Project 20208-15

Racom
RAy3-24

Wireless Test Report

FCC 15.249, 101.111
RSS-210 Annex I
RSS-191

Prepared for:

Racom
Mirova cp. 1283
592 31 Nove Mesto na Morave
Czech Republic

By

Professional Testing (EMI), Inc.
1601 North A.W. Grimes Blvd., Suite B
Round Rock, Texas 78665

6 Jun 2019

Reviewed by

Shakil Murad
Lead EMC Engineer

Written by

Eric Lifsey
EMC Engineer

Table of Contents

Revision History

Revision Number	Description	Date
01	Draft for review.	3 Jun, 2019
02	Reviewed	4 June, 2019
03	Revised to add ISED/IC citations, correct typos, update table 1.2.2.	6 June 2019
Final 03	Remove RSS-191. Added antenna details. Add mains emissions.	19 June 2019

Errata:

None.

Compliance Certificate

FCC MRA Designation Number: US5270 NVLAP Accreditation Number: 200062-0

Applicant	Device & Test Identification	
Racom (Jiři Hruška) Mirova cp. 1283 592 31 Nove Mesto na Morave Czech Republic Certificate Date: 24 May 2019	FCC ID: IC ID: Model(s): Laboratory Project ID:	SQT-RAY3-24 24993-RAY324 RAy3-24 20208-15

The EUT(s) listed above were tested utilizing the following documents and found to be in compliance with the required criteria.

Requirement	Reference	Detail
USA/FCC		
Part 15 C	15.249	Radiated Power and Spurious Emissions
Part 15 C	15.209	Radiated emission limits; general requirements.
Part 15 C	15.203	Antenna Requirements
Part 101	101.111	Emission Mask
Canada/ISED		
RSS-210	Annex I (a), (b) & (d)	Radiated Power and Spurious Emissions
RSS-210	Annex I (b)	Radiated emission limits; general requirements.
RSS-210	Annex I (c)	Antenna Requirements

I, Eric Lifsey, for Professional Testing (EMI), Inc., being familiar with the above rules and test procedures have reviewed the test setup, measured data, and this report. I believe them to be true and accurate.

Eric Lifsey
EMC Engineer

This report has been reviewed and accepted by the Applicant**.** The undersigned is responsible for ensuring that this device will continue to comply with the requirements listed above.

_____

Representative of Applicant

1.0 Introduction

1.1 Scope

Demonstrate conformance to the intentional wireless radiator requirements of North America.

1.2 EUT Description

The EUT is a point to point microwave data link intended for professional installation in locations not accessible to the public. Its RF interface is a circular waveguide feeding an attached parabolic reflector antenna. It transmits and receives in full-duplex with the transmitter and receiver cross-polarized.

Table 1.2.1: EUT Essential Information

Manufacturer & Model	Description	Power
Racom RAy3-24	24 GHz Point to Point Microwave Link Sample A, S/N 1803523941 Sample B, S/N 1801524241	20 - 60 VDC or PoE, max 1.5 A

Table 1.2.2: EUT RF Specifications

Power Output to Antenna Range	-30 to +10 dBm
Frequency Range	24050 - 24250 MHz
Channel Bandwidth Schemes MHz	3.5 | 5 | 7 | 10 | 14 | 20 | 28 | 40 | 56 | 80 | 100 | 112
Channels per Bandwidth Scheme	47 | 32 | 23 | 15 | 11 | 7 | 5 | 3 | 2 | 1 | 1 | 1
Modulation Methods	QPSK QPSK_S 16QAM 32QAM 64QAM 128QAM 256QAM 512QAM 1024QAM 2048QAM 4096QAM

A complete list of antennas for this system is presented in the user manual exhibit.

1.3 EUT Operation

The EUT was operated in continuous transmit mode at maximum power with modulation. It was configured for vertical polarity of the transmitter; the receive polarity is then horizontal.

Except for the frequency stability test, the EUT was powered by a 3rd party PoE power injecting power supply.

Except for the frequency stability test, the EUT was operated attached to a 1.2 m parabolic antenna/reflector assembly. Details regarding the antenna appear in this report.

1.4 Test Site

Measurements were made at the PTI semi-anechoic facility designated Site 45 (FCC 459644, IC 3036B-1) in Austin, Texas. This site is registered with the FCC under Section 2.948 and Industry Canada per RS-GEN and is subsequently confirmed by laboratory accreditation (NVLAP). Site 45 is located at 11400 Burnett Rd., Austin, Texas, 78758. The main office is located at 1601 N. A.W. Grimes Blvd., Suite B, Round Rock, Texas, 78665.

1.5 Radiated Measurements

Radiated levels are determined as follows:

Raw Measured Level + Antenna Factor + Cable Losses – Amplifier Gain = Corrected Level

In addition, measurement distance extrapolation factors are applied and documented where used.

1.6 Applicable Documents and Clauses

Table 1.6.1: Applicable Documents	
Document	**Title**
ANSI C63.4 2009	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low Voltage Electrical and Electronic Equipment
ANSI C63.10:2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
47 CFR	Part 15 – Radio Frequency Devices Subpart C -Intentional Radiators
47 CFR	Part 101 – Fixed Microwave Services
RSS-210 Issue 9	Licence-Exempt Radio Apparatus: Category I Equipment
RSS-Gen Issue 4	General Requirements for Compliance of Radio Apparatus

Table 1.6.2: Applicable Clauses		
Parameter	**FCC Part 15 Rule Paragraphs**	**ISED/IC RSS-210, RSS-191**
Transmitter Characteristics	15.249	RSS-210 Annex I (a) & (b)
Spurious Radiated Power	15.249, 15.209	RSS-210 Annex I (d)
Antenna Requirement	15.203	RSS-210 Annex I (c)
Emission Mask	101.111	

2.0 Fundamental Emission Measurements

2.1 Test Procedure

The EUT was positioned on a motorized turntable at a distance of 1 meter as measured from the closest point of the EUT antenna and to the measurement antenna. EUT was set to maximum power of 10 dBm. The EUT modulation was selected which measured as highest peak power.

2.2 Test Criteria

Section Reference	Parameter	Date(s)
15.249(b) // RSS-210 Annex I (a)	15.249: Radiated Field Strength, 2500 mV/m @ 3 m RSS-210: Radiated Field Strength, 25 V/m @ 3 m and no more than 1 mW delivered to the antenna. Power is measured with peak detection.	18 Apr 2019

2.3 Test Results

Modulation modes were compared in lowest applicable transmitter bandwidth for each modulation mode to determine highest peak power for subsequent measurement.

QPSK was found to be the highest peak power modulation. Relative peak radiated power was measured with a diode detector to eliminate limitations of spectrum analyzer bandwidth. And octave standard-gain horn and preamp (with embedded detector) were used.

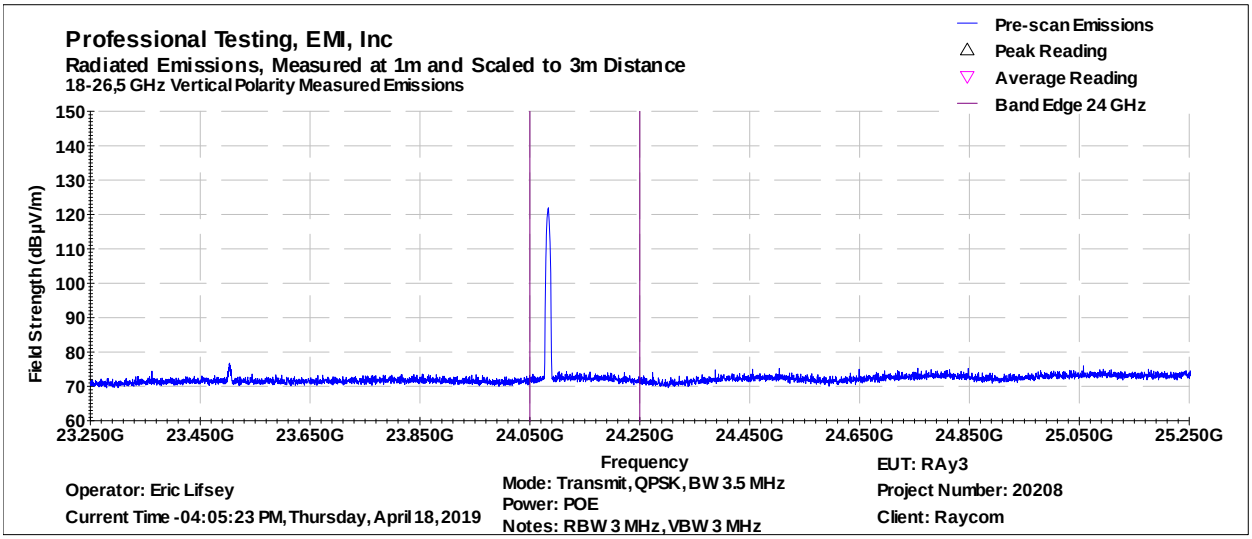
Table 2.3.1 Relative Power vs Modulation Mode Comparison

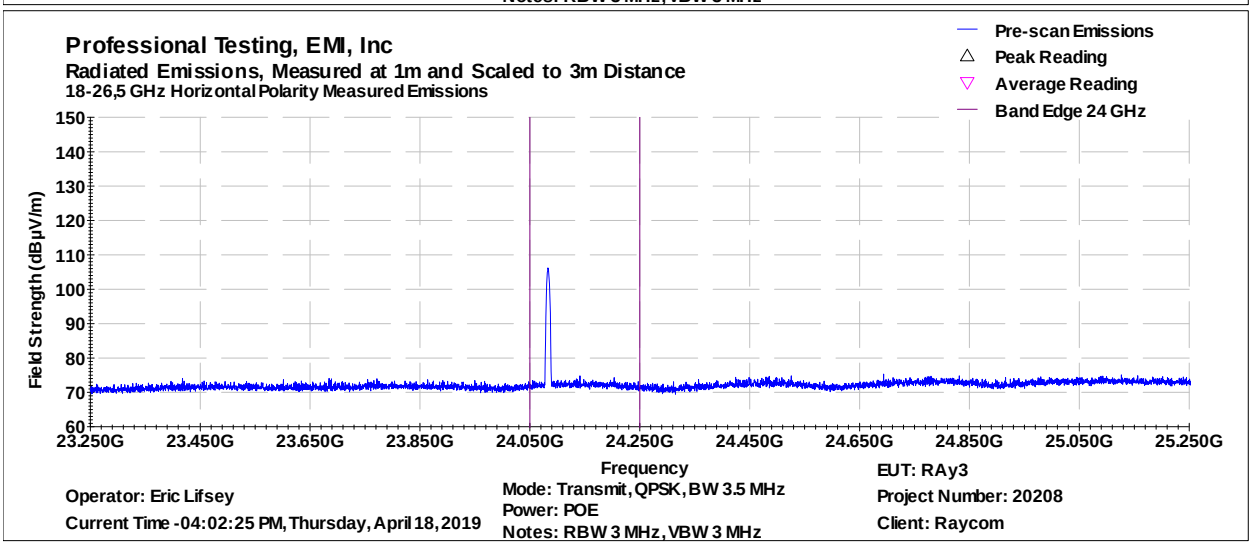
Modulation Mode	DMM Measured Detector Output of Relative Peak Power mV DC
QPSK	0.176
QPSK_S	0.173
16QAM	0.172
32QAM	0.171
64QAM	0.170
128QAM	0.169
256QAM	0.167
512QAM	0.165
1024QAM	0.165
2048QAM	0.171
4096QAM	0.168

Table 2.3.2: Corrected Maximum Power in Maximum Power Modulation Mode		
Frequency MHz	Polarity	Measured Radiated At 3 m dBµV/m
24.084	V	121.9
24.084	H	105.8
24.164	V	121.7
24.164	H	105.8
24.244	V	120.7
24.244	H	108.8

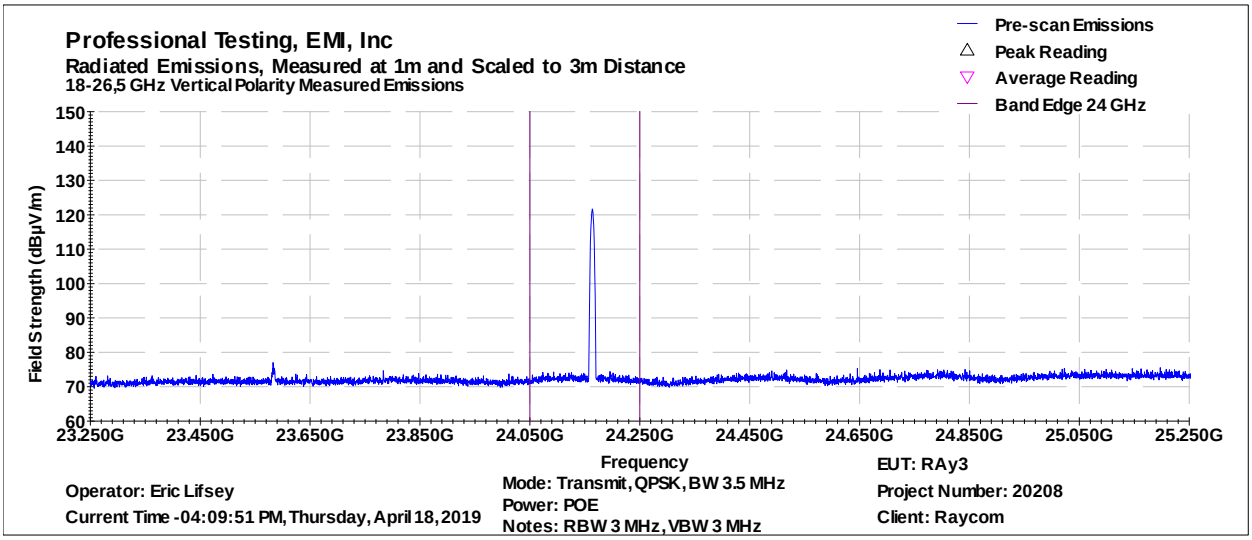
The EUT satisfies the FCC criteria. The EUT satisfies the RSS-210 criteria when power is set to 0 dBm (1 mW) or less during installation. The EUT operates in 100 % duty cycle. Recorded results appear below.

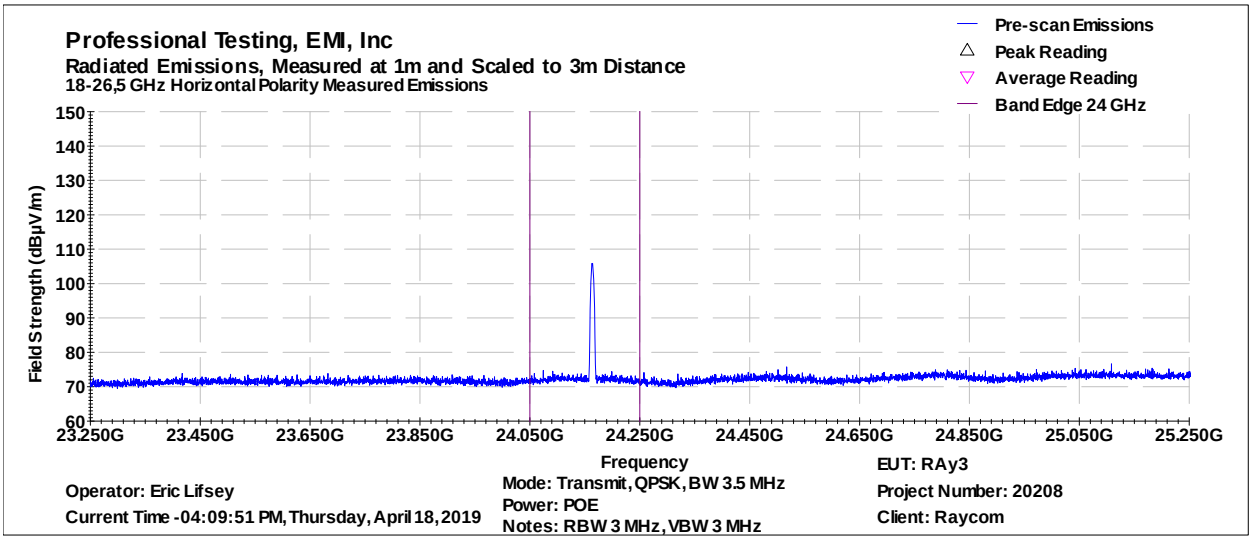
Bottom Channel



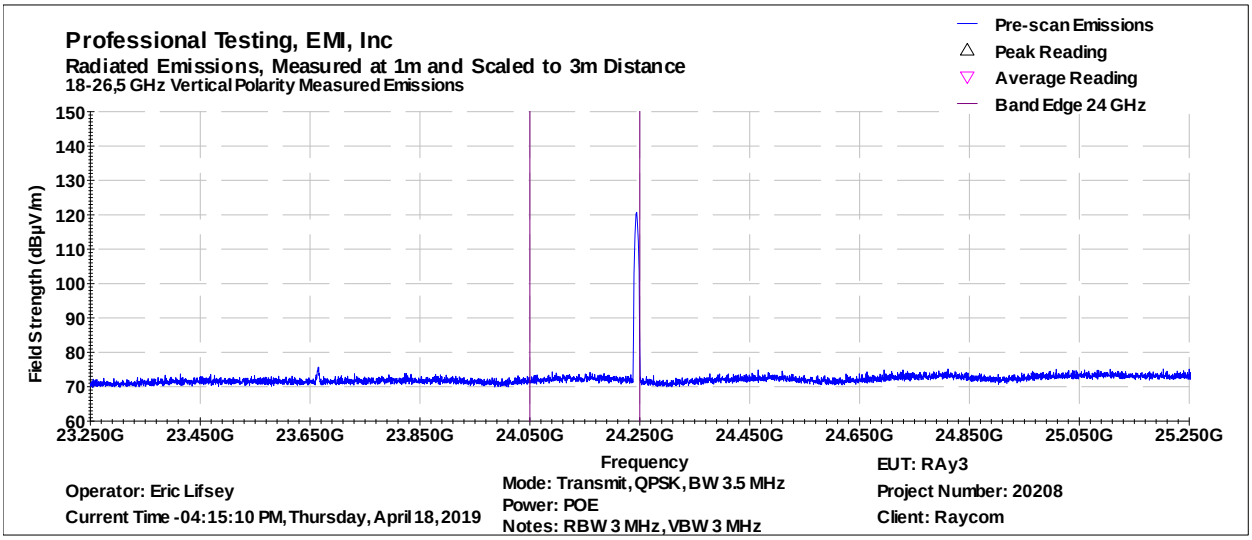


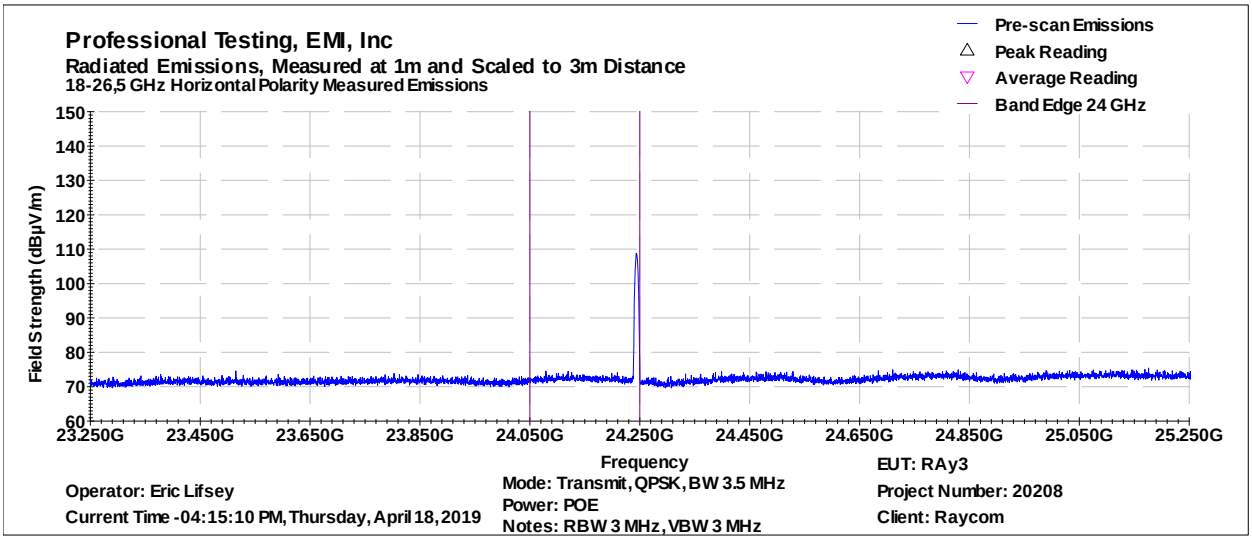
Middle Channel





Top Channel


Professional Testing, EMI, Inc
Radiated Emissions, Measured at 1m and Scaled to 3m Distance
18-26,5 GHz Vertical Polarity Measured Emissions
Pre-scan Emissions
Peak Reading
Average Reading
Band Edge 24 GHz
Field Strength (dBµV/m)
150
140
130
120
110
100
90
80
70
60
23.250G
23.450G
23.650G
23.850G
24.050G
24.250G
24.450G
24.650G
24.850G
25.050G
25.250G
Frequency
Operator: Eric Lifsey
Current Time -04:15:10 PM, Thursday, April 18, 2019
Mode: Transmit, QPSK, BW 3.5 MHz
Power: POE
Notes: RBW 3 MHz, VBW 3 MHz
EUT: RAy3
Project Number: 20208
Client: Raycom


Professional Testing, EMI, Inc
Radiated Emissions, Measured at 1m and Scaled to 3m Distance
18-26,5 GHz Horizontal Polarity Measured Emissions
Pre-scan Emissions
Peak Reading
Average Reading
Band Edge 24 GHz
Field Strength (dBµV/m)
150
140
130
120
110
100
90
80
70
60
23.250G
23.450G
23.650G
23.850G
24.050G
24.250G
24.450G
24.650G
24.850G
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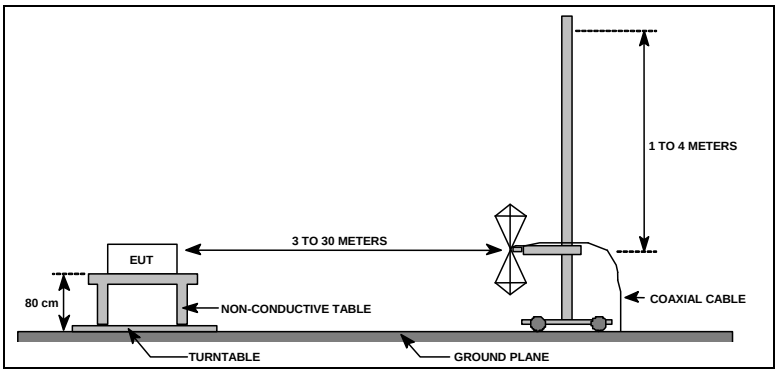
Mode: Transmit, QPSK, BW 3.5 MHz
Power: POE
Notes: RBW 3 MHz, VBW 3 MHz
EUT: RAy3
Project Number: 20208
Client: Raycom

3.0 Radiated Spurious Emissions

3.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a motorized turntable which allows 360 degree rotation.



Test Site Diagram

3.2 Test Criteria

The 3 m limits were extrapolated according to measurement distances in the table below.

Table 3.2.1 FCC/IC Emission Limits

Frequency MHz	Test Distance (Meters)	Field Strength Limit (µV/m @ 3m)	(dBµV/m @ Test Distance)
30 to 88	10	100	29.5
88 to 216	10	150	33.0
216 to 960	10	200	35.5
960 to 1000	10	500	43.5
1000 to 18000	3	500	54.0
18000 to 26500	1	500	63.6
26500 to 100000	.1	500	83.5

3.3 Test Results

Emissions were measured from 30 MHz to 100 GHz. Peak detection was used during the test for the fundamental and harmonics. Quasi-Peak detection was used for spurious emissions below 1 GHz.

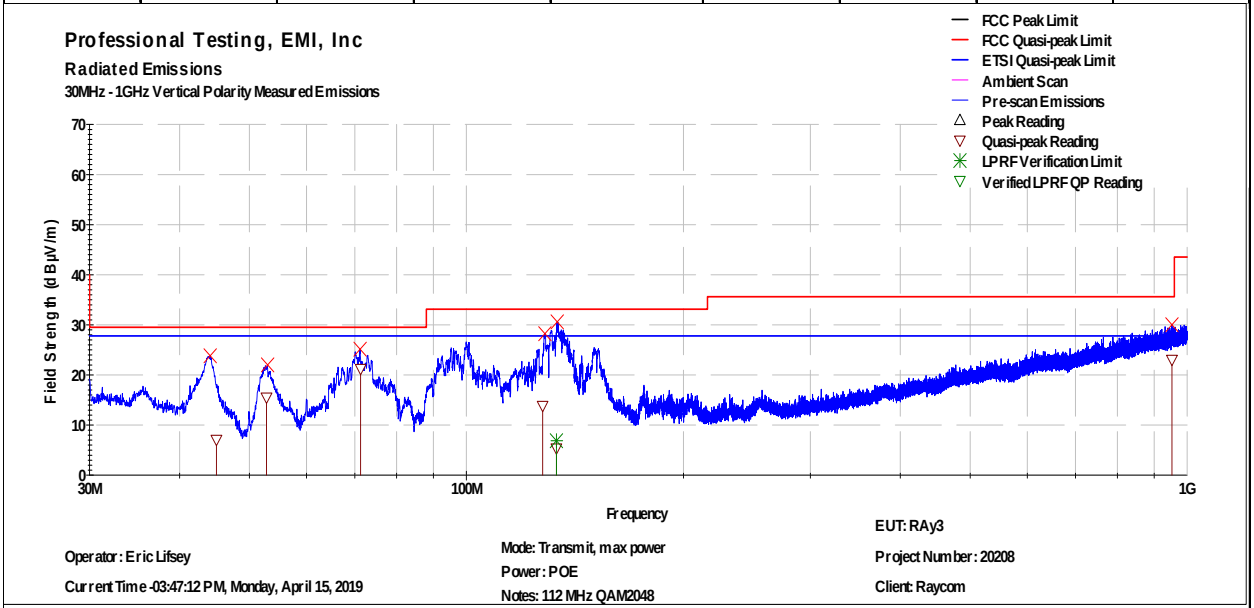
The EUT satisfied the criteria.

3.3.1 Emissions 30 MHz to 1 GHz

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	4/15/2019	EUT Serial #:	U18015233941
Customer:	Racom	EUT Part #:	
Project Number:	20208-15	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	RAy3-24	Witness' Name:	None

Radiated Emissions Test Results Data Sheet			
EUT Line Voltage:	POE VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	30MHz to 1GHz
EUT Mode of Operation:		Transmit	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
44.991	10	20	1.28	Quasi-peak	7.077	29.5	-22.4	Pass
52.809	10	148	1.84	Quasi-peak	15.509	29.5	-14.0	Pass
71.332	10	5	1.27	Quasi-peak	21.207	29.5	-8.3	Pass
127.564	10	261	1.25	Quasi-peak	13.852	33.1	-19.2	Pass
133.286	10	290	1.27	Quasi-peak	5.348	33.1	-27.8	Pass
952.581	10	354	1.25	Quasi-peak	23.038	35.6	-12.6	Pass



≤ 1GHz Vertical Antenna Polarity Measured Emissions

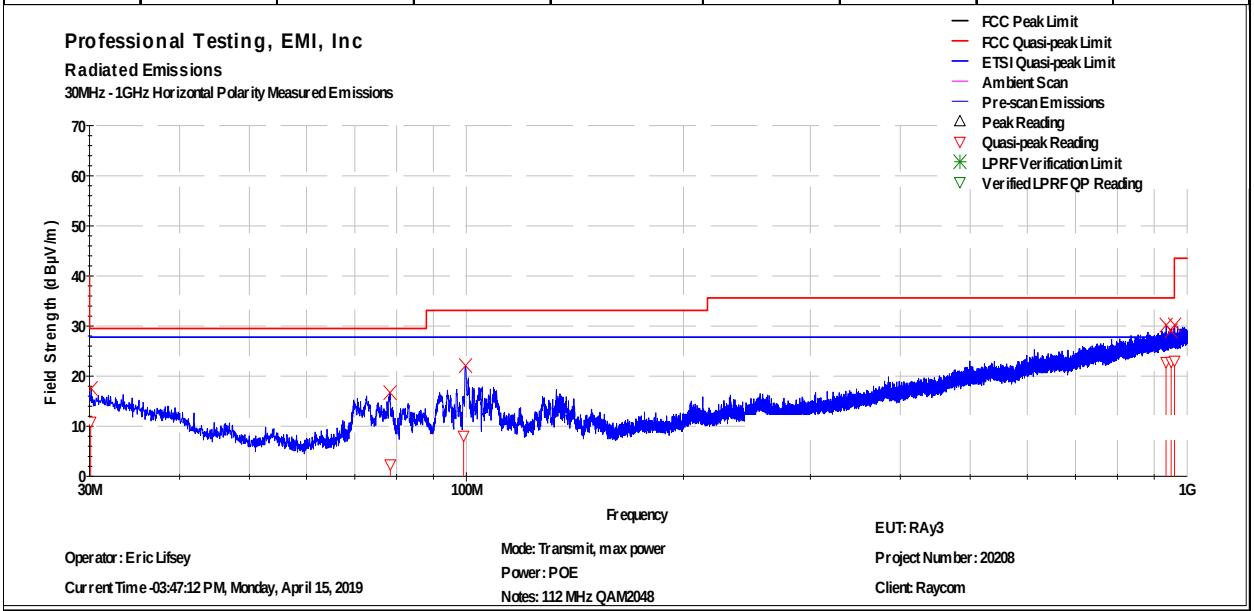
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	4/15/2019	**EUT Serial #:**	U18015233941
Customer:	Racom	**EUT Part #:**	
Project Number:	20208-15	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	RAy3-24	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet

EUT Line Voltage:	POE VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	30MHz to 1GHz
EUT Mode of Operation:		Transmit	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
30.102	10	194	1.26	Quasi-peak	10.929	29.5	-18.6	Pass
78.403	10	357	1.71	Quasi-peak	2.431	29.5	-27.1	Pass
99.097	10	226	1.26	Quasi-peak	8.117	33.1	-25.0	Pass
934.957	10	162	1.24	Quasi-peak	22.834	35.6	-12.8	Pass
950.327	10	2	1.25	Quasi-peak	22.88	35.6	-12.7	Pass
960.455	10	228	1.02	Quasi-peak	23.096	43.5	-20.4	Pass



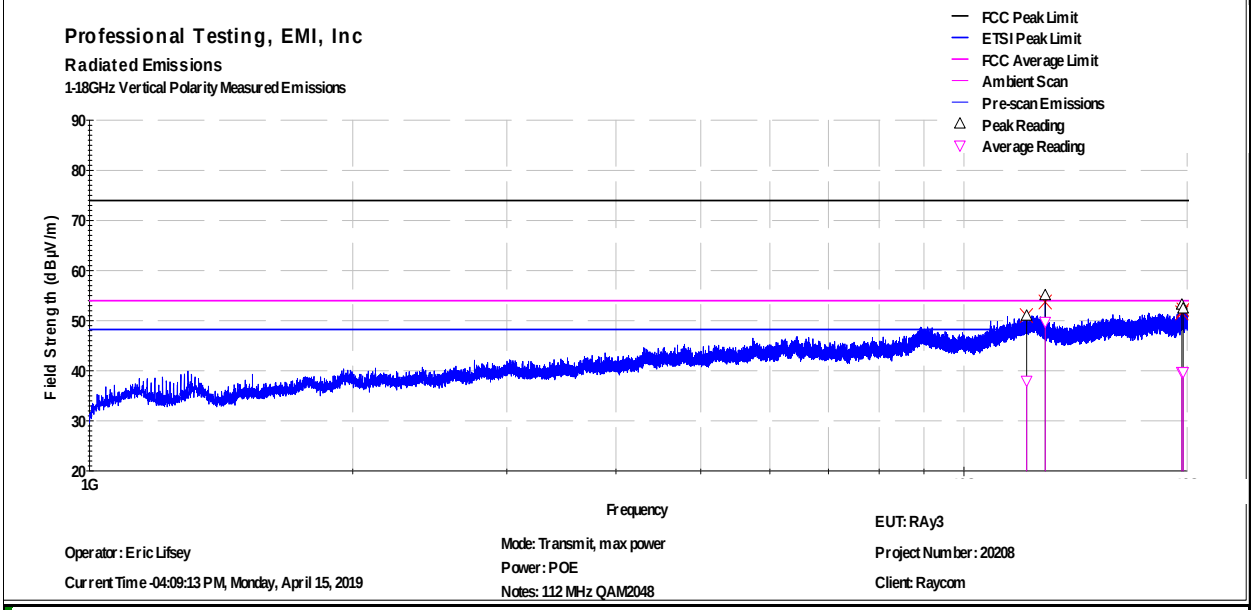
≤ 1GHz Horizontal Antenna Polarity Measured Emissions

3.3.2 Emissions 1 GHz to 18 GHz

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	4/15/2019	EUT Serial #:	U18015233941
Customer:	Racom	EUT Part #:	
Project Number:	20208-15	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	RAy3-24	Witness' Name:	None

Radiated Emissions Test Results Data Sheet			
EUT Line Voltage:	POE VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	Above 1GHz
EUT Mode of Operation:		Transmit	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
11792.4	3	249	1.04	Average	38.025	54.0	-15.9	Pass
12385.1	3	122	2.31	Average	49.784	54.0	-4.2	Pass
17750.61	3	184	1.79	Average	39.779	54.0	-14.2	Pass
17807.69	3	147	1.02	Average	39.735	54.0	-14.2	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

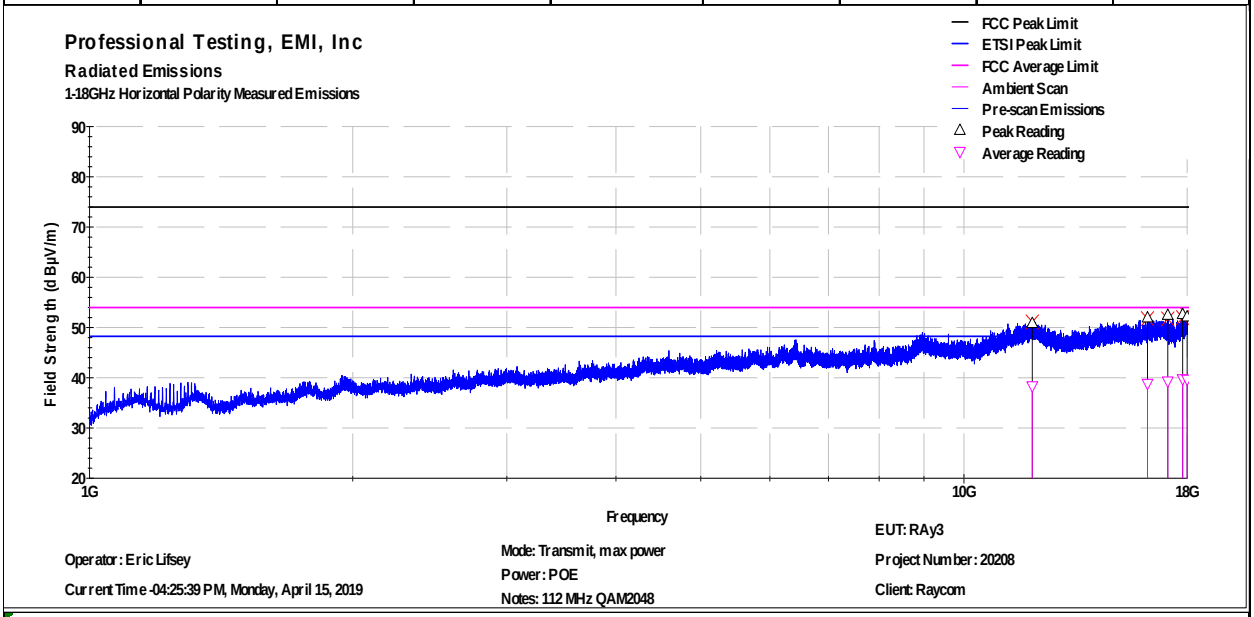
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.10: 2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	4/15/2019	**EUT Serial #:**	U18015233941
Customer:	Racom	**EUT Part #:**	
Project Number:	20208-15	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	RAy3-24	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet

EUT Line Voltage:	POE VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Transmit	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
11969.34	3	3	1.26	Average	38.338	54.0	-15.6	Pass
16216	3	229	1.23	Average	38.811	54.0	-15.1	Pass
17102.75	3	283	2.6	Average	39.296	54.0	-14.7	Pass
17783.75	3	110	3.07	Average	39.73	54.0	-14.2	Pass
17998.38	3	2	3.75	Average	39.628	54.0	-14.3	Pass

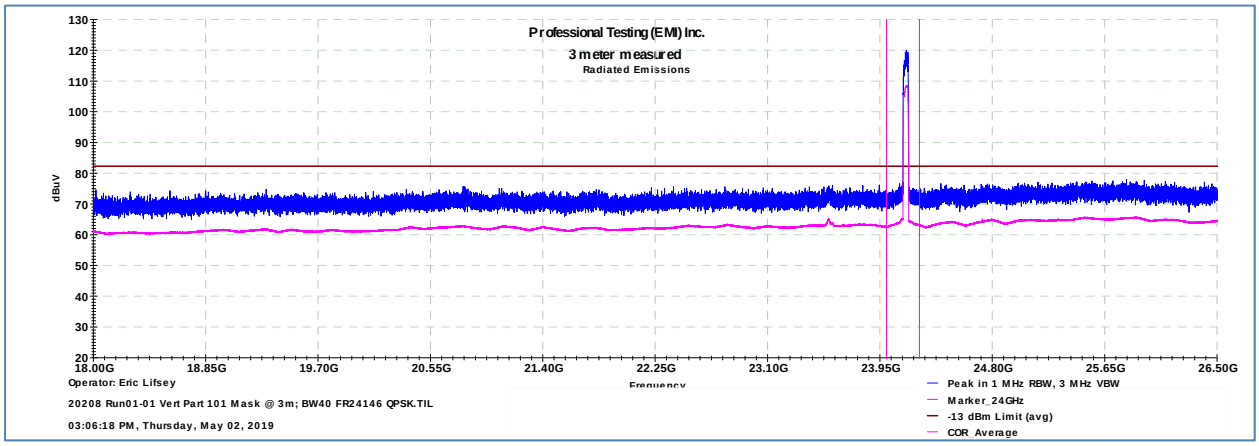


> 1GHz Horizontal Antenna Polarity Measured Emissions

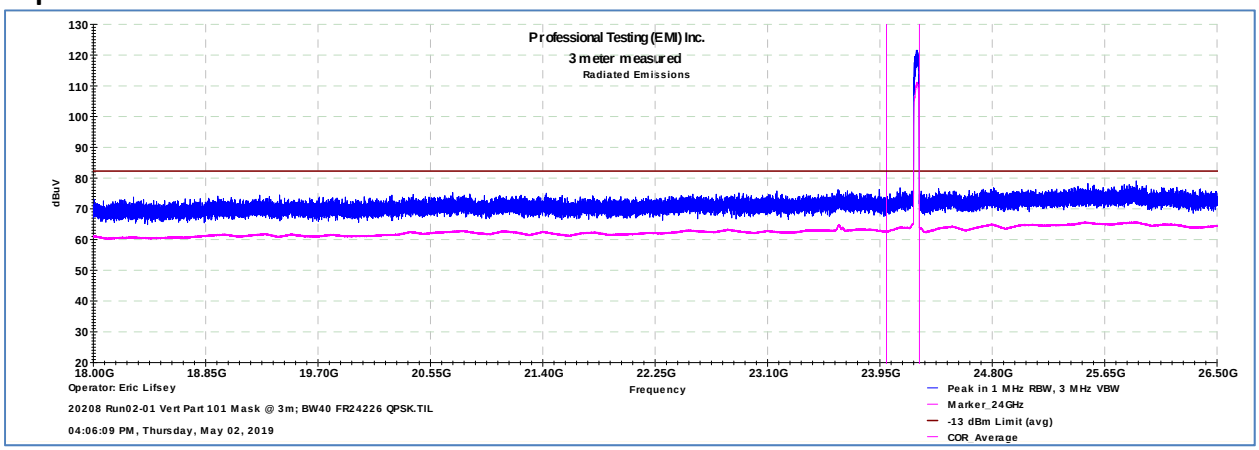
3.3.3 Emissions 18 GHz to 26.5 GHz

Limit for LMDS applied.

Bottom Channel



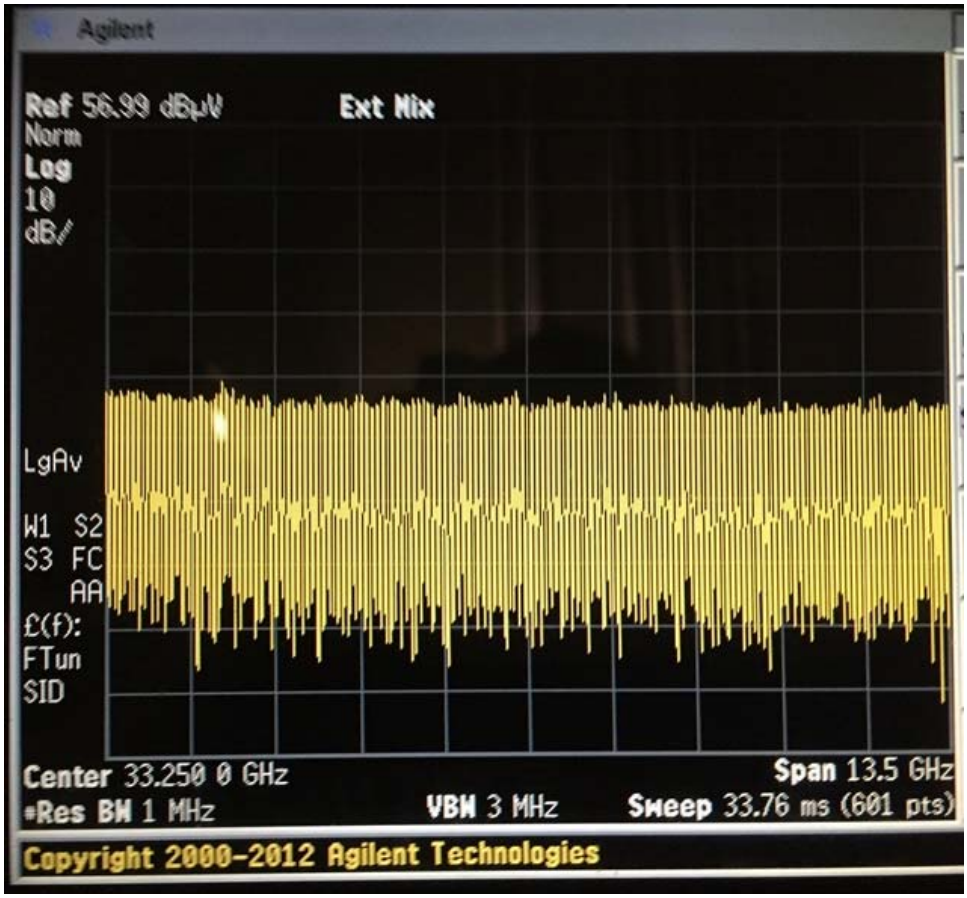
Top Channel



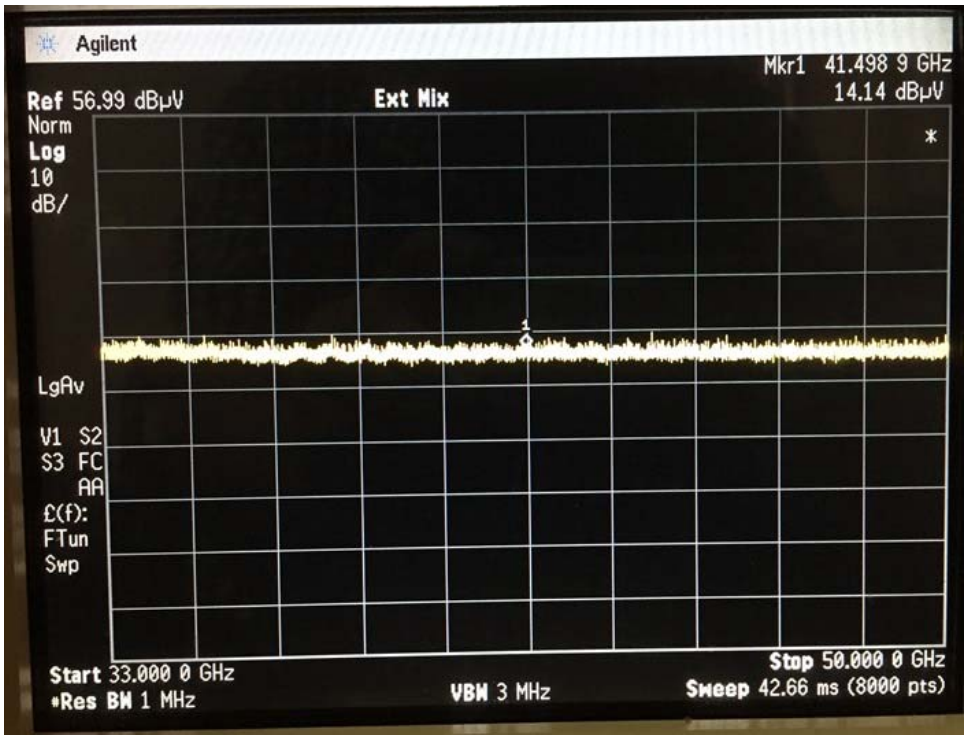
3.3.4 Emissions 26.5 GHz to 100 GHz

For this measurement the receive antenna was manually used to search for emissions of both polarities. The analyzer Signal Ident feature was used to identify valid signals; the display was recorded photographically.

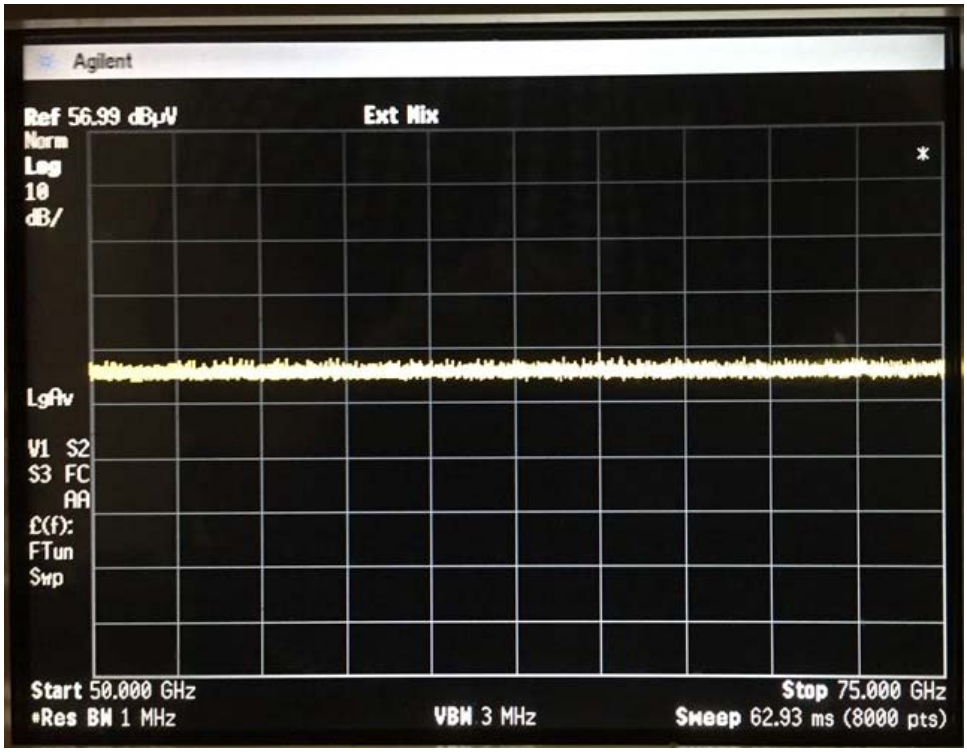
No signals were detected above the fundamental band. Signals 26.5 to 50 GHz were observed but all were eliminated when the Signal Ident function was enabled. At the higher bands up to 100 GHz there were no signals observed without the Signal Ident function.



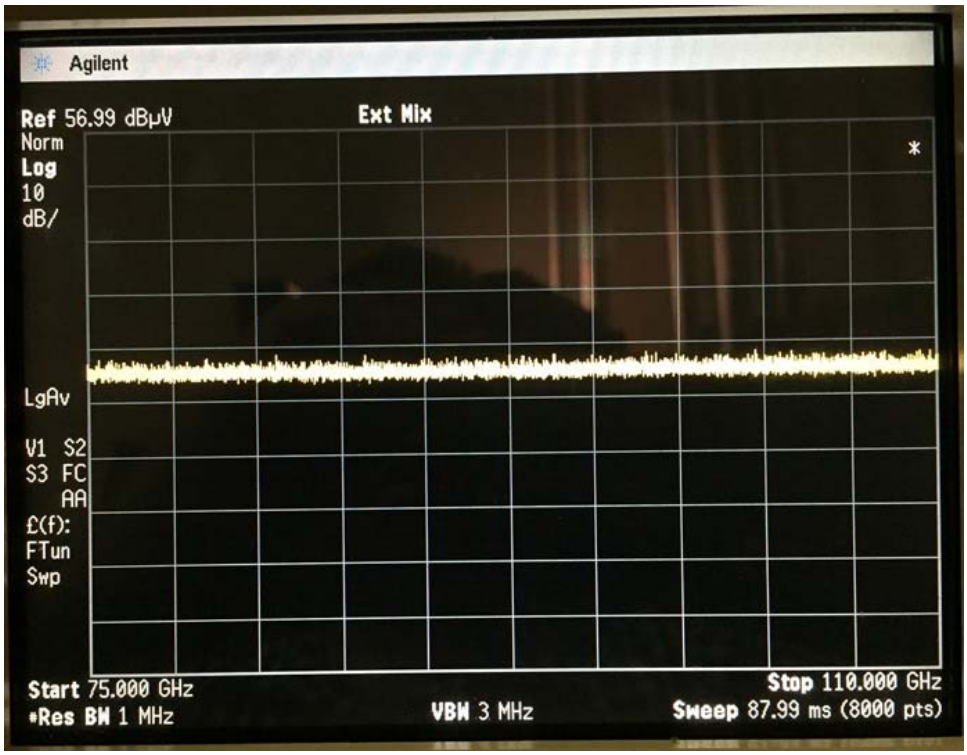
26.5 to 40 GHz



33 to 50 GHz



50 to 75 GHz


Agilent
Ref 56.99 dBµV
Ext Mix
Norm
Log
10
dB/
*
LgAv
V1 S2
S3 FC
AA
£(f):
FTun
Swp
Start 75.000 GHz
#Res BW 1 MHz
VBW 3 MHz
Stop 110.000 GHz
Sweep 87.99 ms (8000 pts)

75 to 110 GHz

4.0 FCC Part 101 Paragraph 111(a)(2)(iv) Emission Mask

4.1 Test Procedure

The EUT is placed into the widest bandwidth mode and each modulation type is measured to verify emission satisfies the criteria.

4.2 Test Criteria

"101.111(a)(2)(iv) The emission mask for LMDS and the 24 GHz Service shall use the equation in paragraph (a)(2)(ii) of this section and apply it only to the band edge of each block of spectrum […]"

$A = 11 + 0.4(P-50) + 10 Log_{10} B$. (Attenuation greater than 56 decibels or to an absolute power of less than -13 dBm/1MHz is not required.)

The mask is a band-edge measurement for 24000 to 24250 MHz for the top 3 widest bandwidth settings and for each supported modulation scheme. (As the rule cited 40 MHz bandwidth, that and the two higher supported bandwidths were measured.)

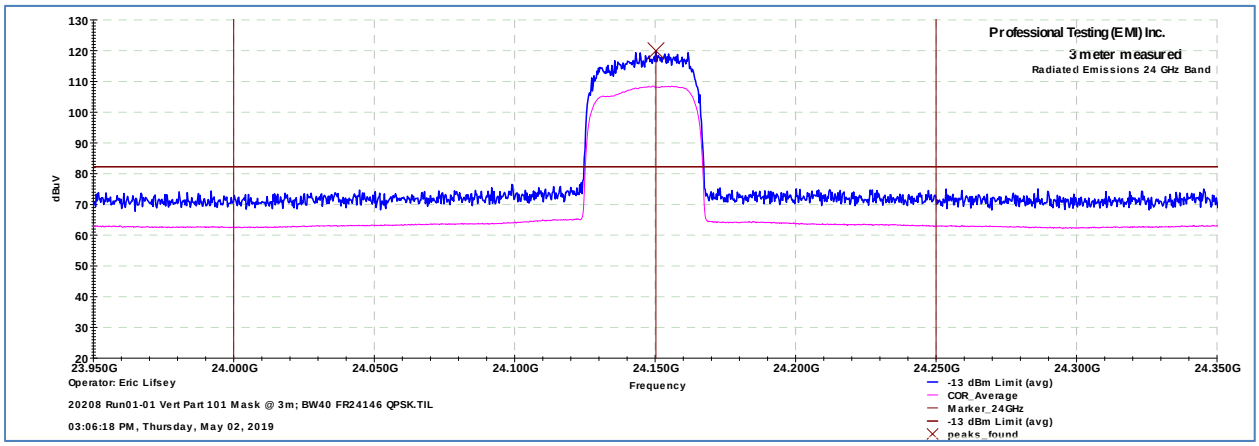
4.3 Test Results

In the plots below the spectrum from 18 to 26.5 GHz is presented with vertical marker lines marking the top and bottom of the 24000 to 24250 MHz band. Peak and video average detection is employed.

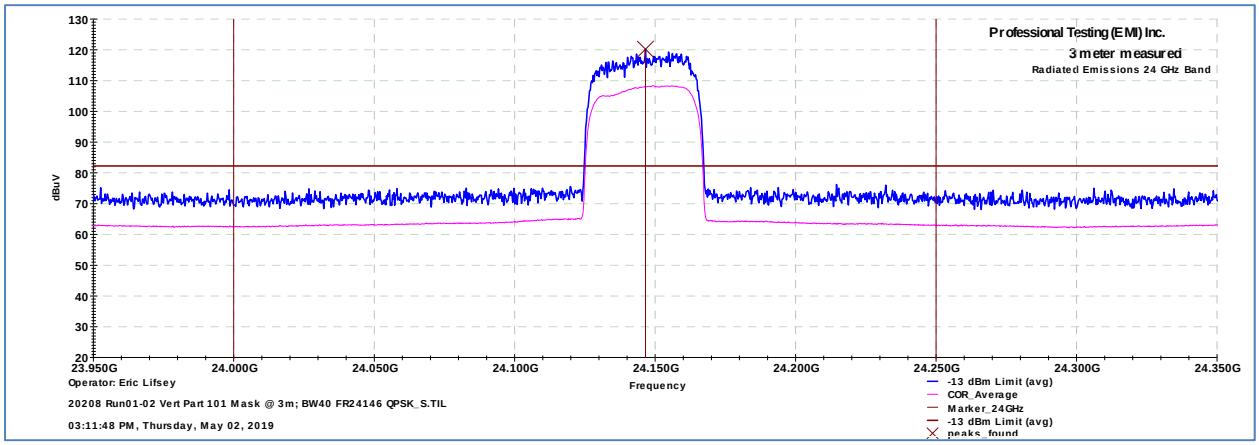
The EUT satisfied the requirements.

In the plots below it can be seen that out of band emissions at and beyond the band edges are well under the -13 dBm limit when restated as a radiated field at 1 meter. At these low levels the calculation of A attenuation was not required.

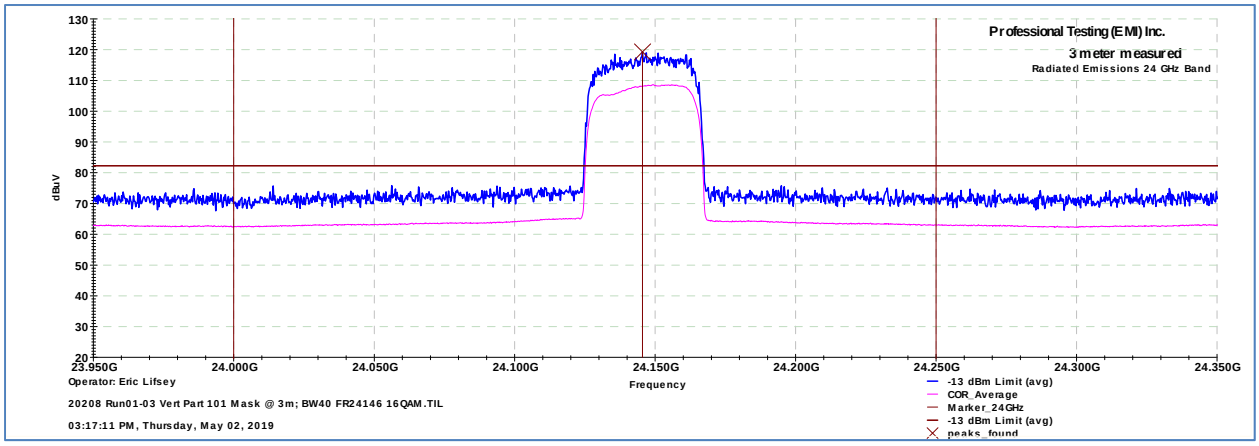
Bottom Channel 24.146 GHz



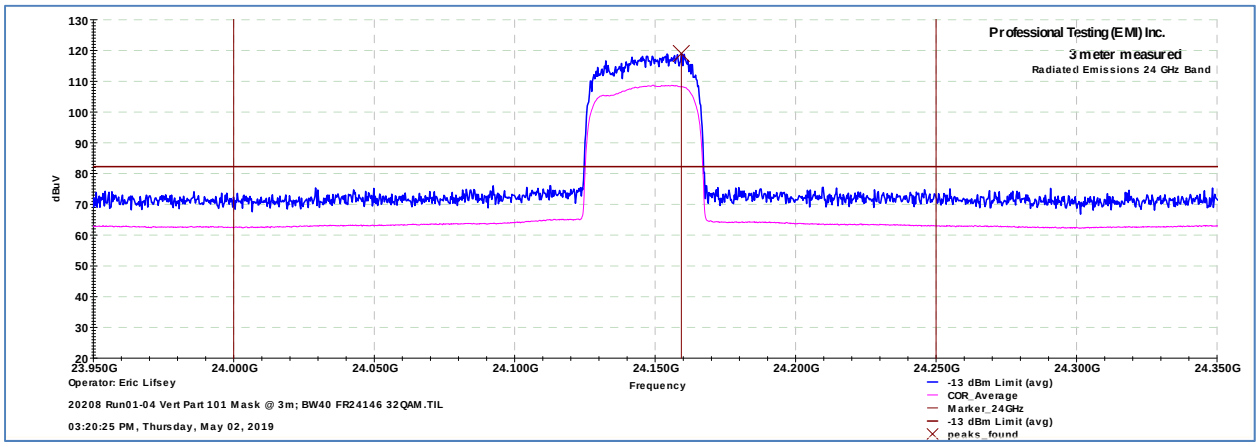
Bottom Channel 24.146 GHz BW 40 MHz QPSK



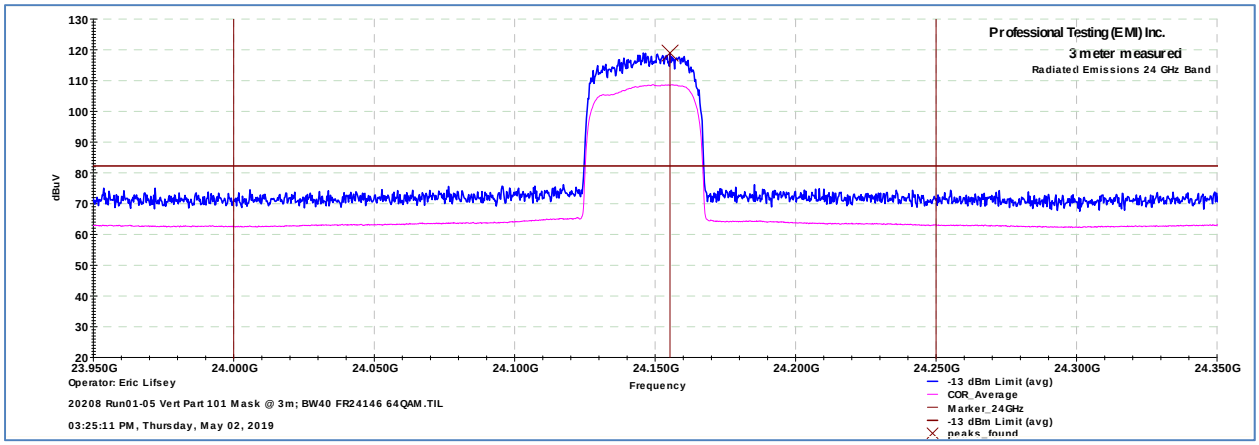
Bottom Channel 24.146 GHz BW 40 MHz QPSK_S



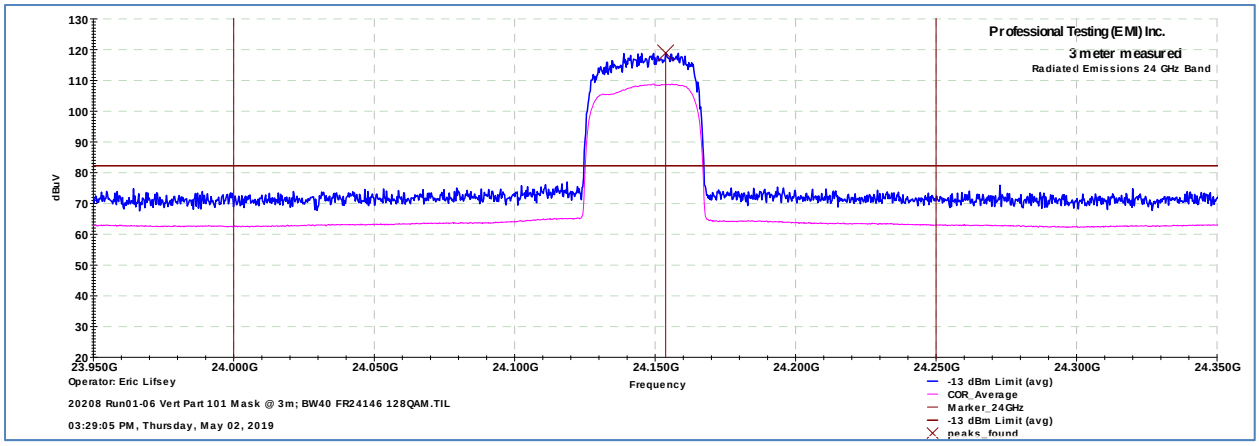
Bottom Channel 24.146 GHz BW 40 MHz 16QAM



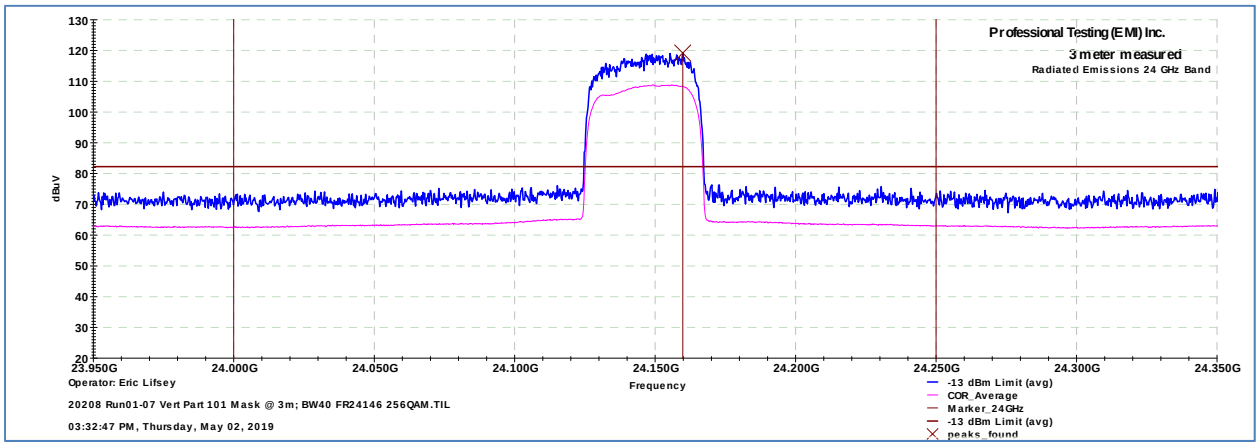
Bottom Channel 24.146 GHz BW 40 MHz 32QAM



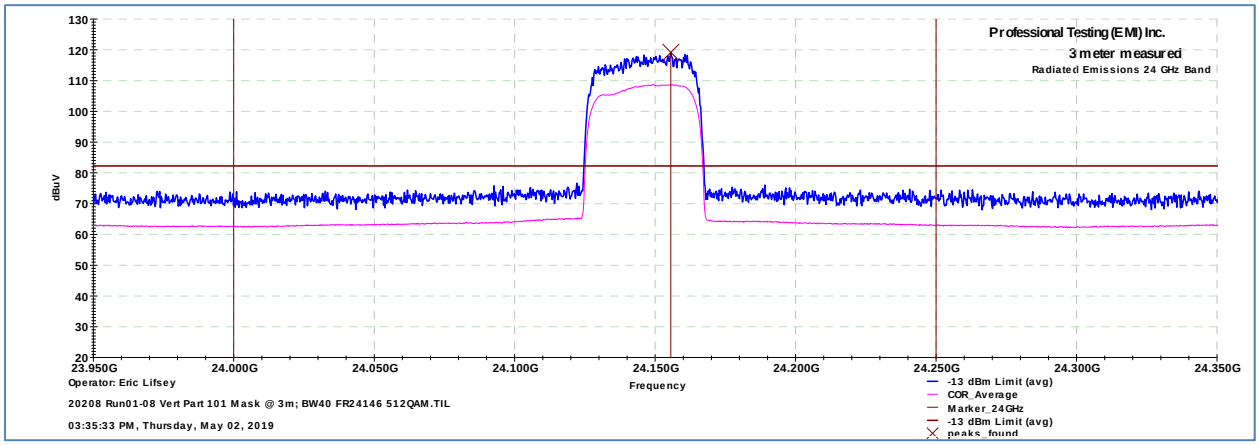
Bottom Channel 24.146 GHz BW 40 MHz 64QAM



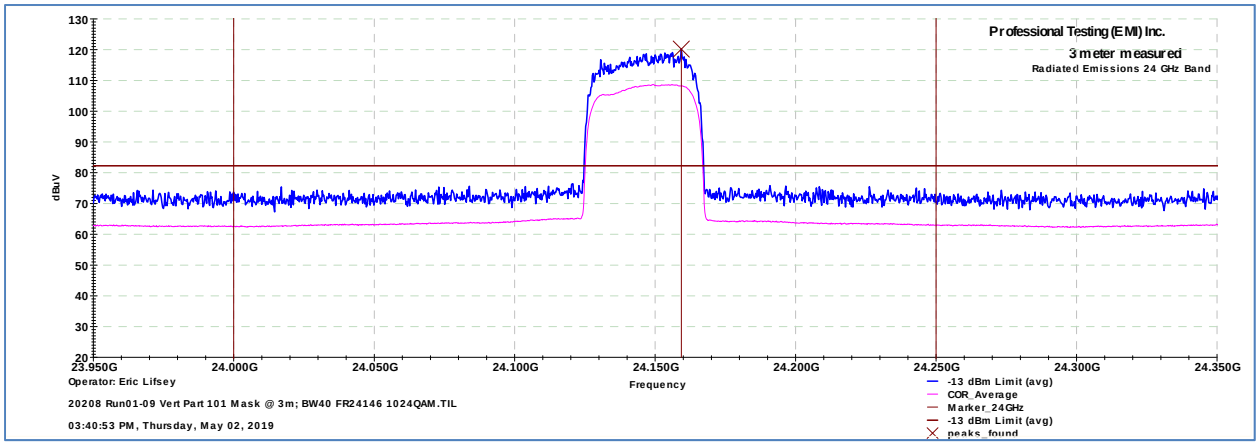
Bottom Channel 24.146 GHz BW 40 MHz 128QAM



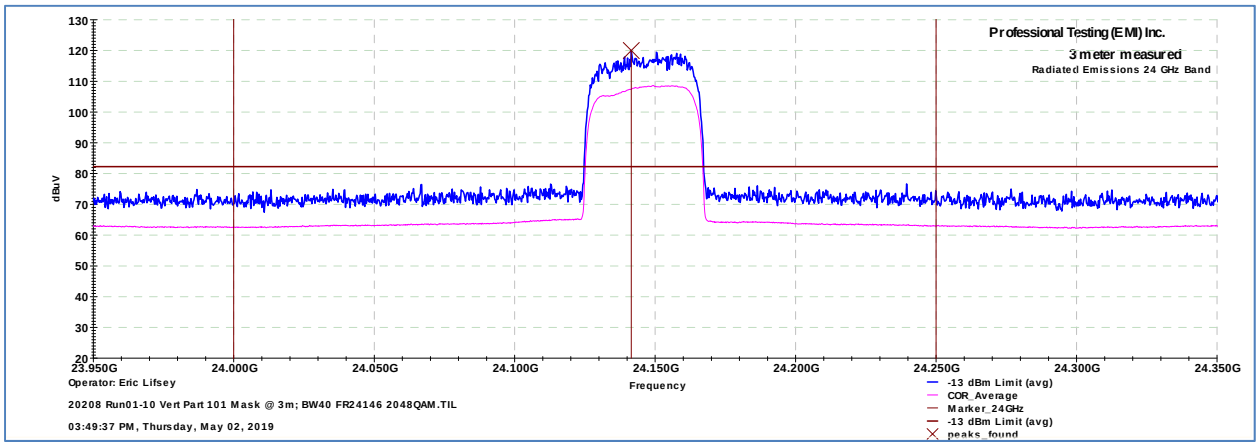
Bottom Channel 24.146 GHz BW 40 MHz 256QAM



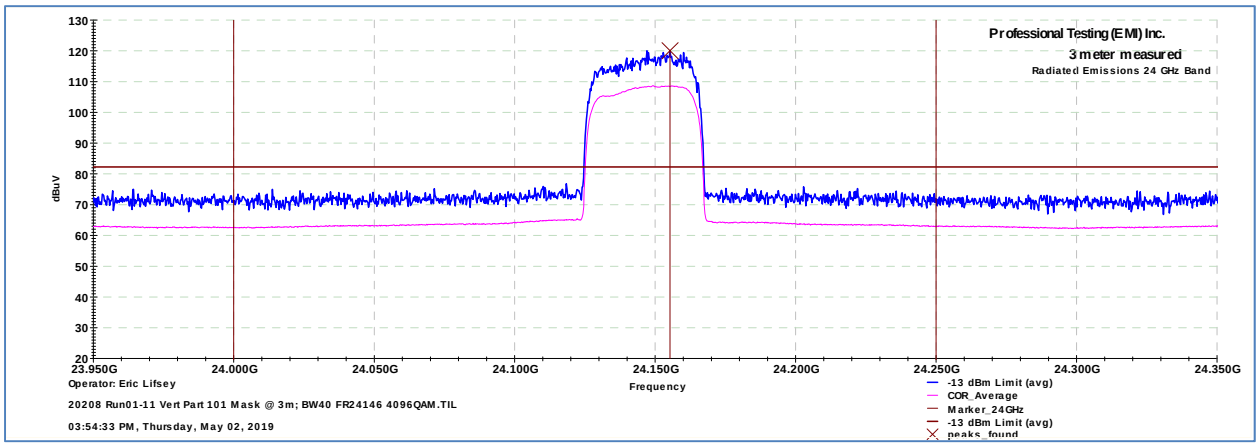
Bottom Channel 24.146 GHz BW 40 MHz 512QAM



Bottom Channel 24.146 GHz BW 40 MHz 1024QAM

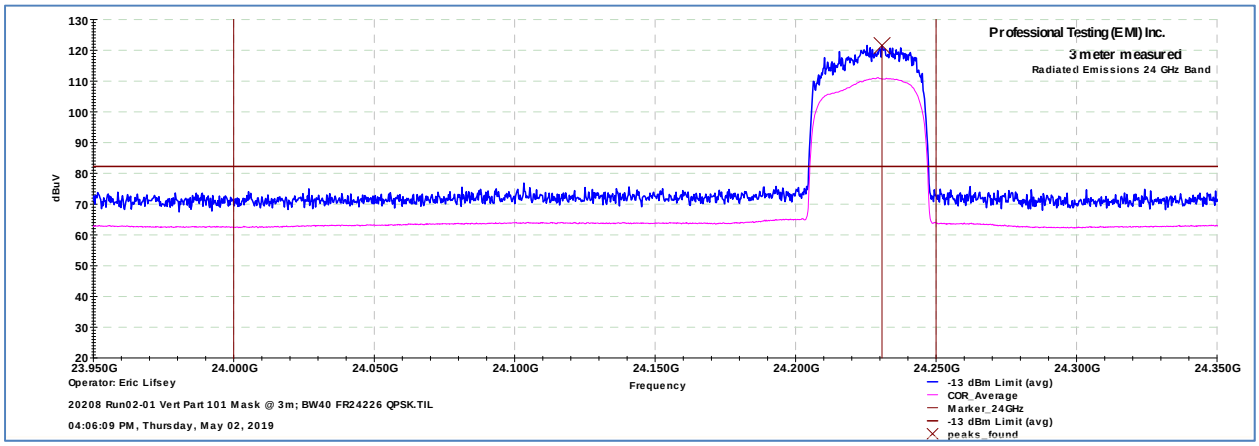


Bottom Channel 24.146 GHz BW 40 MHz 2048QAM

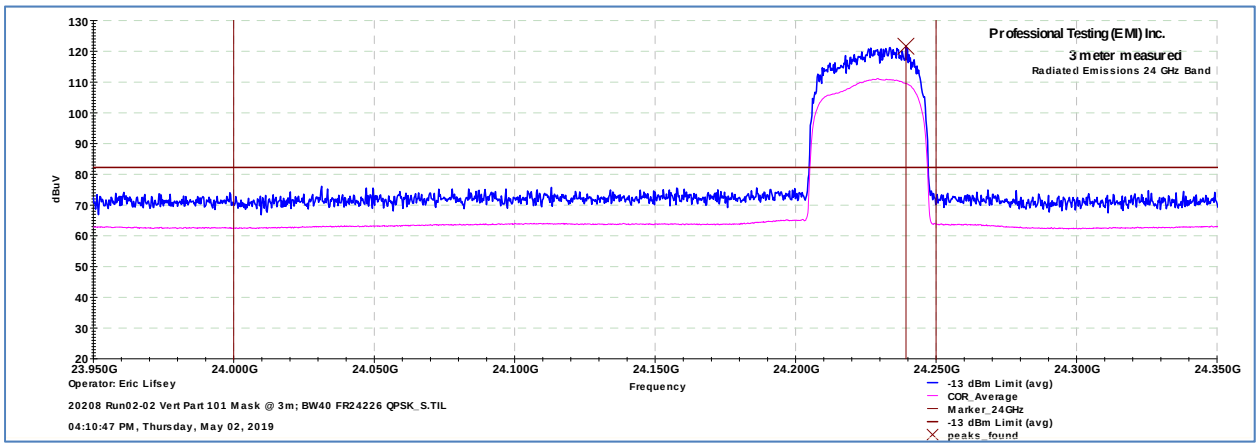


Bottom Channel 24.146 GHz BW 40 MHz 4096QAM

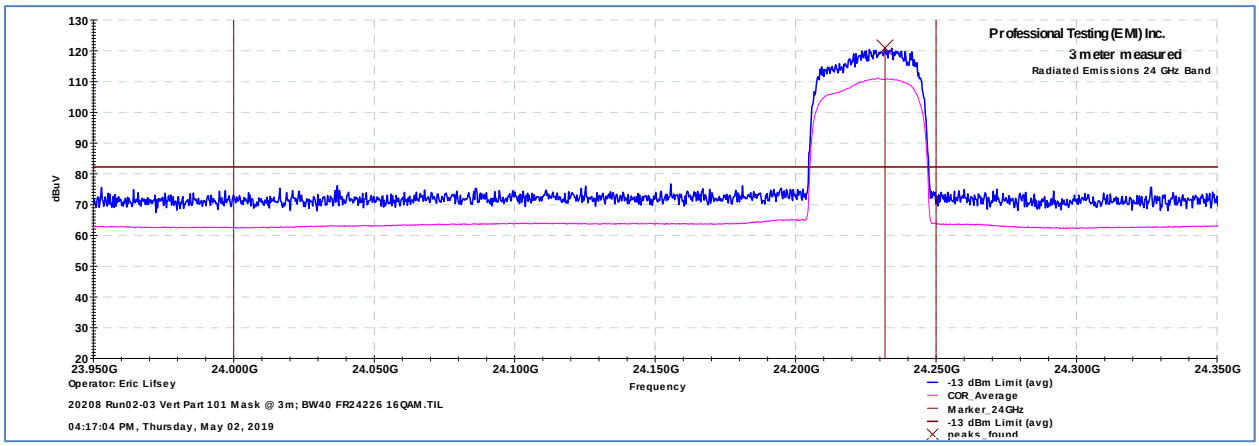
Top Channel 24.226 GHz



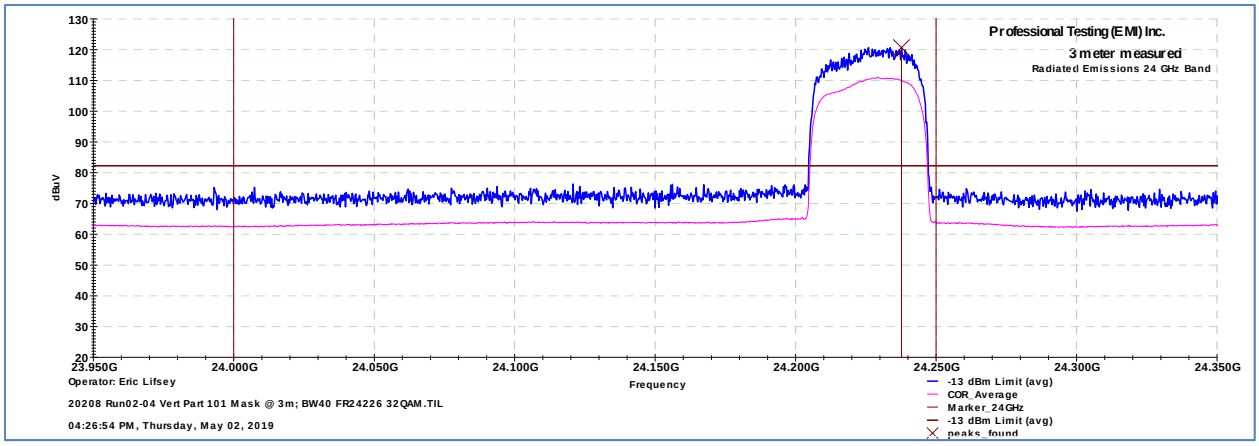
Top Channel 24.226 GHz BW 40 MHz QPSK



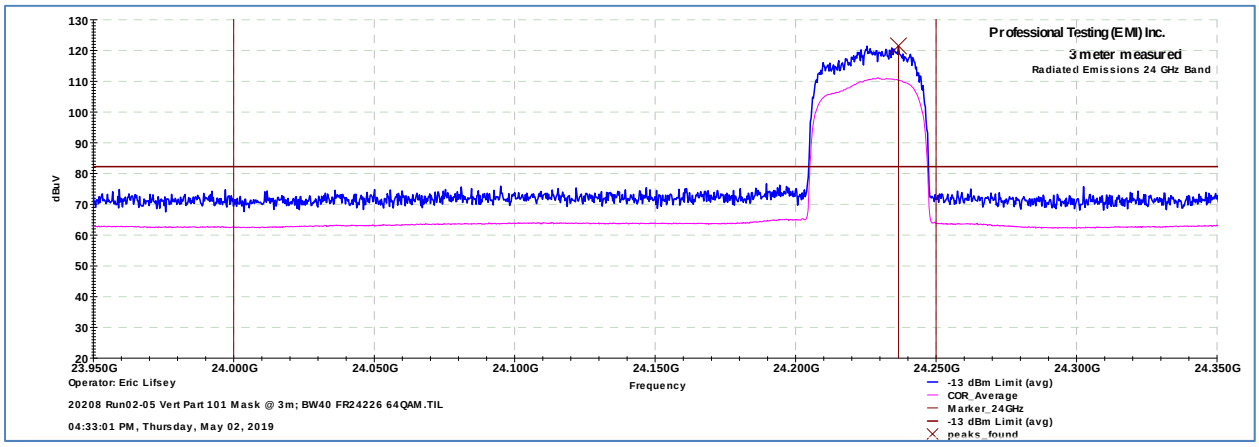
Top Channel 24.226 GHz BW 40 MHz QPSK_S



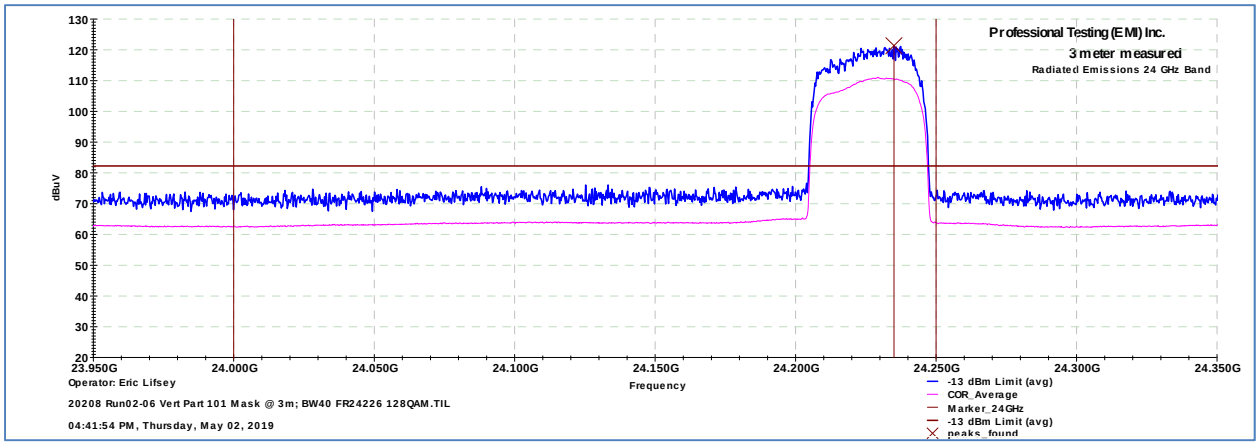
Top Channel 24.226 GHz BW 40 MHz 16QAM



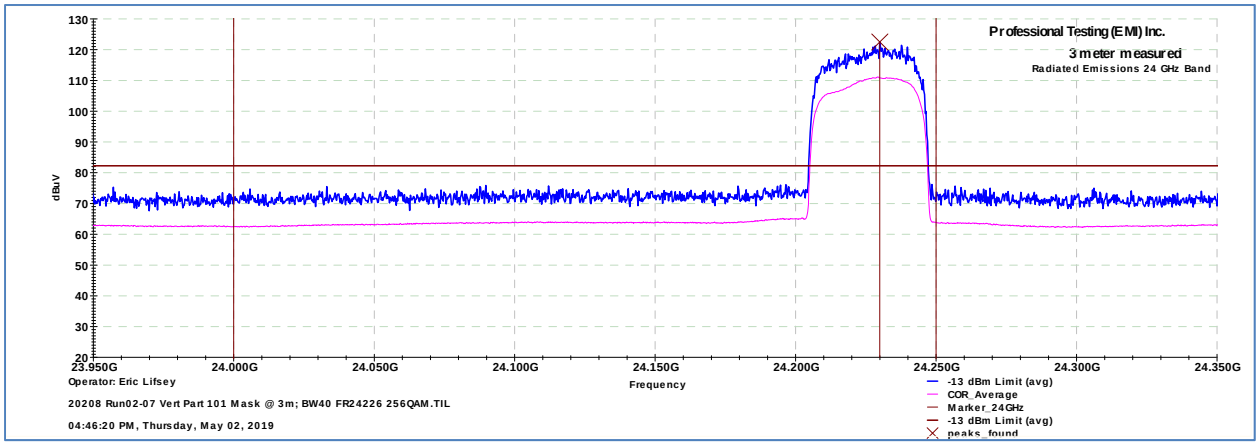
Top Channel 24.226 GHz BW 40 MHz 32QAM



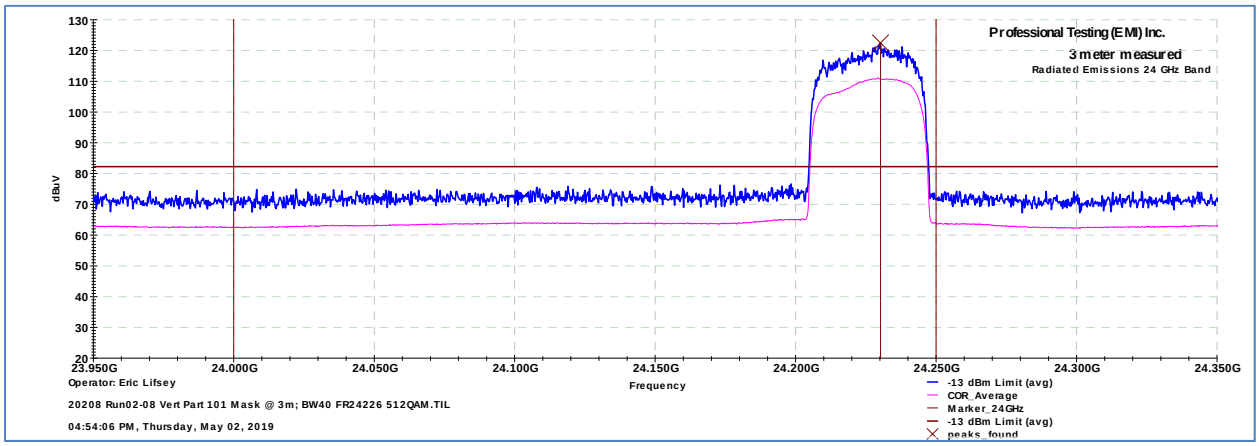
Top Channel 24.226 GHz BW 40 MHz 64QAM



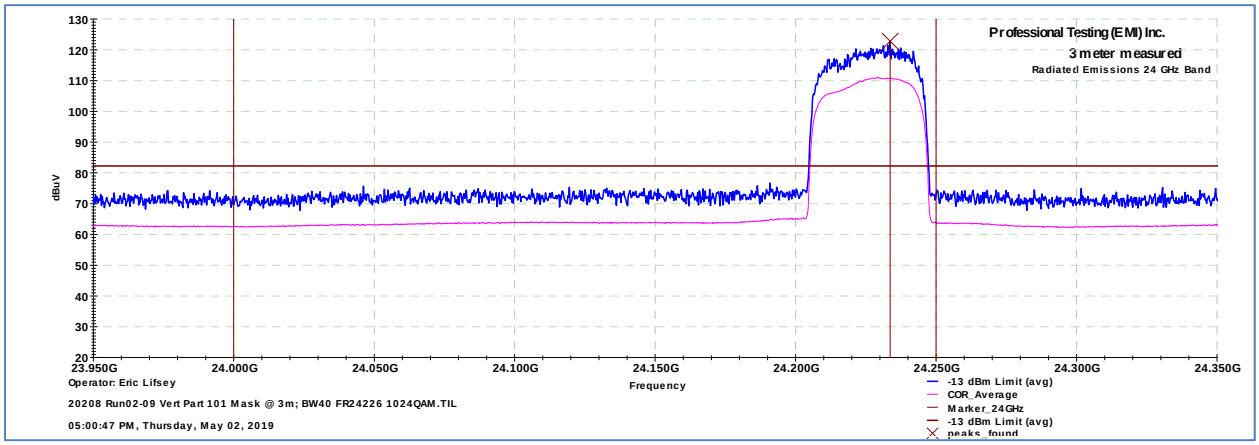
Top Channel 24.226 GHz BW 40 MHz 128QAM



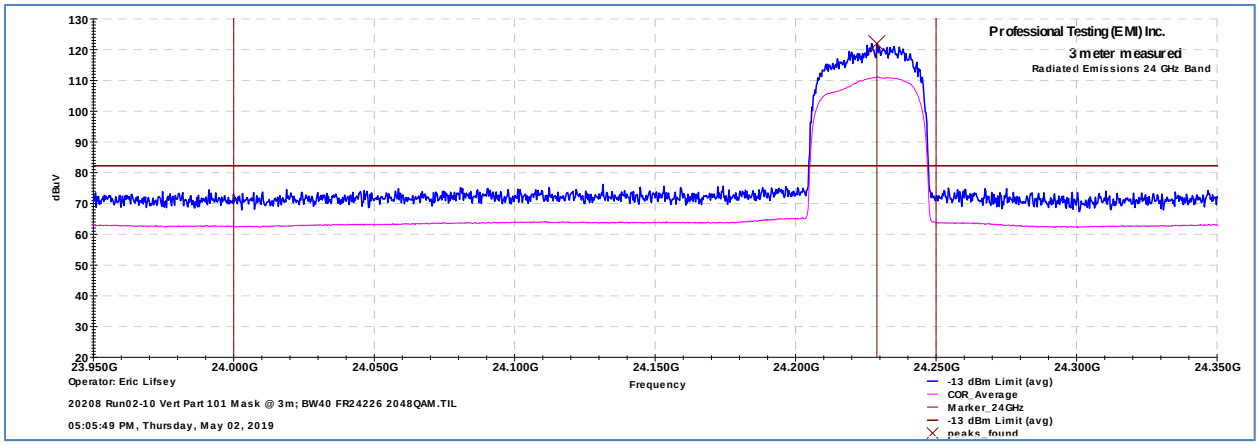
Top Channel 24.226 GHz BW 40 MHz 256QAM



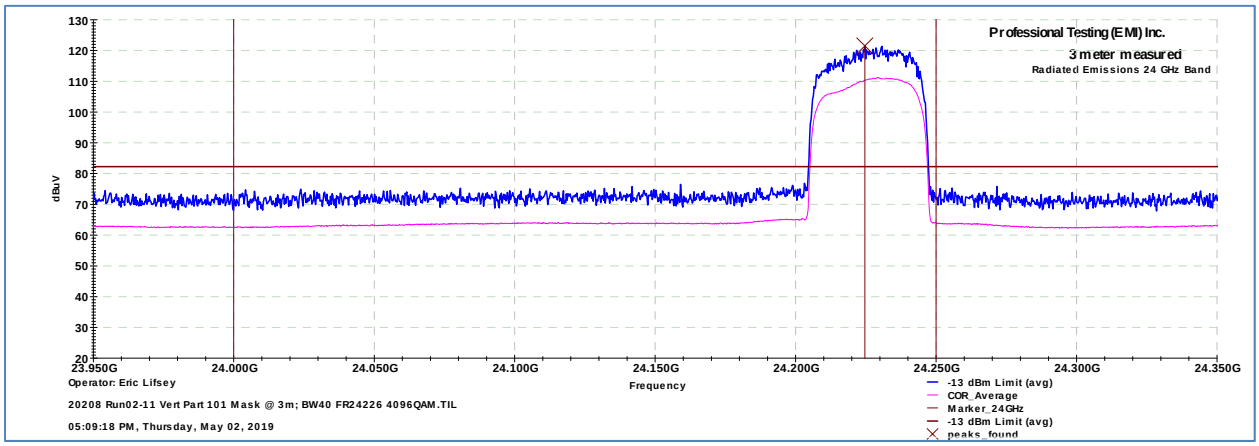
Top Channel 24.226 GHz BW 40 MHz 512QAM



Top Channel 24.226 GHz BW 40 MHz 1024QAM

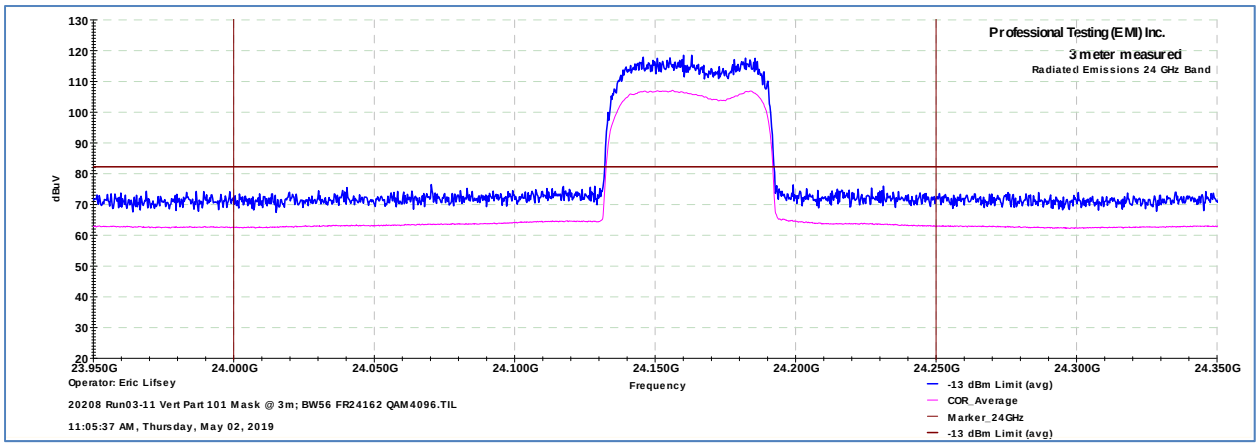


Top Channel 24.226 GHz BW 40 MHz 2048QAM



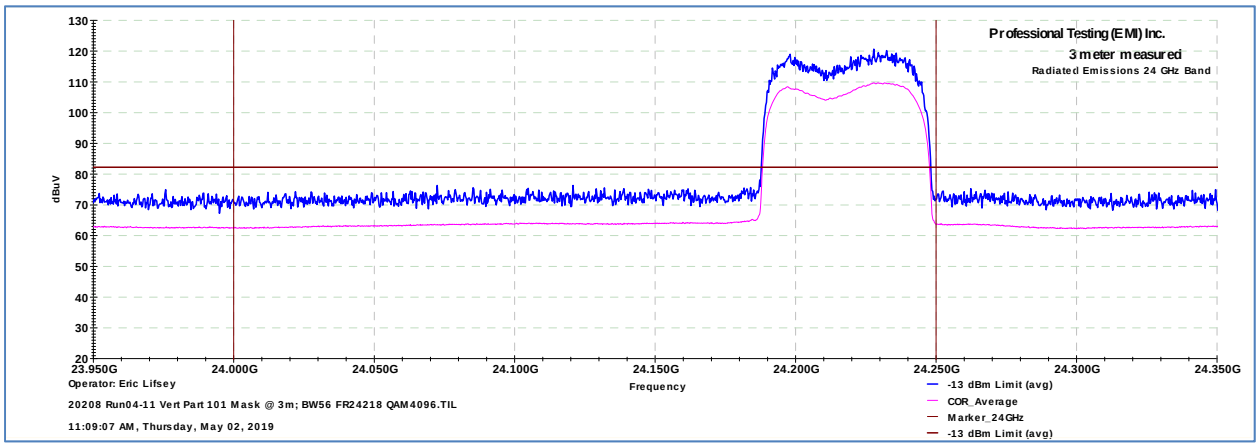
Top Channel 24.226 GHz BW 40 MHz 4096QAM

Bottom Channel 24.162 GHz



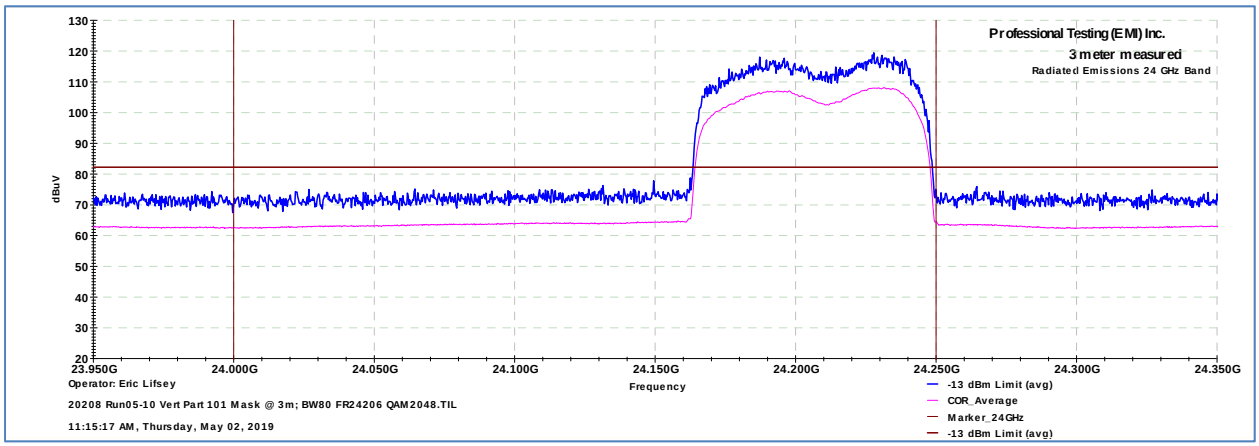
Bottom Channel 24.162 GHz BW 56 MHz QAM 4096

Top Channel 24.218 GHz

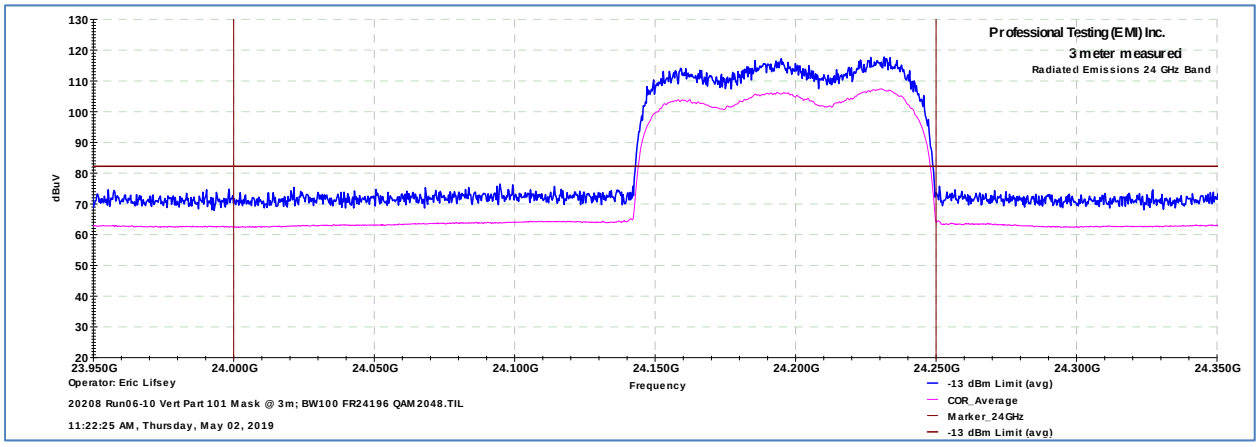


Top Channel 24.218 GHz BW 56 MHz QAM 4096

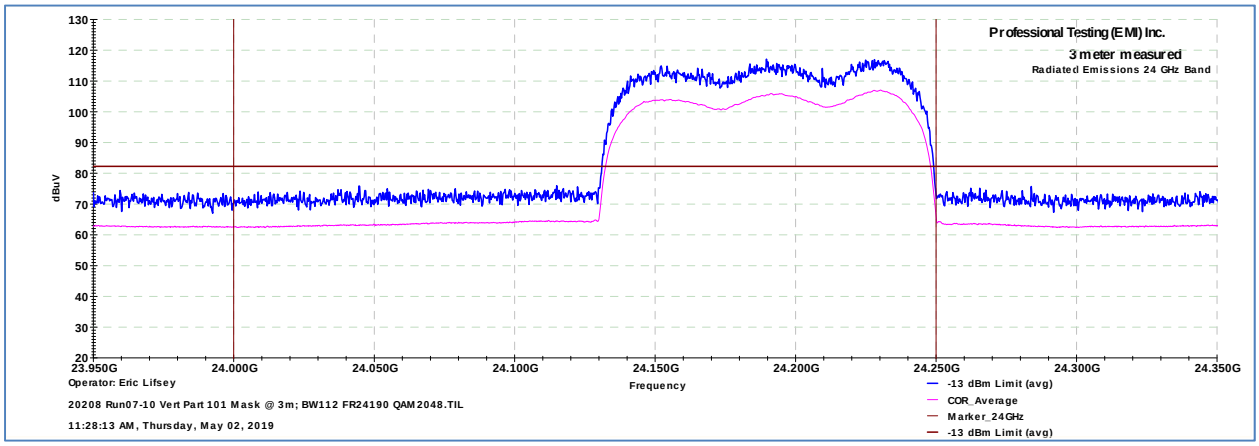
Single Channel for Bandwidths 80, 100, and 112 MHz



Single Channel BW 80 MHz QAM 2048



Single Channel BW 100 MHz QAM 2048



Single Channel BW 112 MHz QAM 2048

5.0 Antenna Requirement

5.1 Procedure

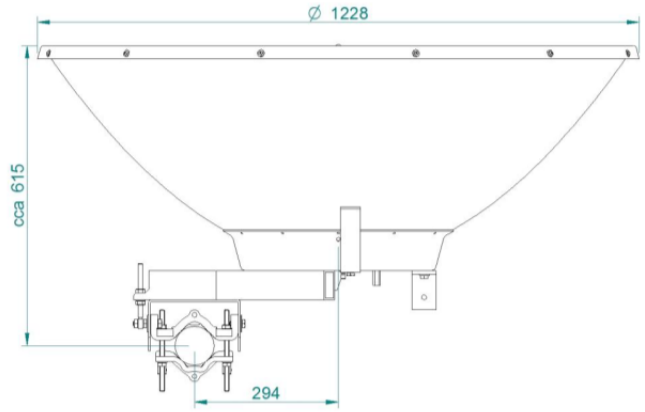
Examine the EUT antenna design and compare to the rule requirements.

5.2 Criteria & Results

Table 5.2.1: Criteria		
Section Reference	**Evaluation**	**Pass/Fail**
15.249(b)(3), RSS-210 Annex I (c) Minimum gain 33 dBi or main lobe beamwidth smaller than 3.5 degrees.	Antenna used for test gain is specified as 46.6 dBi. Other antennas of lower gain that comply are listed in the user manual.	Pass
15.249(b)(3), RSS-210 Annex I (c) At antenna gains over 33 dBi, power must be reduced to satisfy the 2500 mV/m limit.	At highest output power the EUT satisfied the field strength limit.	Pass

The EUT and antenna satisfied the requirements.

Table 5.2.2: Antenna Construction	
Model:	JRMB - 1200 -24Ra
Manufacturer:	Jirous, spol. s r.o. Nad Krocínkou 46Prague 9 190 00 Czech Republic
Type:	Parabolic



Frequency range	24.0 – 24.25 GHz
Gain	46.6 ± 0.6 dBi
Front to back ratio	≥ 66,2 dB
Beamwidth$_{-3\ dB}$	0.5°
Cross-port isolation	≥ 45 dB
Polarization	Vertical / Horizontal
Return loss (VSWR)	≥ 16 dB (≤ 1.4)
ETSI standard	EN 302-217-4-2 v1.5.1 Class 2

6.0 Frequency Stability

6.1 Test Procedure

The EUT is subjected to temperature and operating voltage extremes with the operating frequency measured.

6.2 Test Criteria

Section Reference	Parameter	Date(s)
15.249(b)	Frequency tolerance ± 0.001 % At 24000 MHz = 240 kHz	29-30 Apr 2019

6.3 Test Results

The EUT was unable to transmit unmodulated so the lowest bandwidth mode was employed. The settings were:

Modulation Mode: QPSK
Modulation BW: 3.5 MHz
Spectrum Analyzer RBW: 100 kHz
Sample: S/N 1801524241

The center frequency was determined by marking a randomly selected crossing of amplitude lines below the signal peak, one each symmetrically above and below the apparent center, then calculating the arithmetic mean.

An octave horn covering the operating frequency was placed covering the waveguide output of the EUT to receive the transmitted signal.

Note that the EUT was operated at a reduced power level of -6 dBm to prevent damage or other influence on operation by the marginally terminated waveguide.

Tabular results are presented below.

6.3.1 Operating Voltage

The EUT operated from either power over Ethernet (PoE) or from direct DC input voltage. The direct DC input was used for this test and the voltage range expanded beyond ±15% to cover the wider operating voltage specification of the EUT.

Low Channel				
Condition	**Voltage**	**Frequency**		
Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
User Def	20.00	24055	24055.017	17000
User Def	40.00	24055	24055.010	10000
User Def	60.00	24055	24055.015	15000

Middle Channel				
Condition	**Voltage**	**Frequency**		
Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
User Def	20.00	24125	24125.020	20000
User Def	40.00	24125	24125.015	15000
User Def	60.00	24125	24125.015	15000

High Channel				
Condition	**Voltage**	**Frequency**		
Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
User Def	20.00	24175	24175.020	20000
User Def	40.00	24175	24175.015	15000
User Def	60.00	24175	24175.015	15000

6.3.2 Operating Temperature

Low Channel			
Condition	**Frequency**		**Deviation**
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-20	24055	24055.020	20000
-10	24055	24055.020	20000
0	24055	24055.015	15000
10	24055	24055.020	20000
20	24055	24055.010	10000
30	24055	24055.005	5000
40	24055	24055.000	0
50	24055	24055.005	5000
Max Deviation (Hz)			20000
Min Deviation (Hz)			0

Middle Channel			
Condition	**Frequency**		**Deviation**
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-20	24125	24125.020	20000
-10	24125	24125.020	20000
0	24125	24125.005	5000
10	24125	24125.010	10000
20	24125	24125.015	15000
30	24125	24125.005	5000
40	24125	24124.990	-10000
50	24125	24125.005	5000
Max Deviation (Hz)			20000
Min Deviation (Hz)			-10000

High Channel			
Condition	**Frequency**		**Deviation**
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-20	24175	24175.015	15000
-10	24175	24175.010	10000
0	24175	24175.010	10000
10	24175	24175.015	15000
20	24175	24175.015	15000
30	24175	24175.015	15000
40	24175	24175.010	10000
50	24175	24175.015	15000
Max Deviation (Hz)			15000
Min Deviation (Hz)			10000

7.0 Mains Conducted Emissions

7.1 Test Procedure

Measure emissions the EUT injects into the AC mains network when terminated into a standard line impedance network (LISN).

7.2 Criteria

Section Reference	Parameter	Date(s)
15.107 RSS-Gen	Conducted Emissions AC Mains 150 kHz to 30 MHz	19 Jun 2019

7.3 Results

The EUT satisfied the requirements. Results presented below.

Professional Testing, EMI, Inc.

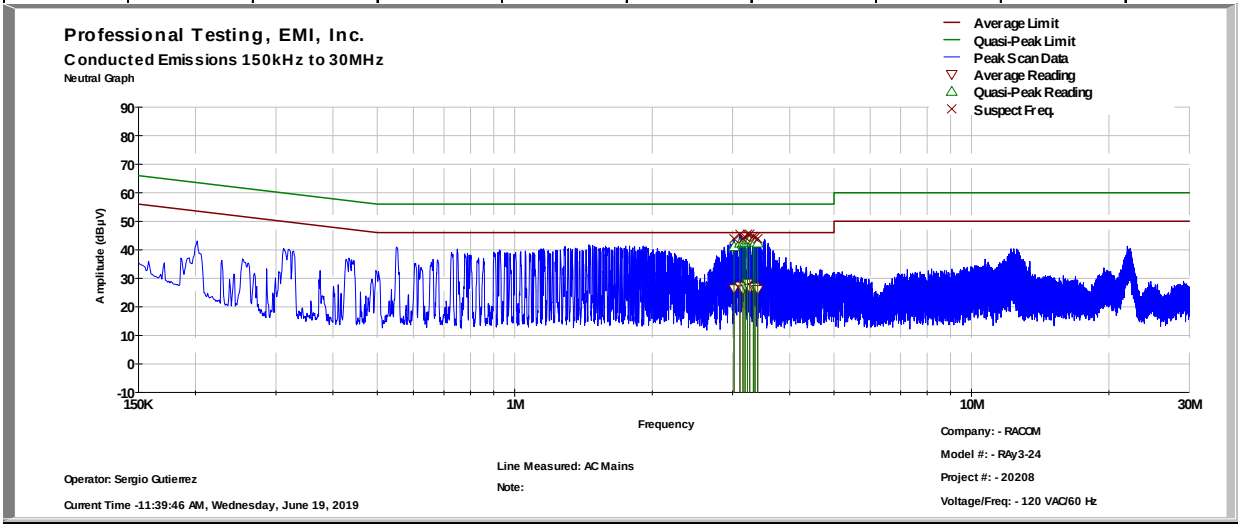
Test Method:	**ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz**
In accordance with:	**FCC Part 15.107 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Conducted Limits**
Section:	**15.107**

Test Date(s):	**6/19/2019**	**EUT Serial #:**	**1801524241**
Customer:	**RACOM**	**EUT Part #:**	**RAy3-24**
Project Number:	**20208**	**Test Technician:**	**Sergio Gutierrez**
Purchase Order #:	**N/A**	**Supervisor:**	**Shakil Murad**
Equip. Under Test:	**RAy3-24**	**Witness' Name:**	**N/A**

Conducted Emissions Test Results Data Sheet - Neutral Lead **Page: 1 of 2**

EUT Line Voltage:	**120**	**VAC**	**EUT Line Frequency:**	**60**	**Hz**

Frequency Measured (MHz)	Peak Detector Reading (dBµV)	Quasi-peak Detector Reading (dBµV)	Quasi-peak Detector Limit (dBµV)	Quasi-peak Detector Margin (dB)	Quasi-peak Detector Test Results	Average Detector Reading (dBµV)	Average Detector Limit (dBµV)	Average Detector Margin (dB)	Average Detector Test Results
3.0216	45.6	41	56	-15	PASS	26.4	46	-19.6	PASS
3.1141	47.2	42.2	56	-13.8	PASS	27.4	46	-18.6	PASS
3.1599	46.9	42.4	56	-13.6	PASS	26.1	46	-19.9	PASS
3.1937	47.1	42.6	56	-13.4	PASS	27.3	46	-18.7	PASS
3.2335	48.1	43.3	56	-12.7	PASS	28.4	46	-17.6	PASS
3.2693	47.9	43.5	56	-12.5	PASS	26.6	46	-19.4	PASS
3.332	48.2	43.3	56	-12.7	PASS	26.8	46	-19.2	PASS
3.3579	47.8	42.5	56	-13.5	PASS	27	46	-19	PASS
3.4056	47.1	42.3	56	-13.7	PASS	26.2	46	-19.8	PASS



Measured Conducted Emissions - Neutral Lead

Professional Testing, EMI, Inc.

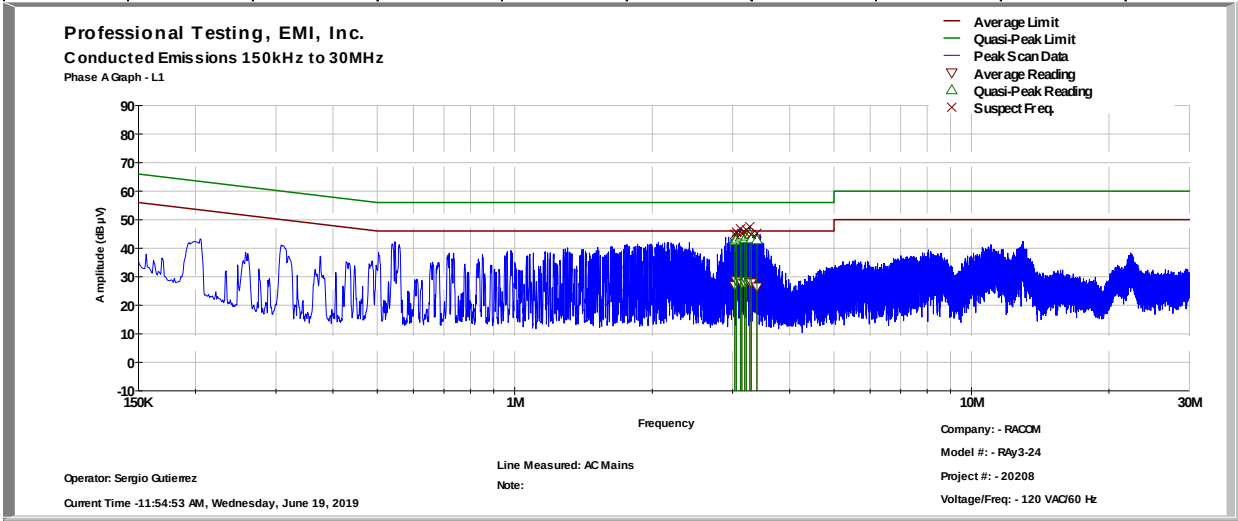
Test Method:	**ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz**
In accordance with:	**FCC Part 15.107 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Conducted Limits**
Section:	**15.107**

Test Date(s):	**6/19/2019**	**EUT Serial #:**	**1801524241**
Customer:	**RACOM**	**EUT Part #:**	**RAy3-24**
Project Number:	**20208**	**Test Technician:**	**Sergio Gutierrez**
Purchase Order #:	**N/A**	**Supervisor:**	**Shakil Murad**
Equip. Under Test:	**RAy3-24**	**Witness' Name:**	**N/A**

Conducted Emissions Test Results Data Sheet - Phase Lead (Line 1) **Page: 2 of 2**

EUT Line Voltage:	**120**	**VAC**	**EUT Line Frequency:**	**60**	**Hz**

Frequency Measured (MHz)	Peak Detector Reading (dBµV)	Quasi-peak Detector Reading (dBµV)	Quasi-peak Detector Limit (dBµV)	Quasi-peak Detector Margin (dB)	Quasi-peak Detector Test Results	Average Detector Reading (dBµV)	Average Detector Limit (dBµV)	Average Detector Margin (dB)	Average Detector Test Results
3.0335	47.2	42.5	56	-13.5	PASS	27	46	-19	PASS
3.0584	47.6	43.1	56	-12.9	PASS	28.7	46	-17.3	PASS
3.1221	48.4	43.8	56	-12.2	PASS	28.3	46	-17.7	PASS
3.143	48.8	44.5	56	-11.5	PASS	27.6	46	-18.4	PASS
3.1897	47.9	43.2	56	-12.8	PASS	27.7	46	-18.3	PASS
3.2156	48.3	44.1	56	-11.9	PASS	28.5	46	-17.5	PASS
3.2713	49.2	44.8	56	-11.2	PASS	28	46	-18	PASS
3.2962	48.4	43.1	56	-12.9	PASS	28	46	-18	PASS
3.3897	48	42.8	56	-13.2	PASS	26.5	46	-19.5	PASS



Measured Conducted Emissions - Phase Lead (Line 1)

8.0 Test Equipment

Table 8.0.1 – Radiated Emissions 30 MHz to 26.5 GHz

Radiated Emissions Test Equipment List					
Tile! Software Version:		**Version: 7.1.2.17 (Jan 08, 2016 - 02:12:48 PM) or 4.1.A.0, April 14, 2009, 11:01:00PM**			
Test Profile:		**2018_Radiated Emissions_TILE7_v1.2.til**			
Asset #	**Manufacturer**	**Model**	**Equipment Nomenclature**	**Serial Number**	**Calibration Due Date**
1509A	Braden	TDK 10M	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	7/10/2019
1890	HP	8447F-H64	Preamp/Amp, 9kHz-1300MHz, 28/25dB	3313A05298	1/10/2020
1937	Agilent	E4440A - AYZ	PSA , 3 Hz - 26.5 GHz, Opt. AYZ	MY44808298	11/8/2019
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	135454	3/11/2021
C027	none	RG214	Cable Coax, N-N, 25m, 30MHz - 1GHz	None	9/21/2019
1327	EMCO	1050	Controller, Antenna Mast	none	N/A
0942	EMCO	11968D	Turntable, 4ft.	9510-1835	N/A
1969	HP	11713A	Attenuator/Switch Driver	3748A04113	N/A
1509B	Braden	TDK 10M	TDK 10M Chamber,sVSWR > 1 GHz	DAC-012915-005	11/16/2019
2004	Miteq	AFS44-00101800-2S-10P-44	Amplifier, 40dB, .1-18GHz	0	1/10/2020
C030	none	none	Cable Coax, N-N, 30m, 1 - 18GHz	None	9/21/2019
1325	EMCO	1050	Controller, Antenna Mast	9003-1461	N/A
1780	ETS-Lindgren	3117	Antenna, Double Ridged Guide Horn, 1 - 18 GHz	110313	3/11/2021
1973	Agilent	83017A	Amplifier, Microwave 0.5-26.5 GHz	MY39500497	11/7/2020
2295	Keysight	E4440A-AYZ	PSA Spectrum Analyzer	MY46186204	11/6/2019
1542	A.H. Systems	SAS-572	Antenna, Horn 18-26.5GHz, 20dB gain	225	N/A

Table 8.0.2 – Radiated Emissions 26.5 GHz to 100 GHz

Asset #	Manufacturer	Model #	Description	Calibration Due
2295	Agilent	E4440A	Spectrum Analyzer SN MY44303298	6 Nov 2019
None	Agilent	5061-5458	Agilent harmonic mixer cable 1: IF/LO SN none	NCR
None	Agilent	5061-5458	Agilent harmonic mixer cable 2: IF/LO SN none	NCR
2063	Agilent	11970A	Mixer, Harmonic, 26.5 - 40 GHz SN 3003A08717	NCR
2062	Agilent	11970Q	Mixer, Harmonic, 33 - 50 GHz SN 3003A03234	NCR
2064	Agilent	11970V	Mixer, Harmonic, 50 - 75 GHz SN MY30033017	NCR
2061	Agilent	11970W	Mixer, Harmonic, 75 - 110 GHz SN 2521A00784	NCR
0730	Millitech	SGH-19	Standard Gain Horn (no mixer) SN B020598	NCR
0730	Millitech	SGH-12	Standard Gain Horn (no mixer) SN 035-8344	NCR
0730	Millitech	SGH-10	Standard Gain Horn (no mixer) SN 085-8344	NCR
0730	Millitech	SGH-08	Standard Gain Horn (no mixer) SN 012-8344	NCR

Table 8.0.3 –Frequency Stability

Asset #	Manufacturer	Model #	Description	Calibration Due
1831	Agilent	6622A	Adjustable Bench Power Supply	CIU
0463	Fluke	77A	DMM	10 Jul 2019
C255	Pasternack	Unspecified	Coaxial cable, RG-223 Type	CNR
1542	AH Systems	SAS-572	18-26 GHz Horn Antenna	CNR
2134	Tenny	TPC T2C	Temperature Chamber	9 Oct 2019

Table 8.0.4 –Mains Conducted Emissions

Conducted Emissions Test Equipment List					
Tile! Software Version:	Version: 7.1.2.17 (Jan 08, 2016 - 02:12:48 PM) or 4.1.A.0, April 14, 2009, 11:01:00PM				
Test Profile:	2017_CE_TILE7_v2.til				
Asset #	**Manufacturer**	**Model**	**Equipment Nomenclature**	**Serial Number**	**Calibration Due Date**
1145	HP	8568B	Spectrum Analyzer 100Hz-1.5GHz	2517A01821	7/12/2019
2113	HP	85662A	Spec Anal Dsply for A/N 1842	2403A07470	N/A
0990	HP	85685A	RF Preselector	3010A01119	7/12/2019
0085	HP	85650A	Quasi-Peak Adapter CISPR	3033A01458	11/1/2019
1173	PTI	100k HPF	Filter, High Pass, 100kHz	none	2/6/2020
1087	PTI	PTI-ALF3	Attenuator Limiter Filter	none	9/14/2019
C176	HP	none	Cable, RF, BNC-BNC, 0.610m, Grey	None	6/5/2020
C303	Coleman Cable	RG-58A/U	Cable, BNC-BNC, 0.914m Black	None	2/22/2020
C107	Pomona	RG-223	Cable, BNC-BNC, 2.64m, RG-223 (black)	None	8/1/2020
1185	EMCO	3825/2	LISN, 10kHz-100MHz	1235	8/28/2019

Table 8.0.5 –Supporting Equipment

Tag	Manufacturer, Model	S/N	Description
None	Phihong, POE38U-1AT-R	P84600273D1	Power over Ethernet; single port injector and power supply.
None	unspecified	None	Unshielded Ethernet cables.
None	Jirous, JRMB - 1200 -24	LAAA3748	1.2 m diameter, 46.6 dBi gain, parabolic reflector/antenna assembly.
None	Unspecified	Unspecified	Laptop computer to connect by Ethernet to web based software on EUT to select operating modes of EUT.

Appendix: Policy, Rationale, and Evaluation of EMC Measurement Uncertainty

All uncertainty calculations, estimates and expressions thereof shall be in accordance with NIST policy. Since PTI operates in accordance with NIST (NVLAP) Handbook 150-11: 2007, all instrumentation having an effect on the accuracy or validity of tests shall be periodically calibrated or verified traceable to national standards by a competent calibration laboratory. The certificates of calibration or verification on this instrumentation shall include estimates of uncertainty as required by NIST Handbook 150-11.

1. Rationale and Summary of Expanded Uncertainty.

Each piece of instrumentation at PTI that is used in making measurements for determining conformance to a standard (or limit), shall be assessed to evaluate its contribution to the overall uncertainty of the measurement in which it is used. The assessment of each item will be based on either a type A evaluation or a type B evaluation. Most of the evaluations will be type B, since they will be based on the manufacturer's statements or specifications of the calibration tolerances, or uncertainty will be stated along with a brief rationale for the type of evaluation and the resulting stated uncertainties.

The individual uncertainties included in the combined standard uncertainty for a specific test result will depend on the configuration in which the item of instrumentation is used. The combination will always be based on the law of propagation of uncertainty. Any systematic effects will be accommodated by including their uncertainties, in the calculation of the combined standard uncertainty; except that if the direction and amount of the systematic effect cannot be determined and separated from its uncertainty, the whole effect will be treated as uncertainty and combined along with the other elements of the test setup.

Type A evaluations of standard uncertainty will usually be based on calculating the standard deviation of the mean of a series of independent observations, but may be based on a least-squares curve fit or the analysis of variance for unusual situations. Type B evaluations of standard uncertainty will usually be based on manufacturer's specifications, data provided in calibration reports, and experience. The type of probability distribution used (normal, rectangular, a priori, or u-shaped) will be stated for each Type B evaluation.

In the evaluation of the uncertainty of each type of measurement, the uncertainty caused by the operator will be estimated. One notable operator contribution to measurement uncertainty is the manipulation of cables to maximize the measured values of radiated emissions. The operator contribution to measurement uncertainty is evaluated by having several operators independently repeat the same test. This results in a Type A evaluation of operator-contributed measurement uncertainty.

A summary of the expanded uncertainties of PTI measurements is shown as Table 1. These are the worst-case uncertainties considering all operative influence factors.

Table 1: Summary of Measurement Uncertainties for Site 45

Type of Measurement	Frequency Range	Meas. Dist.	Expanded Uncertainty U, dB (k=2)
Mains Conducted Emissions	150 kHz to 30 MHz	N/A	2.9
Telecom Conducted Emissions	150 kHz to 30 MHz	N/A	2.8
Radiated Emissions	30 to 1,000 MHz	10 m	4.8
	1 to 18 GHz	3 m	5.7

END OF REPORT

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