4.7 Transmitter Radiated Emissions
FCC Rule 15.247(d), 15.209, 15.205

4.7.1 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.

4.7.2 Procedure

Radiated emission measurements were performed from 30 MHz to 26,000 MHz. Spectrum Analyzer Resolution Bandwidth is 100 kHz or greater for frequencies 30 MHz to 1000 MHz, 1 MHz for frequencies above 1000 MHz.

The EUT is placed on a plastic turntable that is 80 cm in height. 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

Radiated Band Edge measurements made were made from 2300- 2410 MHz for the low channel and 2470 – 2510 MHz for the high channel. Radiated Band Edge measurements made were made without a preamp.

Radiated Spurious 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 or Peak limits for 1GHz – 26GHz where applicable.

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

EUT was tested with Internal Antenna.

4.7.3 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(μV/m)
RA = Receiver Amplitude (including preamplifier) in dB(μV); 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(μV) 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(μV/m). This value in dB(μV/m) was converted to its corresponding level in μV/m.
RA = 52.0 dB(μV)
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(μV/m).
Level in μV/m = Common Antilogarithm [(32 dBμV/m)/20] = 39.8 μV/m.

4.7.4 Test Results

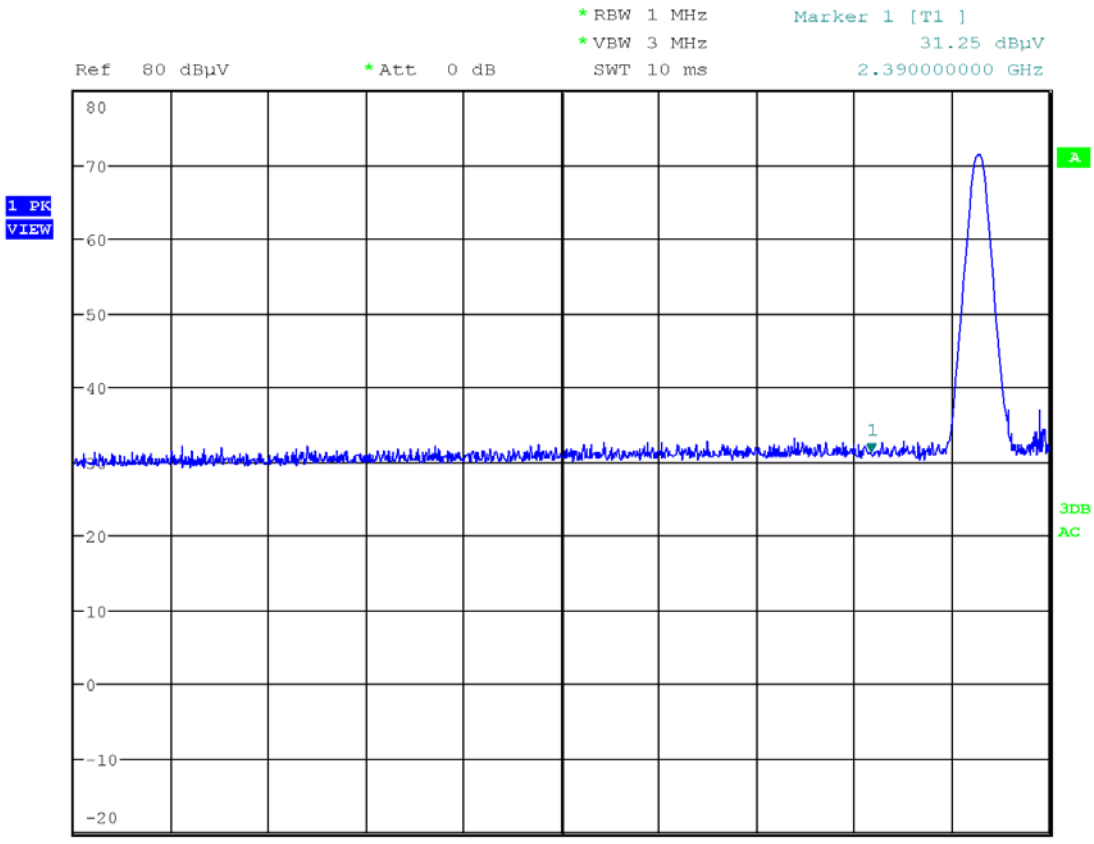
The data on the following pages list the significant emission frequencies, the limit and the margin of compliance.

Radiated emission measurements were performed up to 26GHz. No other emissions were detected above the noise floor which is at least 10 dB below the limit.

Tested By:	Anderson Soungpanya
Test Date:	July 26 – 28, 2017

4.7.4 Test Results: 15.209/15.205 Restricted Band Emissions with Internal Antenna

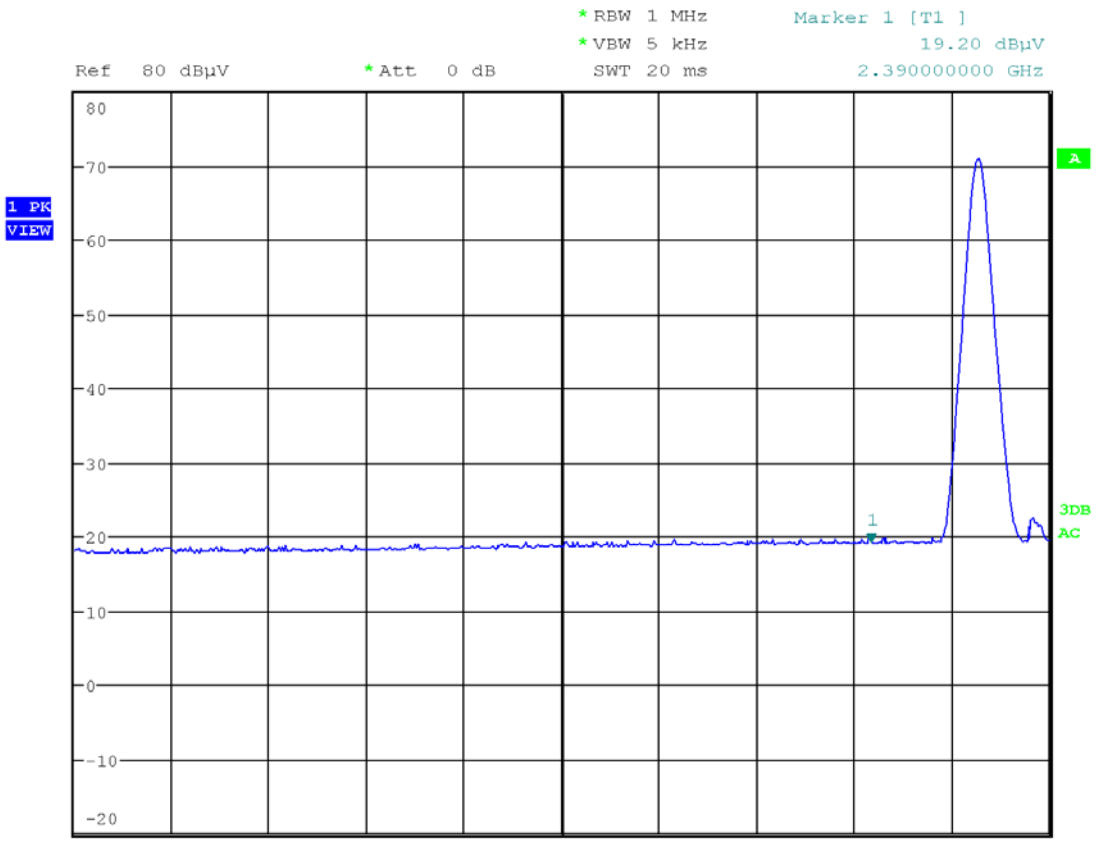
GSFK Modulation for Out-of-Band Spurious Emissions at the Band Edge



Date: 26.JUL.2017 06:50:37

Radiated Band Edge measurements made were made from 2300- 2410 MHz

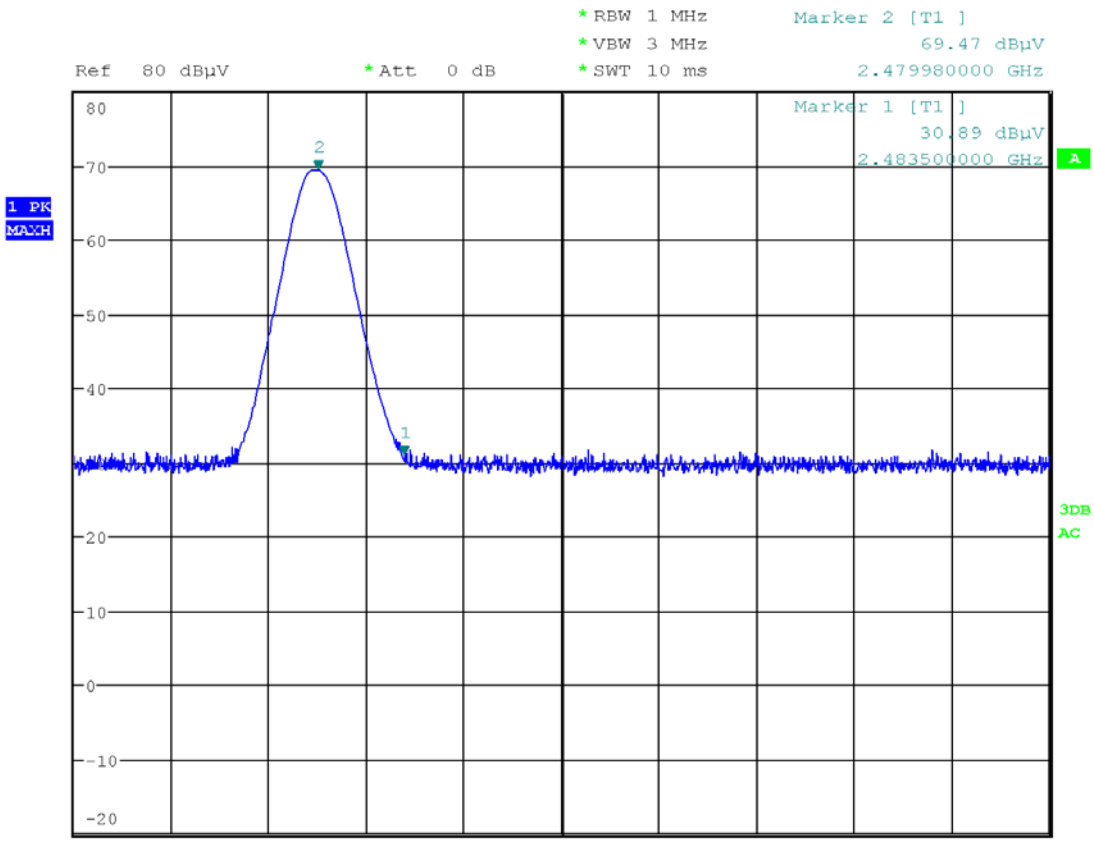
Modulation Type	Detector	EUT Channel	Frequency	Raw Amplitude at 3m	Corr. Factor	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV)	dB	dB(uV/m)	dB(uV/m)	dB(uV/m)	
GFSK	Peak	0	2402	31.3	33.9	65.2	74	-8.8	Pass



Date: 26.JUL.2017 07:35:31

Radiated Band Edge measurements made were made from 2300- 2410 MHz

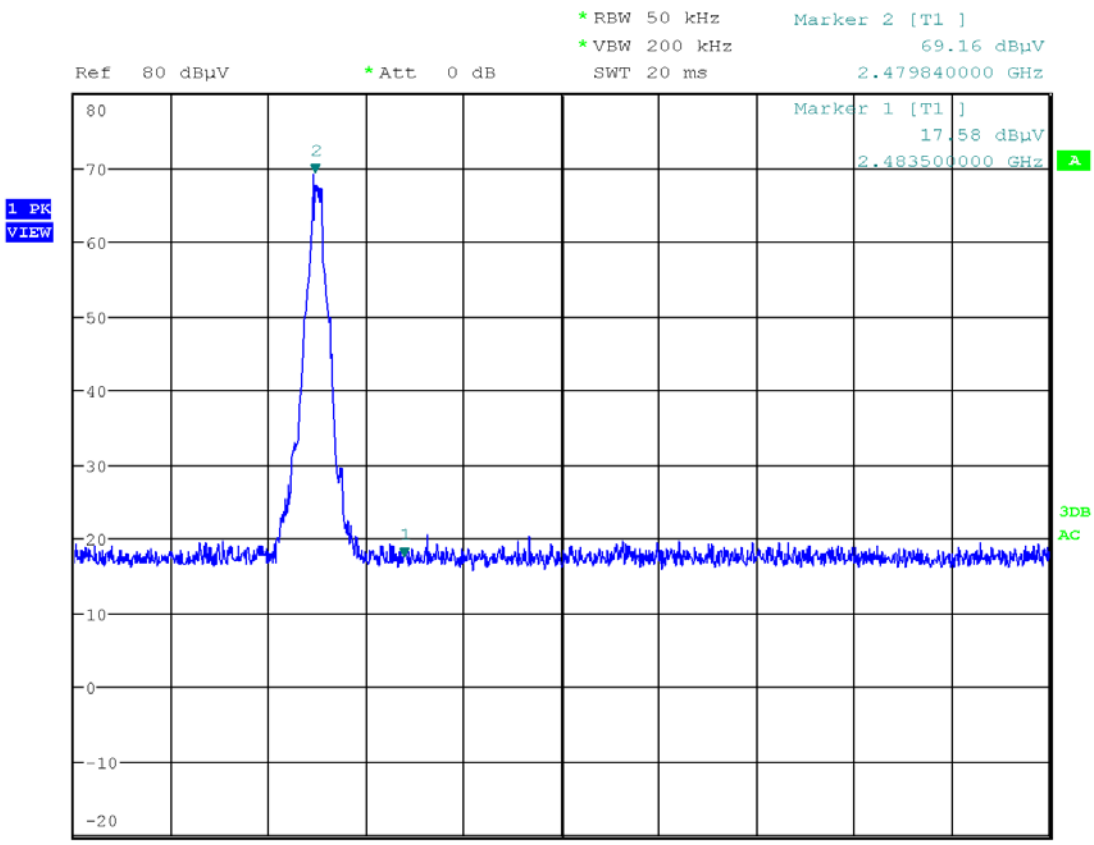
Modulation Type	Detector	EUT Channel	Frequency	Raw Amplitude at 3m	Corr. Factor	FS at 3m	Ave Limit	Margin	Results
			MHz	dB(uV)	dB	dB(uV/m)	dB(uV/m)	dB(uV/m)	
GFSK	Avg	0	2402	19.2	33.9	53.1	54	-0.9	Pass



Date: 26.JUL.2017 08:01:00

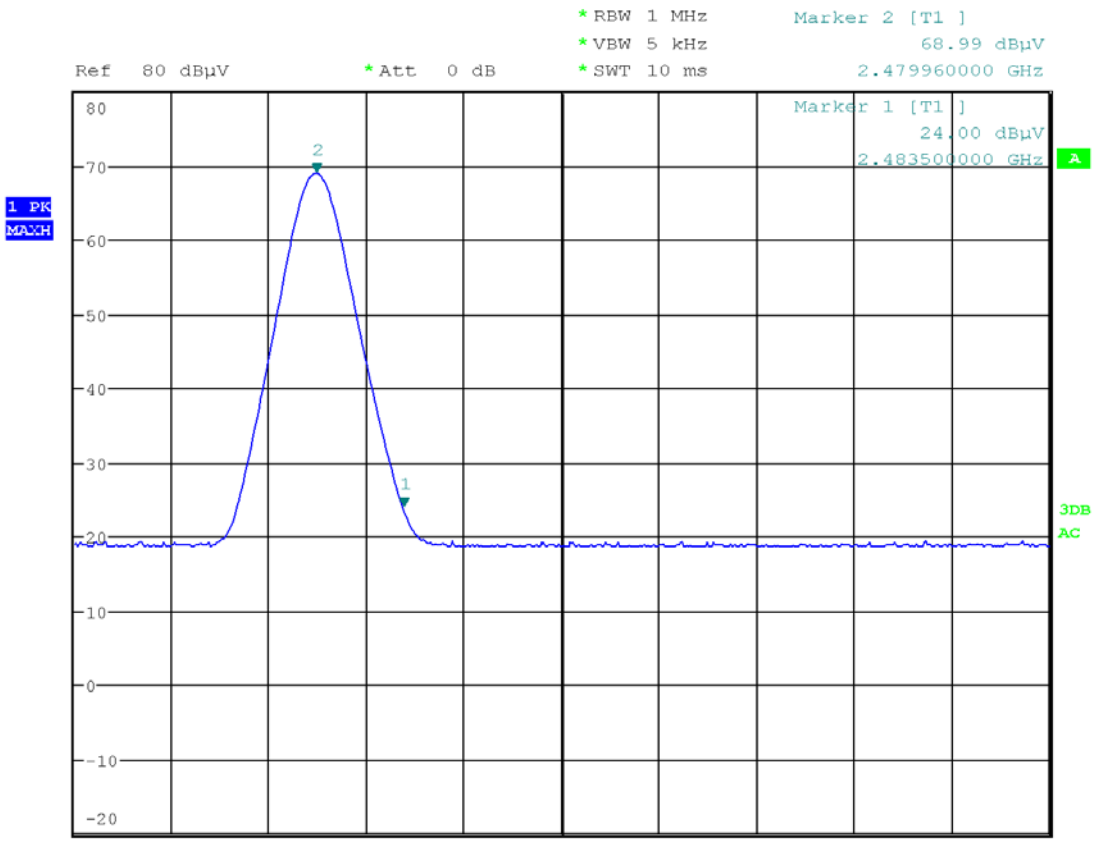
Radiated Band Edge measurements made were made from 2470 – 2510 MHz

Modulation Type	Detector	EUT Channel	Frequency	Raw Amplitude at 3m	Corr. Factor	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV)	dB	dB(uV/m)	dB(uV/m)	dB(uV/m)	
GFSK	Peak	78	2480	30.9	33.9	64.8	74	-9.2	Pass



Radiated Band Edge measurements made were made from 2470 – 2510 MHz

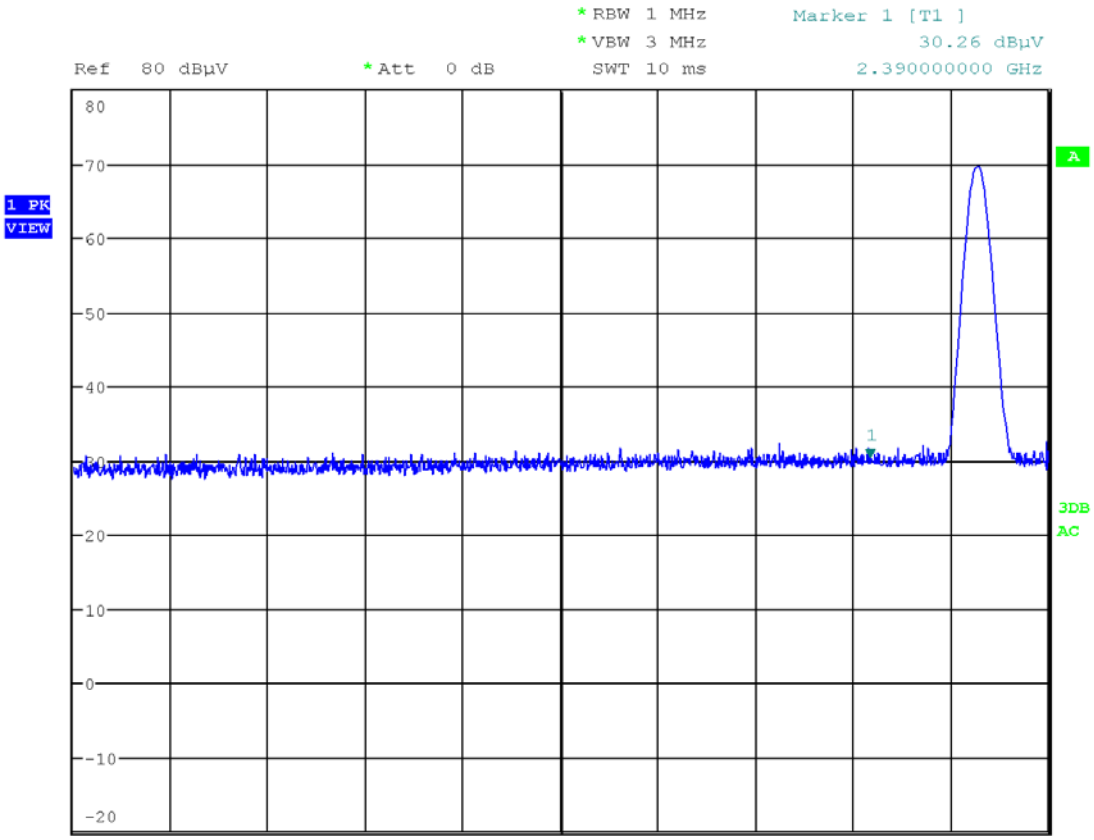
Modulation Type	Detector	EUT Channel	Frequency	Peak to Band Edge Delta
			MHz	dB(uV)
GFSK	Peak	78	2480	51.6



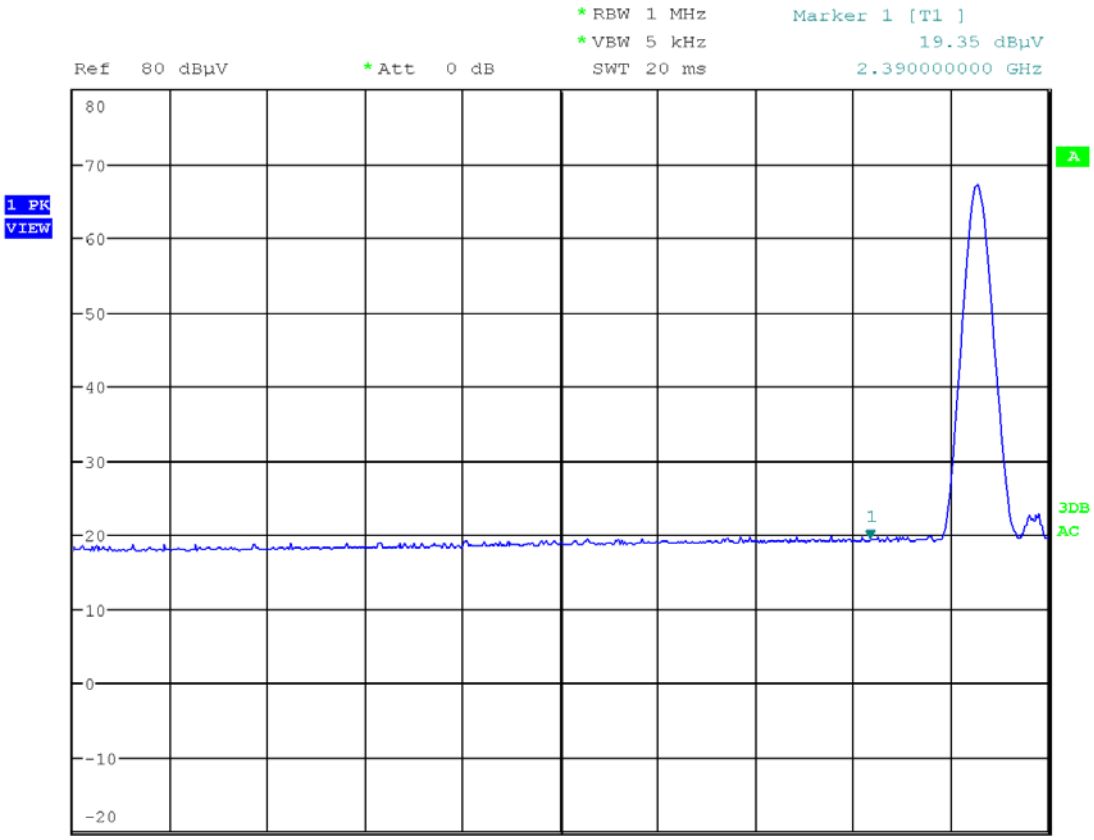
Date: 26.JUL.2017 08:03:56

Radiated Band Edge measurements made were made from 2470 – 2510 MHz

Frequency	Raw FS Amplitude at 3m	Corr. Factor	FS at 3m	Peak to Band Edge Delta	Corrected Band edge FS at 3m	Ave Limit	Margin	Results
MHz	dB(uV)	dB	dB(uV/m)	dB(uV)	dB(uV/m)	dB(uV/m)	dB(uV/m)	
2480	69.0	33.9	102.9	51.6	51.3	54	-2.7	Pass

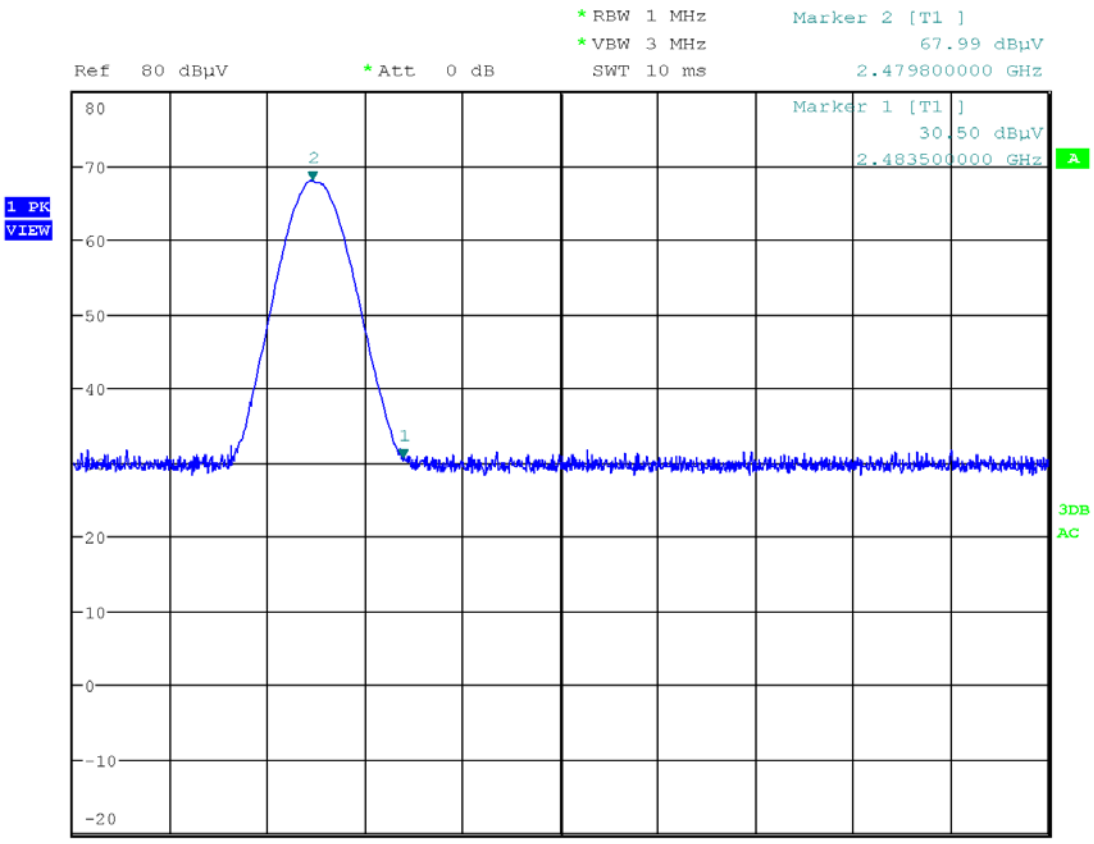


Modulation Type	Detector	EUT Channel	Frequency	Raw Amplitude at 3m	Corr. Factor	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV)	dB	dB(uV/m)	dB(uV/m)	dB(uV/m)	
π/4-DQPSK	Peak	0	2402	30.3	33.9	64.2	74	-9.8	Pass



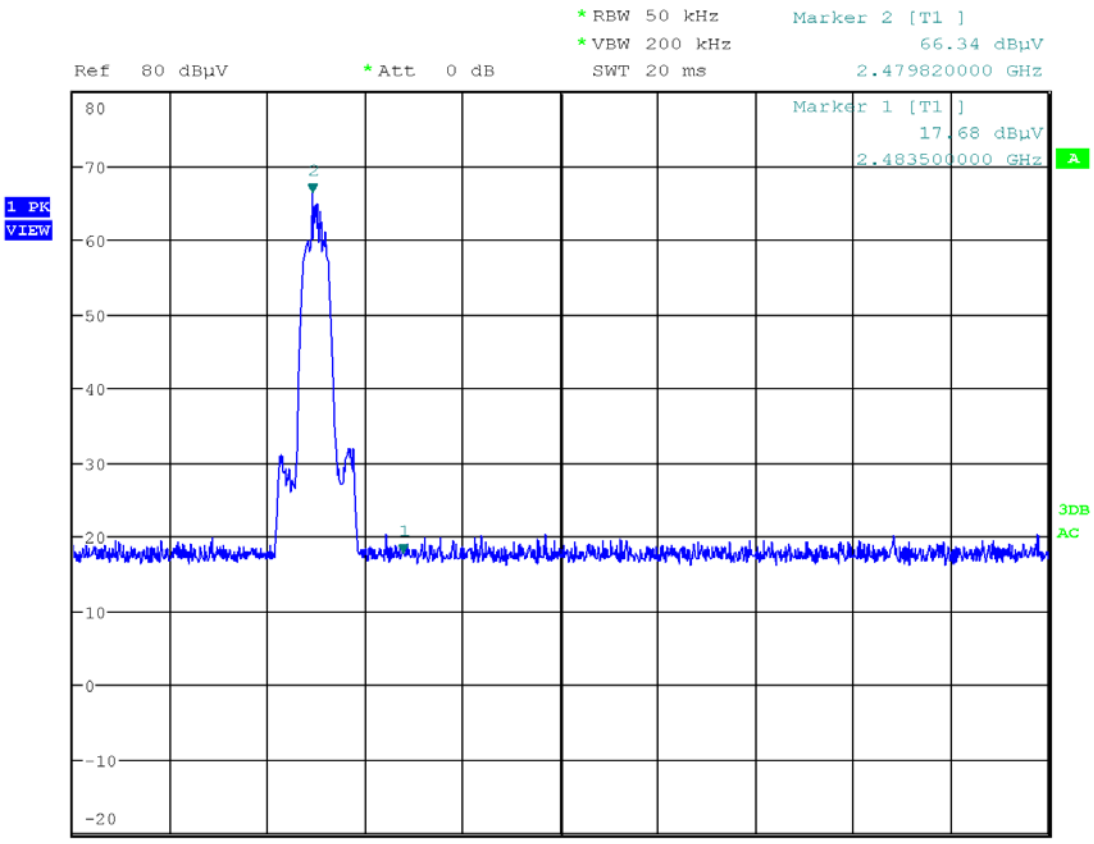
Date: 26.JUL.2017 07:39:07

Modulation Type	Detector	EUT Channel	Frequency	Raw Amplitude at 3m	Corr. Factor	FS at 3m	Ave Limit	Margin	Results
			MHz	dB(uV)	dB	dB(uV/m)	dB(uV/m)	dB(uV/m)	
π/4-DQPSK	Avg	0	2402	19.4	33.9	53.3	54	-0.7	Pass

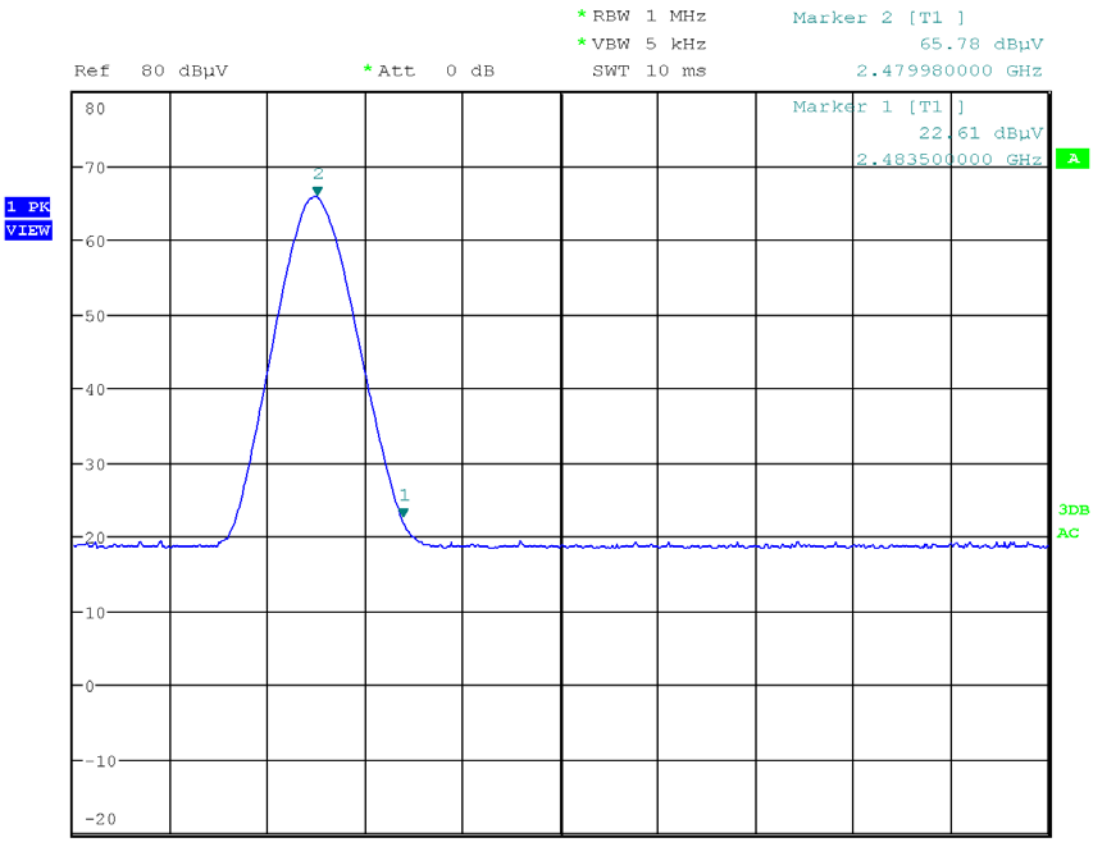


Date: 26.JUL.2017 08:12:10

Modulation Type	Detector	EUT Channel	Frequency	Raw Amplitude at 3m	Corr. Factor	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV)	dB	dB(uV/m)	dB(uV/m)	dB(uV/m)	
π/4-DQPSK	Peak	78	2480	30.5	33.9	64.4	74	-9.6	Pass



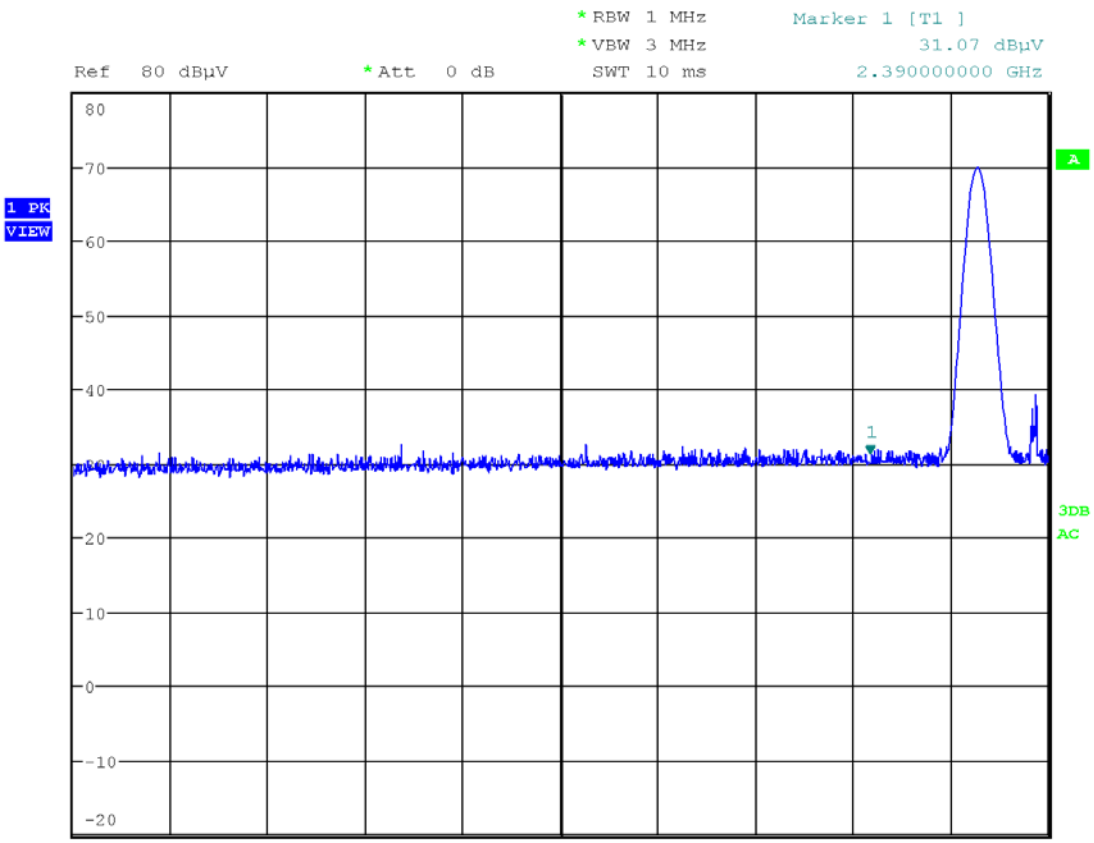
Modulation Type	Detector	EUT Channel	Frequency	Peak to Band Edge Delta
			MHz	dB(uV)
π/4-DQPSK	Peak	78	2480	48.7



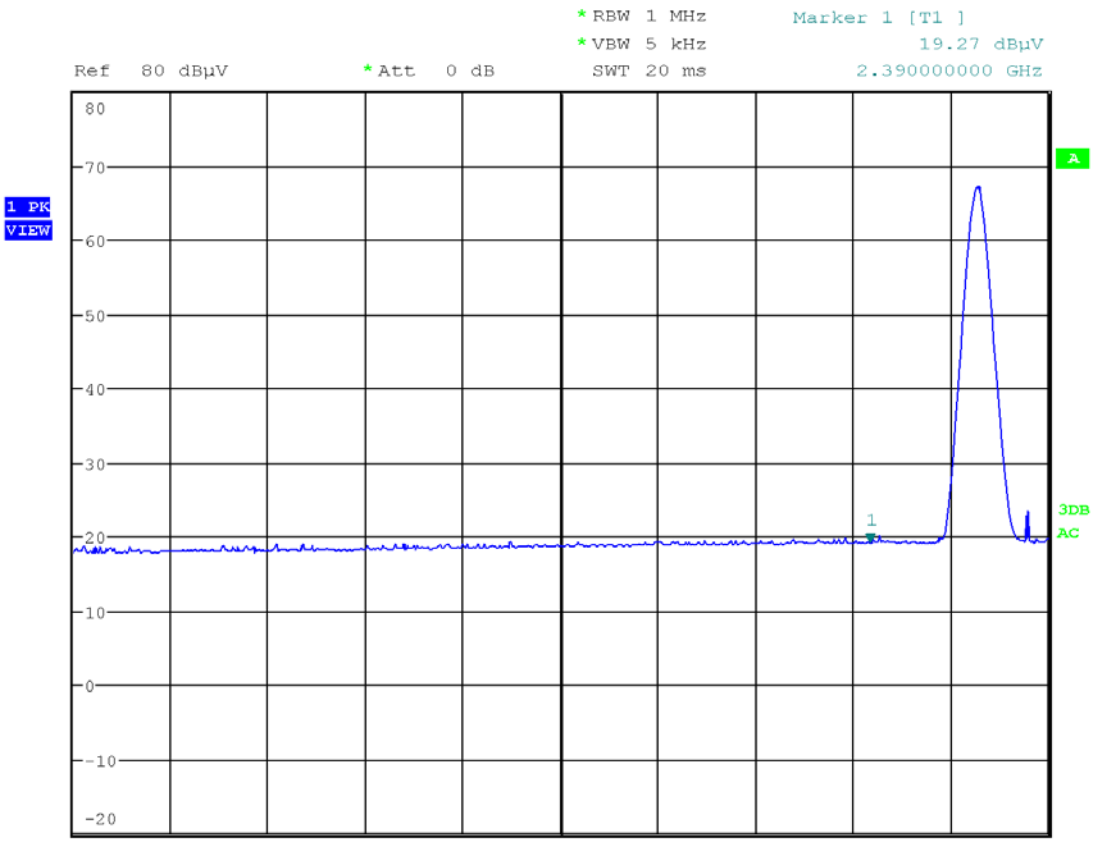
Date: 26.JUL.2017 08:13:15

Frequency	Raw FS Amplitude at 3m	Corr. Factor	FS at 3m	Peak to Band Edge Delta	Corrected Band edge FS at 3m	Ave Limit	Margin	Results
MHz	dB(uV)	dB	dB(uV/m)	dB(uV)	dB(uV/m)	dB(uV/m)	dB(uV/m)	
2480	65.8	33.9	99.7	48.7	51.0	54	-3.0	Pass

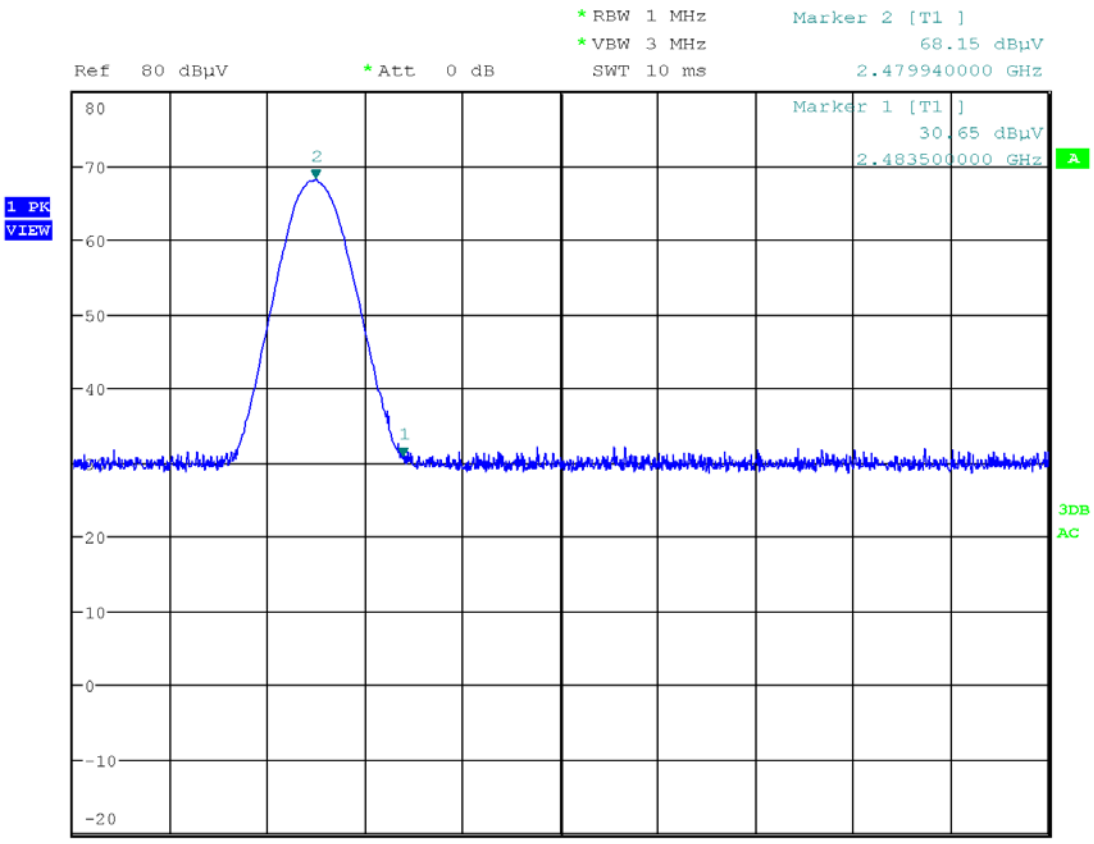
8DPSK Modulation for Out-of-Band Spurious Emissions at the Band Edge



Modulation Type	Detector	EUT Channel	Frequency	Raw Amplitude at 3m	Corr. Factor	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV)	dB	dB(uV/m)	dB(uV/m)	dB(uV/m)	
8DPSK	Peak	0	2402	31.1	33.9	65.0	74	-9.0	Pass

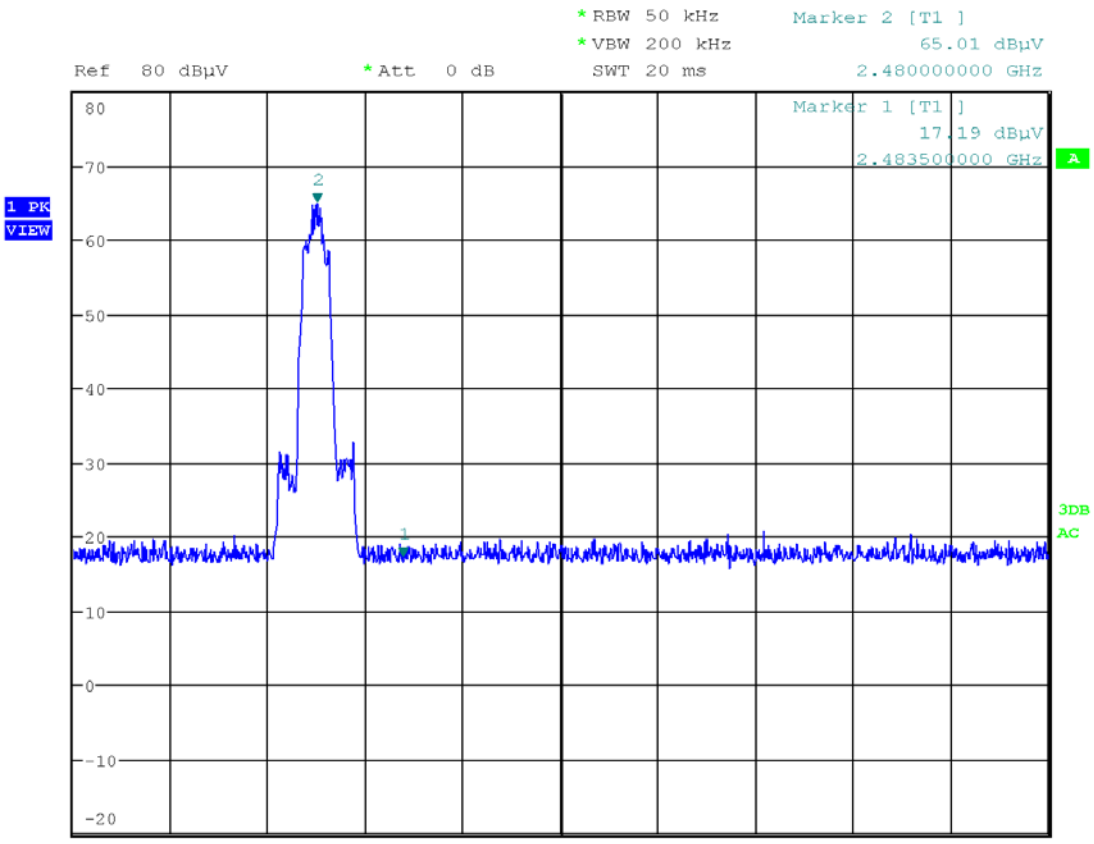


Modulation Type	Detector	EUT Channel	Frequency	Raw Amplitude at 3m	Corr. Factor	FS at 3m	Ave Limit	Margin	Results
			MHz	dB(uV)	dB	dB(uV/m)	dB(uV/m)	dB(uV/m)	
8DPSK	Avg	0	2402	19.3	33.9	53.2	54	-0.8	Pass

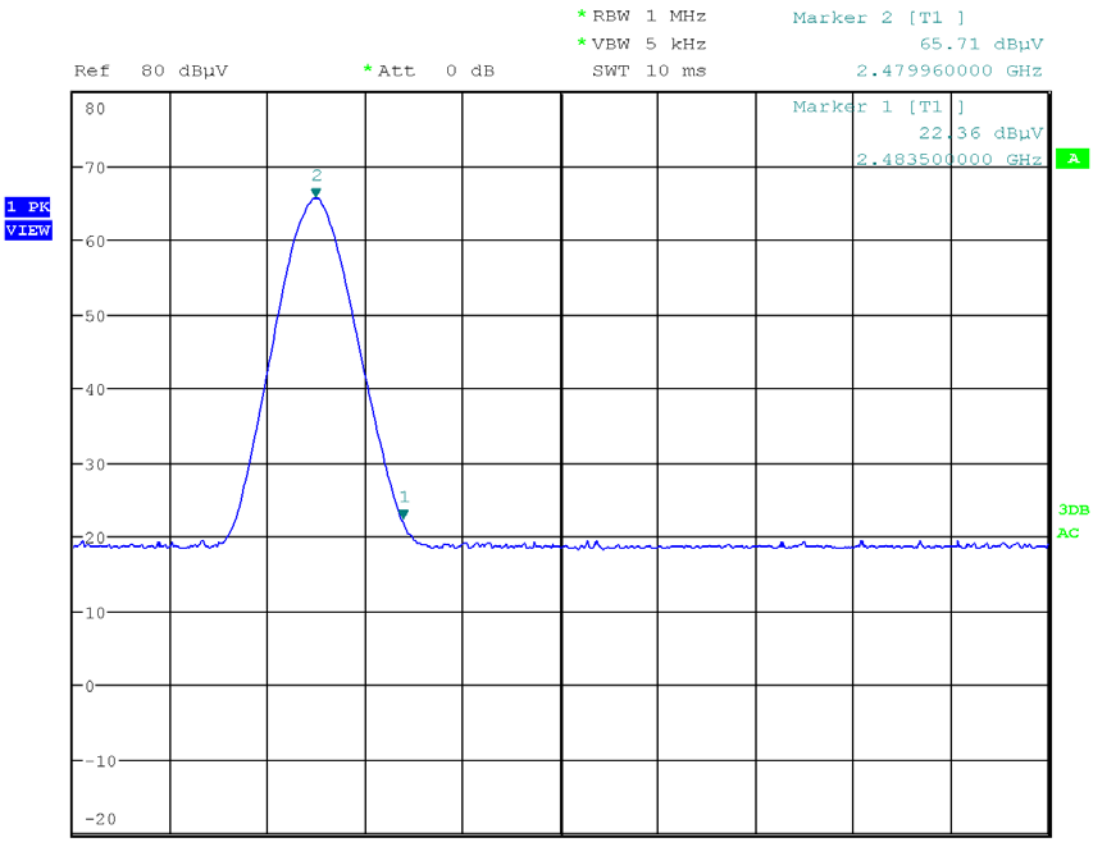


Date: 26.JUL.2017 08:23:18

Modulation Type	Detector	EUT Channel	Frequency	Raw Amplitude at 3m	Corr. Factor	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV)	dB	dB(uV/m)	dB(uV/m)	dB(uV/m)	
8DPSK	Peak	78	2480	30.7	33.9	64.6	74	-9.4	Pass



Modulation Type	Detector	EUT Channel	Frequency	Peak to Band Edge Delta
			MHz	dB(uV)
8DPSK	Peak	78	2480	47.8

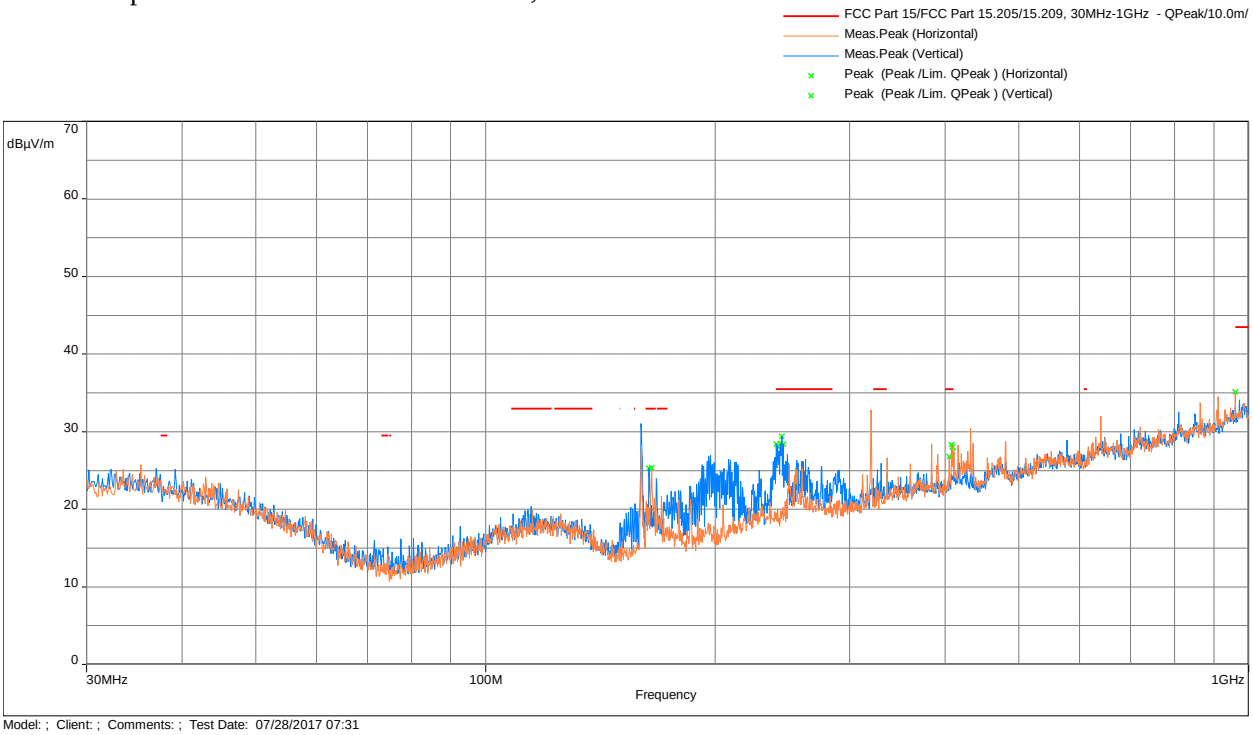


Date: 26.JUL.2017 08:24:35

Frequency	Raw FS Amplitude at 3m	Corr. Factor	FS at 3m	Peak to Band Edge Delta	Corrected Band edge FS at 3m	Ave Limit	Margin	Results
MHz	dB(uV)	dB	dB(uV/m)	dB(uV)	dB(uV/m)	dB(uV/m)	dB(uV/m)	
2480	65.7	33.9	99.6	47.8	51.8	54	-2.2	Pass

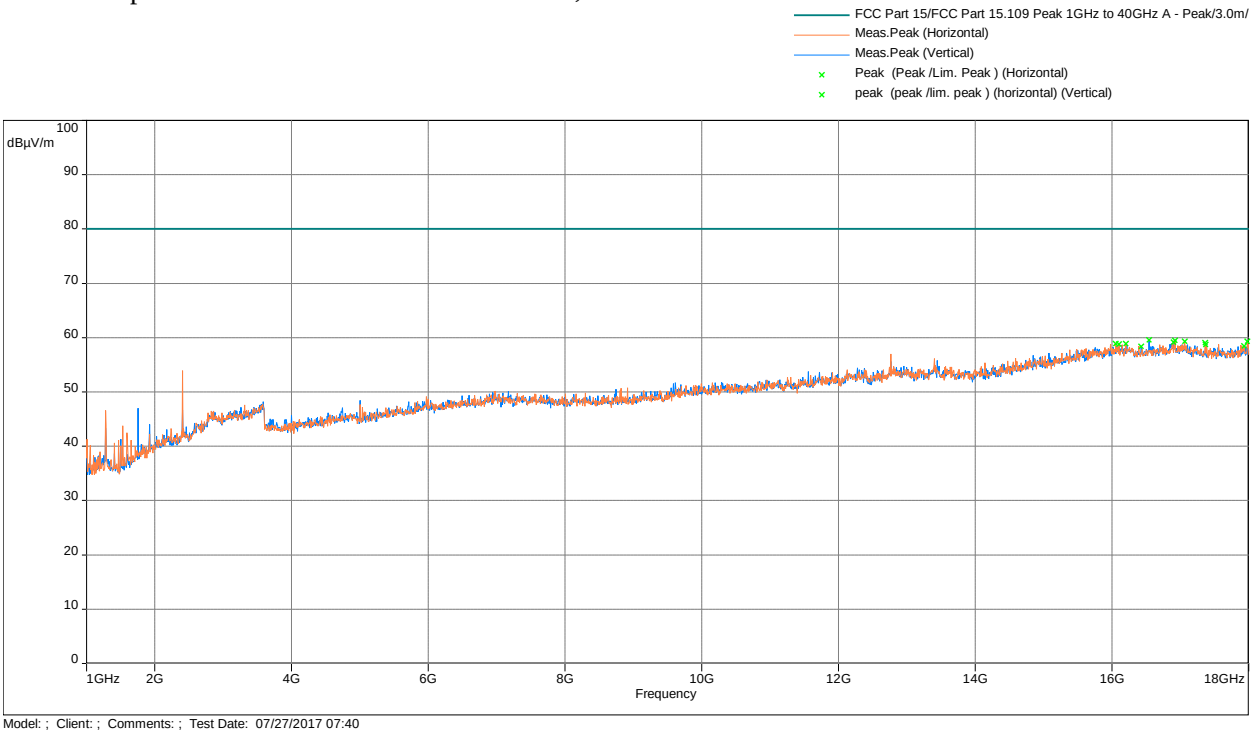
Test Results: 15.209 Out-of-Band Radiated Spurious Emissions, 2402MHz GFSK

Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



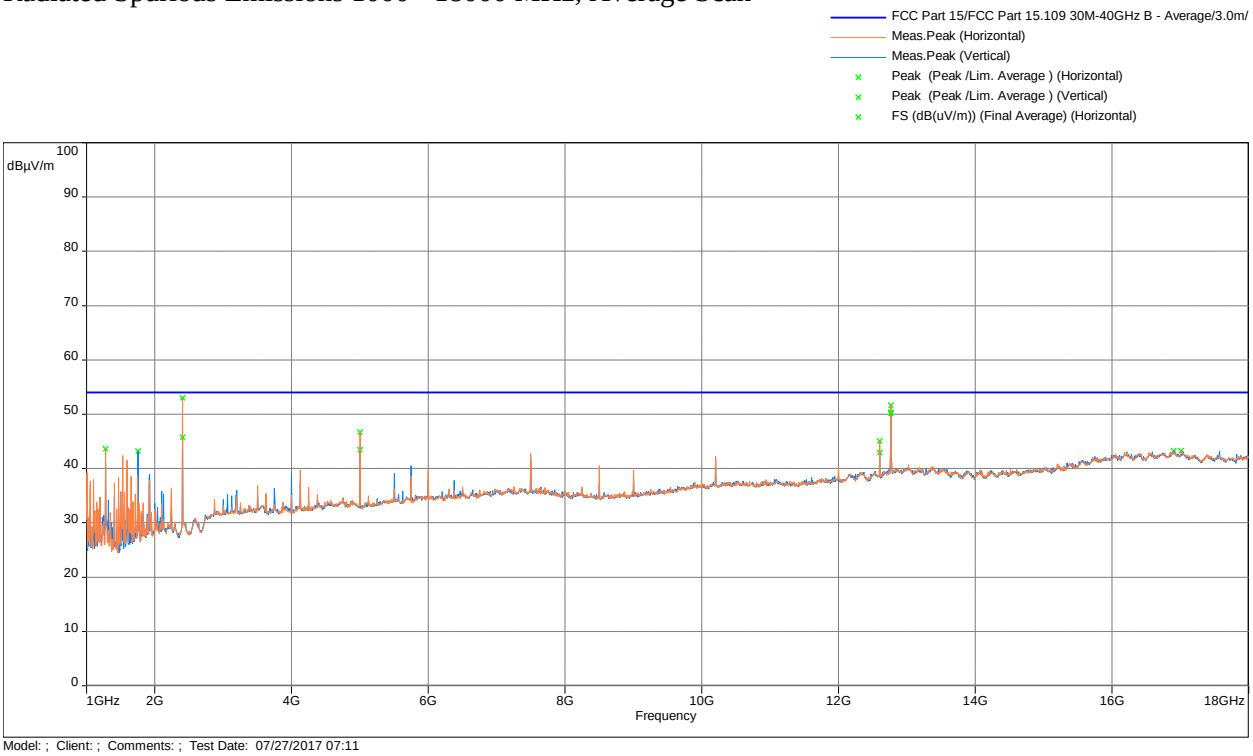
Model: ; Client: ; Comments: ; Test Date: 07/28/2017 07:31

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Model: ; Client: ; Comments: ; Test Date: 07/27/2017 07:40

Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan



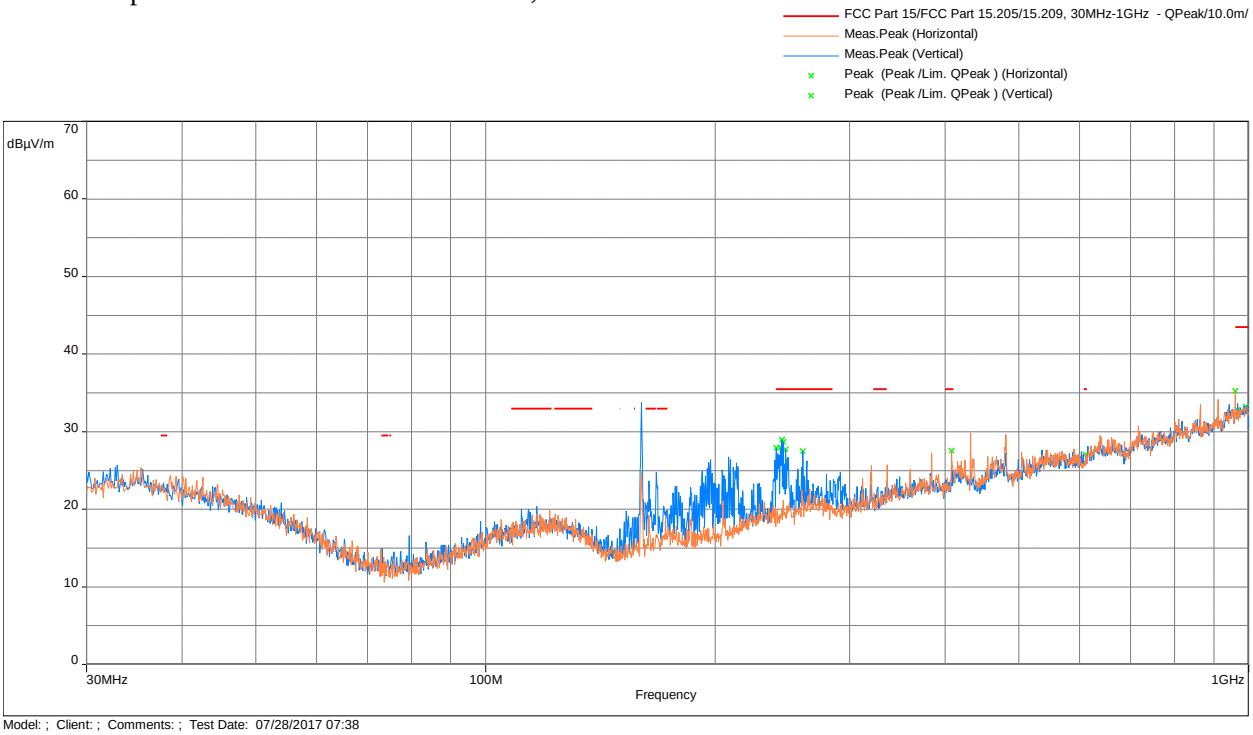
Model: ; Client: ; Comments: ; Test Date: 07/27/2017 07:11

Frequency (MHz)	Avg Amplitude (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity (H/V)	Raw Avg (dBµV)	Correction (dB)
12762	50.3	54	-3.7	11	1.68	H	36.5	13.8

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

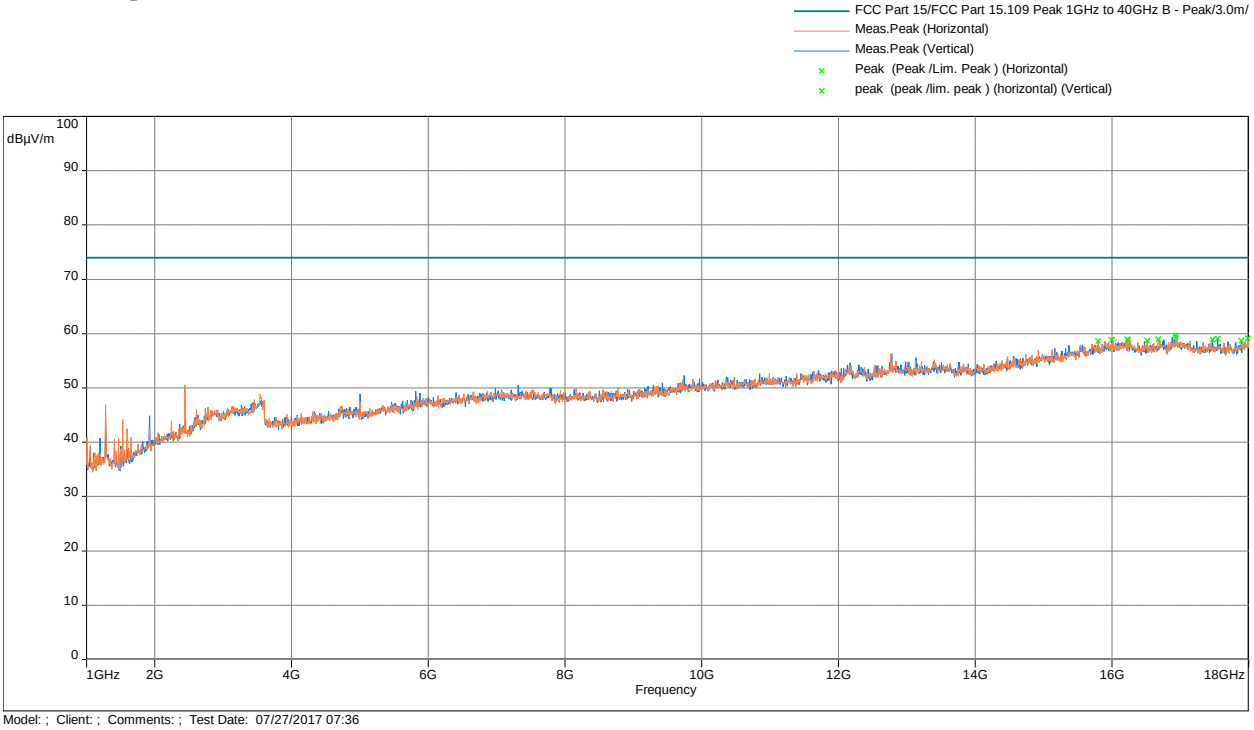
Results	Complies

Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



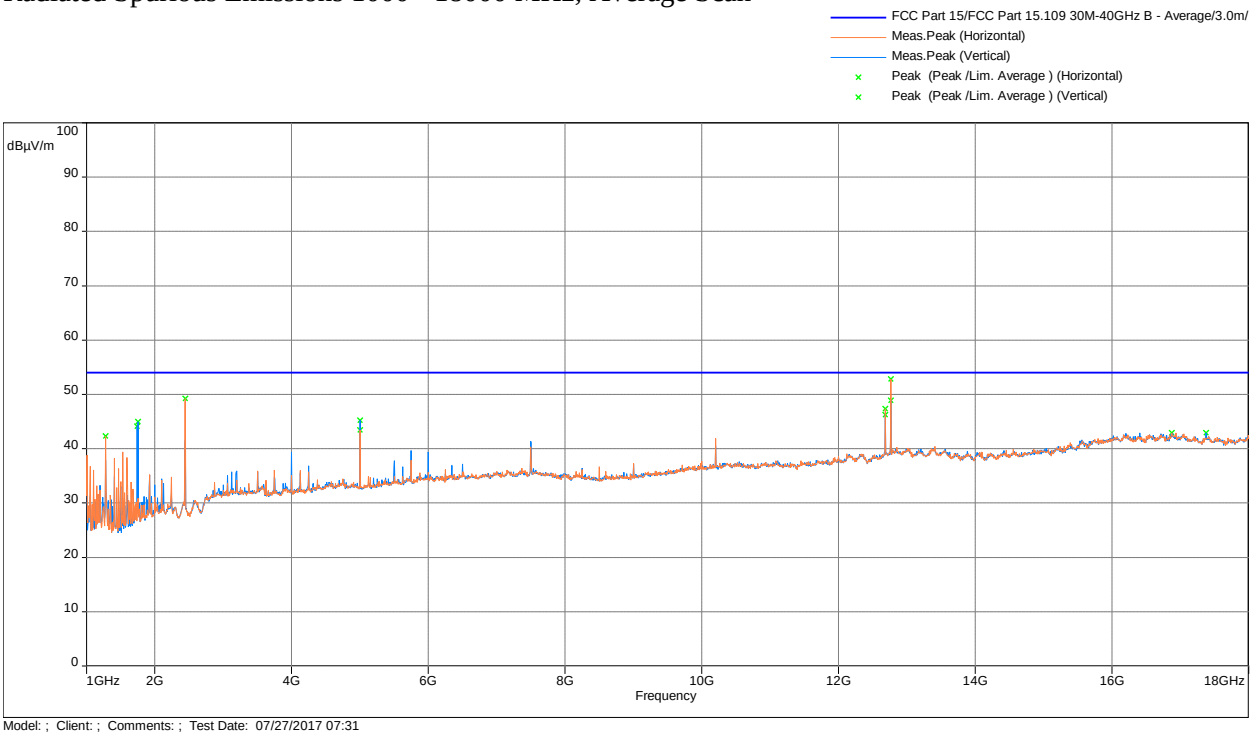
Model: ; Client: ; Comments: ; Test Date: 07/28/2017 07:38

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Model: ; Client: ; Comments: ; Test Date: 07/27/2017 07:36

Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan



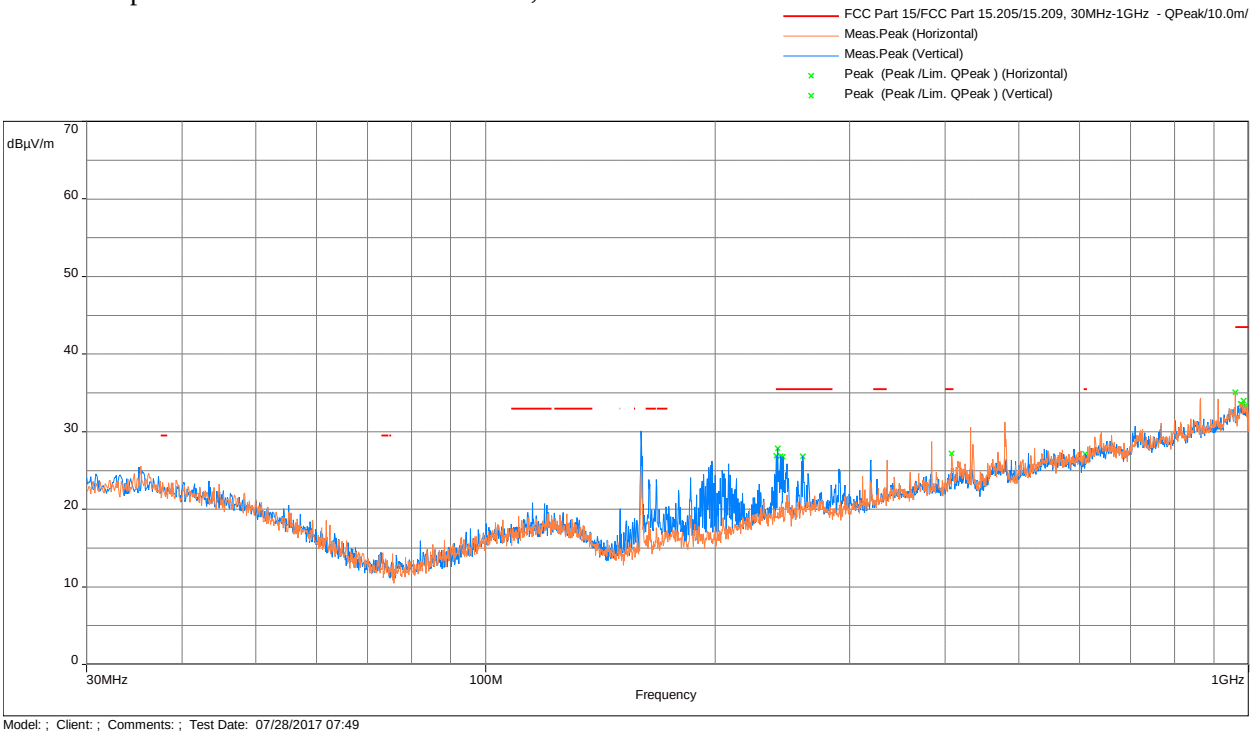
Model: ; Client: ; Comments: ; Test Date: 07/27/2017 07:31

Frequency (MHz)	Avg Amplitude (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity (H/V)	Raw Avg (dBµV)	Correction (dB)
12762	50.8	54	-3.2	15	1.71	H	37.0	13.8

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

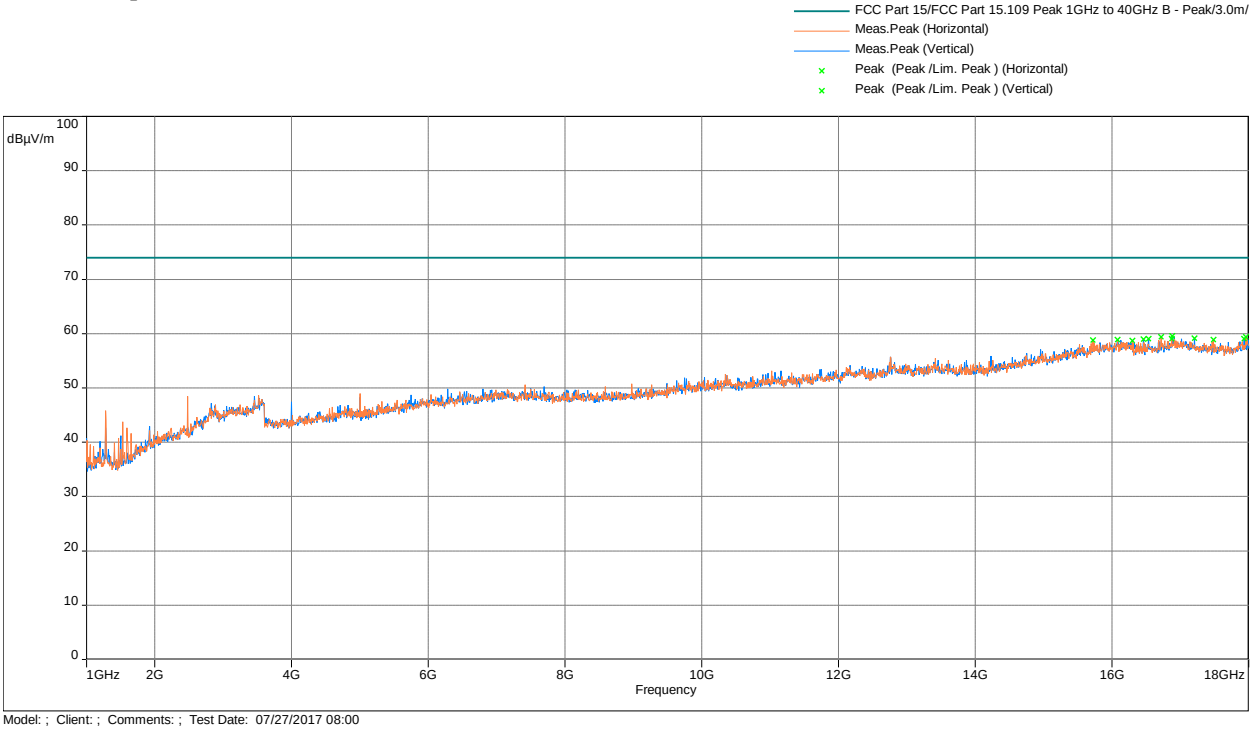
Results	Complies

Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



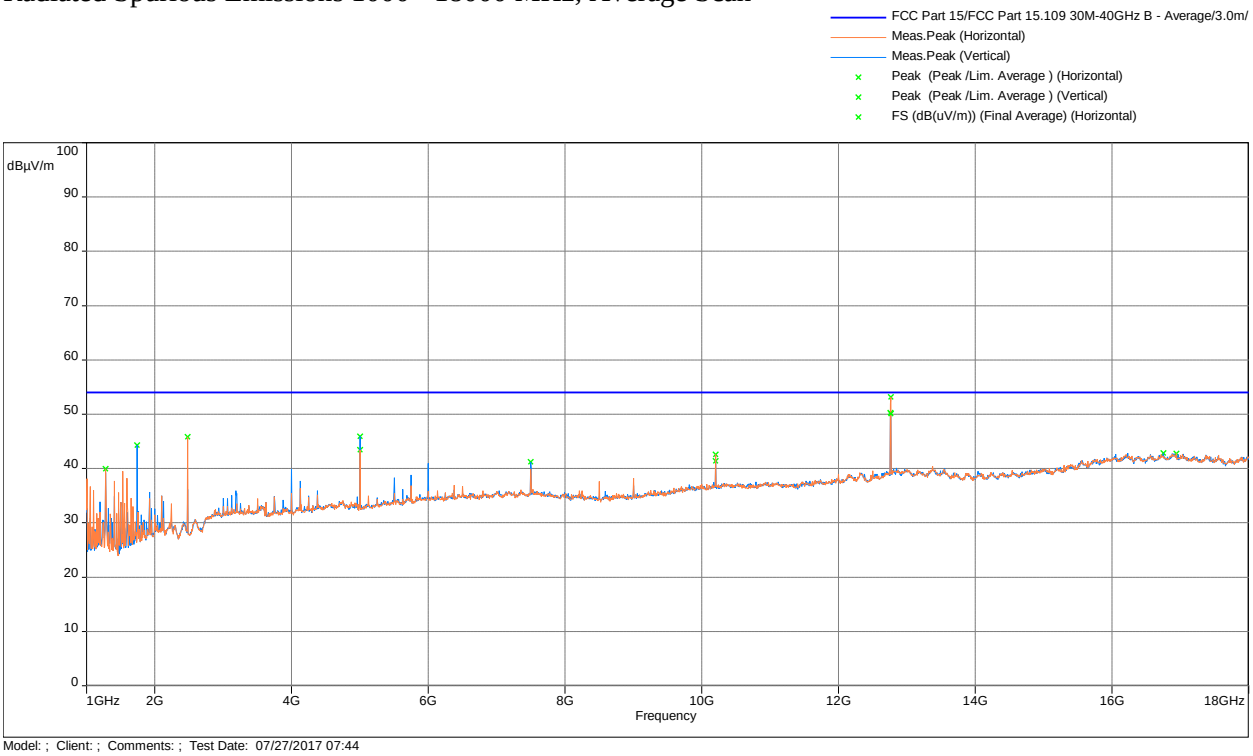
Model: ; Client: ; Comments: ; Test Date: 07/28/2017 07:49

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:00

Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan



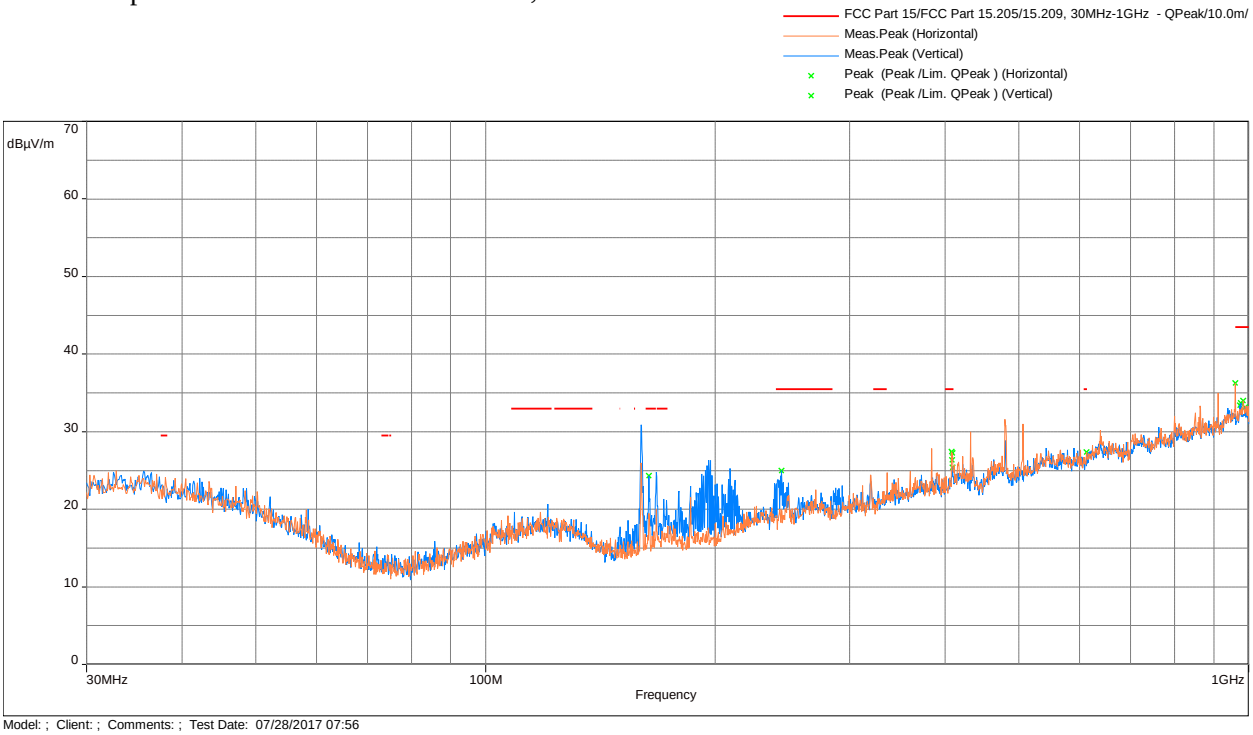
Model: ; Client: ; Comments: ; Test Date: 07/27/2017 07:44

Frequency (MHz)	Avg Amplitude (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity (H/V)	Raw Avg (dBµV)	Correction (dB)
12762	50.1	54	-3.9	15	1.95	H	36.3	13.8

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

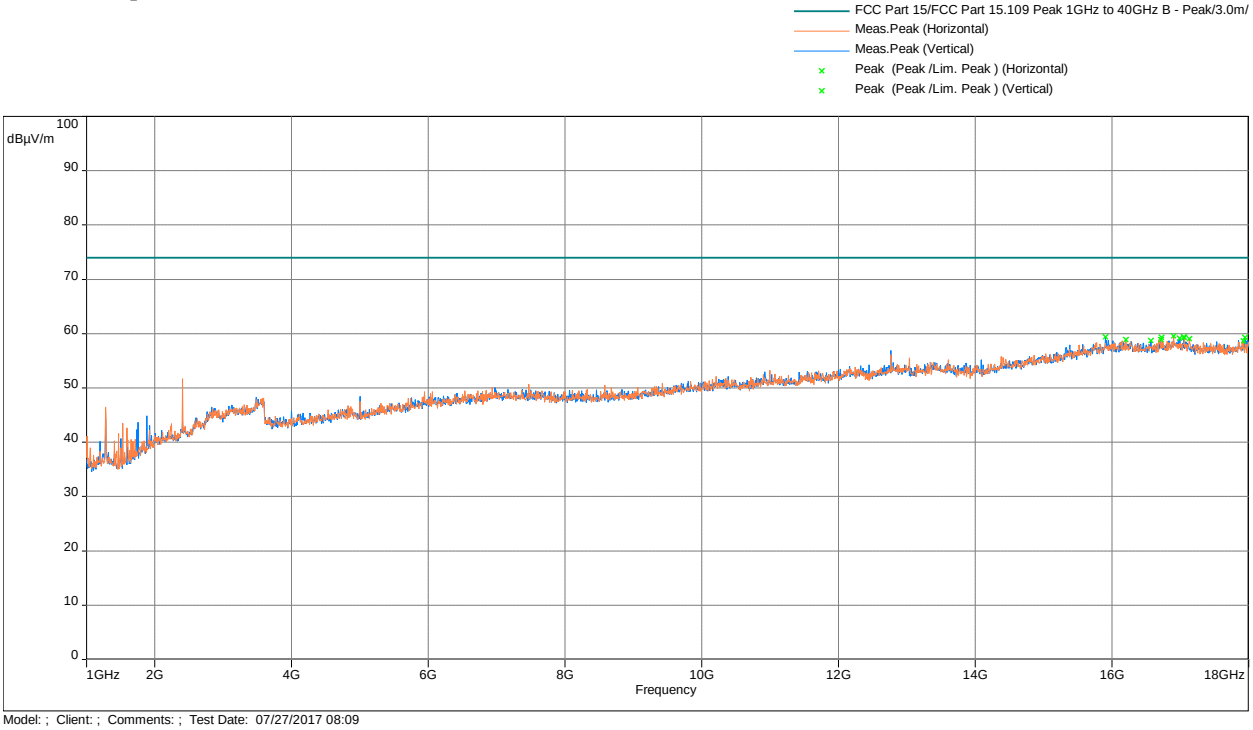
Results	Complies

Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



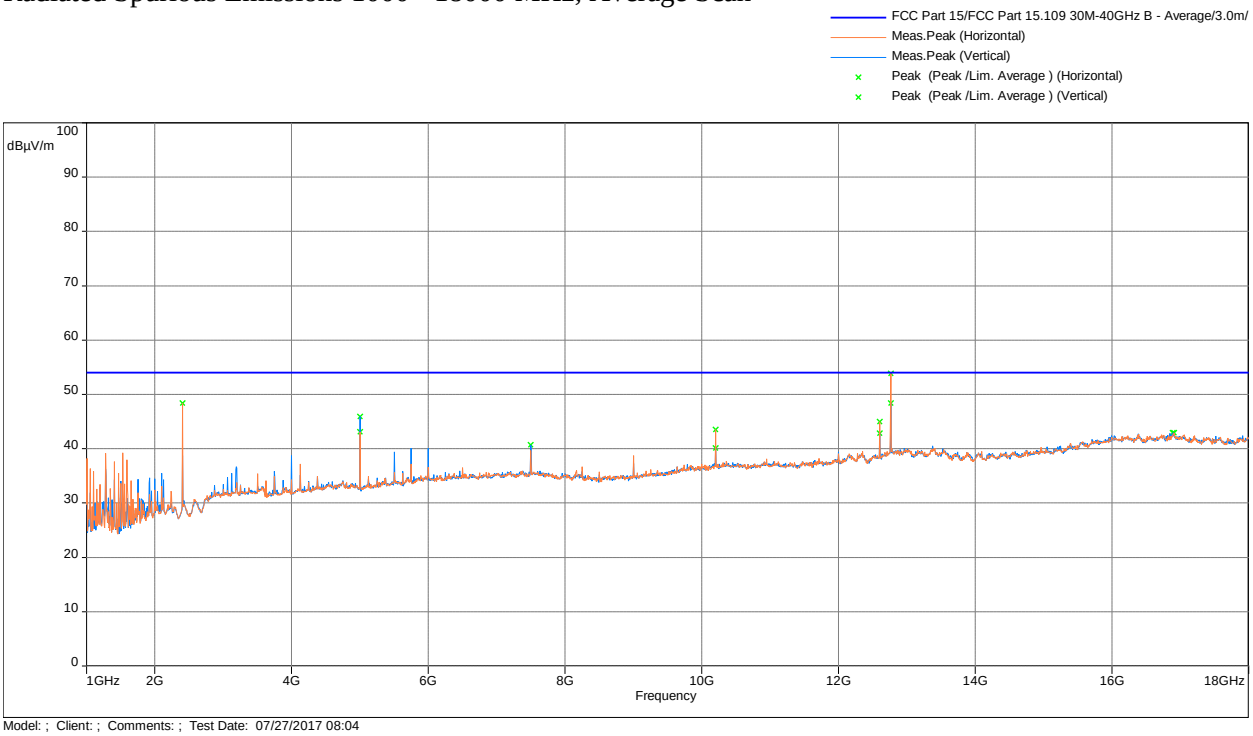
Model: ; Client: ; Comments: ; Test Date: 07/28/2017 07:56

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:09

Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan



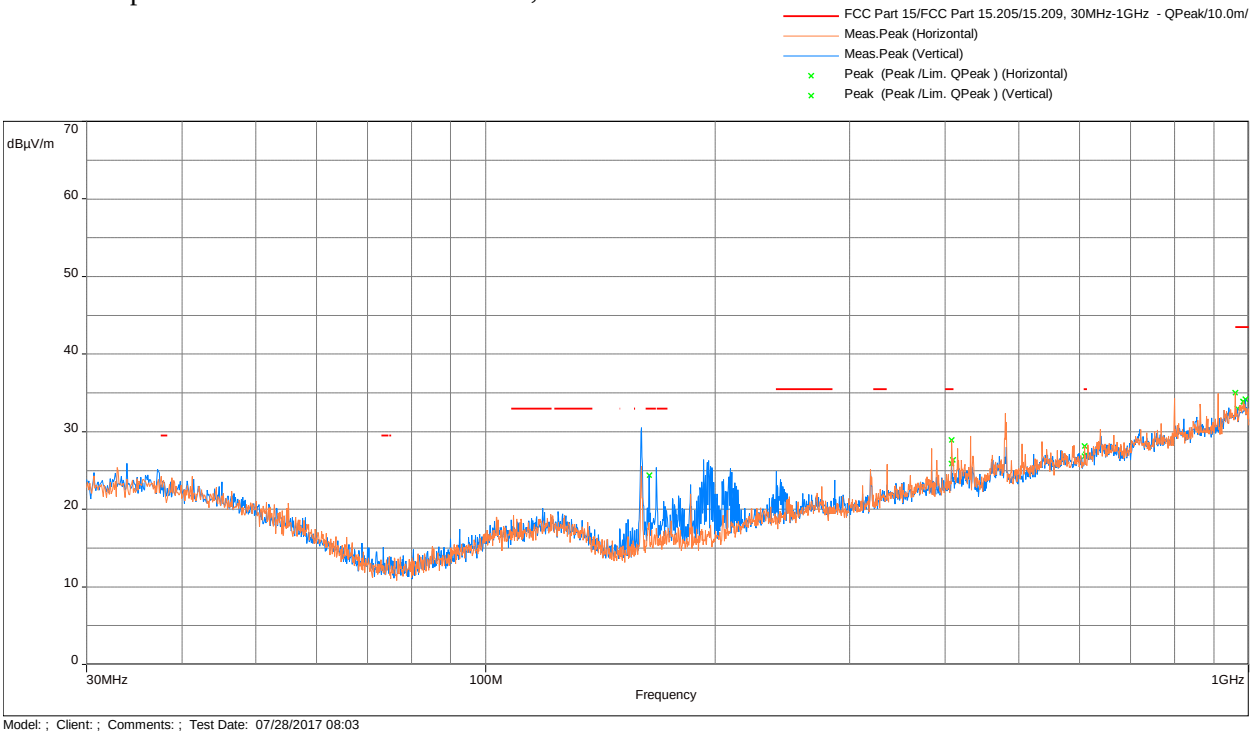
Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:04

Frequency (MHz)	Avg Amplitude (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity (H/V)	Raw Avg (dBµV)	Correction (dB)
12762	51.1	54	-2.9	40	1.51	H	37.3	13.8

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

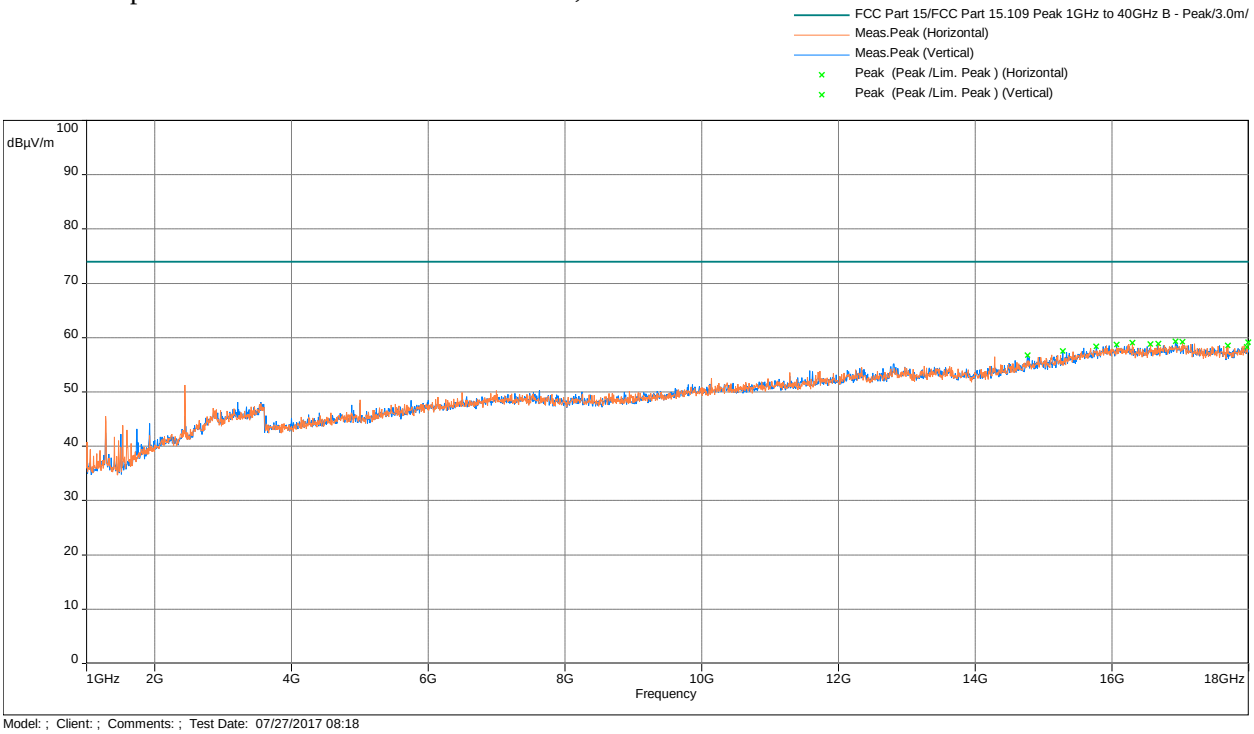
Results	Complies

Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



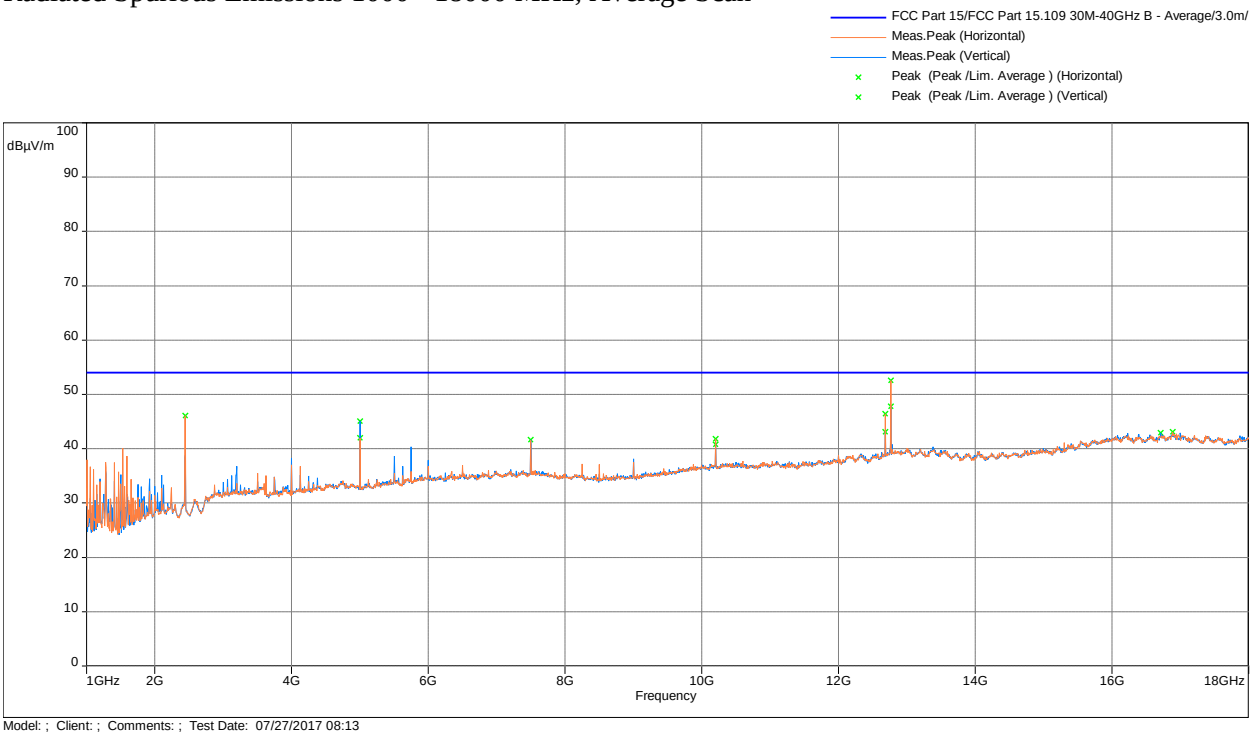
Model: ; Client: ; Comments: ; Test Date: 07/28/2017 08:03

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:18

Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan



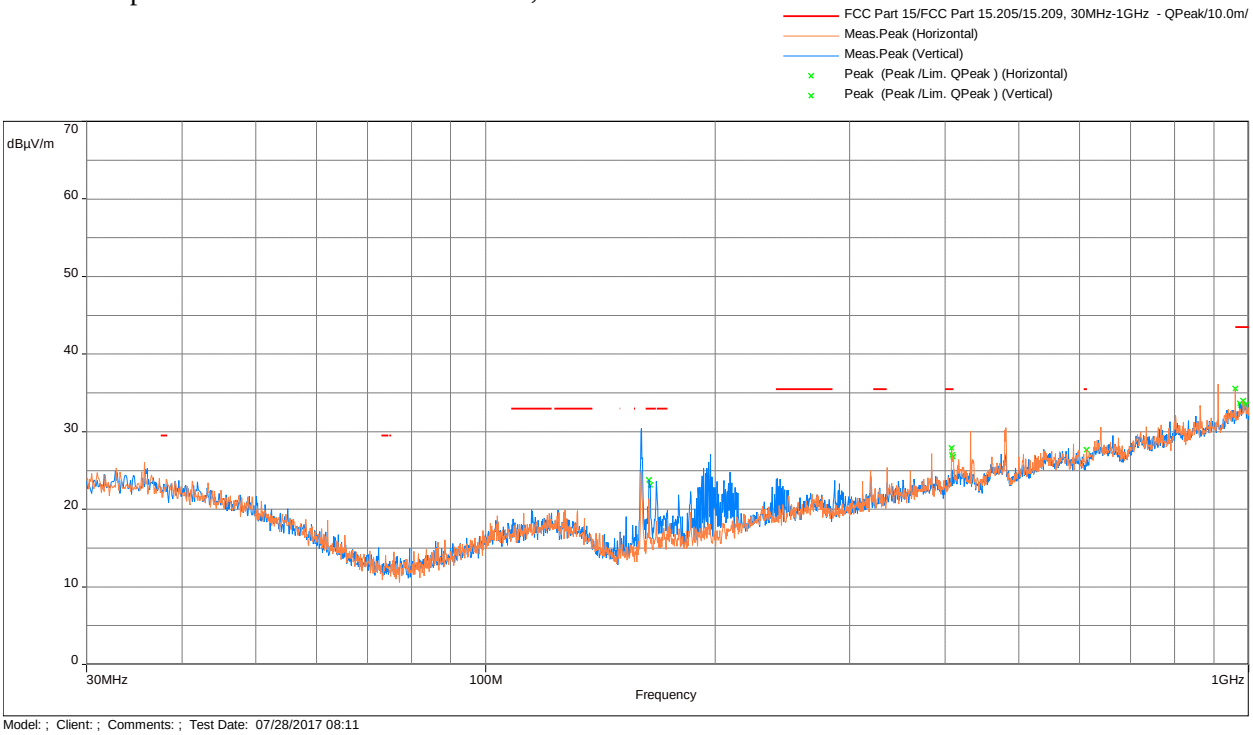
Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:13

Frequency (MHz)	Avg Amplitude (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity (H/V)	Raw Avg (dBµV)	Correction (dB)
12762	50.6	54	-3.4	22	1.55	H	36.8	13.8

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

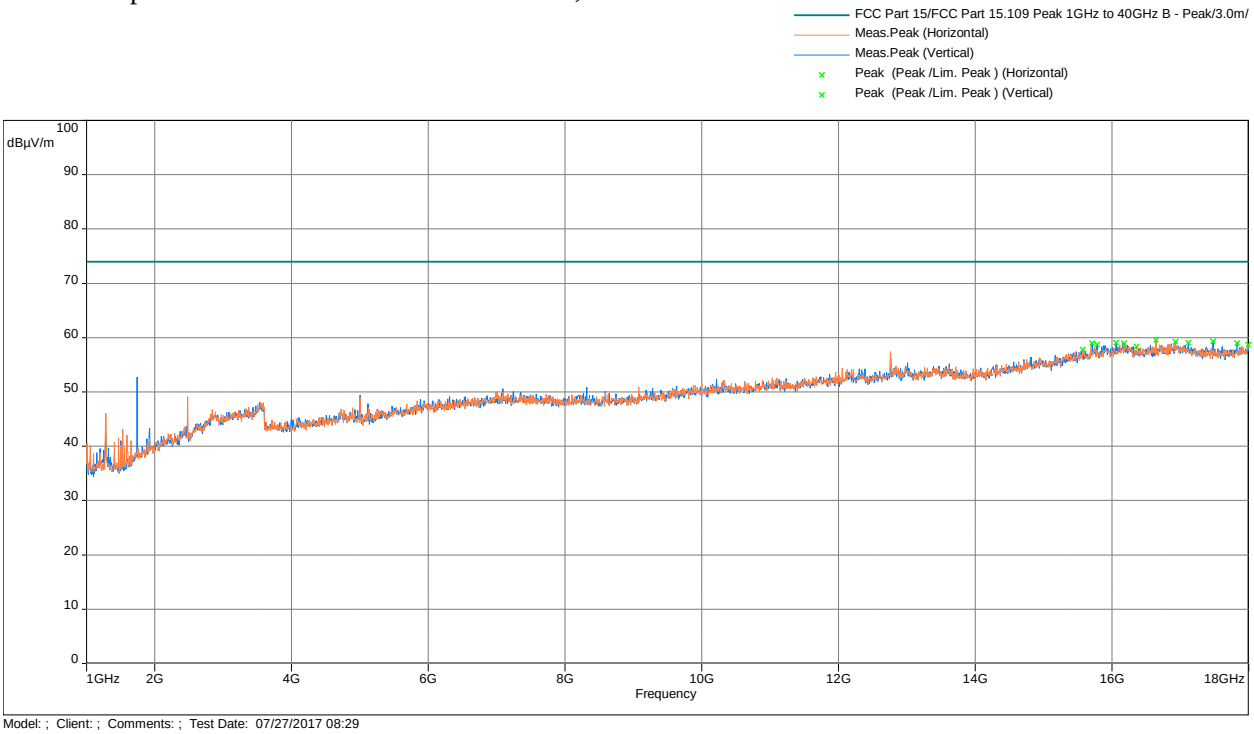
Results	Complies

Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



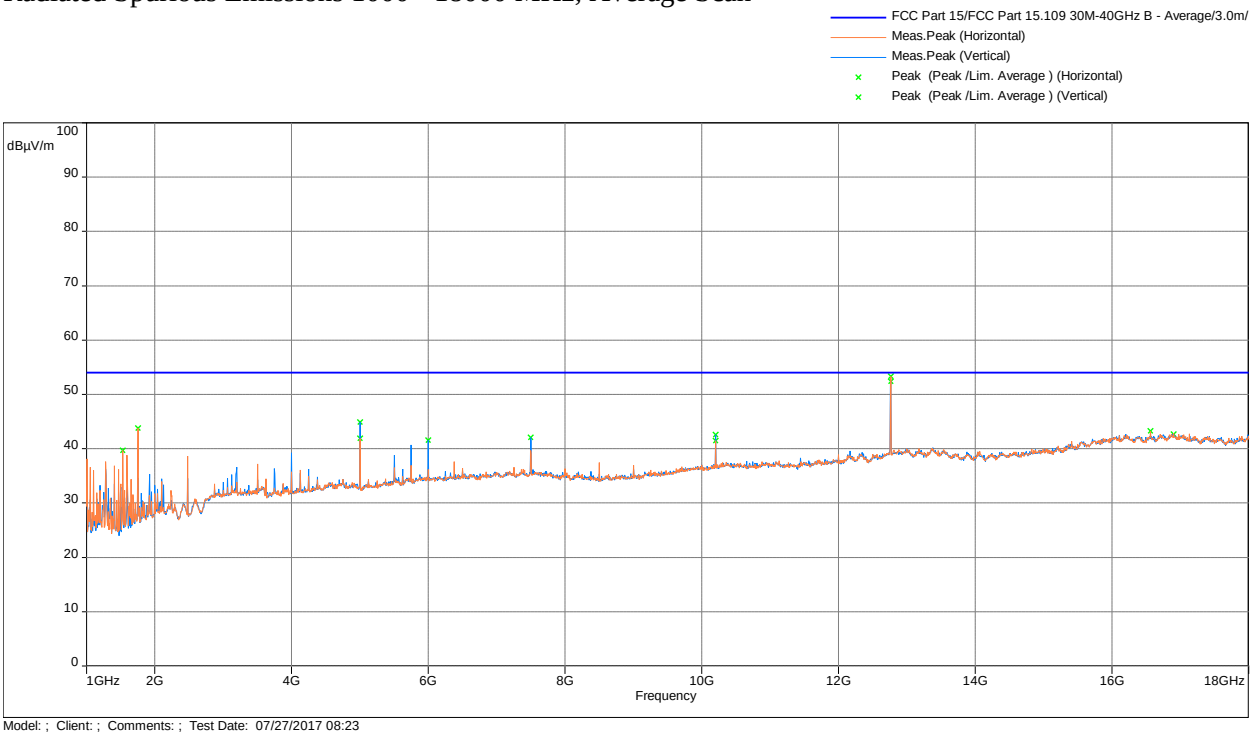
Model: ; Client: ; Comments: ; Test Date: 07/28/2017 08:11

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:29

Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan



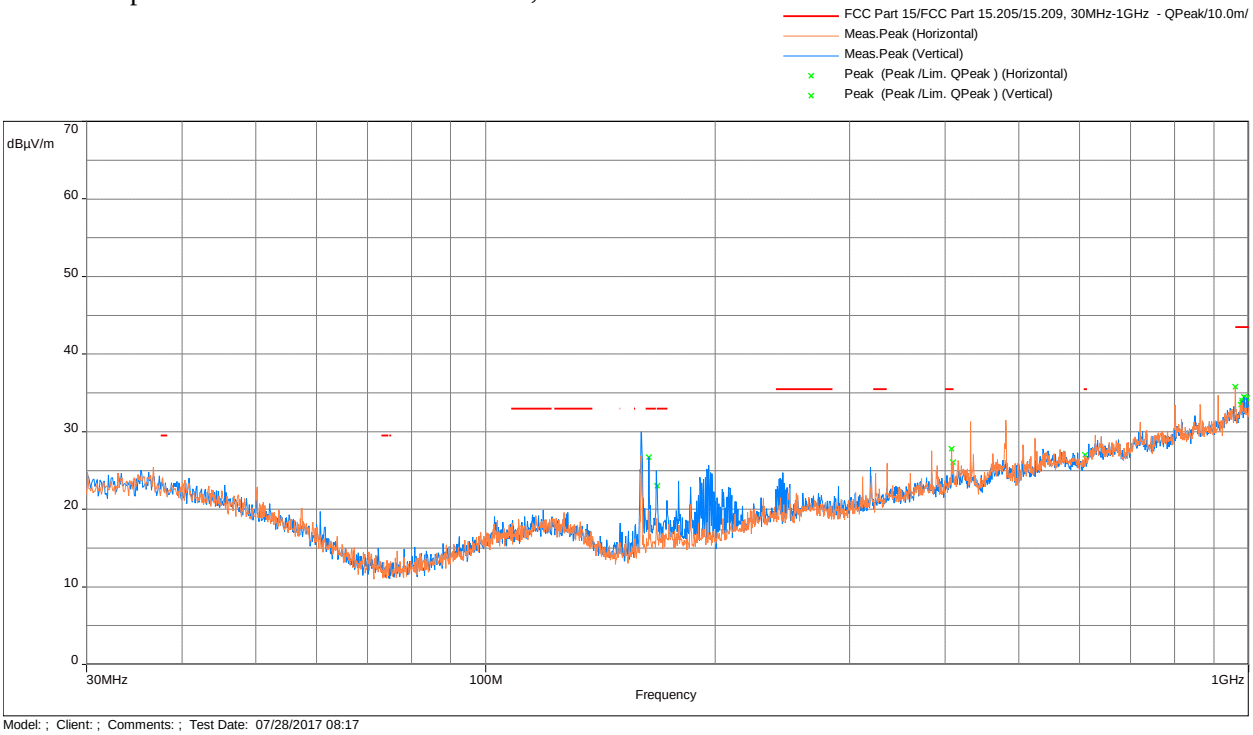
Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:23

Frequency (MHz)	Avg Amplitude (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity (H/V)	Raw Avg (dBµV)	Correction (dB)
12762	50.7	54	-3.3	15	1.74	H	36.9	13.8

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

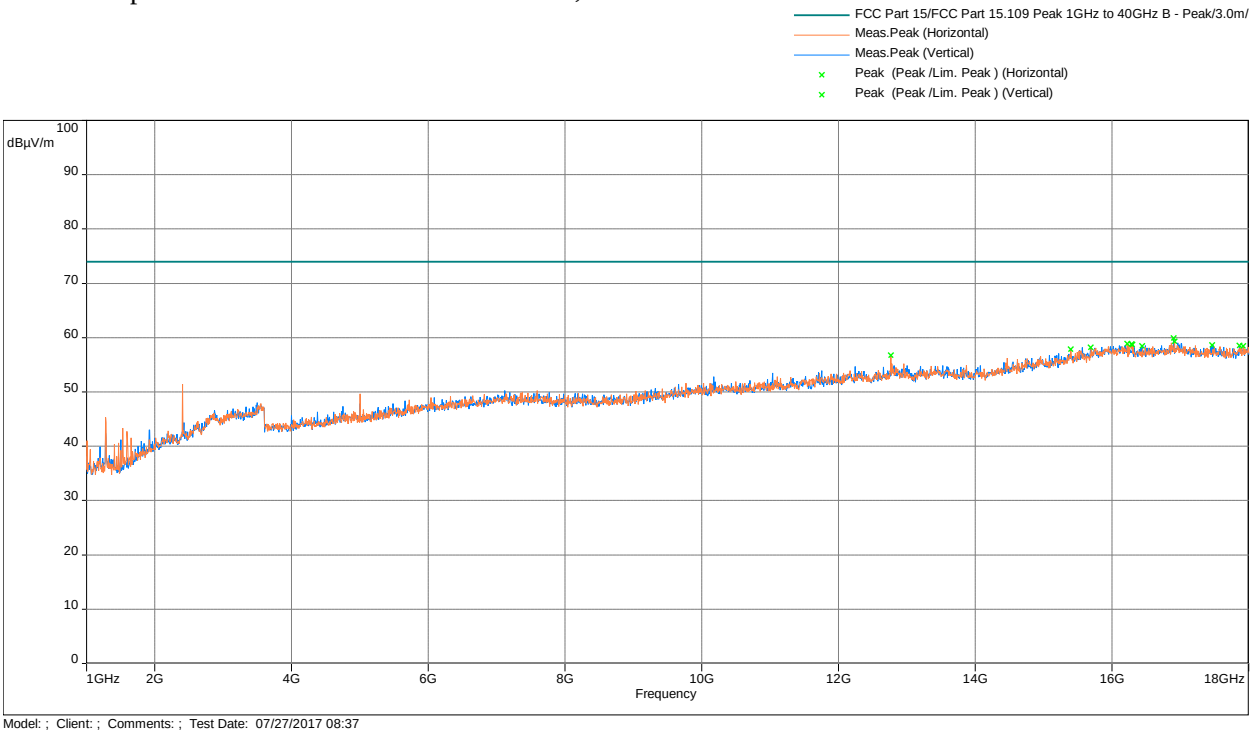
Results	Complies

Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



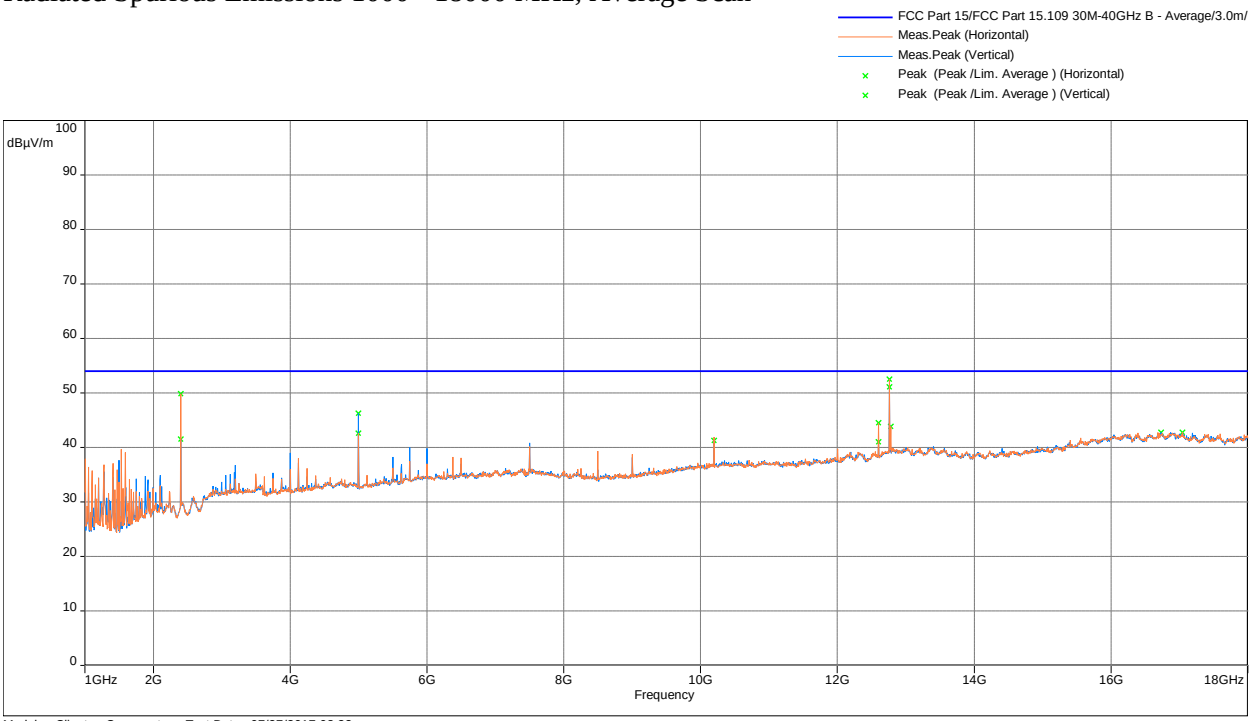
Model: ; Client: ; Comments: ; Test Date: 07/28/2017 08:17

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:37

Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan



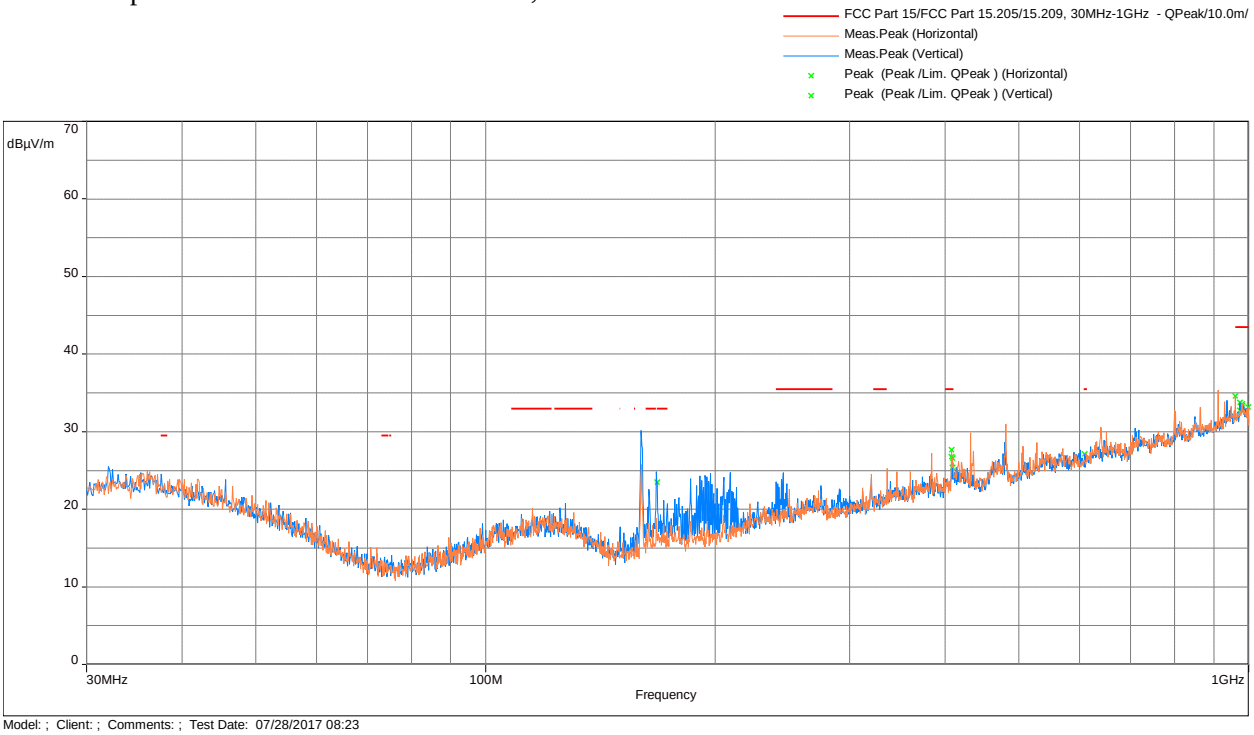
Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:32

Frequency (MHz)	Avg Amplitude (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity (H/V)	Raw Avg (dBµV)	Correction (dB)
12762	50.2	54	-3.8	13	1.71	H	36.4	13.8

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

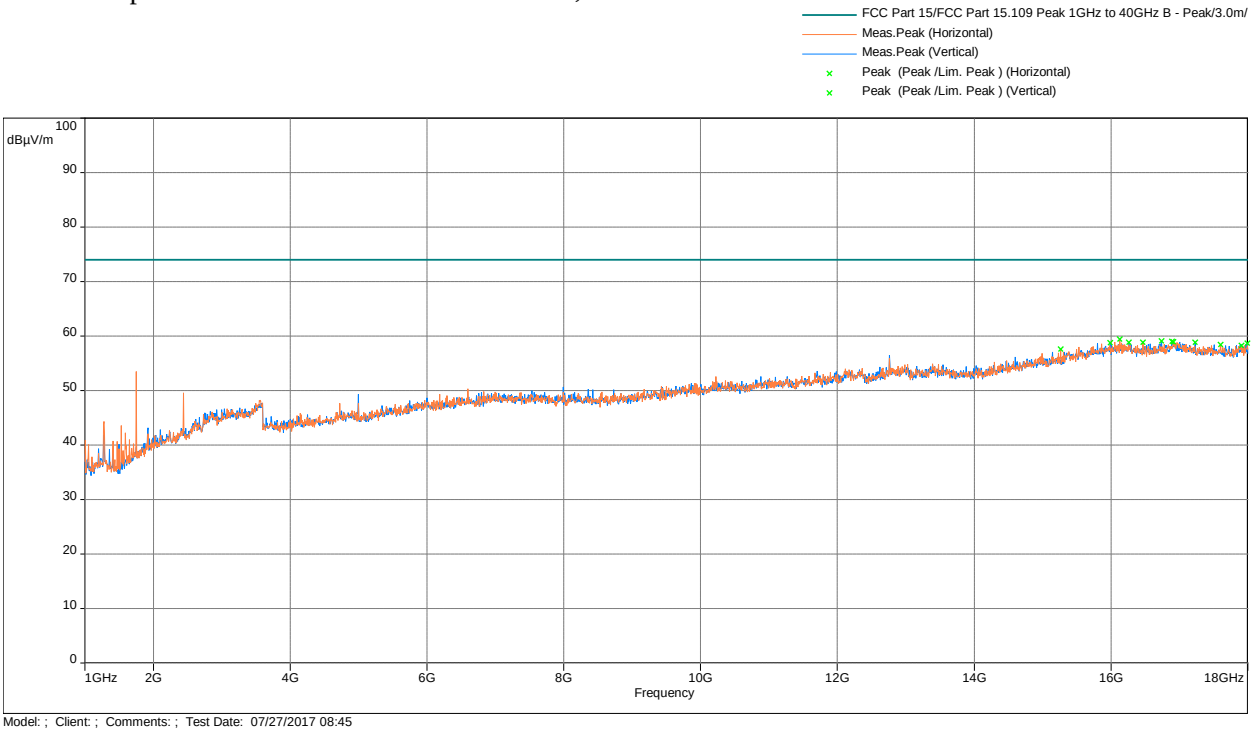
Results	Complies

Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan

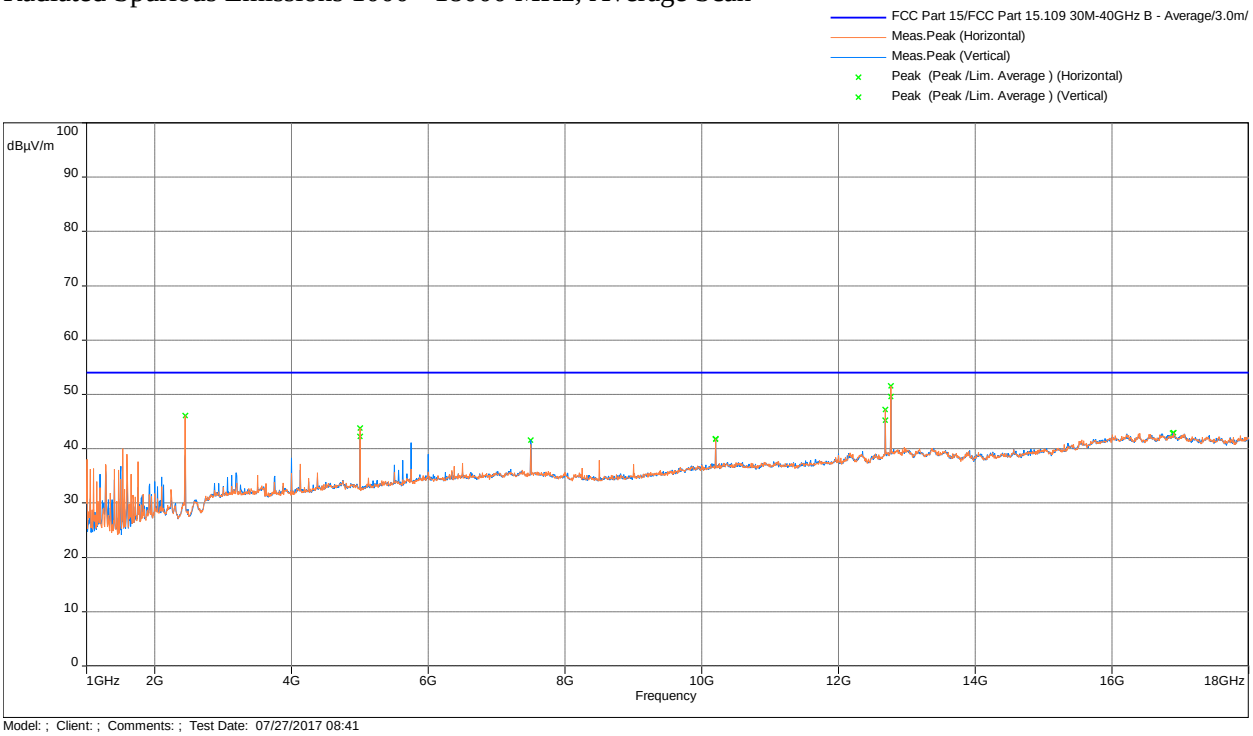


Model: ; Client: ; Comments: ; Test Date: 07/28/2017 08:23

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:45



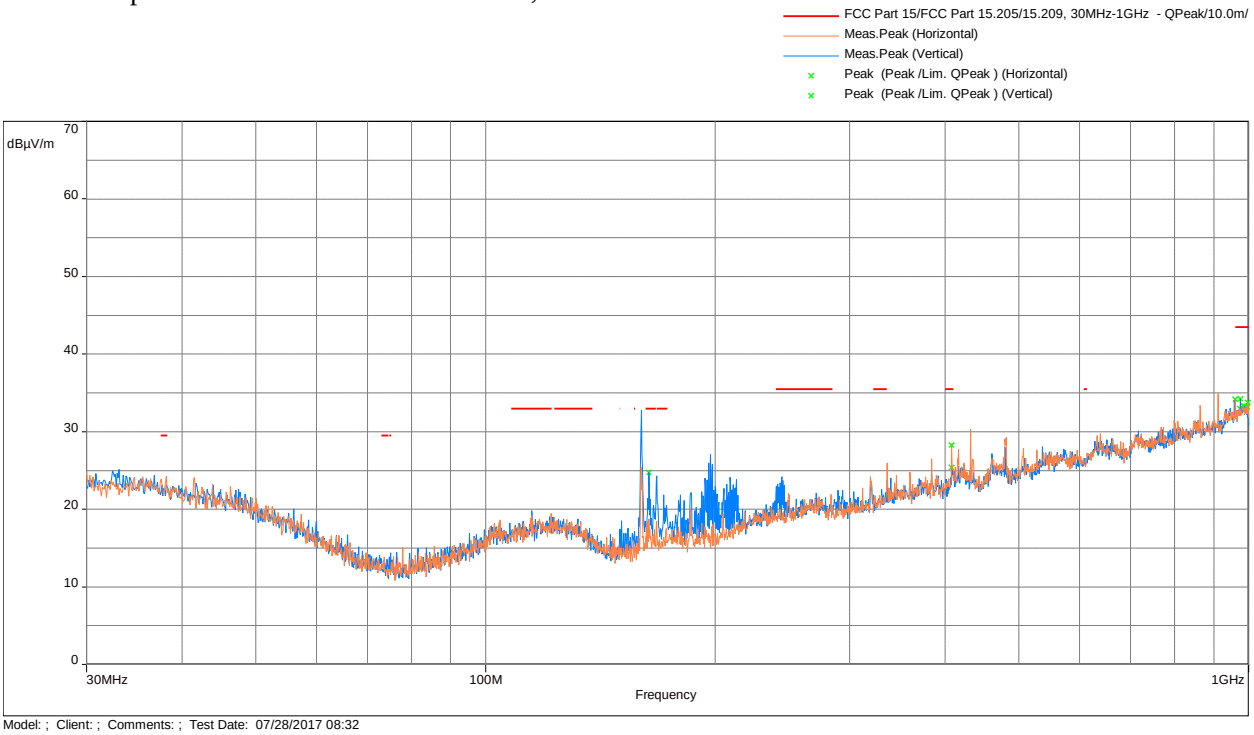
Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:41

Frequency (MHz)	Avg Amplitude (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity (H/V)	Raw Avg (dBµV)	Correction (dB)
12762	50.2	54	-3.8	11	1.70	H	36.4	13.8

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

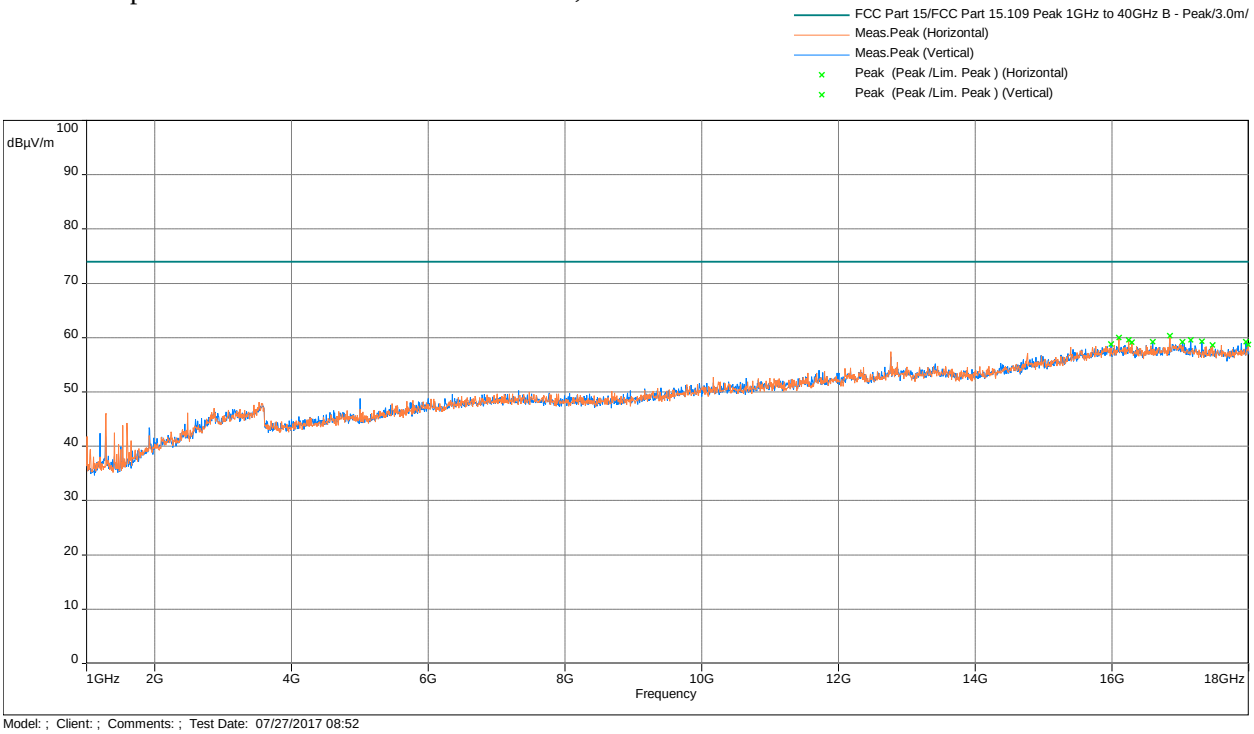
Results	Complies

Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan

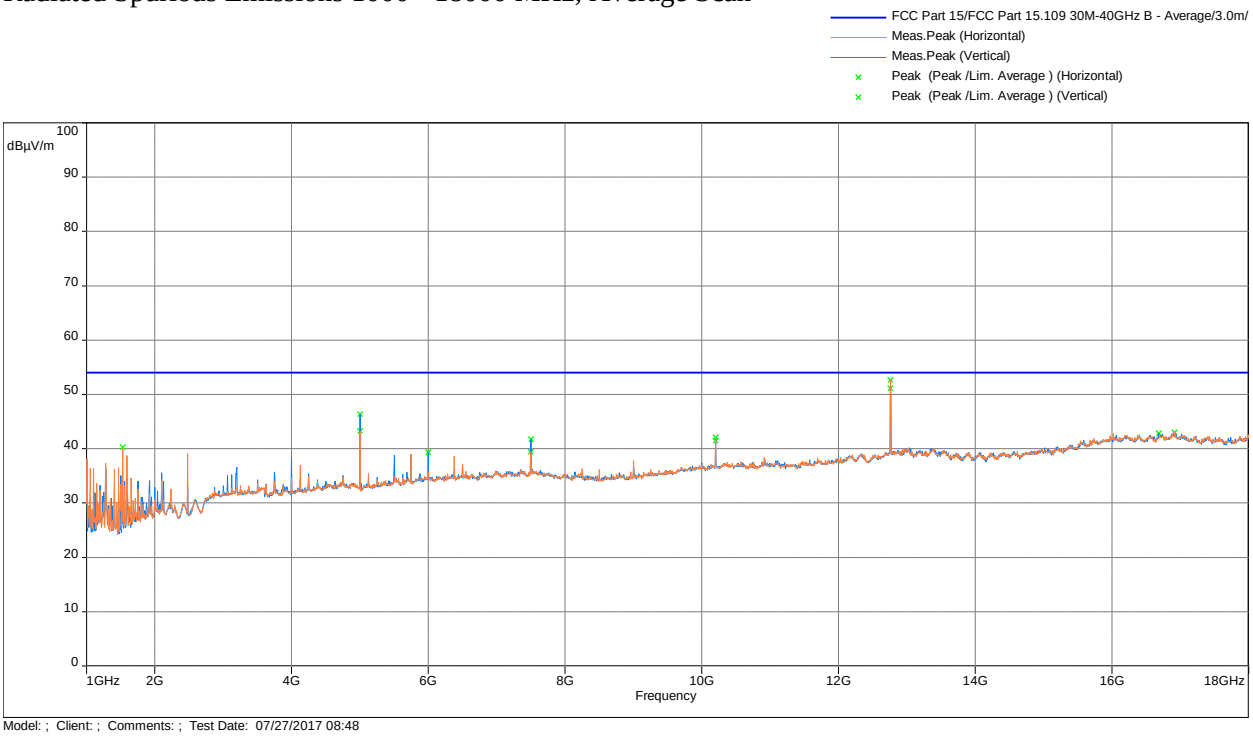


Model: ; Client: ; Comments: ; Test Date: 07/28/2017 08:32

Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:52



Model: ; Client: ; Comments: ; Test Date: 07/27/2017 08:48

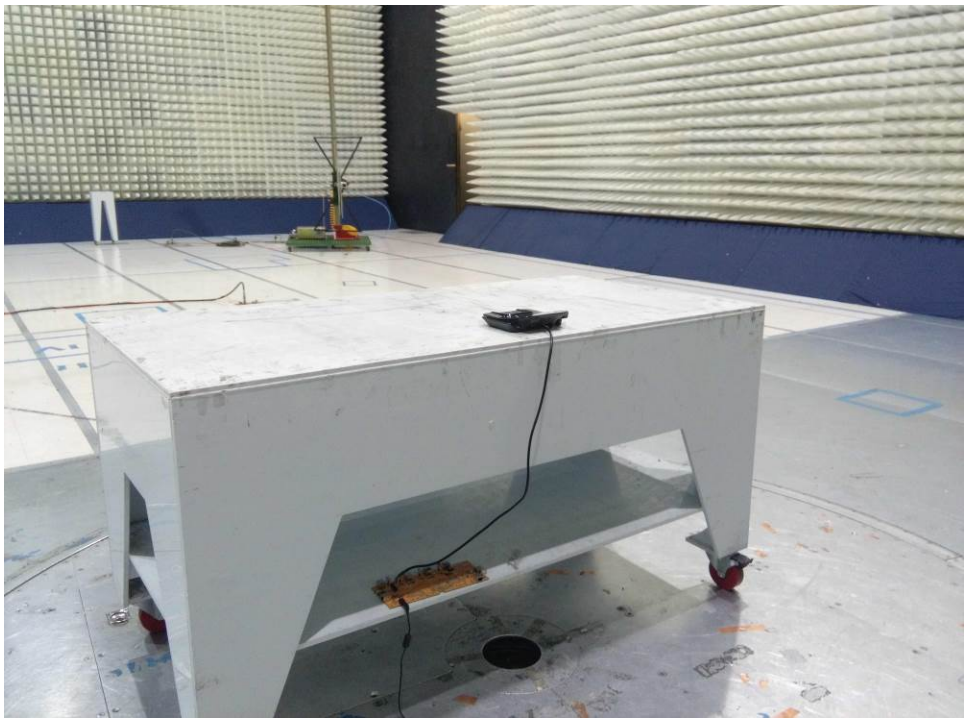
Frequency (MHz)	Avg Amplitude (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity (H/V)	Raw Avg (dBµV)	Correction (dB)
12762	50.9	54	-3.1	15	1.65	H	37.1	13.8

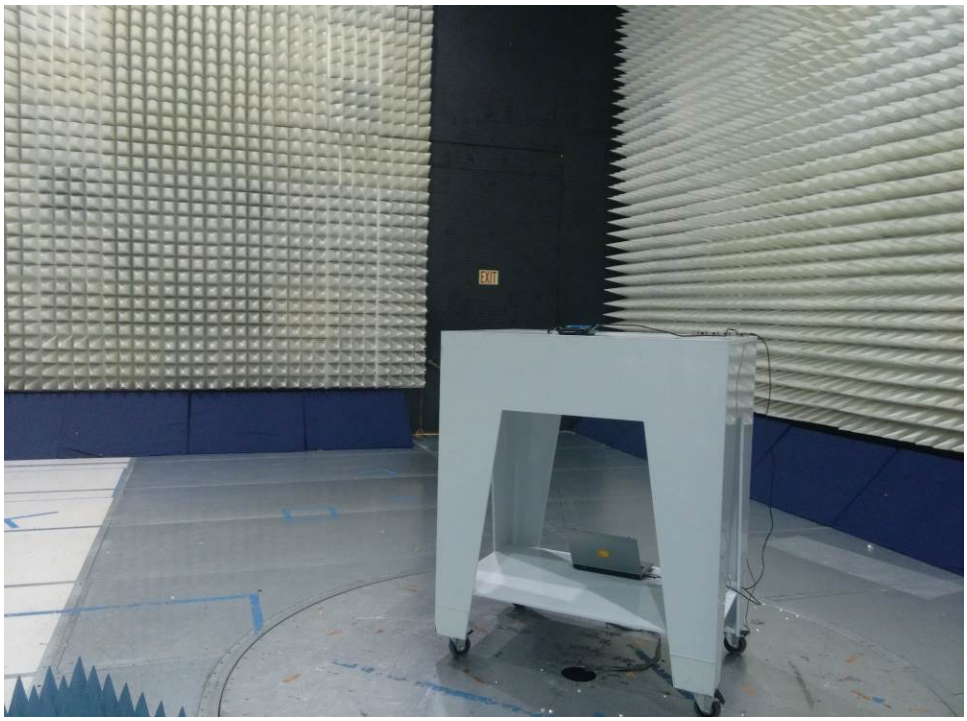
Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

Results	Complies

4.7.5 Test Setup Photographs

The following photographs show the testing configurations used.





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	01/12/18
Pyramidal Horn Antenna	EMCO	3160-09	ITS 00571	#	#
Pre-Amplifier (18-40GHz)	Miteq	TTA1840-35-S-M	ITS 01393	12	04/18/18
Pre-Amplifier (1-18GHz)	Miteq	AMF-4D-001180-24-10P	ITS 00526	12	09/29/17
Horn Antenna	ETS-Lindgren	3117	ITS 01325	12	09/07/17
EMI Receiver	Rohde and Schwarz	ESU	ITS 00961	12	07/10/18
BI-Log Antenna	Antenna Research	LPB-2513	ITS 00355	12	09/09/17
Pre-Amplifier	Sonoma Instrument	310	ITS 01493	12	09/28/17
RF Cable	TRU Corporation	TRU CORE 300	ITS 01462	12	08/19/18
Notch Filter	Micro-Tronics	BRM50702	ITS 01166	12	02/08/18
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	Mini Circuits	BW-N3W5+	ITS 01315	12	10/19/17
Notch Filter	MICRO-TRONICS	BRM50702	ITS 01166	12	12/08/18
Attenuator	Narda	FSCM99899	ITS 01583	12	08/31/18
RF Cable	Megaphase	EMC1-K1K1-236	ITS 01538	12	06/13/18
RF Cable	Megaphase	EMC1-K1K1-19	ITS 01482	12	08/25/17
RF Cable	Megaphase	TM40-K1K1-19	ITS 01154	12	01/26/18
Transient Limiter	COM-POWER	LIT-153A	ITS 01452	12	06/19/18
RF Cable	TRU Corporation	TRU CORE 300	ITS 01462	12	08/24/17
RF Cable	Megaphase	TM40-K1K1-59 RF	ITS 01156	12	01/26/18

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 Spurious_30M-26GHz
BAT-EMC	Nexio	3.16.0.64	102971715_VerifoneFHSS.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 / G102971715	AS	KV	August 09, 2017	Original document