TESTING CERT #1255.01
W66 N220 Commerce Court ● Cedarburg, WI 53012
Phone: 262.375.4400 ● Fax: 262.375.4248
www.lsr.com

TEST REPORT # 316132
LSR Job #: C-2581

Compliance Testing of:
IntelliCenter Virtual Cable

Test Date(s):
11/22/16 – 12/8/16

Prepared For:
Attn: Ed Feten
Pentair
10951 West Los Angeles Ave
Moorpark, CA 93021

This Test Report is issued under the Authority of:
Coty Hammerer, EMC Engineer

Signature: Coty Hammerer Date: 2/6/17

Test Report Reviewed by:	**Project Engineer:**
Adam Alger, Quality Systems Engineer	Coty Hammerer, EMC Engineer
Signature: Adam O Alger Date: 2-5-17	Signature: Coty Hammerer Date: 1/25/17

TABLE OF CONTENTS

EXHIBIT 1. INTRODUCTION

1.1 - Scope

References:	FCC Part 15, Subpart C, Section 15.247 & RSS-247, RSS-GEN
Title:	FCC : Telecommunication – Code of Federal Regulations, CFR 47, Part 15
Purpose of Test:	FCC and IC Certification for Low-Power License-Exempt Transmitters
Test Procedures:	FCC KDB 558074 D01 DTS Measurement Guidance v03r05 ANSI C63.10 ANSI C63.4
Environmental Classification:	Residential

1.2 – Normative References

Publication	Year	Title
FCC CFR Parts 0-15	2016	Code of Federal Regulations – Telecommunications
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.
ANSI C63.10	2013	American National Standard for Testing Unlicensed Wireless Devices
FCC KDB 558074 D01 DTS Measurement Guidance v03r05	2016	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
RSS-247	2015	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Networks (LE-LAN) Devices
RSS-GEN	2014	General Requirements for Compliance of Radio Apparatus

1.3 - LS Research, LLC Test Facility

LS Research, LLC in Review

As an EMC Testing Laboratory, our Accreditation and Assessments are recognized through the following:

TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025: 2005 with Electrical (EMC) Scope of Accreditation
A2LA Certificate Number: 1255.01

Federal Communications Commission (FCC) – USA

Listing of two 3 Meter Semi-Anechoic Chambers based on Title 47 CFR – Part 2.948
FCC Registration Number: 90756

Industrie Canada Industry Canada

Industry Canada

On file, 3 Meter Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-2
On file, 3 Meter Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-3

1.4 – Location of Testing

All testing was performed at the following location utilizing the facilities listed below, unless otherwise noted.

LS Research, LLC
W66 N220 Commerce Court
Cedarburg, Wisconsin, 53012 USA,

List of Facilities Located at LS Research, LLC:

3m Semi-Anechoic Chamber

1.5 – Test Equipment Utilized

A complete list of equipment utilized in testing is provided in Appendix A of this test report. Calibration dates are indicated in Appendix A. All test equipment is calibrated by a calibration laboratory accredited to the requirements of ISO/IEC 17025, and traceable to the SI standard.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 – Client Information

Manufacturer Name:	Pentair
Address:	10951 West Los Angeles Ave Moorpark, CA 93021
Contact Name:	Ed Feten

2.2 - Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	IntelliCenter Virtual Cable
Model Number:	ICVC
Serial Number:	Engineering Sample 1: Tx Radiated/ Conducted Emissions Engineering Sample 2: Rx Radiated Emissions Engineering Sample 3: Conducted Radio Measurements

2.3 - Associated Antenna Description

The only associated antenna is a trace monopole antenna. This antenna has a peak gain of 1.75 dBi.

2.4 - EUT'S Technical Specifications

EUT Frequency Range (in MHz)	2405MHz – 2475MHz
Type of Modulation	DSSS
Transmitter Spurious (worst case) at 3 meters)	53.90 dBµV/m (Average Measurement)
Frequency Tolerance %, Hz, ppm	Better than 100 ppm
Microprocessor Model # (if applicable)	ATMEL ATmega256RFR2
Antenna Information	
Detachable/non-detachable	Non-detachable
Type	Trace Monopole Antenna
Gain	1.75 dBi
EUT will be operated under FCC Rule Part(s)	Title 47 part 15.247
Modular Filing	☐ Yes ☒ No

2.5 - Product Description

The IntelliCenter Virtual Cable is a 2.4GHz wireless transceiver (IEEE 802.15.4 with DSSS modulation) that allows swimming pool owners to control their Pentair IntelliCenter Pool Automation system with a wireless remote. The IntelliCenter Virtual Cable is connected to the Pentair IntelliCenter Pool Automation system via an rs485 cable. The IntelliCenter Virtual Cable is powered by the rs485 cable and is mounted outside near the pool equipment pad. The benefit of the virtual cable is that a physical wired connection does not need to exist between the swimming pool equipment pad and the user's home.

EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 - Climate Test Conditions

Temperature:	70°- 78° F
Humidity:	35% - 40%

3.2 - Applicability & Summary of EMC Emission Test Results

FCC and IC Paragraph	Test Requirements	Compliance (Yes/No)
FCC : 15.207	Power Line Conducted Emissions Measurements	Yes
FCC : 2.1049 (a)	99% Bandwidth	Yes
FCC : 15.247(b)(3) & 1.1310, RSS-247 (5.4)(4)	Maximum Output Power	Yes
FCC :15.247(d), RSS-247 (5.5)	RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
FCC:15.247 (a)(2), RSS-247 (5.2)(1)	6 dB Bandwidth of a Digital Modulation System	Yes
FCC:15.247 (e), RSS-247 (5.2)(2)	Power Spectral Density of a Digital Modulation System	Yes
FCC : 15.247(d), 15.209 & 15.205	Transmitter Radiated Emissions	Yes

3.3 - Modifications Incorporated In The EUT For Compliance Purposes

☒ None ☐ Yes (explain below)

3.4 - Deviations & Exclusions From Test Specifications

☒ None ☐ Yes (explain below)

EXHIBIT 4. CONFORMANCE SUMMARY

When tested between November 22nd and December 8th, 2016 it was determined that the EUT, the IntelliCenter Virtual Cable, was compliant to the requirements of:

FCC Title 47 CFR Part 15.247, RSS-GEN, and RSS-247

Using the methods of ANSI C63.10-2013

Any modifications made to the EUT after the specified test date(s) will invalidate the data herein.

If some emissions measurements are seen to be within the uncertainty value, as listed in Appendix C there is a possibility that this unit may not meet the required limit specification if subsequently tested.

EXHIBIT 5. UNWANTED EMISSIONS INTO THE RESTRICTED FREQUENCY BANDS.

5.1 - Test Setup

The EUT was placed on a 150 cm high non-conductive pedestal (80 cm for measurements under 1 GHz), centered on a flush mounted turntable inside a 3 meter Semi-Anechoic Chamber. The EUT was operated in continuous transmit mode for final testing. The unit has the capability to operate on 3 channels, controllable via proprietary software provided by the manufacturer.

The applicable limits apply at a 3 meter distance. The calculations to determine these limits are detailed in the following pages. Please refer to Appendix A for a complete list of test equipment. The test sample was operated on one of three (3) standard channels to comply with FCC Part 15.31(m).

5.2 - Test Procedure

Radiated RF measurements were performed on the EUT in a 3 meter Semi-Anechoic, FCC listed Chamber. The frequency range from 30 MHz to 25000 MHz was scanned and investigated. The radiated emission levels were manually noted at the various fixed degree settings of azimuth on the turntable and antenna height. The EUT was placed on a non-conductive pedestal in the 3 meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters from the EUT. A Biconical Antenna was used to measure emissions from 30 MHz to 200 MHz, and a Log Periodic Antenna was used to measure emissions from 200 MHz to 1000 MHz. A Double-Ridged Waveguide Horn Antenna was used from 1 GHz to 18 GHz while a standard gain horn antenna was used in the 18 GHz to 25 GHz range. The maximum radiated RF emissions between 30MHz to 25 GHz were found by raising and lowering the sense antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities. A tilt gear was utilized to keep the EUT within the cone of radiation for measurements above 1 GHz.

The EUT was positioned in one orientation as the manufacturer states the EUT should be mounted vertically on a wall for proper use.

5.3 - Test Equipment Utilized

A list of the test equipment and antennas utilized for the Radiated Emissions test can be found in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. All calibrations of the antennas used were performed at a calibration laboratory accredited to ISO 17025, and are traceable to the SI standard. The resulting correction factors and the cable loss factors from these calibrations were entered into the EMI Receiver database. As a result, the data taken from the EMI Receiver accounts for the antenna correction factor as well as cable loss or other corrections, and can therefore be entered into the database as a corrected meter reading. The EMI Receiver was operated with a resolution bandwidth of 120 kHz for measurements below 1 GHz (video bandwidth of at least 300 kHz), and a resolution bandwidth of 1 MHz for measurements above 1 GHz (video bandwidth of at least 3 MHz). For some plots, a reduced video bandwidth was used in order to identify spurious emissions (The relevant plots are labeled as such). In these cases, the standard video bandwidth was used with the appropriate detectors for measurement.

5.4 - Test Results

The EUT was found to **MEET** the Radiated Emissions requirements of Title 47 CFR, FCC Part 15.247, and RSS-247 for a DTS transmitter. The frequencies with significant RF signal strength were recorded and plotted as shown in the Data Charts and Graphs.

5.5 - Calculation of Radiated Emissions Limits and reported data.

Reported data:

For both fundamental and spurious emissions measurement, the data reported includes all necessary correction factors. These correction factors are loaded onto the EMI receiver when measurements are performed.

Reported Measurement data = Raw receiver measurement (dBµV) + Antenna correction Factor + Cable factor (dB) + Miscellaneous factors when applicable (dB) – amplification factor when applicable (dB).

Generic example of reported data at 200 MHz:

Reported Measurement data = 18.2 (raw receiver measurement) + 15.8 (antenna factor) + 1.45 (cable factor) = 35.45 (dBµV/m).

As specified in 15.247 (d), radiated emissions that fall within the restricted band described in 15.205(c) for FCC must comply with the general emissions limit and the RSS-247 limits which are equivalent.

The following table depicts the general radiated emission limits above 30 MHz. These limits are obtained from Title 47 CFR, Part 15.209, for radiated emissions measurements. These limits were applied to any signals found in the 15.205 restricted bands. The mentioned limits correspond to those limits listed in RSS GEN.

Frequency (MHz)	3 m Limit µV/m	3 m Limit (dBµV/m)	1 m Limit (dBµV/m)
30-88	100	40.0	-
88-216	150	43.5	-
216-960	200	46.0	-
960-40,000	500	54.0	63.5

Sample conversion of field strength (µV/m to dBµV/m):
dBµV/m = 20 log $_{10}$ (100) = 40 dBµV/m (from 30-88 MHz)

5.6 - Data

Manufacturer:	Pentair						
Date(s) of Test:	11/23/16 – 12/2/16						
Project Engineer(s):	Coty Hammerer						
Test Engineer(s):	Coty Hammerer						
Voltage:	120 VAC, 60 Hz						
Operation Mode:	Continuous transmit, modulated						
Environmental Conditions in the Lab:	Temperature: 74° F Relative Humidity: 38%						
EUT Power:	X	Single Phase 120VAC		3 Phase ___VAC			
		Battery		Other: Bench DC Supply			
EUT Placement:	X	150 cm non-conductive pedestal (80 cm for <1 GHz)		10cm Spacers			
EUT Test Location:	X	3 Meter Semi-Anechoic FCC Listed Chamber		3/10m OATS			
Measurements:		Pre-Compliance		Preliminary	X	Final	
Detectors Used:	X	Peak	X	Quasi-Peak	X	Average	

Measurements below 1 GHz:

Frequency (MHz)	Height (m)	Azimuth (degree)	Quasi Peak Reading (dBµV/m)	Quasi Peak Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation	Mode
58.12	1.00	0.00	24.24	40.00	15.76	Vertical	Vertical	Tx
56.05	1.00	342.00	21.84	40.00	18.16	Vertical	Vertical	Tx
176.00	1.36	227.00	27.42	43.50	16.08	Vertical	Vertical	Tx
614.61	159.30	199.60	44.29	46.00	1.71	Horizontal	Vertical	Tx
833.70	100.20	262.40	36.65	46.00	9.35	Horizontal	Vertical	Tx
406.52	100.00	208.60	38.32	46.00	7.68	Horizontal	Vertical	Tx

Measurements above 1 GHz:

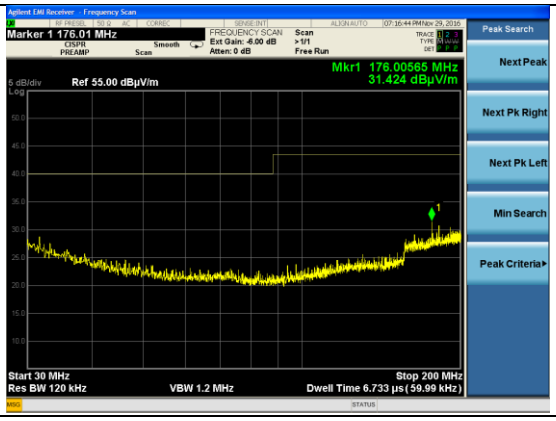
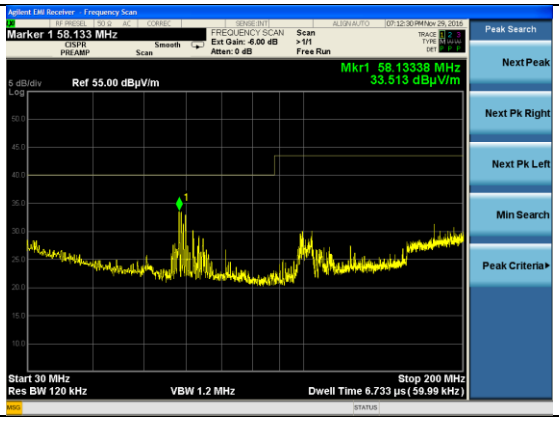
Note: Table below shows the emissions from each channel at or above 1 GHz.

Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading (dBµV/m)	Average Reading (dBµV/m)	Average Limit (dBµV/m)	Margin (dB)	Antenna Polarity	EUT orientation	Mode
1000.00	2.95	303.00	56.84	38.04	54.0	15.96	Horizontal	Vertical	Tx
4810.00	1.54	339.00	53.74	46.29	54.0	7.71	Horizontal	Vertical	Tx
4810.00	2.31	360.00	55.93	48.92	54.0	5.08	Vertical	Vertical	Tx
4880.00	1.71	333.00	50.46	46.75	54.0	7.25	Horizontal	Vertical	Tx
7320.00	1.00	50.00	49.04	45.07	54.0	8.93	Horizontal	Vertical	Tx
4880.00	2.09	350.00	56.47	49.66	54.0	4.34	Vertical	Vertical	Tx
7320.00	1.19	340.00	57.49	49.51	54.0	4.49	Vertical	Vertical	Tx
4950.00	1.84	330.00	45.56	35.57	54.0	18.43	Horizontal	Vertical	Tx
4950.00	1.91	0.00	47.5	37.89	54.0	16.11	Vertical	Vertical	Tx
7425.00	1.41	330.00	47.72	37.27	54.0	16.73	Vertical	Vertical	Tx
19516.00	1.83	52.50	60.15	50.85	54.0	3.15	Horizontal	Vertical	Tx
19523.00	3.08	13.75	54.14	42.51	54.0	11.49	Vertical	Vertical	Tx
19284.00	2.03	56.00	61.56	53.90	54.0	0.10	Horizontal	Vertical	Tx
19284.00	1.00	293.00	53.96	43.69	54.0	10.31	Vertical	Vertical	Tx
19716.00	1.48	52.25	58.51	46.80	54.0	7.20	Horizontal	Vertical	Tx

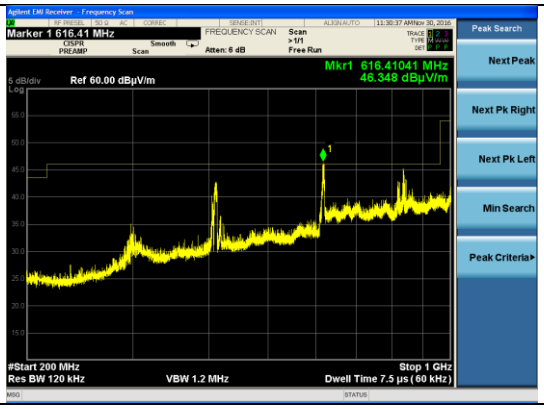
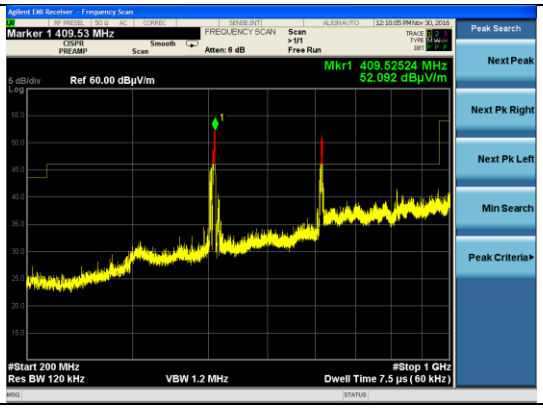
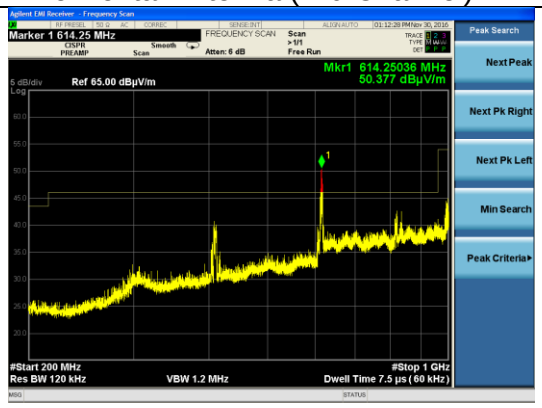
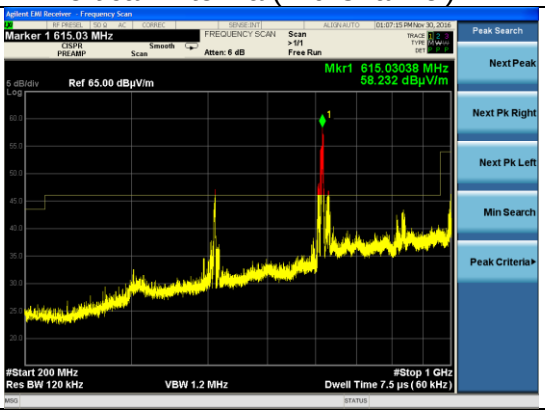
5.7 – Screen Captures.

The screen captures below are those using the Peak detector of the analyzer. In addition, the screen captures presented are those which were deemed to be an appropriate representation of the spectrum scan.

30 to 200 MHz, 3m distance

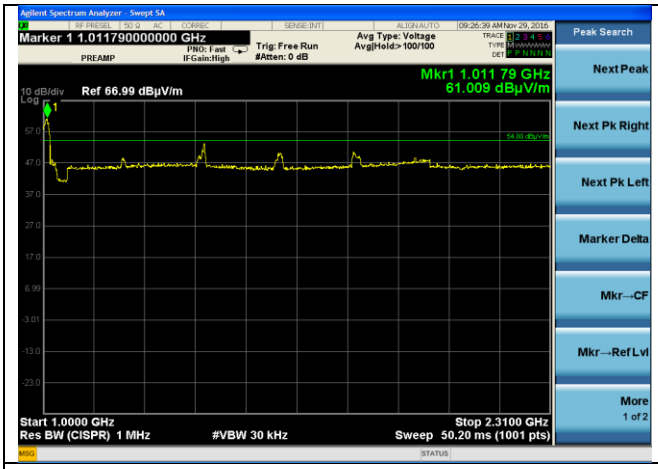
	
Horizontal Antenna (Mid Channel)	Vertical Antenna (Mid Channel)

200 to 1000 MHz, 3m distance.

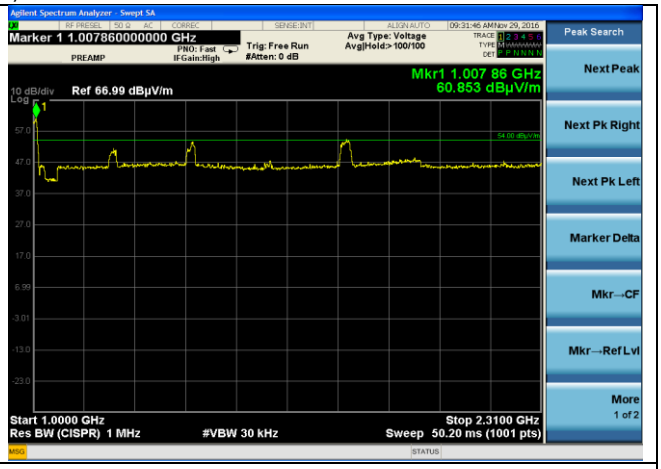
	
Horizontal Antenna (Mid Channel) Tx	Vertical Antenna (Mid Channel) Tx
	
Horizontal Antenna, EUT NOT Powered!	Vertical Antenna, EUT NOT Powered!

Note: The emissions from 200-1000 MHz are not a function of the EUT! Connected secondary equipment used to program the EUT is the origin of these emissions.

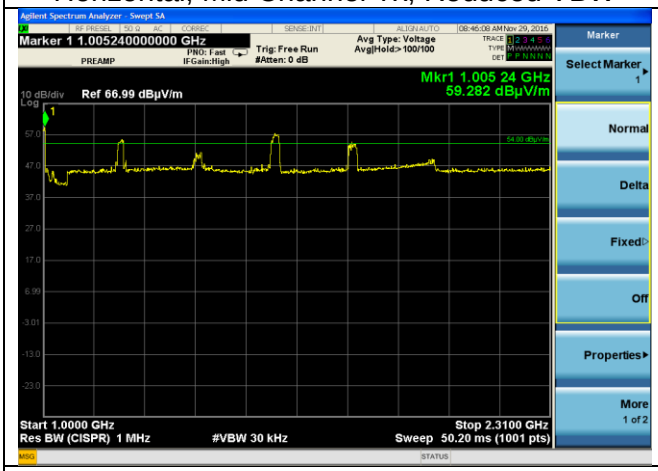
1000 to 2310 MHz, 3m distance



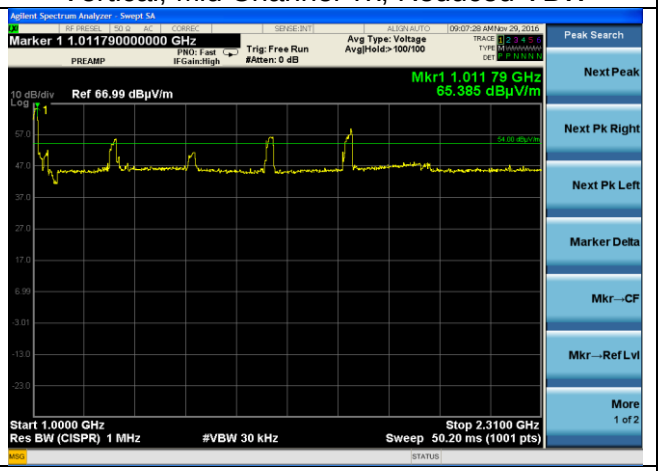
Horizontal, Mid Channel Tx, Reduced VBW



Vertical, Mid Channel Tx, Reduced VBW



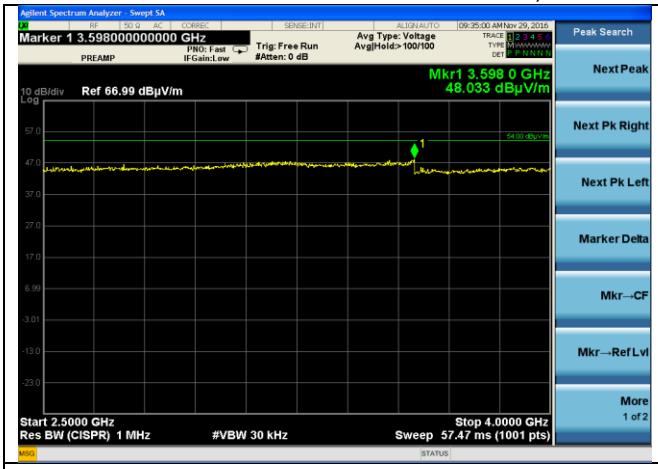
Horizontal, Mid Channel, Radio in Stand-By, Reduced VBW



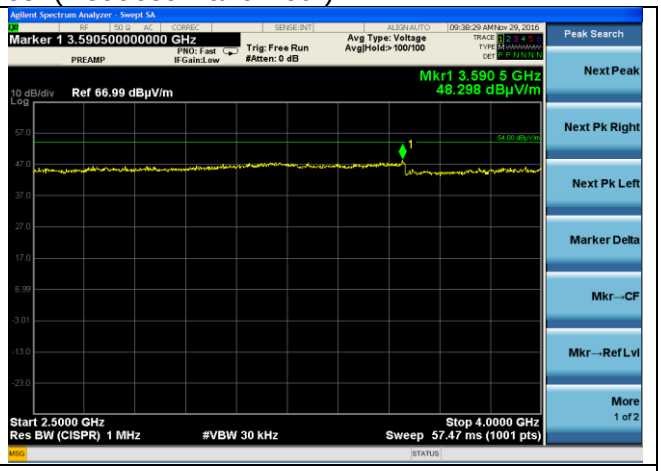
Vertical, Mid Channel, Radio in Stand-By, Reduced VBW

Note: The ranges 2310 to 2390 and 2483.5 to 2500 MHz are in section 8 of this report (Band-edges).

2500 to 4000 MHz, 3m distance. (Reduced Bandwidth)



Horizontal, Mid Channel



Vertical, Mid Channel

4000 to 18000 MHz, 3m distance.

Horizontal, Mid Channel, Reduced VBW

Vertical, Mid Channel, Reduced VBW

18000 to 25000 MHz, 3m distance.

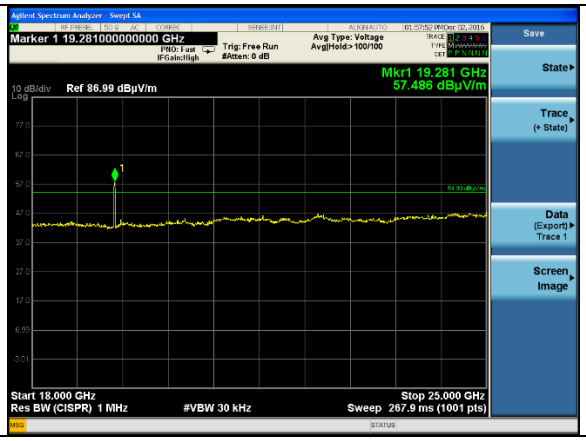
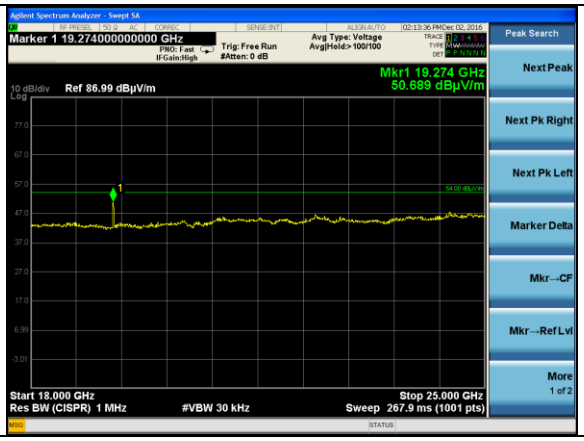
	
Horizontal, Channel 12, Reduced VBW	Vertical, Channel 12, Reduced VBW

EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE

6.1 Test Setup

The EUT was placed on a non-conductive wooden table, with a height of 80 cm above the reference ground plane. The power supply was then plugged into a 50Ω (ohm) Line Impedance Stabilization Network (LISN). The AC power supply was provided via an appropriate broadband EMI Filter, and then to the LISN line input. After the EUT was setup and connected to the LISN, the RF Sampling Port of the LISN was connected through an internal limiter to EMI receiver System. The LISN used has the ability to terminate the unused port with a 50Ω (ohm) load when switched to either L1 (line) or L2 (neutral). Final readings were then taken and recorded.

6.2 Test Procedure

The EUT was investigated in continuous modulated transmit mode for this portion of the testing. The appropriate frequency range and bandwidths were selected on the EMI Receiver, and measurements were made. The bandwidth used for these measurements is 9 kHz, as specified in CISPR 16-1, Section 1, Table 4, for Quasi-Peak and Average detectors in the frequency range of 150 kHz to 30 MHz. Final readings were then taken and recorded.

6.3 Test Equipment Utilized

A list of the test equipment and accessories utilized for the Conducted Emissions test is provided in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. The emissions are measured on the EMI System, which contains correction factors to account for the equipment used in measurements.

6.4 Test Results

The EUT was found to **MEET** the Conducted Emission requirements of FCC Part 15.207 and RSS-247 for Conducted Emissions for an Intentional Radiator. See the Data Charts and Graphs for more details of the test results.

6.5 FCC Limits of Conducted Emissions at the AC Mains Ports

Frequency Range (MHz)	Class B Limits (dBµV)		Measuring Bandwidth
	Quasi-Peak	Average	
0.150 -0.50 *	66-56	56-46	RBW = 9 kHz VBW ≥ 9 kHz for QP VBW = 1 Hz for Average
0.5 – 5.0	56	46	
5.0 – 30	60	50	
* The limit decreases linearly with the Logarithm of the frequency in this range.			

6.6 Conducted Emissions Test Data Chart

Frequency Range inspected: 150 KHz to 30 MHz

Manufacturer:	Pentair					
Date(s) of Test:	12/8/16					
Project Engineer:	Coty Hammerer					
Test Engineer:	Coty Hammerer					
Voltage:	120VAC to 16 VDC Off-The-Shelf Power Supply					
Operation Mode:	Continuous transmit, modulated					
Environmental Conditions in the Lab:	Temperature: 72° F Relative Humidity: 38%					
Test Location:	X	AC Mains Test area				Chamber
EUT Placed On:	X	40cm from Vertical Ground Plane				10cm Spacers
	X	80cm above Ground Plane				Other:
Measurements:		Pre-Compliance		Preliminary	X	Final
Detectors Used:		Peak	X	Quasi-Peak	X	Average

Note: All points measured below were measured with Radio transmitting on mid channel, Data/Plots were not dependent on frequency.

Line	Frequency (MHz)	Q-Peak Reading (dBµV)	Q-Peak Limit (dBµV)	Quasi-Peak Margin (dB)	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)	Mode
1	0.177	44.20	64.63	20.43	32.55	54.63	22.1	Tx
1	0.231	41.29	62.41	21.12	29.92	52.41	22.5	Tx
1	0.159	44.46	65.52	21.06	32.61	55.52	22.9	Tx
2	0.155	43.78	65.73	21.95	23.38	55.73	32.3	Tx
2	0.582	33.15	56.00	22.85	17.55	46.00	28.5	Tx
2	1.180	25.57	56.00	30.43	14.40	46.00	31.6	Tx

6.7 Screen Captures – Conducted Emissions Test

These screen captures represent the worst-case Peak Emissions. For conducted emission measurements, both a Quasi-Peak detector function and an Average detector function are utilized.

Transmit Mode (Channel 18)

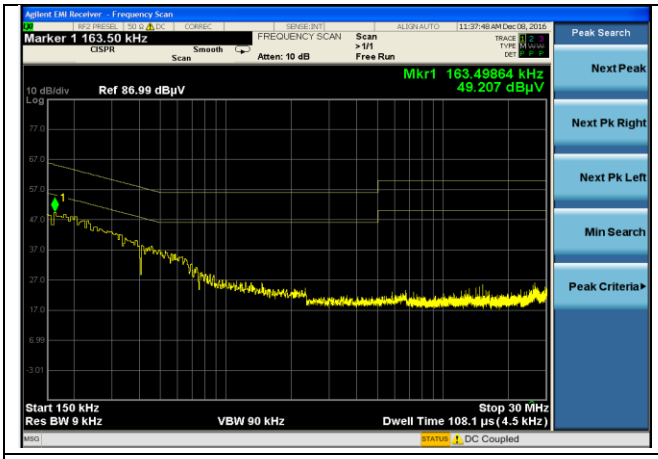
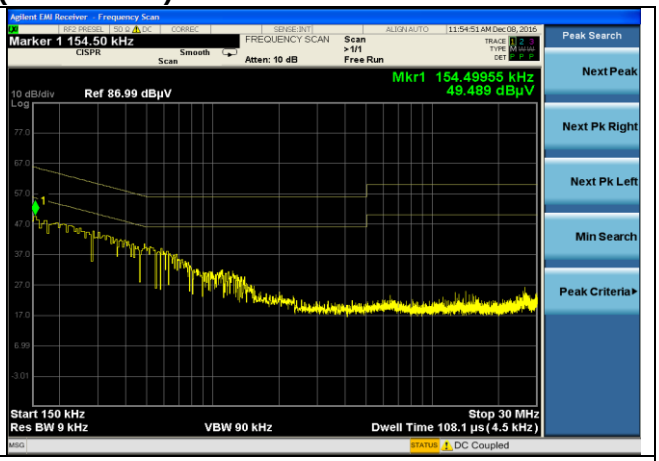
	
Line 1	Line 2

EXHIBIT 7. OCCUPIED BANDWIDTH

Test Engineer(s): Shane Dock

7.1 - Limits

For a DTS system operating in the 2400 to 2483.5 MHz band, the minimum 6dB emission bandwidth limit is 500 kHz.

7.2 - Method of Measurements

For this portion of the tests, a direct measurement of the transmitted signal was performed at the antenna port of the EUT, via a cable connection to a spectrum analyzer. An attenuator was placed in series with the cable to protect the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings thereby allowing direct measurements, without the need for any further corrections. The EUT was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. A bandwidth measurement function that is built into the spectrum analyzer was used to measure the 20dB/emission bandwidth while the 6dB bandwidth was measured in accordance **FCC OET KDB 558074 section 8.**

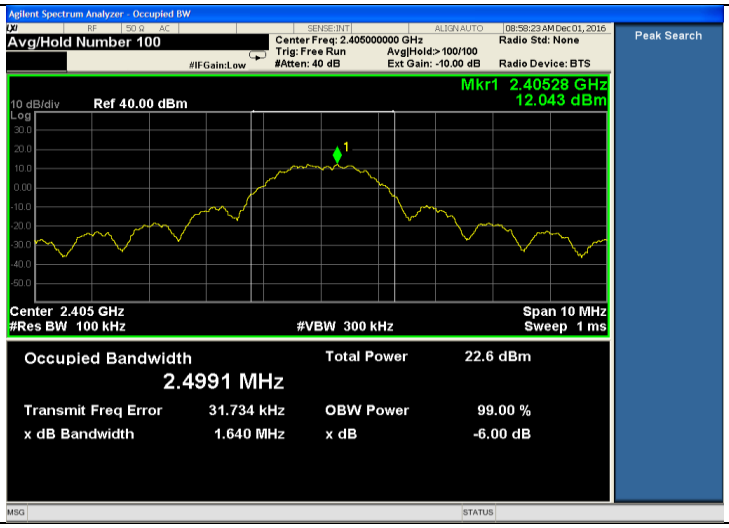
7.3 - Test Data

Channel	6 dB BW (MHz)	99% BW (MHz)
11	1.640	2.577
18	1.678	2.478
25	1.673	2.610

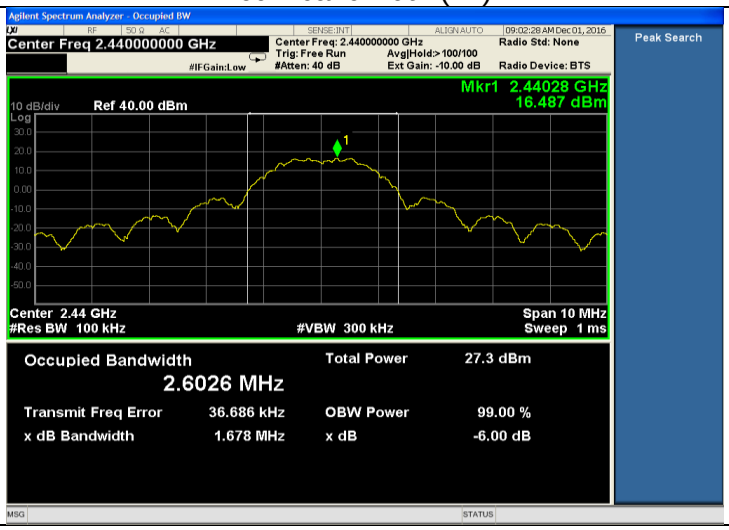
7.4 – Screen Captures

Examples of bandwidth measurements:

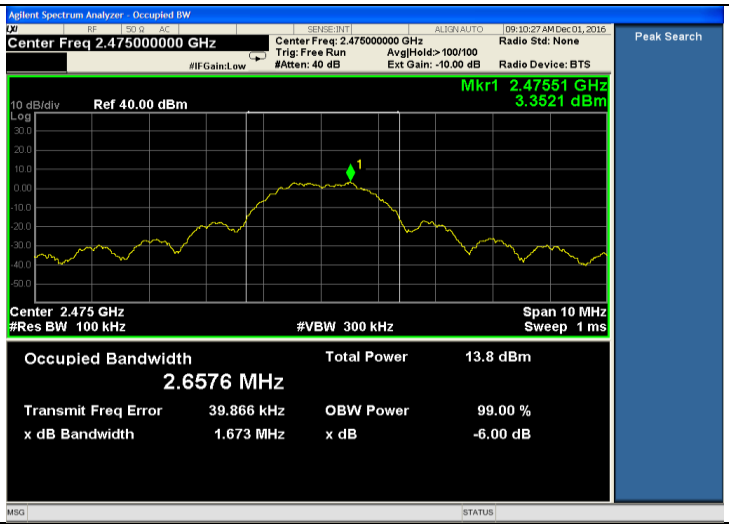
6 dB Bandwidth



6dB bandwidth (11)

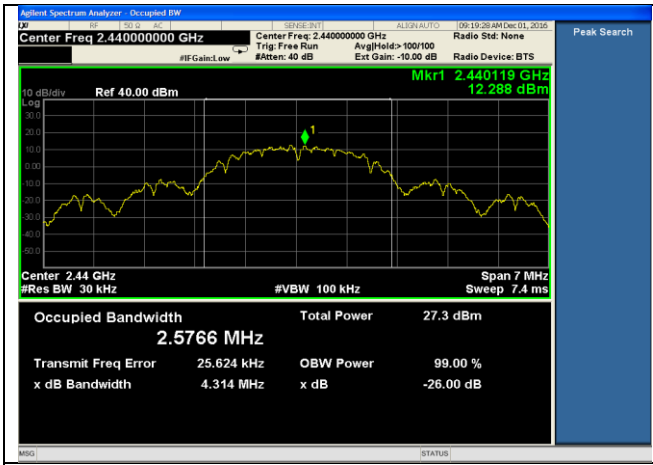


6dB bandwidth (18)

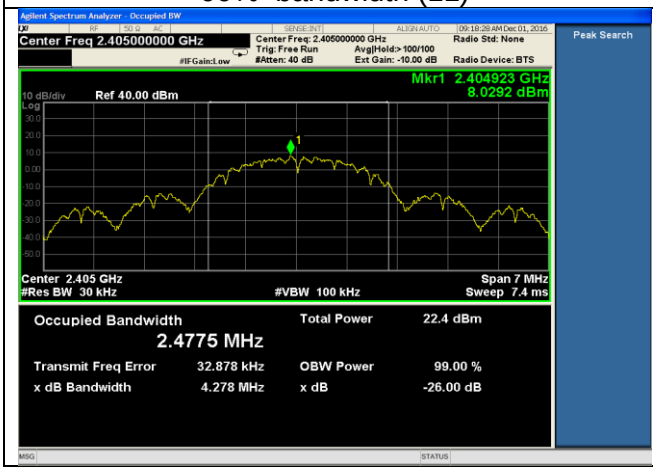


6dB bandwidth (25)

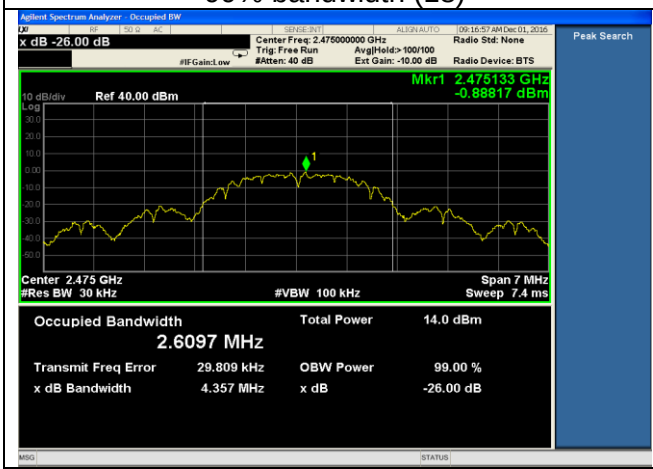
99% Bandwidth



99% bandwidth (11)



99% bandwidth (18)



99% bandwidth (25)

EXHIBIT 8. BAND EDGE MEASUREMENTS

Test Engineer(s): Shane Dock

8.1 - Method of Measurements

FCC 15.247 requires a measurement of spurious emission levels at the restricted band to be compliant to the general emissions limit, in particular at the Band-Edges where the intentional radiator operates. The EUT was operated in continuous transmit mode with continuous modulation, with internally generated data as the modulating source.

The Band-edge measurements were performed conducted (100 kHz bandwidth) and radiated. The measurement of band-edge was performed to satisfy FCC 15.247(d).

Per FCC KDB 558074 D01 Measurement Guidance v03r05 (section 11), conducted measurements were performed with 100 kHz bandwidth for all emissions outside of the band of operation. For measuring radiated emissions in the restricted band, a bandwidth of 120 kHz (below 1000MHz) or 1MHz (above 1000MHz) was used in accordance with C63.4.

For both conducted and radiated measurements, correction factors and the cable loss factors were entered into the EMI Receiver database. **As a result, the plots taken from the EMI Receiver accounts for all applicable correction factor as well as cable loss, and can therefore be entered into the database as a corrected meter reading.**

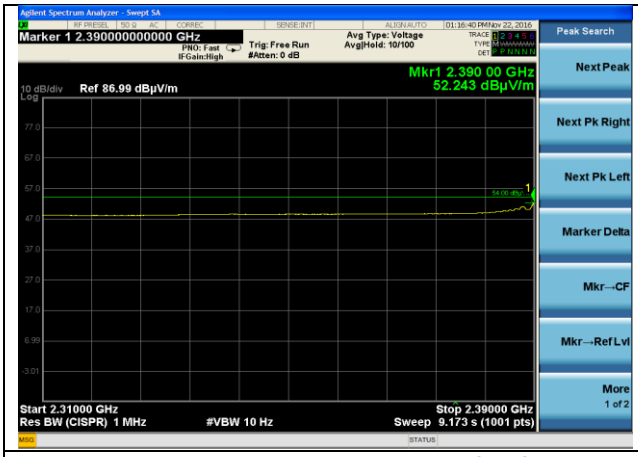
8.2. Band Edge Screen Captures

The data presented below are samples selected from the various data rates and channels tested.

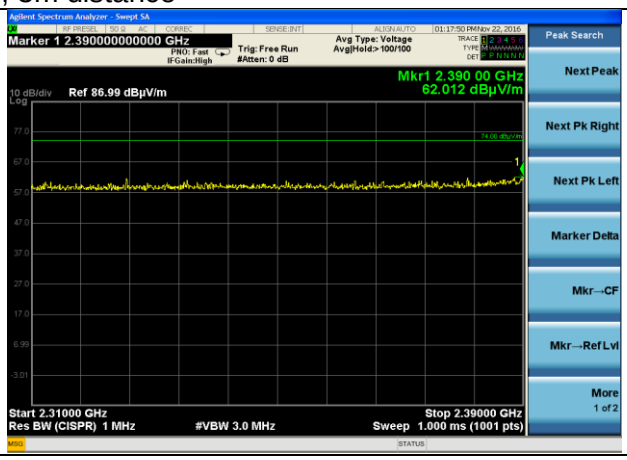
Band-Edge in Restricted Band

Radiated Band-edge in Restricted Band:

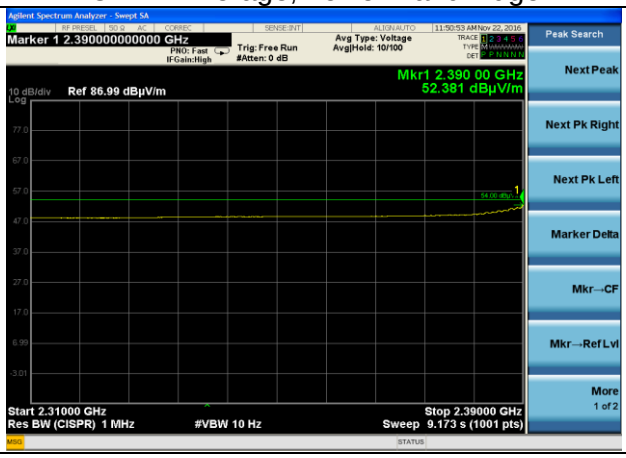
2310 to 2390 MHz, 3m distance



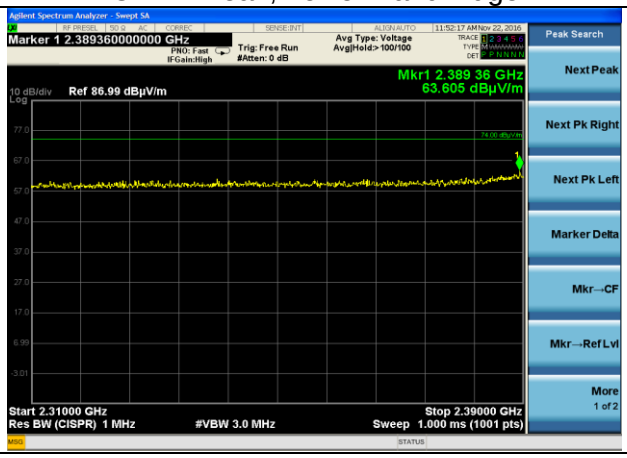
CH 11 Average, Lower Band-Edge



CH 11 Peak, Lower Band-Edge



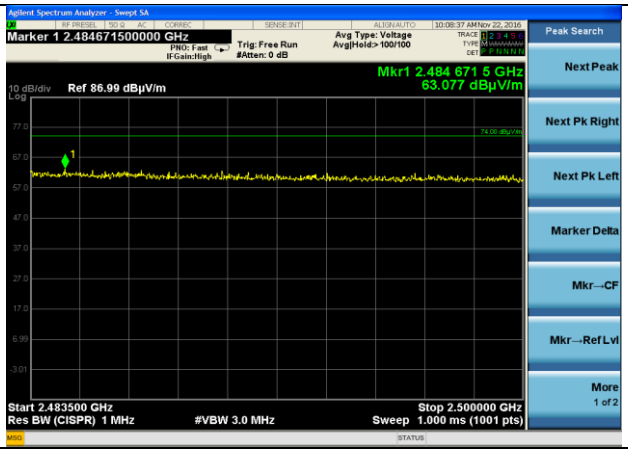
CH 12 Average, Lower Band-Edge



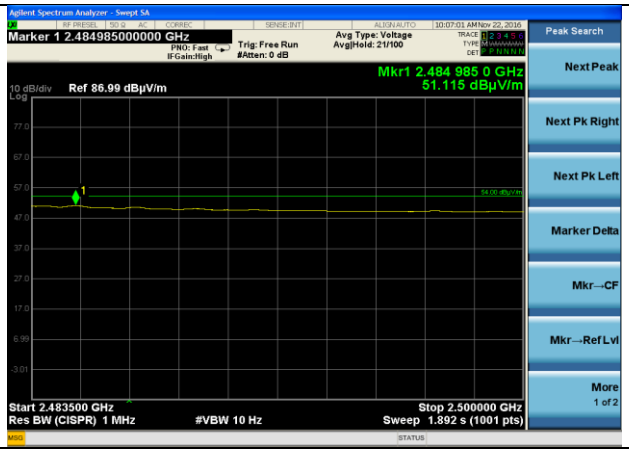
CH 12 Peak, Lower Band-Edge

2483.5 to 2500 MHz Restricted band

CH 23

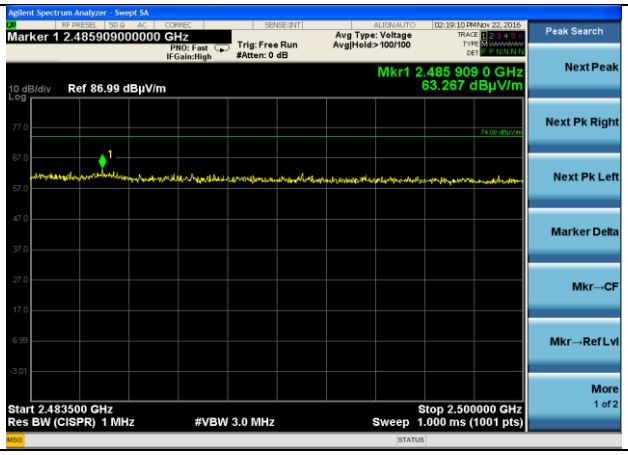


Upper Band-Edge Peak



Upper Band-Edge Average

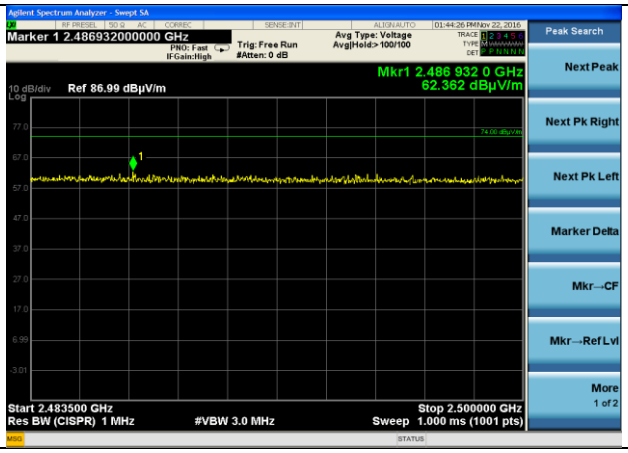
CH 24



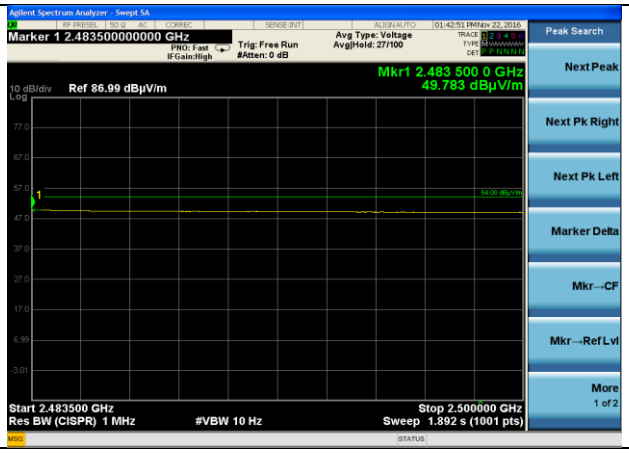
Upper Band-Edge Peak

Upper Band-Edge Average

CH 25



Upper Band-Edge Peak



Upper Band-Edge Average

Radiated Band-Edge Data

Channel	Frequency (GHz)	Average (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)	Frequency (GHz)	Peak (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)
11	2390.00	52.243	54	1.757	2390.00	62.012	74	11.988
12	2390.00	52.381	54	1.619	2389.36	63.605	74	10.395
23	2484.99	51.115	54	2.885	2484.67	63.077	74	10.923
24	2485.98	51.528	54	2.472	2485.91	63.267	74	10.733
25	2483.50	49.783	54	4.217	2486.93	62.362	74	11.638

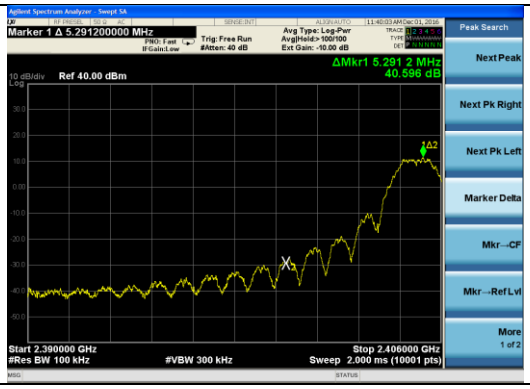
Note: Refer to Radiated Band-Edge Plots for Specific Frequency.

Conducted Band-Edge Reference Pictures

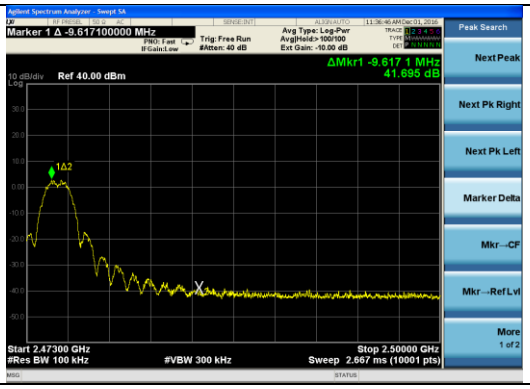
Refer to Section 7.4 (6 dB bandwidth Plots) for reference levels. Display lines on spurious Plots do not represent limit line.

Channel	Reference Level	Limit (dBm)
11	10.880	-9.120
18	16.121	-3.879
25	2.315	-17.685

Band-edge in 100 kHz bandwidth (Conducted Band Edge)



CH 11 Lower Band-Edge



CH 25 Upper Band-Edge

EXHIBIT 9. POWER OUTPUT (CONDUCTED): 15.247(b)

Test Engineer(s): Shane Dock

9.1 - Method of Measurements

The conducted RF output power of the EUT was measured at the antenna port using a short RF cable along with an attenuator as protection for the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings thereby allowing direct measurements without the need for any further corrections. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source.

Measurement procedure used was FCC OET KDB 558074 D01 Measurement Guidance v03r05 section 9.1.1.

Peak Conducted Output Power Limit = 1 Watt (30 dBm).

9.2 - Test Data

The data reported includes all necessary correction factors. These correction factors are loaded onto the EMI receiver when measurements are performed.

Reported Measurement data = Raw receiver measurement (dBm) + Cable factor (dB) + Miscellaneous factors when applicable (dB).

Generic example of reported data at 2440 MHz:

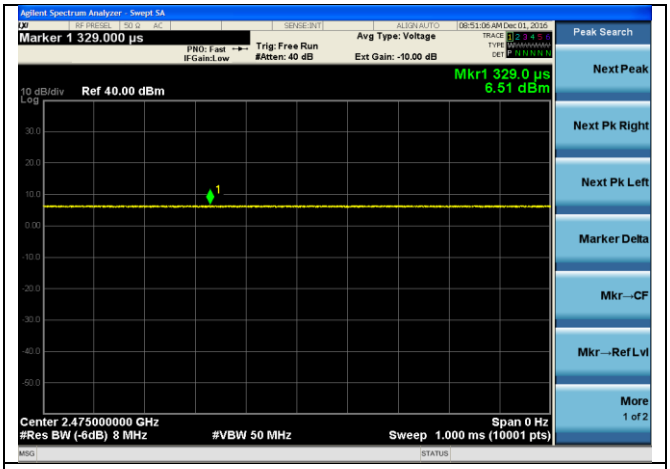
Reported Measurement data = 8.55 (raw receiver measurement in dBm) + 0.85 (cable factor in dB) = 9.4 (dBm).

9.2.1. Maximum conducted peak power:

9.2.1.1 Duty cycle:

Measurement procedure: **FCC OET KDB 558074 D01 Measurement Guidance v03r05.**

Screen captures:



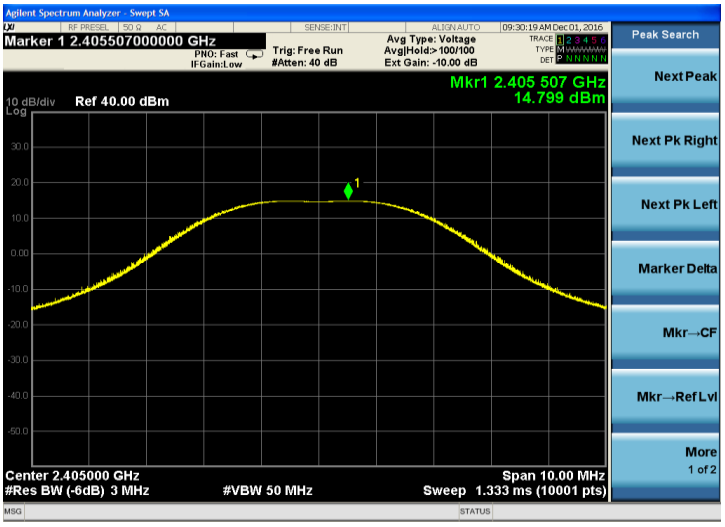
Duty Cycle

100% for all channels, so no duty cycle correction is necessary.

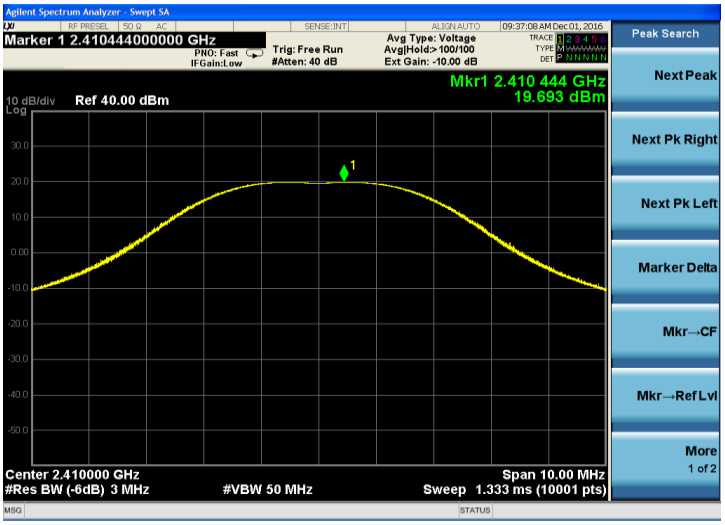
9.2.1.2 Maximum conducted (Peak) output power:

Channel	Peak Power (dBm)
11	14.799
12	19.693
18	19.474
23	19.037
24	11.108
25	6.188

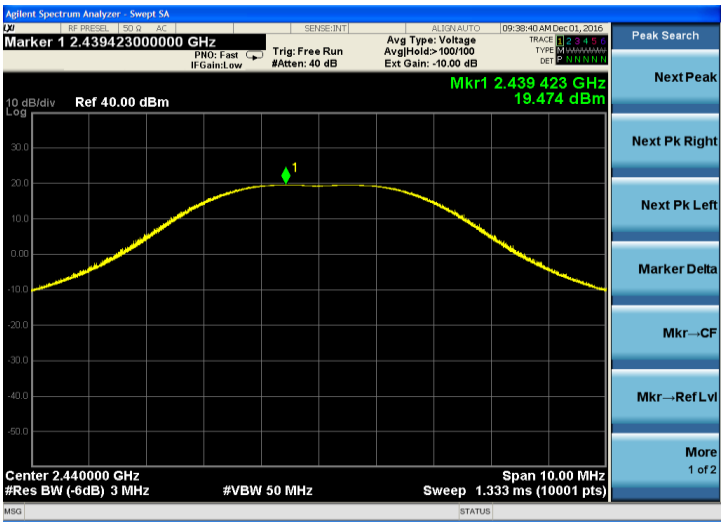
CH 11



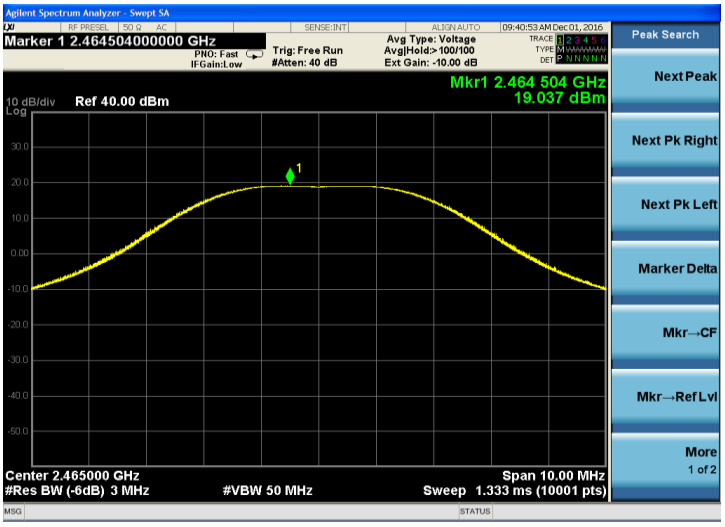
CH 12



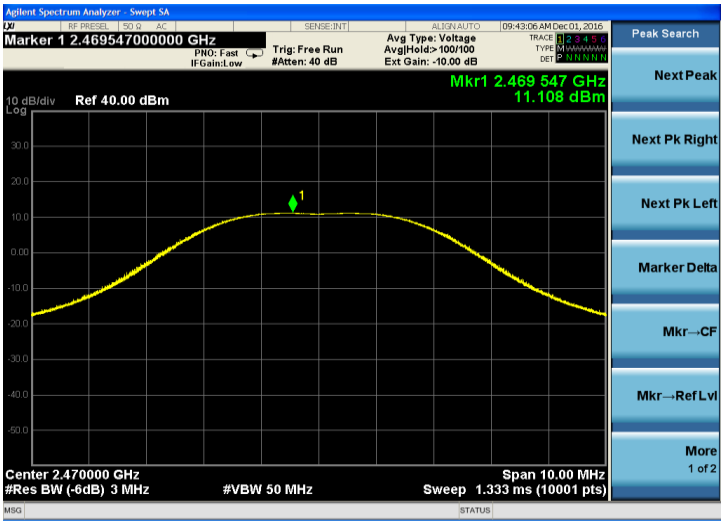
CH 18



CH 23



CH 24



CH 25

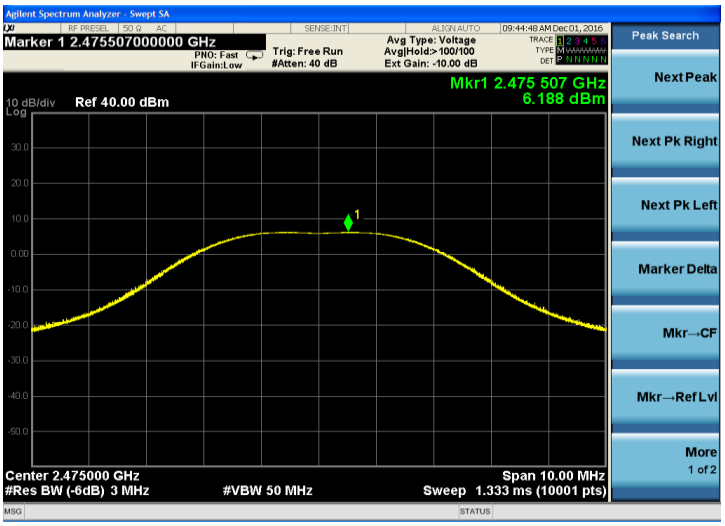


EXHIBIT 10. CONDUCTED SPURIOUS EMISSIONS: 15.247(d)

Test Engineer(s): Shane Dock

10.1 - Limits

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

10.2 – Conducted Harmonic and Spurious RF Measurements

FCC Part 15.247(d) and IC RSS 247 both require a measurement of conducted harmonic and spurious RF emission levels, as reference to the carrier level when measured in a 100 kHz bandwidth. For this test, the spurious and harmonic RF emissions from the EUT were measured at the EUT antenna port using a short RF cable along with an attenuator as protection for the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings, thereby allowing direct readings of the measurements made without the need for any further corrections. A spectrum analyzer was used with the resolution bandwidth set to 100 kHz for this portion of the tests. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with measurements from a peak detector presented in the chart below. Screen captures were acquired and any noticeable spurious and harmonic signals were identified and measured.

Measurement procedure used was FCC OET KDB 558074 D01 Measurement Guidance v03r05 section 11.

The data reported includes all necessary correction factors. These correction factors are loaded onto the EMI receiver when measurements are performed.

Reported Measurement data = Raw receiver measurement (dBm) + Cable factor (dB) + Miscellaneous factors when applicable (dB).

Generic example of reported data at 2440 MHz:

Reported Measurement data = 8.55 (raw receiver measurement in dBm) + 0.85 (cable factor in dB) = 9.4 (dBm).

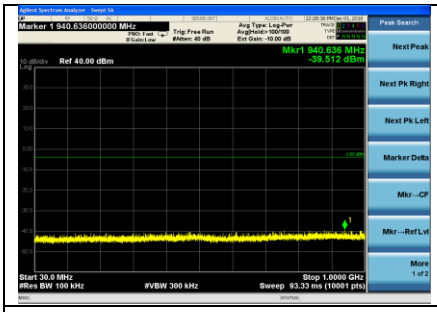
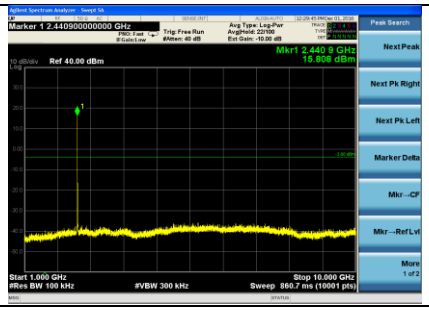
10.3 - Test Data

The data presented below is a sample of channel 18. Display lines on captures do not represent limit lines, so refer to the fundamental picture for limits. Pictures below are samples.

Note: Refer to 6 dB bandwidth screenshots in Section 7.4 for limits

Channel	Reference Level	Limit (dBm)
11	10.880	-9.120
18	16.121	-3.879
25	2.315	-17.685

Example: Channel 18

		
30 to 1000 MHz	1000 to 10000 MHz	10000 to 25000 MHz

Note: All emissions were greater than 20 dB below the limit for each channel tested.

EXHIBIT 11. POWER SPECTRAL DENSITIES: 15.247(e)

11.1 Limits

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

In accordance with FCC Part 15.247(e) and RSS 247, the peak power spectral density should not exceed +8 dBm in any 3 kHz band. This measurement was performed along with the conducted power output readings as described in previous sections. The peak output frequency for each representative frequency was scanned, with a narrow bandwidth, and reduced sweep, and a power density measurement was performed.

Measurement procedure used was FCC OET KDB 558074 D01 Measurement Guidance v03r05 section 10.2.

The data reported includes all necessary correction factors. These correction factors are loaded onto the EMI receiver when measurements are performed.

Reported Measurement data = Raw receiver measurement (dBm) + Cable factor (dB) + Miscellaneous factors when applicable (dB).

Generic example of reported data at 2440 MHz:

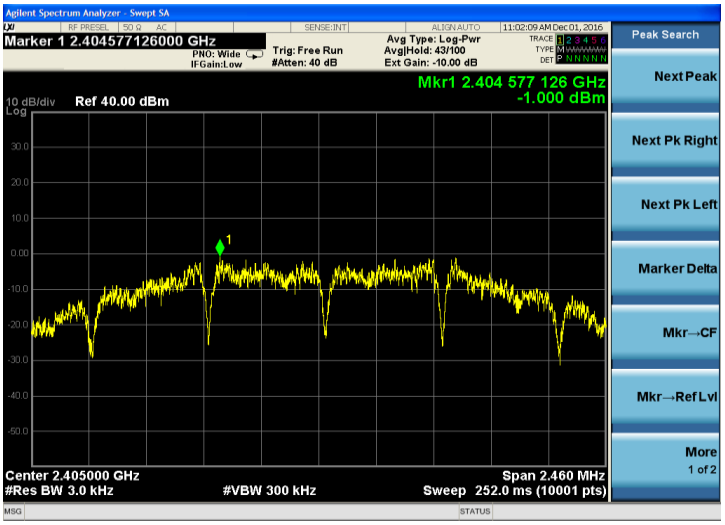
Reported Measurement data = 8.55 (raw receiver measurement in dBm) + 0.85 (cable factor in dB) = 9.4 (dBm).

11.2 Test Data

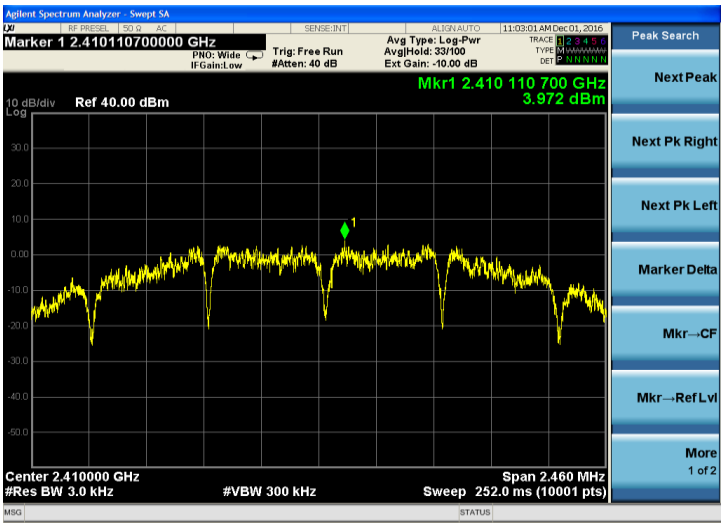
Channel	Peak PSD in 3kHz (dBm)	PSD in 3kHz limit(dBm)	PSD margin (dB)
11	-1.00	8.0	9.0
12	3.97	8.0	4.0
18	3.83	8.0	4.2
23	2.86	8.0	5.1
24	-5.24	8.0	13.2
25	-9.36	8.0	17.4

11.3 Screen Captures – Power Spectral Density

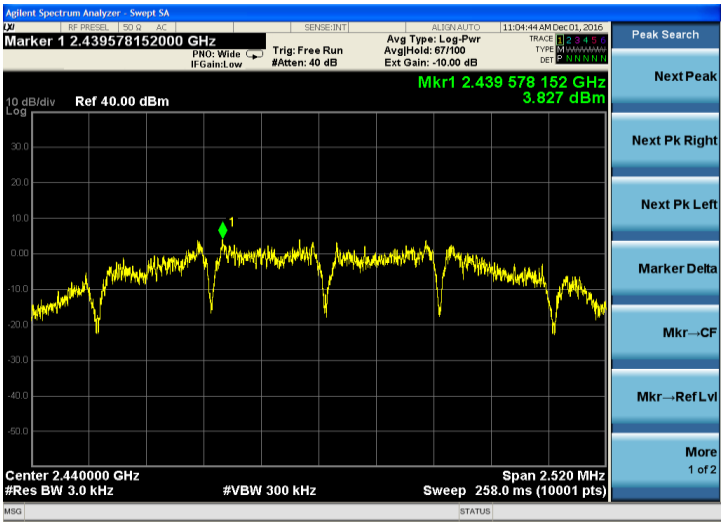
CH 11



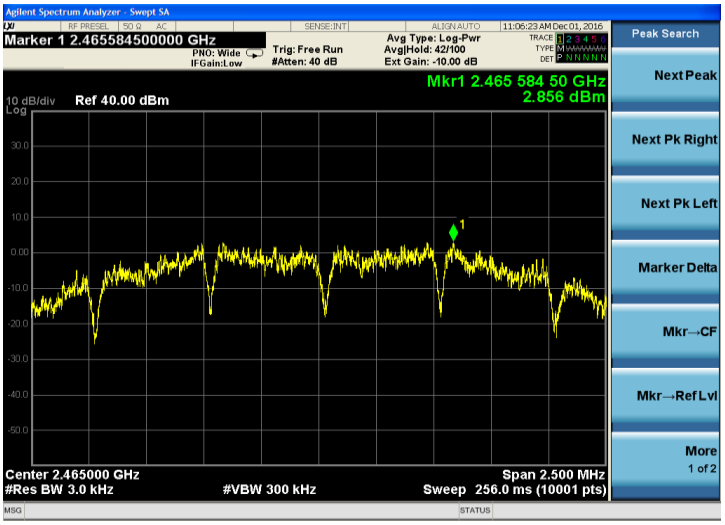
CH 12



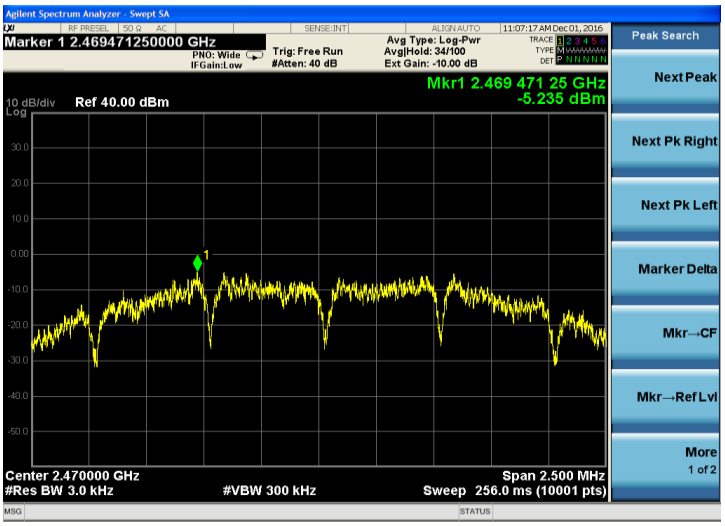
CH 18



CH 23



CH 24



CH 25

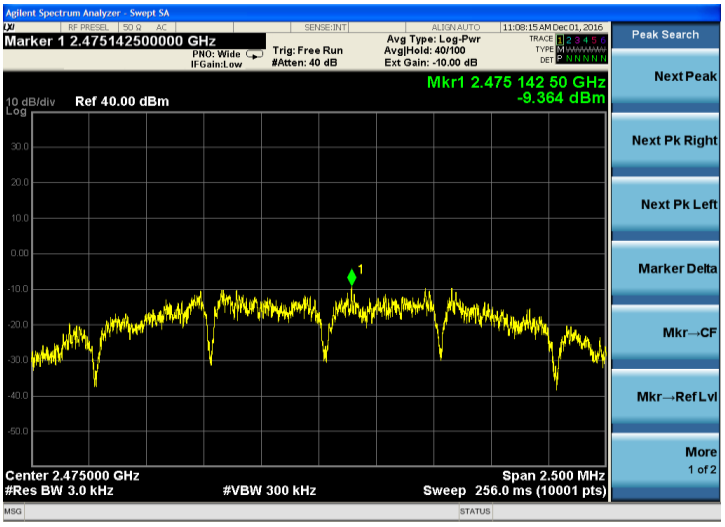

Agilent Spectrum Analyzer - Swept SA
RF PRESEL
50 Ω AC
SENSE:INT
ALIGN AUTO
11:08:15 AM Dec 01, 2016
Marker 1 2.475142500000 GHz
PNO: Wide
IFGain:Low
Trig: Free Run
#Atten: 40 dB
Avg Type: Log-Pwr
Avg|Hold: 40/100
Ext Gain: -10.00 dB
TRACE 1 2 3 4 5
TYPE M
DET P N N N N
Mkr1 2.475 142 50 GHz
-9.364 dBm
10 dB/div
Log
Ref 40.00 dBm
30.0
20.0
10.0
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
Center 2.475000 GHz
#Res BW 3.0 kHz
#VBW 300 kHz
Span 2.500 MHz
Sweep 256.0 ms (10001 pts)
MSG
STATUS
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2

EXHIBIT 12. FREQUENCY STABILITY OVER VOLTAGE VARIATIONS

Test Engineer(s): Coty Hammerer

The frequency stability of the device was examined as a function of the input voltage available to the EUT. A Spectrum Analyzer was used to measure the RF output power and frequency at the appropriate frequency markers. Power was supplied by an external bench-type DC power supply (To simulate battery power). The Power supply was varied ±15% from the nominal value.

The power was then cycled On/Off to observe system response. No unusual response was observed, the emission characteristics were well behaved, and the system returned to the same state of operation as before the power cycle.

Bench DC Power Supply

	11.9 VDC	14.0 VDC	16.1 VDC	
Channel	Frequency (Hz)	Frequency (Hz)	Frequency (Hz)	Frequency Drift (Hz)
2405	2404530588	2404528804	2404529527	1783.575
2440	2439530697	2439528876	2439529894	1821.596
2475	2474530978	2474529384	2474530194	1594.585

Note: EUT is at 5.49% of the allowable 100 parts per million.

APPENDIX A – Test Equipment List

LSR
a Laird Business

Date : 1-Dec-2016 Type Test : Conducted Measurements Job # : C-2581

Prepared By: Coty Hammerer Customer : Pentair Quote #: 316132

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960085	N9038A MXE 26.5GHz Receiver	Agilent	N9038A	MY51210148	5/12/2016	5/12/2017	Active Calibration
2	EE 960001	Multimeter	HP	971A	JP36004055	4/18/2016	4/18/2017	Active Calibration
3	EE 960077	DC Power Supply	GW Instek	GPS-3030DD	EJ810521	Verification	Verification	System

Project Engineer: Coty Hammerer Quality Assurance:

LSR
a Laird Business

Date : 8-Dec-2016 Type Test : Conducted Emissions Job # : C-2581

Prepared By: Coty Hammerer Customer : Pentair Quote #: 316132

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960089	LISN - 15A	COM-POWER	LI-215A	191943	3/8/2016	3/8/2017	Active Calibration
2	EE 960162	LISN - 15A	COM-POWER	LI-215A	191969	8/15/2016	8/15/2017	Active Calibration
3	EE 960085	N9038A MXE 26.5GHz Receiver	Agilent	N9038A	MY51210148	5/12/2016	5/12/2017	Active Calibration

Project Engineer: Coty Hammerer Quality Assurance:

LSR
a Laird Business

Date : 23-Nov-2016 Type Test : Radiated Emissions Job # : C-2581

Prepared By: Coty Hammerer Customer : Pentair Quote #: 316132

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960158	Double Ridge Horn Antenna	ETS Lindgren	3117	109300	10/13/2016	10/13/2017	Active Calibration
2	EE 960159	Low Noise Amplifier	Mini-Circuits	ZVA-213X-S+	40201429	10/13/2016	10/13/2017	Active Calibration
3	AA 960154	High Pass Filter 2.4 GHz	KWM	HPF-L-14186	7272-02	7/25/2016	7/25/2017	Active Calibration
4	AA 960171	Cable - low loss 6m	A.H. Systems, Inc.	SAC-26G-6	386	3/31/2016	3/31/2017	Active Verification
5	EE 960085	EMI Receiver	Agilent	N9038A	MY51210148	5/12/2016	5/12/2017	Active Calibration
6	AA 960146	Comb Generator	COM-POWER	CGO-5100	281545	10/14/2016	1/12/2017	Verification Due
7	AA 960174	Small Horn Antenna	ETS Lindgren	3116C-PA	00206880	4/23/2016	4/23/2017	Active Calibration
8	AA 960150	Biconical Antenna	ETS Lindgren	3110B	0003-3346	2/1/2016	2/1/2017	Active Calibration
9	EE 960088	MXE Spectrum Analyzer	Agilent	N9038A	MY51210138	2/24/2016	2/23/2017	Active Calibration
10	AA 960005	Biconical Antenna	EMCO	93110B	9601-2280	1/14/2016	1/14/2017	Calibration Due
11	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	3/31/2016	3/31/2017	Active Calibration

Project Engineer: Coty Hammerer Quality Assurance:

APPENDIX B – Test Standards: CURRENT PUBLICATION DATES RADIO

STANDARD #	DATE	Am. 1	Am. 2
ANSI C63.4	2014		
ANSI C63.10	2013		
FCC 47 CFR, Parts 15	2016		
RSS-247	2015		
RSS-GEN	2014		

APPENDIX C - Uncertainty Statement

This uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k = 2.

Measurement Type	*Configuration*	*Uncertainty Values*
Radiated Emissions	*Biconical Antenna*	*5.0 dB*
Radiated Emissions	*Log Periodic Antenna*	*5.3 dB*
Radiated Emissions	*Horn Antenna*	*4.7 dB*
AC Line Conducted Emissions	*AMN*	*3.4 dB*
Telecom Conducted Emissions	*AAN*	*4.9 dB*
Disturbance Power (Emissions)	*Absorbing Clamp*	*4.1 dB*
Radiated Immunity	*3 Volts/Meter*	*2.2 dB*
Conducted Immunity	*CDN/EM/BCI*	*2.4/3.5/3.4 dB*
EFT Burst / Surge	*Peak pulse voltage*	*164 volts*
ESD Immunity	*15 kV level*	*1377 Volts*

Parameter	ETSI U.C.+/-	U.C.+/-
Radio Frequency, from F0	$1x10^{-7}$	$0.55x10^{-7}$
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (PM)	1.5 dB	1.2 dB
RF conducted emissions (SA)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
Supply voltages	3 %	1 %