

#### 4.5 Transmitter Radiated Emissions FCC Rule 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 C64.10. 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.

Measurements made from 1 GHz to 18GHz had a 2.4-2.5GHz notch filter in place. 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  $52.0\text{ dB}(\mu V)$  is obtained. The antennas factor of  $7.4\text{ dB}(1/m)$  and cable factor of  $1.6\text{ dB}$  is added. The amplifier gain of  $29\text{ dB}$  is subtracted, giving field strength of  $32\text{ dB}(\mu V/m)$ . This value in  $dB(\mu V/m)$  was converted to its corresponding level in  $\mu V/m$ .

$RA = 52.0\text{ dB}(\mu V)$

$AF = 7.4\text{ dB}(1/m)$

$CF = 1.6\text{ dB}$

$AG = 29.0\text{ dB}$

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

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

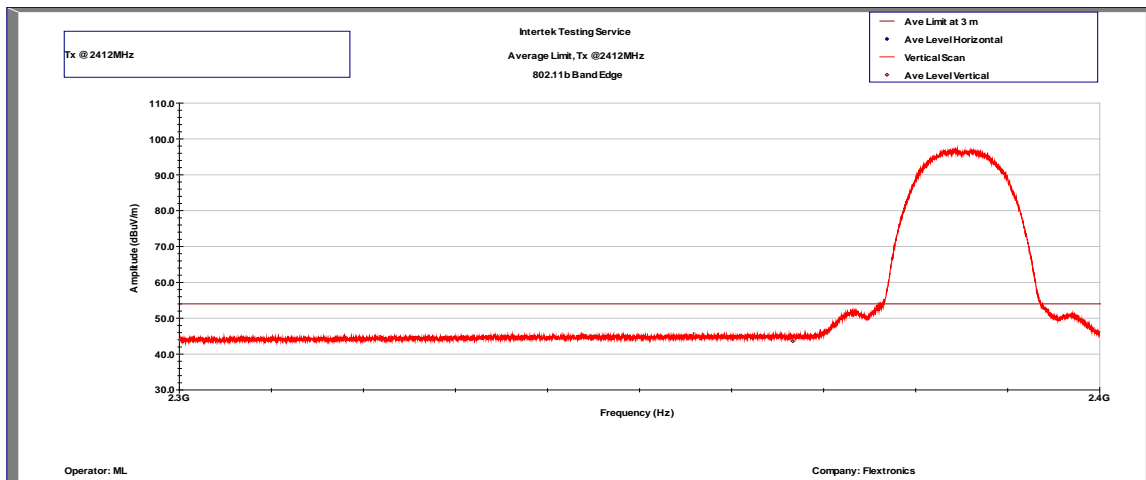
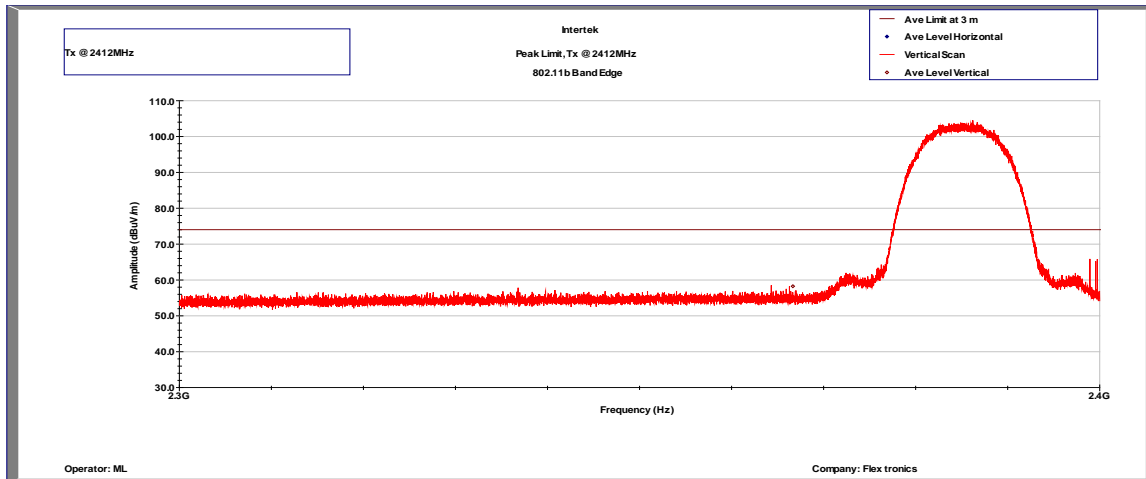
#### 4.5.4 Test Results

The data on the following pages list the significant emission frequencies, the limit and the margin of compliance.

The EUT passed the test by 5.3dB

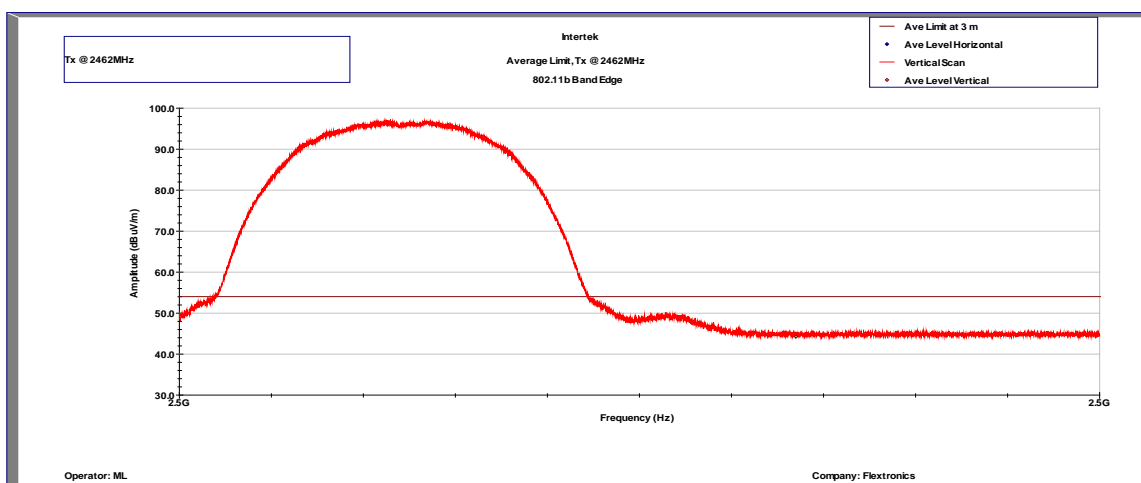
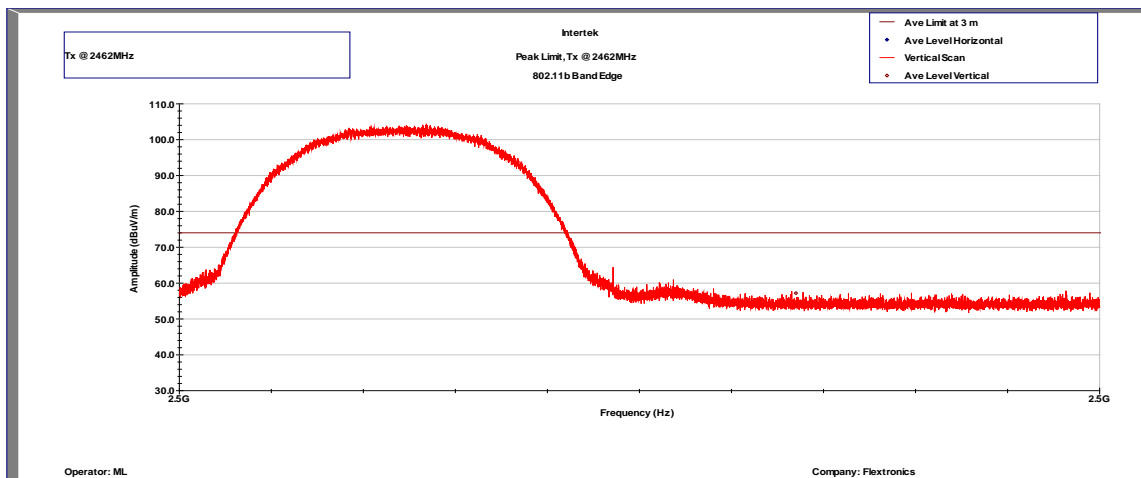
Test Results: 15.209/15.205 Restricted Band Emissions

### Out-of-Band Radiated spurious emissions at the Band-edge @1m distance 802.11b, 2310–2390 MHz



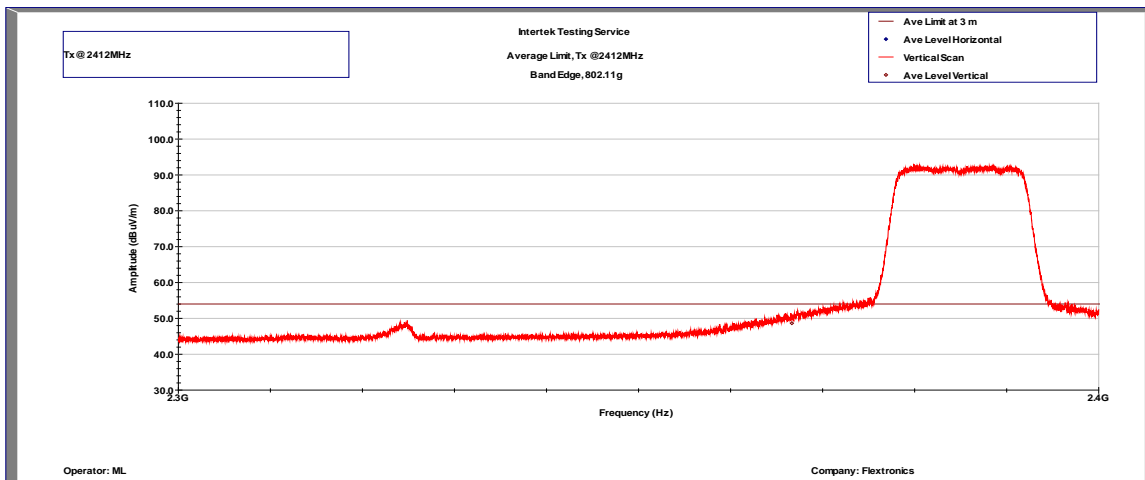
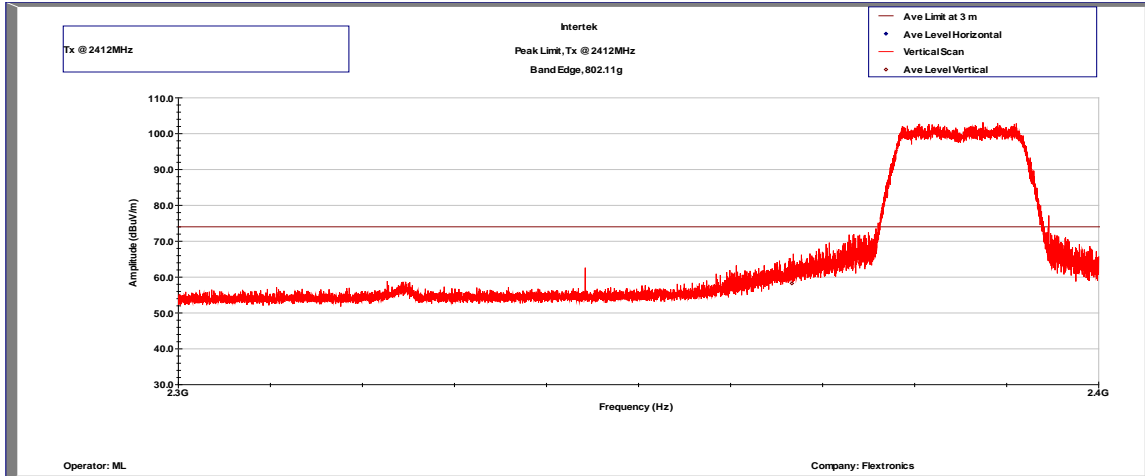
Frequency	RA @ 1 m	AF	DCF	CF + Attenuator	FS @ 3m	Detector	Limit @ 3 m	Margin
(MHz)	(dBuV/m)	(dB/m)	(dB)	(dB)	(dBuV/m)	(Peak) / (Average)	(dBuV/m)	(dB)
2390.0	32.5	28.0	9.5	7.3	58.3	Peak	74.0	-15.7
	17.8	28.0	9.5	7.3	43.6	Average	54.0	-10.4

## Out-of-Band Radiated spurious emissions at the Band-edge @1m distance 802.11b, 2483.5–2500 MHz



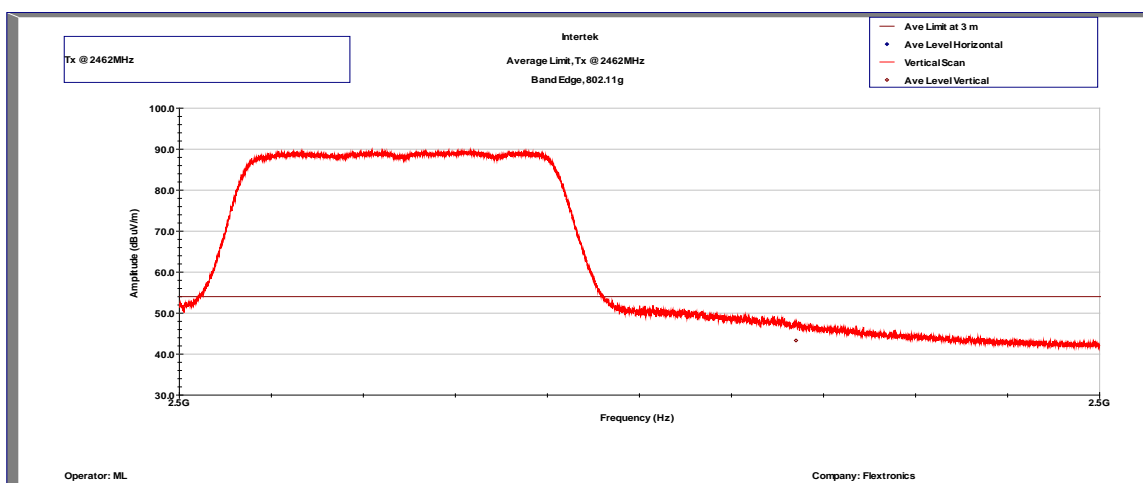
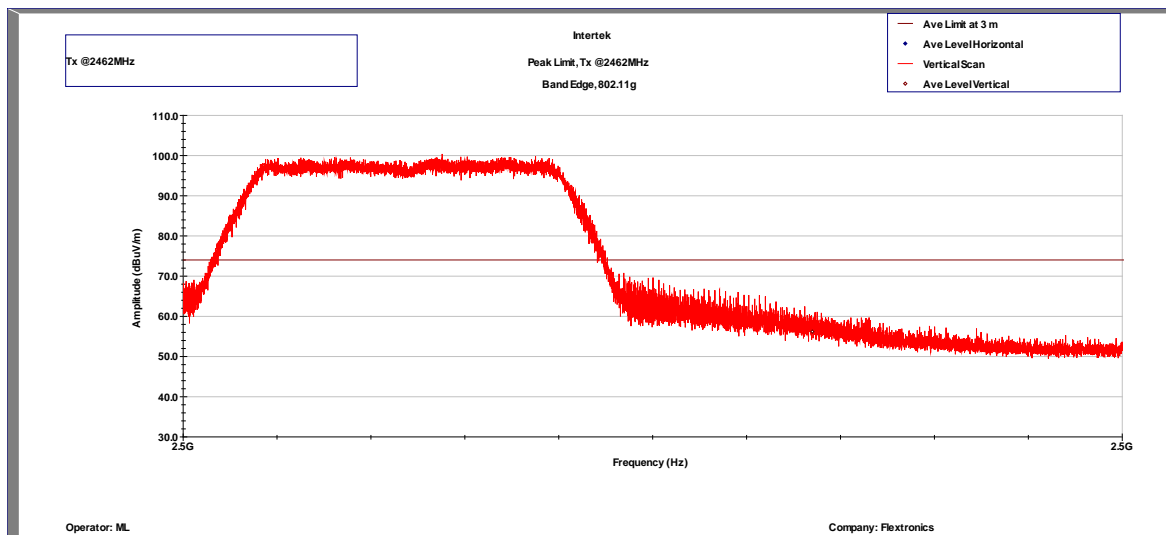
Frequency	RA @ 1 m	AF	DCF	CF + Attenuator	FS @ 3m	Detector	Limit @ 3 m	Margin
(MHz)	(dBuV/m)	(dB/m)	(dB)	(dB)	(dBuV/m)	(Peak) / (Average)	(dBuV/m)	(dB)
2483.5	31.2	28.1	9.5	7.42	57.2	Peak	74.0	-16.8
	18.2	28.1	9.5	7.42	44.0	Average	54.0	-6.0

## Out-of-Band Radiated spurious emissions at the Band-edge @1m distance 802.11g, 2310–2390 MHz



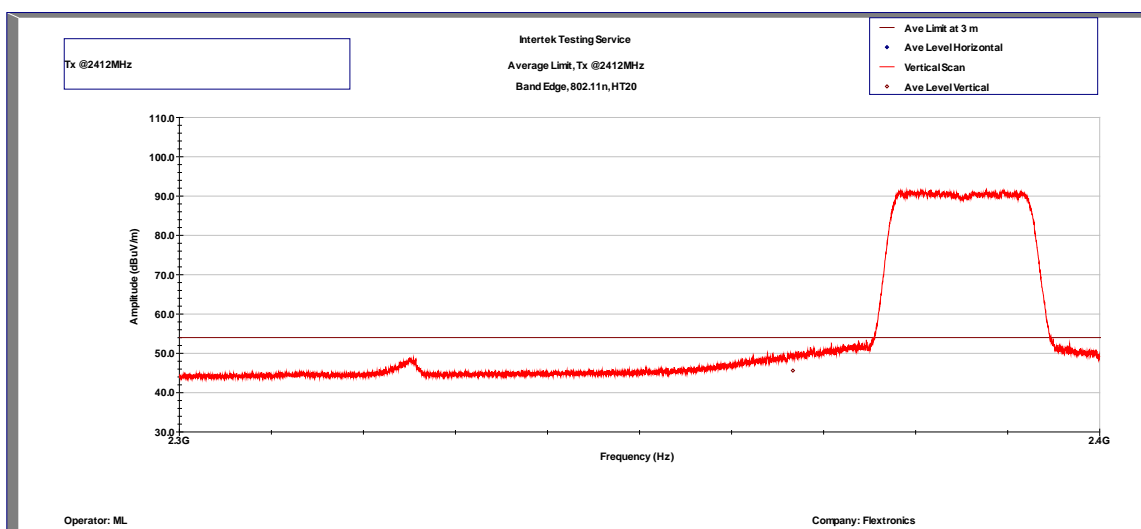
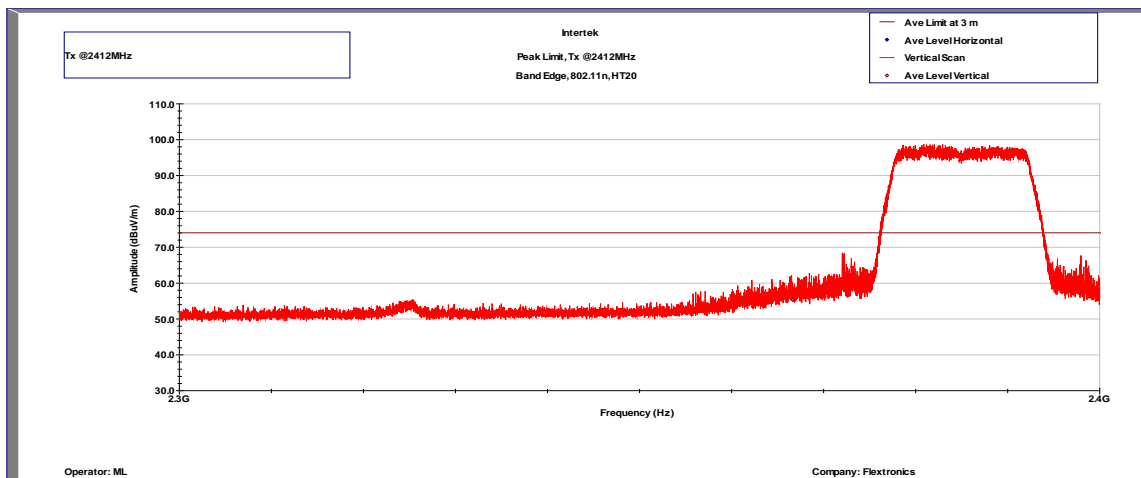
Frequency	RA @ 1 m	AF	DCF	CF + Attenuator	FS @ 3m	Detector	Limit @ 3 m	Margin
(MHz)	(dBuV/m)	(dB/m)	(dB)	(dB)	(dBuV/m)	(Peak) / (Average)	(dBuV/m)	(dB)
2390.0	32.5	28.0	9.5	7.3	58.3	Peak	74.0	-15.7
	22.9	28.0	9.5	7.3	48.7	Average	54.0	-5.3

## Out-of-Band Radiated spurious emissions at the Band-edge @1m distance 802.11g, 2483.5–2500 MHz



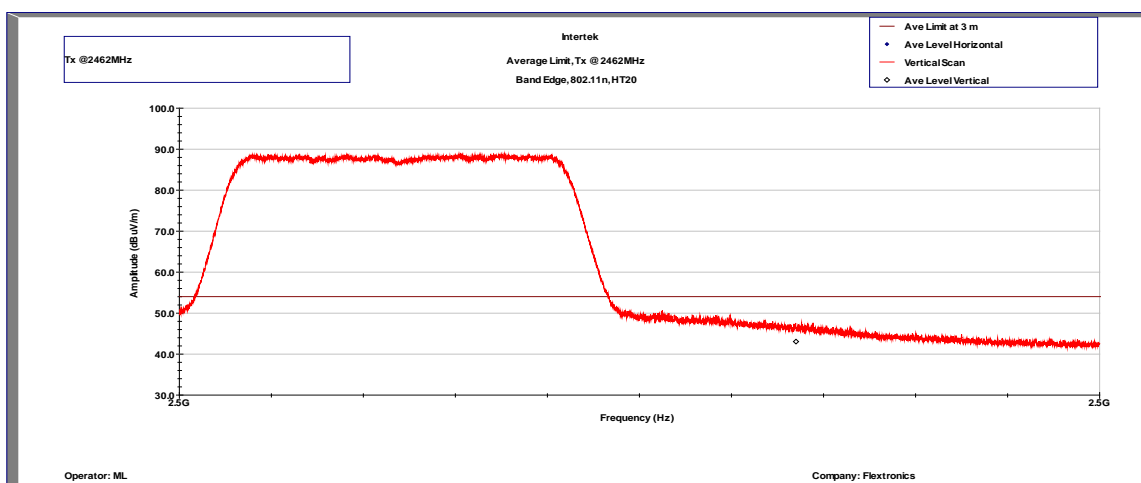
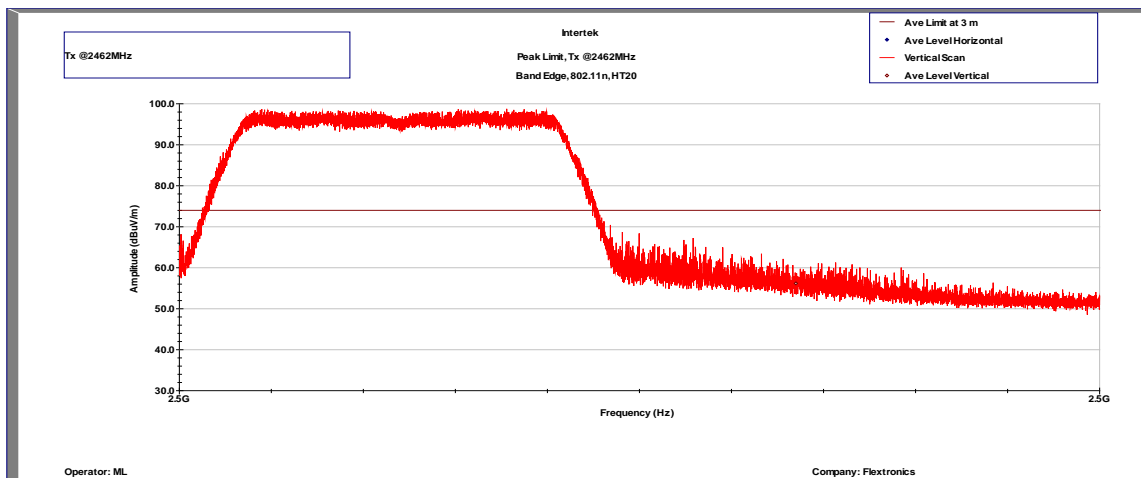
Frequency	RA @ 1 m	AF	DCF	CF + Attenuator	FS @ 3m	Detector	Limit @ 3 m	Margin
(MHz)	(dBuV/m)	(dB/m)	(dB)	(dB)	(dBuV/m)	(Peak) / (Average)	(dBuV/m)	(dB)
2483.5	33.1	28.1	9.5	7.42	58.9	Peak	74.0	-15.1
	20.2	28.1	9.5	7.42	46.0	Average	54.0	-8.0

## Out-of-Band Radiated spurious emissions at the Band-edge @1m distance 802.11n, 2310–2390 MHz



Frequency	RA @ 1 m	AF	DCF	CF + Attenuator	FS @ 3m	Detector	Limit @ 3 m	Margin
(MHz)	(dBuV/m)	(dB/m)	(dB)	(dB)	(dBuV/m)	(Peak) / (Average)	(dBuV/m)	(dB)
2390.0	32.5	28.0	9.5	7.3	58.3	Peak	74.0	-15.7
	19.8	28.0	9.5	7.3	45.6	Average	54.0	-8.4

## Out-of-Band Radiated spurious emissions at the Band-edge @1m distance 802.11n, 2483.5–2500 MHz

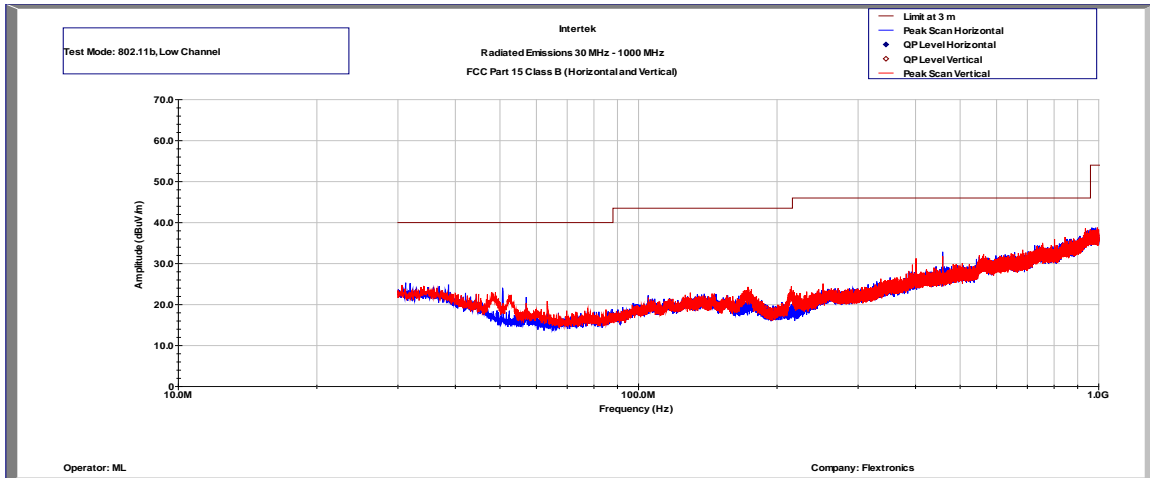


Frequency	RA @ 1 m	AF	DCF	CF + Attenuator	FS @ 3m	Detector	Limit @ 3 m	Margin
(MHz)	(dBuV/m)	(dB/m)	(dB)	(dB)	(dBuV/m)	(Peak) / (Average)	(dBuV/m)	(dB)
2483.5	33.1	28.1	9.5	7.42	58.9	Peak	74.0	-15.1
	19.9	28.1	9.5	7.42	45.7	Average	54.0	-8.3

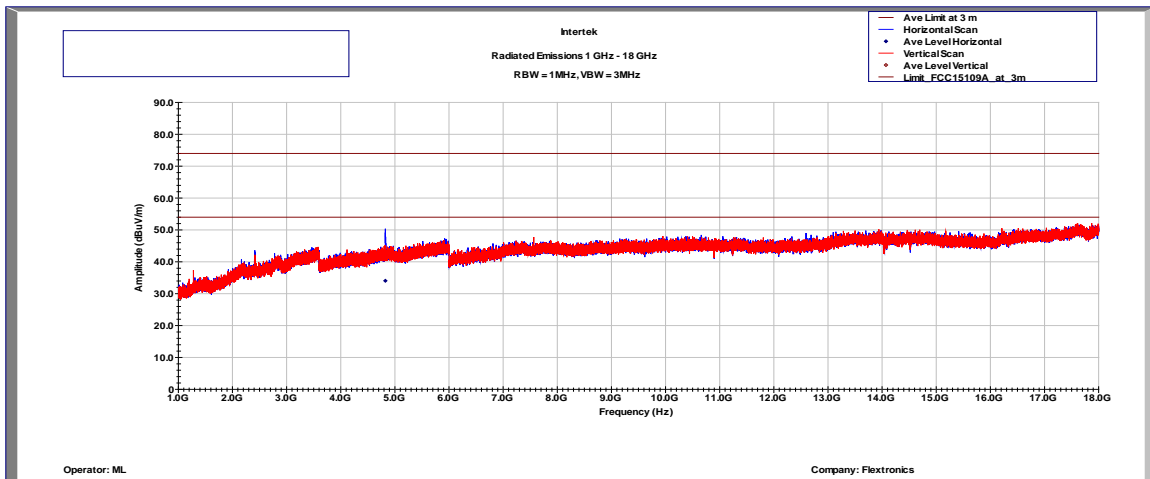


## Tx @ 2412MHz 802.11b

### Radiated Spurious 30 MHz to 1 GHz



### Radiated Spurious 1 GHz to 18 GHz

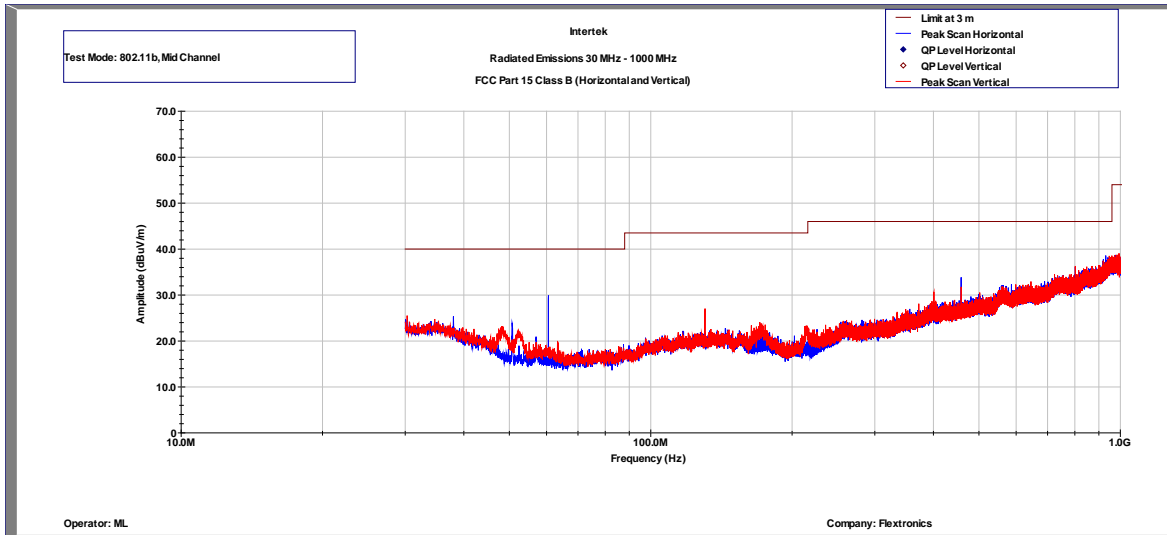


Note: All other emissions not reported are noise floor which is at least 10 dB below the limit.

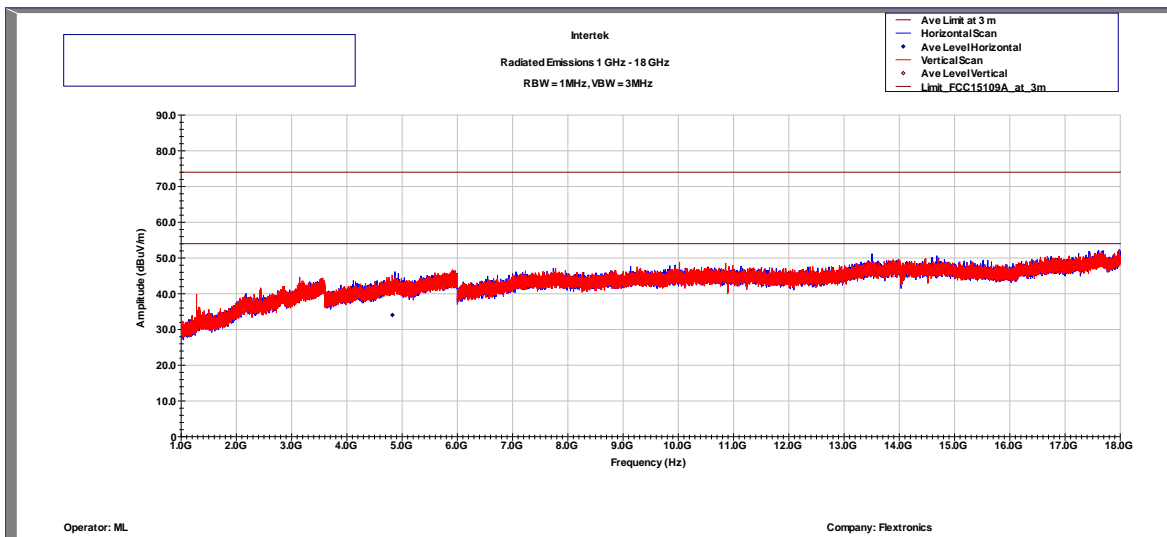
Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz.

## Tx @ 2437MHz 802.11b

### Radiated Spurious 30 MHz to 1 GHz



### Radiated Spurious 1 GHz to 18 GHz

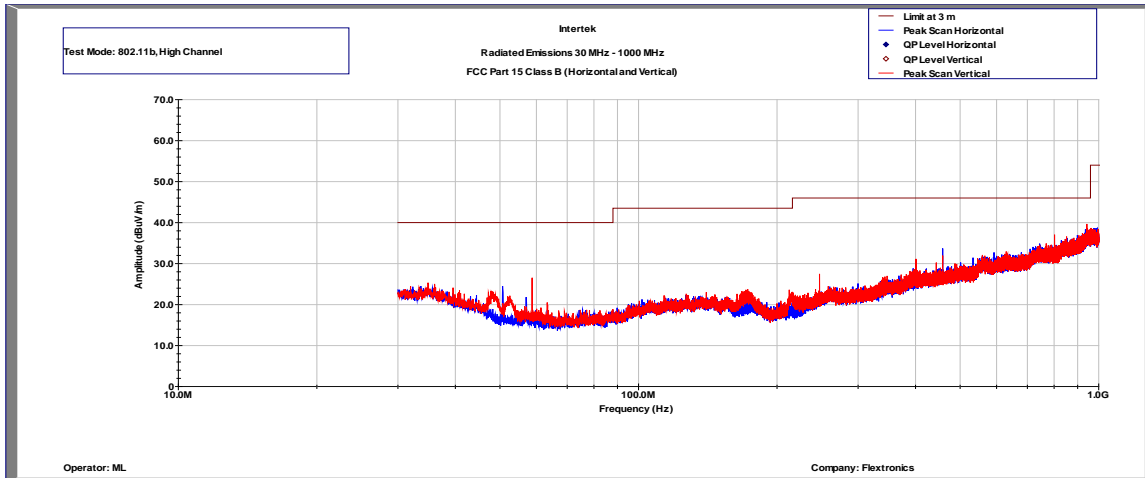


Note: All other emissions not reported are noise floor which is at least 10 dB below the limit.

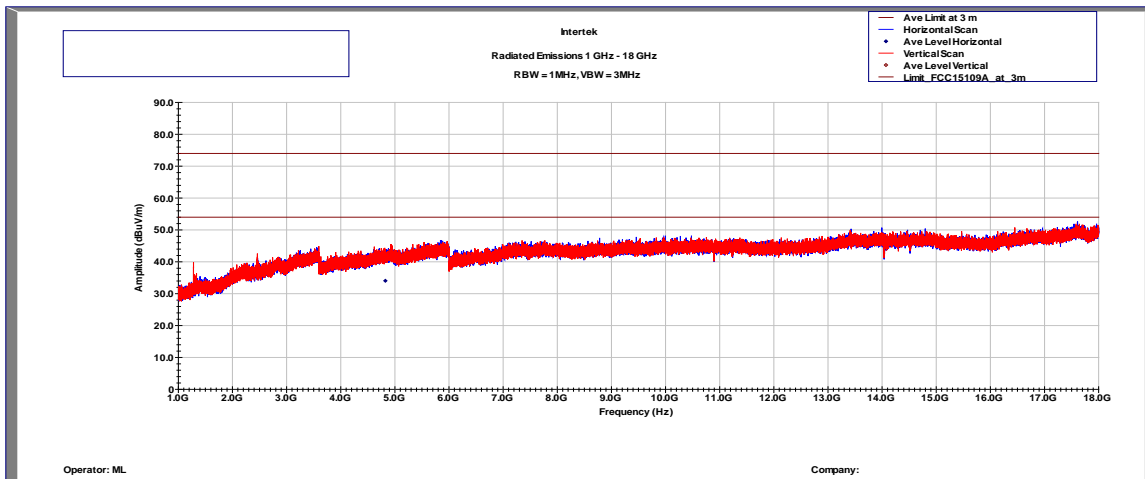
Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz.

## Tx @ 2462MHz 802.11b

### Radiated Spurious 30 MHz to 1 GHz



### Radiated Spurious 1 GHz to 18 GHz

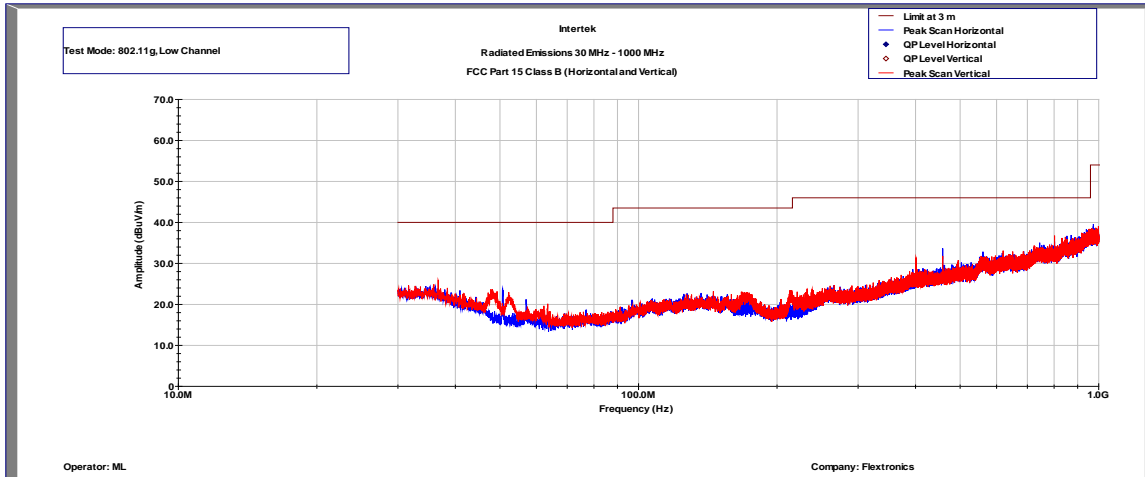


Note: All other emissions not reported are noise floor which is at least 10 dB below the limit.

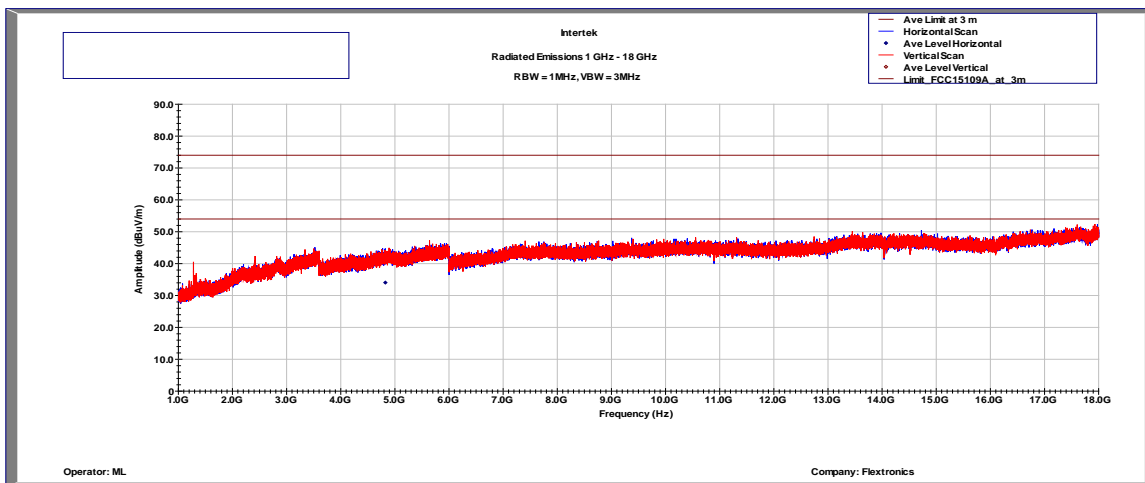
Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz.

## Tx @ 2412MHz 802.11g

### Radiated Spurious 30 MHz to 1 GHz



### Radiated Spurious 1 GHz to 18 GHz

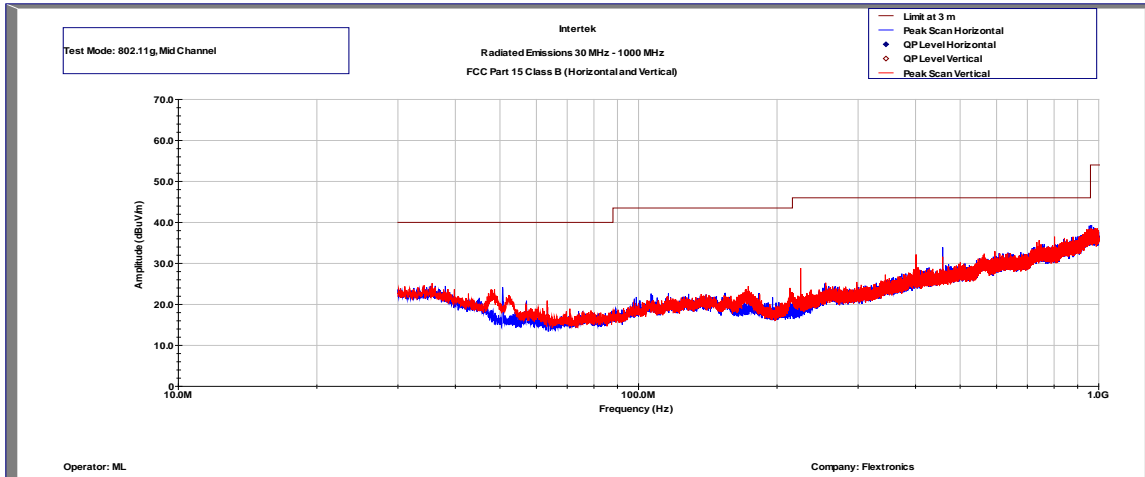


Note: All other emissions not reported are noise floor which is at least 10 dB below the limit.

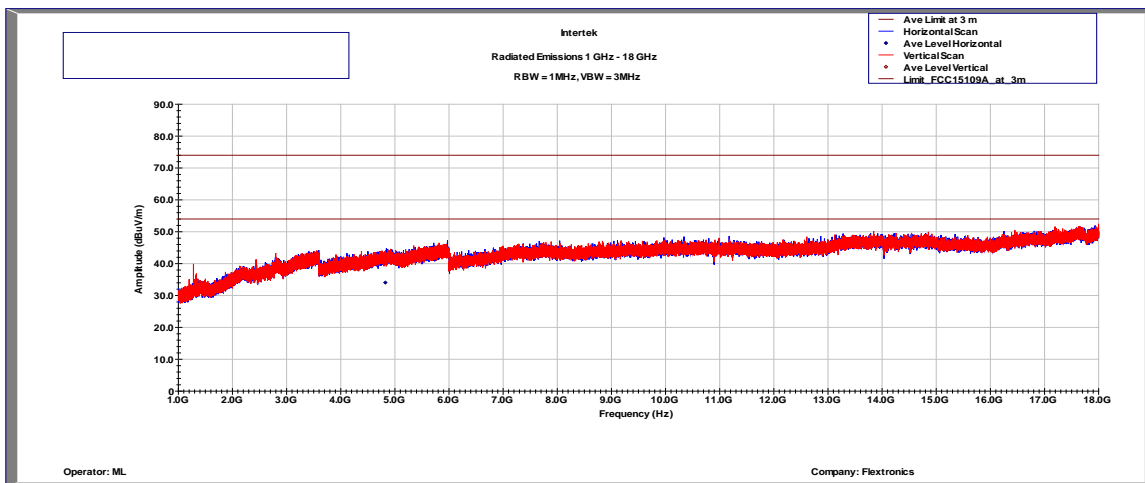
Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz.

## Tx @ 2437MHz 802.11g

### Radiated Spurious 30 MHz to 1 GHz



### Radiated Spurious 1 GHz to 18 GHz

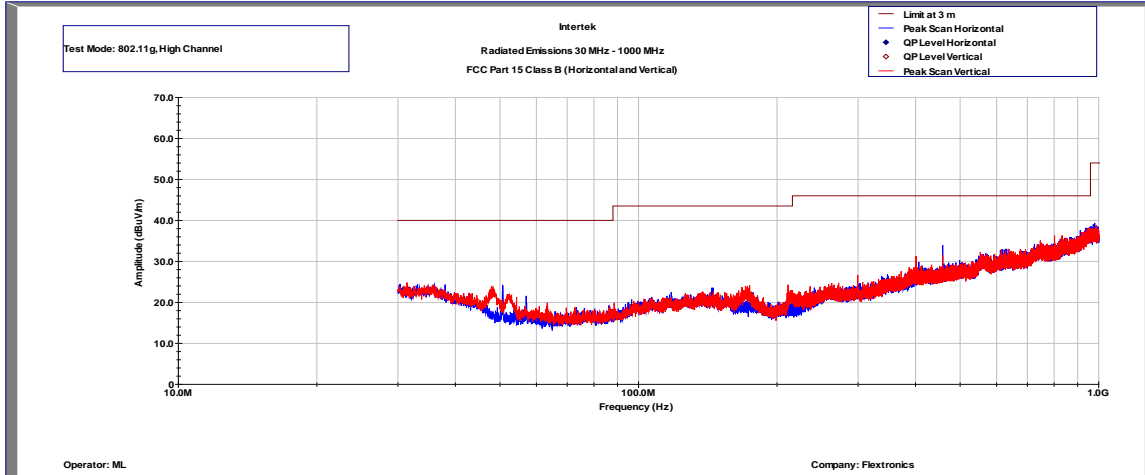


Note: All other emissions not reported are noise floor which is at least 10 dB below the limit.

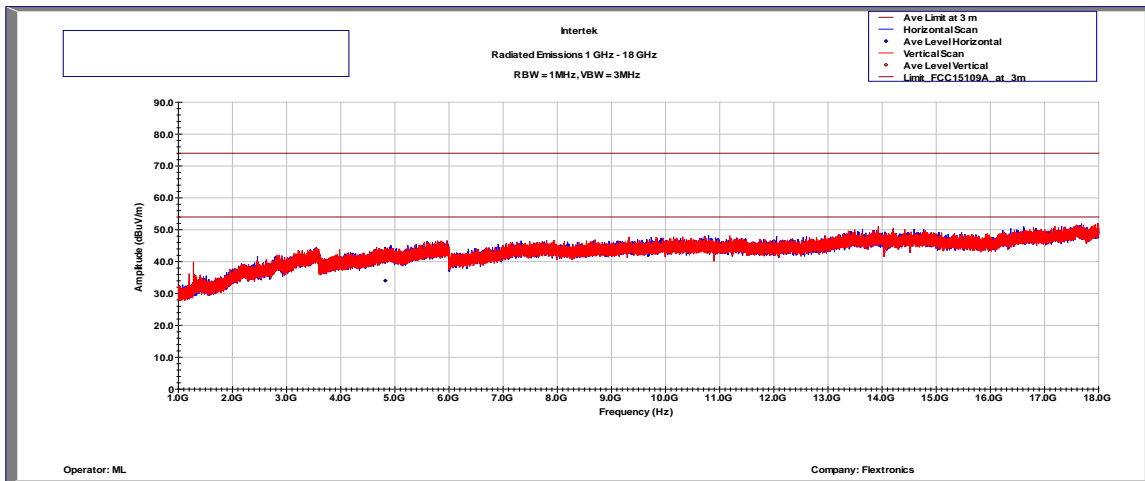
Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz.

## Tx @ 2462MHz 802.11g

### Radiated Spurious 30 MHz to 1 GHz



### Radiated Spurious 1 GHz to 18 GHz

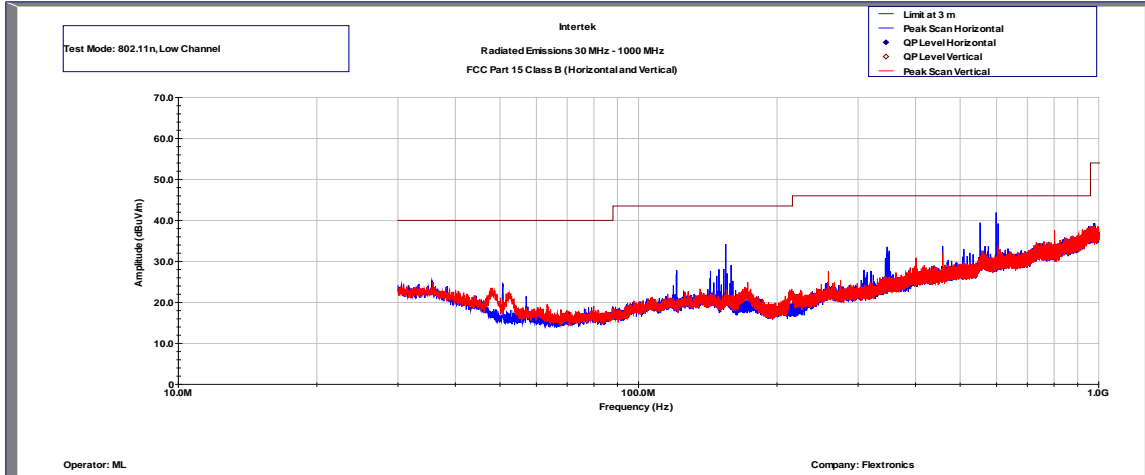


Note: All other emissions not reported are noise floor which is at least 10 dB below the limit.

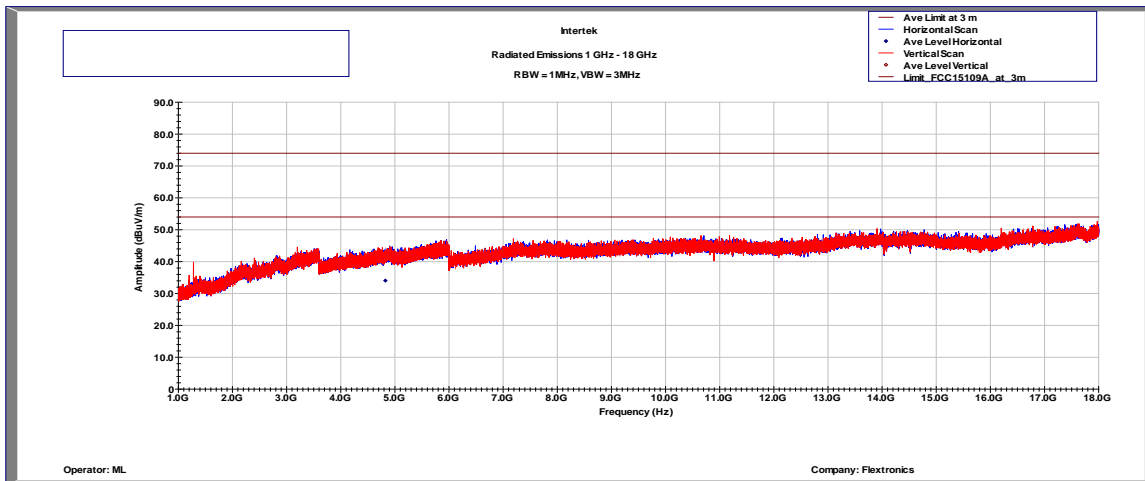
Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz.

**Tx @ 2412MHz 802.11n, HT20**

**Radiated Spurious 30 MHz to 1 GHz**



**Radiated Spurious 1 GHz to 18 GHz**

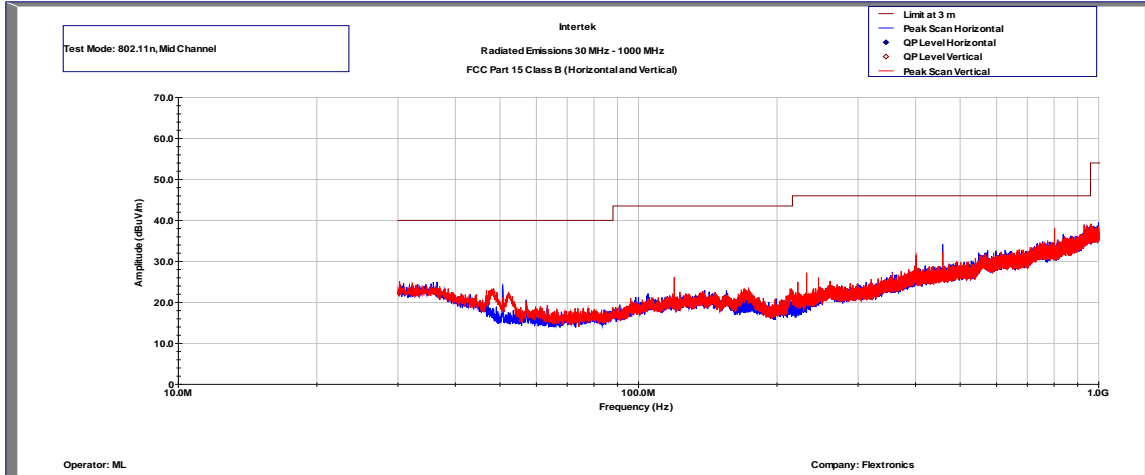


Note: All other emissions not reported are noise floor which is at least 10 dB below the limit.

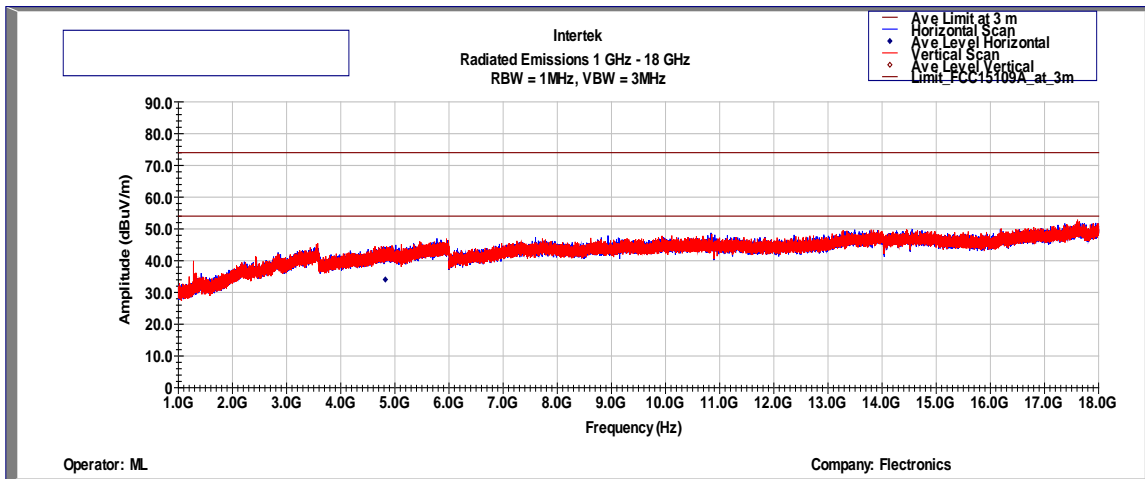
Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz.

**Tx @ 2437MHz 802.11n, HT20**

**Radiated Spurious 30 MHz to 1 GHz**



**Radiated Spurious 1 GHz to 18 GHz**



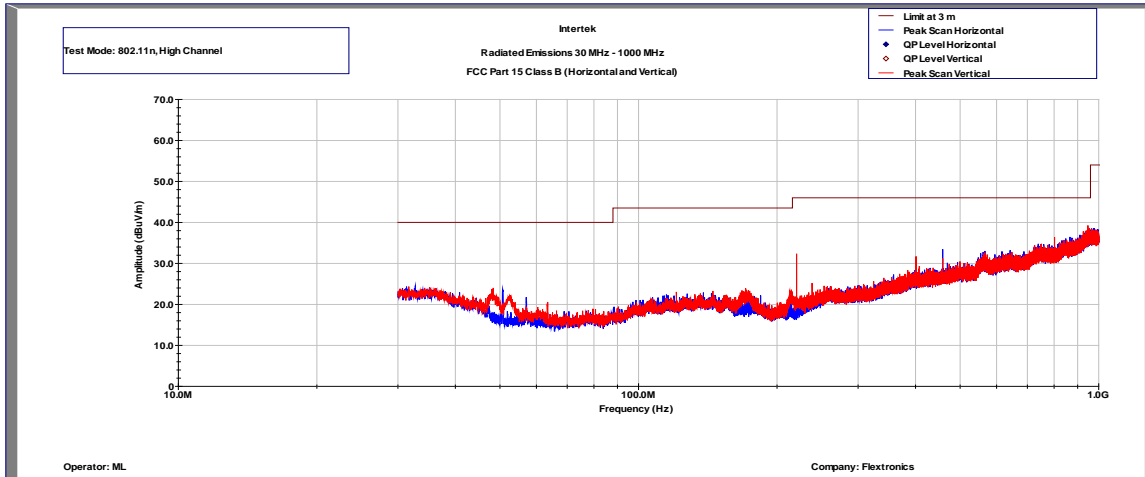
Note: All other emissions not reported are noise floor which is at least 10 dB below the limit.

Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz.

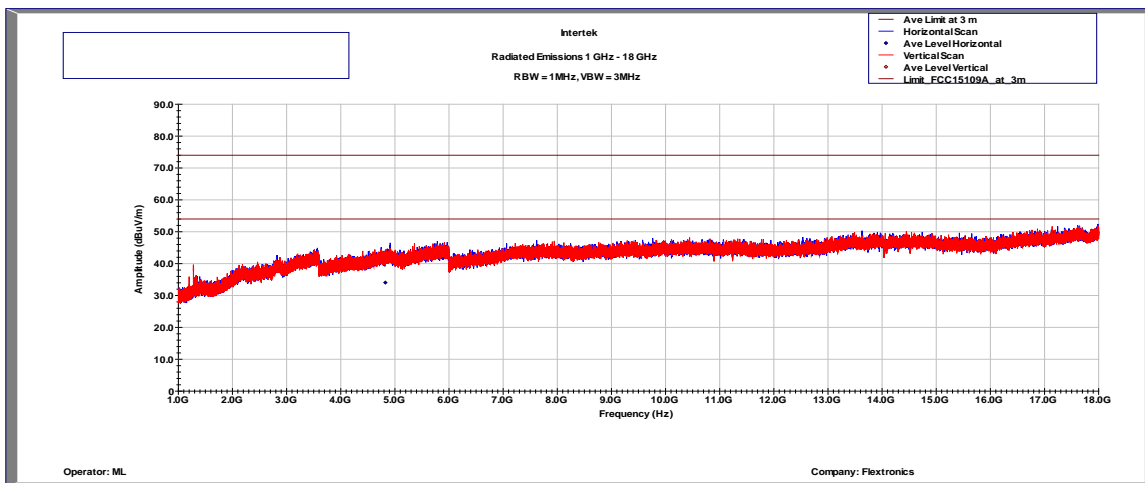


**Tx @ 2462MHz 802.11n, HT20**

**Radiated Spurious 30 MHz to 1 GHz**



**Radiated Spurious 1 GHz to 18 GHz**

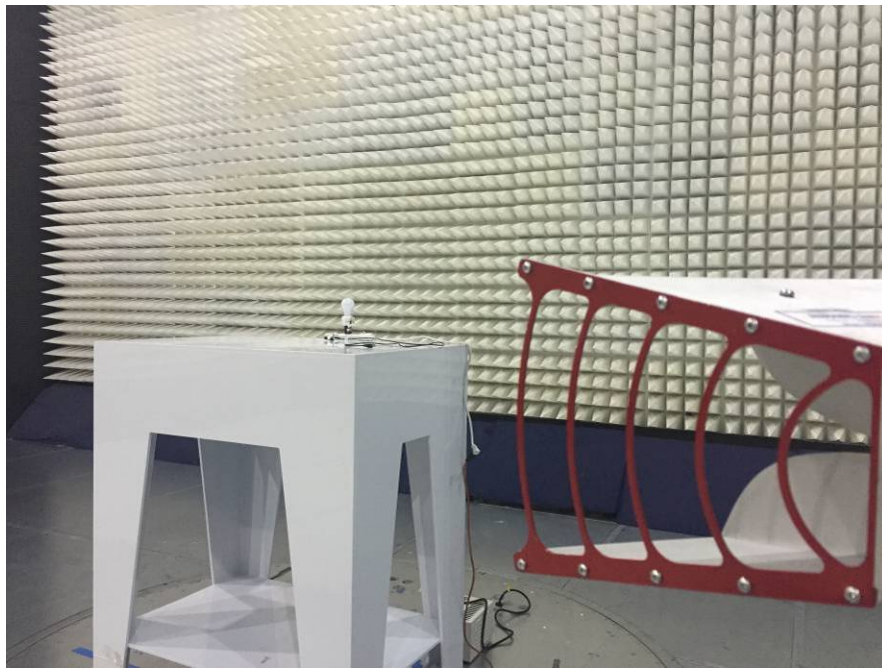
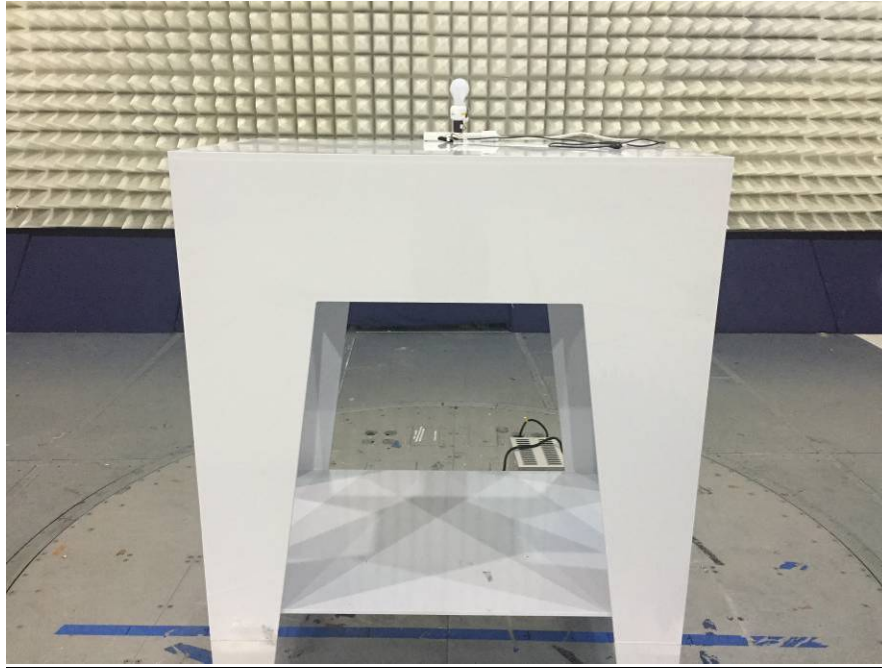


Note: All other emissions not reported are noise floor which is at least 10 dB below the limit.

Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz.

## 4.5.4 Test Setup Photographs

The following photographs show the testing configurations used.



#### 4.6 AC Line Conducted Emission FCC 15.207

##### 4.6.1 Requirement

Frequency Band MHz	Class B Limit dB ( $\mu$ V)	
	Quasi-Peak	Average
0.15-0.50	66 to 56 Decreases linearly with the logarithm of the frequency	56 to 46 Decreases linearly with the logarithm of the frequency
0.50-5.00	56	46
5.00-30.00	60	50

*Note: At the transition frequency the lower limit applies.*

##### 4.6.2 Procedure

Measurements are carried out using quasi-peak and average detector receivers in accordance with CISPR 16. An AMN is required to provide a 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.

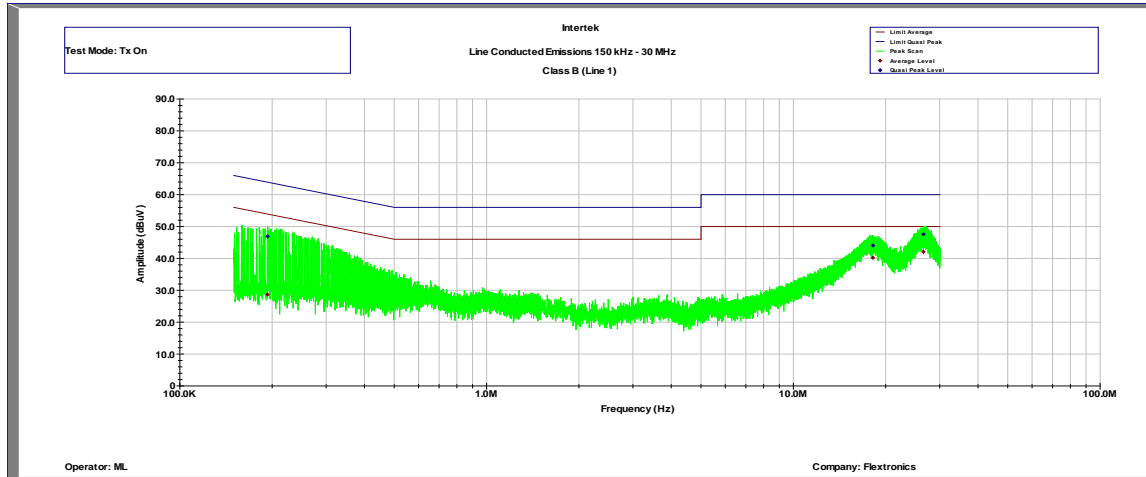
Floor standing EUT are placed on a horizontal metal ground plane and isolated from the ground plane by resting on an insulating material. The metal ground plane extends at least 0.5m beyond the boundaries of the EUT and has minimum dimensions of 2m by 2m.

Equipment setup for conducted disturbance tests followed the guidelines of ANSI C63.4.



#### 4.6.3 Test Result

#### AC Line Conducted Emission Data, EUT in transmitting mode



Intertek Testing Services  
Line Conducted Emissions 150 kHz - 30 MHz  
FCC Class B (Line 1)

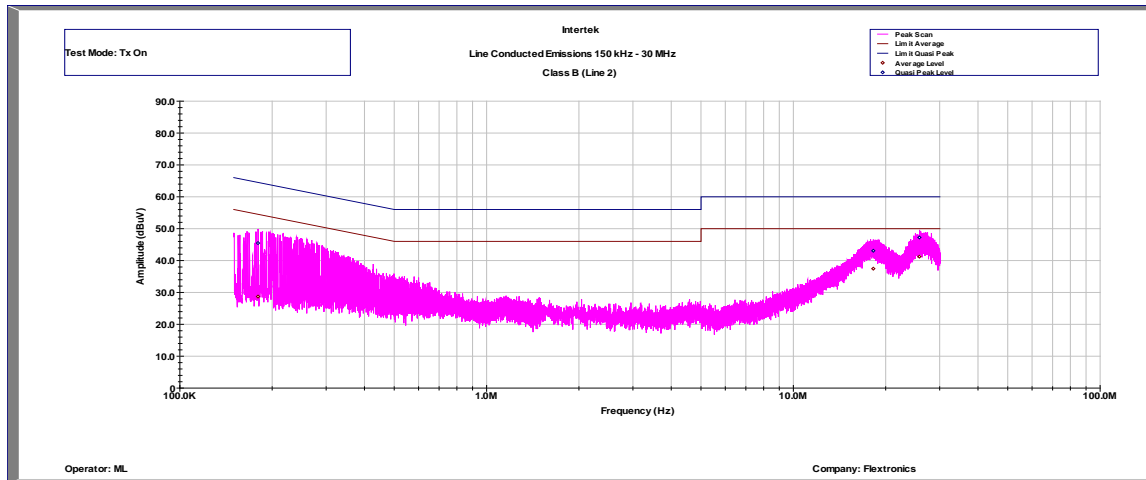
Operator: ML

Model Number: SE26W001  
Company: Emberlight, Inc.

Frequency	Av Level	QP Level	Av Limit	QP Limit	Av Margin	QP Margin
MHz	dBuV	dBuV	dBuV	dBuV	dB	dB
0.193	28.7	46.9	54.8	64.8	-26.1	-17.9
18.156	40.2	44.1	50.0	60.0	-9.8	-15.9
26.536	42.1	47.6	50.0	60.0	-7.9	-12.4

Test Mode: Transmitter On, 120V 60Hz  
Temp.: 20.6C  
Humidity: 49.9%

## AC Line Conducted Emission Data, EUT in transmitting mode



Intertek Testing Services  
Line Conducted Emissions 150 kHz - 30 MHz  
FCC Class B (Line 2)  
Operator: ML

Model Number: SE26W001  
Company: Emberlight, Inc.

Frequency	Av Level	QP Level	Av Limit	QP Limit	Av Margin	QP Margin
MHz	dBuV	dBuV	dBuV	dBuV	dB	dB
0.180	28.7	45.5	55.1	65.1	-26.5	-19.7
18.209	37.4	43.1	50.0	60.0	-12.6	-16.9
25.736	41.2	47.2	50.0	60.0	-8.8	-12.8

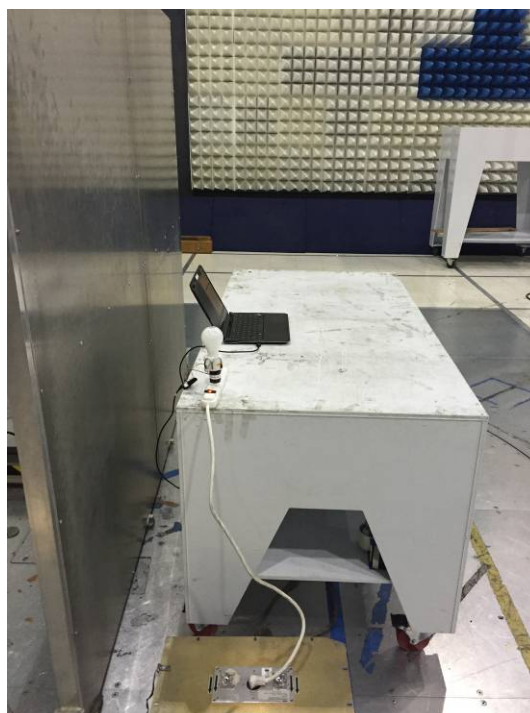
Test Mode: Transmitter On, 120V 60Hz  
Temp.: 20.6C  
Humidity: 49.9%

### Results

Complies by 7.9 dB

#### 4.6.4 Test Configuration Photographs

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



## 5.0 RF Exposure Evaluation

### MPE Evaluation (WiFi radio)

The EUT is a wireless device used in a mobile application, at least 20 cm from any body part of the user or nearby persons.

The maximum Peak EIRP calculated is +11.26 dBm or 13.39 mW; therefore, to comply with RF Exposure Requirement, the MPE is calculated.

The Power Density can be calculated using the formula

$$S = \text{EIRP} / 4\pi D^2$$

Where: S is Power Density in  $\text{W/m}^2$

D is the distance from the antenna.

It is considered that 20 cm is the minimum distance that user can go closest to the EUT.

At 20 cm,  $S = 0.0266 \text{ W/m}^2$ , which is below the MPE Limit of  $10 \text{ W/m}^2$

## 6.0 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	ITS00913	12	12/16/15
EMI Receiver	Rohde and Schwarz	ESU	ITS 00961	12	06/02/16
BI-Log Antenna	Teseq	CBL 6111D	ITS 01058	12	11/21/15
Pyramidal Horn Antenna	EMCO	3160-09	ITS00571	#	#
Pre-Amplifier	Sonoma Instrument	310N	ITS 00942	12	11/26/15
Pre-Amplifier (1-18GHz)	Miteq	AMF-4D-001180-24-10P	ITS 00526	12	10/06/16
Pre-Amplifier (18-40GHz)	Miteq	JSD44-18004000-305P	ITS 00921	12	06/18/16
Horn Antenna	ETS Lindgren	3115	ITS 00982	12	11/21/15
LISN	FCC	FCC-LISN-50-50-M-H	ITS 00552	12	05/05/16

# No Calibration required





## 7.0 Document History

Revision/ Job Number	Writer Initials	Reviewers Initials	Date	Change
1.0 / G102248754	ML	KV	October 22, 2015	Original document