4.6 Out-of-Band Conducted Emissions
FCC 15.247(d)

4.6.1 Requirement

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.

4.6.2 Procedure

The Procedure described in the ANSI C63.10:2013 for Frequency Hopping Spread Spectrum Systems was used to determine the Out-of-Band Conducted Emissions.

- Span = wide enough to capture the peak level of the in-band emission and all spurious
- emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the
- 10th harmonic. Typically, several plots are required to cover this entire span.
- RBW = 100 kHz
- VBW = 3 x RBW
- Sweep = auto
- Detector function = peak
- Trace = max hold

Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded. The level displayed must comply with the limit specified in this Section.

A spectrum analyzer was connected to the antenna port of the transmitter. Analyzer Resolution Bandwidth was set to 100 kHz. For each channel investigated, the in-band and out-of-band emission measurements were performed. The out-of-band emissions were measured from 30 MHz to 26 GHz.

Tested By:	Aaron Chang
Test Date:	October 19 - 20, 2017

4.6.3 Test Result

Refer to the following plots and out-of-band conducted spurious emissions at the Band-Edge, Table 4.1 & 4.2 for the test results:

Table 4.1

Radio	Channel	Frequency MHz	Description	Plot #
GFSK	0	2402	Scan 30 MHz – 26 GHz	4.1
	39	2441	Scan 30 MHz – 26 GHz	4.2
	78	2480	Scan 30 MHz – 26 GHz	4.3
π/4-DQPSK	0	2402	Scan 30 MHz – 26 GHz	4.4
	39	2441	Scan 30 MHz – 26 GHz	4.5
	78	2480	Scan 30 MHz – 26 GHz	4.6
8DPSK	0	2402	Scan 30 MHz – 26 GHz	4.7
	39	2441	Scan 30 MHz – 26 GHz	4.8
	78	2480	Scan 30 MHz – 26 GHz	4.9

Out-of-Band Conducted Spurious Emissions at the Band-Edge:

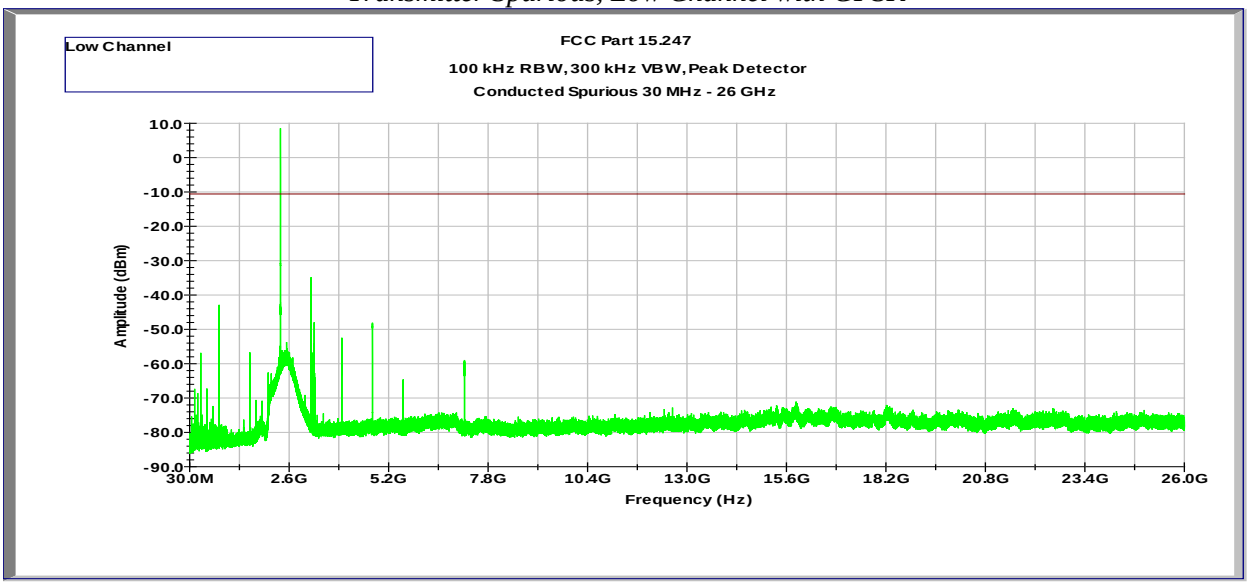
Table 4.2

Radio	Channel	Frequency MHz	Out-band emissions margin to In-band emissions	Plot #
GFSK	0	2402	Complies	4.10
	Hopping	Low Band Edge	Complies	4.11
	78	2480	Complies	4.12
	Hopping	High Band Edge	Complies	4.13
π/4-DQPSK	0	2402	Complies	4.14
	Hopping	Low Band Edge	Complies	4.15
	78	2480	Complies	4.16
	Hopping	High Band Edge	Complies	4.17
8DPSK	0	2402	Complies	4.18
	Hopping	Low Band Edge	Complies	4.19
	78	2480	Complies	4.20
	Hopping	High Band Edge	Complies	4.21

Results	**Complies**

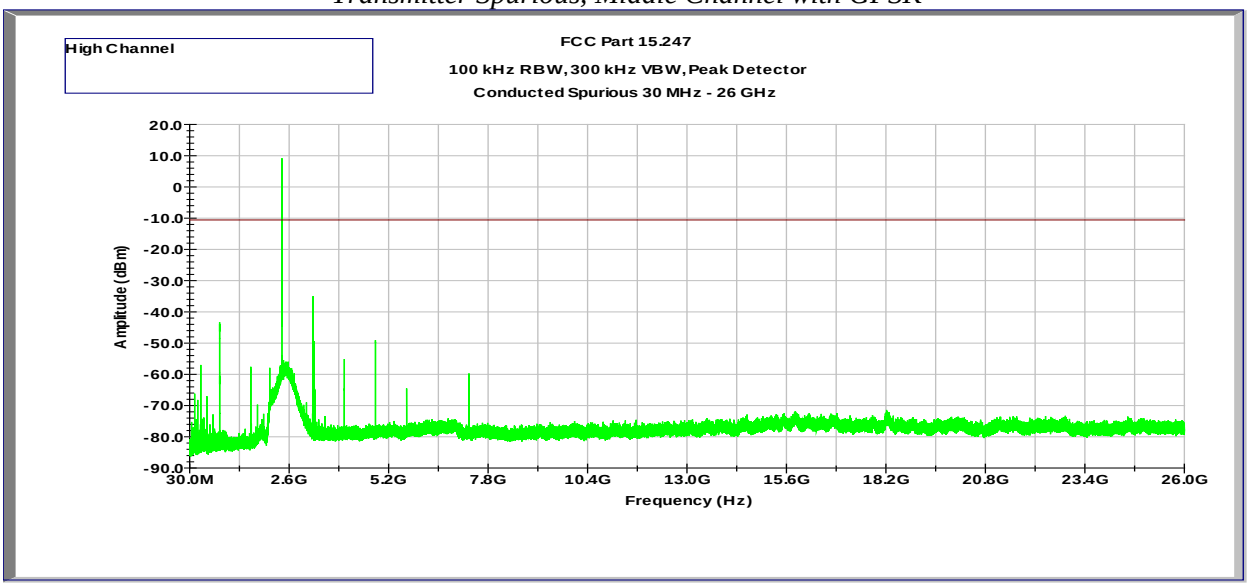
Plot 4.1

Transmitter Spurious, Low Channel with GFSK



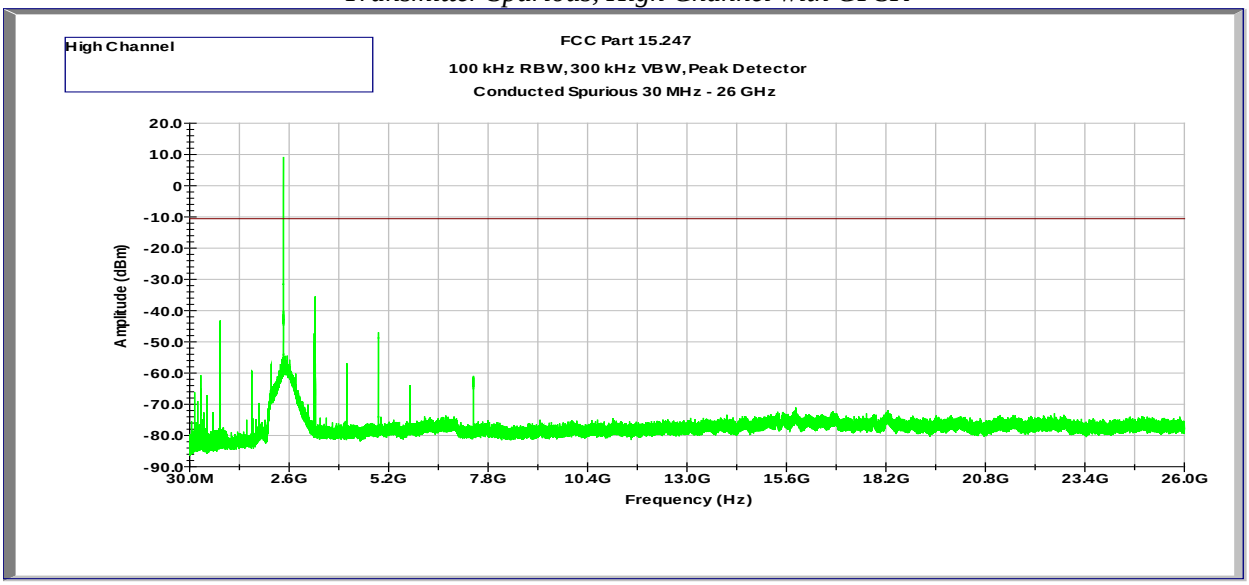
Plot 4.2

Transmitter Spurious, Middle Channel with GFSK



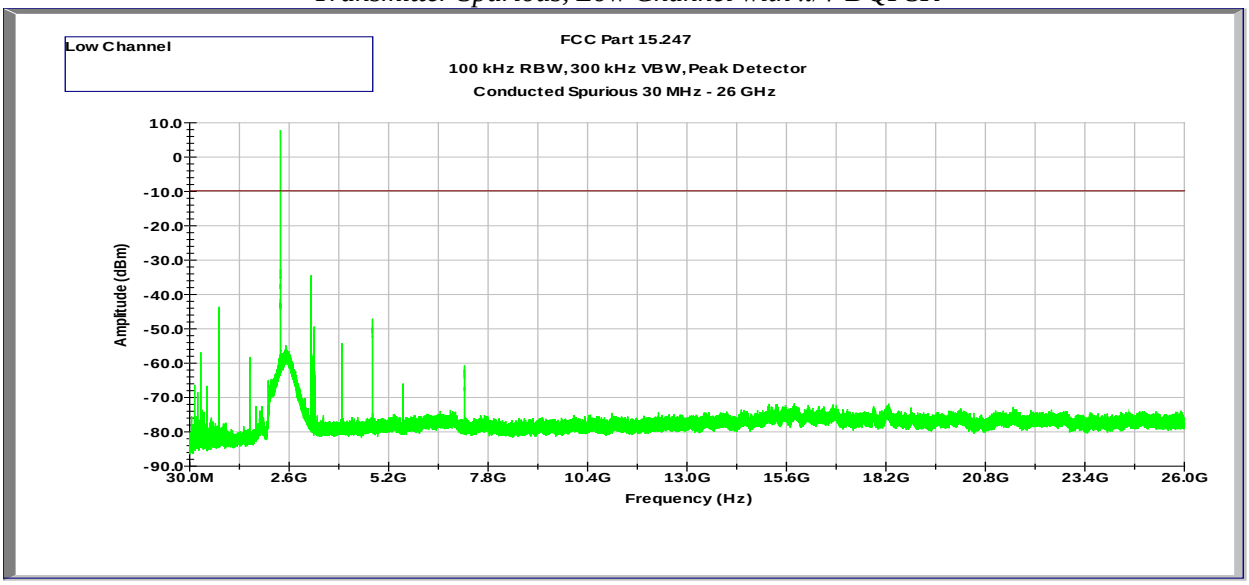
Plot 4.3

Transmitter Spurious, High Channel with GFSK



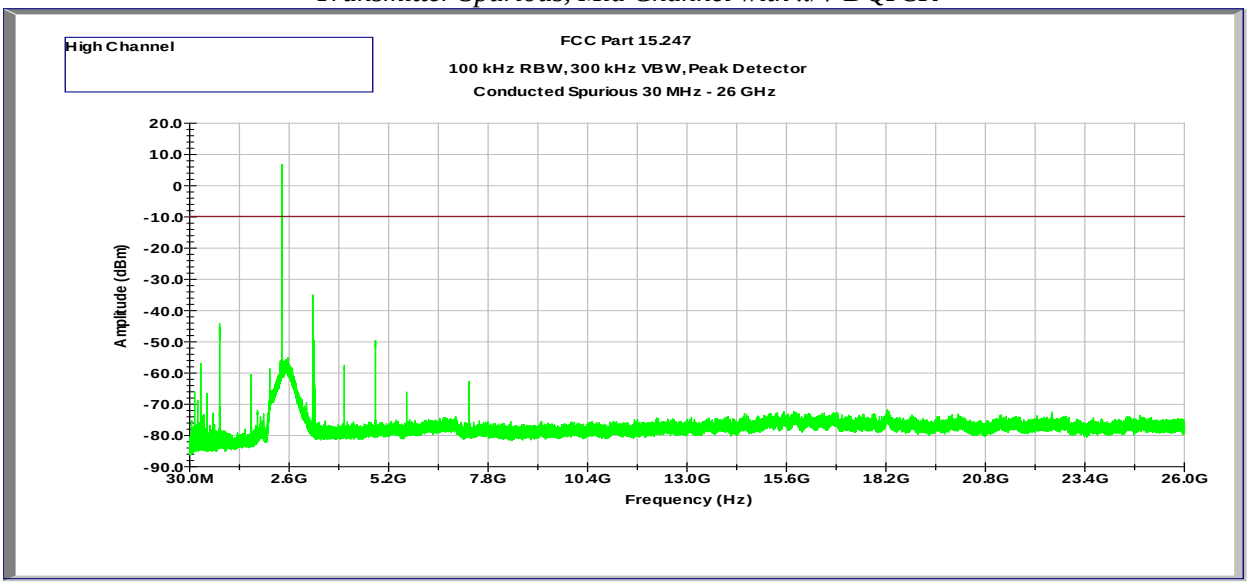
Plot 4.4

Transmitter Spurious, Low Channel with π/4-DQPSK



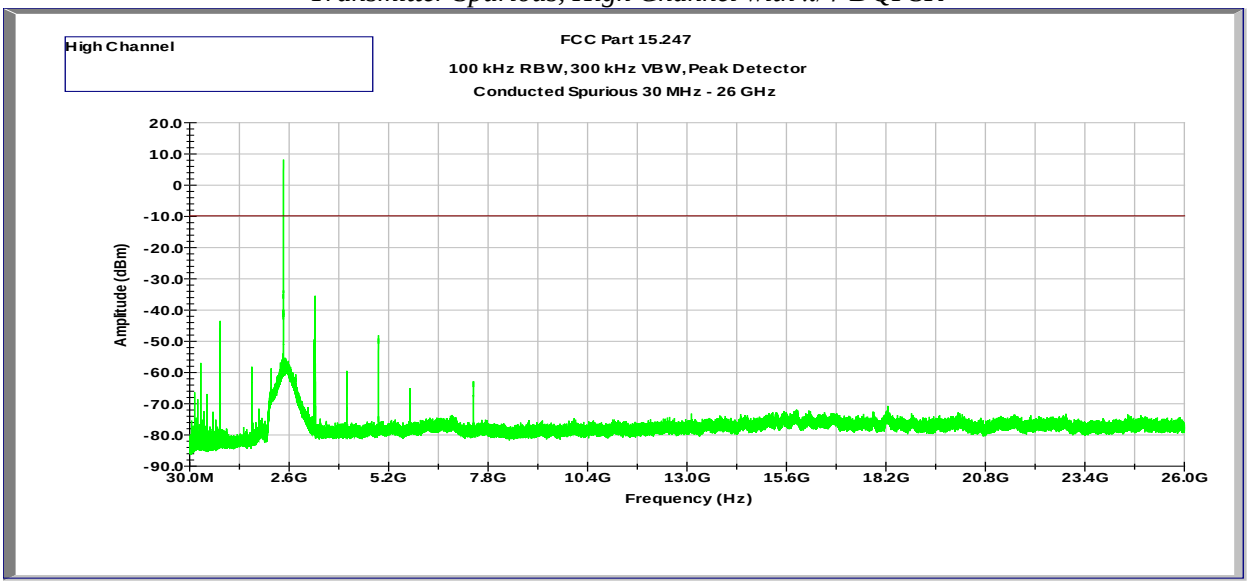
Plot 4.5

Transmitter Spurious, Mid Channel with π/4-DQPSK



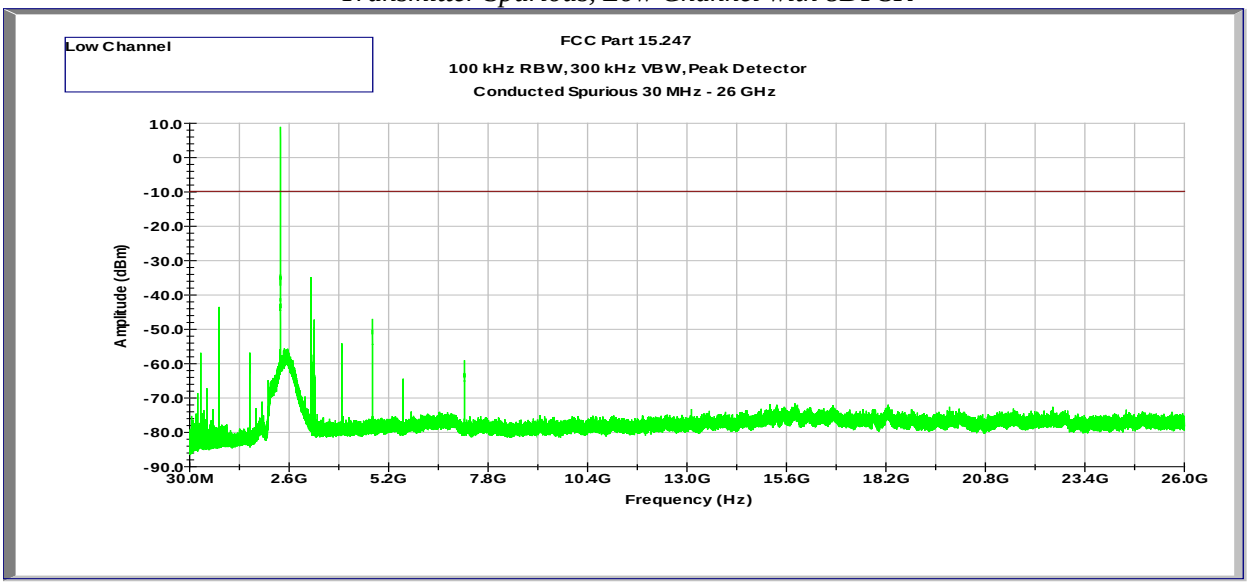
Plot 4.6

Transmitter Spurious, High Channel with π/4-DQPSK



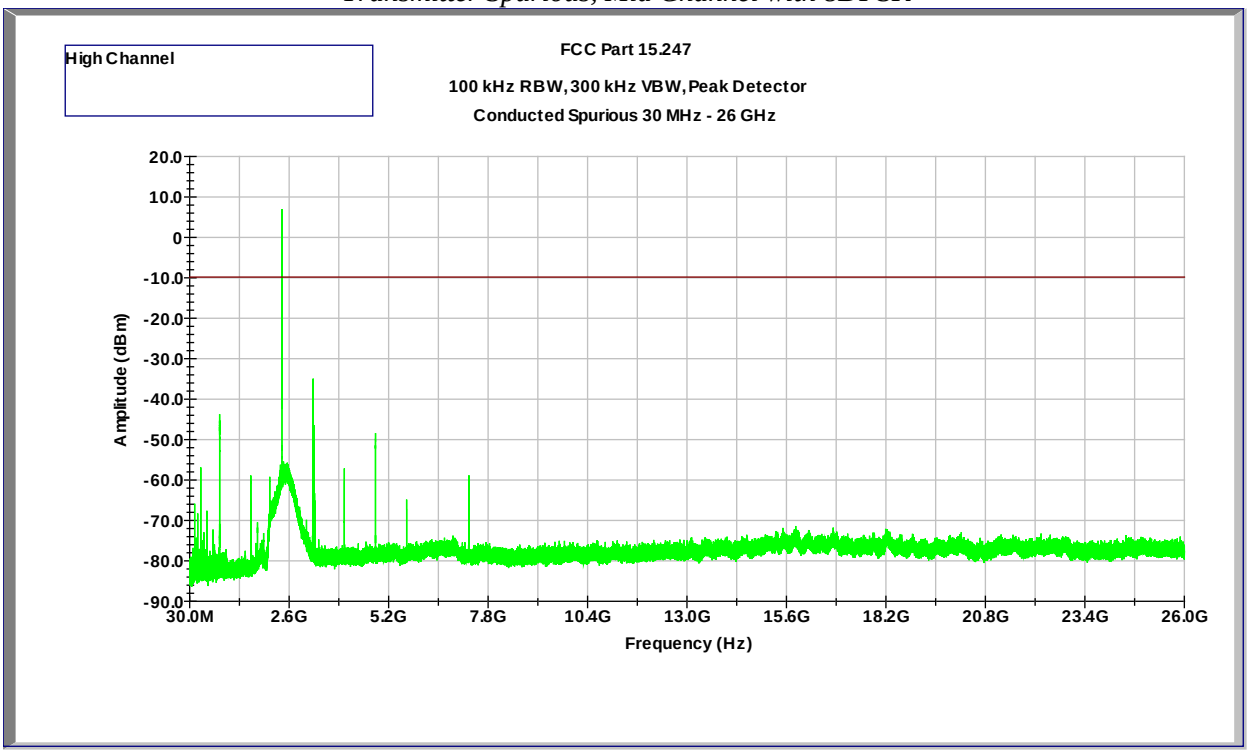
Plot 4.7

Transmitter Spurious, Low Channel with 8DPSK



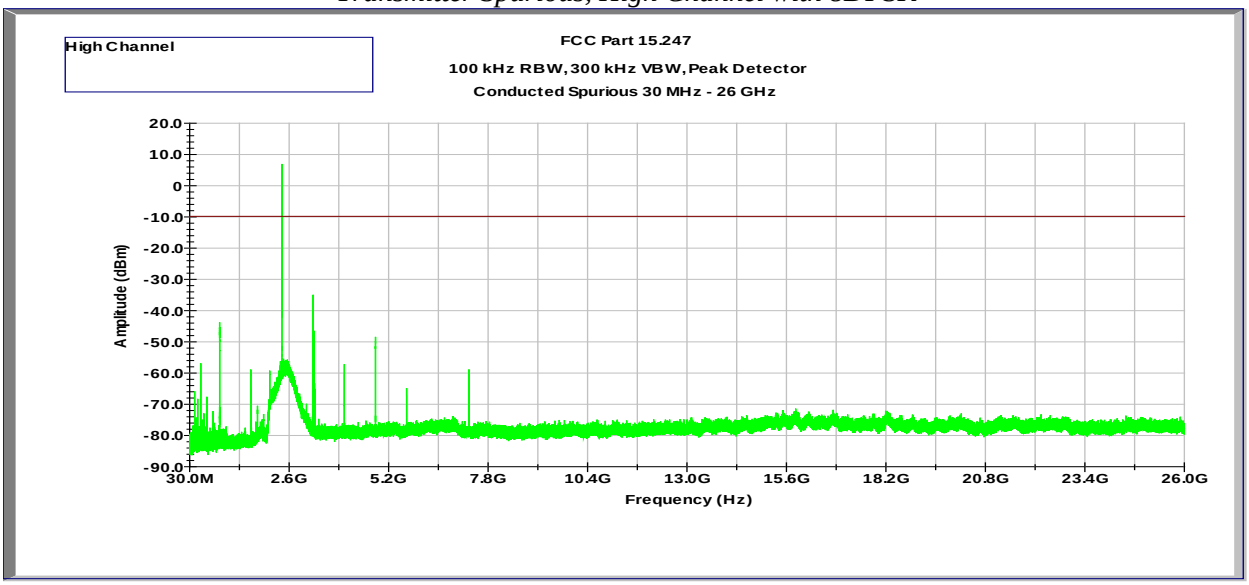
Plot 4.8

Transmitter Spurious, Mid Channel with 8DPSK

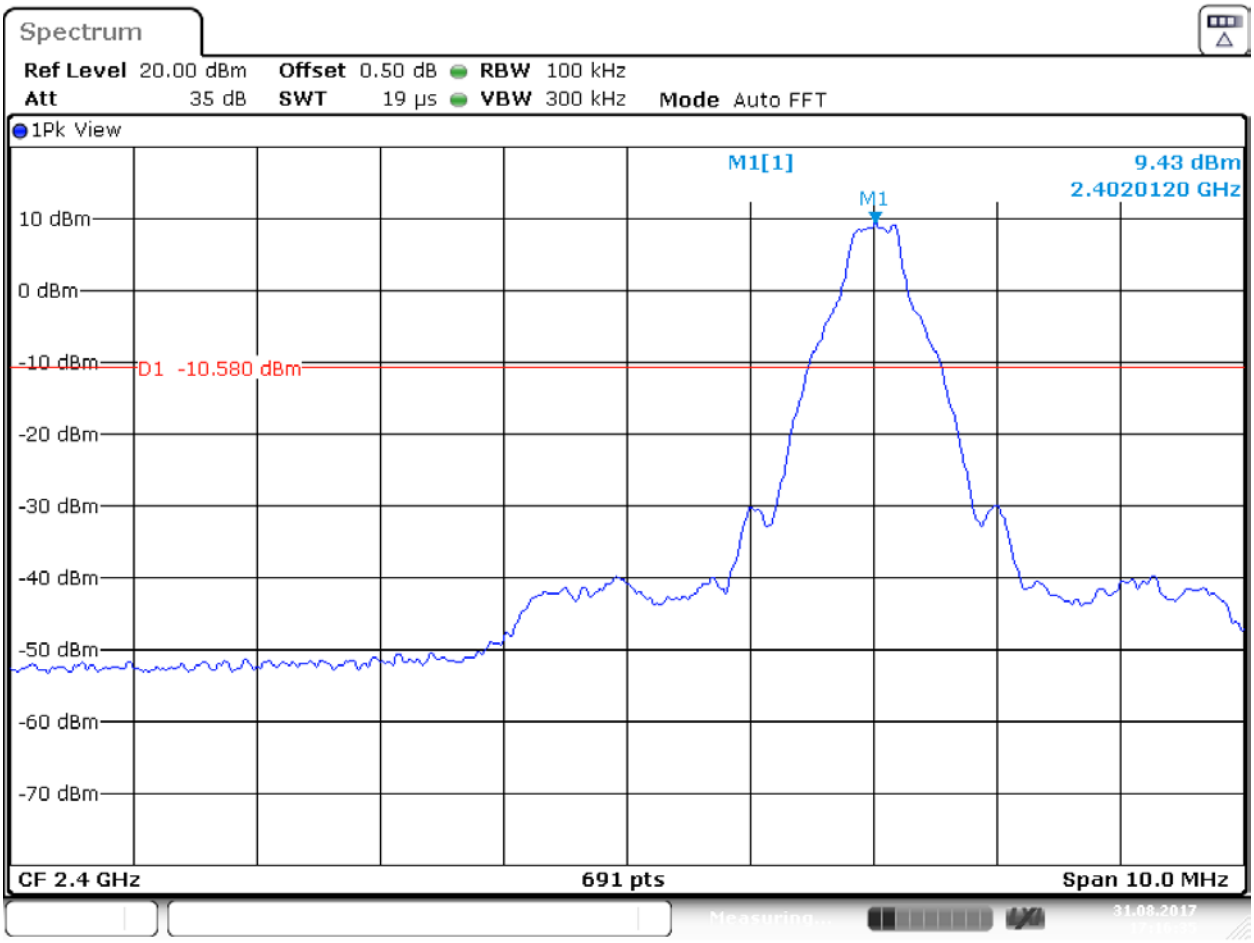


Plot 4.9

Transmitter Spurious, High Channel with 8DPSK

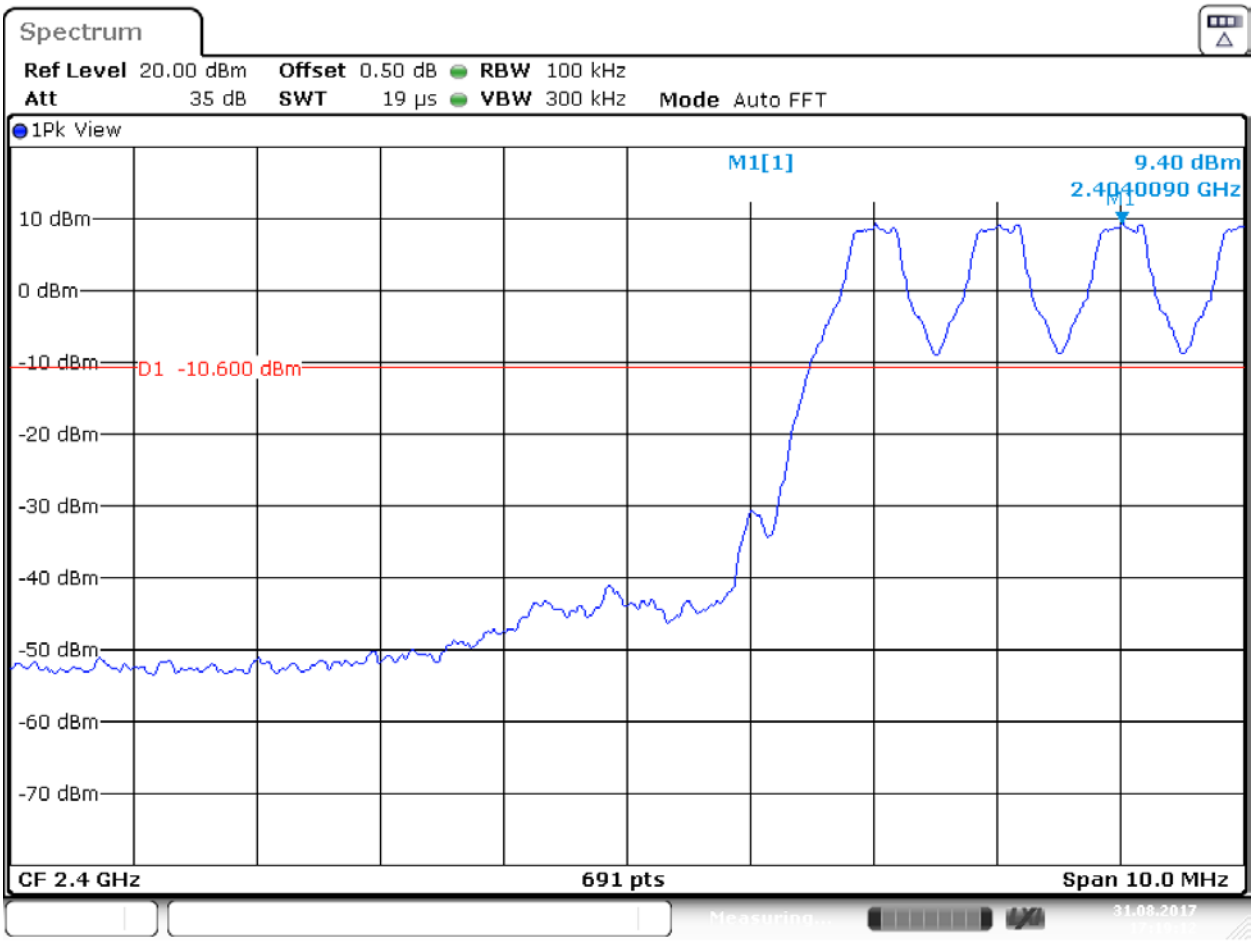


Plot 4.10
Conducted Band Edge, Low Channel with GFSK



Date: 31.AUG.2017 17:16:36

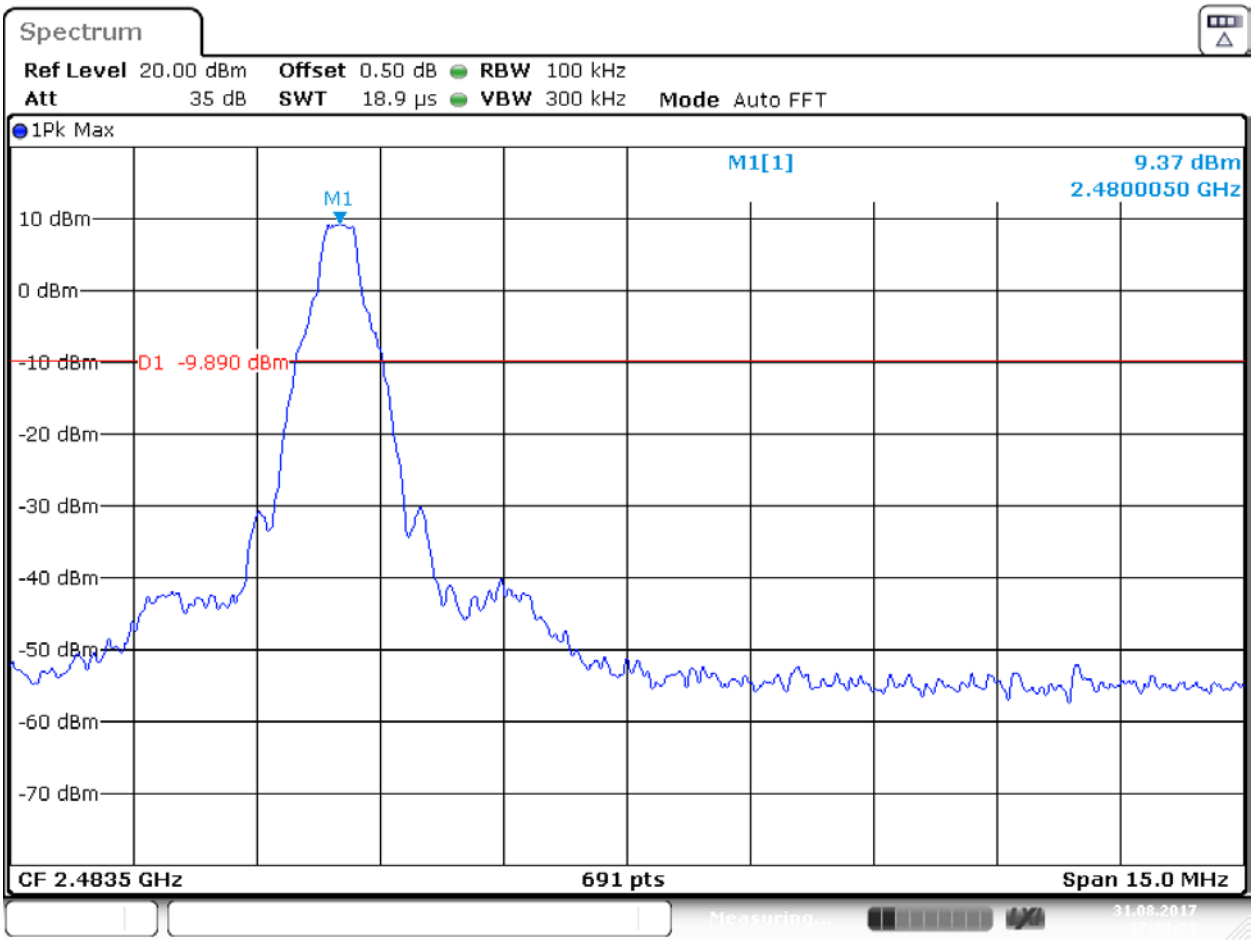
Plot 4.11
Conducted Band Edge, with GFSK (Hopping)



Date: 31.AUG.2017 17:19:12

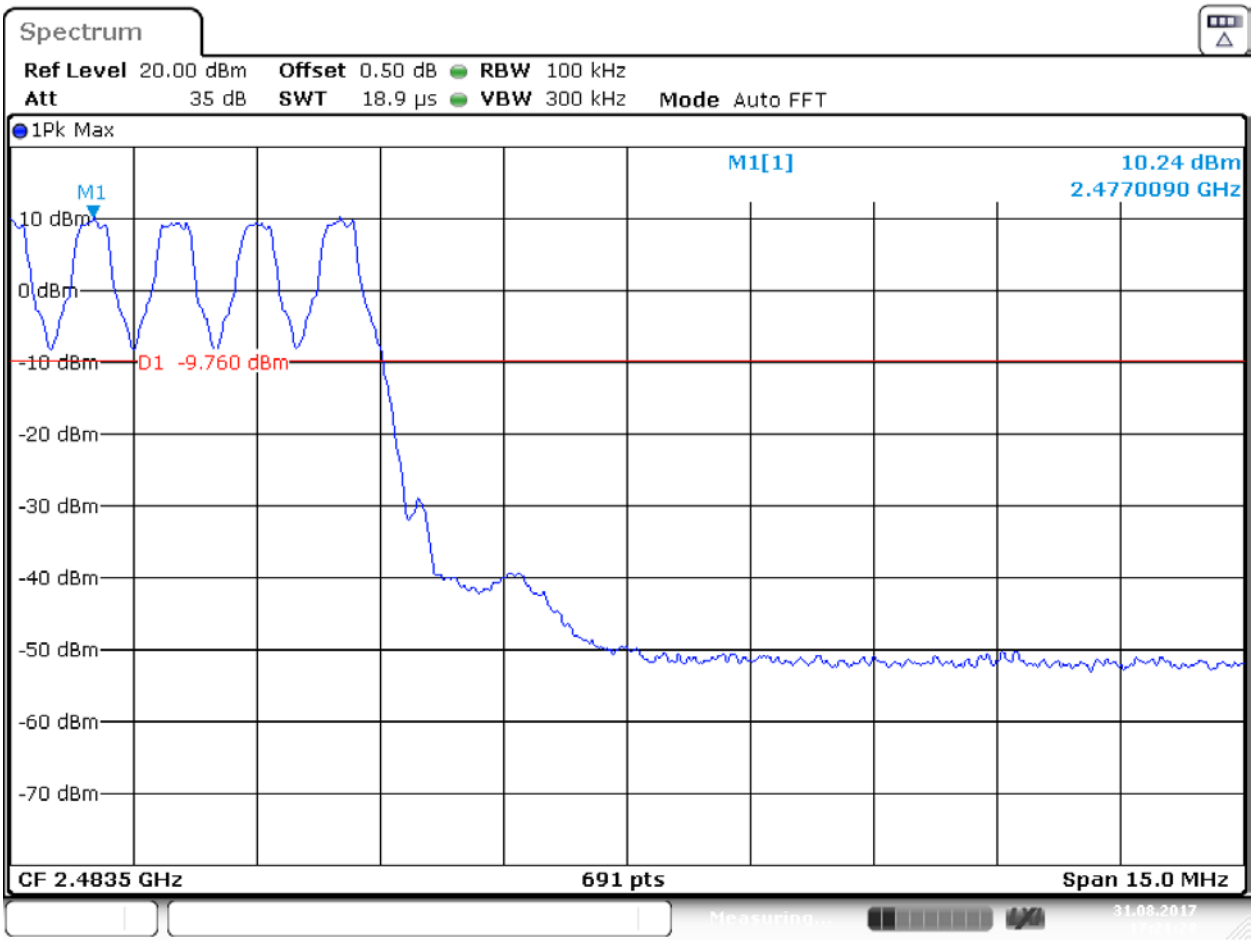
Plot 4.12

Conducted Band Edge, High Channel with GFSK



Date: 31.AUG.2017 17:20:29

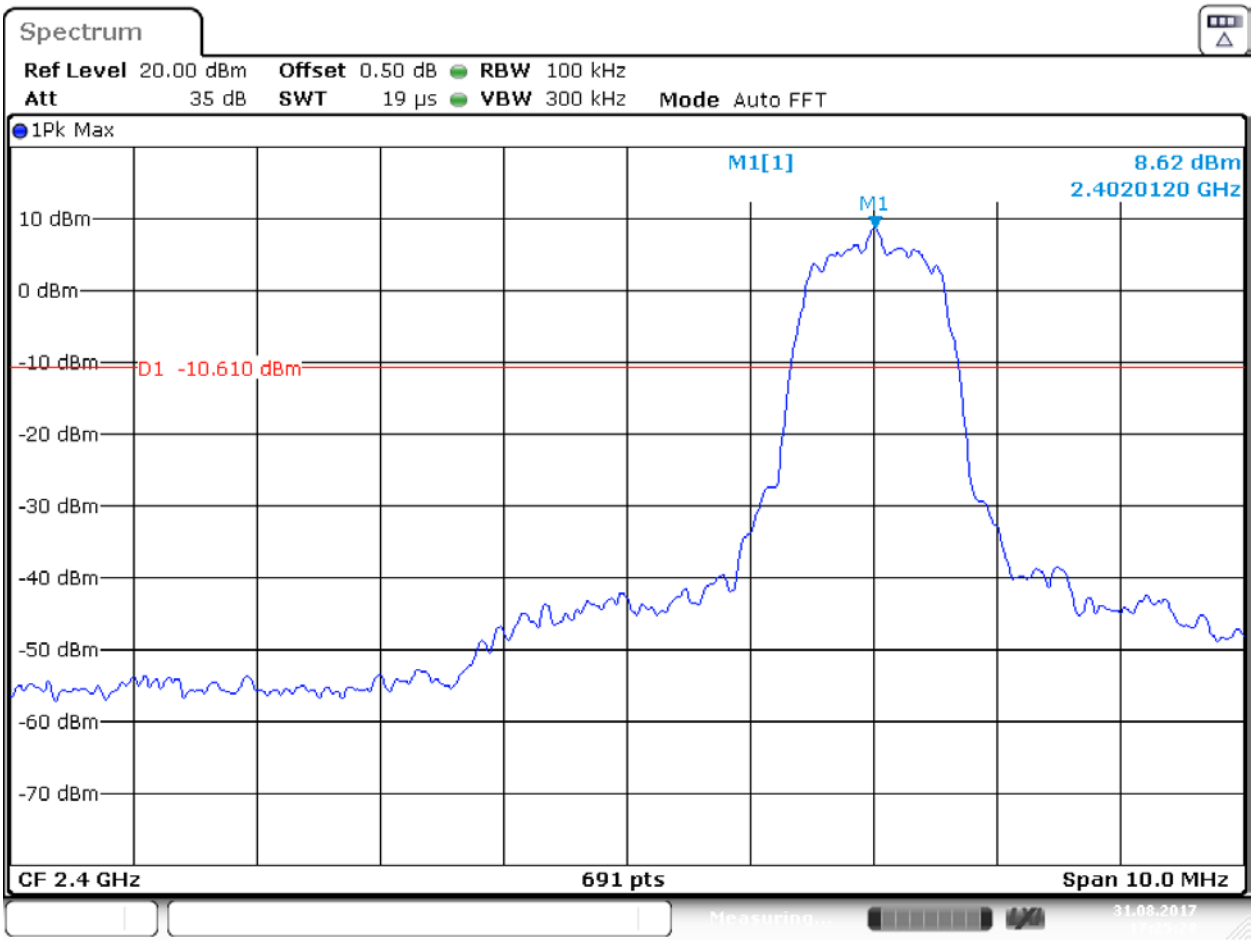
Plot 4.13
Conducted Band Edge, with GFSK (Hopping)



Date: 31.AUG.2017 17:21:29

Plot 4.14

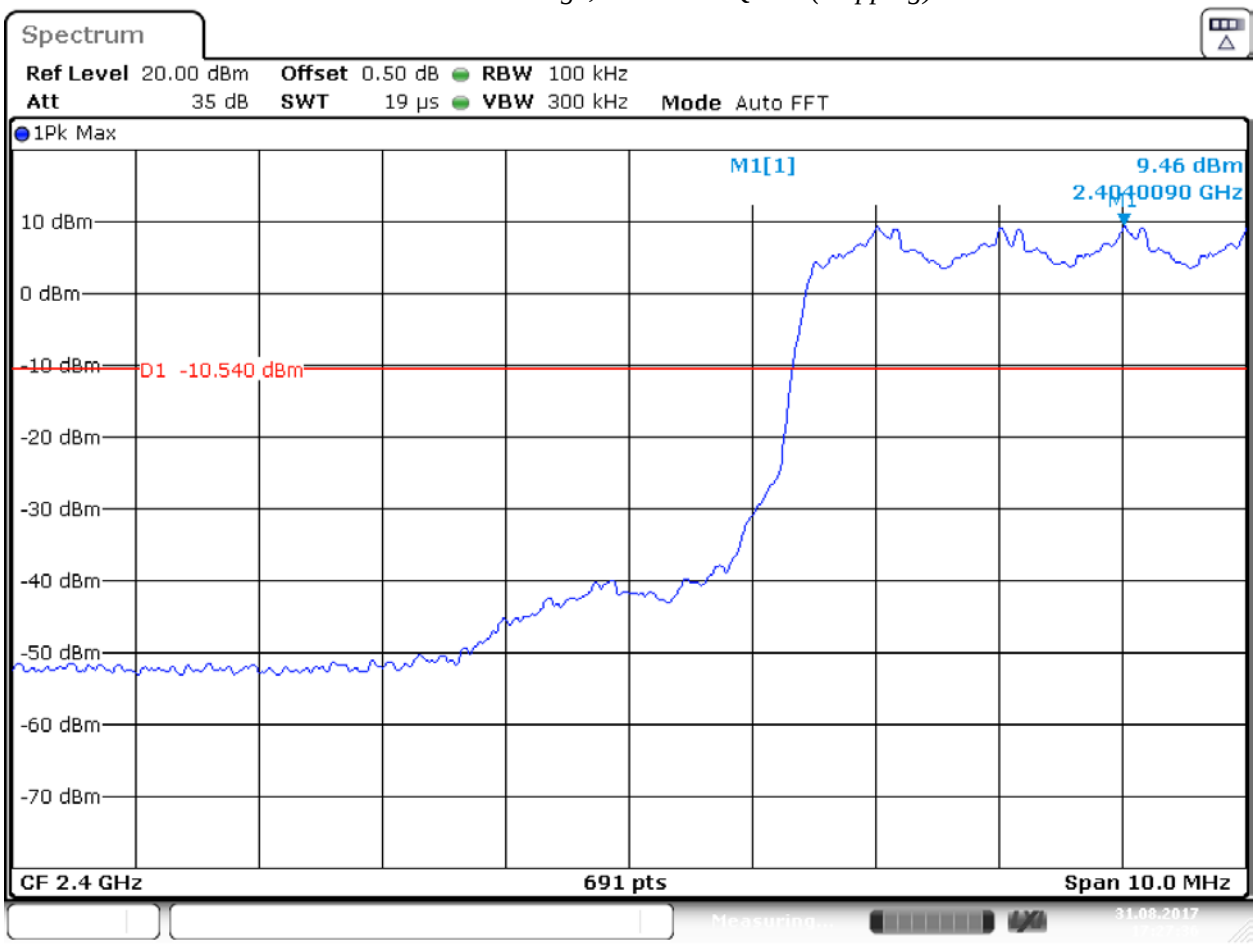
Conducted Band Edge, Low Channel with π/4-DQPSK



Date: 31.AUG.2017 17:25:28

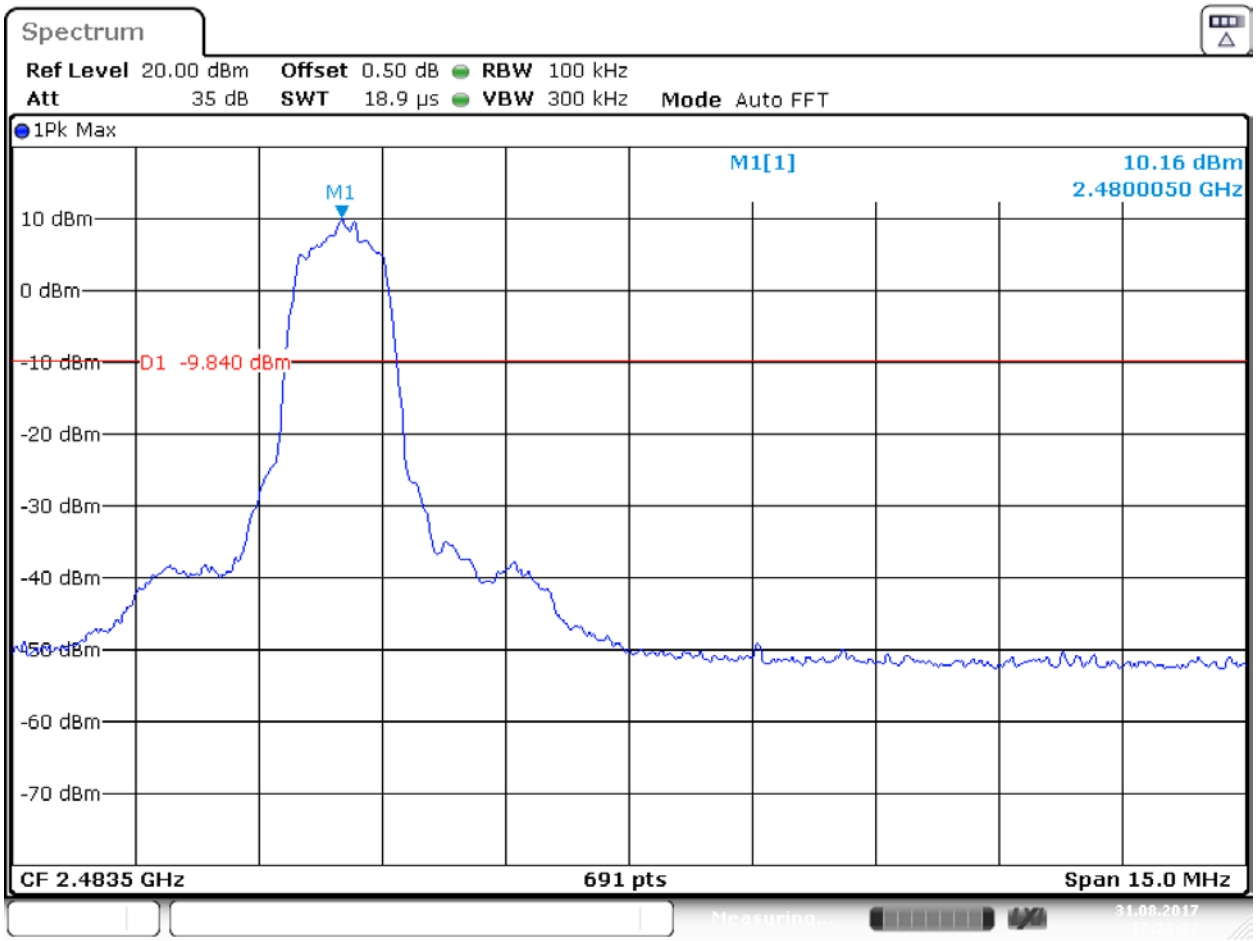
Plot 4.15

Conducted Band Edge, with π/4-DQPSK (Hopping)



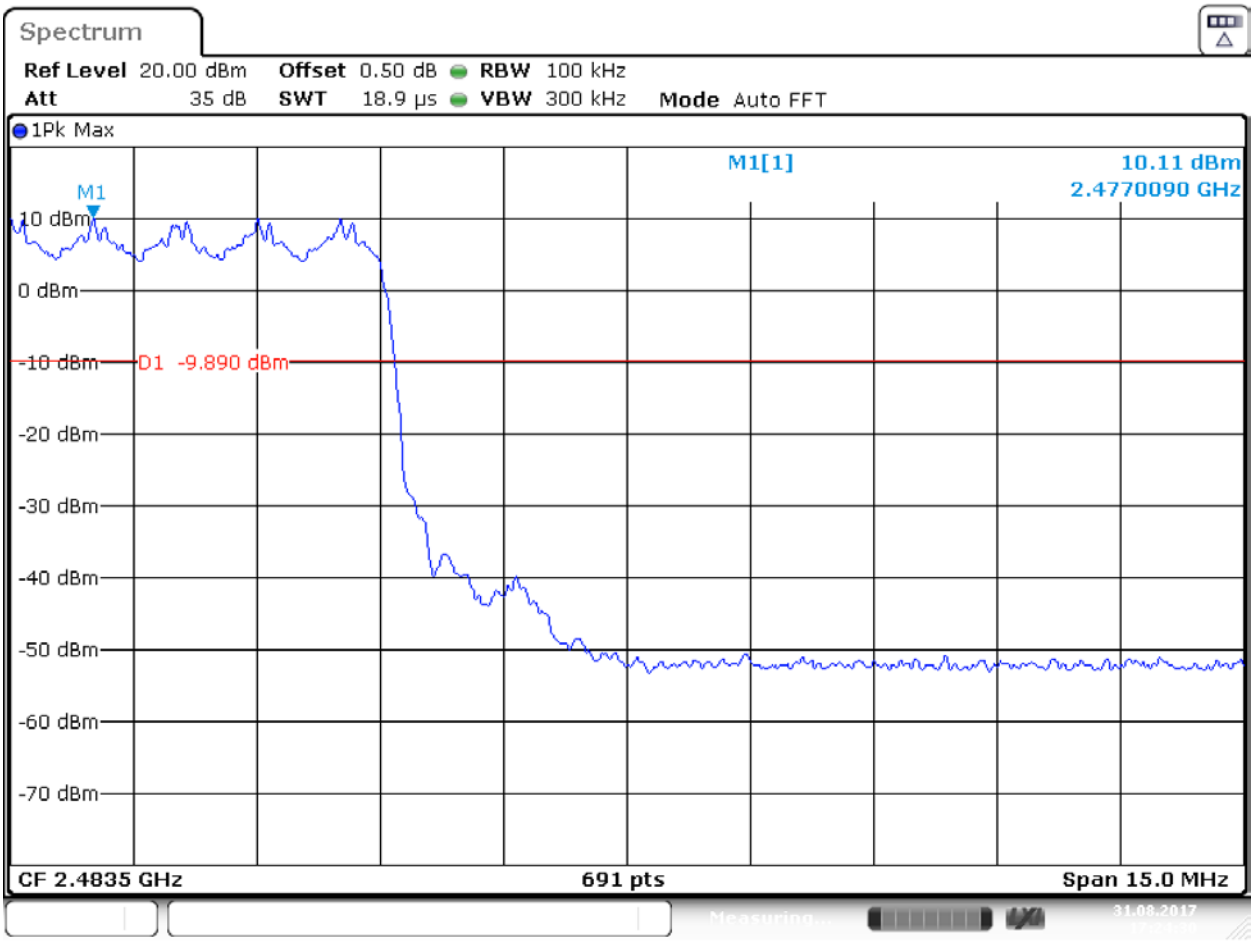
Date: 31.AUG.2017 17:27:37

Plot 4.16
Conducted Band Edge, High Channel with π/4-DQPSK



Date: 31.AUG.2017 17:23:12

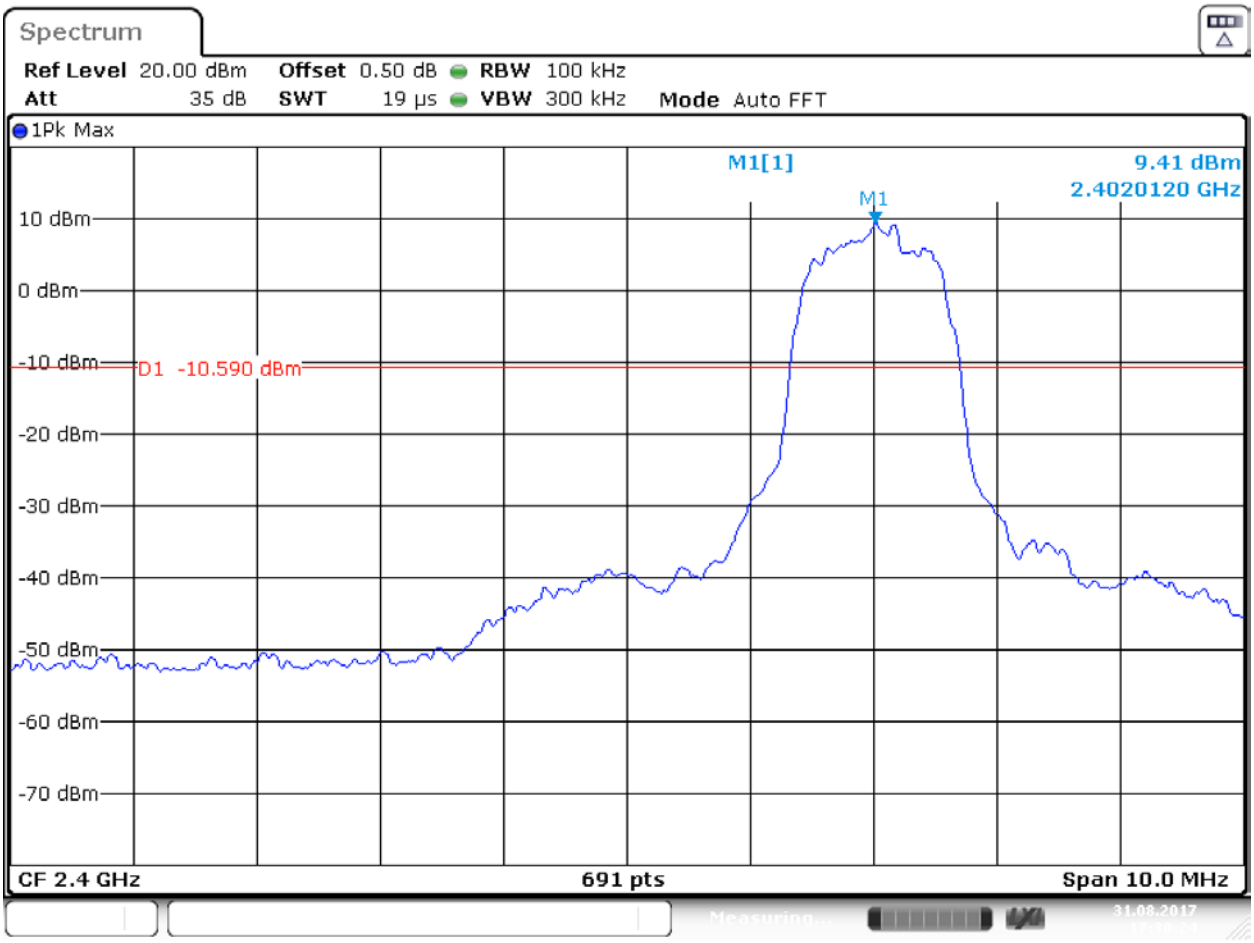
Plot 4.17
Conducted Band Edge, with π/4-DQPSK (Hopping)



Date: 31.AUG.2017 17:24:30

Plot 4.18

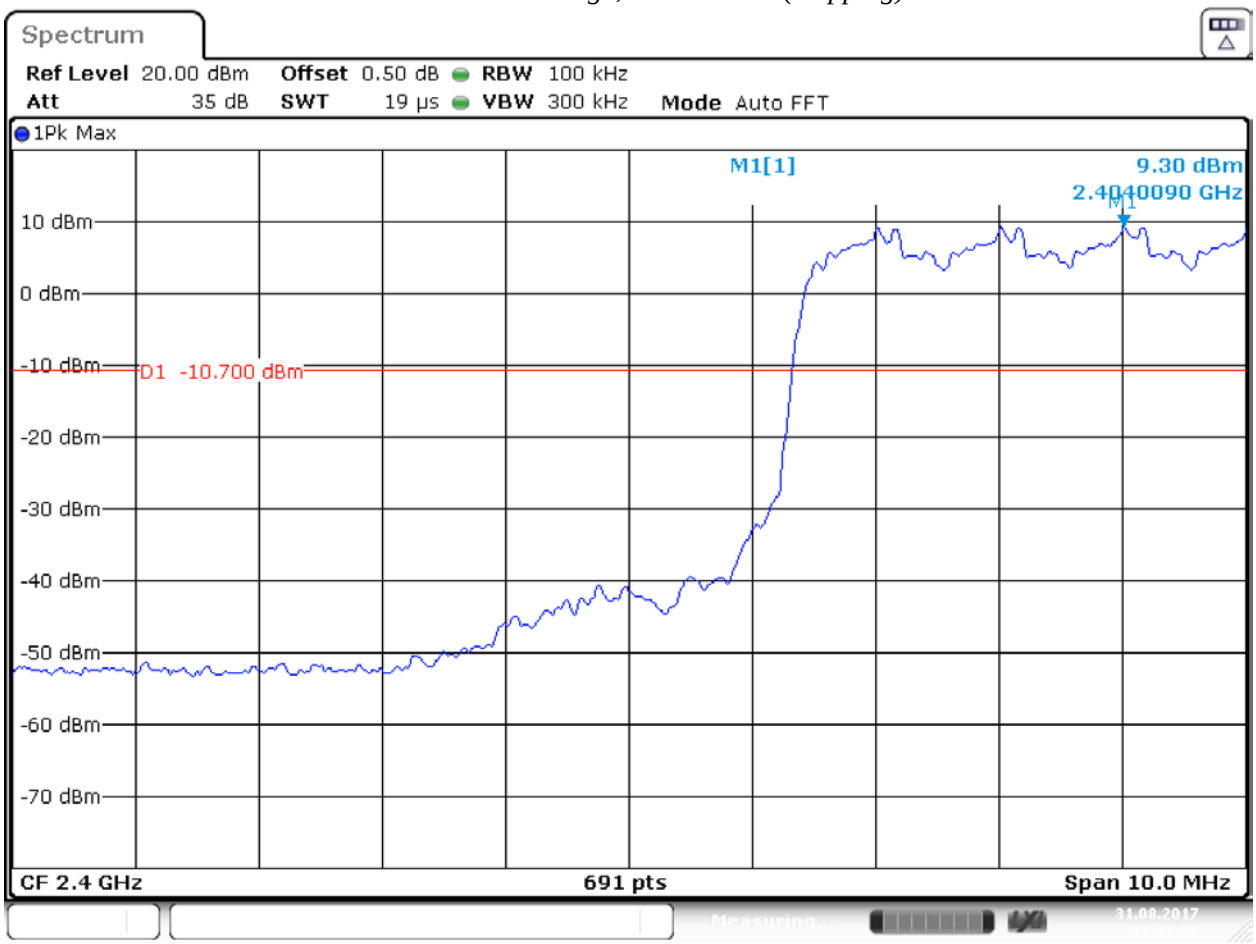
Conducted Band Edge, Low Channel with 8DPSK



Date: 31.AUG.2017 17:30:24

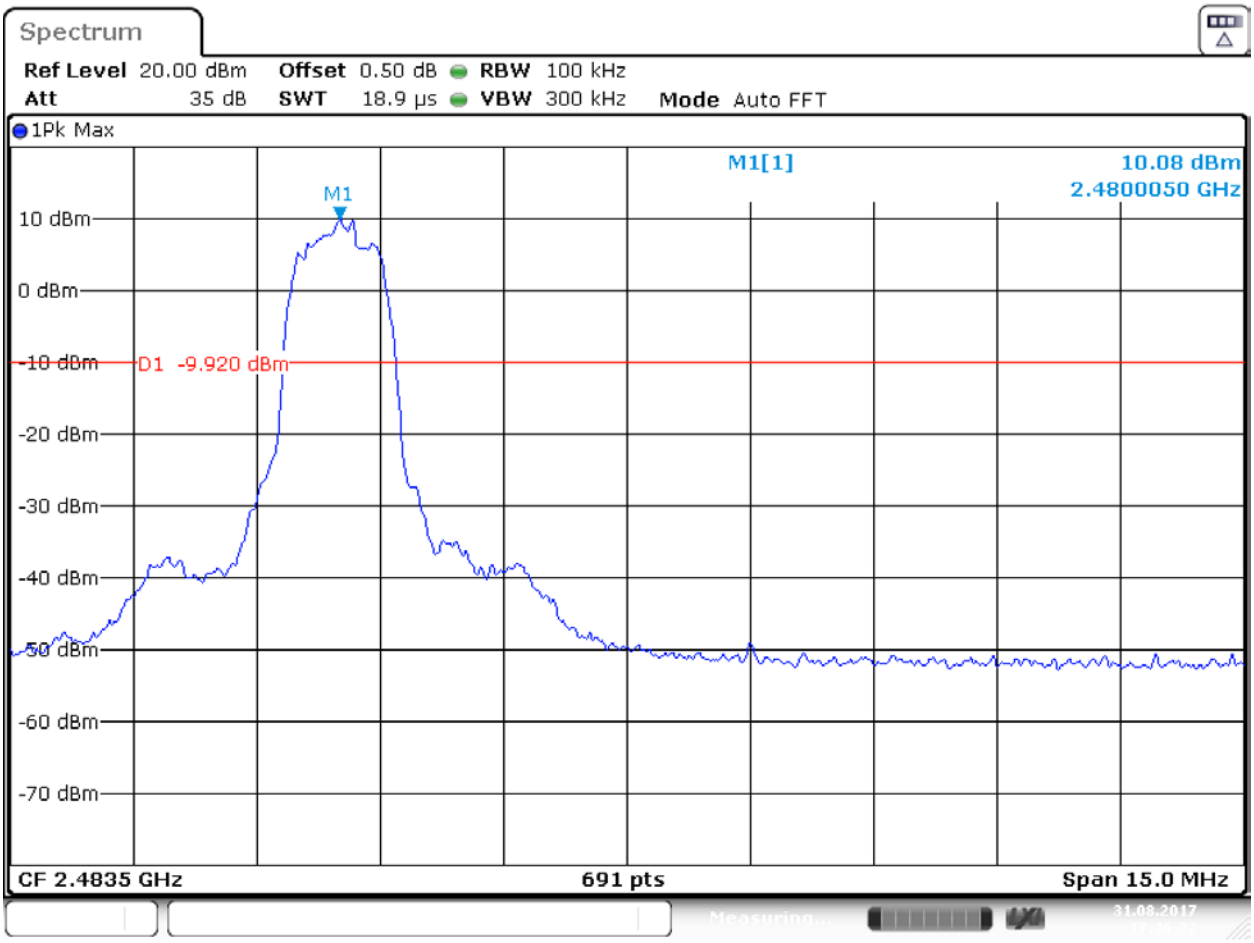
Plot 4.19

Conducted Band Edge, with 8DPSK (Hopping)



Date: 31.AUG.2017 17:41:38

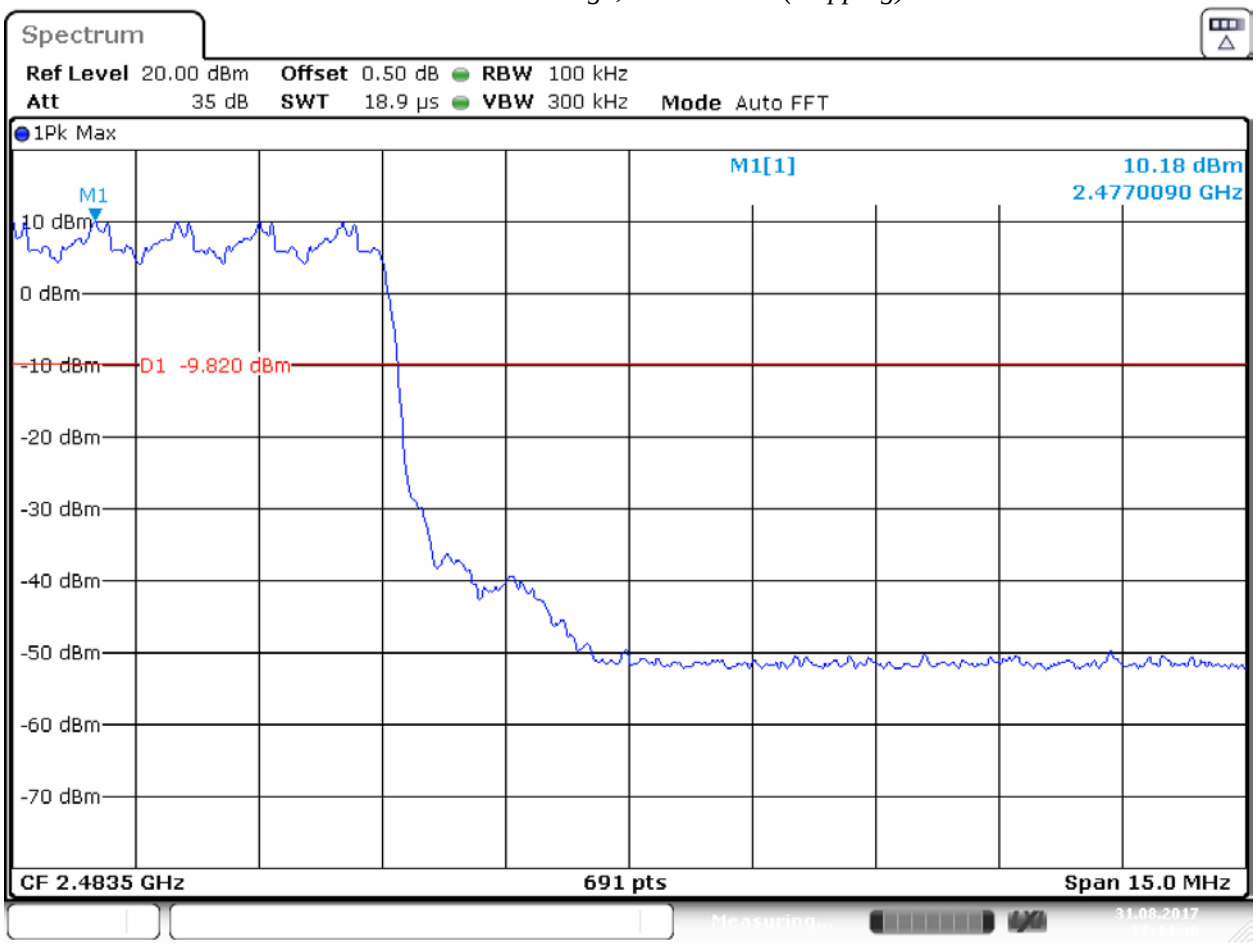
Plot 4.20
Conducted Band Edge, High Channel with 8DPSK



Date: 31.AUG.2017 17:46:22

Plot 4.21

Conducted Band Edge, with 8DPSK (Hopping)



Date: 31.AUG.2017 17:44:46

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.

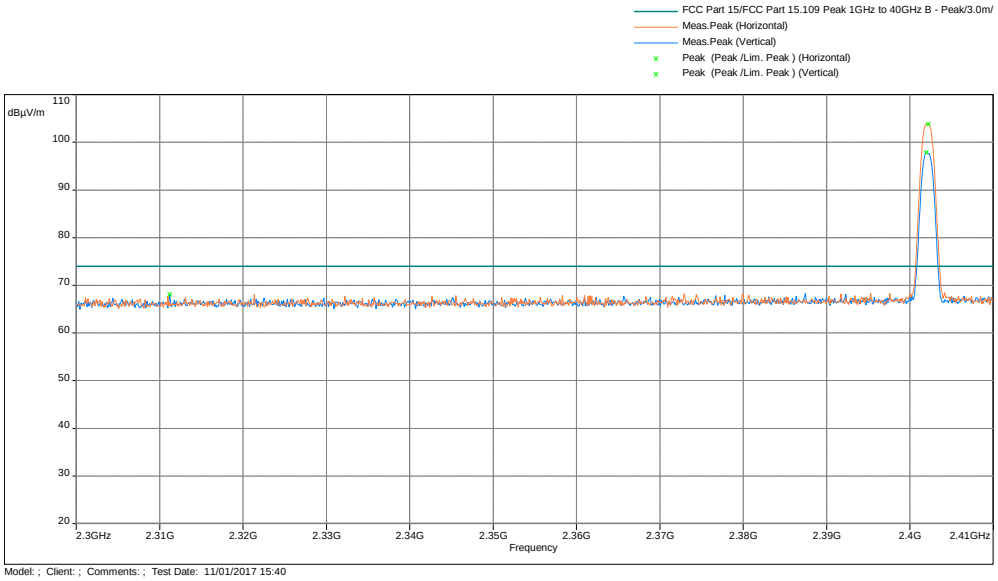
All radiated measurements were conducted with the AC adapter and Battery mode. The worst case data was reported.

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

Tested By:	Aaron Chang
Test Date:	October 2 – 24 & November 1, 2017

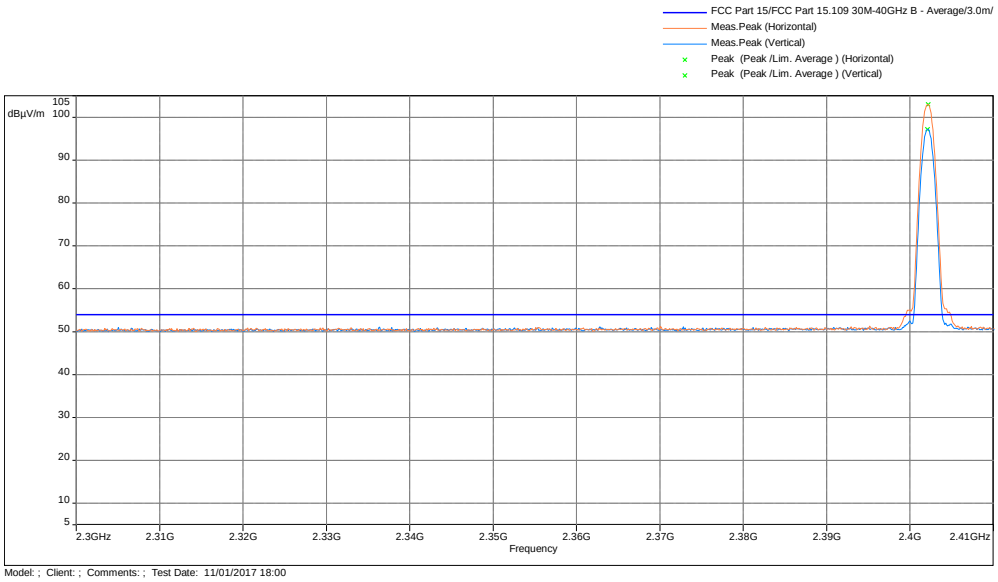
4.7.4 Test Results: 15.209/15.205 Restricted Band Emissions with Internal Antenna

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



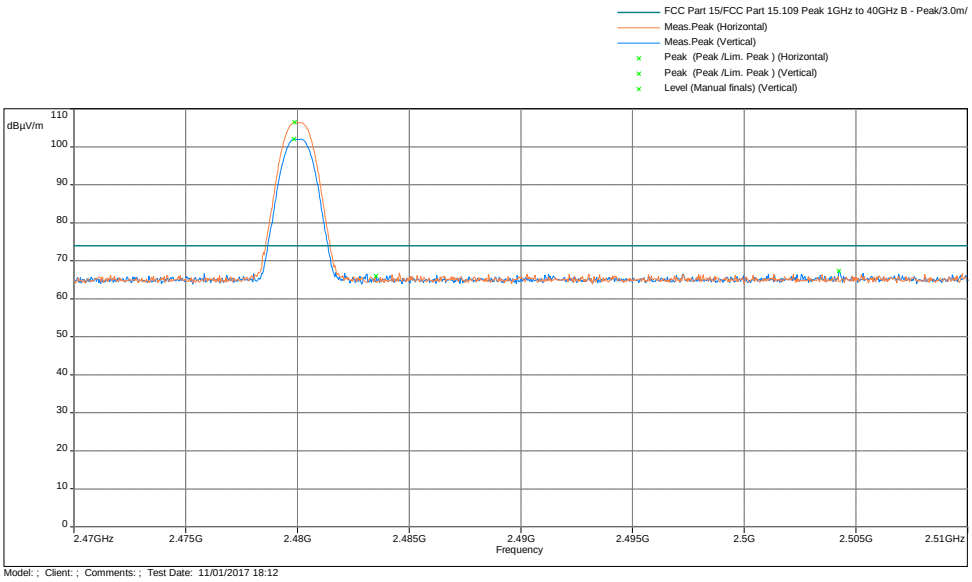
Radiated Band Edge measurements made were made from 2300- 2410 MHz

Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
GFSK	Peak	0	2402	67.4	74	-6.4	Pass



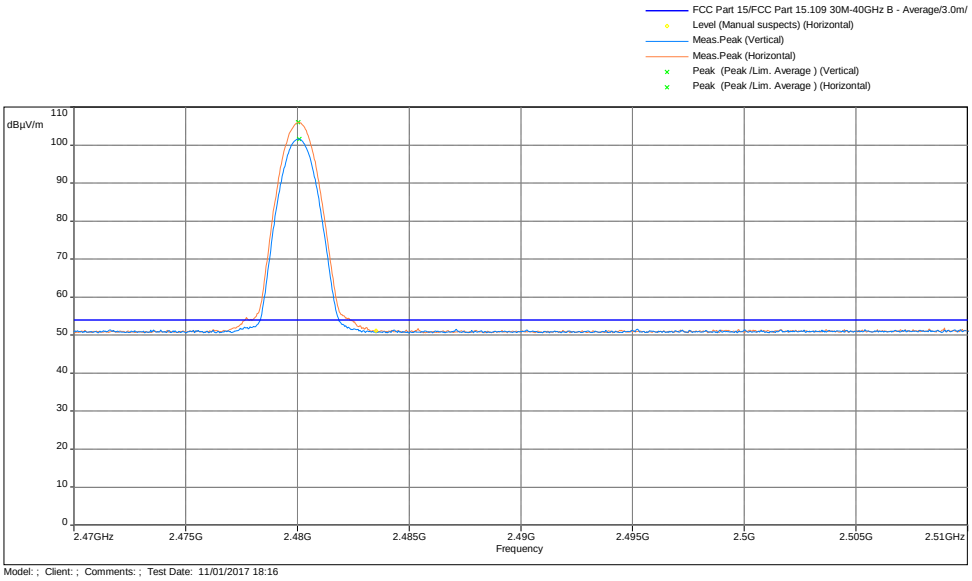
Radiated Band Edge measurements made were made from 2300- 2410 MHz

Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Ave Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
GFSK	Avg	0	2402	50.2	54	-3.8	Pass



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

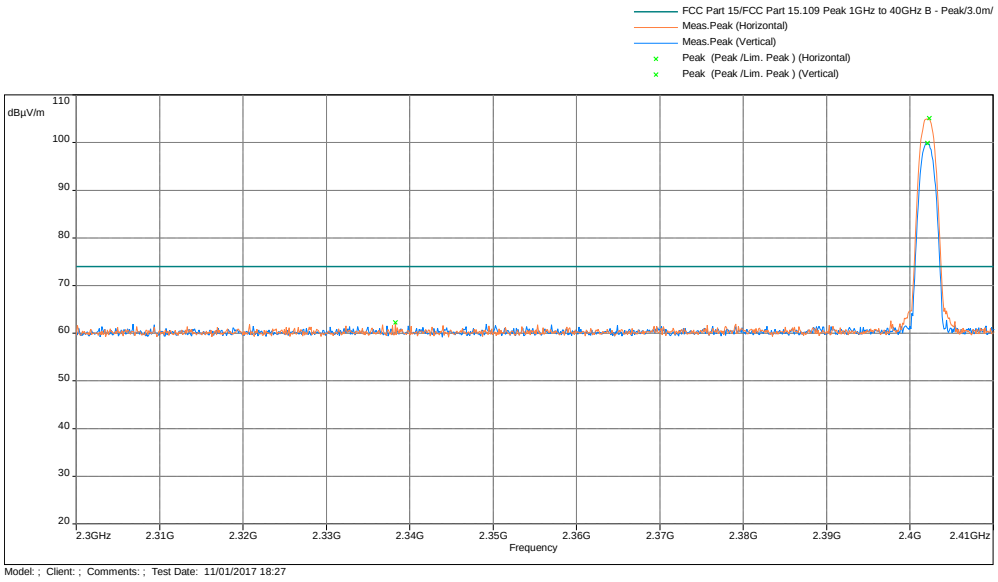
Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
GFSK	Peak	78	2480	66.0	74	-8.0	Pass



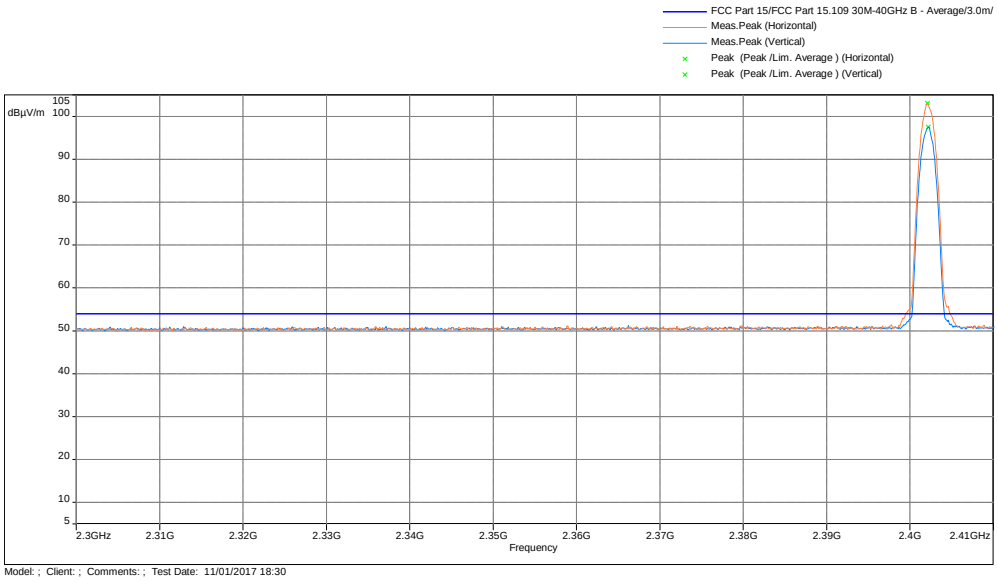
Radiated Band Edge measurements made were made from 2470 – 2510 MHz

Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Avg Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
GFSK	Avg	78	2480	51.3	54	-2.7	Pass

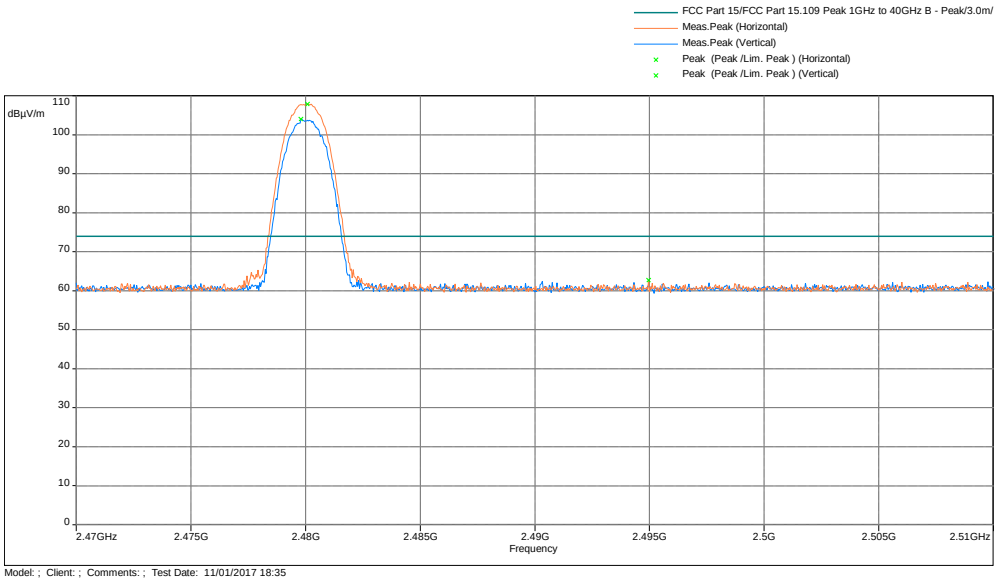
π/4-DQPSK Modulation for Out-of-Band Spurious Emissions at the Band Edge



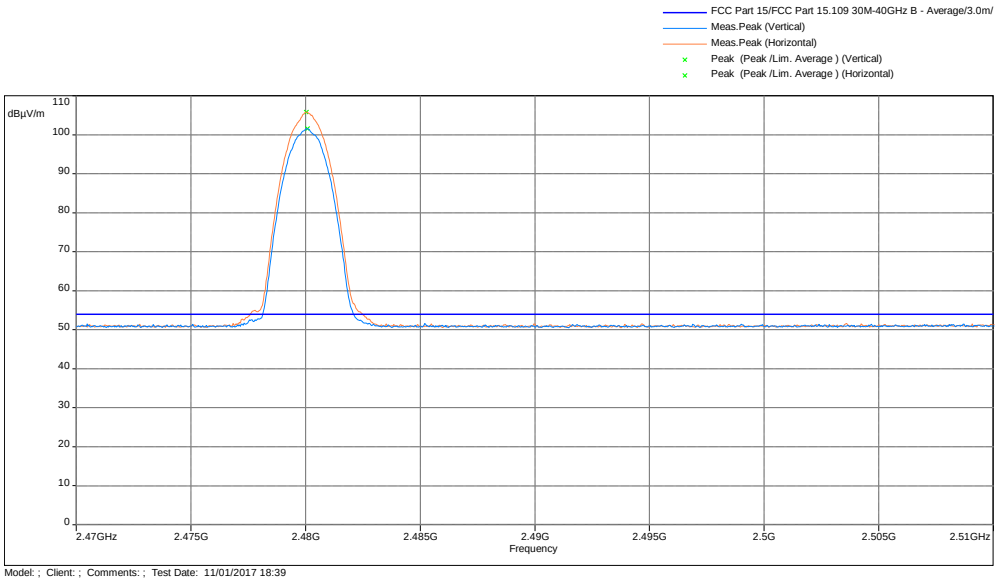
Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
π/4-DQPSK	Peak	0	2402	67.5	74	-6.5	Pass



Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Ave Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
π/4-DQPSK	Avg	0	2402	50.2	54	-3.8	Pass

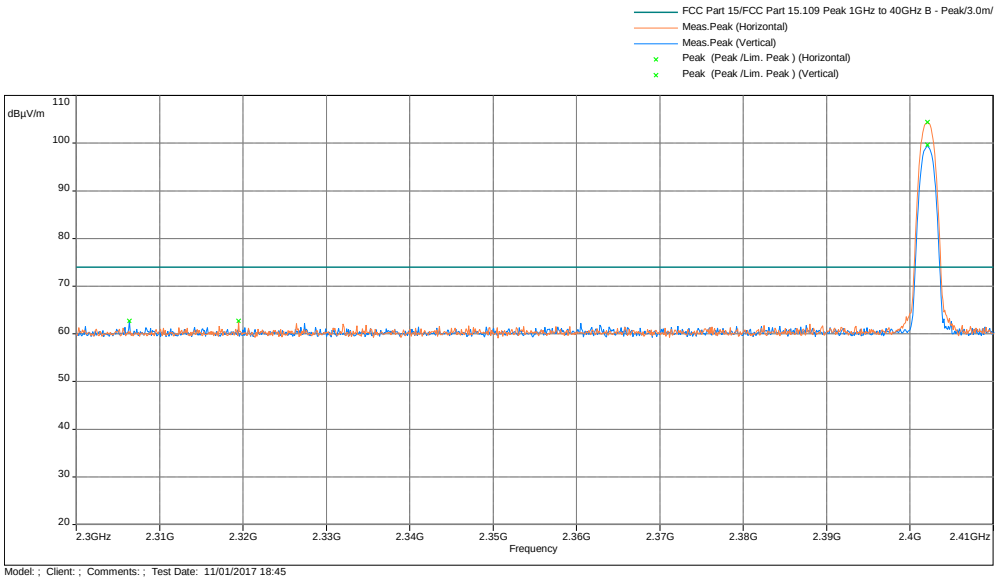


Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
π/4-DQPSK	Peak	78	2480	60.9	74	-13.1	Pass

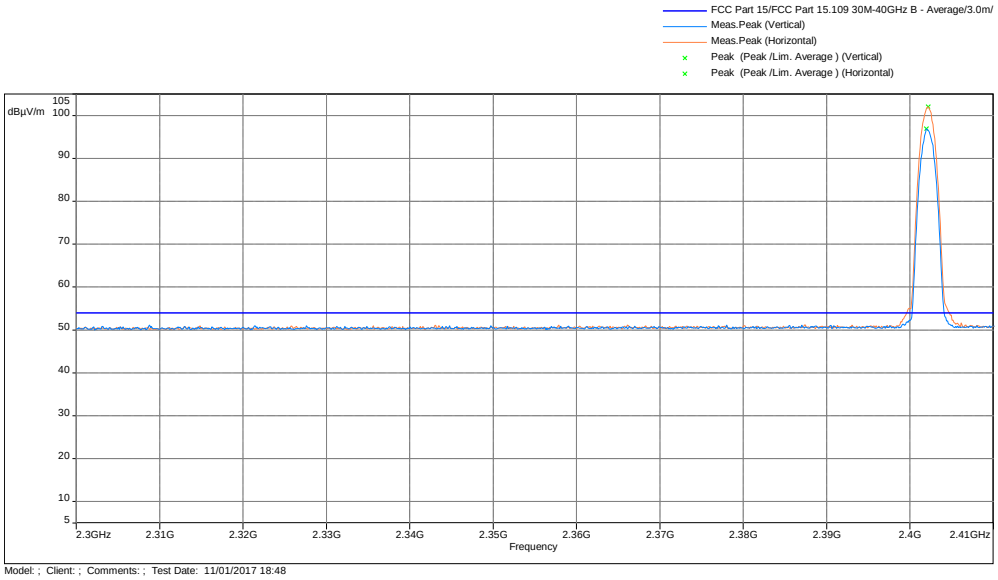


Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Avg Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
π/4-DQPSK	Avg	78	2480	51.5	54	-2.5	Pass

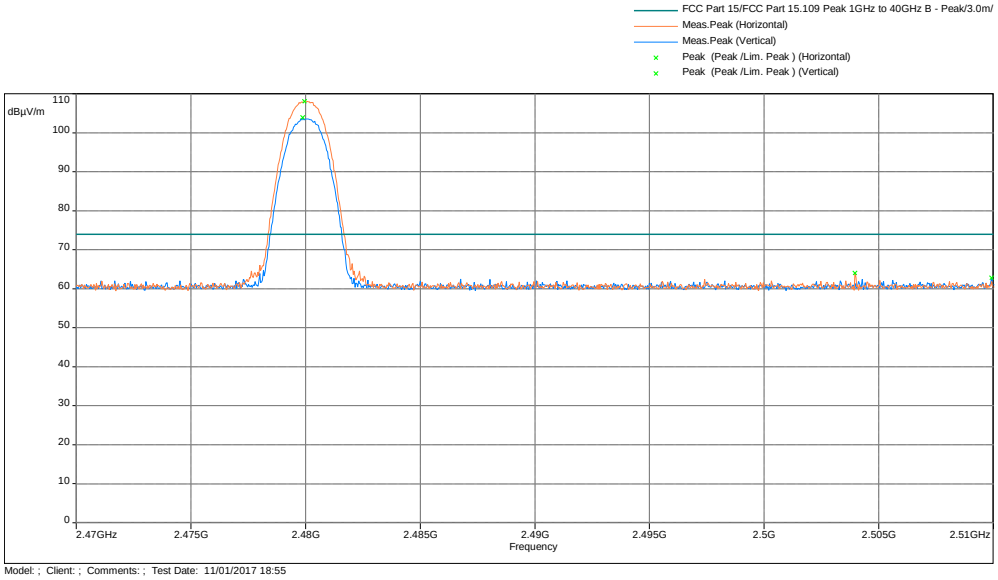
8DPSK Modulation for Out-of-Band Spurious Emissions at the Band Edge



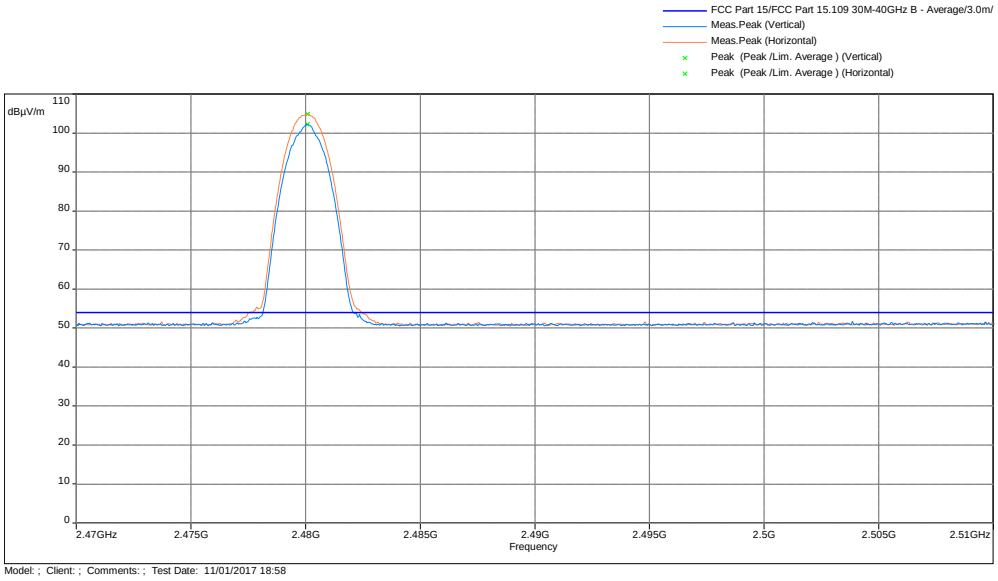
Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
8DPSK	Peak	0	2402	60.9	74	-13.1	Pass



Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Ave Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
8DPSK	Avg	0	2402	50.6	54	-3.4	Pass



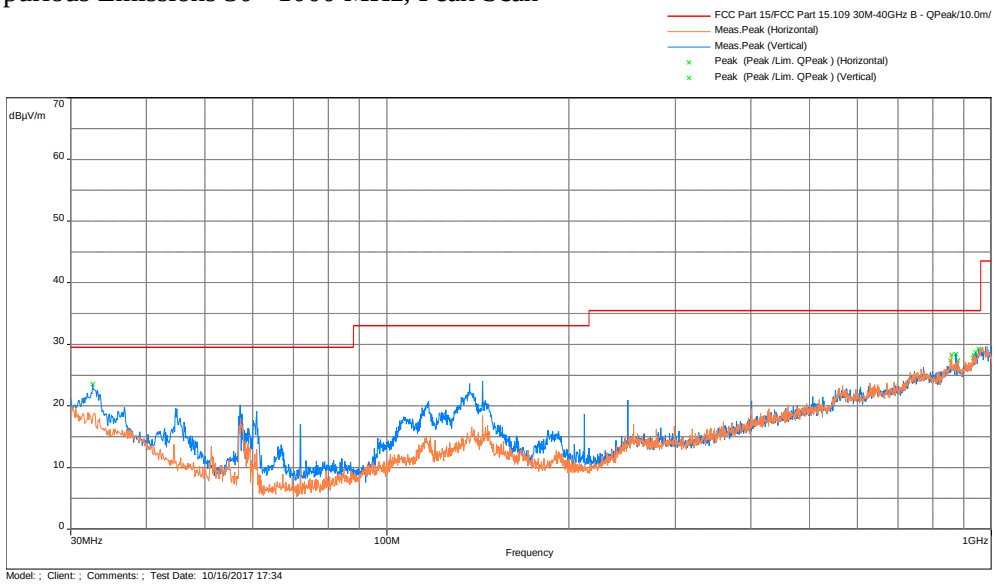
Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Peak Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
8DPSK	Peak	78	2480	60.4	74	-13.6	Pass



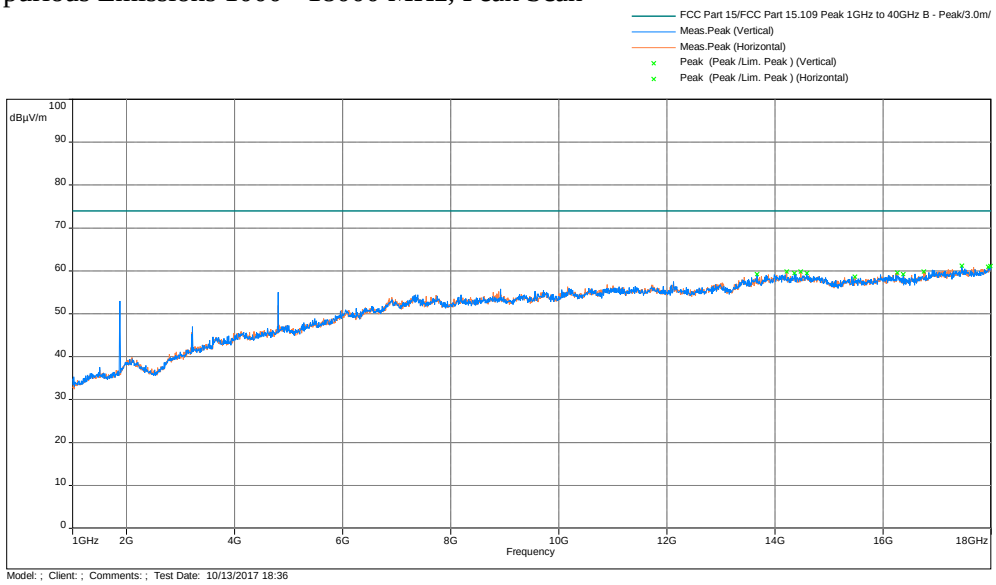
Modulation Type	Detector	EUT Channel	Frequency	FS at 3m	Avg Limit	Margin	Results
			MHz	dB(uV/m)	dB(uV/m)	dB(uV/m)	
8DPSK	Avg	78	2480	51.0	54	-3.0	Pass

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

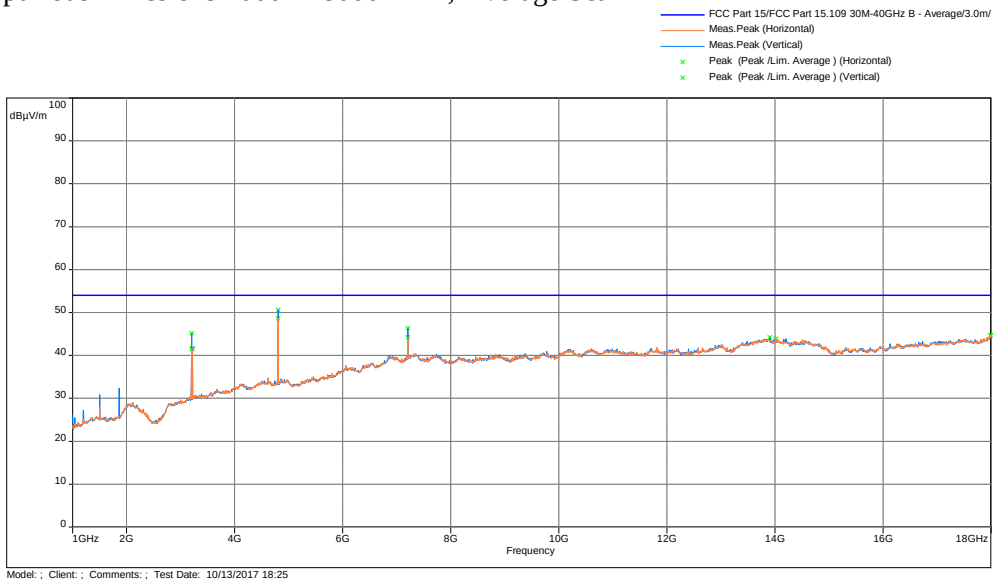
Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan

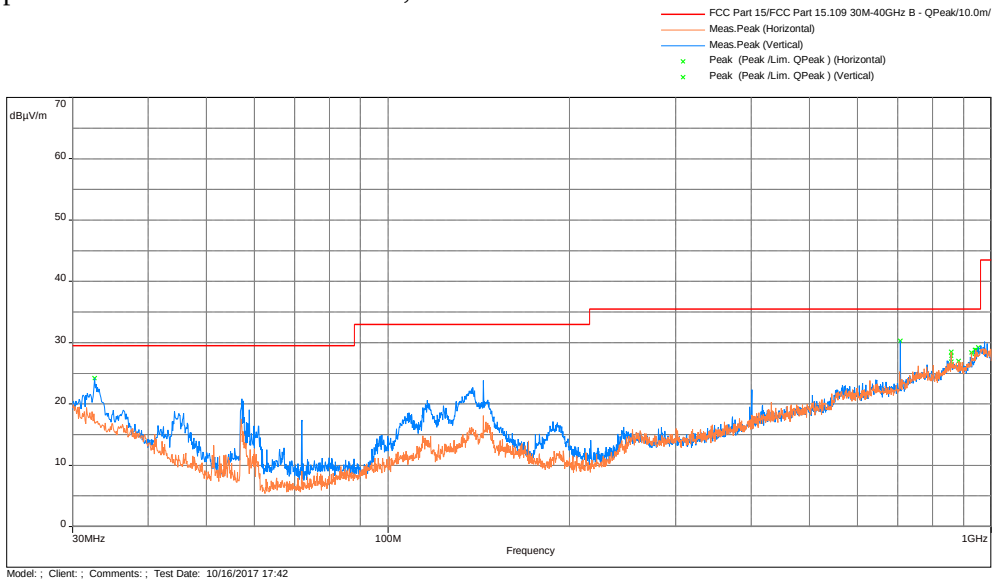


Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

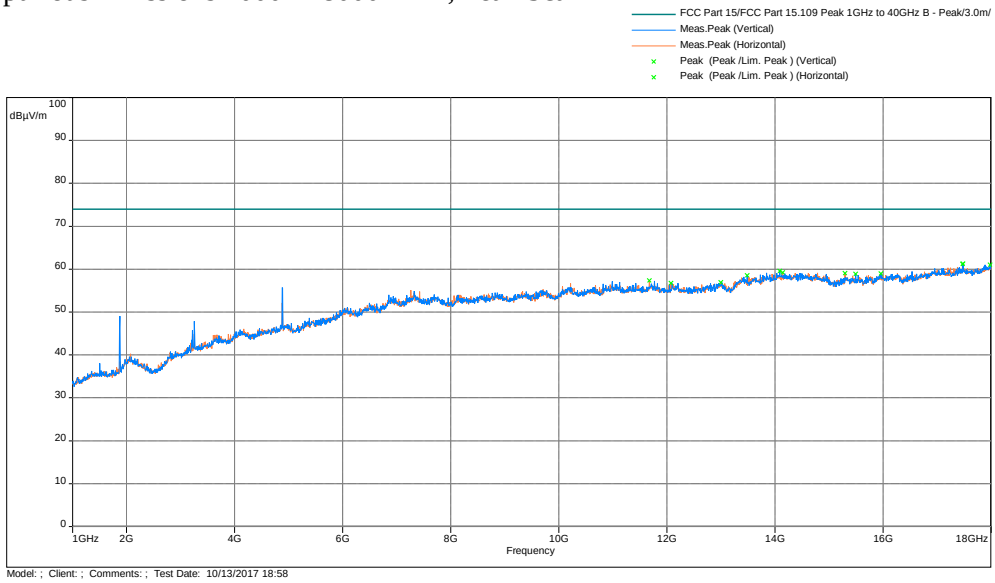
Results	**Complies**

Test Results: 15.209 Out-of-Band Radiated Spurious Emissions, 2441MHz GFSK

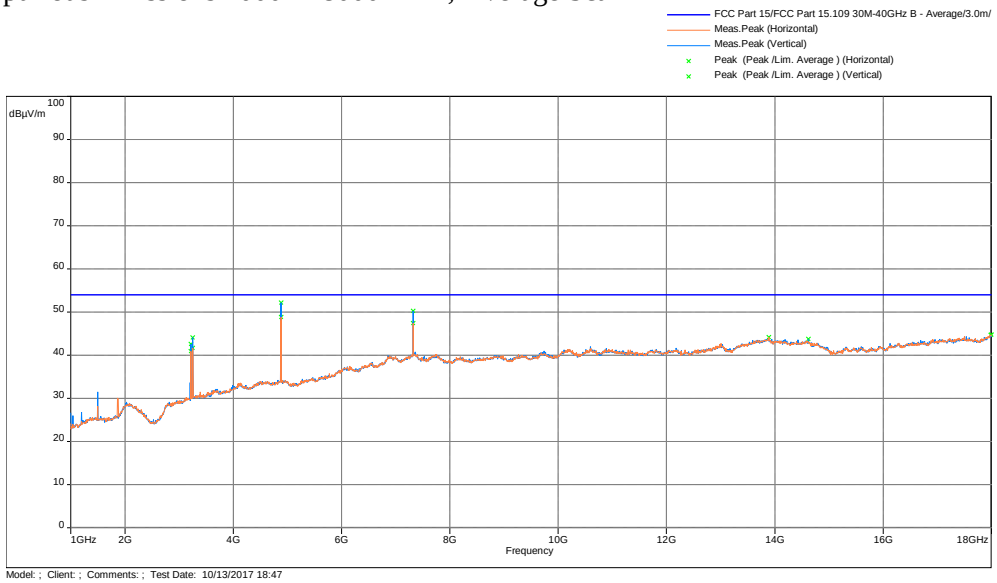
Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan

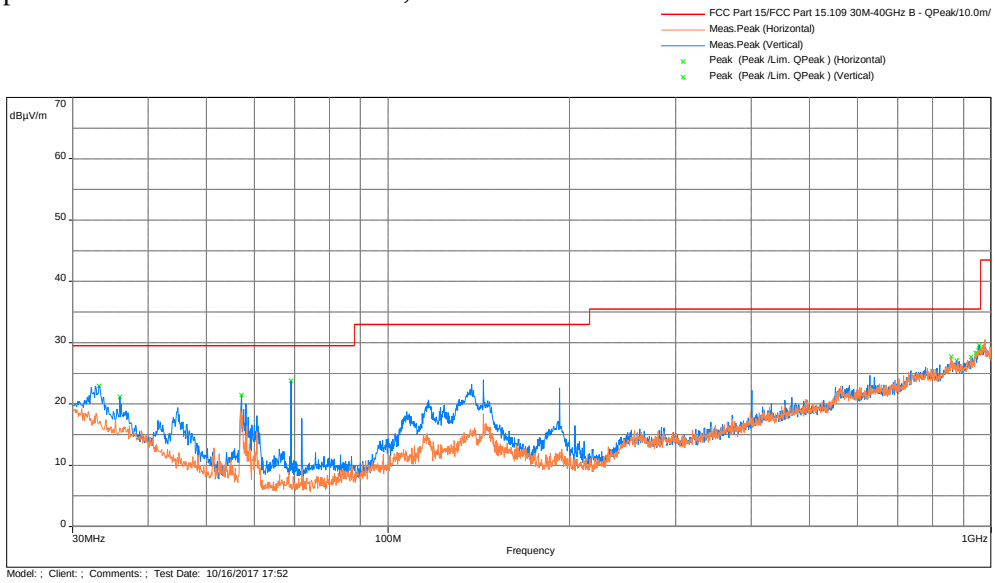


Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

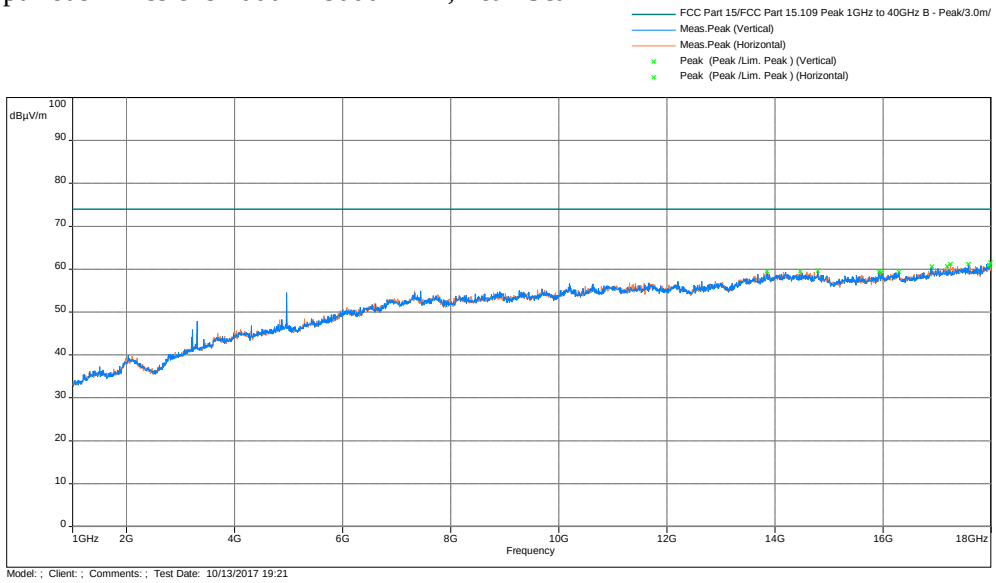
Results	**Complies**

Test Results: 15.209 Out-of-Band Radiated Spurious Emissions, 2480 MHz GFSK

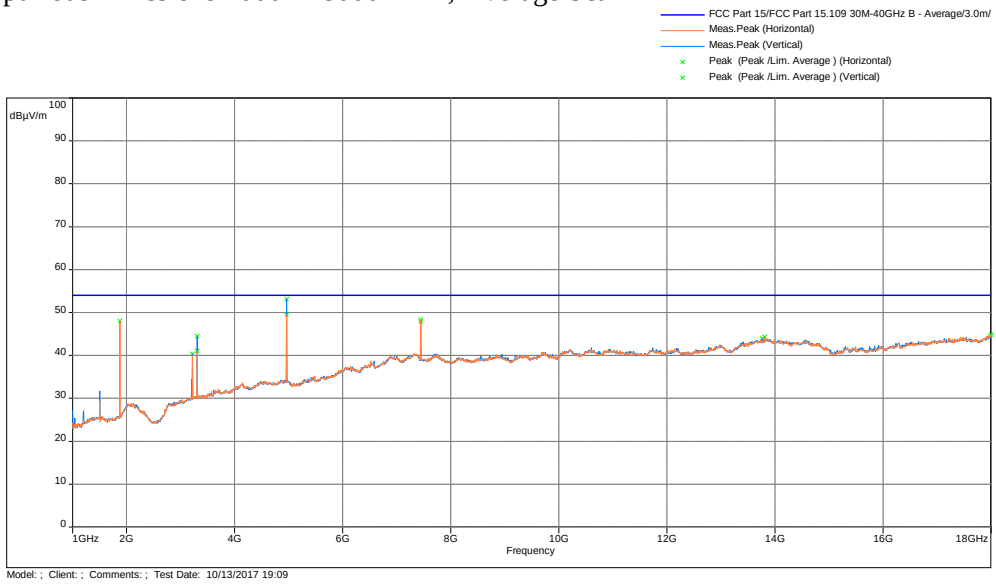
Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan

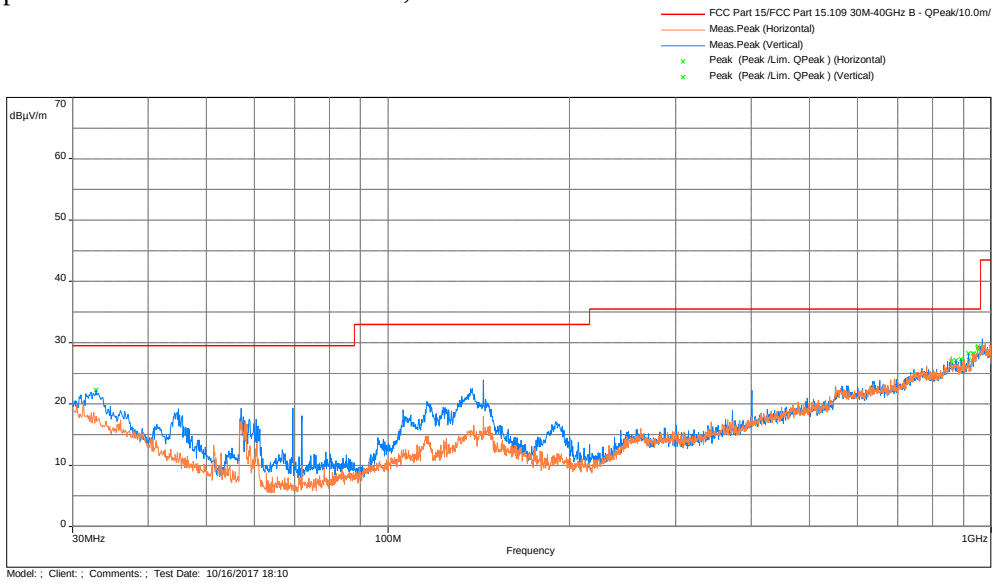


Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

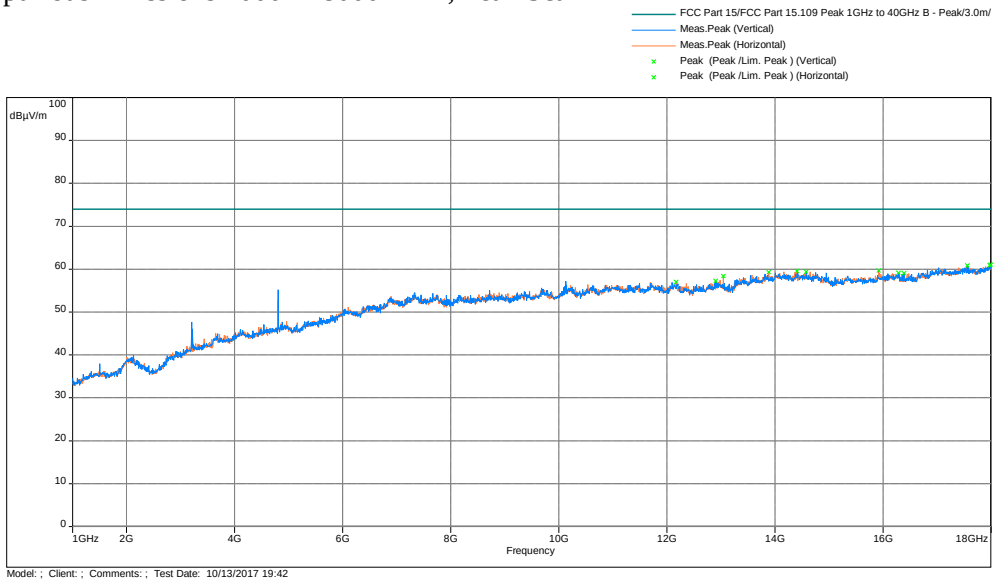
Results	**Complies**

Test Results: 15.209 Out-of-Band Radiated Spurious Emissions, 2402 MHz π/4-DQPSK

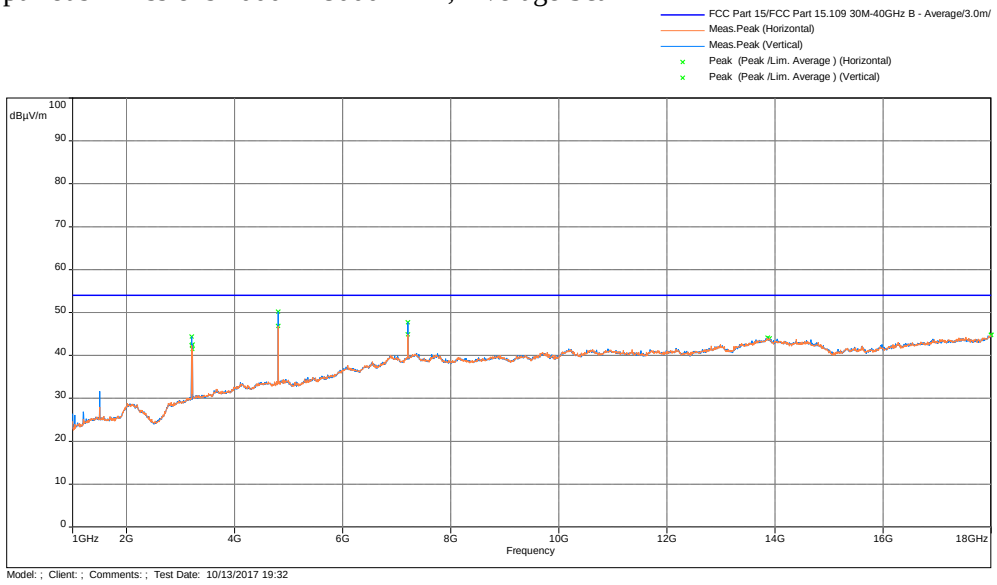
Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan

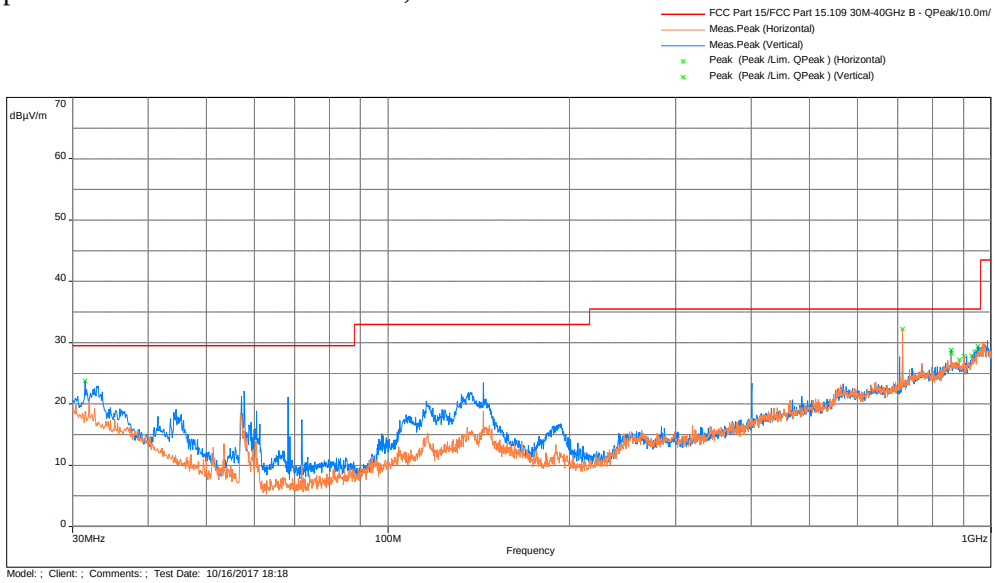


Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

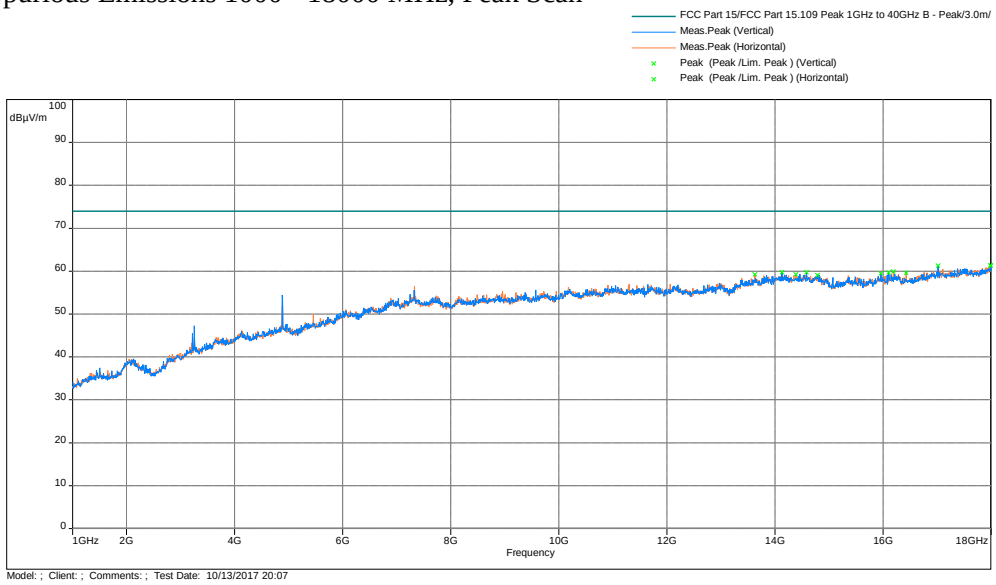
Results	**Complies**

Test Results: 15.209 Out-of-Band Radiated Spurious Emissions, 2441 MHz π/4-DQPSK

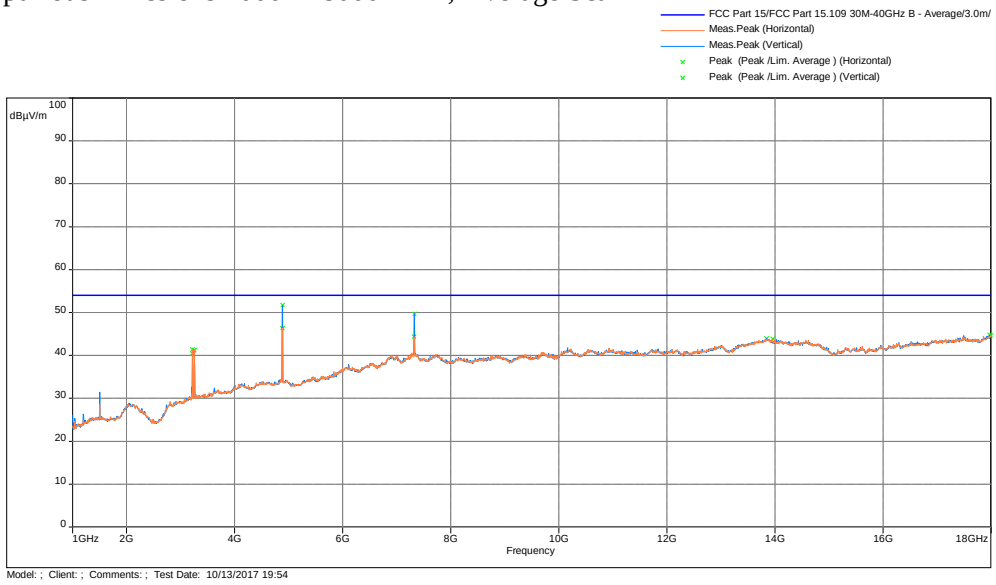
Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan

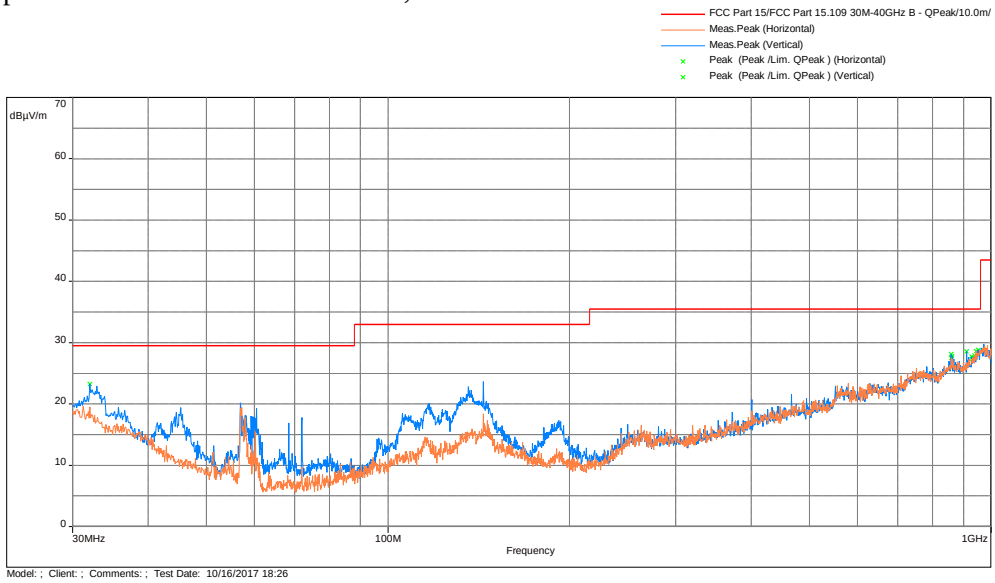


Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

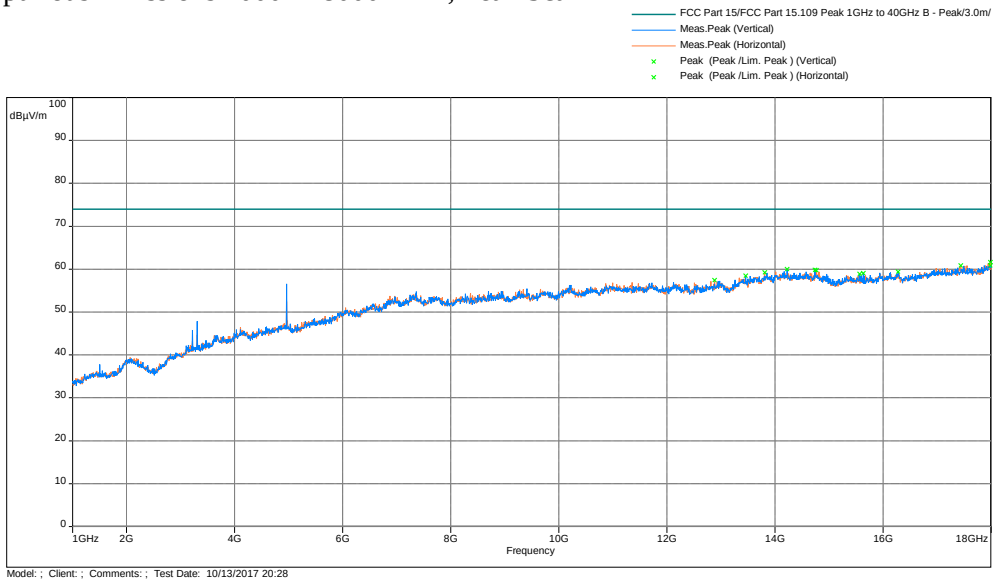
Results	**Complies**

Test Results: 15.209 Out-of-Band Radiated Spurious Emissions, 2480 MHz π/4-DQPSK

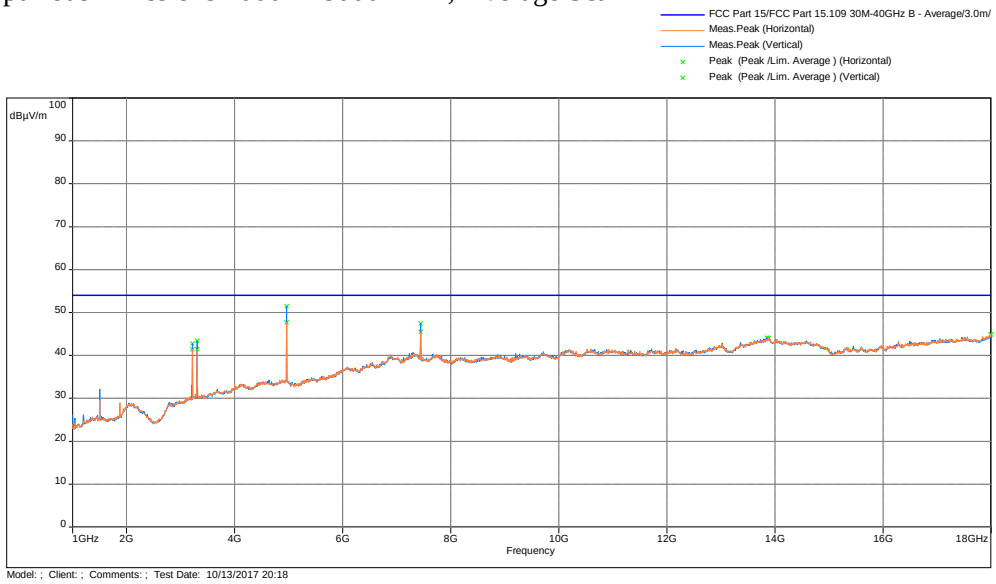
Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan



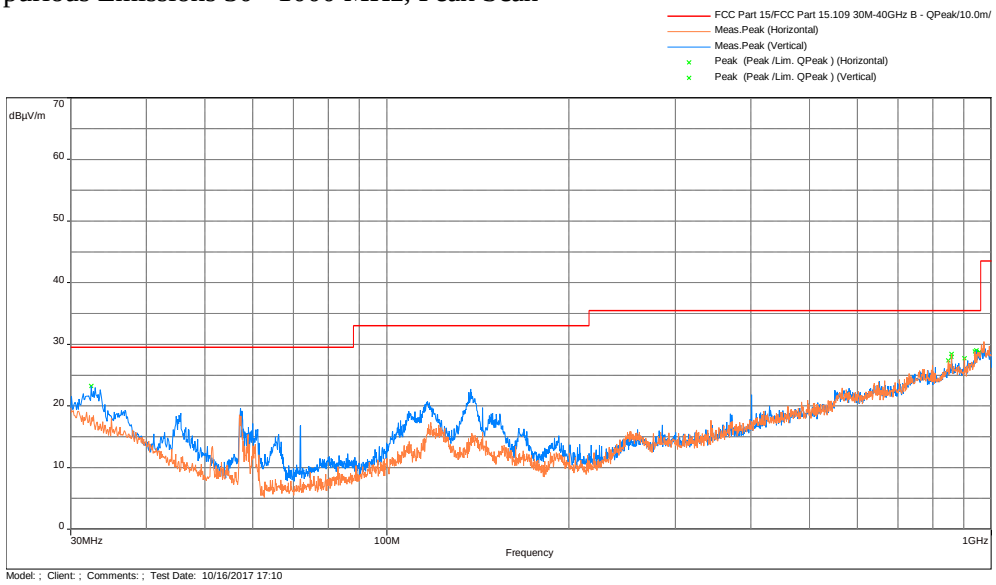
Frequency (MHz)	Avg Amplitude (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity (H/V)	Raw Avg (dBµV)	Correction (dB)
12762	50.7	54	-3.3	15	1.74	H	36.9	13.8

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

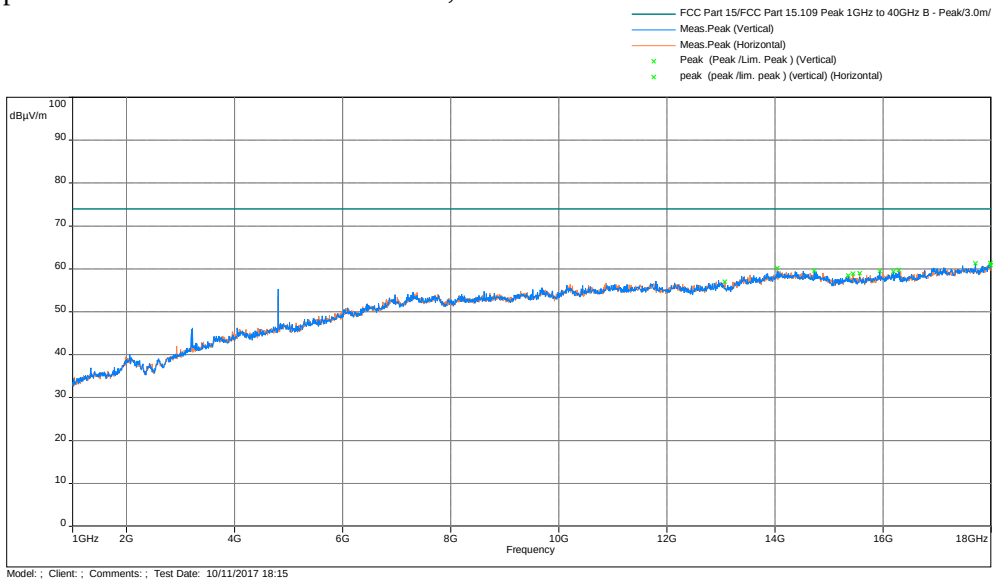
Results	**Complies**

Test Results: 15.209 Out-of-Band Radiated Spurious Emissions, 2402 MHz 8DPSK

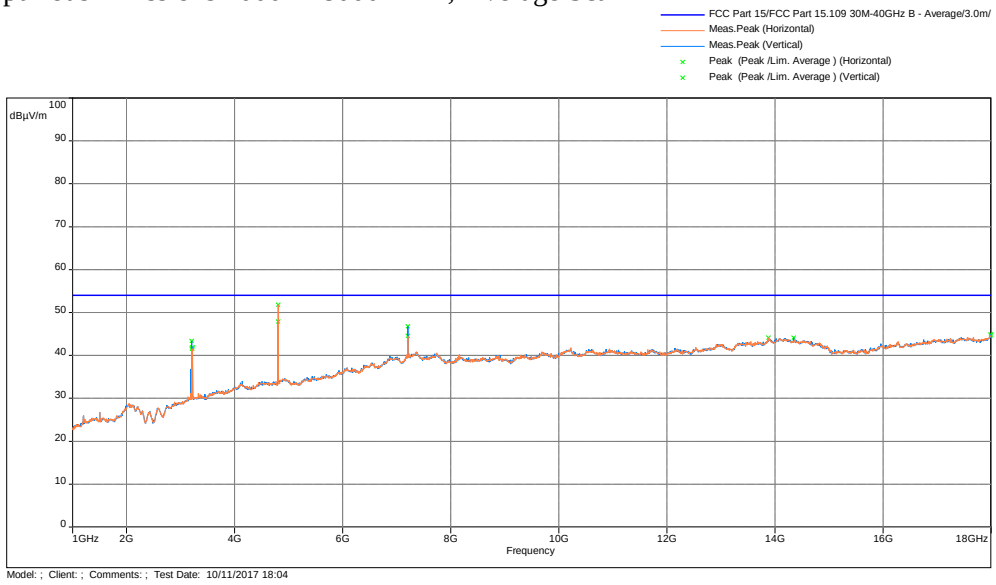
Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan

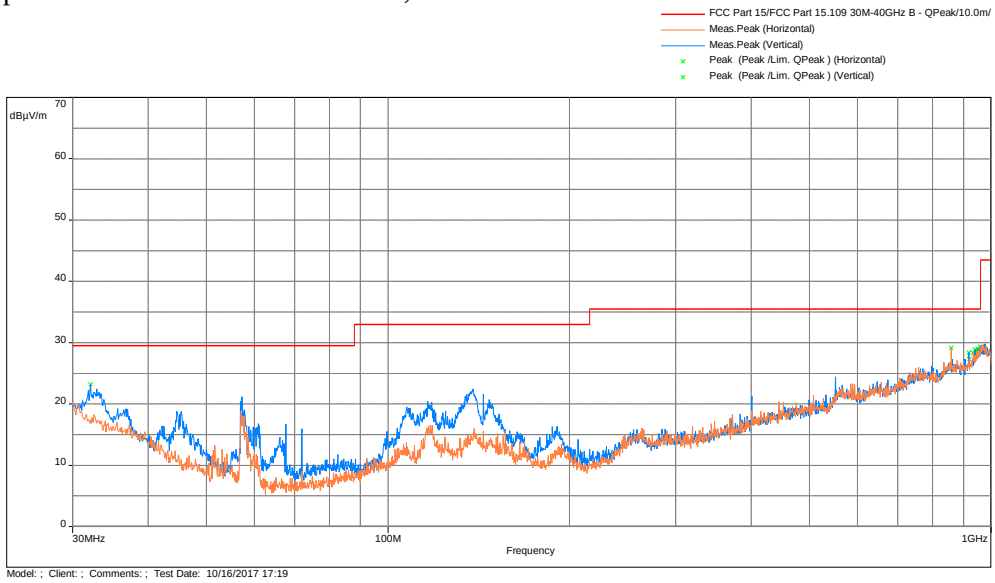


Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

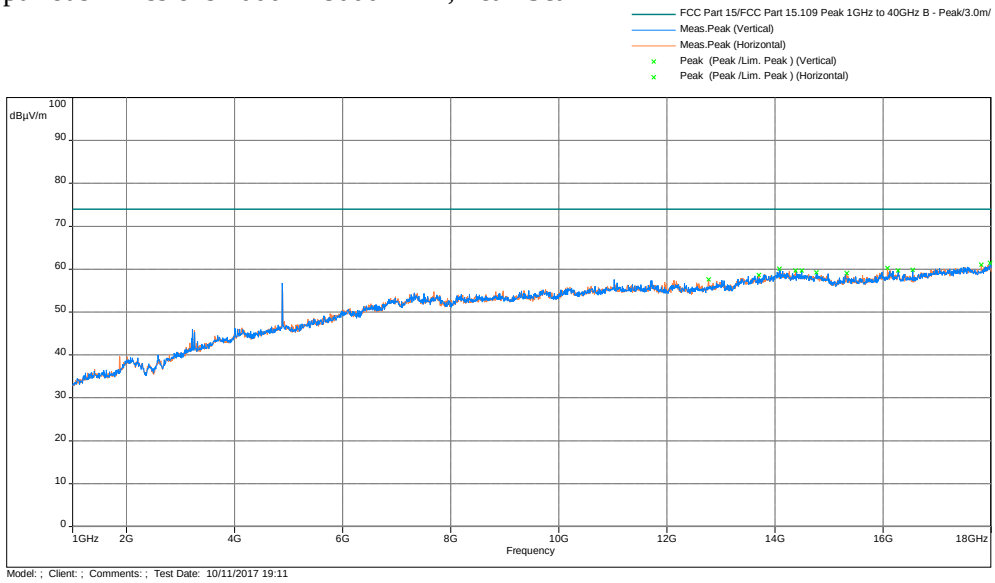
Results	**Complies**

Test Results: 15.209 Out-of-Band Radiated Spurious Emissions, 2441 MHz 8DPSK

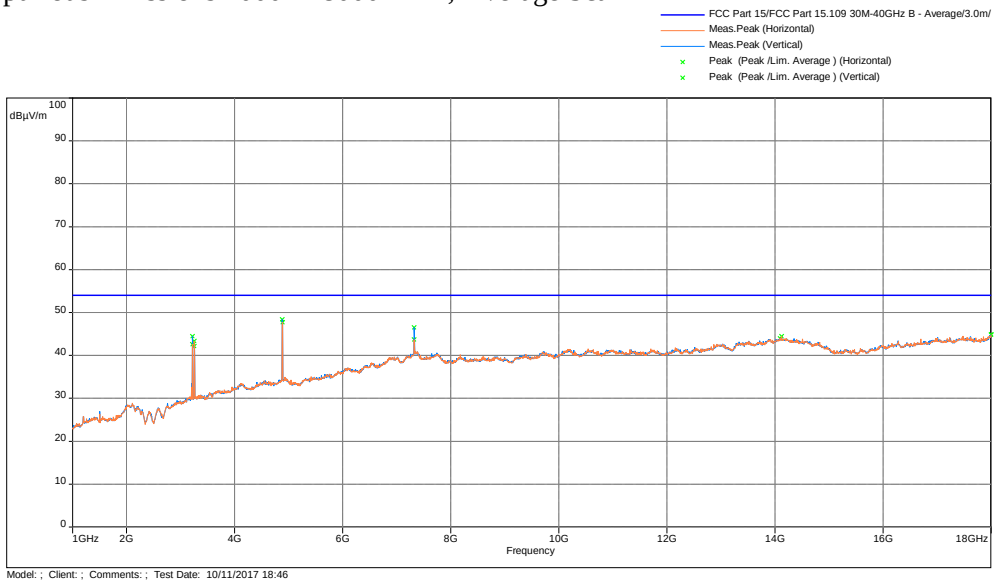
Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan

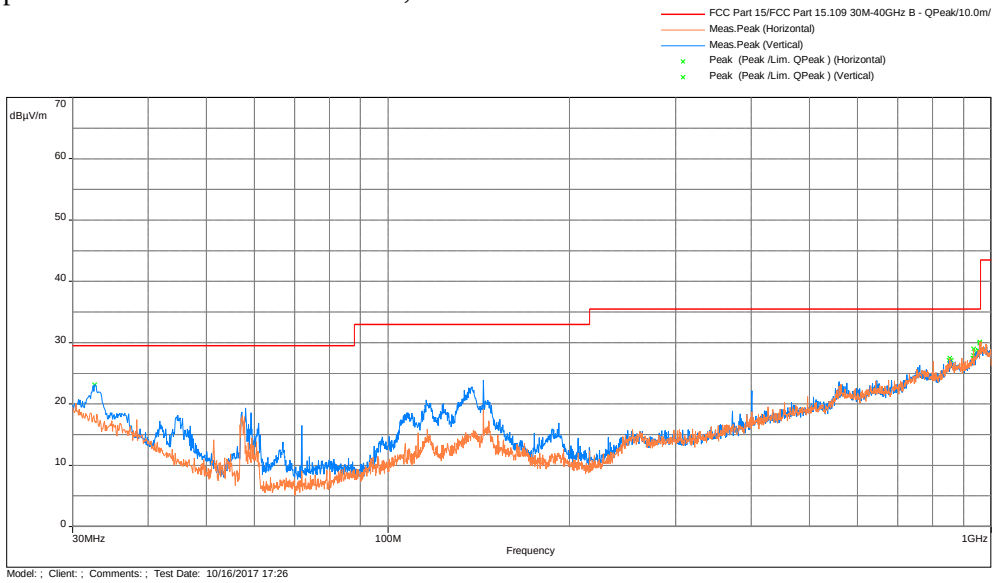


Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

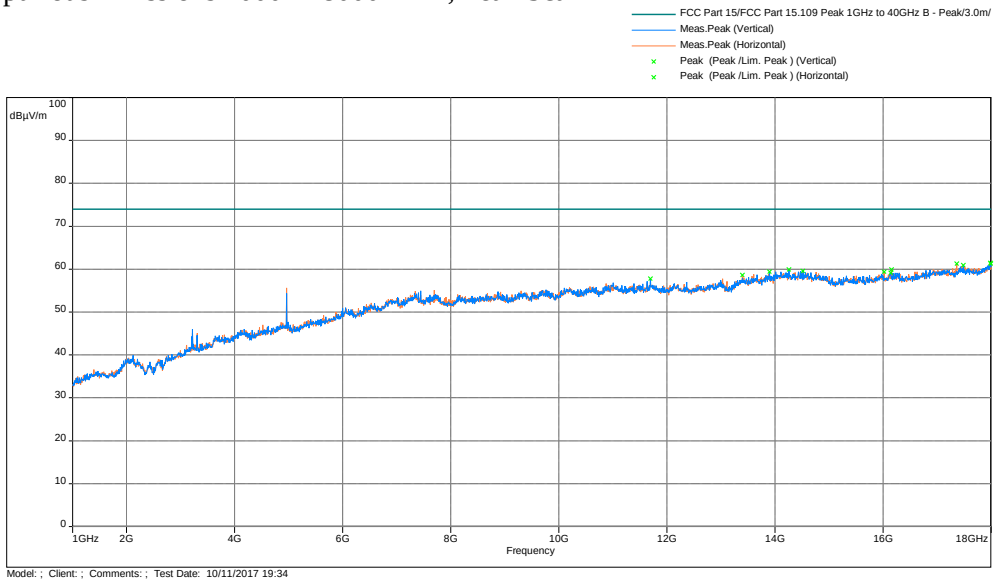
Results	**Complies**

Test Results: 15.209 Out-of-Band Radiated Spurious Emissions, 2480 MHz 8DPSK

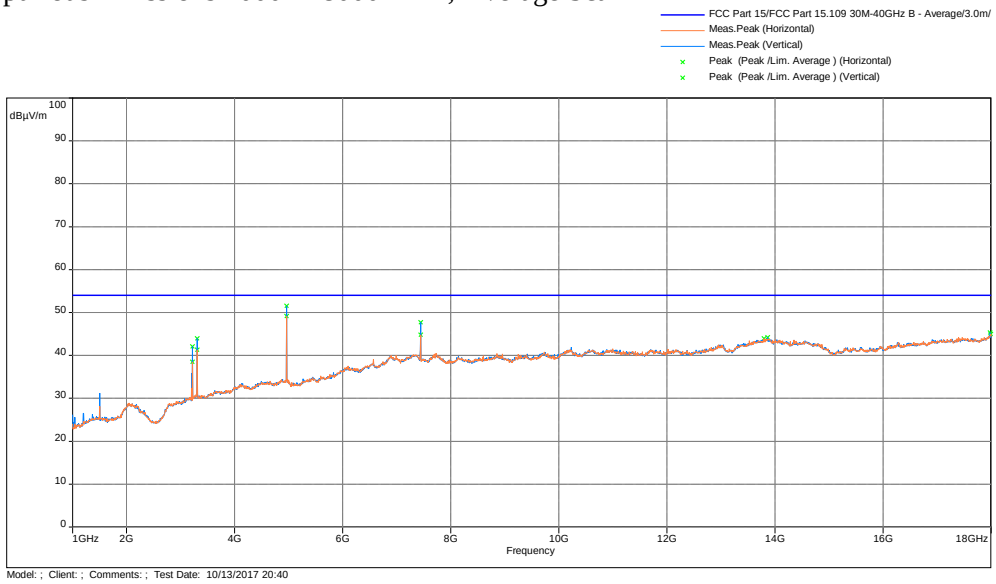
Radiated Spurious Emissions 30 - 1000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Peak Scan



Radiated Spurious Emissions 1000 - 18000 MHz, Average Scan



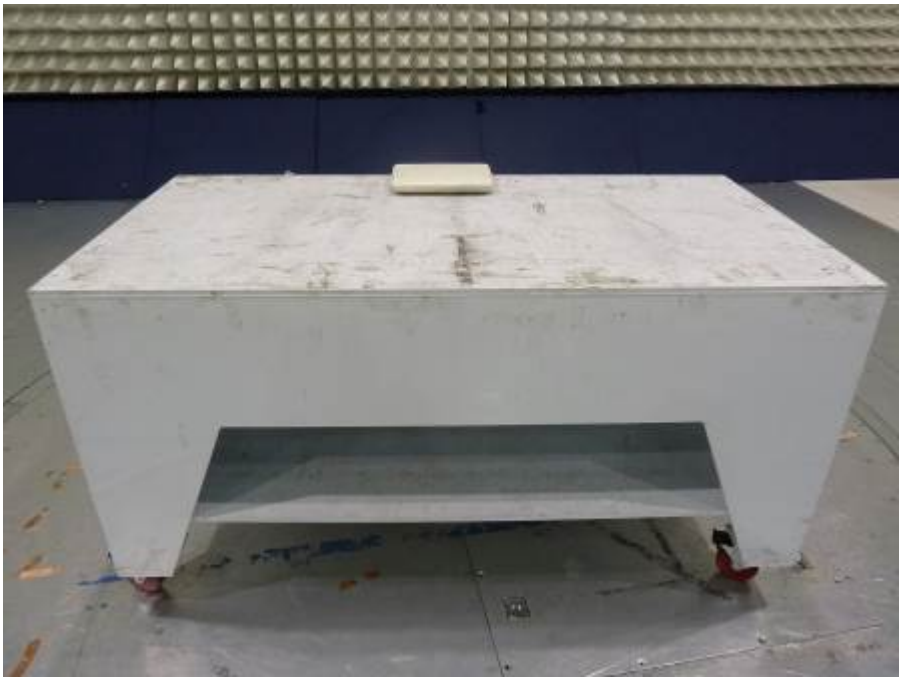
Frequency (MHz)	Avg Amplitude (dBµV/m)	Avg Limit (dBµV/m)	Margin (dB)	Azimuth (deg)	Height (m)	Polarity (H/V)	Raw Avg (dBµV)	Correction (dB)
12762	50.9	54	-3.1	15	1.65	H	37.1	13.8

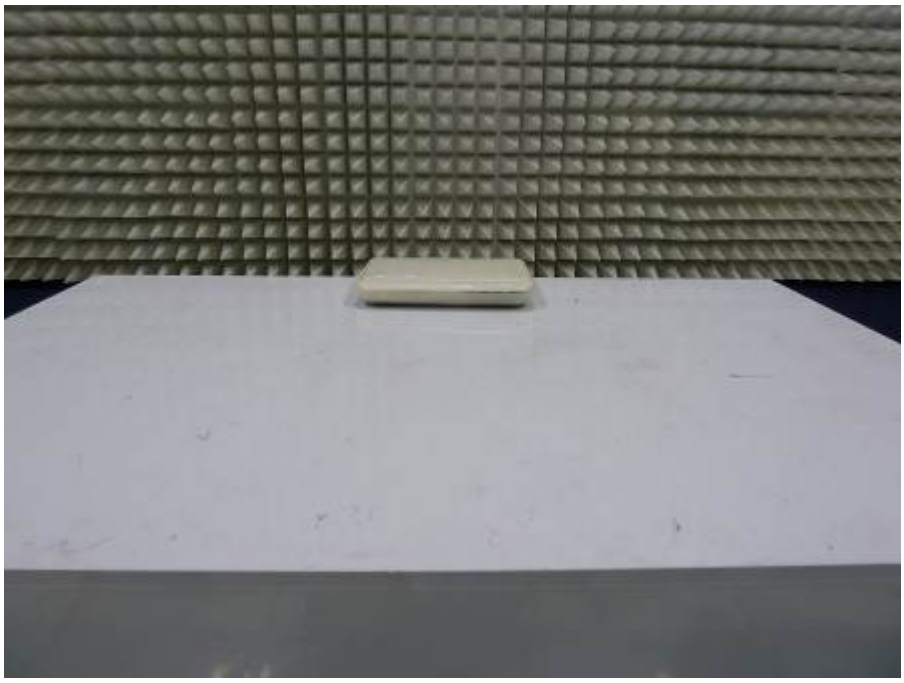
Note: Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz

Results	**Complies**

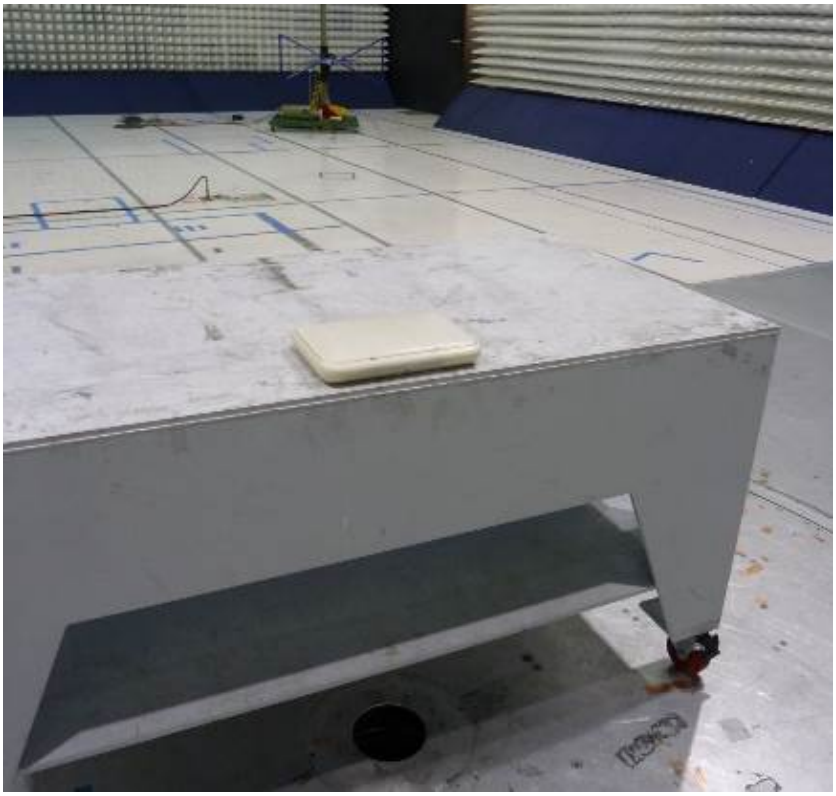
4.7.5 Test Setup Photographs

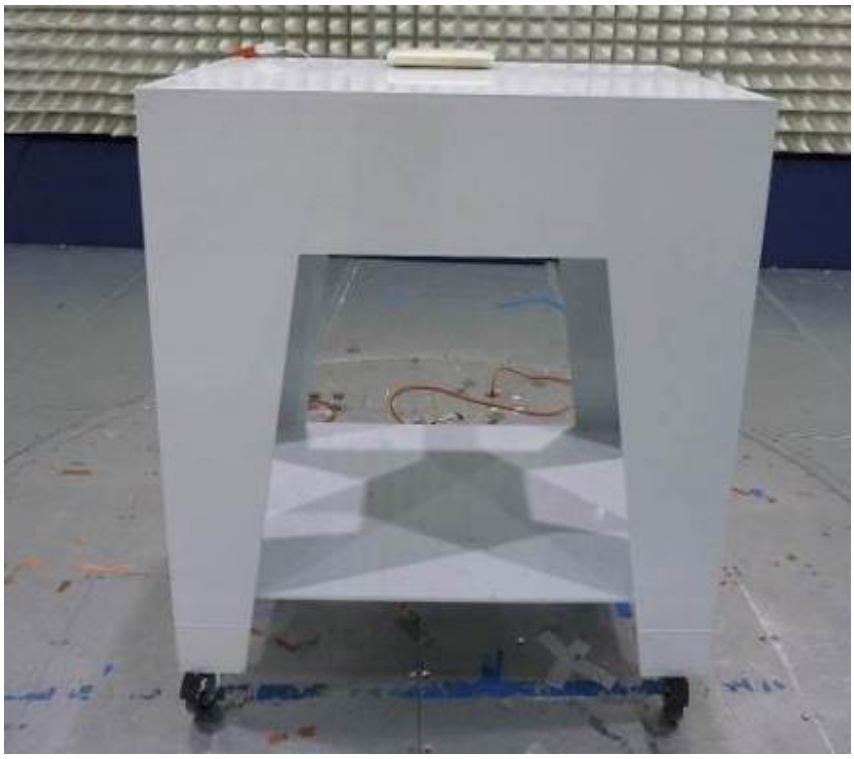
The following photographs show the testing configurations used.



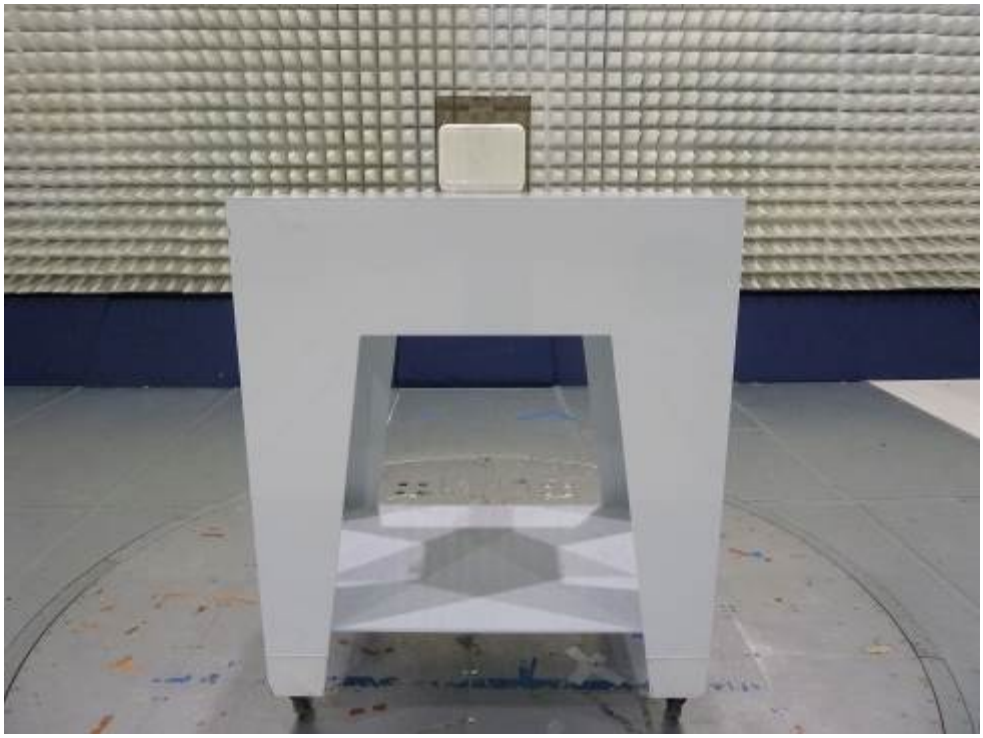


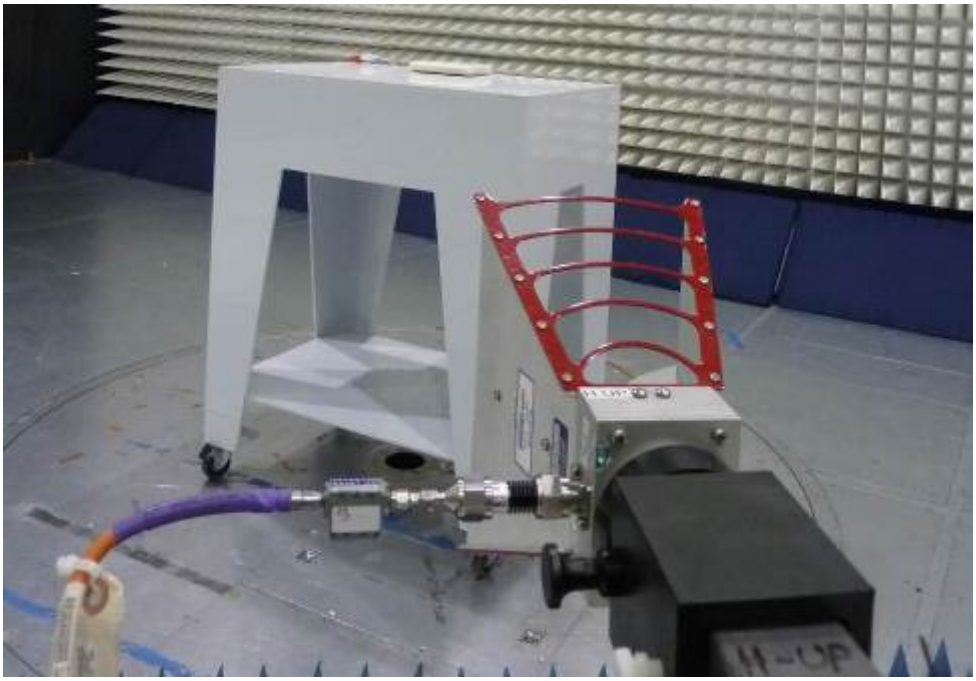
4.7.5 Test Setup Photographs (Continued)





4.7.5 Test Setup Photographs (Continued)





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	FSV	ITS 01534	12	05/16/18
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	01/04/18
Horn Antenna	ETS-Lindgren	3115	ITS 00982	12	02/03/18
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	01/19/18
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	Narda	FSCM99899	ITS 01583	12	08/31/18
RF Cable	Megaphase	EMC1-K1K1-236	ITS 01538	12	06/13/18
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	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 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	Towerview 10-3-17.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 / G103177090	AC	KV	November 06, 2017	Original document