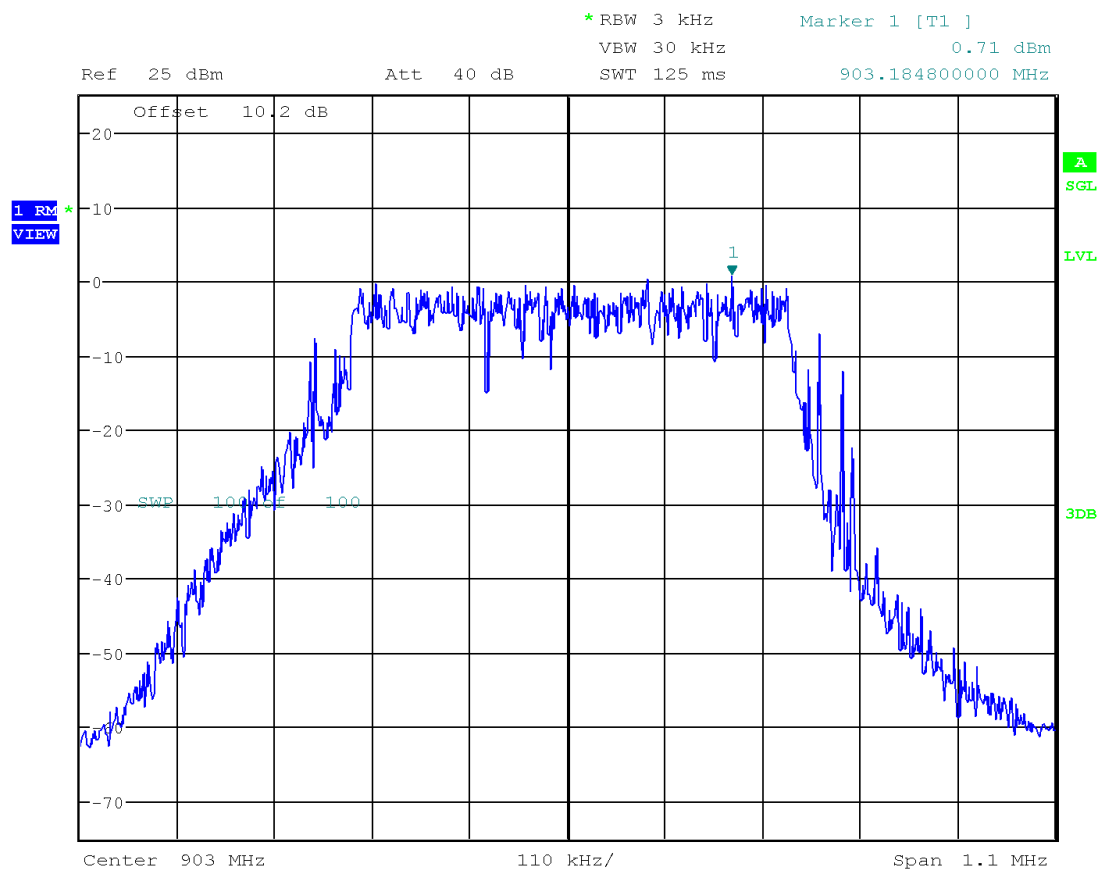
##### 4.3.3 Test Result

Refer to the following plots for the test result

Frequency, MHz	Maximum Power Spectral Density, dBm	Maximum Power Spectral Density Limit, dBm	Margin, dB	Plot
903	0.71	8.0	-7.29	3.1
907.8	0.27	8.0	-7.73	3.2
914.2	0.75	8.0	-7.25	3.3

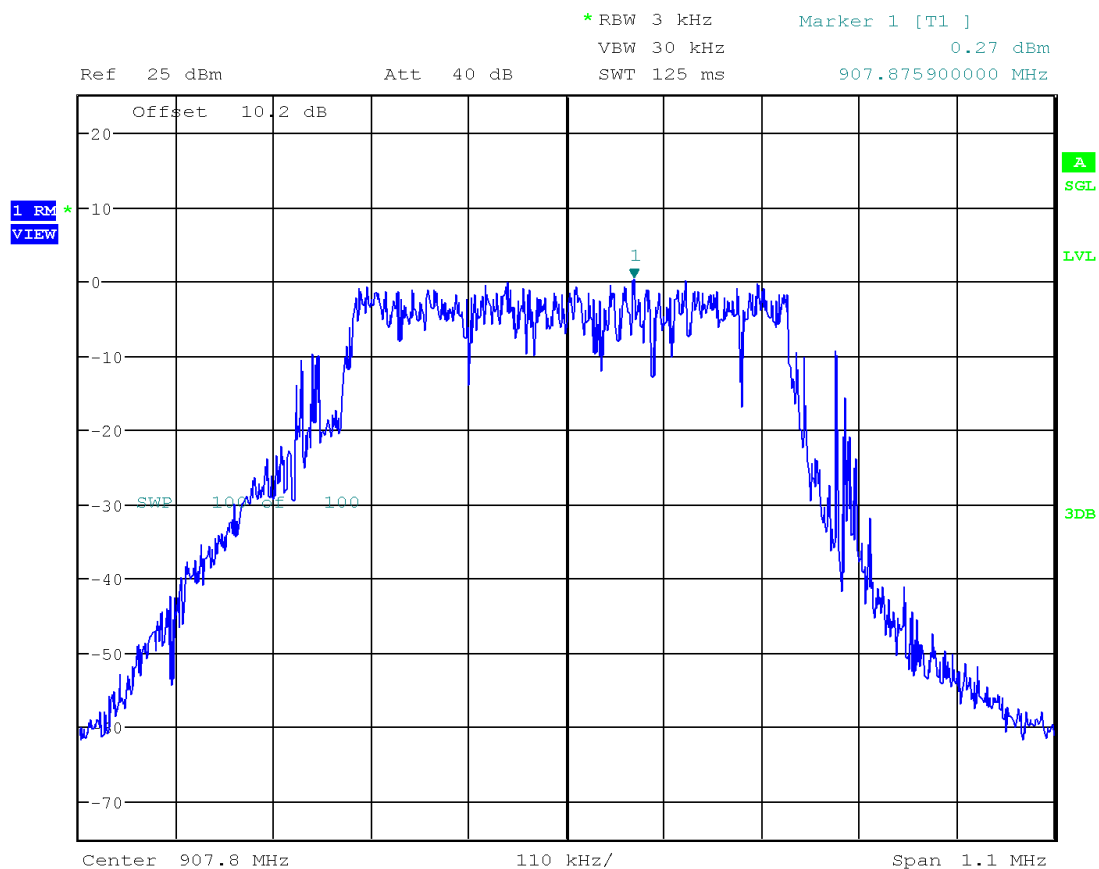
<b>Date of Test:</b>	March 6, 2018
<b>Results</b>	<b>Complies</b>

Plot 3. 1



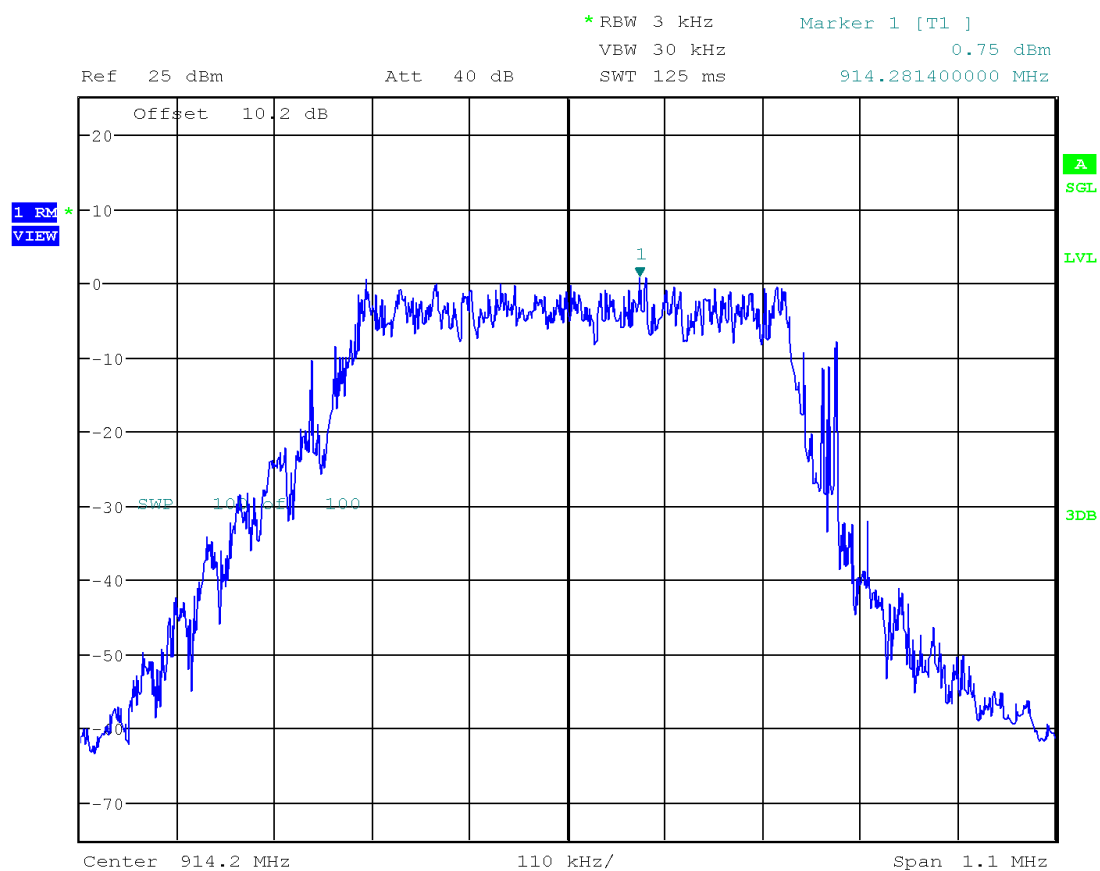
Date: 6.MAR.2018 18:10:03

Plot 3.2



Date: 6.MAR.2018 18:11:10

Plot 3.3



Date: 6.MAR.2018 18:12:03



#### 4.4 Unwanted Conducted Emissions FCC: 15.247(d); RSS-247 A8.5;

##### 4.4.1 Requirement

In any 100 kHz bandwidth outside the EUT pass-band, the RF power shall be below the maximum in-band 100 kHz emissions by at least 20 dB (if peak power of in-band emission is measured) or 30 dB (if average power of in-band emission is measured).

In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a)

##### 4.4.2 Procedure

The procedure described in FCC Publication 558074 D01 DTS Meas Guidance v04, specifically section 11.0 Emissions in non-restricted frequency bands.

A spectrum analyzer was connected to the antenna port of the transmitter.

1. Set the RBW = 100 kHz.
2. Set the VBW  $\geq 3 \times$  RBW.
3. Detector = peak.
4. Sweep time = auto couple.
5. Trace mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum amplitude level.

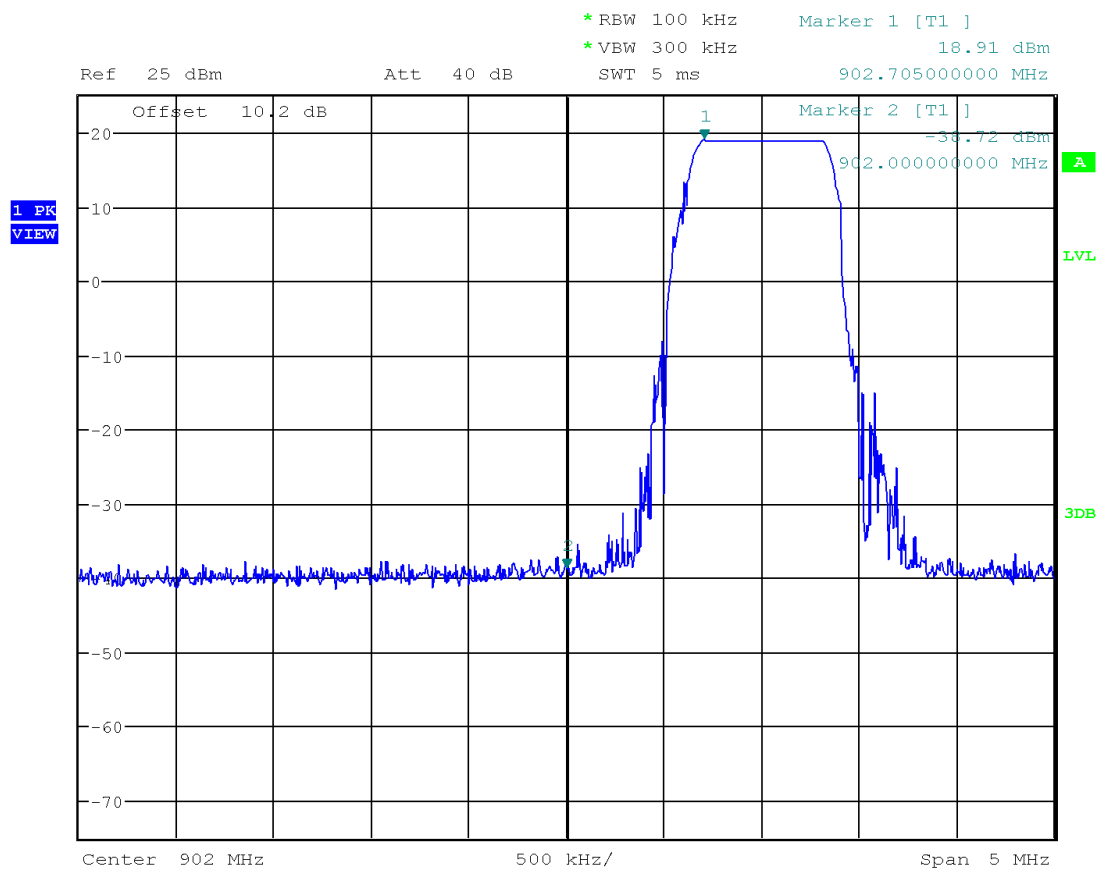
The unwanted emissions were measured from 30 MHz to 25 GHz. Plots below are corrected for cable loss and then compared to the limits.

##### 4.4.3 Test Result

Refer to the following plots 4.1 – 4.5 for unwanted conducted emissions. The plot shows -20dB attenuation limit line.

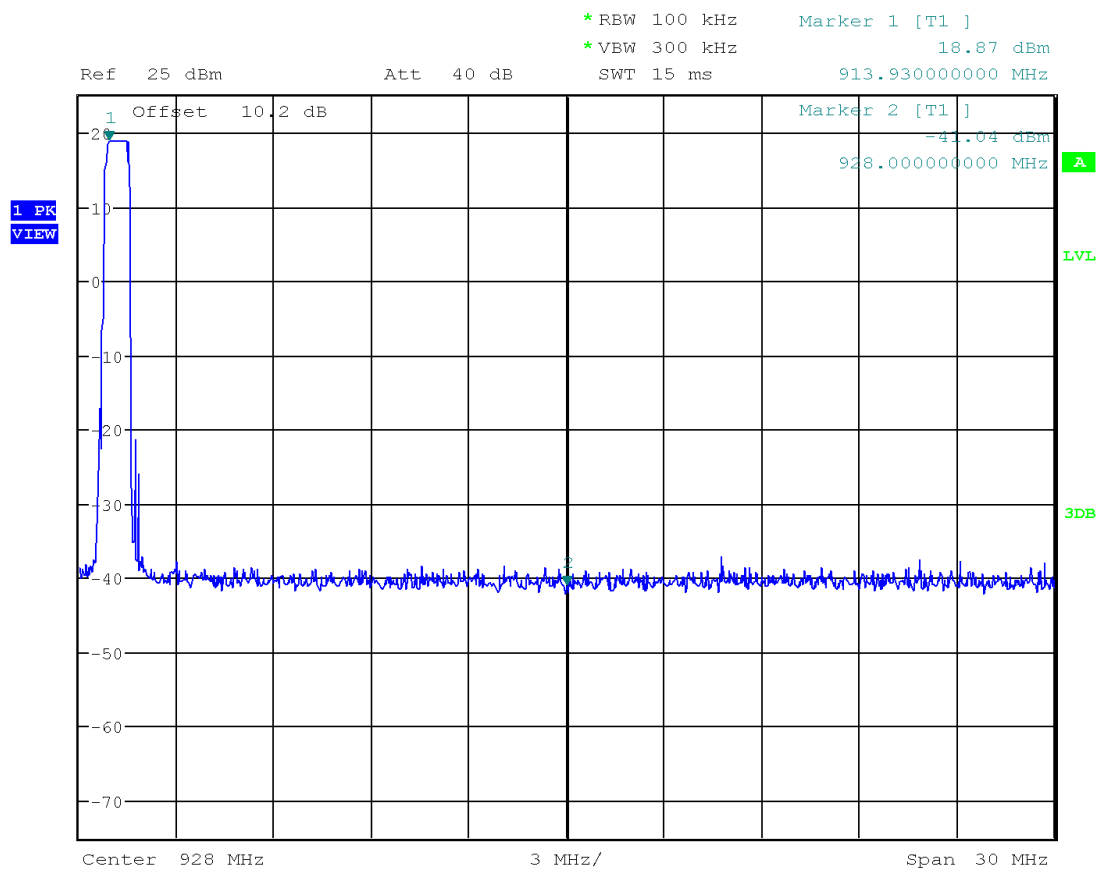
<b>Date of Test:</b>	March 6, 2018
<b>Results</b>	<b>Complies</b>

Tx @ Low Channel, 902 MHz Band Edge  
Plot 4.1



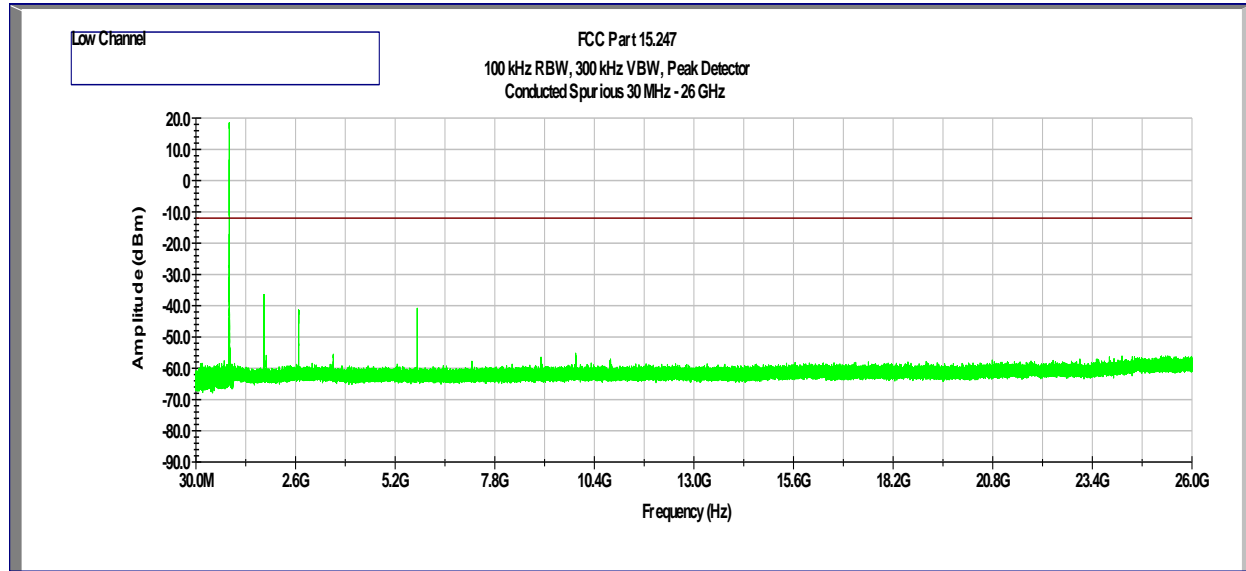
Date: 6.MAR.2018 18:29:22

# Tx @ High Channel, 928 MHz Band Edge Plot 4.2

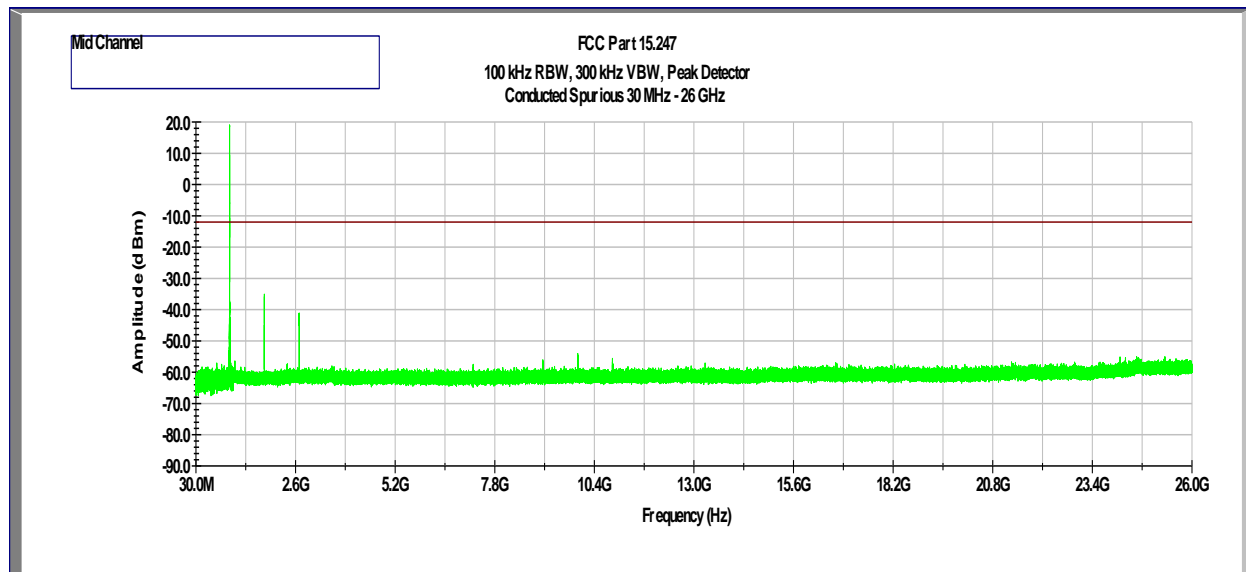


Date: 6.MAR.2018 18:30:47

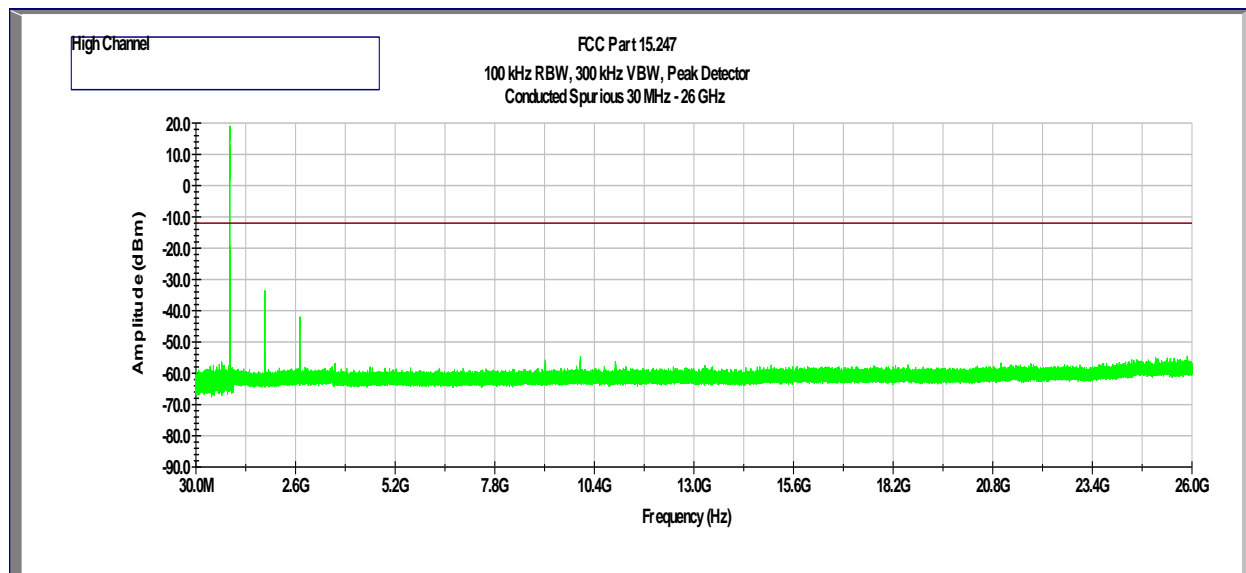
Tx @ Low Channel, 903 MHz  
30MHz -26GHz Conducted Spurious  
Plot 4.3



Tx @ Mid Channel, 907.8 MHz  
30MHz -26GHz Conducted Spurious  
Plot 4.4



Tx @ High Channel, 914.2 MHz  
30MHz -26GHz Conducted Spurious  
Plot 4.5



#### 4.5 Transmitter Radiated Emissions FCC Rules: 15.247(d), 15.209, 15.205; RSS-247;

##### 4.5.1 Requirement

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

For out of band radiated emissions (except for frequencies in restricted bands), in any 100 kHz bandwidths outside the EUT pass-band, the RF power shall be at least 20dB (peak) or 30 dB (average) below that of the maximum in-band 100 kHz emissions.

##### 4.5.2 Procedure

Radiated emission measurements were performed from 30 MHz to 25 GHz according to the procedure described in ANSI C63.10: 2013. Spectrum Analyzer Resolution Bandwidth is 100 kHz or greater for frequencies 30 MHz to 1000 MHz, 1 MHz for frequencies above 1000 MHz. Above 1000 MHz Peak and Average measurements were performed.

The EUT is placed on a plastic turntable that is 80 cm in height for below 1000MHz and 1.5m in height for above 1GHz. If the EUT attaches to peripherals, they are connected and operational (as typical as possible). During testing, all cables were manipulated to produce worst-case emissions. The signal is maximized through rotation. The antenna height and polarization are varied during the search for maximum signal level. The antenna height is varied from 1 to 4 meters.

Radiated emissions are taken at 3 meters for frequencies above 1 GHz and at 10 meters for frequencies below 1 GHz.

A preamp was used from 30MHz to 26GHz.

All measurements were made with a Peak Detector and compared to QP limits for 30MHz – 1GHz and Average limits for 1GHz – 26GHz.

Data is included of the worst-case configuration (the configuration which resulted in the highest emission levels).

#### 4.5.3 Field Strength Calculation

##### Field Strength 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:

$FS = RA + AF + CF - AG$ ; if measurement is performed at a distance other than specified in the rule, a Distance Correction Factor (DCF) shall be added.

Where FS = Field Strength in dB( $\mu$ V/m)

RA = Receiver Amplitude (including preamplifier) in dB( $\mu$ V); AF = Antenna Factor in dB(1/m)

CF = Cable Attenuation Factor in dB; AG = Amplifier Gain in dB

Assume a receiver reading of 52.0 dB( $\mu$ V) is obtained. The antennas factor of 7.4 dB(1/m) and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving field strength of 32 dB( $\mu$ V/m). This value in dB( $\mu$ V/m) was converted to its corresponding level in  $\mu$ V/m.

RA = 52.0 dB( $\mu$ V)

AF = 7.4 dB(1/m)

CF = 1.6 dB

AG = 29.0 dB

$FS = 52.0 + 7.4 + 1.6 - 29.0 = 32$  dB( $\mu$ V/m).

Level in  $\mu$ V/m = Common Antilogarithm [ $(32 \text{ dB}\mu\text{V/m})/20$ ] = 39.8  $\mu$ V/m.

#### 4.5.4 Antenna-port conducted measurements

Antenna-port conducted measurements may also be used as an alternative to radiated measurements for demonstrating compliance in the restricted frequency bands. If conducted measurements are performed, then proper impedance matching must be ensured and an additional radiated test for cabinet/case spurious emissions is required.

#### 4.5.6 General Procedure for conducted measurements in restricted bands

- a) Measure the conducted output power (in dBm) using the detector specified for determining quasi-peak, peak, and average conducted output power, respectively.
- b) Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP level (see 12.2.5 for guidance on determining the applicable antenna gain)
- c) Add the appropriate maximum ground reflection factor to the EIRP level (6 dB for frequencies  $\leq 30$  MHz, 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive and 0 dB for frequencies  $> 1000$  MHz).
- d) For devices with multiple antenna-ports, measure the power of each individual chain and sum the EIRP of all chains in linear terms (*e.g.*, Watts, mW).
- e) Convert the resultant EIRP level to an equivalent electric field strength using the following relationship:  

$$E = \text{EIRP} - 20\log D + 104.8 + \text{DCF}$$
 (DCF for Average measurements)  
 where:  
 E = electric field strength in dB $\mu$ V/m,  
 EIRP = equivalent isotropic radiated power in dBm  
 D = specified measurement distance in meters.  
 DCF = Duty Cycle Correction Factor
- f) Compare the resultant electric field strength level to the applicable limit.
- g) Perform radiated spurious emission test

#### 4.5.7 Test Results

The data on the following pages list the significant emission frequencies, the limit and the margin of compliance where emissions are within 3dB of the limit.

All conducted antenna port plots are corrected with the consideration of a 5.1 dBi Antenna Gain.

All radiated measurements were conducted with the AC adapter. The worst case data was reported.

Vertical and Horizontal orientations were pre-tested. Worst case orientation was used throughout emission measurements.

<b>Date of Test:</b>	March 4 - 5, 2018
<b>Results</b>	<b>Complies</b>

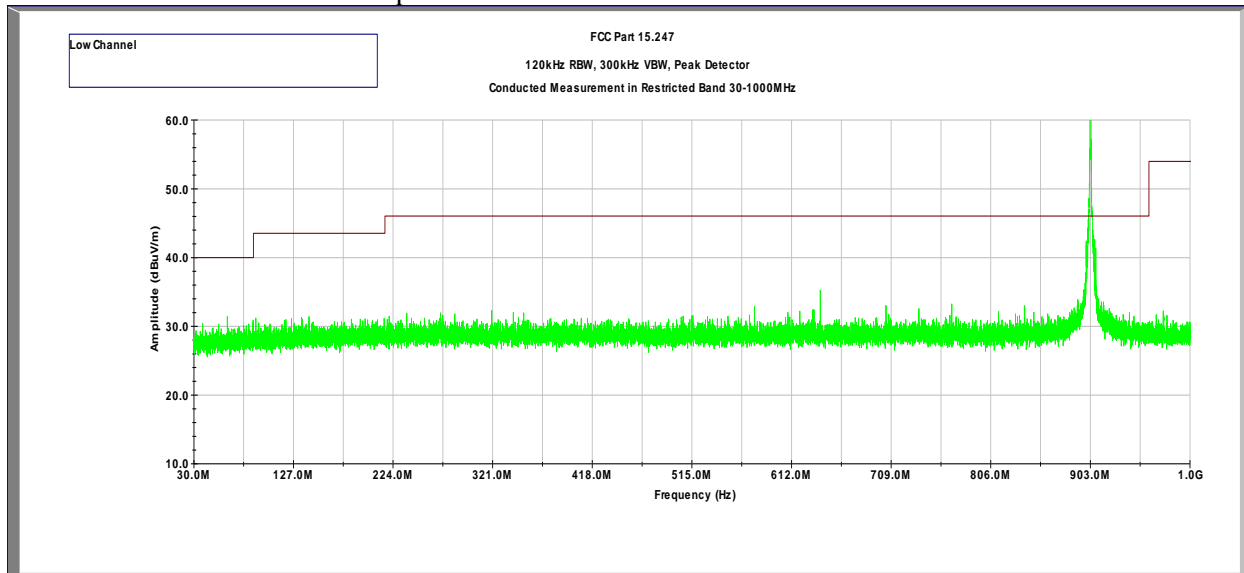


**Test Results: 15.209/15.205 Restricted Band Emissions at Antenna Port**

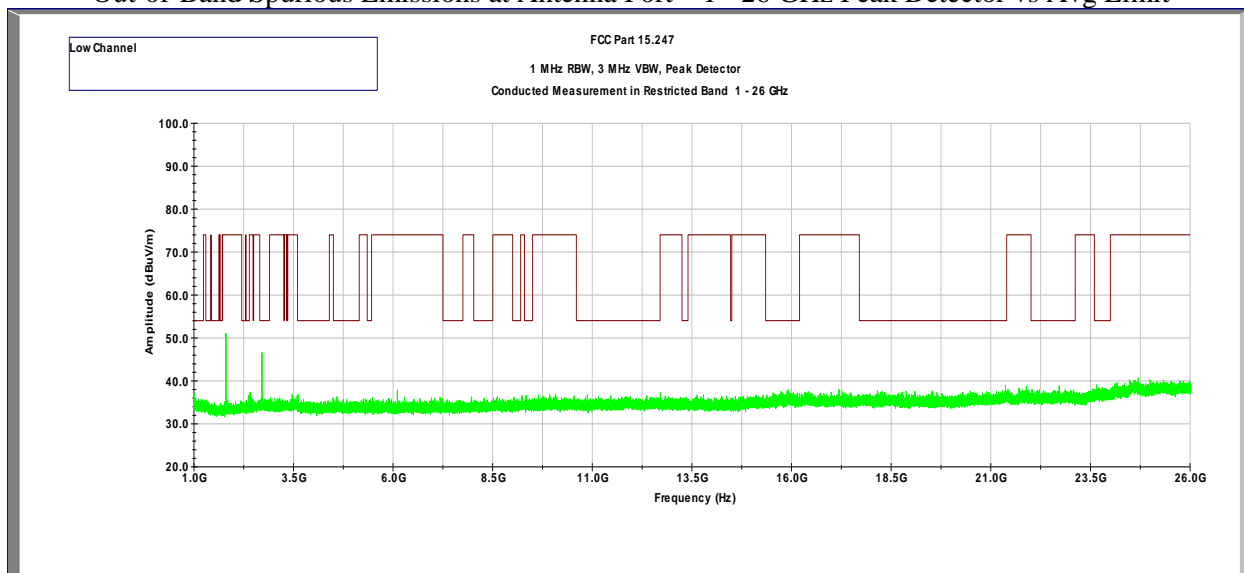
**Out-of-Band Conducted Spurious Emissions (at Antenna Port)**

**Tx @ 903 MHz**

**Out-of-Band Spurious Emissions at Antenna Port - 30 MHz to 1 GHz**



**Out-of-Band Spurious Emissions at Antenna Port – 1 - 26 GHz Peak Detector vs Avg Limit**

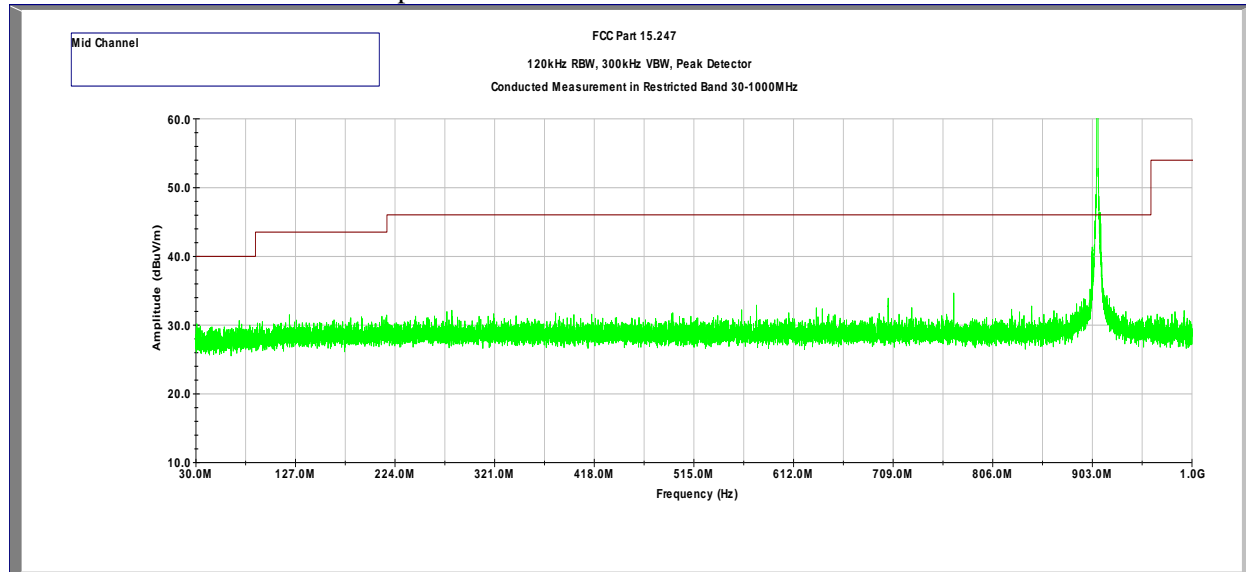


Frequency	Corrected Amplitude	Avg Limit	Margin	Detector	Results
GHz	dBμV/m	dBμV/m	dB		
2.709	46.6	54	-7.4	Peak	Pass

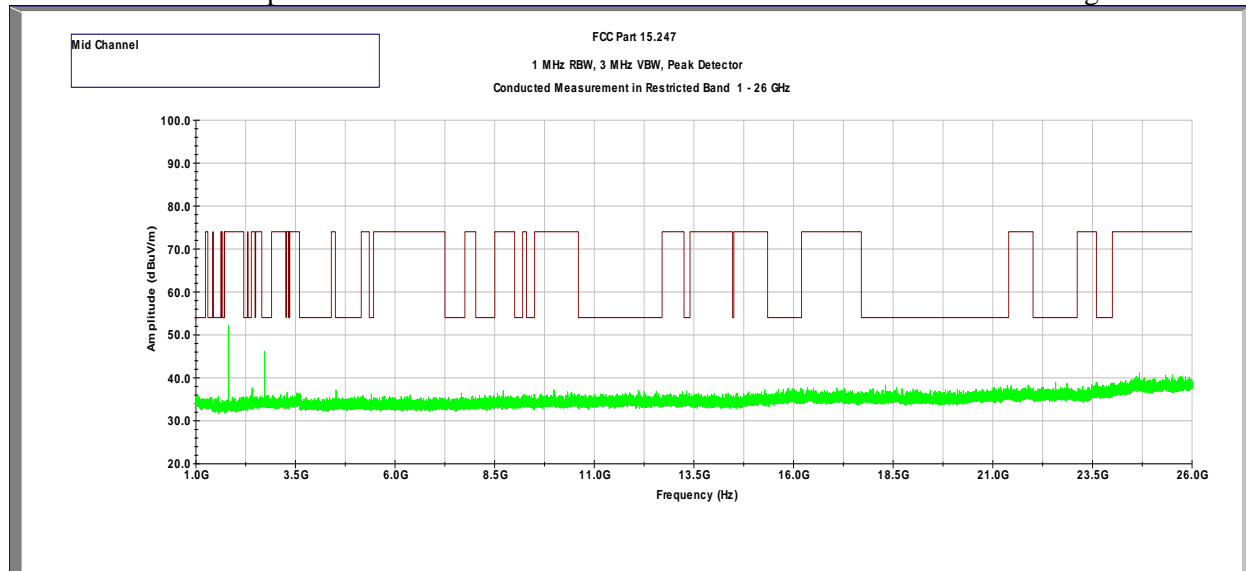
## Out-of-Band Conducted Spurious Emissions (at Antenna Port)

**Tx @ 907.8 MHz**

### Out-of-Band Spurious Emissions at Antenna Port - 30 MHz to 1 GHz



### Out-of-Band Spurious Emissions at Antenna Port – 1 - 26 GHz Peak Detector vs Avg Limit

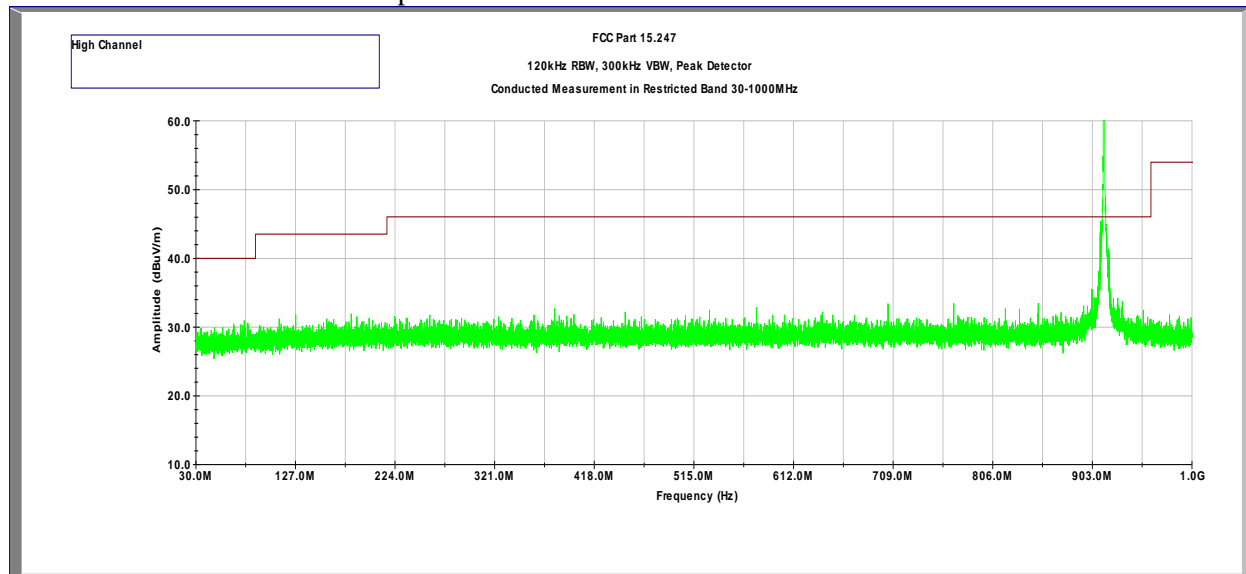


Frequency	Corrected Amplitude	Avg Limit	Margin	Detector	Results
GHz	dBμV/m	dBμV/m	dB		
2.723	46.2	54	-7.8	Peak	Pass

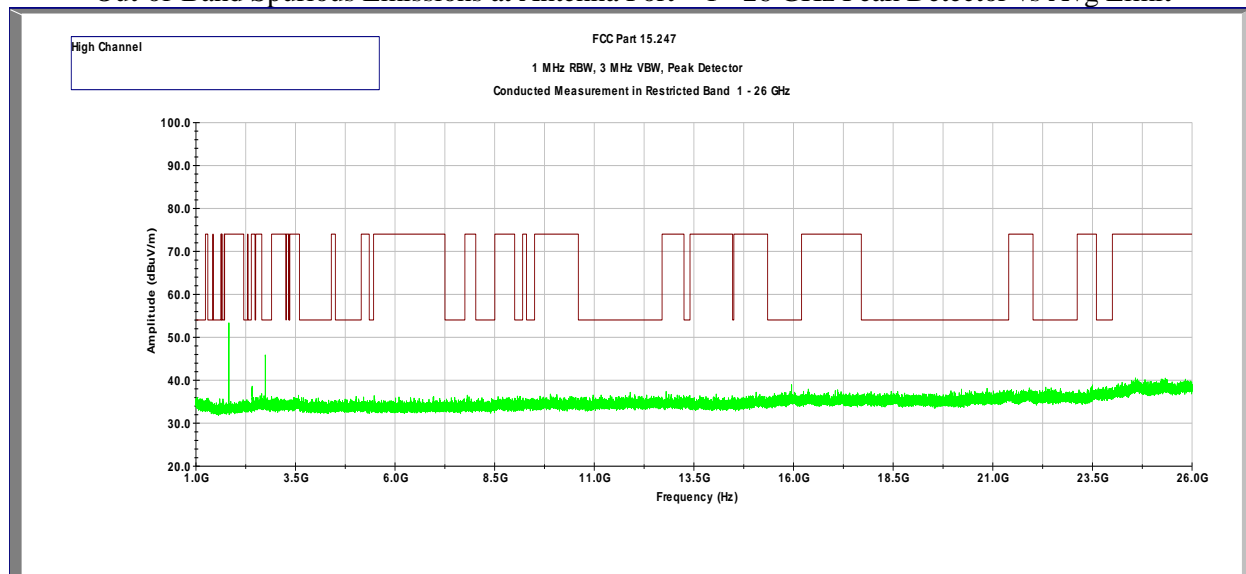
## Out-of-Band Conducted Spurious Emissions (at Antenna Port)

**Tx @ 914.2 MHz**

### Out-of-Band Spurious Emissions at Antenna Port - 30 MHz to 1 GHz



### Out-of-Band Spurious Emissions at Antenna Port – 1 - 26 GHz Peak Detector vs Avg Limit

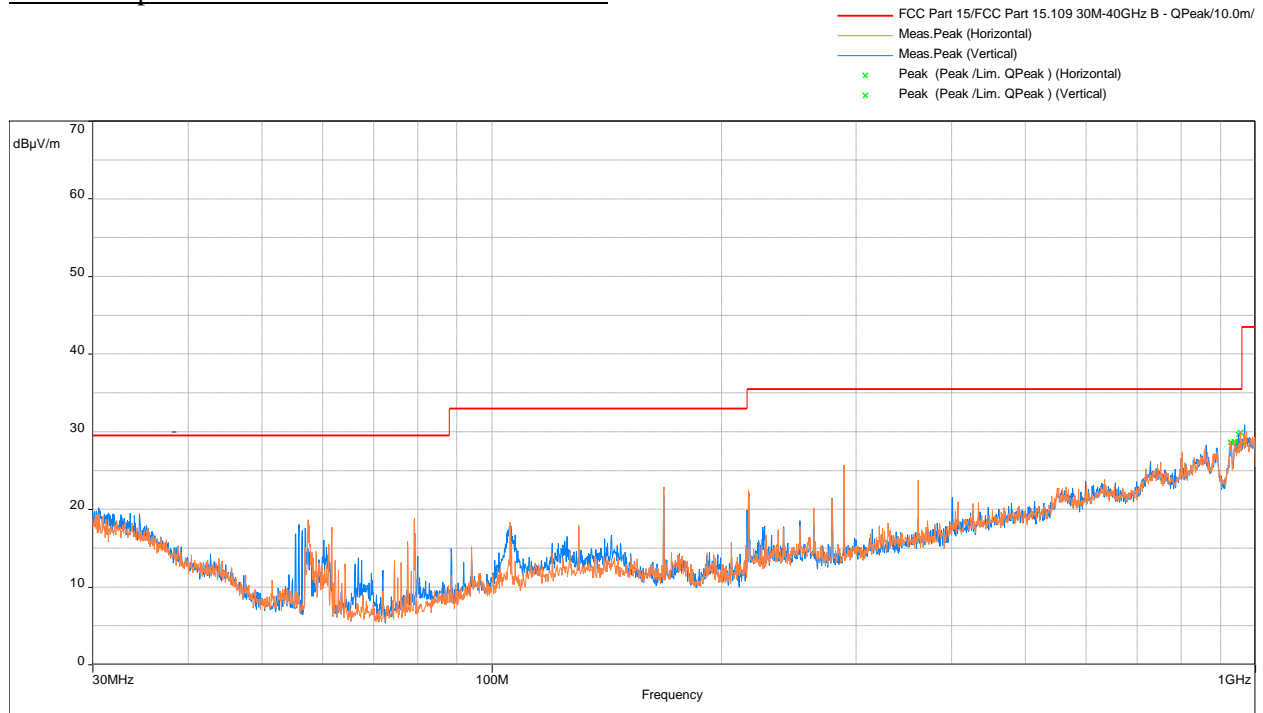


Frequency	Corrected Amplitude	Avg Limit	Margin	Detector	Results
GHz	dBμV/m	dBμV/m	dB		
2.742	45.8	54	-8.2	Peak	Pass

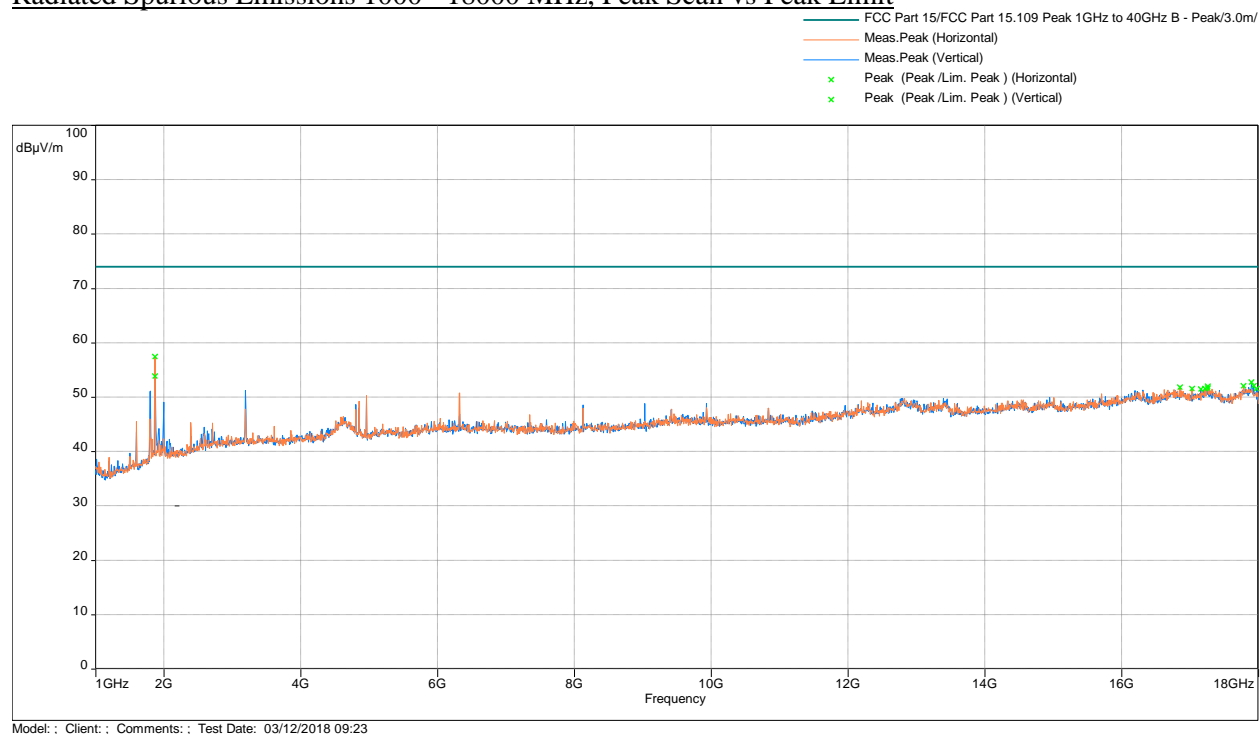
## Out-of-Band Radiated Spurious Emissions (Cabinet Radiation)

Test Results: 15.209 Radiated Spurious Emissions Low Channel, Tx at 903 MHz

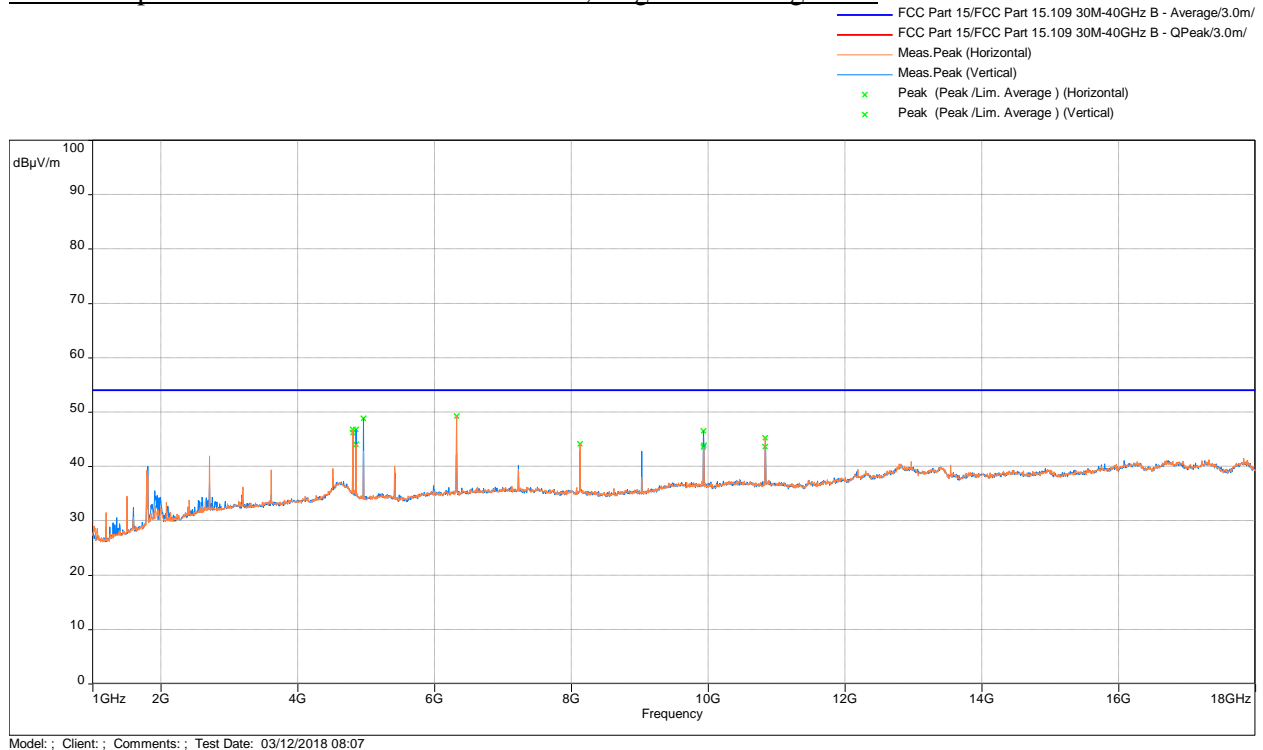
### Radiated Spurious Emissions 30 MHz - 1000 MHz



## Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan vs Peak Limit



## Radiated Spurious Emissions 1000 - 18000 MHz, Avg Scan vs Avg Limit



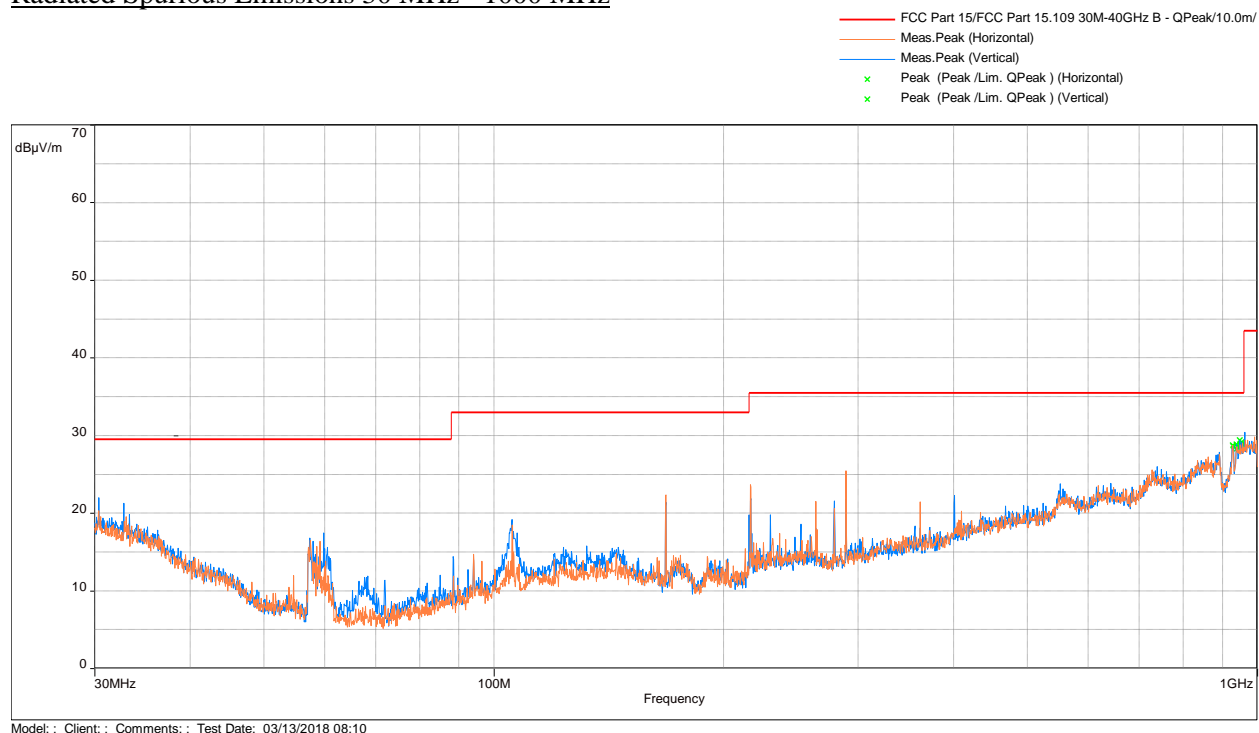
Frequency	Corrected Amplitude	Avg Limit	Margin	Detector	Results
MHz	dBμV/m	dBμV/m	dB		
4958.167	48.8	54	-5.2	Avg	Pass

Note: FS@3m = RA + AF + CF - Preamp

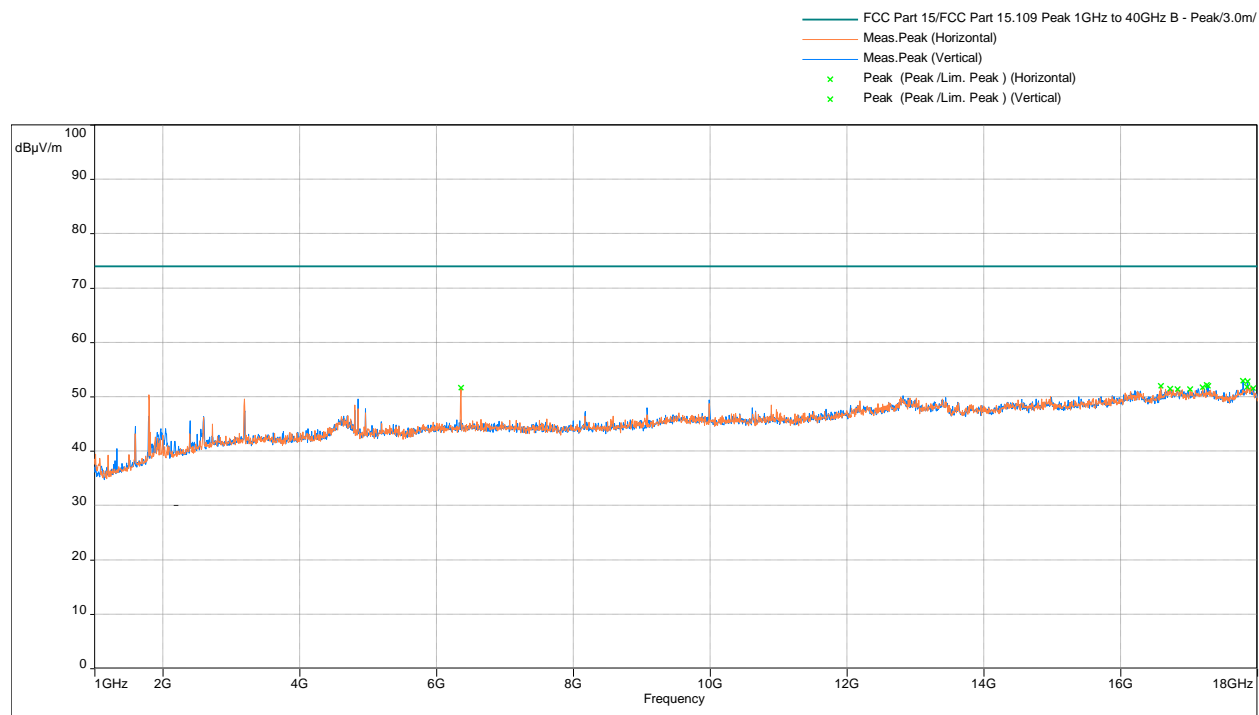
Results	Complies
---------	----------

Test Results: 15.209 Radiated Spurious Emissions Mid Channel, Tx at 907.8 MHz

Radiated Spurious Emissions 30 MHz - 1000 MHz

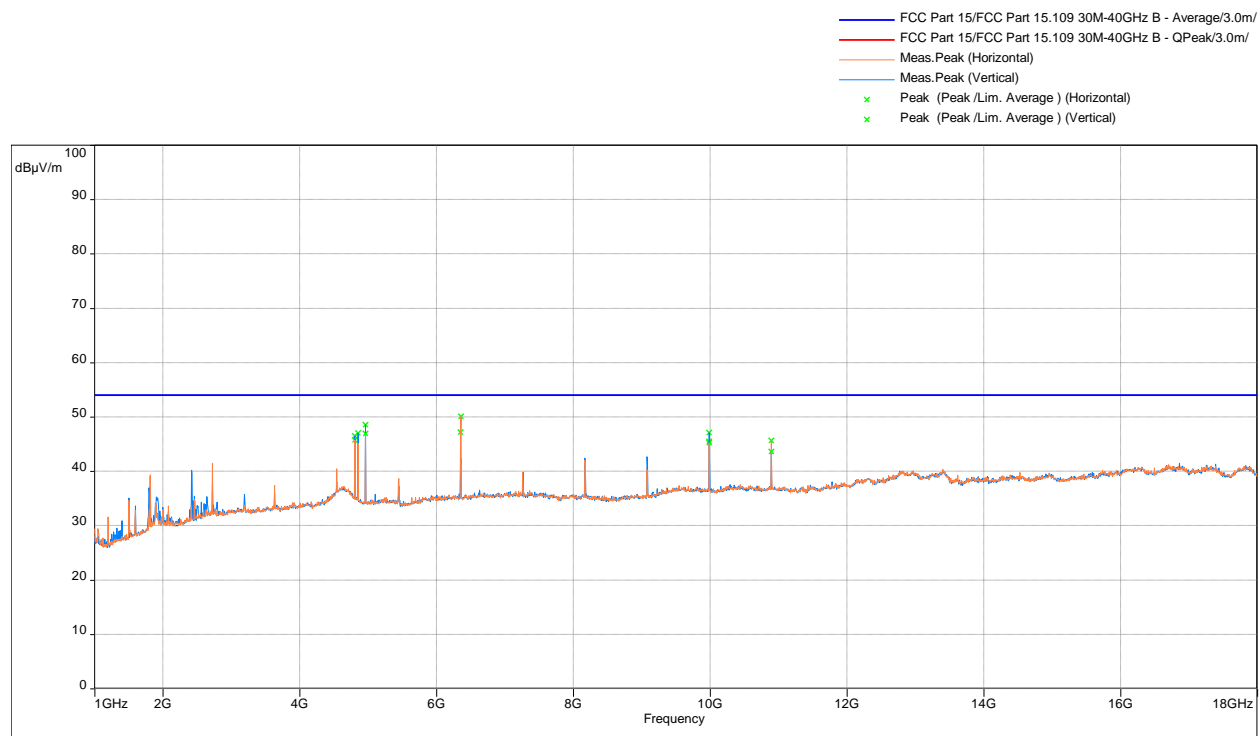


## Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan vs Peak Limit





## Radiated Spurious Emissions 1000 - 18000 MHz, Avg Scan vs Avg Limit



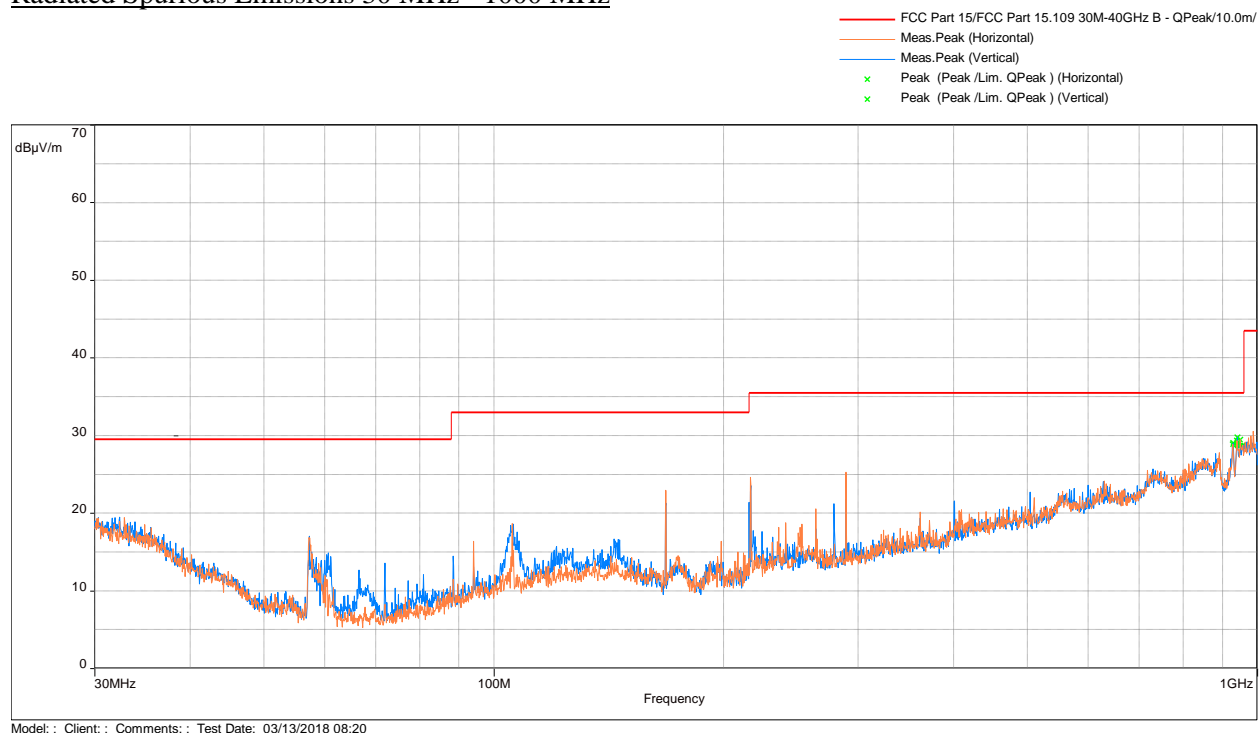
Frequency	Corrected Amplitude	Avg Limit	Margin	Detector	Results
MHz	dBμV/m	dBμV/m	dB		
4958.167	48.6	54	-5.4	Avg	Pass

Note: FS@3m = RA + AF + CF - Preamp

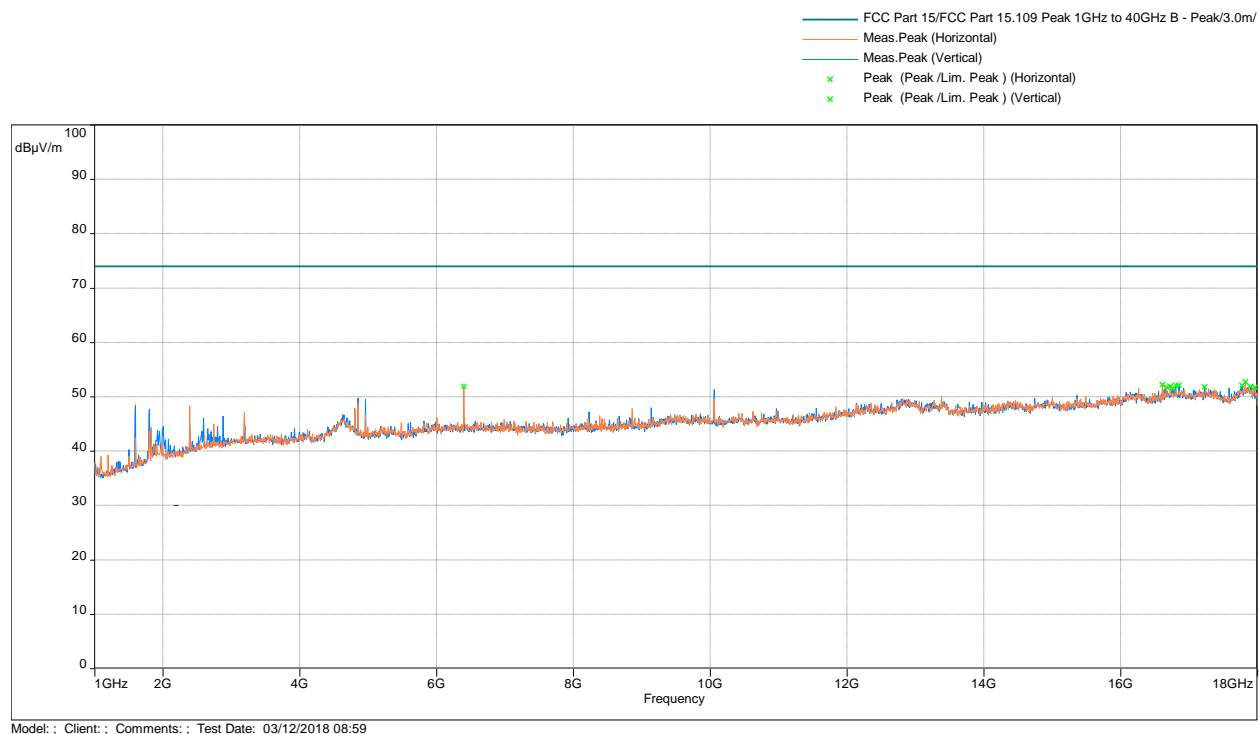
<b>Results</b>	<b>Complies</b>
----------------	-----------------

Test Results: 15.209 Radiated Spurious Emissions High Channel, Tx at 914.2 MHz

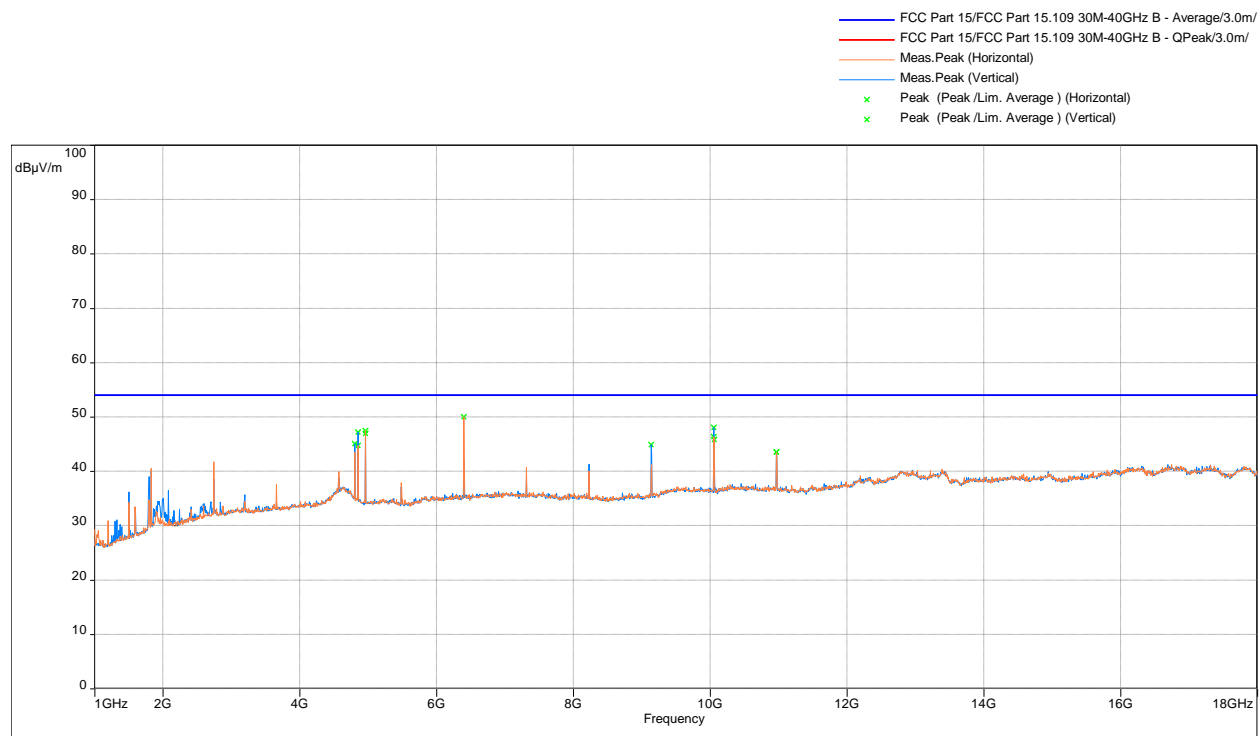
Radiated Spurious Emissions 30 MHz - 1000 MHz



## Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan vs Peak Limit



## Radiated Spurious Emissions 1000 - 18000 MHz, Avg Scan vs Avg Limit



Frequency	Corrected Amplitude	Avg Limit	Margin	Detector	Results
MHz	dBμV/m	dBμV/m	dB		
6399.767	50	54	-4.0	Avg	Pass

Note: FS@3m = RA + AF + CF - Preamp

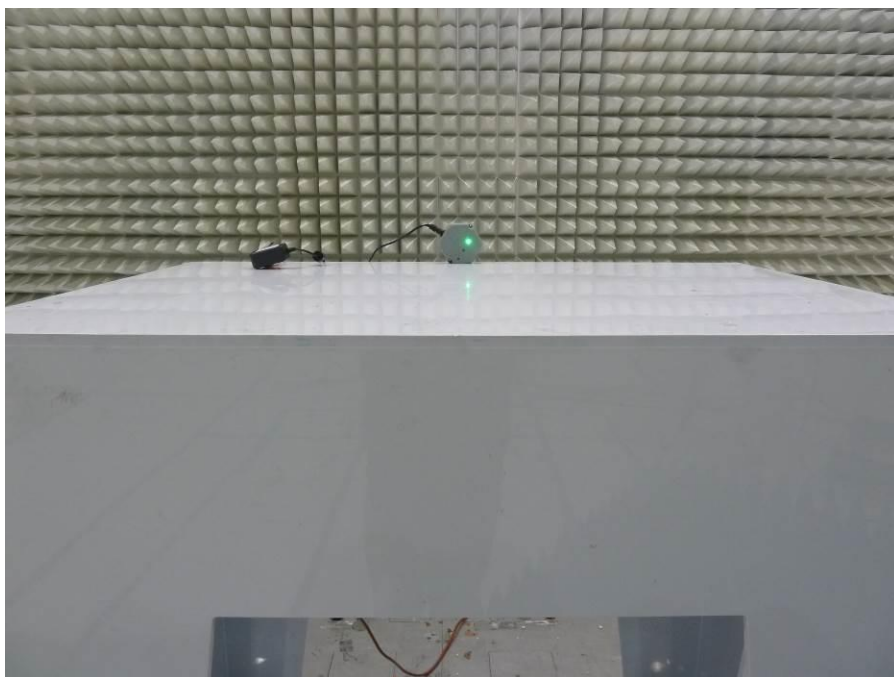
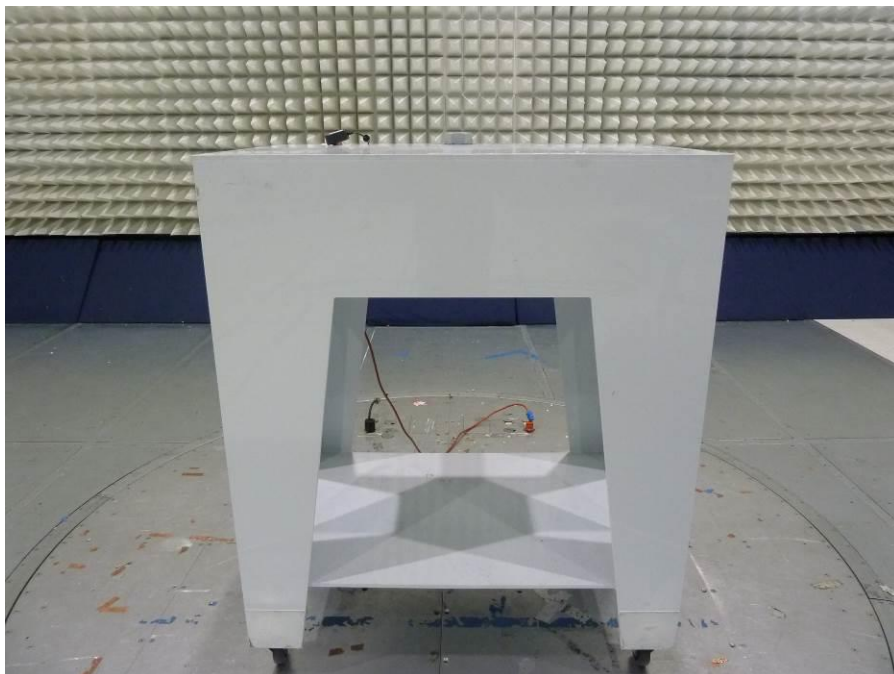
<b>Results</b>	<b>Complies</b>
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#### 4.5.8 Test setup photographs

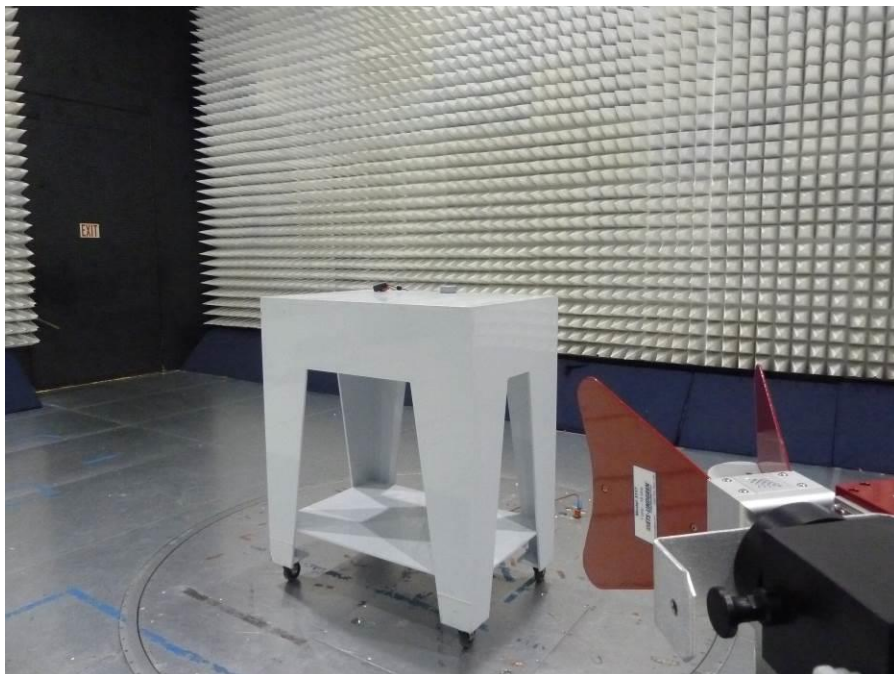
**The following photographs show the testing configurations used.**



#### 4.5.8 Test Setup Photographs (Continued)



#### 4.5.8 Test Setup Photographs (Continued)



#### 4.6 Radiated Emissions

FCC Ref: 15.109, ICES 003

##### 4.6.1 Requirement

***Limits for Electromagnetic Radiated Emissions FCC Section 15.109(b), ICES 003\*, RSS GEN***

<b>Frequency (MHz)</b>	<b>Class A at 10m dB(μV/m)</b>	<b>Class B at 3m dB(μV/m)</b>
30-88	39	40.0
88-216	43.5	43.5
216-960	46.4	46.0
Above 960	49.5	54.0

\* According to FCC Part 15.109(g) an alternative to the radiated emission limits shown above, digital devices may be shown to comply with the limit of CISPR Pub. 22



#### 4.6.2 Procedures

Measurements are conducted with a quasi-peak detector instrument in the frequency range of 30 MHz to 1000 MHz and with the average detector instrument in the frequency range above 1000 MHz. The measuring receiver meets the requirements of Section One of CISPR 16 and the measuring antenna correlates to a balanced dipole.

Measurements of the radiated field are made with the antenna located at a distance of 10 meters from the EUT. If the field-strength measurements at 10m cannot be made because of high ambient noise level or for other reasons, measurements of Class B equipment may be made at a closer distance, for example 3m. An inverse proportionality factor of 20 dB per decade should be used to normalize the measured data to the specified distance for determining compliance.

The antenna is adjusted between 1m and 4m in height above the ground plane for maximum meter reading at each test frequency.

The antenna-to-EUT azimuth is varied during the measurement to find the maximum field-strength readings.

The antenna-to-EUT polarization (horizontal and vertical) is varied during the measurements to find the maximum field-strength readings.

The EUT, where intended for tabletop use, is placed on a table whose top is 0.8m above the ground plane. The table is constructed of non-conductive materials. Its dimensions are 1m by 1.5m, but may be extended for a larger EUT.

Floor standing EUT are placed on a horizontal metal ground plane and isolated from the ground plane by resting on an insulating material.

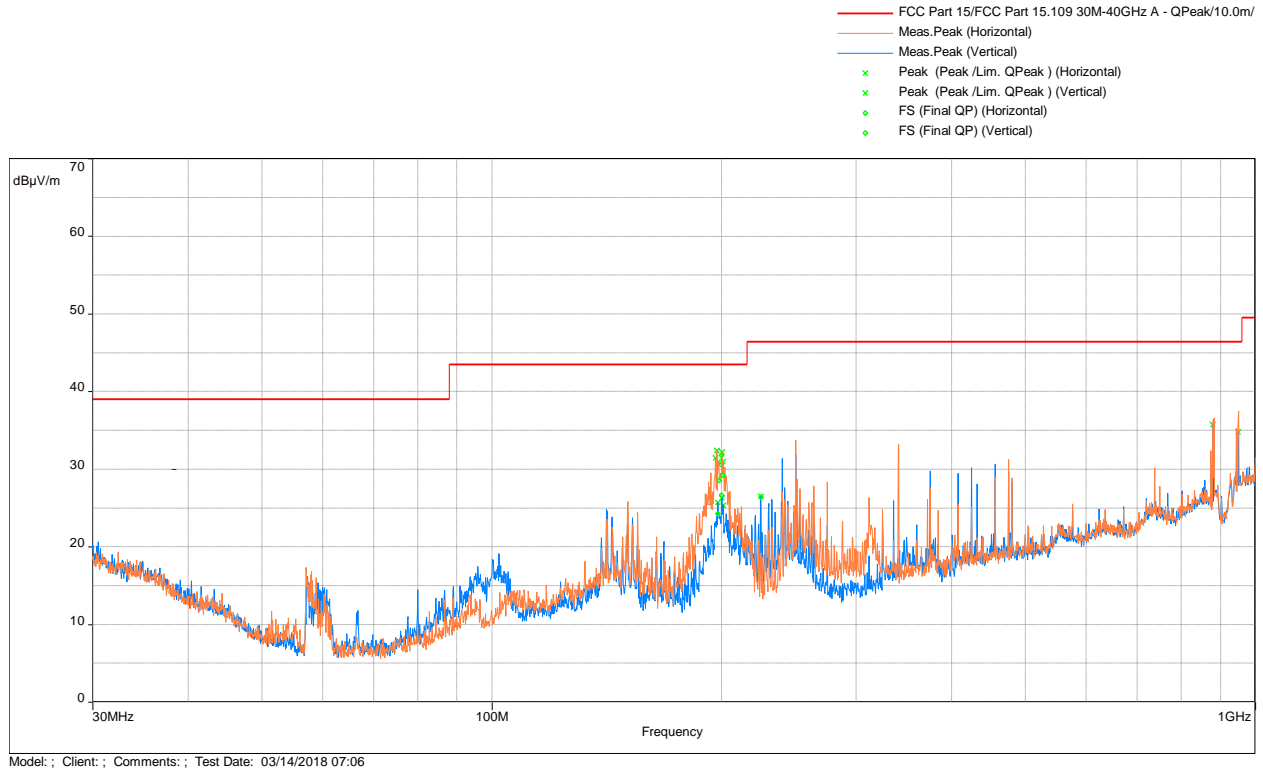
Equipment setup for radiated disturbance tests followed the guidelines of ANSI C63.4-2014.

<b>Tested By:</b>	Aaron Chang
<b>Test Date:</b>	March 12, 2018

#### 4.6.3 Test Results

*The EUT met the radiated disturbance requirements of FCC & ICES 003 for a Class A device.*

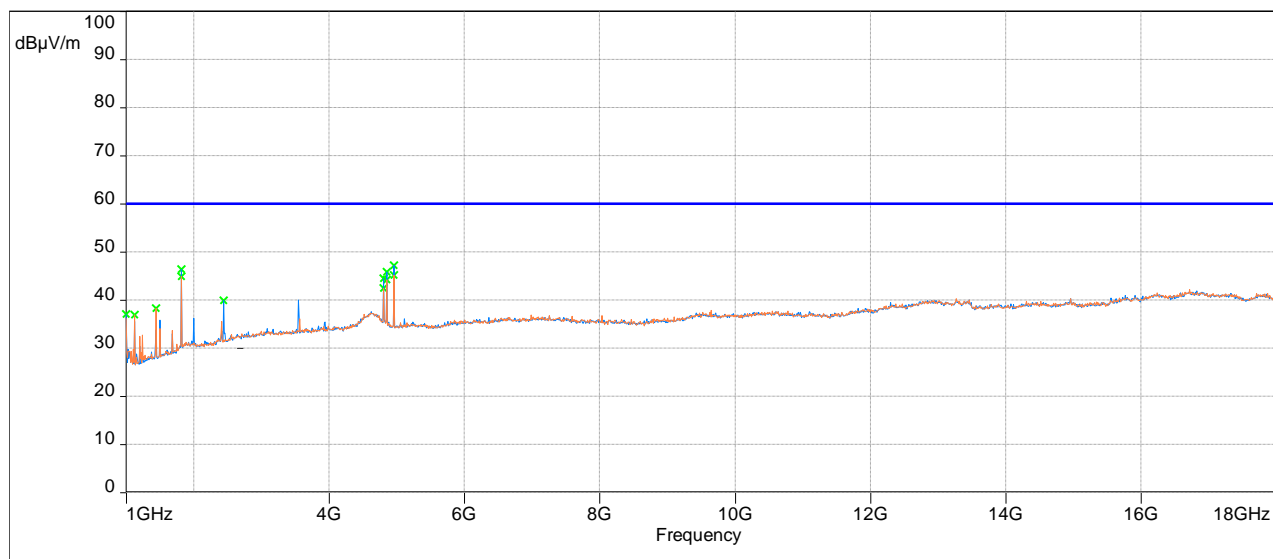
#### **FCC & ICES 003 Radiated Disturbance** **30MHz to 1GHz** **120V 60Hz**



Frequency	FS	Limit	Margin	Azimuth	Height	Polarity	RA	Correction
MHz	dBμV/m	dBμV/m	dB	deg	m		dBμV	dB
198.435	28.57	40	-11.43	96.5	3.83	Horizontal	45.54	-16.97
199.998	31.78	40	-8.22	101.25	3.99	Horizontal	48.72	-16.96
200.787	29.22	40	-10.78	107	3.29	Horizontal	46.08	-16.87
197.800	24.26	40	-15.74	200.25	1.33	Vertical	41.23	-16.97
199.996	26.65	40	-13.35	211.25	1.18	Vertical	43.58	-16.96
224.996	26.43	40	-13.57	145	1.2	Vertical	42.33	-15.9

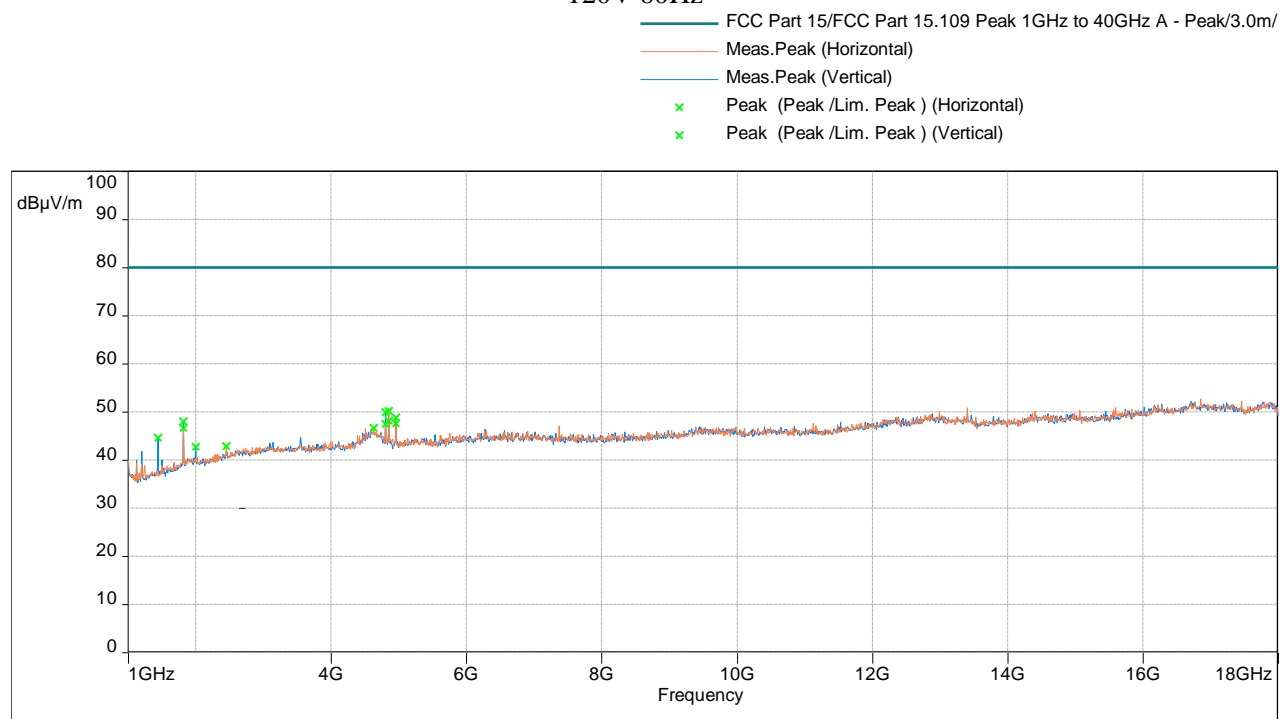
***FCC & ICES 003 Radiated Disturbance***  
***1GHz to 18GHz, Average***  
**120V 60Hz**

- FCC Part 15/FCC Part 15.109 30M-40GHz A - Average/3.0m/
- Meas.Peak (Horizontal)
- Meas.Peak (Vertical)
- x Peak (Peak /Lim. Average ) (Horizontal)
- x Peak (Peak /Lim. Average ) (Vertical)



Model: ; Client: ; Comments: ; Test Date: 03/14/2018 08:59

***FCC & ICES 003 Radiated Disturbance***  
***1GHz to 18GHz, Peak***  
**120V 60Hz**



<b>Result:</b>	<b>Complies by 8.22 dB</b>
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#### 4.6.4 Test Configuration Photographs

**The following photographs** show the testing configurations used.



4.7 AC Line Conducted Emission  
FCC: 15.207, 15.107; RSS-GEN;

4.7.1 Requirement

Frequency Band MHz	FCC 15.207 Limit dB(μV)		FCC 15.107 Class A Limit dB(μV)	
	Quasi-Peak	Average	Quasi-Peak	Average
0.15-0.50	66 to 56 *	56 to 46 *	79	66
0.50-5.00	56	46	73	60
5.00-30.00	60	50	73	60

*Note: \*Decreases linearly with the logarithm of the frequency. At the transition frequency the lower limit applies.*

*Electromagnetic Radiated Disturbance Setup Photograph*

#### 4.7.2 Procedure

Measurements are carried out using quasi-peak and average detector receivers in accordance with CISPR 16. An AMN is required to provide defined impedance at high frequencies across the power feed at the point of measurement of terminal voltage and also to provide isolation of the circuit under test from the ambient noise on the power lines. An AMN as defined in CISPR 16 shall be used.

The EUT is located so that the distance between the boundary of the EUT and the closest surface of the AMN is 0.8m.

Where a flexible mains cord is provided by the manufacturer, this shall be 1m long or if in excess of 1m, the excess cable is folded back and forth as far as possible so as to form a bundle not exceeding 0.4m in length.

The EUT is arranged and connected with cables terminated in accordance with the product specification.

Conducted disturbance is measured between the phase lead and the reference ground, and between the neutral lead and the reference ground. Both measured values are reported.

The EUT, where intended for tabletop use, is placed on a table whose top is 0.8m above the ground plane. A vertical, metal reference plane is placed 0.4m from the EUT. The vertical metal reference-plane is at least 2m by 2m. The EUT shall be kept at least 0.8m from any other metal surface or other ground plane not being part of the EUT. The table is constructed of non-conductive materials. Its dimensions are 1m by 1.5m, but may be extended for larger EUT.

Floor standing EUTs are placed on a horizontal metal ground plane and isolated from the ground plane by an insulating material up to 12mm thick. The metal ground plane extends at least 0.5m beyond the boundaries of the EUT and has minimum dimensions of 2m by 2m.

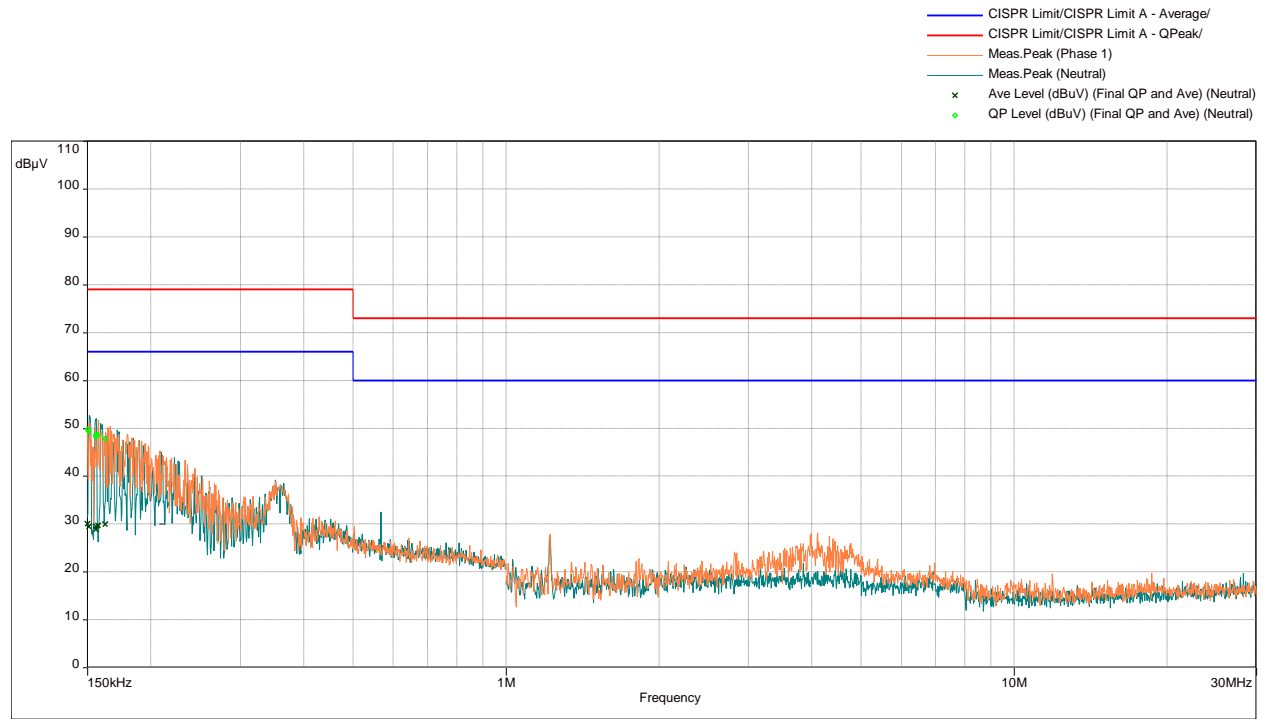
Equipment setup for conducted disturbance tests followed the guidelines of ANSI C63.10: 2013 & ANSI C63.4-2014.

<b>Tested By:</b>	Aaron Chang
<b>Test Date:</b>	March 13, 2018

#### 4.7.3 Test Result

*The EUT met the conducted disturbance requirement of FCC & ICES 003 for a Class A device.*

#### 15.107 FCC & ICES 003 Conducted Disturbance at AC Mains 120V 60Hz

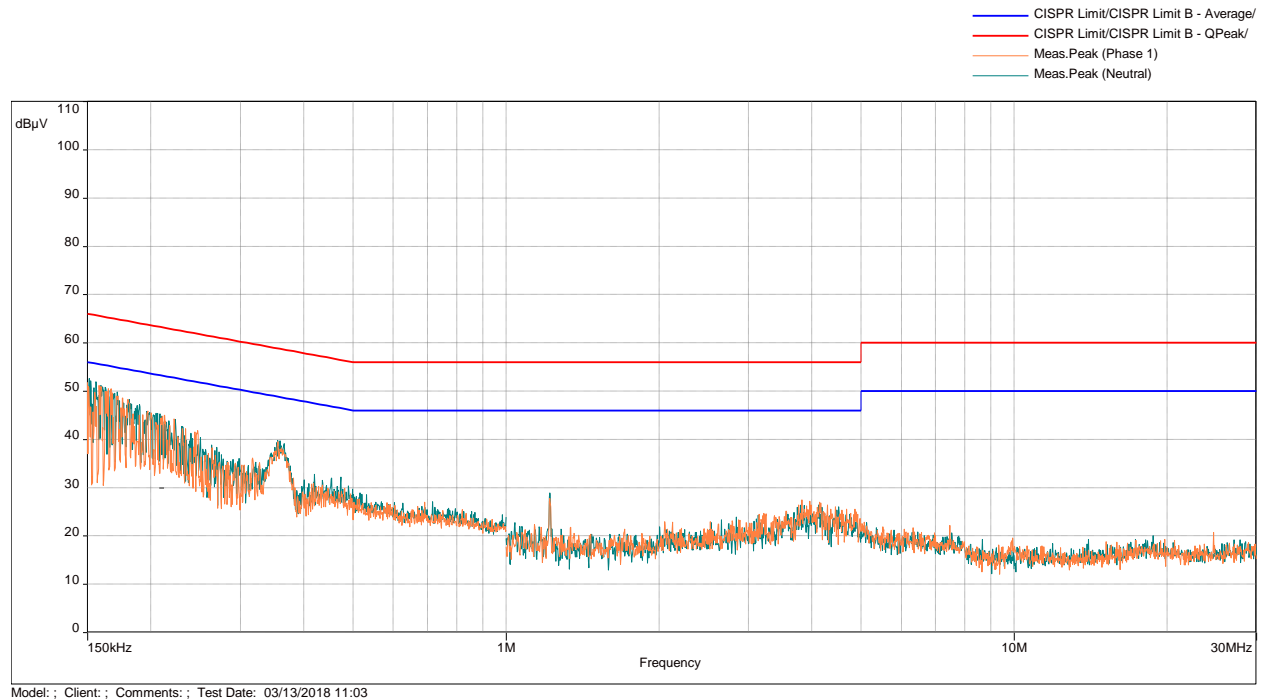


Freq.	Ave Level	QP Level	Ave Limit	QP Limit	Ave Margin	QP Margin	Line	Correction
MHz	dBμV	dBμV	dBμV	dBμV	dB	dB		dB
0.150	29.99	49.81	66	79	-36.01	-29.19	Neutral	11.01
0.151	29.48	49.41	66	79	-36.52	-29.59	Neutral	11.01
0.156	29.42	48.62	66	79	-36.58	-30.38	Neutral	11.02
0.156	28.88	48.21	66	79	-37.12	-30.79	Neutral	11.02
0.157	29.67	48.64	66	79	-36.33	-30.36	Neutral	11.02
0.163	29.89	47.82	66	79	-36.11	-31.18	Neutral	11.02

**Result:** Complies by 29.19 dB



**15.207 FCC & ICES 003 Conducted Disturbance at AC Mains**  
**120V 60Hz**

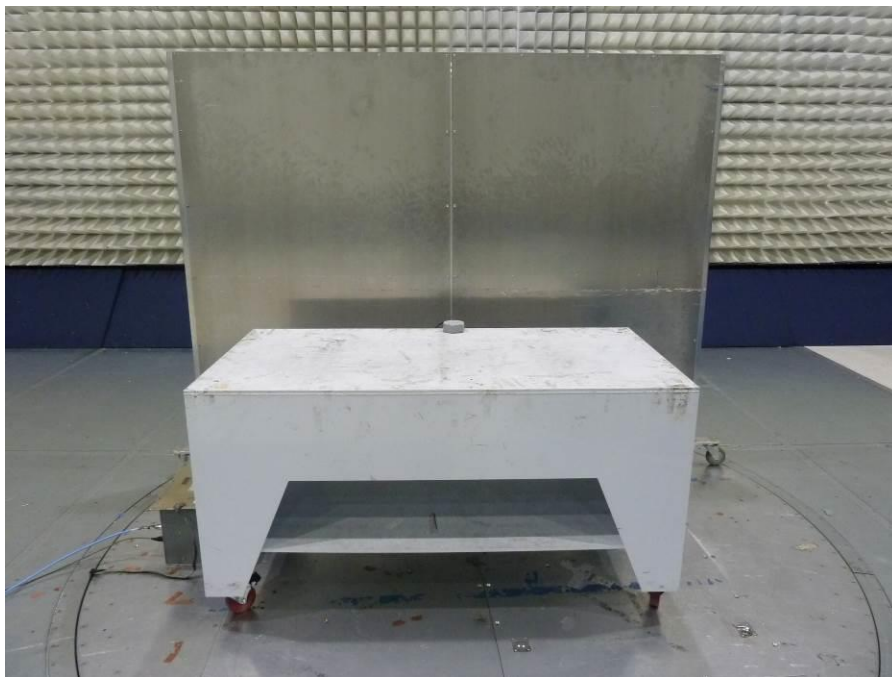


Freq.	Ave Level	QP Level	Ave Limit	QP Limit	Ave Margin	QP Margin	Line	Correction
MHz	dBμV	dBμV	dBμV	dBμV	dB	dB		dB
0.150	31.82	51.82	56	66	-24.18	-14.18	Phase 1	11.01
0.151	30.95	50.95	55.96	65.96	-25.01	-15.01	Phase 1	11.01
0.155	29.72	49.72	55.72	65.72	-26	-16	Phase 1	11.02
0.158	31.2	51.2	55.56	65.56	-24.36	-14.36	Phase 1	11.02
0.159	30.96	50.96	55.5	65.5	-24.54	-14.54	Phase 1	11.02
0.163	29.93	49.93	55.33	65.33	-25.4	-15.4	Phase 1	11.02

**Result:** **Complies by 14.18 dB**

#### 4.7.4 Test Configuration Photographs

**The following photographs show the testing configurations used.**



*AC Mains Line-Conducted Disturbance Setup Photograph*

## 5.0 List of Test Equipment

Measurement equipment used for emission compliance testing utilized the equipment on the following list:

Equipment	Manufacturer	Model/Type	Asset #	Cal Int	Cal Due
Spectrum Analyzer	Rohde and Schwarz	FSU	ITS 00913	12	01/24/19
Spectrum Analyzer	Rohde and Schwarz	ESR	ITS 01607	12	10/09/18
Active Horn Antenna	ETS-Lindgren	3117-PA	ITS 01636	12	01/11/19
EMI Receiver	Rohde and Schwarz	ESU	ITS 00961	12	07/10/18
BI-Log Antenna	Teseq	CBL 6111D	ITS 01058	12	08/11/18
Pre-Amplifier	Sonoma Instrument	310	ITS 00942	12	01/26/19
RF Cable	TRU Corporation	TRU CORE 300	ITS 01462	12	08/19/18
RF Cable	TRU Corporation	TRU CORE 300	ITS 01465	12	08/19/18
RF Cable	TRU Corporation	TRU CORE 300	ITS 01470	12	08/19/18
Attenuator	Narda	FSCM99899	ITS 01583	12	08/31/18
RF Cable	Megaphase	EMC1-K1K1-236	ITS 01538	12	06/13/18
LISN	FCC	FCC-LISN-50-50-M-H	ITS 00552	12	11/14/18
LISN	FCC	FCC-LISN-50-50-M-H	ITS 00551	12	09/15/18
LISN	COM-POWER	LIN-120A	ITS 01612	12	02/05/19

# No Calibration required

Software used for emission compliance testing utilized the following:

Name	Manufacturer	Version	Template/Profile
Tile	Quantum Change	3.4.K.22	Conducted Restricted Band Edge_Avg Conducted Restricted Band Edge_Peak Conducted Restricted Band_1-26GHz Conducted Restricted Band_30M-1GHz Conducted Spurious_30M-26GHz
BAT-EMC	Nexio	3.16.0.64	Fastenal G103406457 3-12-2018.bpp
RS Commander	Rohde Schwarz	1.6.4	Not Applicable (Screen grabber)

## 6.0 Document History

Revision/ Job Number	Writer Initials	Reviewers Initials	Date	Change
1.0 / G103436674	AC	KV	April 05, 2018	Original document