Project 16866-15

Racom
RAy2-24

Wireless Test Report
FCC 15.249, 101.111

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

16 Mar 2016

Reviewed by

Larry Finn
Chief Technical Officer

Written by

Eric Lifsey
EMC Engineer

Table of Contents

Revision History

Revision Number	Description	Date
00	Initial draft released	14 Mar 2016
01	Revised; applicant name/address; antenna used, corrected power.	15 Mar 2016
02	Revised; client name corrected on data sheets; added table 1.2.2.	16 Mar 2016

Compliance Certificate

Applicant	Device & Test Identification
Racom (Jiři Hruška) Mirova cp. 1283 592 31 Nove Mesto na Morave Czech Republic Certificate Date: 16 Mar 2016	FCC ID: SQT-RAY2-24 Model(s): RAy2-24 Laboratory Project ID: 16866-15

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

Requirement	Reference	Detail
FCC 47 CFR Part 15 C	15.249	Radiated Power
FCC 47 CFR Part 15 C	15.209	Radiated emission limits; general requirements.
FCC 47 CFR Part 15 C	15.205	Restricted Bands of Operation
FCC 47 CFR Part 101	101.111	Emission Mask
OET Bulletin 65*	Edition 97-01, and Supplement C, Ed. 01-01	Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

*MPE is reported separately from this document.

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 the USA.

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 fashion with the transmitter and receiver cross-polarized.

Table 1.2.1: EUT Essential Information

Manufacturer & Model	Description	Power
Racom RAy2-24	24 GHz Point to Point Microwave Link Sample A, S/N 10153514 Sample B, S/N 9909503	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	24000 - 24250 MHz						
Channel Bandwidth Schemes	5	10	30	40	50	56TO	MHz
Channels per Bandwidth Scheme	26	24	17	4	2	1	
Modulation Methods	GFSK, QAM16 through QAM256 for all bandwidths.						

Refer to Table 7.0.4 for other details. 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 receiver; the transmit polarity is then horizontal.

Except for the frequency stability test, the EUT was powered by a 3rd part 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.

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

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

1.6 Applicable Documents and Clauses

Table 1.6.1: Applicable Documents	
Document	**Title**
47 CFR	Part 15 – Radio Frequency Devices Subpart C -Intentional Radiators
47 CFR	Part 101 – Fixed Microwave Services
ANSI C63.4 2009	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low Voltage Electrical and Electronic Equipment

Table 1.6.2: Applicable Clauses		
Parameter	**FCC Part 15 Rule Paragraphs**	
Transmitter Characteristics	15.249	
Spurious Radiated Power	15.249, 15.209, 15.205	
Antenna Requirement	15.203	
Mains Conducted Emissions	15.207, 15.107	
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 then all bandwidth settings were measured. QAM64 modulation yielded highest peak power.

2.2 Test Criteria

Section Reference	Parameter	Date(s)
15.249(b)	Radiated Field Strength, 2500 mV/m @ 3 m Restated as 127.96 dBµV/m @ 3 m Or 137.5 dBµV/m @ 1 m For rule section (b), power is measured as peak.	16 Feb 2016 17 Feb 2016

2.3 Test Results

Professional Testing, EMI, Inc.

Test Date(s):	**2/16/2016, 2/17/2016**	**EUT Serial #:**	**10153514 (Sample A)**
Customer:	**Racom**	**EUT Part #:**	**RAy2-24**
Project Number:	**16866-15**	**Test Technician:**	**Eric Lifsey**
Equip. Under Test:	**RAy2-24**	**Witness' Name:**	**None**

1 m Radiated Peak Power Datasheet; in 10 MHz RBW 50 MHz VBW **Page: 1 of 1**

EUT Modulation, BW: QAM64, 5 MHz

Frequency Measured (MHz)	Measured Raw Peak dBµV	Horn Factor dB/m	Corrected Peak Field Strength dBµV/m	Limit Peak Field Strength dBµV/m
24125	86.7	37.0	123.7	137.5
24185	89.6	37.0	126.6	137.5
24245	90.3	37.0	127.3	137.5

1 m Radiated Peak Power Datasheet; in 10 MHz RBW 50 MHz VBW **Page: 1 of 1**

EUT Modulation, BW: QAM64, 10 MHz

Frequency Measured (MHz)	Measured Raw Peak dBµV	Horn Factor dB/m	Corrected Peak Field Strength dBµV/m	Limit Peak Field Strength dBµV/m
24135.000	87.9	37.0	124.9	137.5
24185.000	88.6	37.0	125.6	137.5
24240.000	89.0	37.0	126.0	137.5

1 m Radiated Peak Power Datasheet; in 10 MHz RBW 50 MHz VBW **Page: 1 of 1**

EUT Modulation, BW: QAM64, 30 MHz

Frequency Measured (MHz)	Measured Raw Peak dBµV	Horn Factor dB/m	Corrected Peak Field Strength dBµV/m	Limit Peak Field Strength dBµV/m
24150.000	86.5	37.0	123.5	137.5
24185.000	87.3	37.0	124.3	137.5
24225.000	85.4	37.0	122.4	137.5

Professional Testing, EMI, Inc.			
Test Date(s):	2/16/2016, 2/17/2016	EUT Serial #:	10153514 (Sample A)
Customer:	Racom	EUT Part #:	RAy2-24
Project Number:	16866-15	Test Technician:	Eric Lifsey
Equip. Under Test:	RAy2-24	Witness' Name:	None

1 m Radiated Peak Power Datasheet; in 10 MHz RBW 50 MHz VBW Page: 1 of 1

EUT Modulation, BW: QAM64, 40 MHz

Frequency Measured (MHz)	Measured Raw Peak dBµV	Horn Factor dB/m	Corrected Peak Field Strength dBµV/m	Limit Peak Field Strength dBµV/m
24160.000	85.3	37.0	122.3	137.5
24185.000	86.2	37.0	123.2	137.5
24215.000	86.0	37.0	123.0	137.5

1 m Radiated Peak Power Datasheet; in 10 MHz RBW 50 MHz VBW Page: 1 of 1

EUT Modulation, BW: QAM64, 50 MHz

Frequency Measured (MHz)	Measured Raw Peak dBµV	Horn Factor dB/m	Corrected Peak Field Strength dBµV/m	Limit Peak Field Strength dBµV/m
24190.000	84.7	37.0	121.7	137.5
24195.000	85.4	37.0	122.4	137.5
24200.000	84.3	37.0	121.3	137.5

1 m Radiated Peak Power Datasheet; in 10 MHz RBW 50 MHz VBW Page: 1 of 1

EUT Modulation, BW: QAM64, 56 MHz

Frequency Measured (MHz)	Measured Raw Peak dBµV	Horn Factor dB/m	Corrected Peak Field Strength dBµV/m	Limit Peak Field Strength dBµV/m
NA				
24195.000	85.6	37.0	122.6	137.5
NA				

Table 2.3.2: Corrected Maximum Power

Measured Radiated At 1 m dBµV/m	Restated as Radiated At 3 m dBµV/m	Restated as EIRP dBm	Restated as Linear EIRP mW
127.3	117.8	22.57	180.8

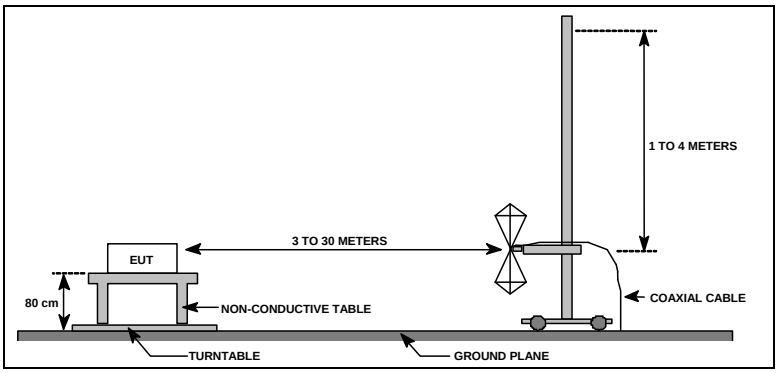
The EUT satisfies the criteria.

The EUT operates in 100 % duty cycle.

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.

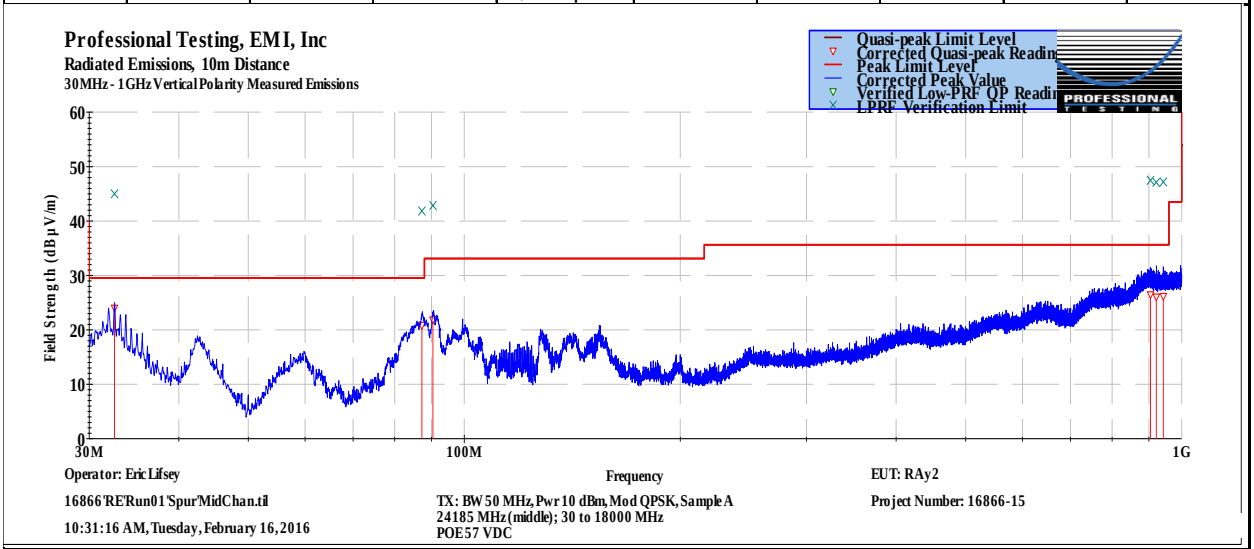
The EUT satisfied the criteria.

3.3.1 Emissions 30 MHz to 1 GHz

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
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):	2/16/2016, 2/17/2016	EUT Serial #:	10153514 (Sample A)
Customer:	Racom	EUT Part #:	RAy2-24
Project Number:	16866-15	Test Technician:	Eric Lifsey
Purchase Order #:	NA	Supervisor:	Lisa Arndt
Equip. Under Test:	RAy2-24	Witness' Name:	None

Radiated Emissions Test Results Data Sheet			Page: 1 of 1
EUT Line Voltage:	57 VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	30MHz to 1GHz
EUT Mode of Operation:		Transmit, 50 MHz BW, QPSK, 10 dBm Power (max)	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
32.5386	10	287	3.09	Quasi-peak	35.5	23.976	29.5	-5.5	Pass
87.2608	10	155	1.8	Quasi-peak	40.8	20.833	29.5	-8.7	Pass
90.4403	10	181	3.01	Quasi-peak	41.4	21.833	33.1	-11.3	Pass
904.9	10	301	1.18	Quasi-peak	21.3	26.474	35.6	-9.1	Pass
921.766	10	127	1.78	Quasi-peak	21.1	26.075	35.6	-9.5	Pass
942.894	10	190	4.12	Quasi-peak	21.1	26.176	35.6	-9.4	Pass



≤ 1GHz Vertical Antenna Polarity Measured Emissions

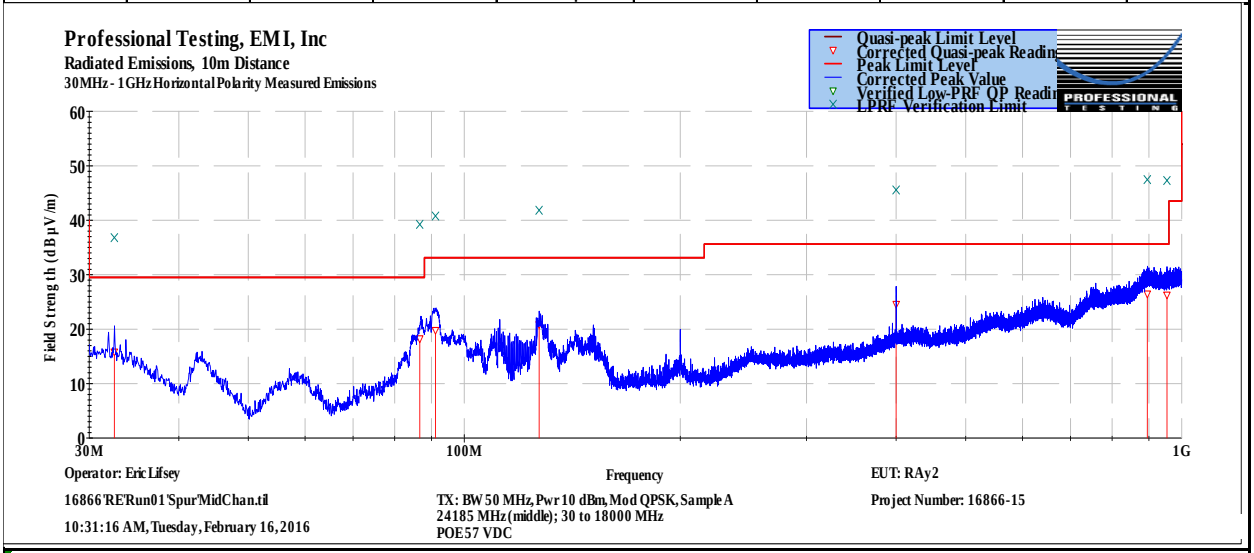
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
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):	2/16/2016, 2/17/2016	**EUT Serial #:**	10153514 (Sample A)
Customer:	Racom	**EUT Part #:**	RAy2-24
Project Number:	16866-15	**Test Technician:**	Eric Lifsey
Purchase Order #:	NA	**Supervisor:**	Lisa Arndt
Equip. Under Test:	RAy2-24	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	57 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	30MHz to 1GHz
EUT Mode of Operation:		Transmit, 50 MHz BW, QPSK, 10 dBm Power (max)	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
32.5268	10	323	1.29	Quasi-peak	27.3	15.812	29.5	-13.7	Pass
86.6749	10	216	3.77	Quasi-peak	38.3	18.234	29.5	-11.3	Pass
91.1778	10	59	3.56	Quasi-peak	39.2	19.772	33.1	-13.3	Pass
127.164	10	53	2.58	Quasi-peak	38.1	20.824	33.1	-12.3	Pass
400.009	10	218	1.06	Quasi-peak	31.4	24.561	35.6	-11.0	Pass
895.627	10	184	2.72	Quasi-peak	21.4	26.463	35.6	-9.1	Pass
953.701	10	6	1.35	Quasi-peak	21	26.284	35.6	-9.3	Pass



≤ 1GHz Horizontal Antenna Polarity Measured Emissions

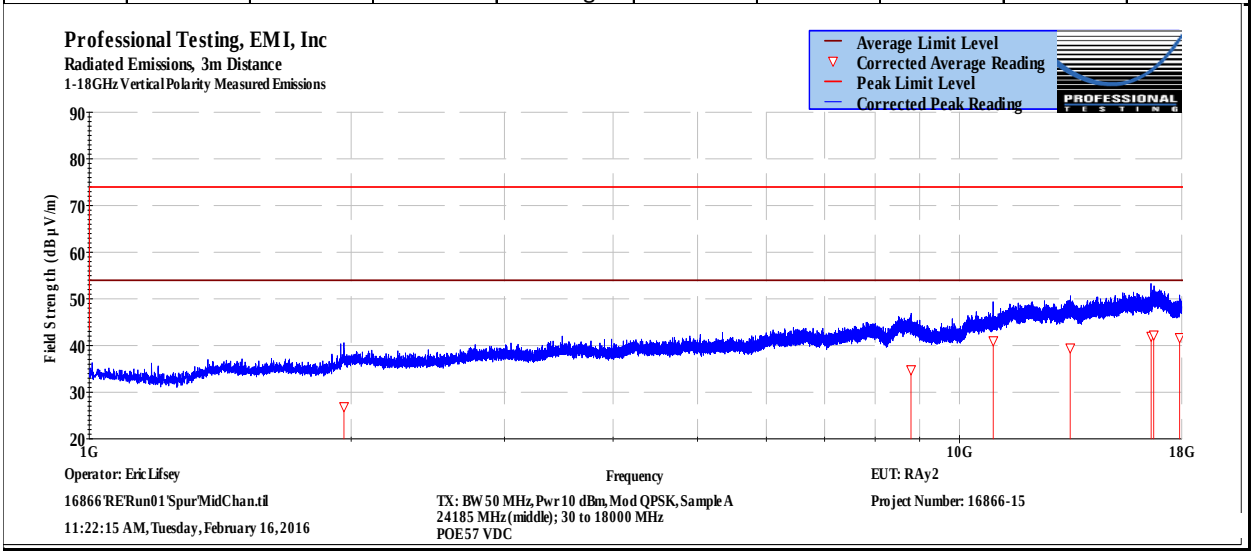
3.3.2 Emissions 1 GHz to 18 GHz

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
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):	2/16/2016, 2/17/2016	**EUT Serial #:**	10153514 (Sample A)
Customer:	Racom	**EUT Part #:**	RAy2-24
Project Number:	16866-15	**Test Technician:**	Eric Lifsey
Purchase Order #:	NA	**Supervisor:**	Lisa Arndt
Equip. Under Test:	RAy2-24	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	57 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Vertical	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Transmit, 50 MHz BW, QPSK, 10 dBm Power (max)	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
1962.63	3	334	0	Average	35.8	26.909	54.0	-27.0	Pass
8797.13	3	142	0	Average	27.5	34.812	54.0	-19.1	Pass
10935.8	3	357	0	Average	31.7	41.035	54.0	-12.9	Pass
13405.4	3	139	0	Average	28.9	39.503	54.0	-14.5	Pass
16603.7	3	48	0	Average	27.4	41.995	54.0	-12.0	Pass
16718.8	3	332	0	Average	27.6	42.281	54.0	-11.7	Pass
17908	3	313	0	Average	26.7	41.7	54.0	-12.3	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

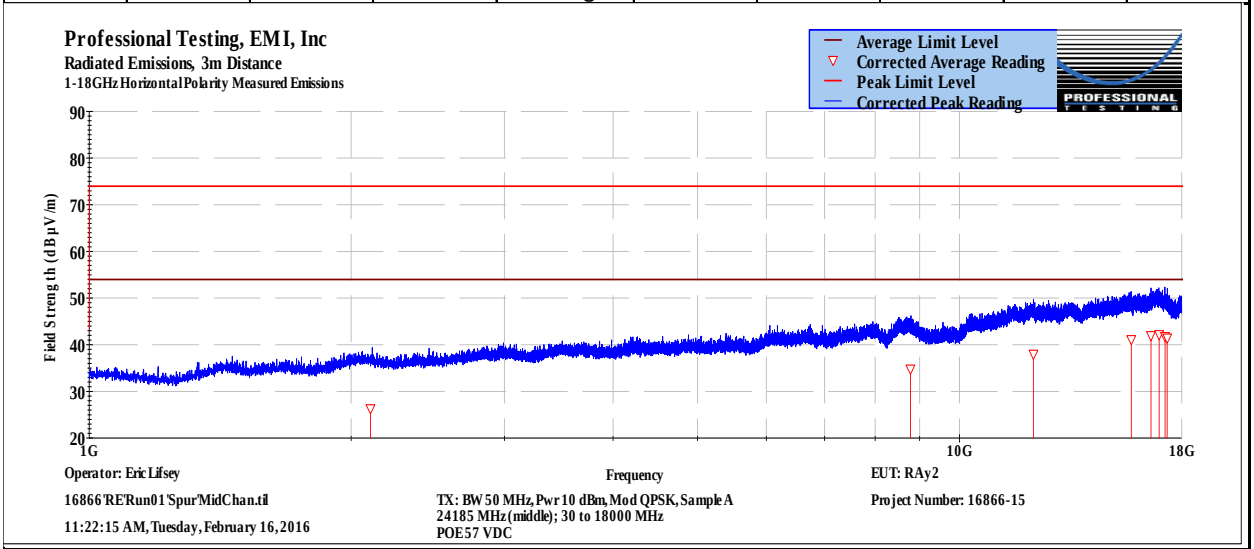
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
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):	2/16/2016, 2/17/2016	**EUT Serial #:**	10153514 (Sample A)
Customer:	Racom	**EUT Part #:**	RAy2-24
Project Number:	16866-15	**Test Technician:**	Eric Lifsey
Purchase Order #:	NA	**Supervisor:**	Lisa Arndt
Equip. Under Test:	RAy2-24	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	57 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Transmit, 50 MHz BW, QPSK, 10 dBm Power (max)	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
2104.63	3	13	0	Average	35.2	26.289	54.0	-27.7	Pass
8785.21	3	207	0	Average	27.4	34.772	54.0	-19.2	Pass
12160.7	3	93	0	Average	27.7	37.972	54.0	-16.0	Pass
15754.4	3	316	0	Average	27.8	41.104	54.0	-12.9	Pass
16597	3	142	0	Average	27.4	41.956	54.0	-12.0	Pass
16954.5	3	87	0	Average	27.5	42.142	54.0	-11.8	Pass
17222.5	3	327	0	Average	27.5	41.764	54.0	-12.2	Pass
17324.8	3	95	0	Average	27.3	41.431	54.0	-12.5	Pass



> 1GHz Horizontal Antenna Polarity Measured Emissions

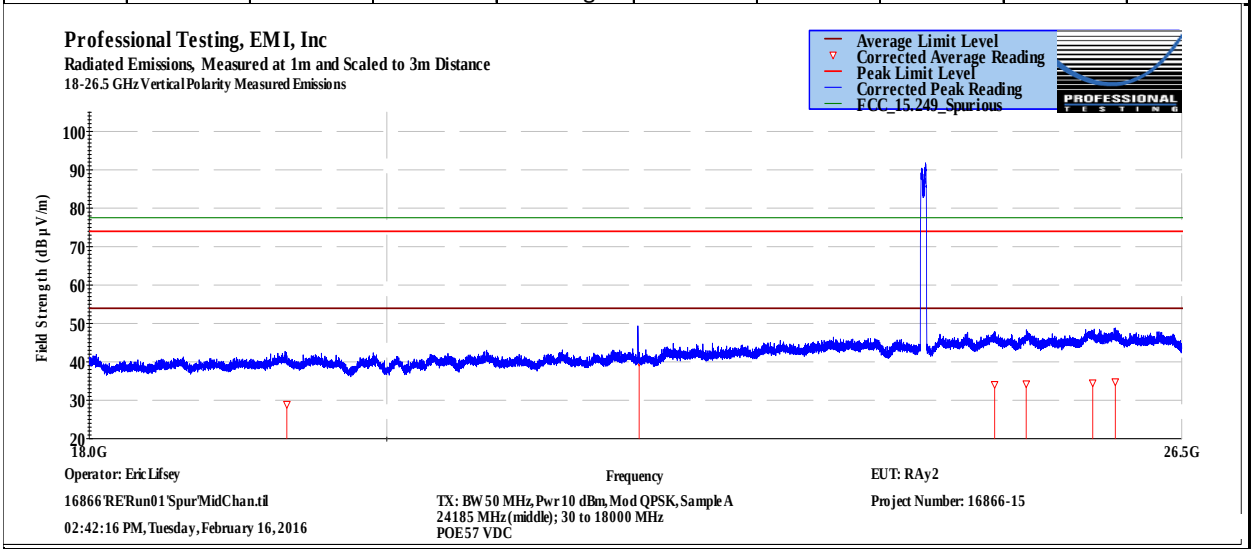
3.3.3 Emissions 18 GHz to 26.5 GHz

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
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):	2/16/2016, 2/17/2016	**EUT Serial #:**	10153514 (Sample A)
Customer:	Racom	**EUT Part #:**	RAy2-24
Project Number:	16866-15	**Test Technician:**	Eric Lifsey
Purchase Order #:	NA	**Supervisor:**	Lisa Arndt
Equip. Under Test:	RAy2-24	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	57 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Vertical	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Transmit, 50 MHz BW, QPSK, 10 dBm Power (max)	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
19305.3	3	74	1	Average	32.9	28.957	54.0	-25.0	Pass
21869.5	3	347	1	Average	43.6	39.936	54.0	-14.0	Pass
24802.2	3	300	1	Average	33.7	34.127	54.0	-19.8	Pass
25081.5	3	207	1	Average	34.1	34.307	54.0	-19.7	Pass
25678.7	3	332	1	Average	34.1	34.537	54.0	-19.4	Pass
25884.3	3	47	1	Average	34.3	34.824	54.0	-19.1	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

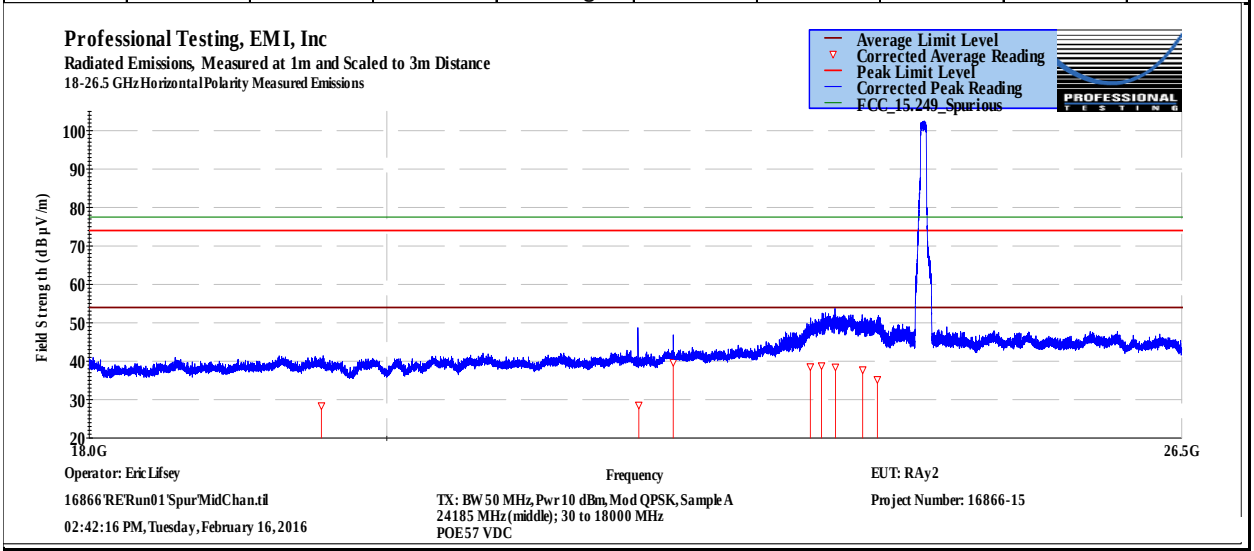
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
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):	2/16/2016, 2/17/2016	**EUT Serial #:**	10153514 (Sample A)
Customer:	Racom	**EUT Part #:**	RAy2-24
Project Number:	16866-15	**Test Technician:**	Eric Lifsey
Purchase Order #:	NA	**Supervisor:**	Lisa Arndt
Equip. Under Test:	RAy2-24	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	57 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Transmit, 50 MHz BW, QPSK, 10 dBm Power (max)	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
19542.9	3	228	1	Average	32.3	28.387	54.0	-25.6	Pass
21866.8	3	114	1	Average	32.3	28.571	54.0	-25.4	Pass
22135	3	332	1	Average	42.4	39.71	54.0	-14.2	Pass
23235.2	3	168	1	Average	40.9	38.584	54.0	-15.4	Pass
23328.1	3	175	1	Average	40.5	38.805	54.0	-15.2	Pass
23442.7	3	182	1	Average	40.2	38.482	54.0	-15.5	Pass
23671.2	3	166	1	Average	39.4	37.758	54.0	-16.2	Pass
23793.2	3	164	1	Average	36.9	35.247	54.0	-18.7	Pass



> 1GHz Horizontal Antenna Polarity Measured Emissions

3.3.4 Emissions 26.5 GHz to 100 GHz

For this measurement the receive antenna was manually brought to within 10 cm of the EUT and a search for emissions of both polarities was conducted. The analyzer Signal Ident feature was used to identify valid signals; the display was recorded photographically.

No signals (denoted below as NS) were detected above the fundamental band.

Professional Testing, EMI, Inc.			
Test Date(s):	2/16/2016, 2/17/2016	EUT Serial #:	10153514 (Sample A)
Customer:	Racom	EUT Part #:	RAy2-24
Project Number:	16866-15	Test Technician:	Eric Lifsey
Equip. Under Test:	RAy2-24	Witness' Name:	None

26.5 to 40 GHz at 10 cm				Page: 1 of 1
EUT Modulation, BW: QAM64, 5 MHz				
Frequency Measured (MHz)	Measured Raw Peak dBµV	Horn Factor dB/m	Corrected Peak Field Strength dBµV/m	Limit Peak Field Strength dBµV/m
24125	NS			
24185	NS			
24245	NS			

AN 2062; 11970 Q: 33 GHz to 50 GHz at 10 cm				Page: 1 of 1
EUT Modulation, BW: QAM64, 5 MHz				
Frequency Measured (MHz)	Measured Raw Peak dBµV	Horn Factor dB/m	Corrected Peak Field Strength dBµV/m	Limit Peak Field Strength dBµV/m
24125	NS			
24185	NS			
24245	NS			

AN 2064; 11970 V: 50 to 75 GHz at 10 cm				Page: 1 of 1
EUT Modulation, BW: QAM64, 5 MHz				
Frequency Measured (MHz)	Measured Raw Peak dBµV	Horn Factor dB/m	Corrected Peak Field Strength dBµV/m	Limit Peak Field Strength dBµV/m
24125	NS			
24185	NS			
24245	NS			

AN 2061; 11970 W: 75 to 110 GHz at 10 cm				Page: 1 of 1
EUT Modulation, BW: QAM64, 5 MHz				
Frequency Measured (MHz)	Measured Raw Peak dBµV	Horn Factor dB/m	Corrected Peak Field Strength dBµV/m	Limit Peak Field Strength dBµV/m
24125	NS			
24185	NS			
24245	NS			

4.0 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.)

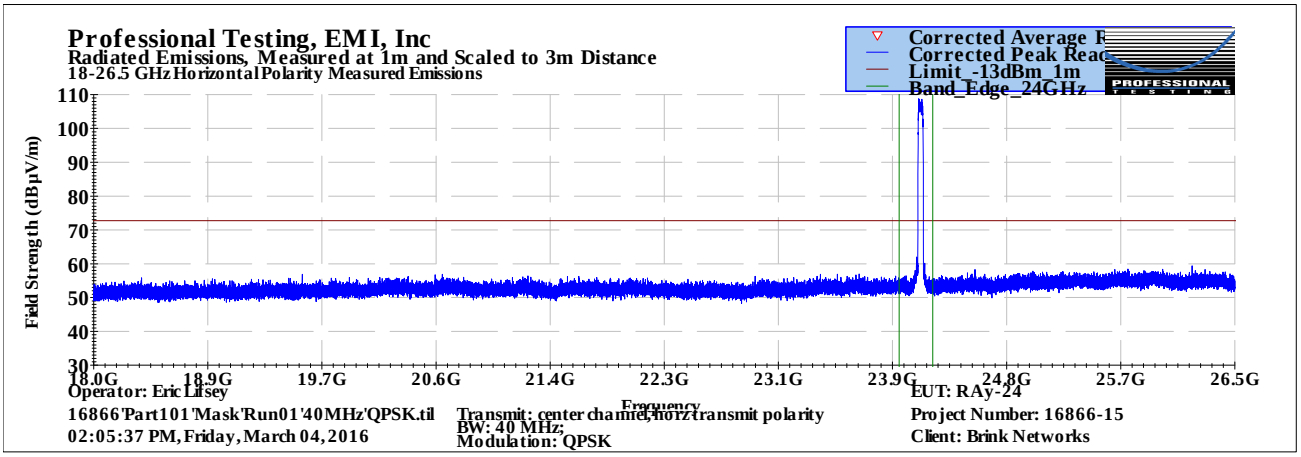
4.3 Test Results

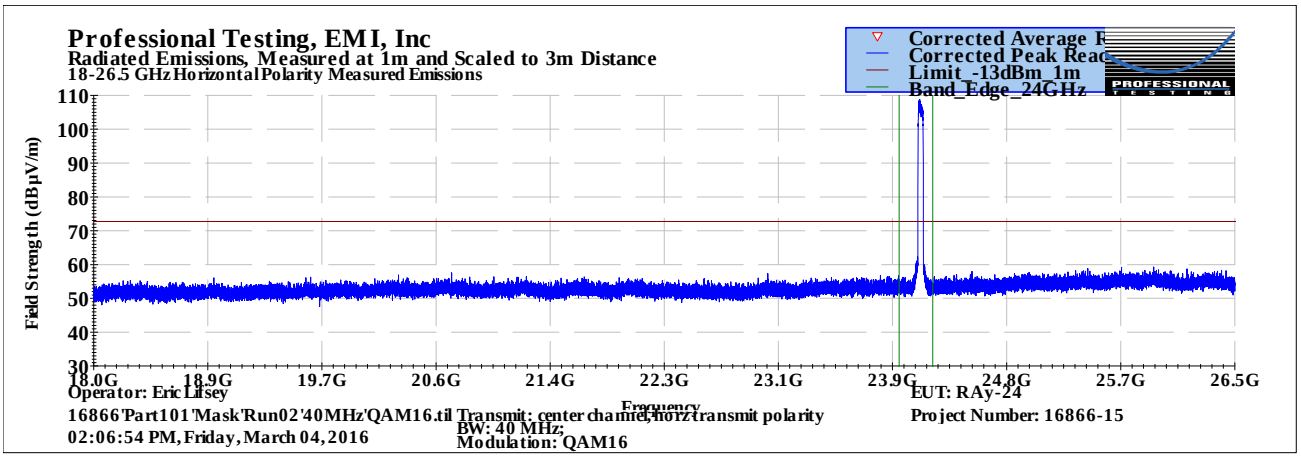
In the plots below the spectrum from 18 to 26.5 GHz is presented with green vertical lines marking the top and bottom of the 24000 to 24250 MHz band. Peak detection is employed.

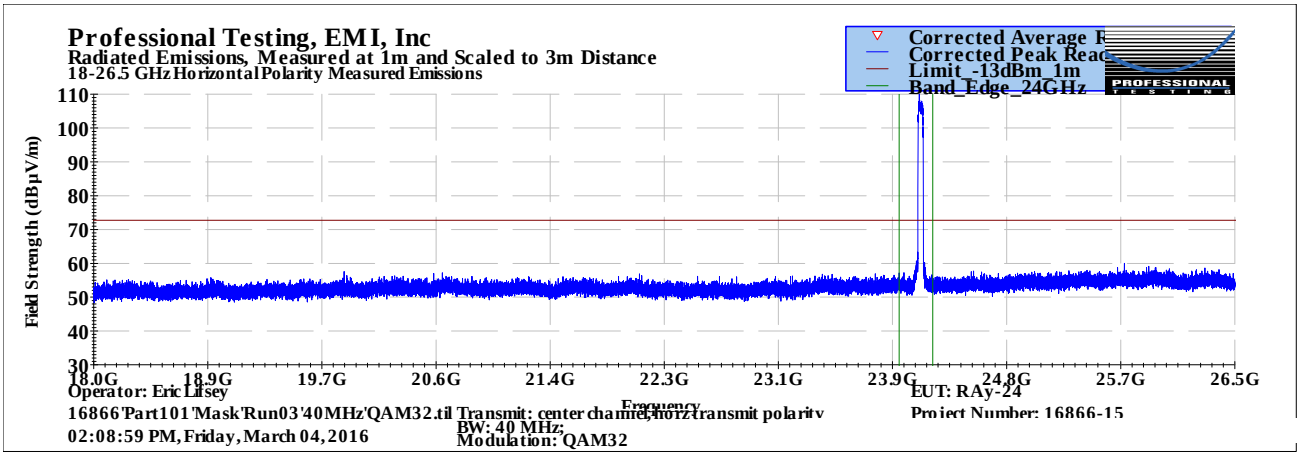
The EUT satisfied the requirements.

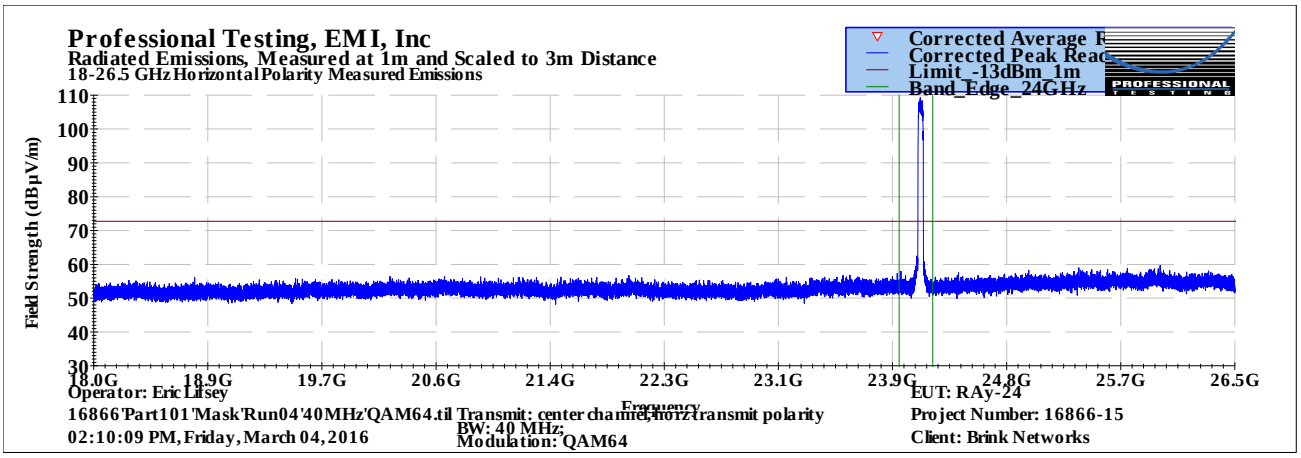
In the plots below it can be seen that out of band emissions at and beyond the band edges are well under the -13 dBm limit when restated as a radiated field at 1 meter. Note that the limit was miscalculated far lower than the actual that is 91.77 dBµV/m. At these low levels the calculation of A attenuation was not required.

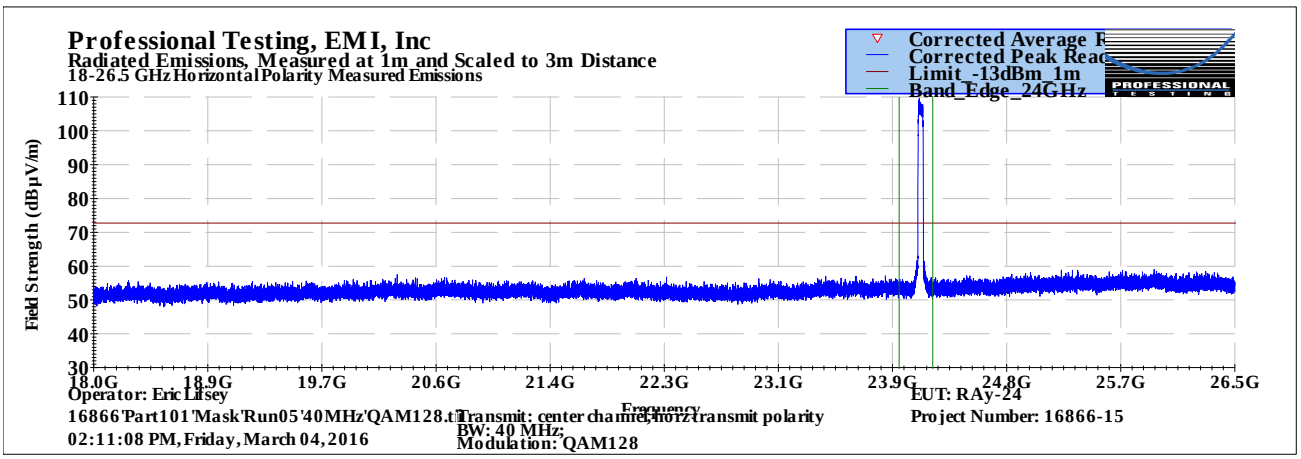
4.3.1 40 MHz Bandwidth

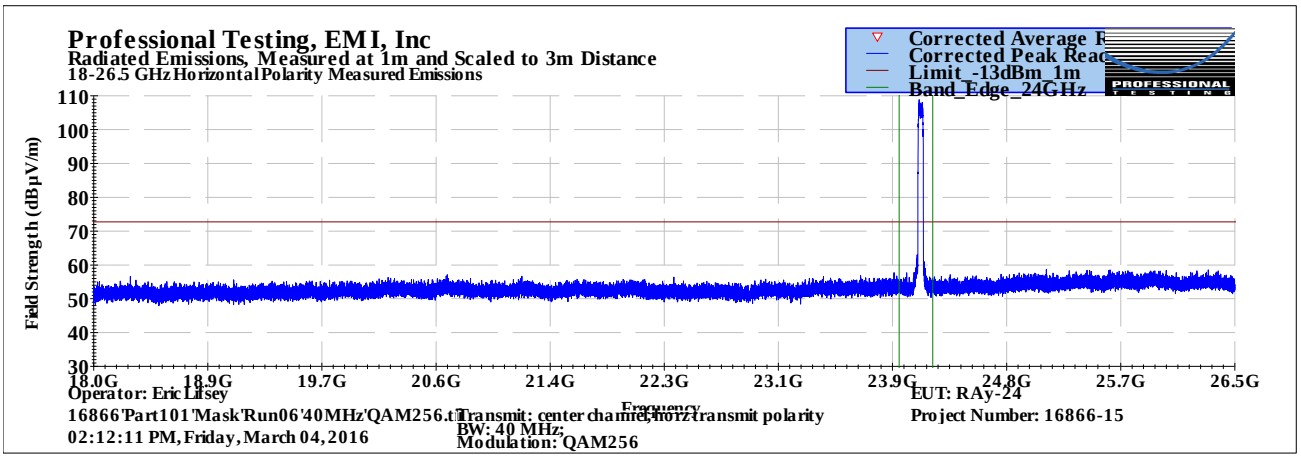




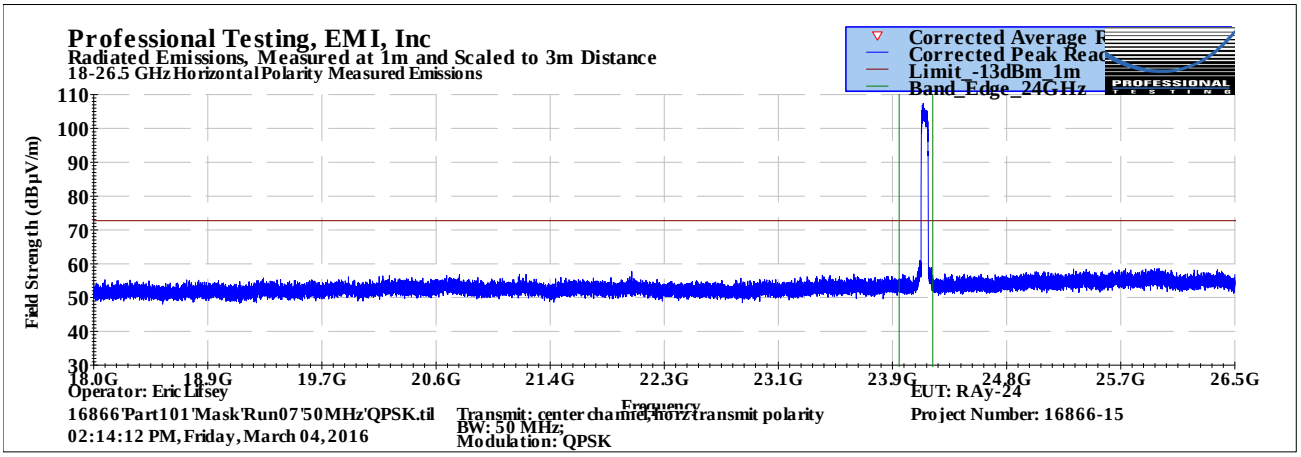


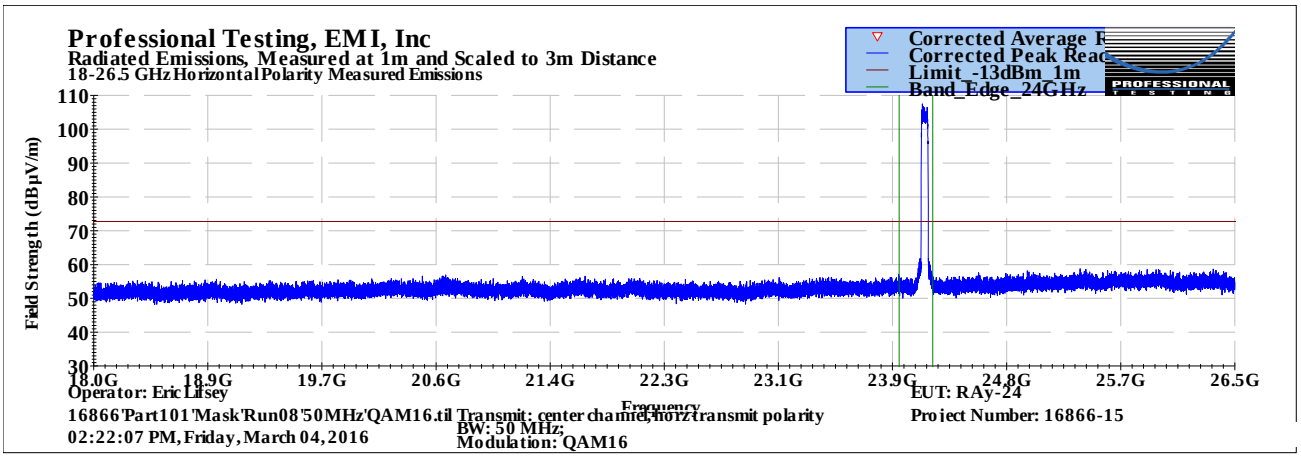

Professional Testing, EMI, Inc
Radiated Emissions, Measured at 1m and Scaled to 3m Distance
18-26.5 GHz Horizontal Polarity Measured Emissions
Corrected Average F
Corrected Peak Reac
Limit -13dBm 1m
Band_Edge_24GHz
PROFESSIONAL
Field Strength (dBµV/m)
110
100
90
80
70
60
50
40
30
18.0G
18.9G
19.7G
20.6G
21.4G
22.3G
23.1G
23.9G
24.8G
25.7G
26.5G
Frequency
Operator: Eric Lifsey
16866 Part101 Mask Run04 40MHz QAM64.til Transmit: center channel, horiz transmit polarity
02:10:09 PM, Friday, March 04, 2016
BW: 40 MHz;
Modulation: QAM64
EUT: RAy-24
Project Number: 16866-15
Client: Brink Networks

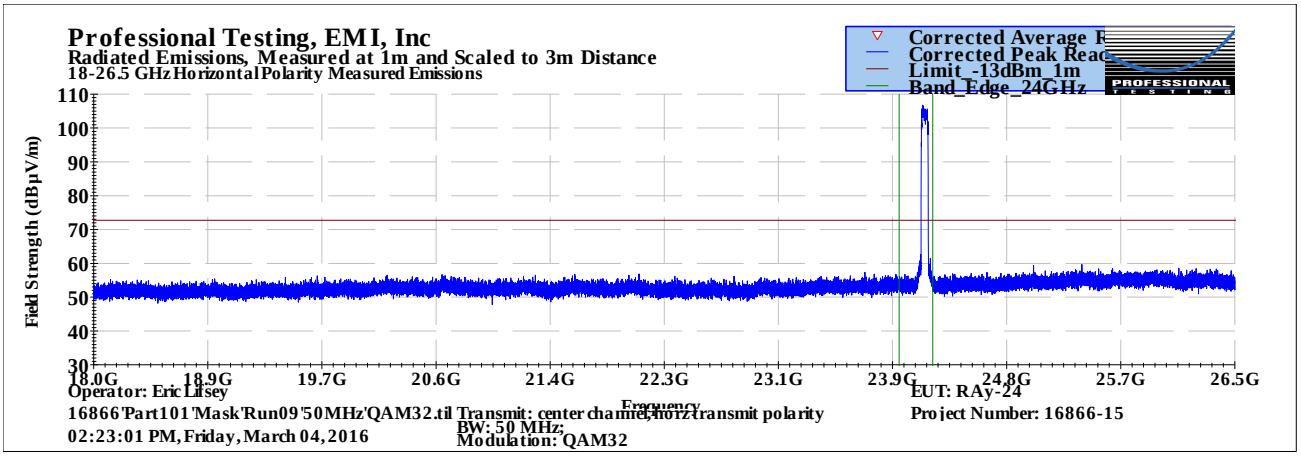

Professional Testing, EMI, Inc
Radiated Emissions, Measured at 1m and Scaled to 3m Distance
18-26.5 GHz Horizontal Polarity Measured Emissions
Corrected Average F
Corrected Peak Reac
Limit -13dBm 1m
Band_Edge_24GHz
PROFESSIONAL
Field Strength (dBµV/m)
110
100
90
80
70
60
50
40
30
18.0G
18.9G
19.7G
20.6G
21.4G
22.3G
23.1G
23.9G
24.8G
25.7G
26.5G
Frequency
Operator: Eric Lifsey
16866 Part101 Mask Run05 40MHz QAM128.til Transmit: center channel, horiz transmit polarity
02:11:08 PM, Friday, March 04, 2016
BW: 40 MHz;
Modulation: QAM128
EUT: RAy-24
Project Number: 16866-15

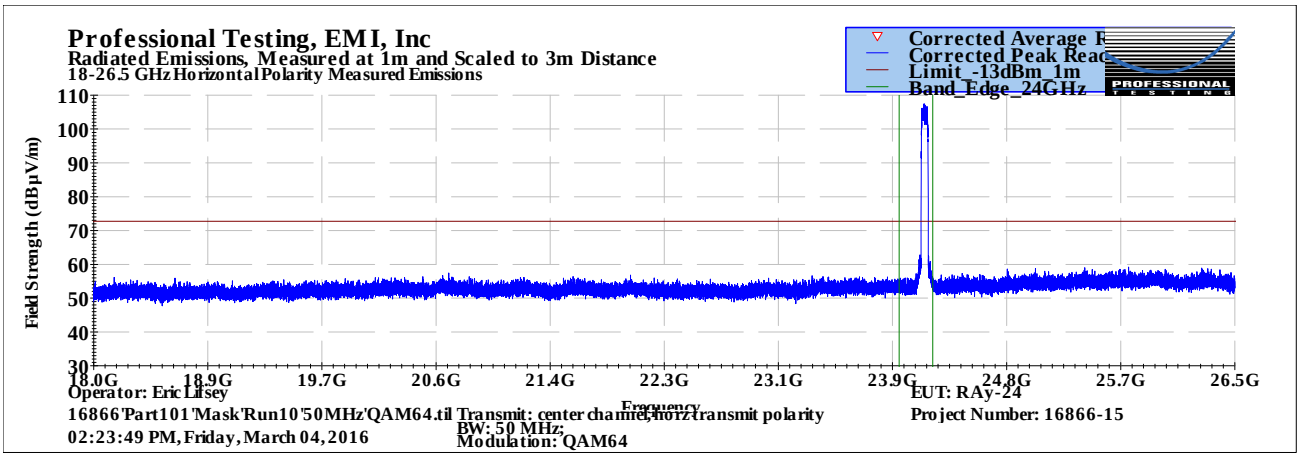

Professional Testing, EMI, Inc
Radiated Emissions, Measured at 1m and Scaled to 3m Distance
18-26.5 GHz Horizontal Polarity Measured Emissions
Corrected Average F
Corrected Peak Reac
Limit -13dBm 1m
Band_Edge_24GHz
PROFESSIONAL
Field Strength (dBµV/m)
110
100
90
80
70
60
50
40
30
18.0G
18.9G
19.7G
20.6G
21.4G
22.3G
23.1G
23.9G
24.8G
25.7G
26.5G
Frequency
Operator: Eric Lifsey
16866 Part101 Mask Run06 40MHz QAM256.til Transmit: center channel, horiz transmit polarity
02:12:11 PM, Friday, March 04, 2016
BW: 40 MHz;
Modulation: QAM256
EUT: RAy-24
Project Number: 16866-15

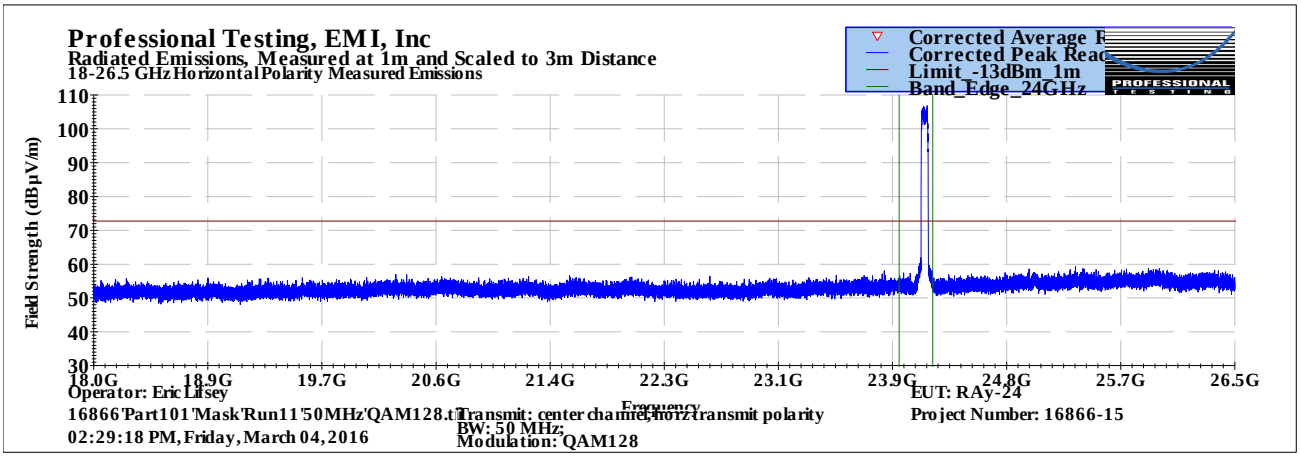
4.3.2 50 MHz Bandwidth

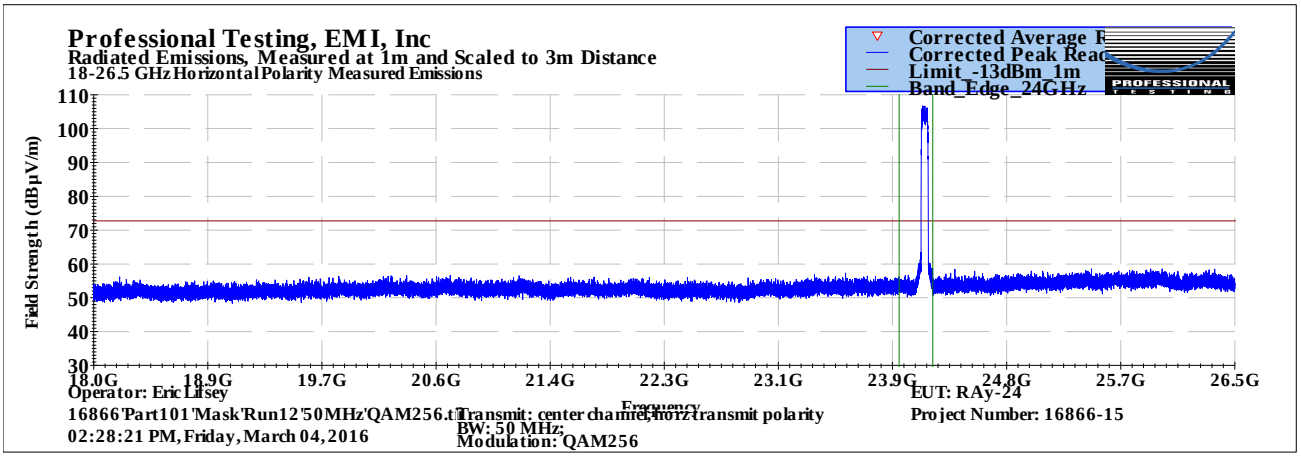




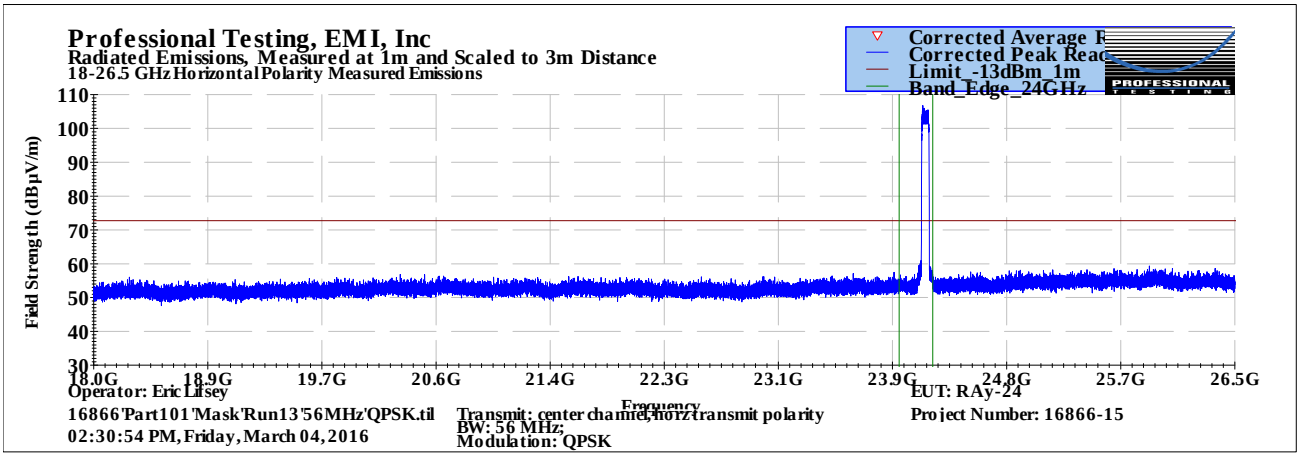


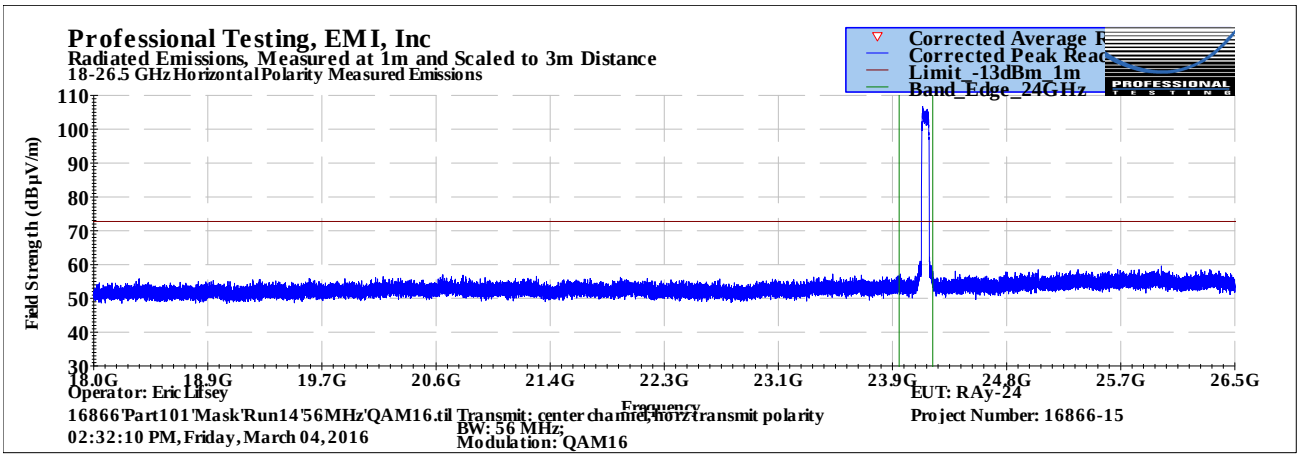

Professional Testing, EMI, Inc
Radiated Emissions, Measured at 1m and Scaled to 3m Distance
18-26.5 GHz Horizontal Polarity Measured Emissions
Corrected Average E
Corrected Peak Reac
Limit -13dBm_1m
Band_Edge_24GHz
Field Strength (dBµV/m)
110
100
90
80
70
60
50
40
30
18.0G
18.9G
19.7G
20.6G
21.4G
22.3G
23.1G
23.9G
24.8G
25.7G
26.5G
Frequency
Operator: Eric Lilsey
16866'Part101'Mask'Run10'50MHz'QAM64.til Transmit: center channel, horiz transmit polarity
02:23:49 PM, Friday, March 04, 2016
BW: 50 MHz;
Modulation: QAM64
EUT: RAy-24
Project Number: 16866-15

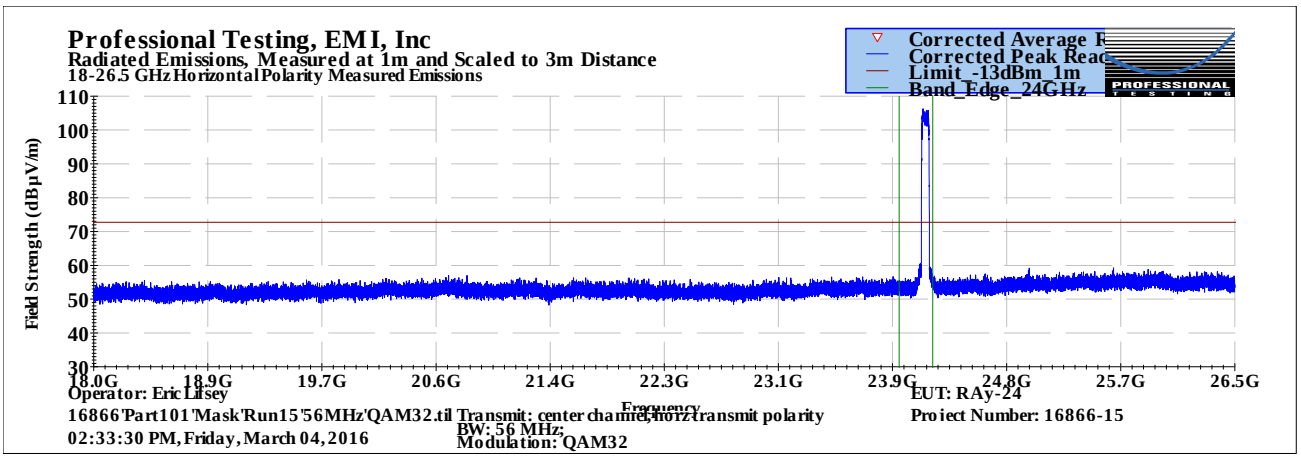

Professional Testing, EMI, Inc
Radiated Emissions, Measured at 1m and Scaled to 3m Distance
18-26.5 GHz Horizontal Polarity Measured Emissions
Corrected Average E
Corrected Peak Reac
Limit -13dBm_1m
Band_Edge_24GHz
Field Strength (dBµV/m)
110
100
90
80
70
60
50
40
30
18.0G
18.9G
19.7G
20.6G
21.4G
22.3G
23.1G
23.9G
24.8G
25.7G
26.5G
Frequency
Operator: Eric Lilsey
16866'Part101'Mask'Run11'50MHz'QAM128.til Transmit: center channel, horiz transmit polarity
02:29:18 PM, Friday, March 04, 2016
BW: 50 MHz;
Modulation: QAM128
EUT: RAy-24
Project Number: 16866-15

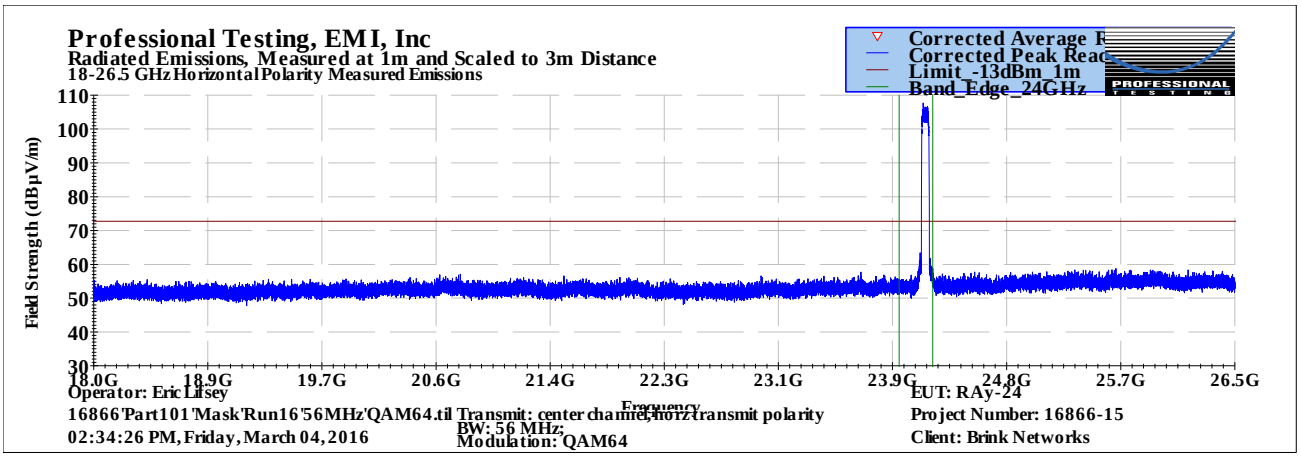

Professional Testing, EMI, Inc
Radiated Emissions, Measured at 1m and Scaled to 3m Distance
18-26.5 GHz Horizontal Polarity Measured Emissions
Corrected Average E
Corrected Peak Reac
Limit -13dBm_1m
Band_Edge_24GHz
Field Strength (dBµV/m)
110
100
90
80
70
60
50
40
30
18.0G
18.9G
19.7G
20.6G
21.4G
22.3G
23.1G
23.9G
24.8G
25.7G
26.5G
Frequency
Operator: Eric Lilsey
16866'Part101'Mask'Run12'50MHz'QAM256.til Transmit: center channel, horiz transmit polarity
02:28:21 PM, Friday, March 04, 2016
BW: 50 MHz;
Modulation: QAM256
EUT: RAy-24
Project Number: 16866-15

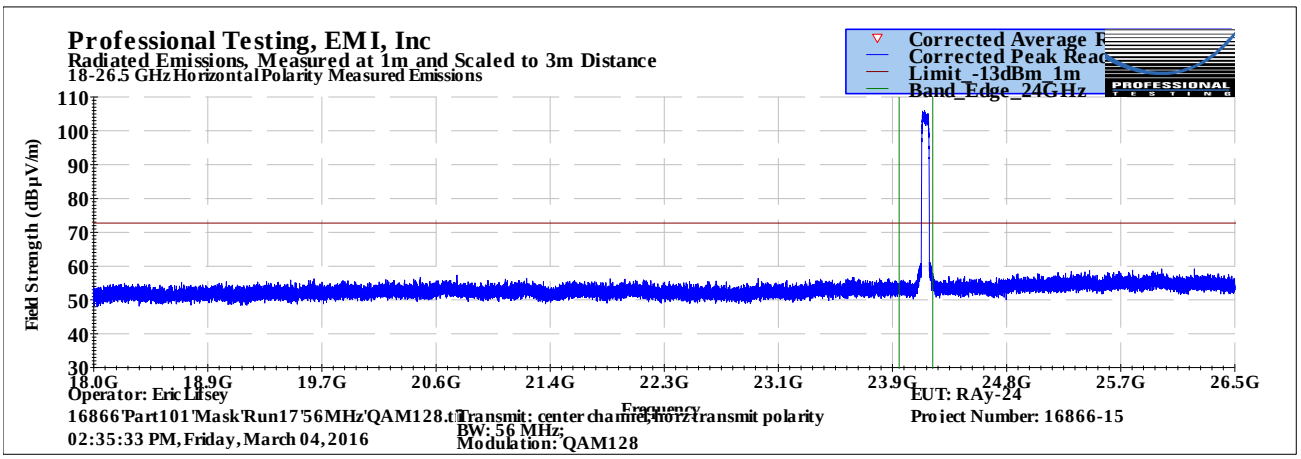
4.3.3 56 MHz Bandwidth

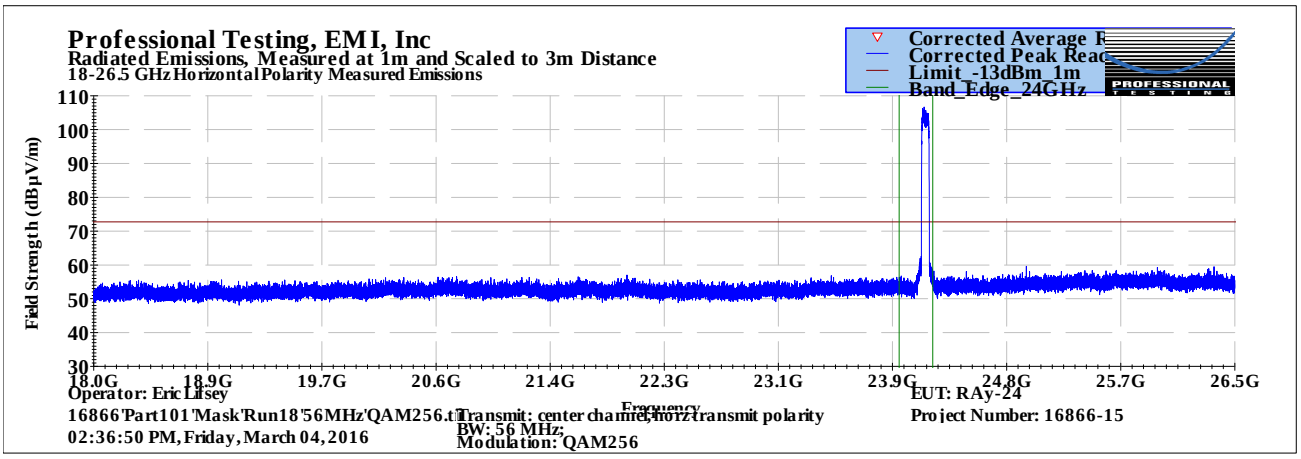







Professional Testing, EMI, Inc
Radiated Emissions, Measured at 1m and Scaled to 3m Distance
18-26.5 GHz Horizontal Polarity Measured Emissions
Corrected Average F
Corrected Peak Reac
Limit -13dBm_1m
Band_Edge_24GHz
PROFESSIONAL
Field Strength (dBµV/m)
110
100
90
80
70
60
50
40
30
18.0G
18.9G
19.7G
20.6G
21.4G
22.3G
23.1G
23.9G
24.8G
25.7G
26.5G
Frequency
Operator: Eric Lifsey
16866 Part101 Mask Run16 56MHz QAM64.til Transmit: center channel, horiz transmit polarity
02:34:26 PM, Friday, March 04, 2016
BW: 56 MHz;
Modulation: QAM64
EUT: RAy-24
Project Number: 16866-15
Client: Brink Networks


Professional Testing, EMI, Inc
Radiated Emissions, Measured at 1m and Scaled to 3m Distance
18-26.5 GHz Horizontal Polarity Measured Emissions
Corrected Average F
Corrected Peak Reac
Limit -13dBm_1m
Band_Edge_24GHz
PROFESSIONAL
Field Strength (dBµV/m)
110
100
90
80
70
60
50
40
30
18.0G
18.9G
19.7G
20.6G
21.4G
22.3G
23.1G
23.9G
24.8G
25.7G
26.5G
Frequency
Operator: Eric Lifsey
16866 Part101 Mask Run17 56MHz QAM128.til Transmit: center channel, horiz transmit polarity
02:35:33 PM, Friday, March 04, 2016
BW: 56 MHz;
Modulation: QAM128
EUT: RAy-24
Project Number: 16866-15


Professional Testing, EMI, Inc
Radiated Emissions, Measured at 1m and Scaled to 3m Distance
18-26.5 GHz Horizontal Polarity Measured Emissions
Corrected Average F
Corrected Peak Reac
Limit -13dBm_1m
Band_Edge_24GHz
PROFESSIONAL
Field Strength (dBµV/m)
110
100
90
80
70
60
50
40
30
18.0G
18.9G
19.7G
20.6G
21.4G
22.3G
23.1G
23.9G
24.8G
25.7G
26.5G
Frequency
Operator: Eric Lifsey
16866 Part101 Mask Run18 56MHz QAM256.til Transmit: center channel, horiz transmit polarity
02:36:50 PM, Friday, March 04, 2016
BW: 56 MHz;
Modulation: QAM256
EUT: RAy-24
Project Number: 16866-15

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) 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 that comply are listed in the user manual.	Pass
15.249(b)(3) 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.

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	3 Mar 2016

6.3 Test Results

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

Modulation Mode: GFSK
Modulation BW: 5 MHz
Spectrum Analyzer RBW: 100 kHz
Sample: B S/N 9909503

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 Test Equipment

Table 7.0.1 – Radiated Emissions 30 MHz to 26.5 GHz

Professional Testing, EMI, Inc.			
Test Method:	**ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference,**		
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):	**2/16/2016, 2/17/2016**	**EUT Serial #:**	**10153514 (Sample A)**
Customer:	**Racom**	**EUT Part #:**	**RAy2-24**
Project Number:	**16866-15**	**Test Technician:**	**Eric Lifsey**
Purchase Order #:	**NA**	**Supervisor:**	**Lisa Arndt**
Equip. Under Test:	**RAy2-24**	**Witness' Name:**	**None**

Radiated Emissions Test Equipment List: 30 MHz to 26.5 GHz					
Tile! Software Version:	**4.2.A, May 23, 2010, 08:38:52 AM**				
Test Profile:	**2015 Rad Emissions_ClassA - LowPRF_072715.til or 2015 Rad Emissions_ClassB - LowPRF_072715.til**				
Asset #	**Manufacturer**	**Model**	**Equipment Nomenclature**	**Serial Number**	**Calibration Due Date**
1509A	Braden	N/A	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	2/5/2017
1890	HP	8447F	Preamp/Amp, 9kHz-1300MHz, 28/25dB	3313A05298	2/1/2018
1937	Agilent	E4440A	Spectrum Analyzer, 3 Hz - 26.5 GHz, Opt. AYZ	MY44808298	12/15/2016
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	135454	1/25/2017
C027D	none	RG214	Cable Coax, N-N, 25m	none	10/1/2016
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	N/A	TDK 10M Chamber, VSWR > 1 GHz	DAC-012915-005	3/14/2017
2004	Miteq	AFS44-00101800-2S-10P-44	Amplifier, 40dB, .1-18GHz	0	1/11/2018
C030	none	none	Cable Coax, N-N, 30m	none	10/1/2016
1325	EMCO	1050	Controller, Antenna Mast	9003-1461	N/A
1780	ETS-Lindgren	3117	Antenna, Double Ridged Guide Horn, 1 - 18 GHz	110313	2/25/2017
1542	A.H. Systems	SAS-572	Antenna, Horn 18-26.5GHz, 20dB gain	225	N/A
1974	Agilent	83017A	Amplifier, Microwave 0.5-26.5 GHz	MY39500684	12/17/2017

Table 7.0.2 – Radiated Emissions 26.5 GHz to 100 GHz

Asset #	Manufacturer	Model #	Description	Calibration Due
1937	Agilent	E4440A	Spectrum Analyzer SN MY44303298	15 Dec 2016
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 7.0.3 –Frequency Stability

Asset #	Manufacturer	Model #	Description	Calibration Due
None	B&K	1710	Adjustable Bench Power Supply	CIU
1668	B&K	1610	Adjustable Bench Power Supply	CIU
0472	Tektronix	THS730A	DMM/Scope	7 Dec 2016
2081	Agilent	E4440A	Spectrum Analyzer	15 Dec 2016
C247	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	13 Oct 2016

Table 7.0.4 –Supporting Equipment

Tag	Manufacturer, Model	S/N	Description
K	Phihong, POE36U-1AT-R	P52701706D1	Power over Ethernet; single port injector and power supply.
C, G	Belkin	None	Shielded Ethernet cables.
L	Jirous, JRMB - 1200 -24Ra	None	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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