CERTIFICATION TEST REPORT

Report Number : 11776542-E2V3

Applicant	:	Whizpace Pte. Ltd. 77 Ayer Rajah Crescent, #02-30 Singapore - 139954
Model	:	WMPB-02
FCC ID	:	2AOQ9WMP-EO2
EUT Description	:	TVWS Fixed Wireless Networking Radio System WhizMesh-External Antenna
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART H

Date of Issue:
February 18, 2019

Prepared by:
UL Verification Services Inc.
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NVLAP Lab code: 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	1/15/19	Initial release	---
V2	2/13/19	Updated product description and section 9.2 and 9.3	F. de Anda
V3	2/18/19	Updated section 10.3 and 10.5.1	F. de Anda

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UL VERIFICATION SERVICES INC.
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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: Whizpace Pte. Ltd.
77 Ayer Rajah Crescent, #02-30
Singapore - 139954

EUT DESCRIPTION: TVWS Fixed Wireless Networking Radio System WhizMesh-External Antenna

MODEL: WMPB-02

SERIAL NUMBER: WZWMPB000001

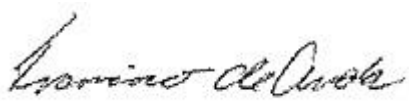
DATE TESTED: November 15, 2017 – November 21, 2017 and August 13 – August 14, 2018

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
FCC PART 15 SUBPART H	Complies

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of the U.S. government.

Approved & Released For
UL Verification Services Inc. By:



Francisco de Anda
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Prepared By:

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Project Engineer
UL Verification Services Inc.

2. SCOPE

This report documents the results of RF, emissions and database tests. This report will demonstrate compliance to the applicable rules in Part 15 Subpart H – White Space Devices.

3. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 15 Subpart H, KDB 416721 D01 v03, and ANSI C63.10-2013.

4. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street
☒ Chamber A	☐ Chamber D
☐ Chamber B	☐ Chamber E
☐ Chamber C	☐ Chamber F
	☐ Chamber G
	☐ Chamber H

The above test sites and facilities are covered under FCC Test Firm Registration # 208313.

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0.

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5. CALIBRATION AND UNCERTAINTY

5.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

5.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)

36.5 dBuV + 18.7 dB/m + 0.6 dB – 26.9 dB = 28.9 dBuV/m

5.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

Parameter	Uncertainty
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.84 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.65 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	3.15 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	5.36 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.32 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.45 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.24 dB

Uncertainty figures are valid to a confidence level of 95%.

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6. EQUIPMENT UNDER TEST

6.1. DESCRIPTION OF EUT

The EUT is a TVWS Fixed Wireless Networking Radio System. Utilizes an external antenna. This product is a commercial product.

6.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum output power as follows;.

UHF BAND				
Frequency Range (MHz)	Conducted		EIRP	
	Output Power (dBm)	Output Power (mW)	Output Power (dBm)	Output Power (W)
515-695	6.36	4.33	8.36	0.007

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes a log periodic antenna, with maximum gain of 2 dBi

6.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was version 3.1

6.5. WORST-CASE CONFIGURATION AND MODE

For below 30MHz, above1GHz radiated emissions and power line conducted emissions were performed with the EUT set to transmit at the channel with the highest power and worst-case data rate as worst-case scenario with external antenna.

For 30Mhz to 1GHz radiated emissions were performed with the EUT set to transmit at L/M/H channels at highest power and worst-case data rate as worst-case scenario with external antenna.

Preliminary baseline tests were performed to determine worst case data rate. The worst case data rate was determined to be BPSK.

All final radiated testing was performed with the EUT in the normal orientation.

6.6. MODIFICATIONS

The following Ferrite was used during AC line conducted emissions testing on the DC input cable of the PoE Switch for AC line conducted emissions:

Manufacturer: KE KITAGAWA , Part Number:GRFC-8.

6.7. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List			
Description	Manufacturer	Model	Serial Number
PoE Switch	TP-LINK	TL-SG1008P(UN) Ver:2.0	2174015003316
PoE AC/DC adapter	TP-LINK	T480125-2-DT	-
Laptop	HP	13-D11TU	CND6254576

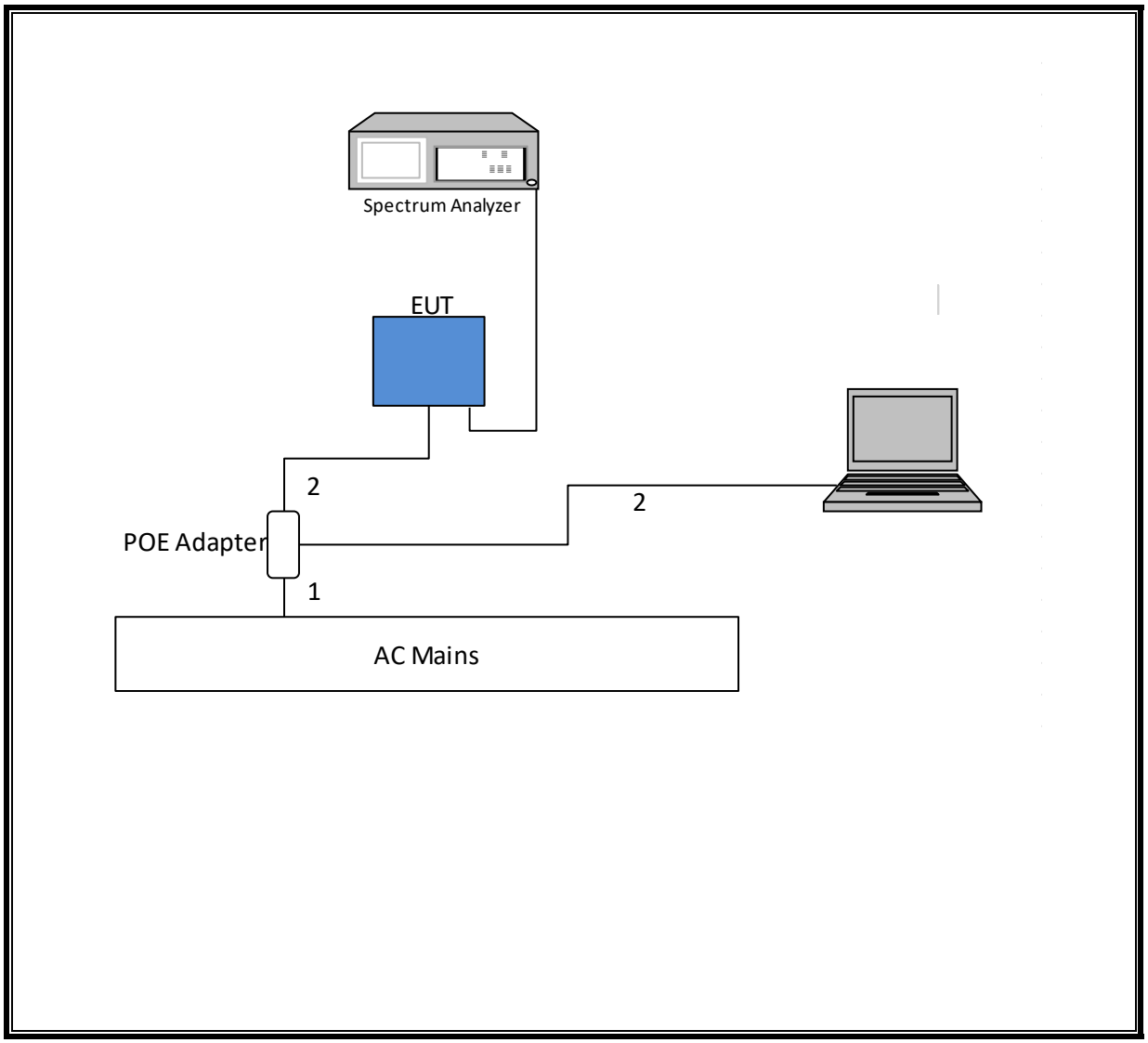
I/O CABLES

I/O CABLE LIST						
Cable No.	Port	No. of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC	1	3-Prong	unshielded	1	
2	Ethernet/PoE	1	RJ45	unshielded	1	
3	DC	1	Barrel	unshielded	0.8	

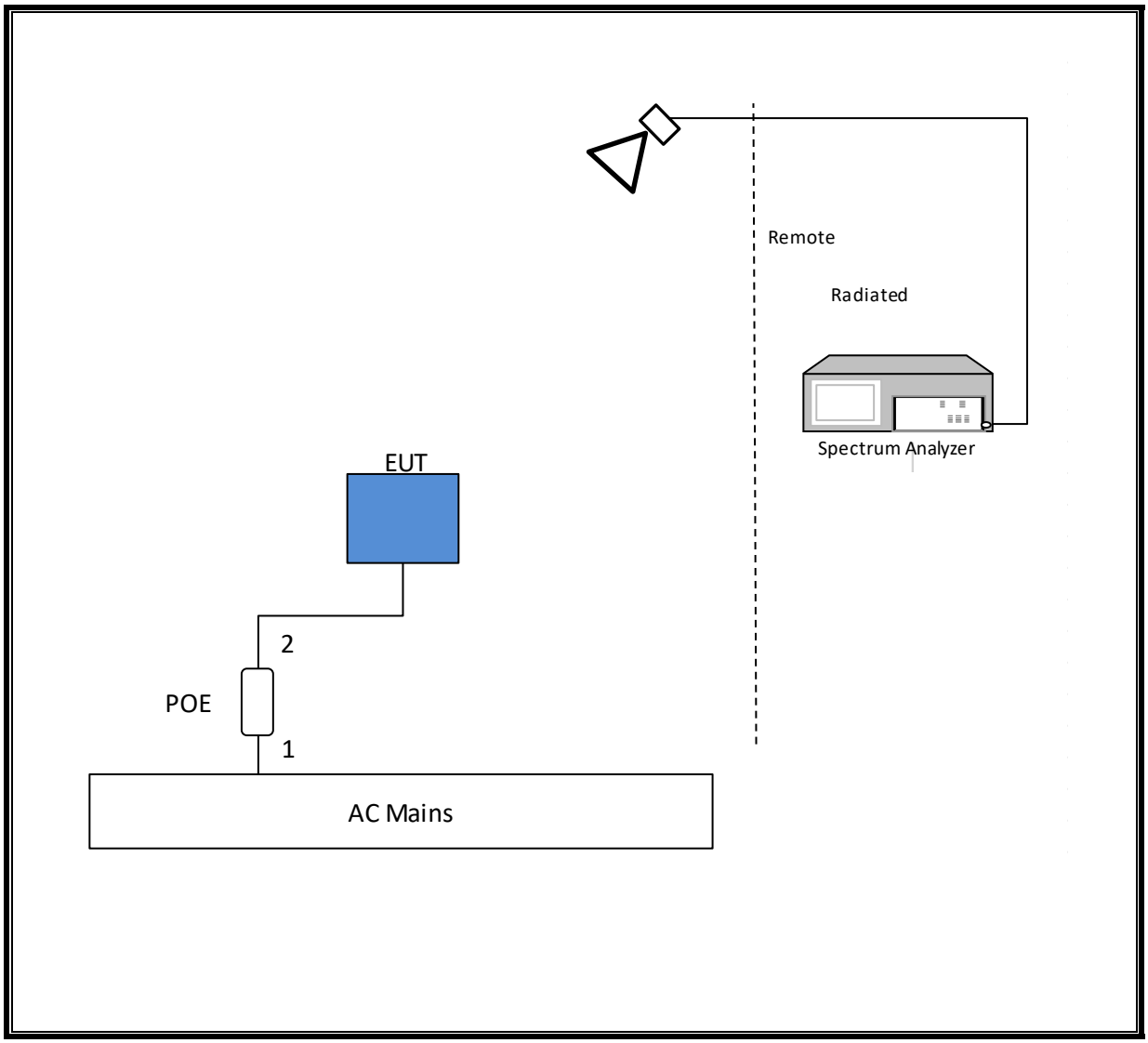
TEST SETUP

The EUT was installed in a typical configuration. The customer provided test software to exercise the EUT during test. Refer to the following diagram.

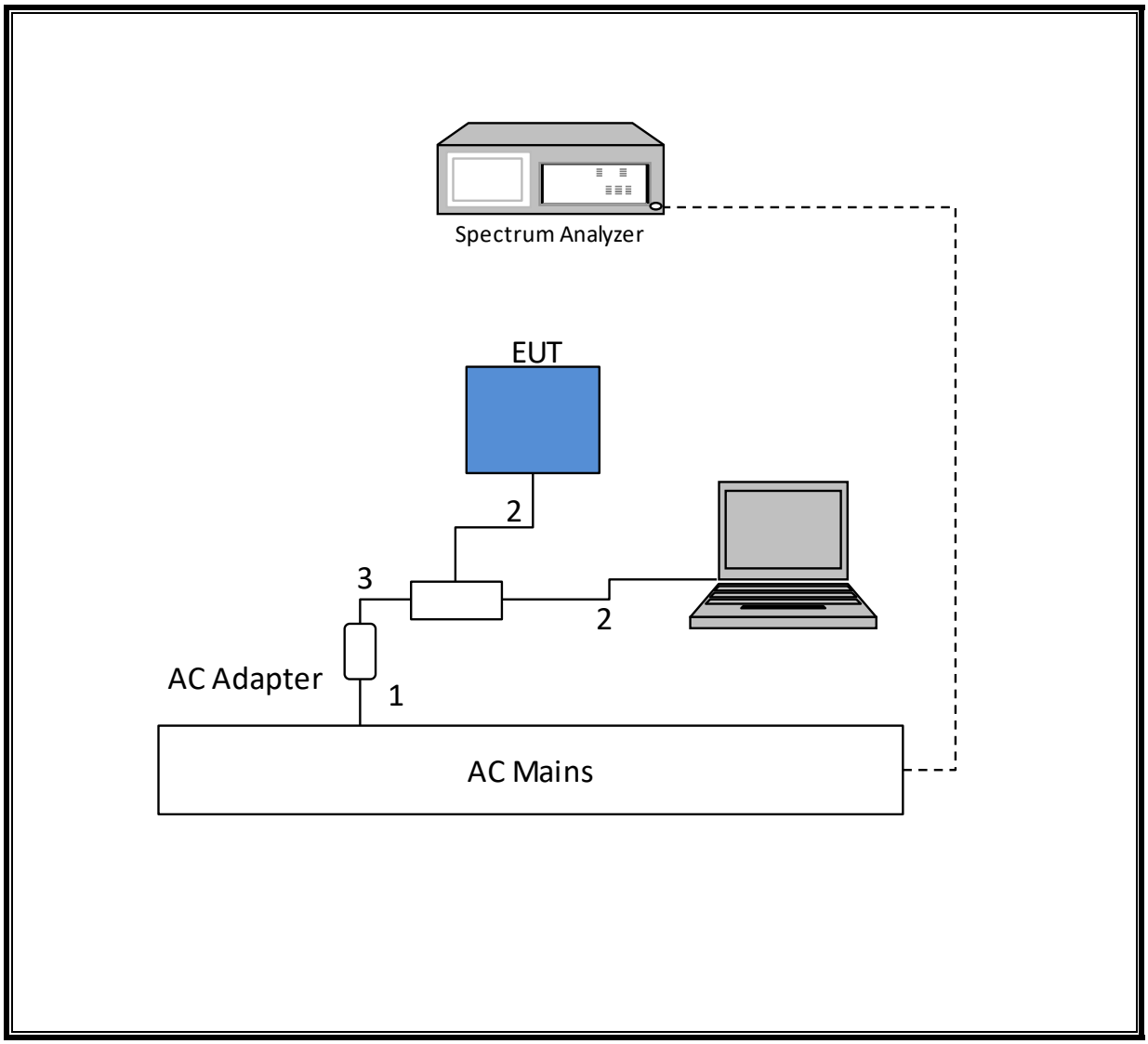
SETUP DIAGRAM FOR ANTENNA PORT TESTS



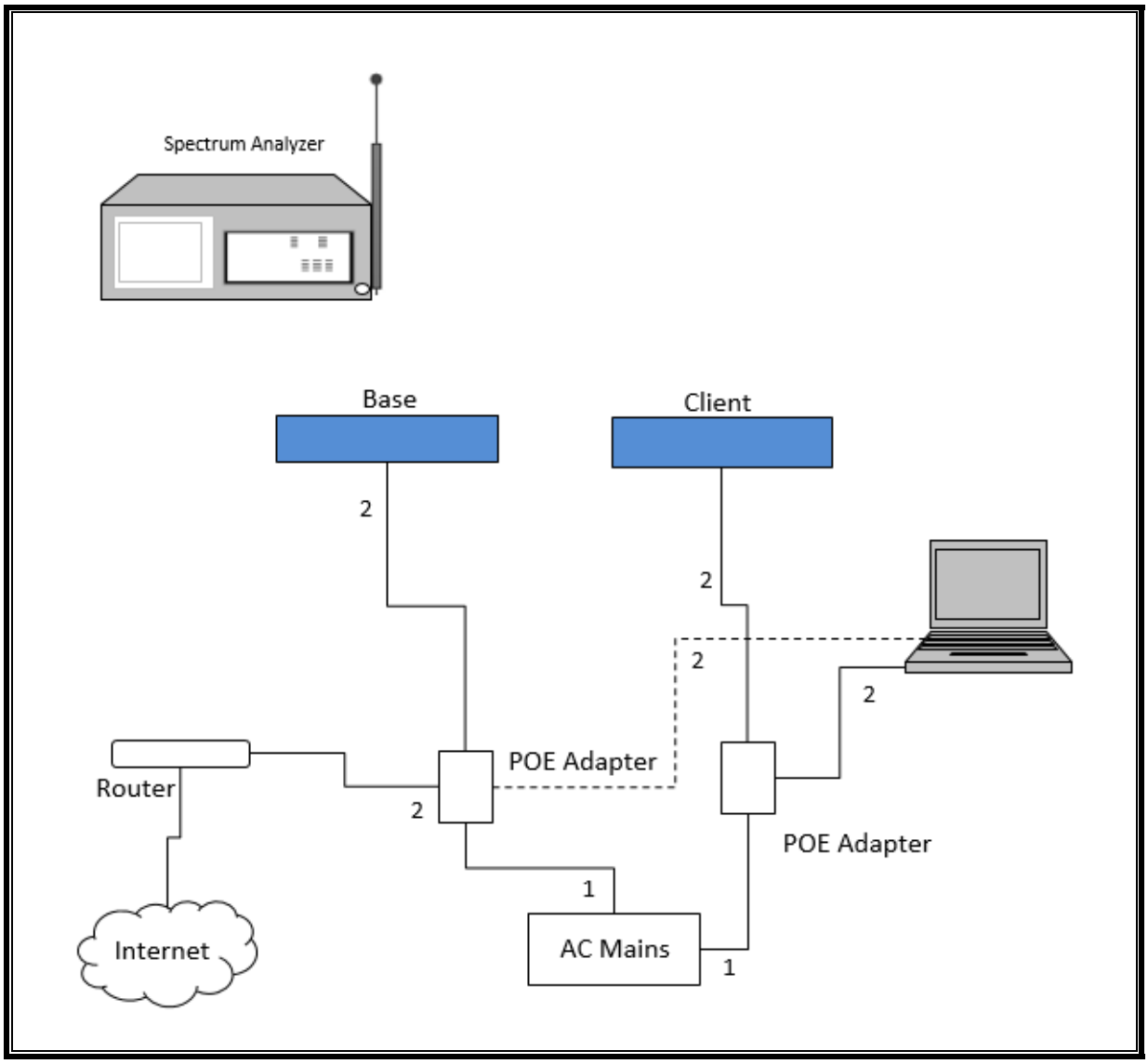
SETUP DIAGRAM FOR RADIATED TESTS



SETUP DIAGRAM FOR AC LINE CONDUCTED TESTS



SETUP DIAGRAM FOR DATABASE TESTS



7. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:
November 15th, 2017 – November 21st, 201

	TEST EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**Asset**	**Cal Date**	**Cal Due**
Antenna, Biconolog, 30MHz-1 GHz	Sunol Sciences	JB1	T130	10/16/17	10/16/18
Antenna, Horn, 1-18GHz	ETS Lindgren	3117	T862	06/09/17	06/09/18
RF Preamplifier, 10kHz - 1GHz	Keysight	8447D	T15	08/14/17	08/14/18
RF Preamplifier, 1 - 8GHz	Miteq	AMF-4D-01000800-30-29P	T1573	06/24/17	06/24/18
Spectrum Analyzer	Keysight	N9030A	T1466	04/11/17	04/11/18
Antenna, Active Loop 9KHz to 30MHz	Com-Power	AL-130R	T1866	10/10/17	10/10/18
EMI Receiver	Rohde & Schwarz	ESR	T1436	01/06/17	01/06/18
LISN	Fischer Custom Communications	FCC-LISN-50/250-25-2-01	T1310	06/15/17	06/15/18
Filter, Notch, 515MHz	EWT Products	EWT-14-0348	T241	04/27/17	04/27/18
Filter, Notch, 587MHz	EWT Products	EWT-14-0338	T239	04/27/17	04/27/18
Filter, Notch, 695MHz	EWT Products	EWT-14-0339	T238	04/27/17	04/27/18
Radiated Software	UL	UL EMC	Ver 9.5, December 01, 2016		

August 13, 2018 – August 14, 2018

	TEST EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**Asset**	**Cal Date**	**Cal Due**
Antenna, Biconolog, 30MHz-1 GHz	Sunol Sciences	JB1	T243	11/02/17	11/02/18
Antenna, Horn, 1-18GHz	ETS Lindgren	3117	T346	04/03/118	04/03/19
RF Preamplifier, 10kHz - 1GHz	Keysight	8447D	T300	12/11/17	12/11/18
RF Preamplifier, 1 - 8GHz	Miteq Inc.	AFS42-00101800-25-S-42	T931	02/24/19	02/24/19
Spectrum Analyzer	Agilent (Keysight) Technologies	N9030A-544	T1210	08/06/18	08/06/19
Antenna, Active Loop 9KHz to 30MHz	Com-Power	AL-130R	PRE0165308	12/13/17	12/13/18
EMI Receiver	Rohde & Schwarz	ESR	T1436	02/23/18	02/23/19
LISN	Fischer Custom Communications	FCC-LISN-50/250-25-2-01	T1310	06/19/18	06/19/19
Filter, Notch, 515MHz	EWT Products	EWT-14-0348	T241	08/13/18	08/13/18
Filter, Notch, 587MHz	EWT Products	EWT-14-0338	T239	08/13/18	08/13/18
Filter, Notch, 695MHz	EWT Products	EWT-14-0339	T238	08/13/18	08/13/18
Radiated Software	UL	UL EMC	Ver 9.5, December 01, 2016		

8. MEASUREMENT METHODS

Output Power & Power Spectral Density (Fixed WSD): KDB 416721 D01 v03 Section II, (2)(c)(i).

Band-Edge Measurement: KDB 416721 D01 v03 Section II (2)(d)(i)

Adjacent Channel Emissions: KDB 416721 D01 v03 Section II (2)(d)(ii)

Beyond Adjacent Channel Emissions: ANSI C63.10, Section 6.5 and 6.6.

AC Power Line Conducted Emissions: ANSI C63.10-2013, Section 6.2.

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9. ANTENNA PORT TEST RESULTS

9.1. OUTPUT POWER AND POWER SPECTRAL DENSITY

LIMITS

§15.709 (b)(1) Fixed White Space Device

For operation at EIRP levels of 36 dBm (4000 mW) or less, fixed white space devices may operate at EIRP levels between the values shown in the table provided that the conducted power and the conducted power spectral density (PSD) limits are linearly interpolated between the values shown and the adjacent channel emission limit of the higher value shown in the table is met. Operation at EIRP levels above 36 dBm (4000 mW) shall follow the requirements for 40 dBm (10,000 mW).

EIRP (6 MHz)	Conducted power limit[1] (6 MHz)	Conducted PSD limit (100 kHz)	Conducted adjacent channel emission limit (100 kHz)
16 dBm (40 mW)	10 dBm (10 mW)	−7.4 dBm	−62.8 dBm
20 dBm (100 mW)	14 dBm (25 mW)	−3.4 dBm	−58.8 dBm
24 dBm (250 mW)	18 dBm (63 mW)	0.6 dBm	−54.8 dBm
28 dBm (625 mW)	22 dBm (158 mW)	4.6 dBm	−50.8 dBm
32 dBm (1600 mW)	26 dBm (400 mW)	8.6 dBm	−46.8 dBm
36 dBm (4000 mW)	30 dBm (1000 mW)	12.6 dBm	−42.8 dBm
40 dBm (10000 mW)	30 dBm (1000 mW)	12.6 dBm	−42.8 dBm

[1]The conducted power spectral density from a fixed white space device shall not be greater than the values shown in the table when measured in any 100 kHz band during any time interval of continuous transmission, except that a 40 mW fixed white space device operating in a four megahertz channel within a seven megahertz guard band must comply with a conducted power spectral density limit of −5.4 dBm.

The conducted power, PSD and adjacent channel limits for fixed white space devices operating at up to 36 dBm (4000 milliwatts) EIRP shown in the table in paragraph (b)(1) of this section are based on a maximum transmitting antenna gain of 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

The conducted power, PSD and adjacent channel limits for fixed white space devices operating at greater than 36 dBm (4000 milliwatts) EIRP shown in the table in paragraph (b)(1) of this section are based on a maximum transmitting antenna gain of 10 dBi. If transmitting antennas of directional gain greater than 10 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 10 dBi.

DIRECTIONAL ANTENNA GAIN

There is only one transmitter output therefore the directional gain is equal to the antenna gain.

RESULTS

9.1.1. UHF BAND

Tested By:	11/16/17
Test Date:	37699 CS

Antenna Gain (dBi)	2.00

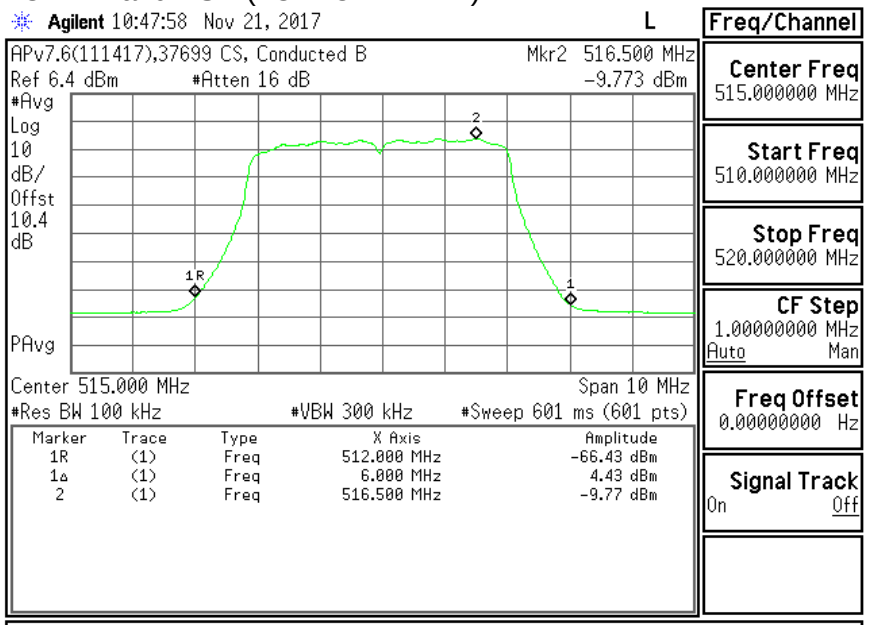
Output Power Results

Channel	Frequency (MHz)	Measured Output Power Chain 0 (dBm)	Measured Total Output Power (dBm)	Measured Total EIRP (dBm)	Conducted Power Limit (dBm)	Margin (dBm)
Low	515	4.43	4.43	6.43	10.00	-5.57
Mid	587	6.20	6.20	8.20	10.00	-3.80
High	695	6.36	6.36	8.36	10.00	-3.64

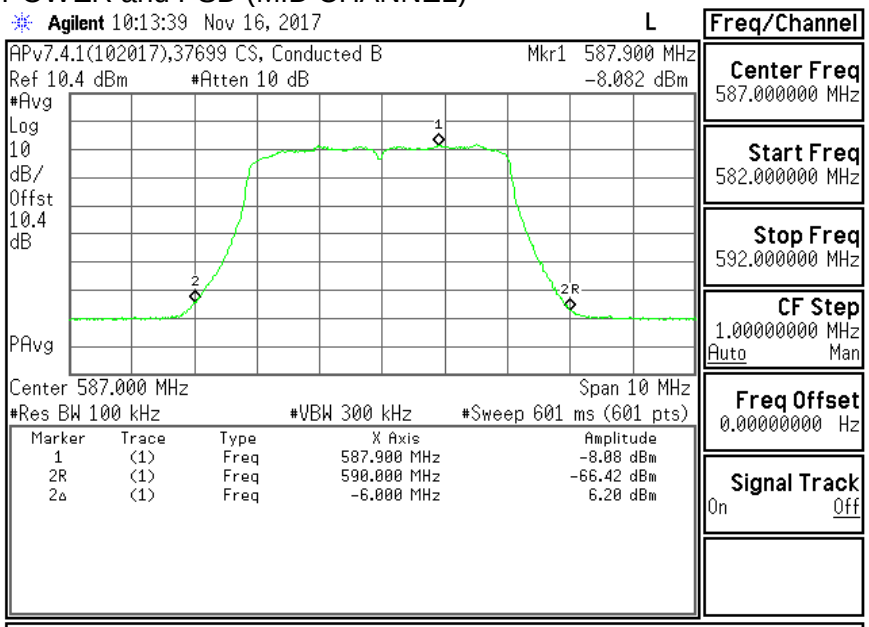
PSD Results

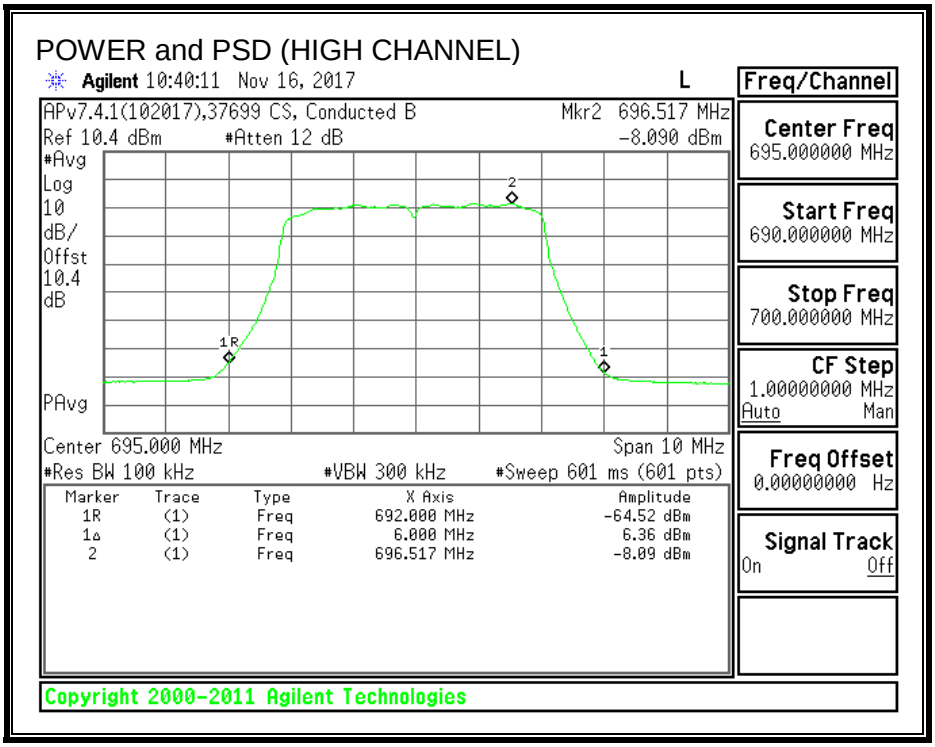
Channel	Frequency (MHz)	Measured Output PSD Chain 0 (dBm)	Measured Total PSD Power (dBm)	Conducted PSD Limit (dBm)	Margin (dBm)
Low	515	-9.77	-9.77	-7.40	-2.37
Mid	587	-8.08	-8.08	-7.40	-0.68
High	695	-8.09	-8.09	-7.40	-0.69

POWER and PSD (LOW CHANNEL)



POWER and PSD (MID CHANNEL)





9.2. BAND-EDGE

LIMITS

§15.709 (b)(1) Fixed White Space Device

For operation at EIRP levels of 36 dBm (4000 mW) or less, fixed white space devices may operate at EIRP levels between the values shown in the table provided that the conducted power and the conducted power spectral density (PSD) limits are linearly interpolated between the values shown and the adjacent channel emission limit of the higher value shown in the table is met. Operation at EIRP levels above 36 dBm (4000 mW) shall follow the requirements for 40 dBm (10,000 mW).

EIRP (6 MHz)	Conducted power limit[1] (6 MHz)	Conducted PSD limit (100 kHz)	Conducted adjacent channel emission limit (100 kHz)
16 dBm (40 mW)	10 dBm (10 mW)	−7.4 dBm	−62.8 dBm
20 dBm (100 mW)	14 dBm (25 mW)	−3.4 dBm	−58.8 dBm
24 dBm (250 mW)	18 dBm (63 mW)	0.6 dBm	−54.8 dBm
28 dBm (625 mW)	22 dBm (158 mW)	4.6 dBm	−50.8 dBm
32 dBm (1600 mW)	26 dBm (400 mW)	8.6 dBm	−46.8 dBm
36 dBm (4000 mW)	30 dBm (1000 mW)	12.6 dBm	−42.8 dBm
40 dBm (10000 mW)	30 dBm (1000 mW)	12.6 dBm	−42.8 dBm

[1]The conducted power spectral density from a fixed white space device shall not be greater than the values shown in the table when measured in any 100 kHz band during any time interval of continuous transmission, except that a 40 mW fixed white space device operating in a four megahertz channel within a seven megahertz guard band must comply with a conducted power spectral density limit of −5.4 dBm.

The conducted power, PSD and adjacent channel limits for fixed white space devices operating at up to 36 dBm (4000 milliwatts) EIRP shown in the table in paragraph (b)(1) of this section are based on a maximum transmitting antenna gain of 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

The conducted power, PSD and adjacent channel limits for fixed white space devices operating at greater than 36 dBm (4000 milliwatts) EIRP shown in the table in paragraph (b)(1) of this section are based on a maximum transmitting antenna gain of 10 dBi. If transmitting antennas of directional gain greater than 10 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 10 dBi.

RESULTS

9.2.1. UHF BAND

Tested By:	37699 CS
Test Date:	11/16/17

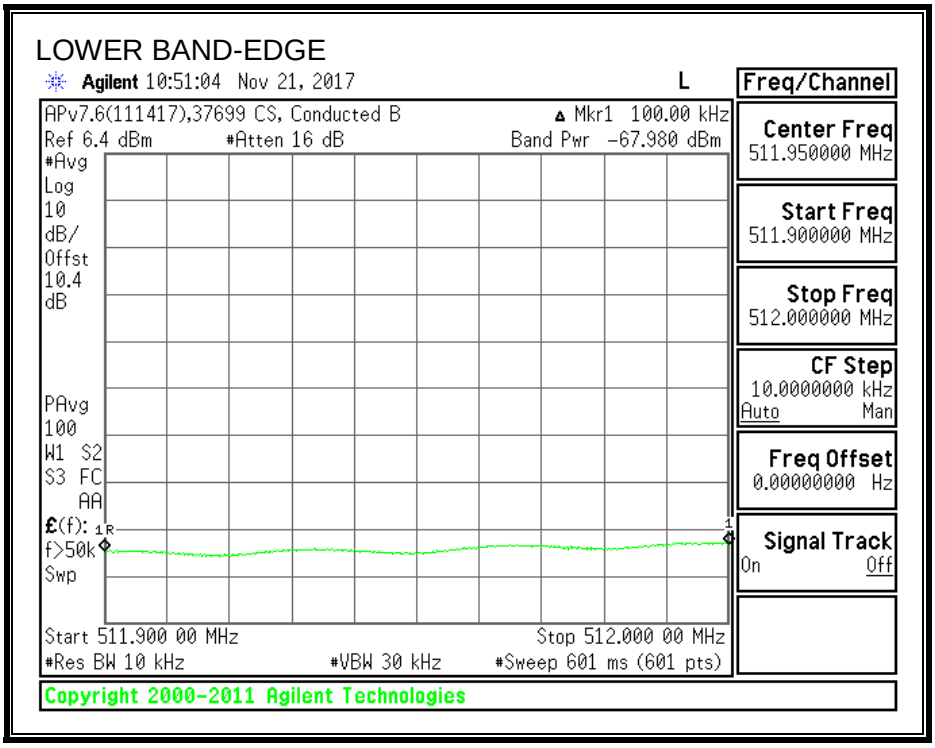
Lower Band-Edge Emissions

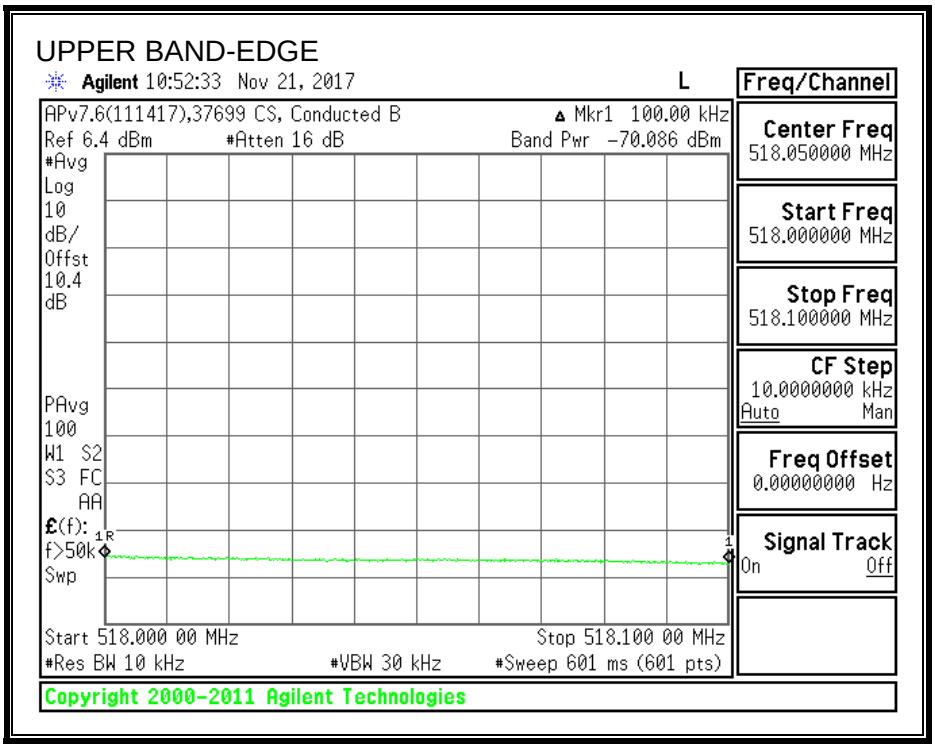
Channel	Frequency (MHz)	Measured Emission Chain 0 (dBm)	Measured Total Emission (dBm)	Emissions Limit (dBm)	Worst Case Margin (dBm)
Low	515	-67.98	-67.98	-63	-4.98
Mid	587	-66.40	-66.40	-63	-3.40
High	695	-65.98	-65.98	-63	-2.97

Upper Band-Edge Emissions

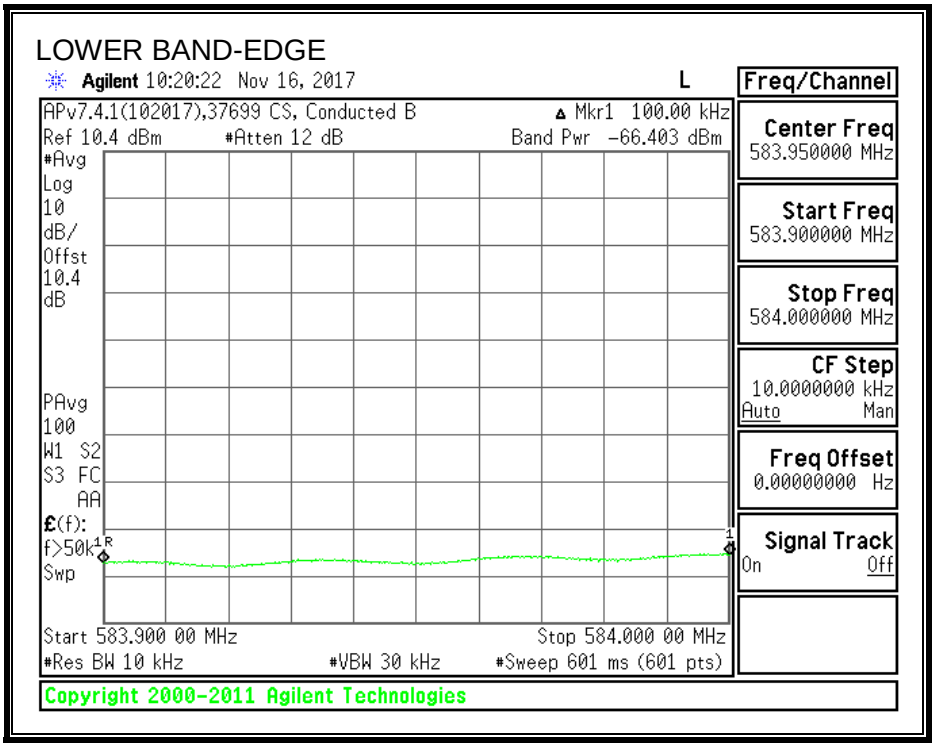
Channel	Frequency (MHz)	Measured Emission Chain 0 (dBm)	Measured Total Emission (dBm)	Emissions Limit (dBm)	Worst Case Margin (dBm)
Low	515	-70.09	-70.09	-63	-7.09
Mid	587	-68.55	-68.55	-63	-5.55
High	695	-68.96	-68.96	-63	-5.96

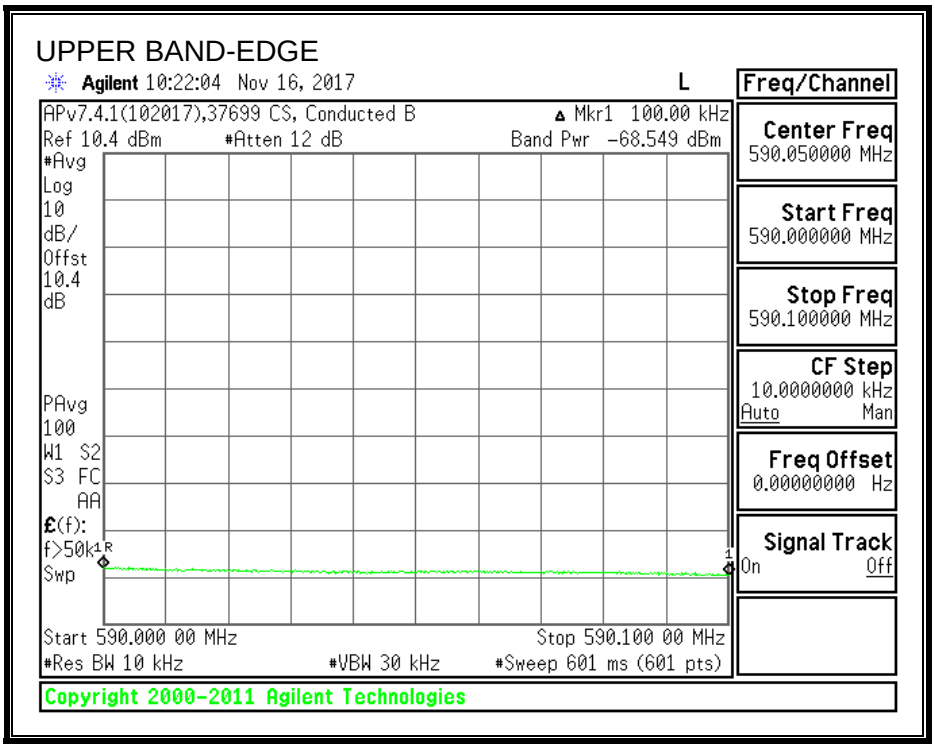
LOW CHANNEL



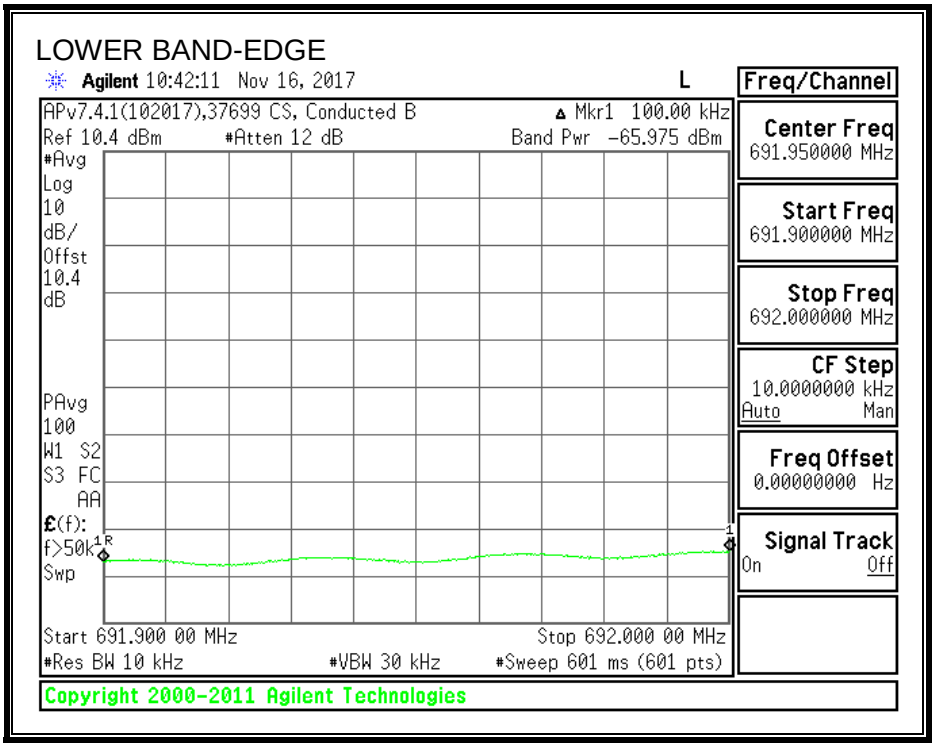


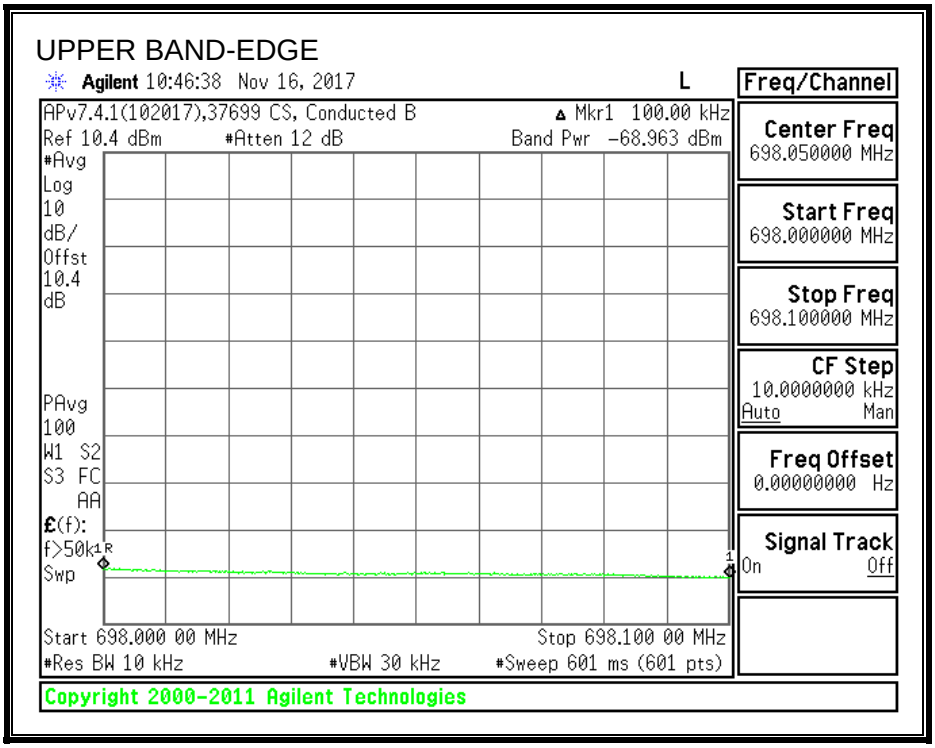
MID CHANNEL





HIGH CHANNEL





9.3. ADJACENT CHANNEL EMISSIONS

LIMITS

§15.709 (b)(1) Fixed White Space Device

For operation at EIRP levels of 36 dBm (4000 mW) or less, fixed white space devices may operate at EIRP levels between the values shown in the table provided that the conducted power and the conducted power spectral density (PSD) limits are linearly interpolated between the values shown and the adjacent channel emission limit of the higher value shown in the table is met. Operation at EIRP levels above 36 dBm (4000 mW) shall follow the requirements for 40 dBm (10,000 mW).

EIRP (6 MHz)	Conducted power limit[1] (6 MHz)	Conducted PSD limit (100 kHz)	Conducted adjacent channel emission limit (100 kHz)
16 dBm (40 mW)	10 dBm (10 mW)	−7.4 dBm	−62.8 dBm
20 dBm (100 mW)	14 dBm (25 mW)	−3.4 dBm	−58.8 dBm
24 dBm (250 mW)	18 dBm (63 mW)	0.6 dBm	−54.8 dBm
28 dBm (625 mW)	22 dBm (158 mW)	4.6 dBm	−50.8 dBm
32 dBm (1600 mW)	26 dBm (400 mW)	8.6 dBm	−46.8 dBm
36 dBm (4000 mW)	30 dBm (1000 mW)	12.6 dBm	−42.8 dBm
40 dBm (10000 mW)	30 dBm (1000 mW)	12.6 dBm	−42.8 dBm

[1]The conducted power spectral density from a fixed white space device shall not be greater than the values shown in the table when measured in any 100 kHz band during any time interval of continuous transmission, except that a 40 mW fixed white space device operating in a four megahertz channel within a seven megahertz guard band must comply with a conducted power spectral density limit of −5.4 dBm.

The conducted power, PSD and adjacent channel limits for fixed white space devices operating at up to 36 dBm (4000 milliwatts) EIRP shown in the table in paragraph (b)(1) of this section are based on a maximum transmitting antenna gain of 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

The conducted power, PSD and adjacent channel limits for fixed white space devices operating at greater than 36 dBm (4000 milliwatts) EIRP shown in the table in paragraph (b)(1) of this section are based on a maximum transmitting antenna gain of 10 dBi. If transmitting antennas of directional gain greater than 10 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 10 dBi.

RESULTS

9.3.1. UHF BAND

Tested By:	37699 CS
Test Date:	11/16/17

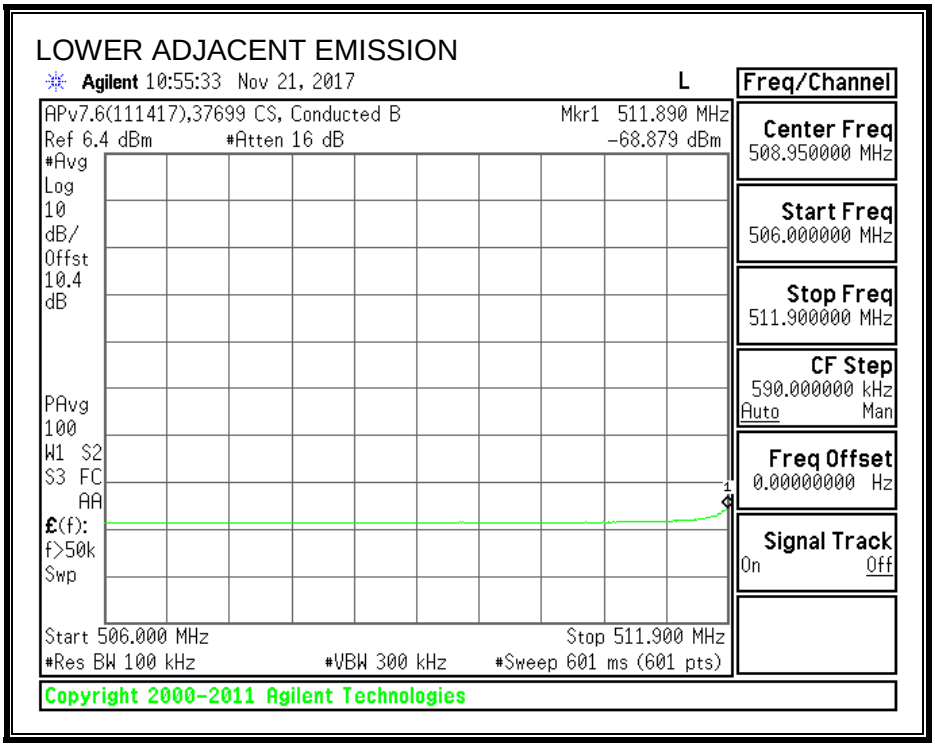
Lower Adjacent Channel Emissions

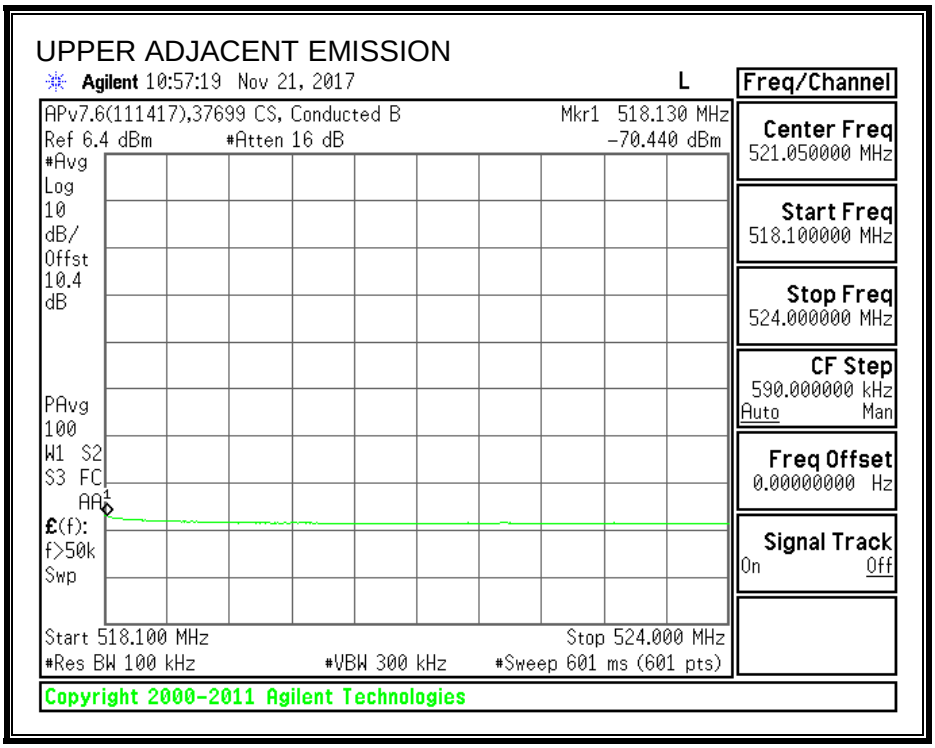
Channel	Frequency (MHz)	Measured Emission Chain 0 (dBm)	Measured Total Emission (dBm)	Emissions Limit (dBm)	Worst Case Margin (dBm)
Low	515	-68.88	-68.88	-63	-5.88
Mid	587	-67.26	-67.26	-63	-4.26
High	695	-66.88	-66.88	-63	-3.88

Upper Adjacent Channel Emissions

Channel	Frequency (MHz)	Measured Emission Chain 0 (dBm)	Measured Total Emission (dBm)	Emissions Limit (dBm)	Worst Case Margin (dBm)
Low	515	-70.44	-70.44	-63	-7.44
Mid	587	-68.85	-68.85	-63	-5.85
High	695	-69.33	-69.33	-63	-6.33

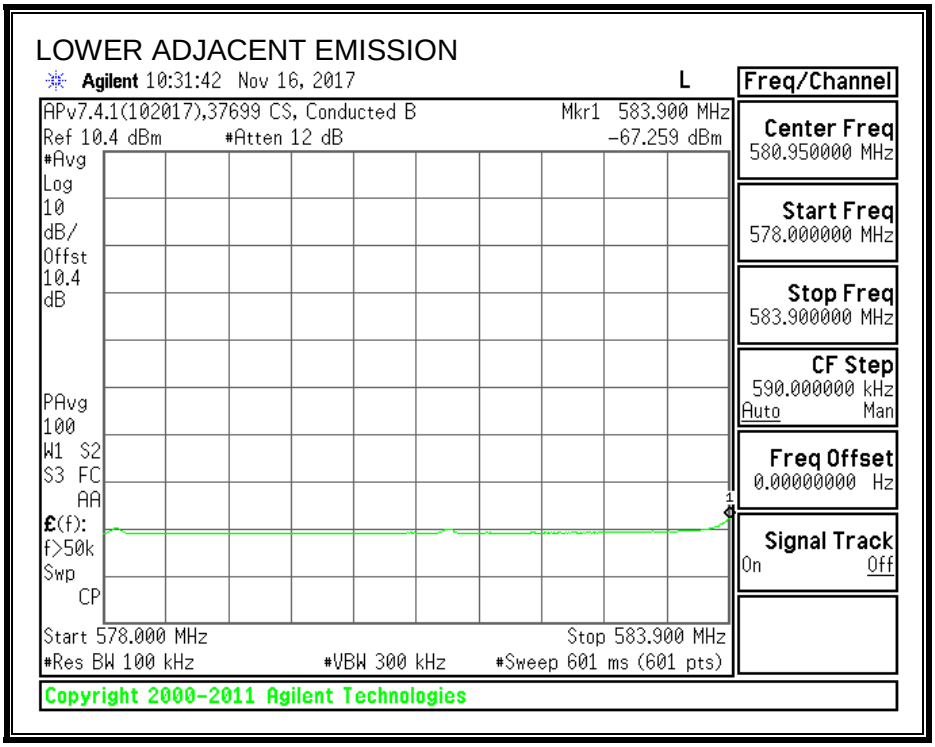
LOW CHANNEL

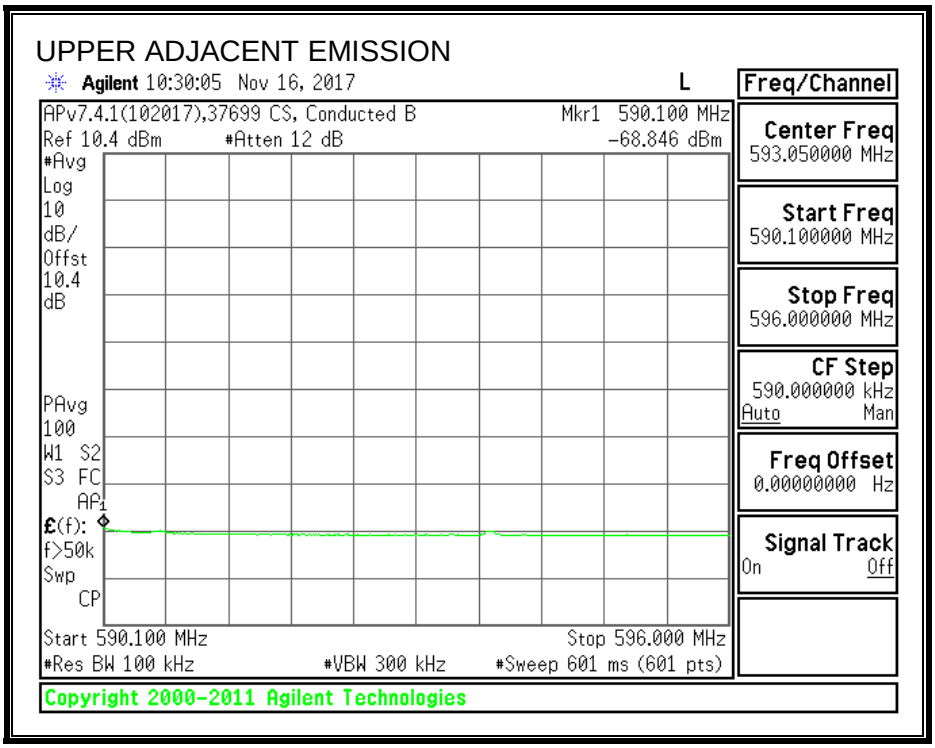




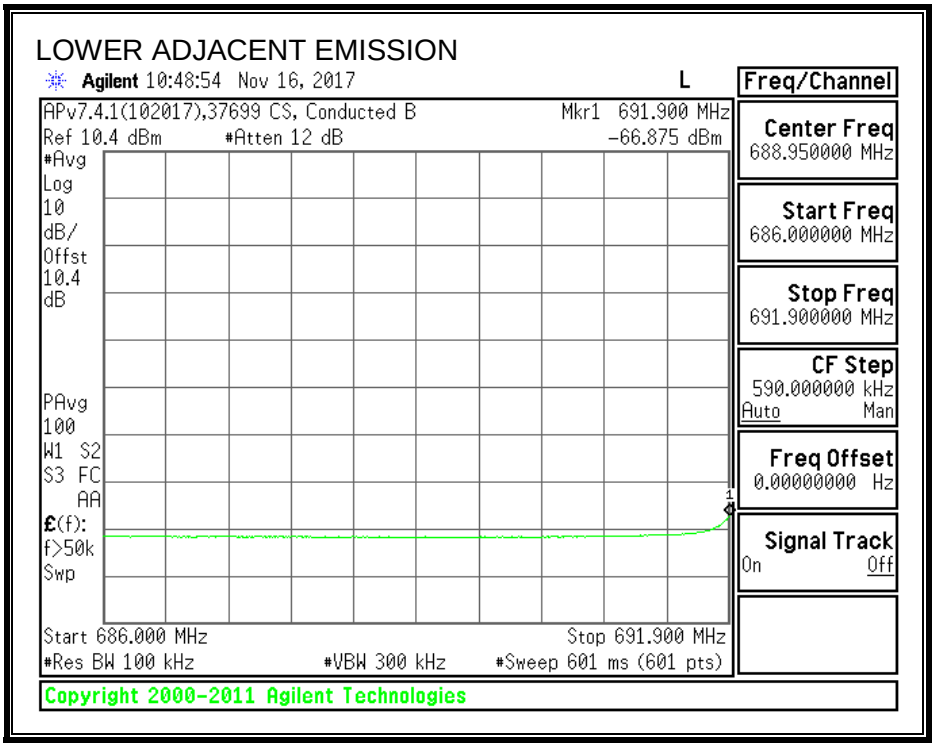
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888

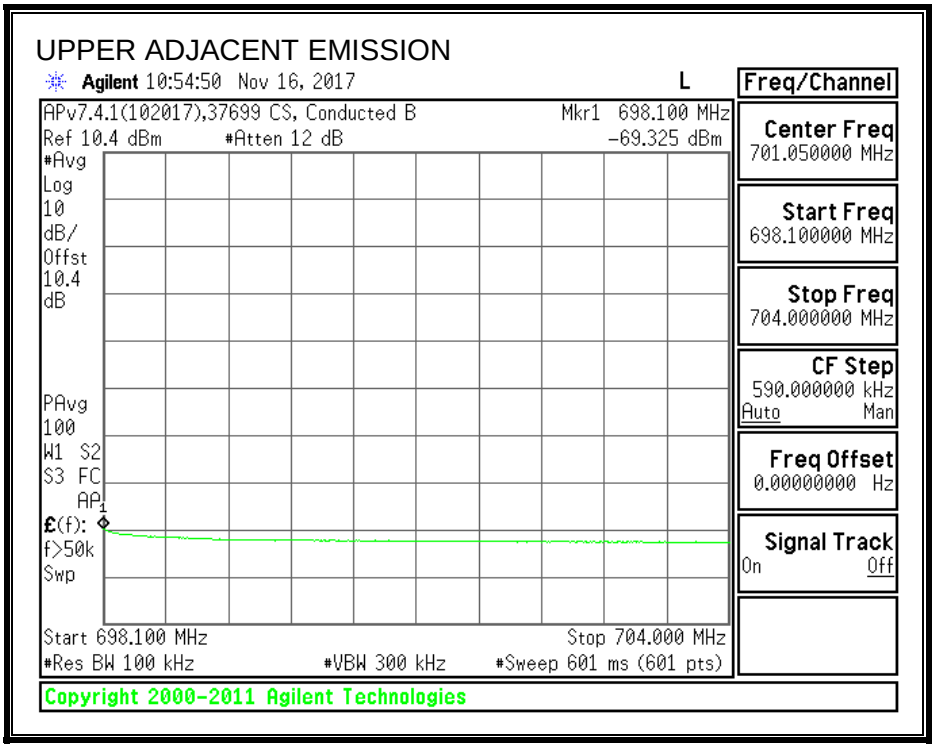
MID CHANNEL





HIGH CHANNEL





10. RADIATED EMISSIONS

BEYOND ADJACENT CHANNEL EMISSION LIMITS

FCC §15.709 (d) (2) At frequencies beyond the six megahertz channel immediately adjacent to each white space channel or group of contiguous white space channels in which the white space device is operating the white space device shall meet the requirements of §15.209.

The DUT must comply with radiated emission limits for a Class B digital device, except that authorization as a Class A device may be considered with appropriate justification for non-residential use.

§15.209 (a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency Range (MHz)	Field Strength Limit (uV/m) at 3 m	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

TEST PROCEDURE

ANSI C63.10-2013.

The EUT is set to transmit in a continuous mode.

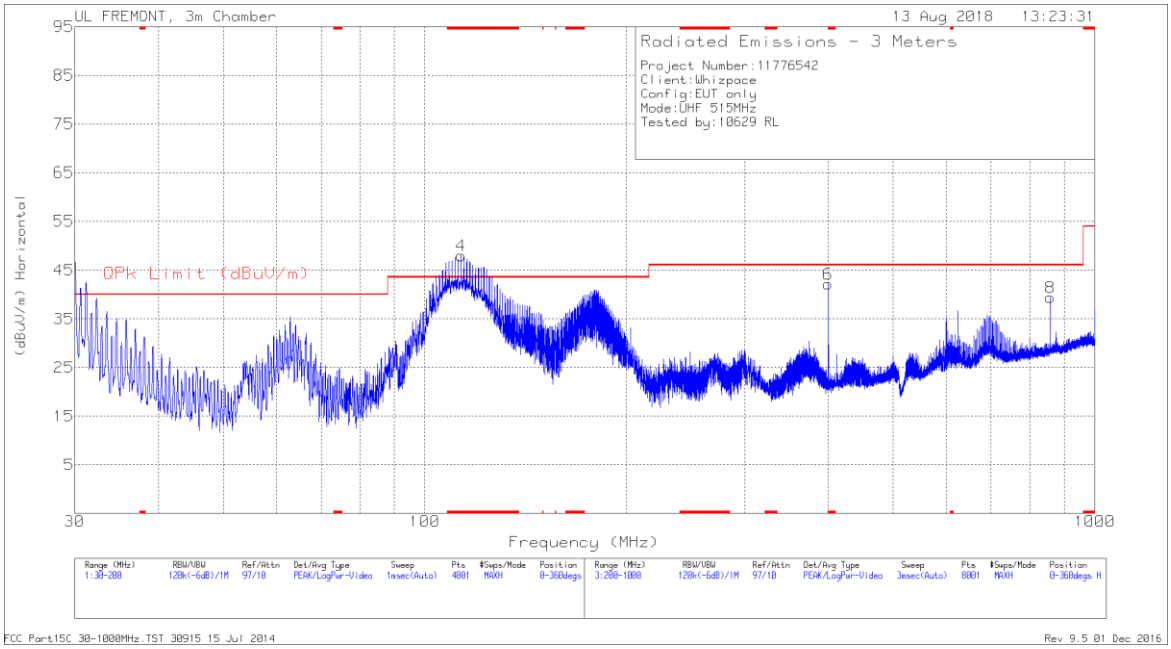
High-Q Cavity Notch filters are used to reduce the amplitude of the intentional transmitter and prevent overload of the system preamplifier.

10.1. TRANSMITTER BELOW 1GHz

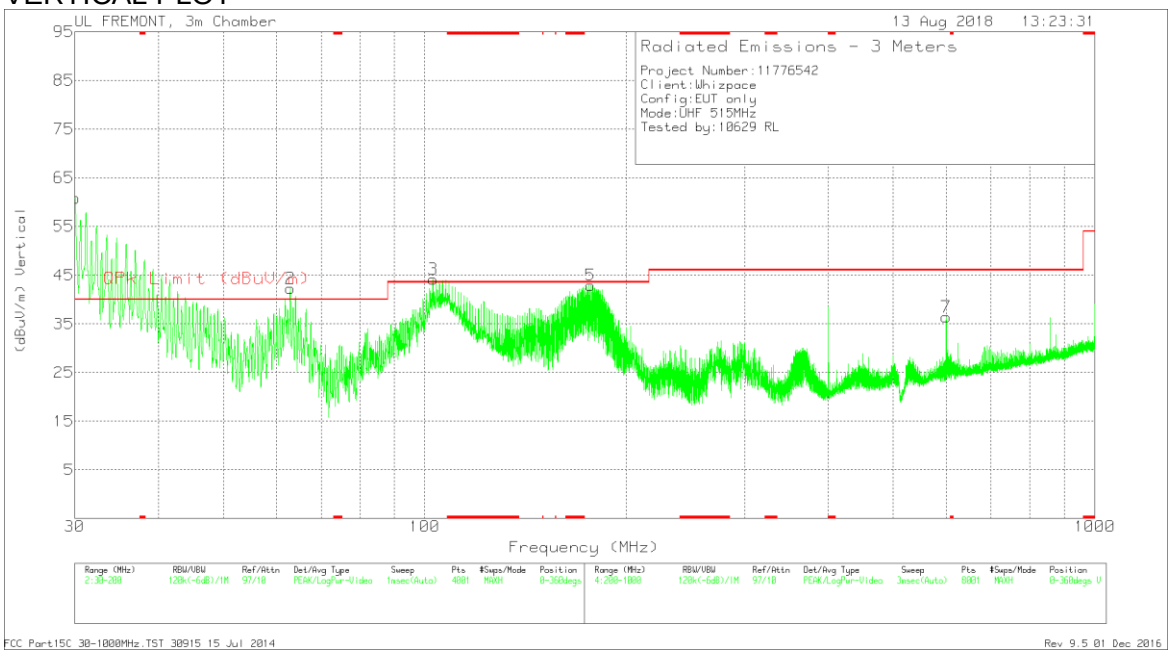
10.1.1. UHF BAND – EXTERNAL ANTENNA

BEYOND ADJACENT CHANNEL (LOW CHANNEL)

HORIZONTAL PLOT



VERTICAL PLOT



LOW CHANNEL DATA

Radiated Emissions

Frequency (MHz)	Meter Reading (dBuV)	Det	AF T243 (dB/m)	Amp/Cbl (dB/m)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
** 113.2447	59.38	Qp	17.2	-30.1	46.48	--	--	107	247	H
* 399.9906	52.07	Qp	19.7	-28.3	43.47	46.02	-2.55	129	168	H
**30.0443	65.61	Qp	25.5	-31.1	60.01	---	--	147	101	V
**62.9769	60.67	Qp	11.7	-30.7	41.67	--	--	126	102	V
102.8381	52.25	Qp	15.2	-30.3	37.15	43.52	-6.37	211	102	V
176.788	56.8	Qp	15.2	-29.6	42.4	43.52	-1.12	140	100	V
599.9796	38.71	Qp	22.6	-27.4	33.91	46.02	-12.11	18	101	V
858.5001	37.97	Qp	25.8	-26.3	37.47	46.02	-8.55	20	104	H

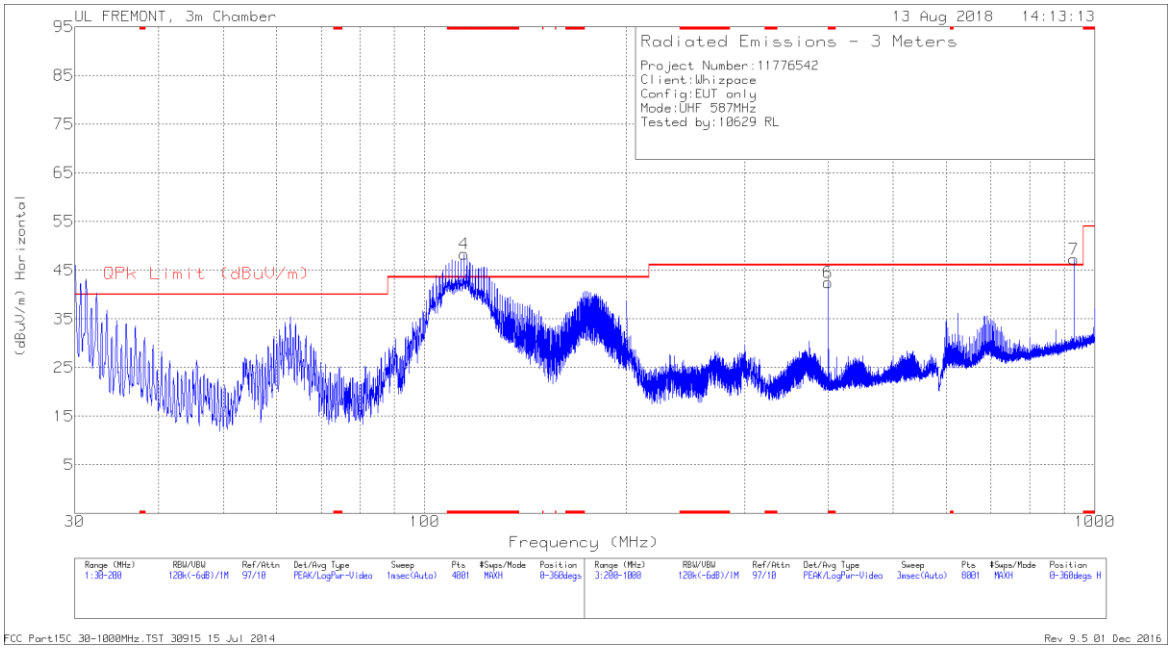
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

** - The emissions noted by ** were observed during the digital device (Part 15 Subpart B) measurements with the transceiver disabled and are therefore subject to the Part 15 B limits. This is a Class A digital device and the digital device emissions comply with the Class A limits.

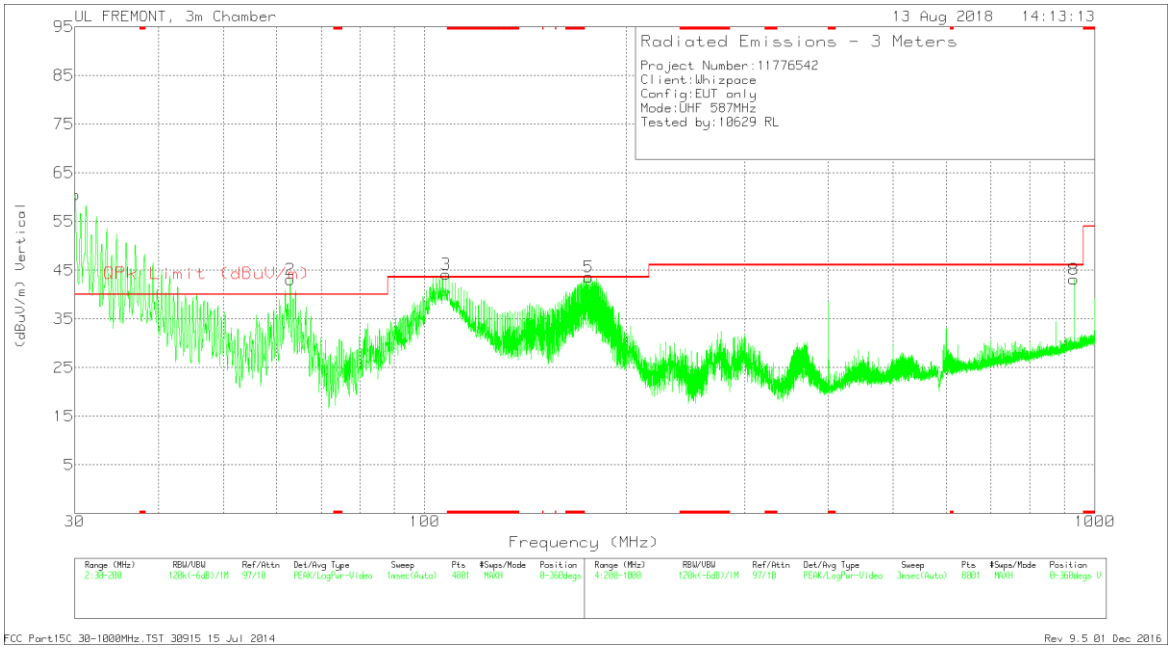
Qp - Quasi-Peak detector

BEYOND ADJACENT CHANNEL (MID CHANNEL)

HORIZONTAL PLOT



VERTICAL PLOT



MID CHANNEL DATA

Trace Markers

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T243 (dB/m)	Amp/Cbl (dB/m)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	**114.405	61.03	Pk	17.4	-30.1	48.33	--	--	0-360	200	H
6	400	51.06	Pk	19.7	-28.3	42.46	46.02	-3.56	0-360	200	H
1	**30.0425	66.07	Pk	25.5	-31.1	60.47	--	--	0-360	100	V
2	**62.98	62.1	Pk	11.7	-30.7	43.1	--	--	0-360	100	V
3	**107.435	58.16	Pk	16.2	-30.2	44.16	--	--	0-360	100	V
5	**175.6475	57.89	Pk	15.3	-29.6	43.59	--	--	0-360	100	V
7	930.5	45.93	Pk	26.7	-25.4	47.23	--	--	0-360	100	H
8	930.5	41.84	Pk	26.7	-25.4	43.14	46.02	-2.88	0-360	100	V

** The emissions noted by ** were observed during the digital device (Part 15 Subpart B) measurements with the transceiver disabled and are therefore subject to the Part 15 B limits. This is a Class A digital device and the digital device emissions comply with the Class A limits.

Pk - Peak detector

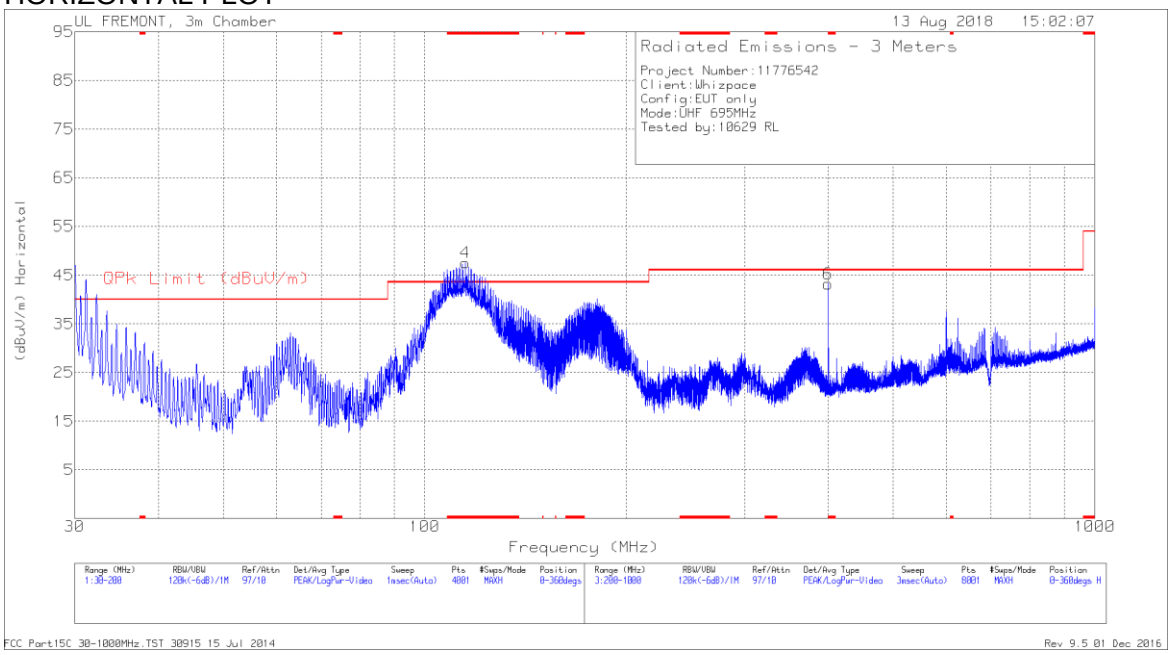
Radiated Emissions

Frequency (MHz)	Meter Reading (dBuV)	Det	AF T243 (dB/m)	Amp/Cbl (dB/m)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
* 399.9932	51.52	Qp	19.7	-28.3	42.92	46.02	-3.1	118	174	H
930.5009	42.64	Qp	26.7	-25.4	43.94	46.02	-2.08	298	100	H
930.5028	38.34	Qp	26.7	-25.4	39.64	46.02	-6.38	328	128	V

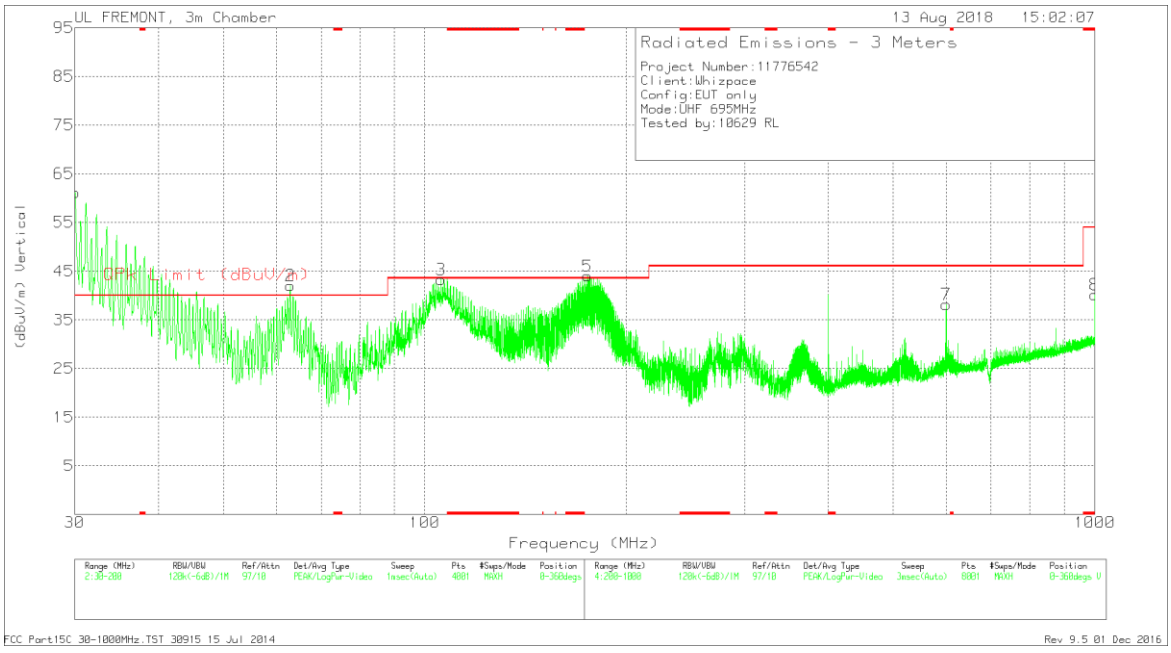
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Qp - Quasi-Peak detector

BEYOND ADJACENT CHANNEL (HIGH CHANNEL)

HORIZONTAL PLOT



VERTICAL PLOT



HIGH CHANNEL DATA

Trace Markers

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF T243 (dB/m)	Amp/Cbl (dB/m)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	** 114.915	60.17	Pk	17.5	-30.1	47.57	--	--	0-360	200	H
6	* 400	51.82	Pk	19.7	-28.3	43.22	46.02	-2.8	0-360	200	H
8	* 1000	36.97	Pk	27.6	-24.4	40.17	53.97	-13.8	0-360	100	V
1	**30.0425	66.71	Pk	25.5	-31.1	61.11	--	--	0-360	100	V
2	**62.98	61.03	Pk	11.7	-30.7	42.03	--	--	0-360	100	V
3	105.735	57.69	Pk	15.8	-30.2	43.29	43.52	-.23	0-360	100	V
5	**174.9675	58.29	Pk	15.3	-29.6	43.99	--	--	0-360	100	V
7	600	42.99	Pk	22.6	-27.4	38.19	46.02	-7.83	0-360	100	V

** - The emissions noted by ** were observed during the digital device (Part 15 Subpart B) measurements with the transceiver disabled and are therefore subject to the Part 15 B limits. This is a Class A digital device and the digital device emissions comply with the Class A limits.

Pk - Peak detector

Radiated Emissions

Frequency (MHz)	Meter Reading (dBuV)	Det	AF T243 (dB/m)	Amp/Cbl (dB/m)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
* 399.9947	53.05	Qp	19.7	-28.3	44.45	46.02	-1.57	134	158	H
* 999.9792	35.01	Qp	27.6	-24.4	38.21	53.97	-15.76	88	101	V
599.9828	39.81	Qp	22.6	-27.4	35.01	46.02	-11.01	40	101	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

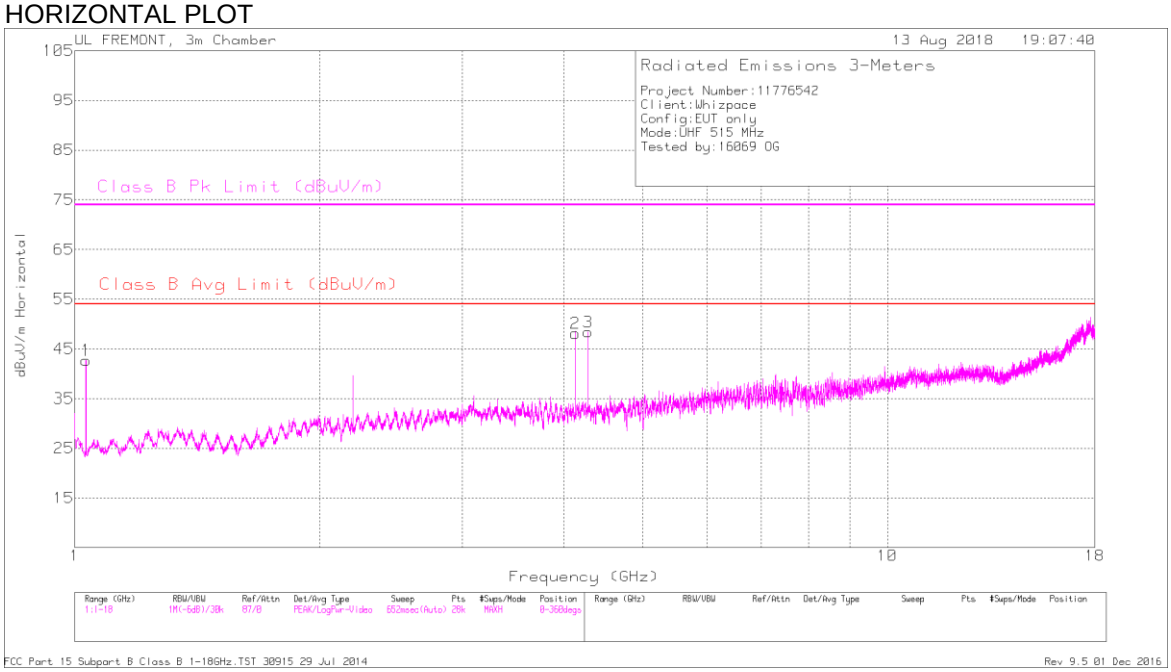
Qp - Quasi-Peak detector

10.2. TRANSMITTER ABOVE 1GHz

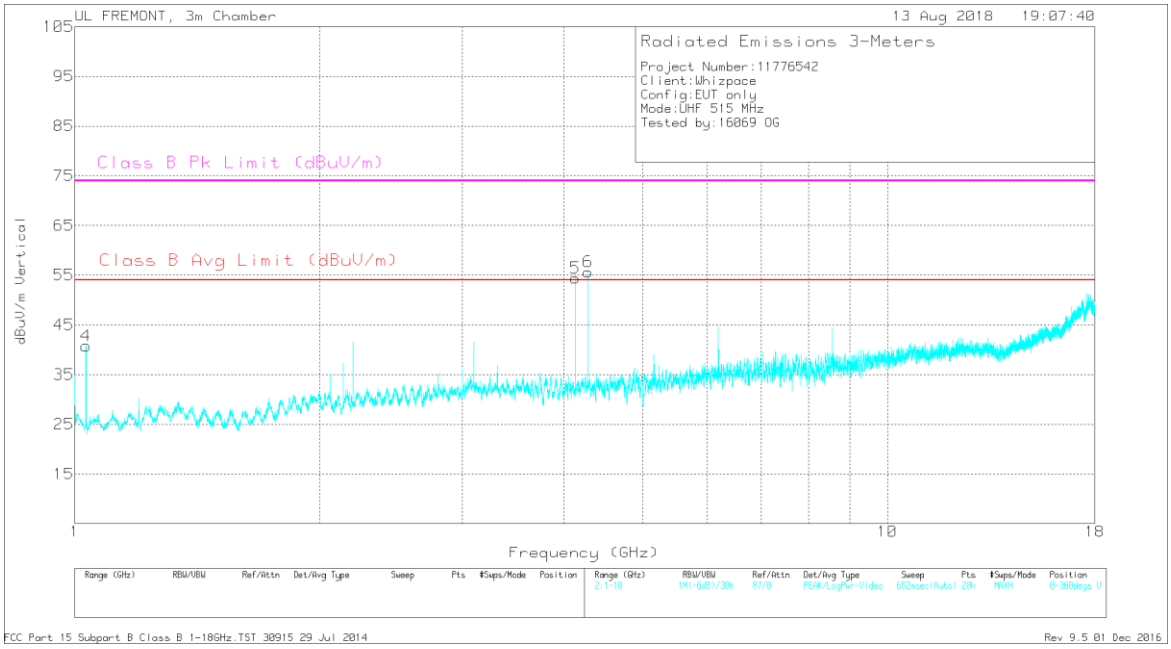
10.2.1. HARMONICS AND SPURIOUS EMISSIONS IN THE UHF BAND - EXTERNAL ANTENNA

LOW CHANNEL

HORIZONTAL PLOT



VERTICAL PLOT



LOW CHANNEL DATA

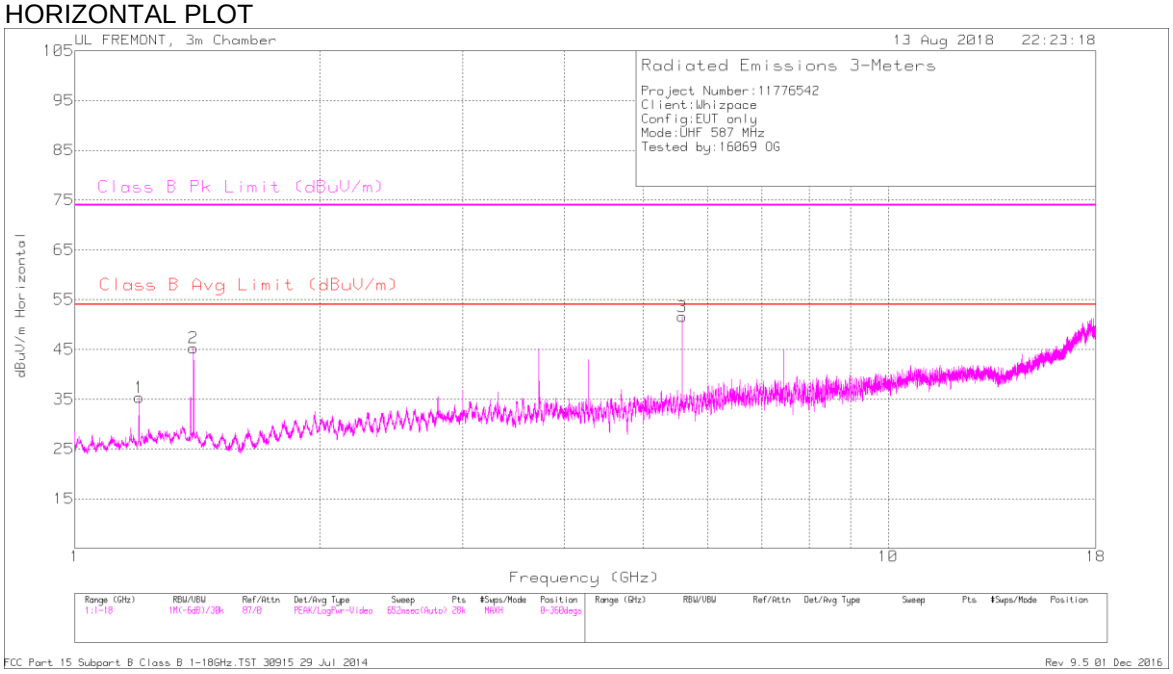
Radiated Emissions

Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl (dB)	Corrected Reading dBuV/m	Class B Avg Limit (dBuV/m)	Av(CISPR)Margin (dB)	Class B Pk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1.032	52.1	Pk	26.9	-32.2	46.8	-	-	74	-27.2	275	326	H
1.032	50.53	Av	26.9	-32.2	45.23	54	-8.77	-	-	275	326	H
1.032	50.11	Av	26.9	-32.2	44.81	-	-	-	-	126	128	V
1.032	42.12	Av	26.9	-32.2	36.82	54	-17.18	-	-	126	128	V
4.13	43.86	Pk	33.5	-28.4	48.96	-	-	74	-25.04	124	107	H
4.13	40.6	Av	33.5	-28.4	45.7	54	-8.3	-	-	124	107	H
4.13	50.8	Pk	33.5	-28.5	55.8	-	-	74	-18.2	328	100	V
4.13	49.0	Av	33.5	-28.5	54	54	0.0	-	-	328	100	V
4.13	50.51	Pk	33.5	-28.5	55.51	-	-	74	-18.49	311	183	V
4.13	49.17	Av	33.5	-28.5	54.17	54	-11.1	-	-	311	183	V
4.281	43.24	Pk	33.6	-29.1	47.74	-	-	74	-26.26	139	251	H
4.281	38.4	Av	33.6	-29.1	42.9	54	-2.55	-	-	139	251	H
4.281	48.93	Pk	33.6	-29.1	53.43	-	-	74	-20.57	174	132	V
4.281	46.95	Av	33.6	-29.1	51.45	54	-8.77	-	-	174	132	V

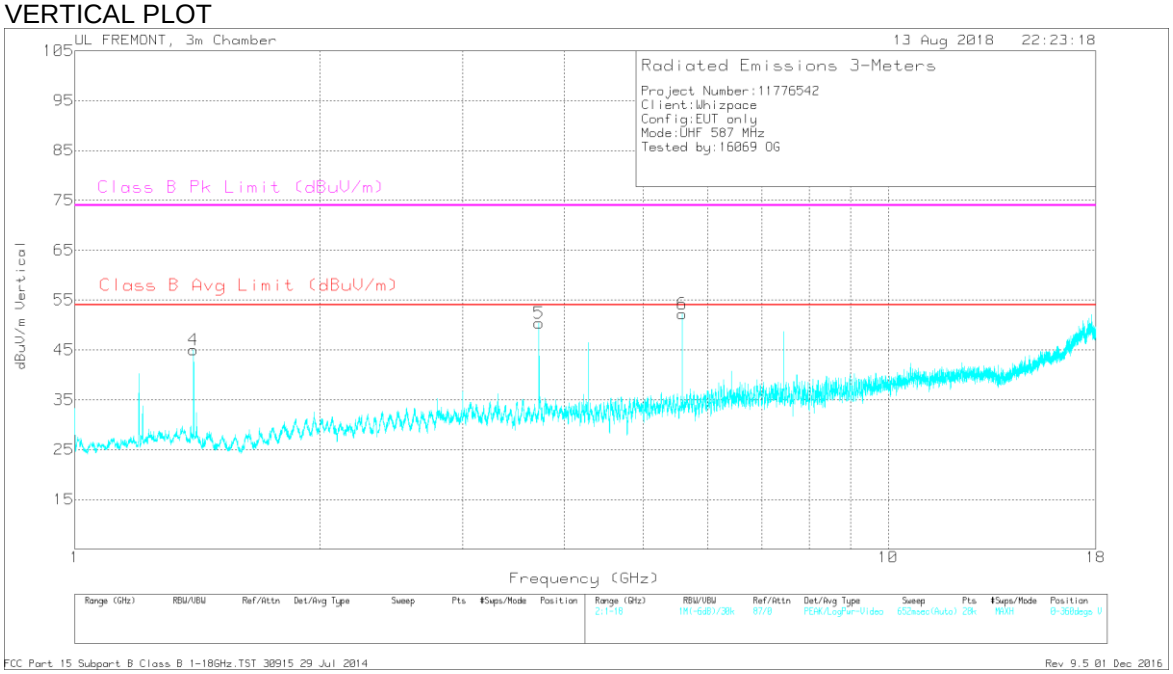
Pk - Peak detector
Av - Average detection

MID CHANNEL

HORIZONTAL PLOT



VERTICAL PLOT



MID CHANNEL DATA

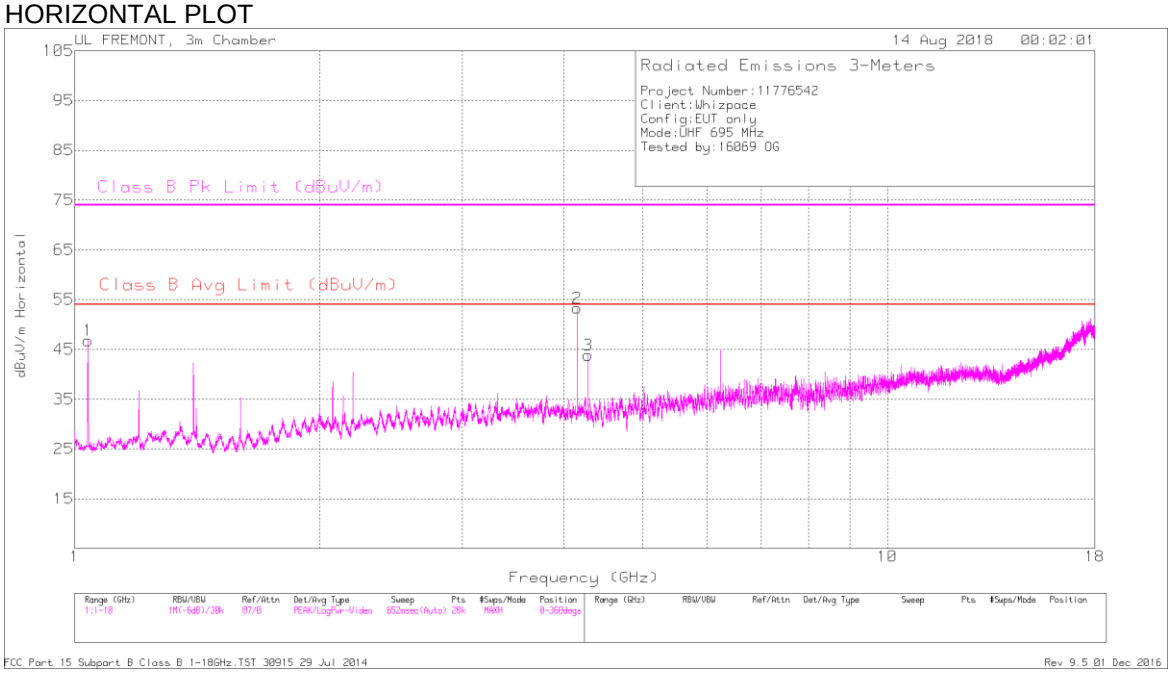
Radiated Emissions

Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl (dB)	Corrected Reading dBuV/m	Class B Avg Limit (dBuV/m)	Av(CISPR)Margin (dB)	Class B Pk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1.2	42.87	Pk	28.3	-31.6	39.57	-	-	74	-34.43	277	215	H
1.2	36.19	Av	28.3	-31.6	32.89	54	-21.11	-	-	277	215	H
1.4	50.7	Pk	28.7	-31.3	48.1	-	-	74	-25.9	85	167	H
1.4	48.53	Av	28.7	-31.3	45.93	54	-8.07	-	-	85	167	H
1.4	49.16	Av	28.7	-31.3	46.56	54	-7.44	-	-	0	198	V
1.4	38.93	Av	28.7	-31.3	36.33	54	-17.67	-	-	0	198	V
3.722	48.64	Pk	33.3	-29.1	52.84	-	-	74	-21.16	212	125	V
3.722	46.23	Av	33.3	-29.1	50.43	54	-3.57	-	-	212	125	V
5.583	46.38	Pk	34.8	-28.2	52.98	-	-	74	-21.02	202	146	H
5.583	44.02	Av	34.8	-28.2	50.62	54	-3.38	-	-	202	146	H
5.583	44.42	Pk	34.8	-28.2	51.02	-	-	74	-22.98	97	119	V
5.583	41.52	Av	34.8	-28.2	48.12	54	-5.88	-	-	97	119	V

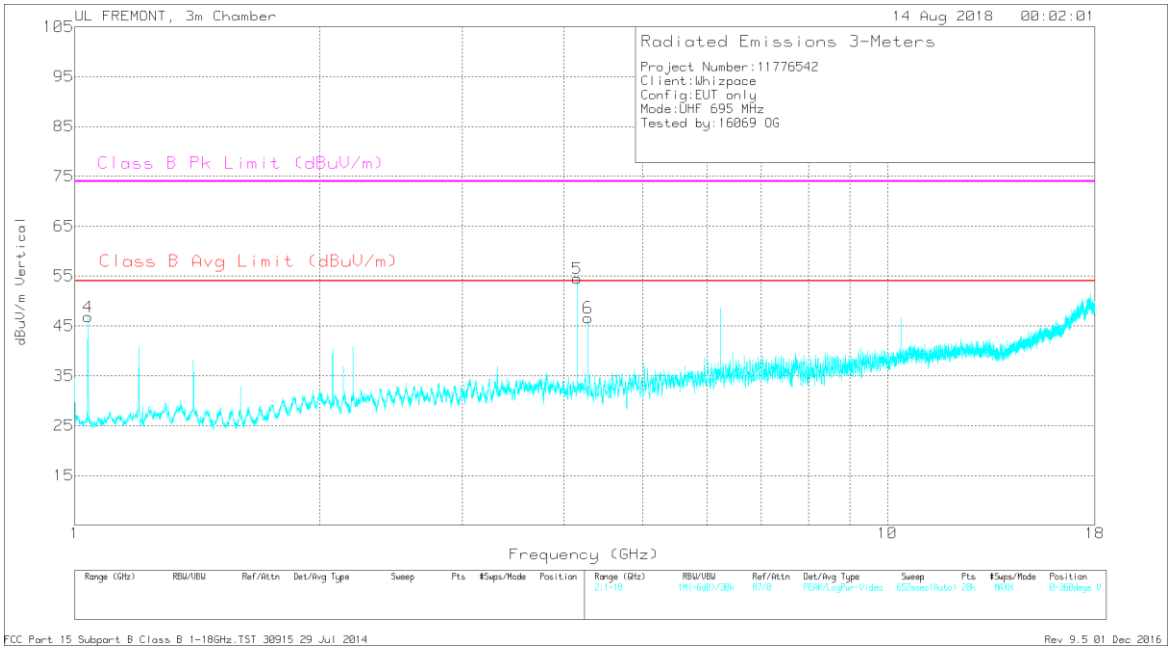
Pk - Peak detector
Av - Average detection

HIGH CHANNEL

HORIZONTAL PLOT



VERTICAL PLOT



HIGH CHANNEL DATA

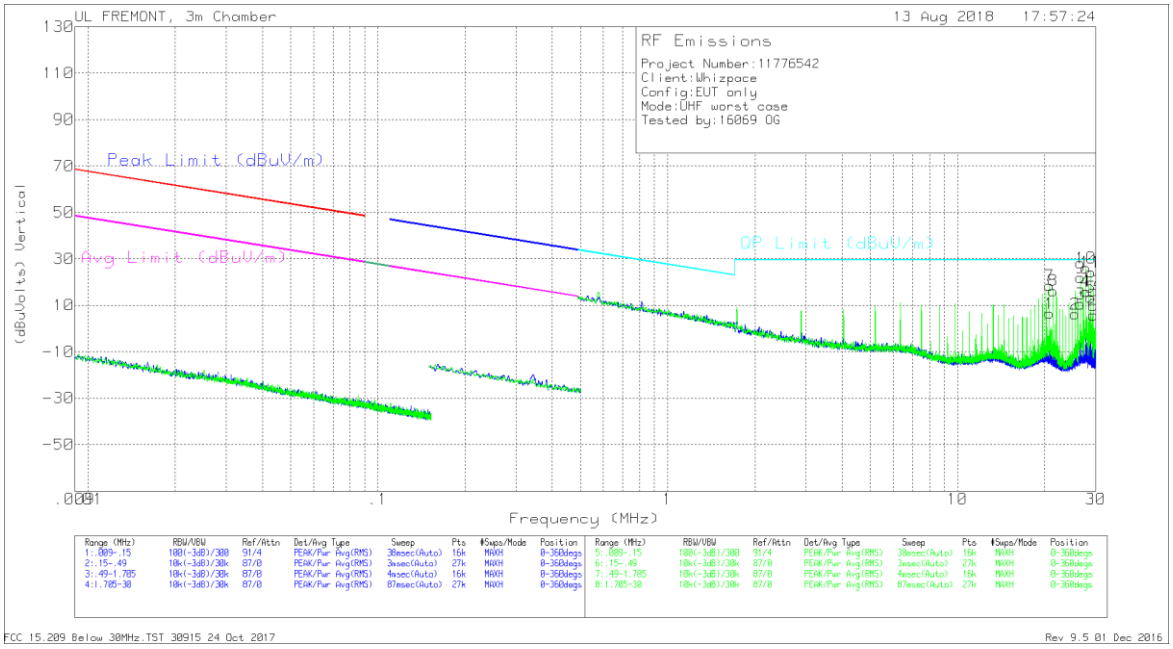
Radiated Emissions

Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl (dB)	Corrected Reading dBuV/m	Class B Avg Limit (dBuV/m)	Av(CISPR)Margin (dB)	Class B Pk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1.037	55.37	Av	26.8	-32.1	50.07	54	-3.93	-	-	41	107	V
1.037	27.24	Av	26.8	-32.1	21.94	54	-32.06	-	-	41	107	V
1.038	53.71	Pk	26.7	-32.2	48.21	-	-	74	-25.79	182	203	H
1.038	52.14	Av	26.7	-32.2	46.64	54	-7.36	-	-	182	203	H
4.154	48.8	Pk	33.5	-29.3	53	-	-	74	-21	174	183	H
4.154	46.7	Av	33.5	-29.3	50.9	54	-3.1	-	-	174	183	H
4.154	49.44	Pk	33.5	-29.3	53.64	-	-	74	-20.36	316	106	V
4.154	47.33	Av	33.5	-29.3	51.53	54	-2.47	-	-	316	106	V
4.281	44.12	Pk	33.6	-29.1	48.62	-	-	74	-25.38	229	165	H
4.281	41.11	Av	33.6	-29.1	45.61	54	-8.39	-	-	229	165	H
4.281	43.39	Pk	33.6	-29.1	47.89	-	-	74	-26.11	357	112	V
4.281	39.38	Av	33.6	-29.1	43.88	54	-10.12	-	-	357	112	V

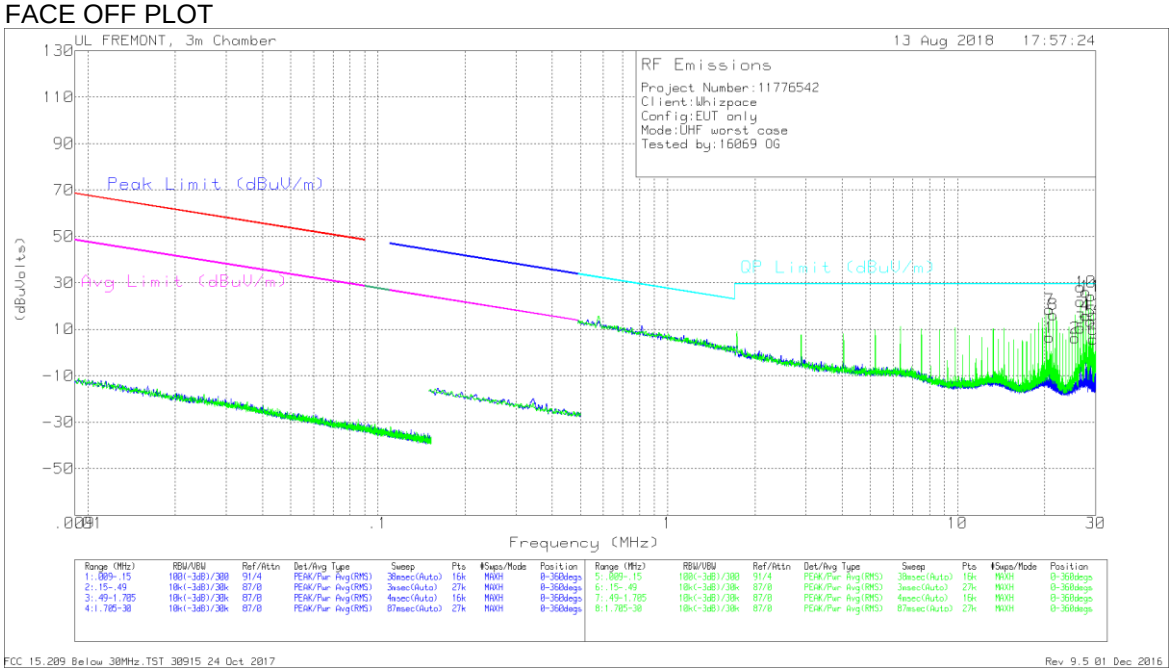
Pk - Peak detector
Av - Average detection

10.3. WORST-CASE TRANSMITTER BELOW 30MHz -EXTERNAL ANTENNA

FACE ON PLOT



FACE OFF PLOT



DATA

Trace Markers

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (dB/m)	Cbl (dB)	Dist Corr 30m	Corrected Reading (dBuVolts)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
7	20.79432	42.19	Pk	14.6	1.7	-40	18.49	29.5	-11.01	0-360
1	20.79642	30.23	Pk	14.6	1.7	-40	6.53	29.5	-22.97	0-360
8	21.36653	40.12	Pk	14.5	1.7	-40	16.32	29.5	-13.18	0-360
2	25.41181	31.66	Pk	12.9	1.7	-40	6.26	29.5	-23.24	0-360
9	26.56566	47.34	Pk	12.9	1.7	-40	21.94	29.5	-7.56	0-360
3	26.57194	36.02	Pk	12.9	1.7	-40	10.62	29.5	-18.88	0-360
4	27.71741	41.17	Pk	13.1	1.7	-40	15.97	29.5	-13.53	0-360
10	27.7195	51.24	Pk	13.1	1.7	-40	26.04	29.5	-3.46	0-360
5	28.87754	38.53	Pk	13.2	1.7	-40	13.43	29.5	-16.07	0-360
11	28.88069	49.33	Pk	13.2	1.7	-40	24.23	29.5	-5.27	0-360
12	29.4529	41.55	Pk	13.1	1.7	-40	16.35	29.5	-13.15	0-360
6	29.45604	30.9	Pk	13.1	1.7	-40	5.7	29.5	-23.8	0-360

Pk - Peak detector

Radiated Emissions

Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (dB/m)	Cbl (dB)	Dist Corr 30m	Corrected Reading (dBuVolts)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
27.7249	51.38	Pk	13.1	1.7	-40	26.18	29.5	-3.32	159
27.7249	43.84	Qp	13.1	1.7	-40	18.64	29.5	-10.86	159
28.8808	49.28	Pk	13.2	1.7	-40	24.18	29.5	-5.32	131
28.8808	41.57	Qp	13.2	1.7	-40	16.47	29.5	-13.03	131

Pk - Peak detector

Qp - Quasi-Peak detector

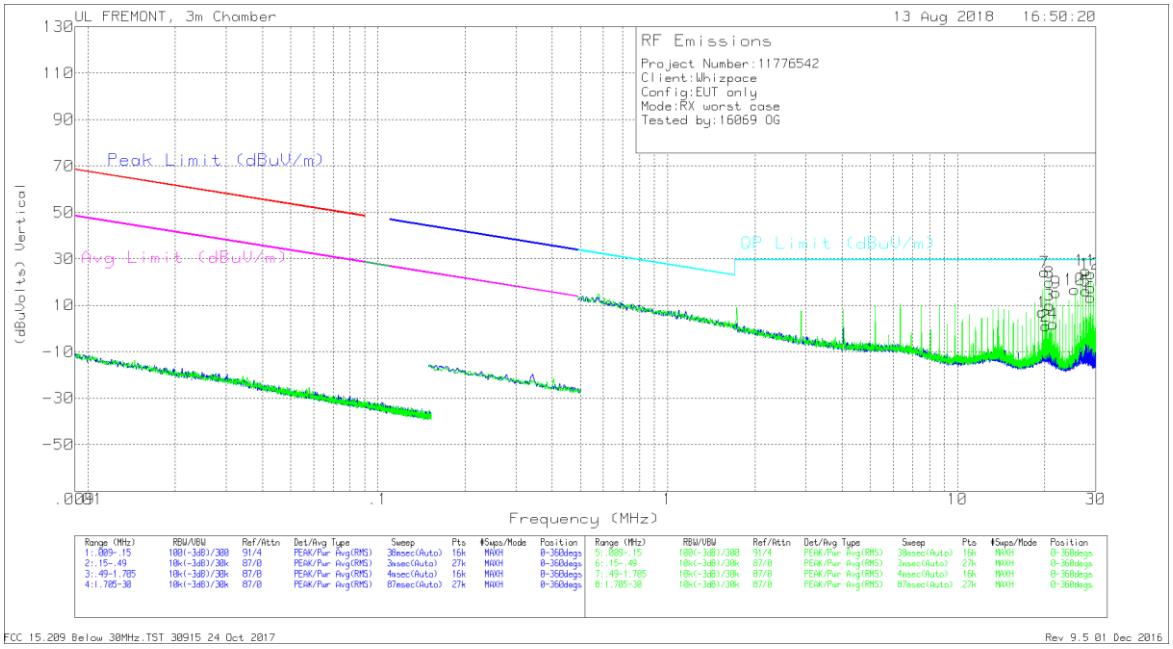
NOTE: KDB 414788 OATS and Chamber Correlation Justification;

Based on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

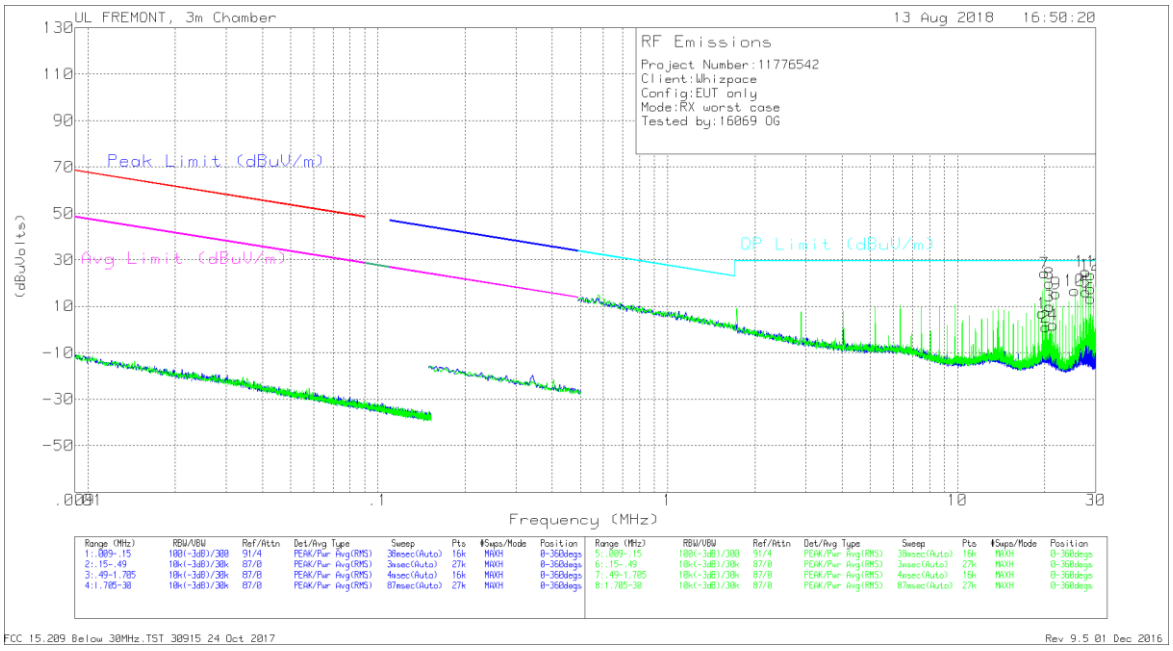
-OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

10.4. WORST-CASE RECEIVER SPURIOUS BELOW 30MHz EXTERNAL ANTENNA

FACE ON PLOT



FACE OFF PLOT



DATA

Trace Markers

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (dB/m)	Cbl (dB)	Dist Corr 30m	Corrected Reading (dBuVolts)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
1	19.6258	30.65	Pk	14.8	1.6	-40	7.05	29.5	-22.45	0-360
7	20.00413	47.85	Pk	14.8	1.6	-40	24.25	29.5	-5.25	0-360
2	20.2043	24.62	Pk	14.8	1.7	-40	1.12	29.5	-28.38	0-360
3	20.7765	33.74	Pk	14.6	1.7	-40	10.04	29.5	-19.46	0-360
8	20.7765	43.55	Pk	14.6	1.7	-40	19.85	29.5	-9.65	0-360
4	21.36024	25.77	Pk	14.5	1.7	-40	1.97	29.5	-27.53	0-360
9	21.92721	39.57	Pk	14.2	1.7	-40	15.47	29.5	-14.03	0-360
10	25.39294	42.15	Pk	12.9	1.7	-40	16.75	29.5	-12.75	0-360
11	27.6975	50.16	Pk	13.1	1.7	-40	24.96	29.5	-4.54	0-360
5	27.70798	41.41	Pk	13.1	1.7	-40	16.21	29.5	-13.29	0-360
12	28.85239	48.63	Pk	13.2	1.7	-40	23.53	29.5	-5.97	0-360
6	28.85554	38.43	Pk	13.2	1.7	-40	13.33	29.5	-16.17	0-360

Pk - Peak detector

Radiated Emissions

Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (dB/m)	Cbl (dB)	Dist Corr 30m	Corrected Reading (dBuVolts)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
20.0042	-6.04	Pk	14.8	1.6	-40	-29.64	29.5	-59.14	4
20.0042	-9.18	Qp	14.8	1.6	-40	-32.78	29.5	-62.28	4
28.1331	58.53	Av	13.1	1.7	-40	33.33	-	-	144
28.8571	40.06	Qp	13.2	1.7	-40	14.96	29.5	-14.54	151
28.8606	49.87	Pk	13.2	1.7	-40	24.77	29.5	-4.73	143
28.8606	36.41	Qp	13.2	1.7	-40	11.31	29.5	-18.19	143

Pk - Peak detector

Qp - Quasi-Peak detector

Av - Average detection

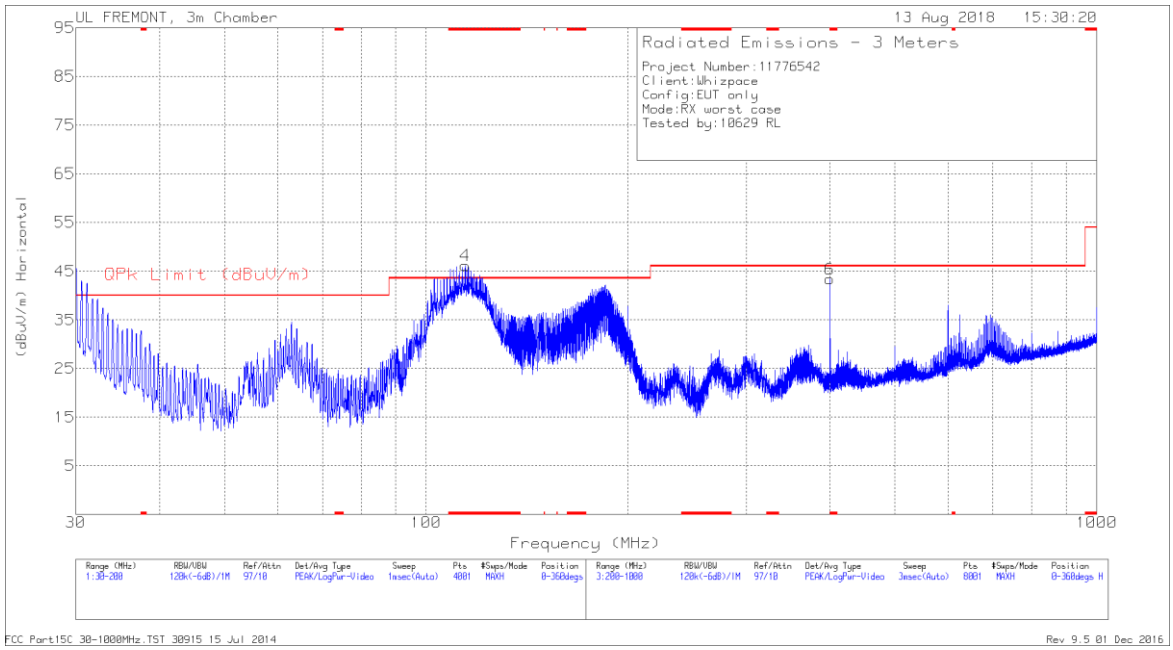
NOTE: KDB 414788 OATS and Chamber Correlation Justification;
-Based on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

-OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

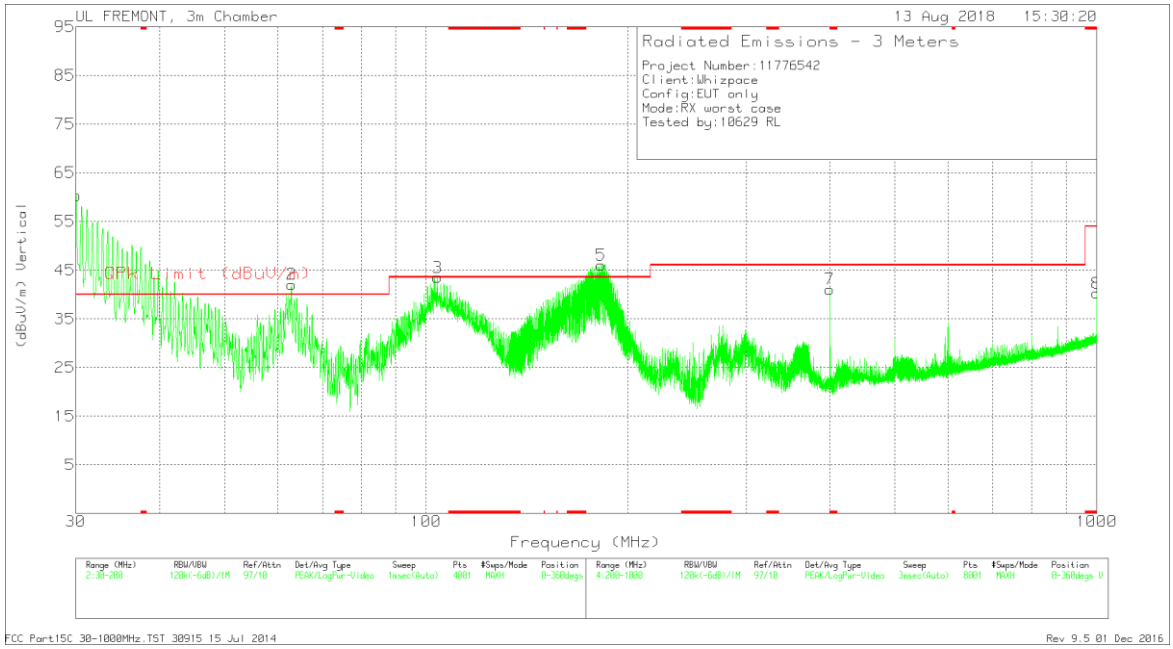
10.5. WORST CASE RECEIVER SPURIOUS EMISSIONS BELOW 1 GHz - EXTERNAL ANTENNA

10.5.1. UHF BAND

HORIZONTAL PLOT



VERTICAL PLOT



DATA

Radiated Emissions

Frequency (MHz)	Meter Reading (dBuV)	Det	AF T243 (dB/m)	Amp/Cbl (dB/m)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
** 114.2898	58.24	Qp	17.4	-30.1	45.54	-	-	124	220	H
* 399.9948	52.98	Qp	19.7	-28.3	44.38	46.02	-1.64	118	167	H
* 399.9974	50.22	Qp	19.7	-28.3	41.62	46.02	-4.4	27	146	V
* 999.9818	29.64	Qp	27.6	-24.4	32.84	53.97	-21.13	337	189	V
**34.0595	60.21	Qp	22.1	-31.1	51.21	-	-	162	101	V
62.9342	58.59	Qp	11.7	-30.7	39.59	40	-.41	94	107	V
103.9015	56.82	Qp	15.5	-30.3	42.02	43.52	-1.5	318	106	V
**182.3889	60.2	Qp	15.1	-29.5	45.8	-	-	153	100	V

* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band

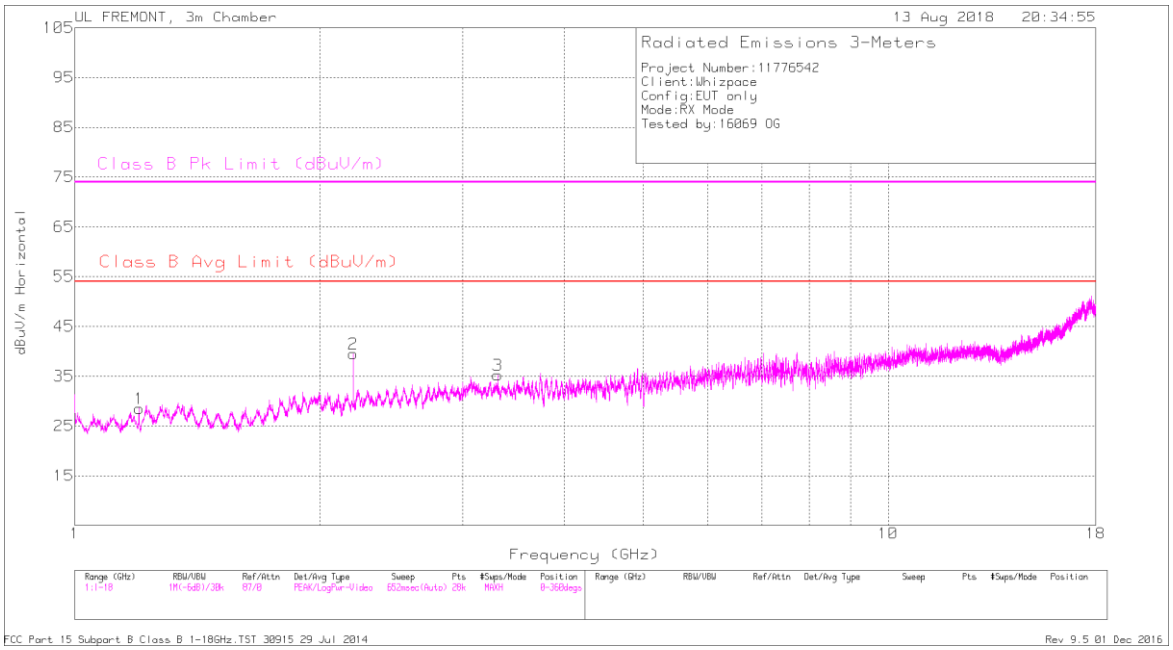
** The emissions noted by ** were observed during the digital device (Part 15 Subpart B) measurements with the transceiver disabled and are therefore subject to the Part 15 B limits. This is a Class A digital device and the digital device emissions comply with the Class A limits.

Qp - Quasi-Peak detector

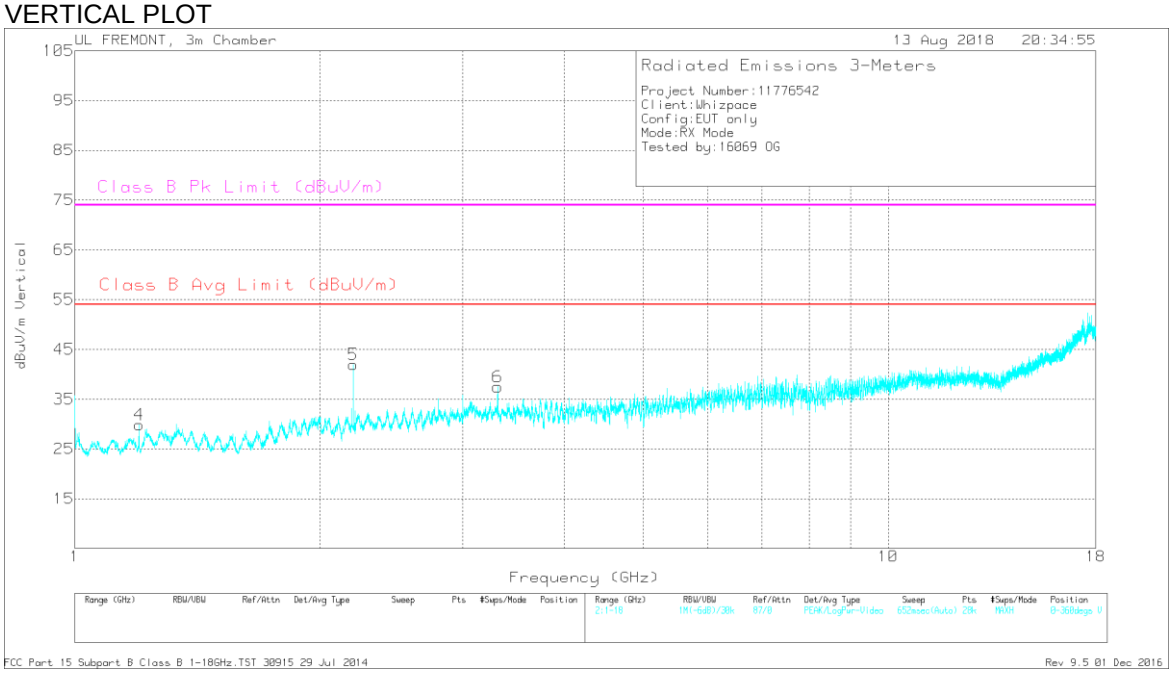
10.6. WORST CASE RECEIVER SPURIOUS EMISSIONS ABOVE 1 GHz - EXTERNAL ANTENNA

10.6.1. UHF BAND

HORIZONTAL PLOT



VERTICAL PLOT



DATA

Radiated Emissions

Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl (dB)	Corrected Reading dBuV/m	Class B Avg Limit (dBuV/m)	Av(CISPR)Margin (dB)	Class B Pk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1.184	46.55	Av	28	-31.7	42.85	54	-11.15	-	-	107	246	V
1.2	39.85	Pk	28.3	-31.6	36.55	-	-	74	-37.45	0	175	H
1.2	28.2	Av	28.3	-31.6	24.9	54	-29.1	-	-	0	175	H
2.2	44.99	Pk	31.5	-30.9	45.59	-	-	74	-28.41	3	279	H
2.2	41.12	Av	31.5	-30.9	41.72	54	-12.28	-	-	3	279	H
2.2	44.71	Pk	31.5	-30.9	45.31	-	-	74	-28.69	188	117	V
2.2	41.02	Av	31.5	-30.9	41.62	54	-12.38	-	-	188	117	V
3.312	39.01	Pk	32.8	-29.9	41.91	-	-	74	-32.09	271	337	H
3.312	27.31	Av	32.8	-29.9	30.21	54	-23.79	-	-	271	337	H
3.312	40.16	Pk	32.8	-29.9	43.06	-	-	74	-30.94	102	130	V
3.312	31.7	Av	32.8	-29.9	34.6	54	-19.4	-	-	102	130	V

Pk - Peak detector
Av - Average detection

11. AC MAINS LINE CONDUCTED EMISSIONS

LIMITS

FCC §15.207 (a)

Frequency of Emission (MHz)	Conducted Limit (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56 *	56 to 46 *
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

TEST PROCEDURE

The EUT is placed on a non-conducting table 40 cm from the vertical ground plane and 80 cm above the horizontal ground plane. The EUT is configured in accordance with ANSI C63.10.

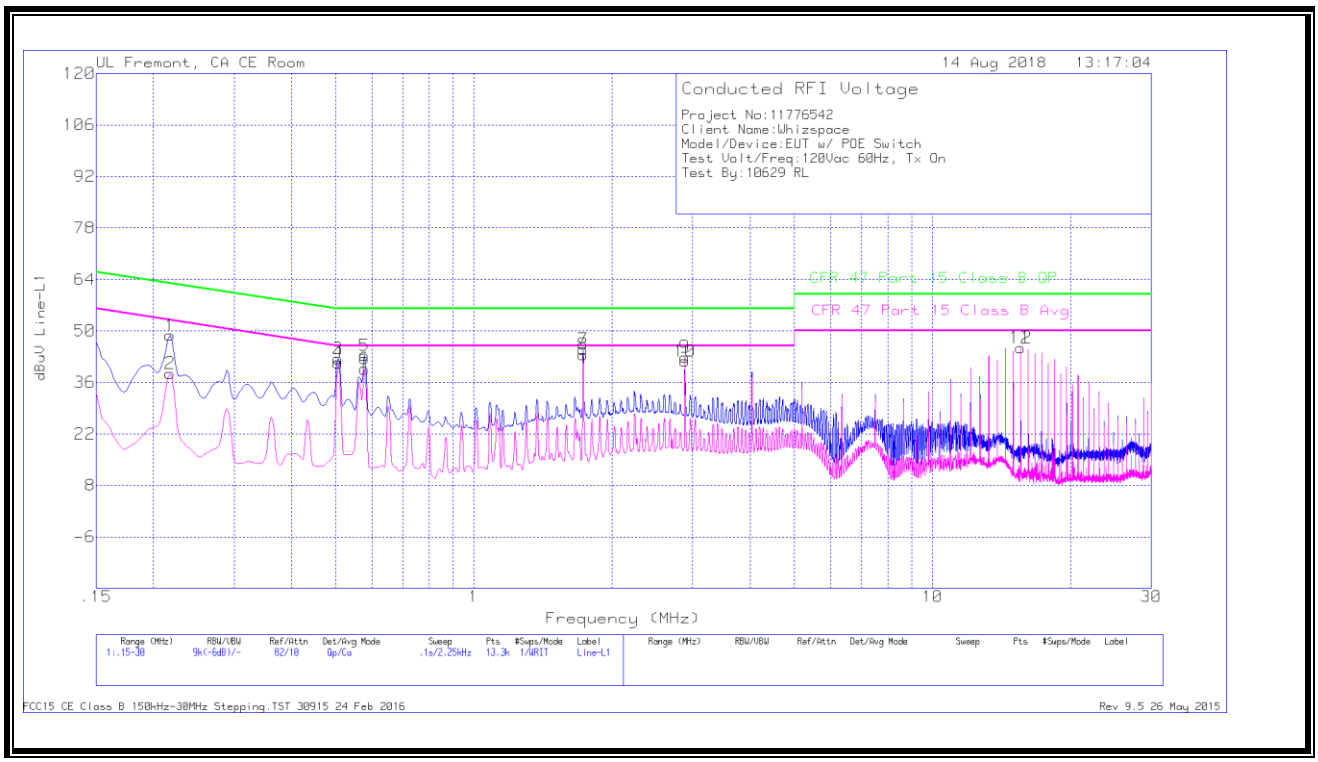
The receiver is set to a resolution bandwidth of 9 kHz. Peak detection is used unless otherwise noted as quasi-peak or average.

Line conducted data is recorded for both NEUTRAL and HOT lines.

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888

11.1. UHF MODE-EXTERNAL ANTENNA

11.1.1. LINE 1 RESULTS



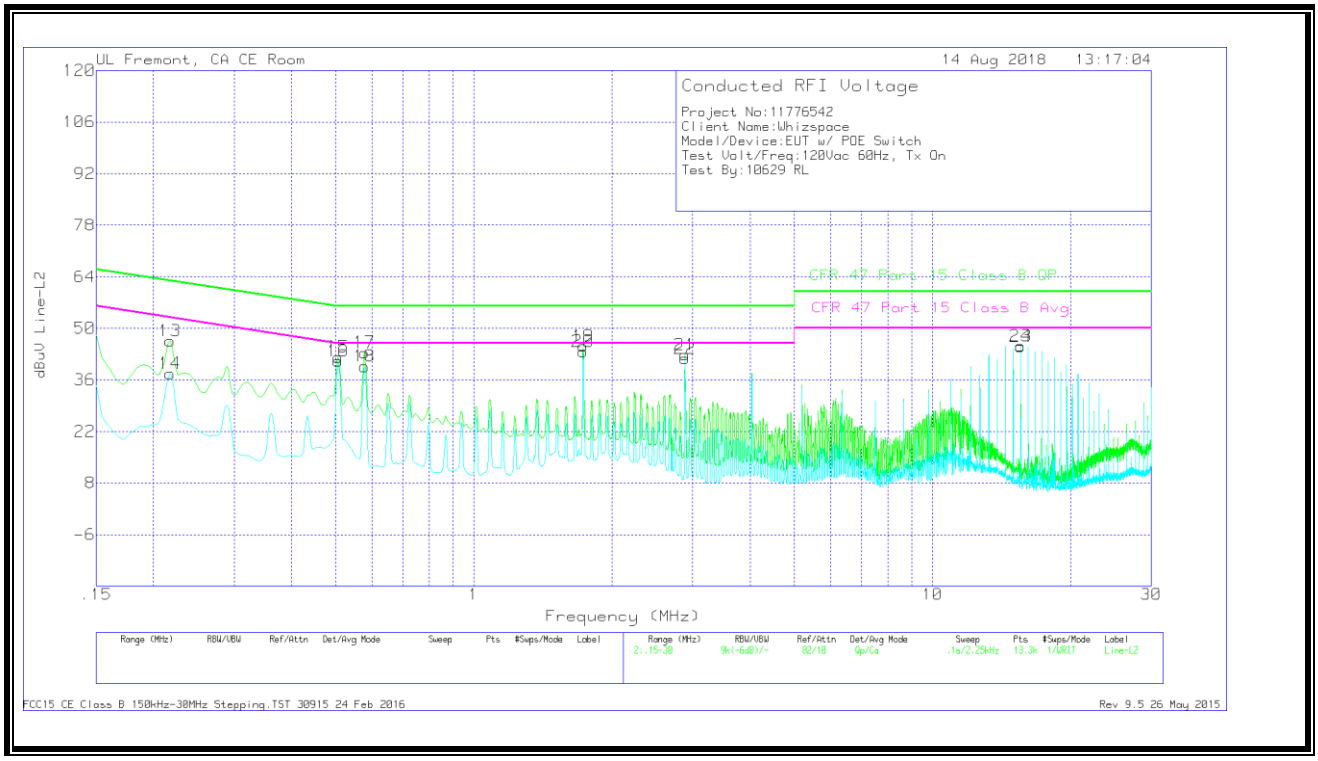
DATA

Range 1: Line-L1 .15 - 30MHz

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L1	LC Cables C1&C3	Limiter (dB)	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	QP Margin (dB)	CFR 47 Part 15 Class B Avg	Av(CISPR) Margin (dB)
1	.2175	38.69	Qp	0	0	10.1	48.79	62.91	-14.12	-	-
2	.2175	28.32	Ca	0	0	10.1	38.42	-	-	52.91	-14.49
3	.5055	32.37	Qp	0	0	10.1	42.47	56	-13.53	-	-
4	.5055	31.28	Ca	0	0	10.1	41.38	-	-	46	-4.62
5	.5775	33.22	Qp	0	0	10.1	43.32	56	-12.68	-	-
6	.5775	29.57	Ca	0	0	10.1	39.67	-	-	46	-6.33
7	1.7295	34.77	Qp	0	.1	10.1	44.97	56	-11.03	-	-
8	1.7295	33.39	Ca	0	.1	10.1	43.59	-	-	46	-2.41
9	2.88375	32.66	Qp	0	.1	10.1	42.86	56	-13.14	-	-
10	2.88375	31.56	Ca	0	.1	10.1	41.76	-	-	46	-4.24
11	15.5715	34.86	Qp	.1	.3	10.2	45.46	60	-14.54	-	-
12	15.5715	34.82	Ca	.1	.3	10.2	45.42	-	-	50	-4.58

Qp - Quasi-Peak detector
Ca - CISPR average detection

11.1.2. LINE 2 RESULTS



DATA

Range 2: Line-L2 .15 - 30MHz

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	LISN L2	LC Cables C2&C3	Limiter (dB)	Corrected Reading dBuV	CFR 47 Part 15 Class B QP	QP Margin (dB)	CFR 47 Part 15 Class B Avg	Av(CISPR)Margin (dB)
13	.2175	36.47	Qp	0	0	10.1	46.57	62.91	-16.34	-	-
14	.2175	27.62	Ca	0	0	10.1	37.72	-	-	52.91	-15.19
15	.5055	32.1	Qp	0	0	10.1	42.2	56	-13.8	-	-
16	.5055	31.01	Ca	0	0	10.1	41.11	-	-	46	-4.89
17	.5775	33.3	Qp	0	0	10.1	43.4	56	-12.6	-	-
18	.5775	29.57	Ca	0	0	10.1	39.67	-	-	46	-6.33
19	1.7295	35	Qp	0	.1	10.1	45.2	56	-10.8	-	-
20	1.7295	33.54	Ca	0	.1	10.1	43.74	-	-	46	-2.26
21	2.88375	32.61	Qp	0	.1	10.1	42.81	56	-13.19	-	-
22	2.88375	31.58	Ca	0	.1	10.1	41.78	-	-	46	-4.22
23	15.57375	34.6	Qp	.1	.3	10.2	45.2	60	-14.8	-	-
24	15.57375	34.52	Ca	.1	.3	10.2	45.12	-	-	50	-4.88

Qp - Quasi-Peak detector
Ca - CISPR average detection

12. FIXED BASE STATION DATABASE CERTIFICATION TESTS

Test Procedure

Both base and client software and hardware are identical the only difference is the deployment location. The test requirements were done on the base except for a few scenarios where client was also tested. Database used for this tests was SpectrumBridge (http://whitespaces.spectrumbridge.com).

12.1. Fixed WSD Registration

CLAUSES

- §15.713(g)(3)

REQUIREMENT

- The Fixed WSD must provide the required information to the database and obtain a successful registration.

- The management software must be able to collect the data listed below. Confirm that the EUT will not operate unless a successful registration notification is received from the database.
  i. FCC ID
  ii. Serial Number
  iii. Location Coordinates
  iv. Location uncertainty with 95% accuracy (covered by section 12.8 in this report)
  v. Antenna Height AGL (must not be > 30 m)
  vi. Contact information (Device owner and device contact)

- For a fixed WSD without a direct connection to the internet, confirm that registration through a registered fixed device takes place only on a channel available to that registered device.

- **PRE-REGISTRATION PROCESS**

- Both the Base and Client Station are registered using an authorized database via the Internet at the depot facility. Following registration a common available channel between each is site is selected as the initial transmitting channel for each site. This channel will be the initial “listening” channel for the Remote Station

12.1.1. SUCCESSFUL REGISTRATION

TEST PROCEDURE

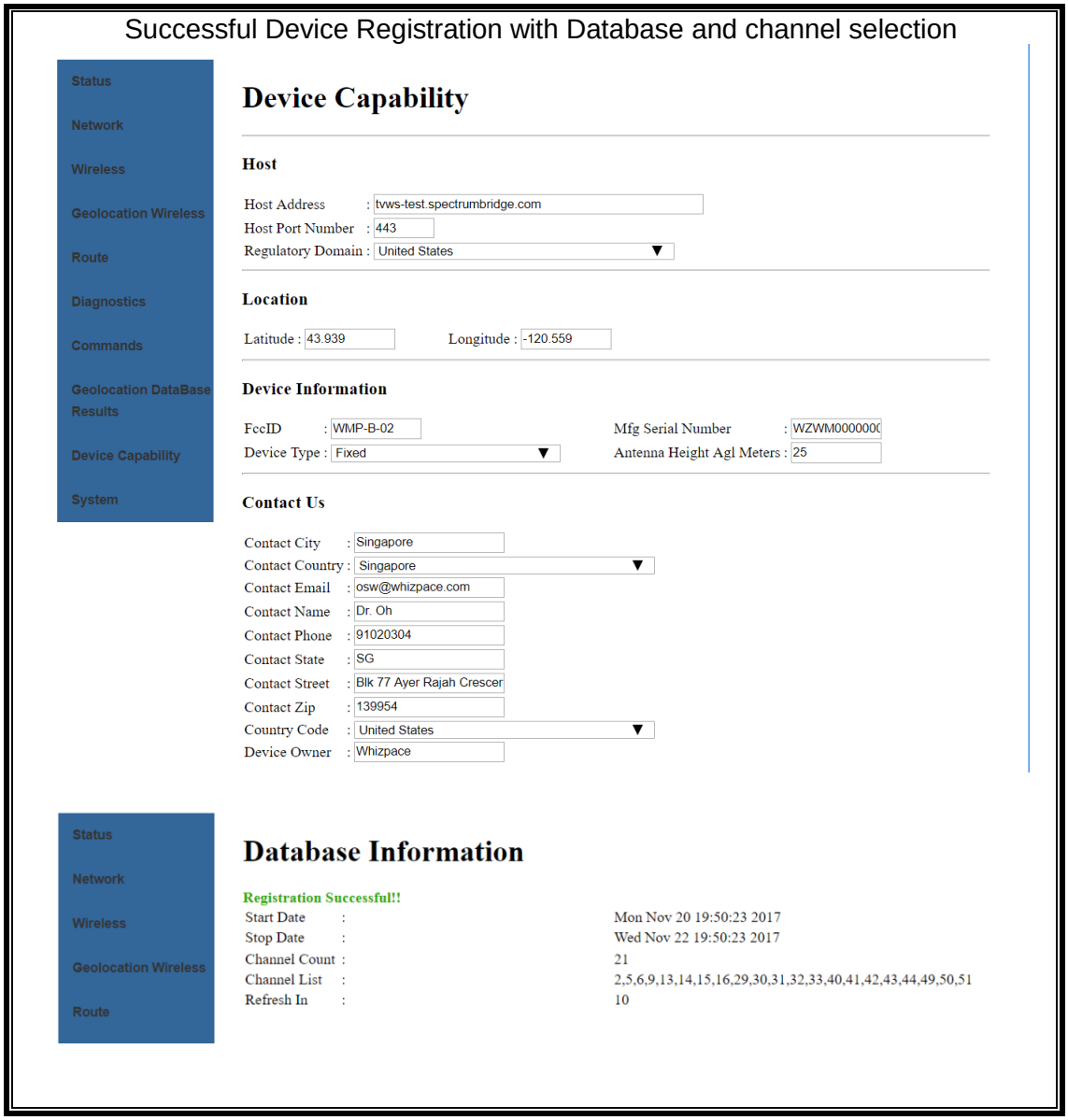
- Configure the base EUT with correct registration information:
    - The FCC ID and serial number are permanently programmed to the device and cannot be modified.
    - Known acceptable geographic coordinates, antenna height AGL and contact information were entered into the EUT.
- The base EUT automatically contacts the TVWS Database to perform device registration.
- Upon successful registration, the base EUT automatically contacts the TVWS Database to retrieve device channel list.
- Selects a channel from the channel list returned from the TVWS Database and start normal radio operation on the selected channel.
- Verify base output signal on the selected channel on the spectrum analyzer.

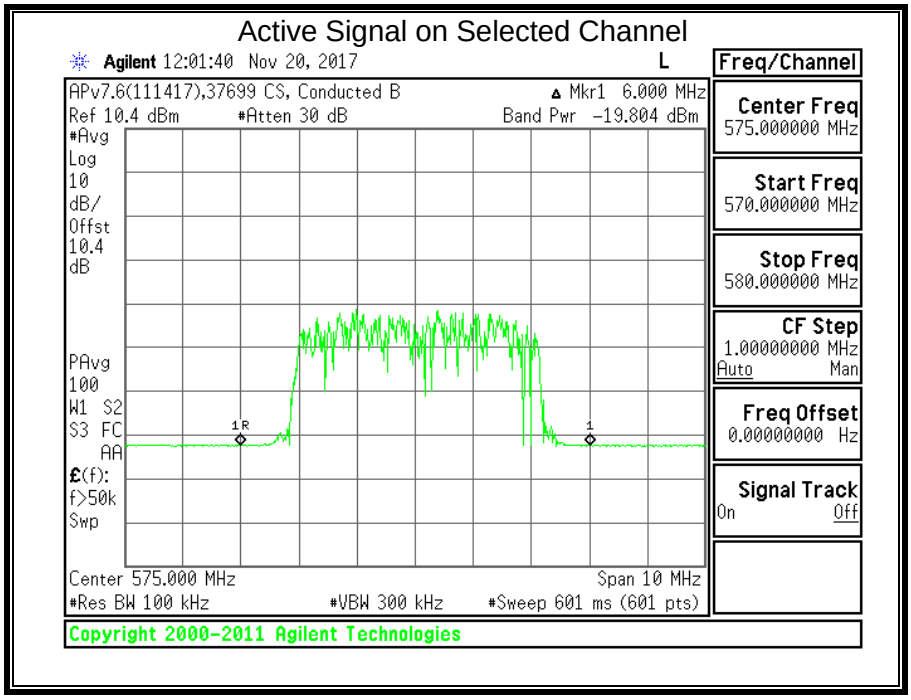
RESULTS

The EUT successfully registered when correct registration information was submitted to the TVWS Database. The EUT transmission was observed on the spectrum analyzer on the selected TV channel from the returned channel list from the TVWS Database.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	37699 CS	11/20/17

Successful Device Registration with Database and channel selection





12.1.2. FAILED REGISTRATION – Location Coordinates

TEST PROCEDURE

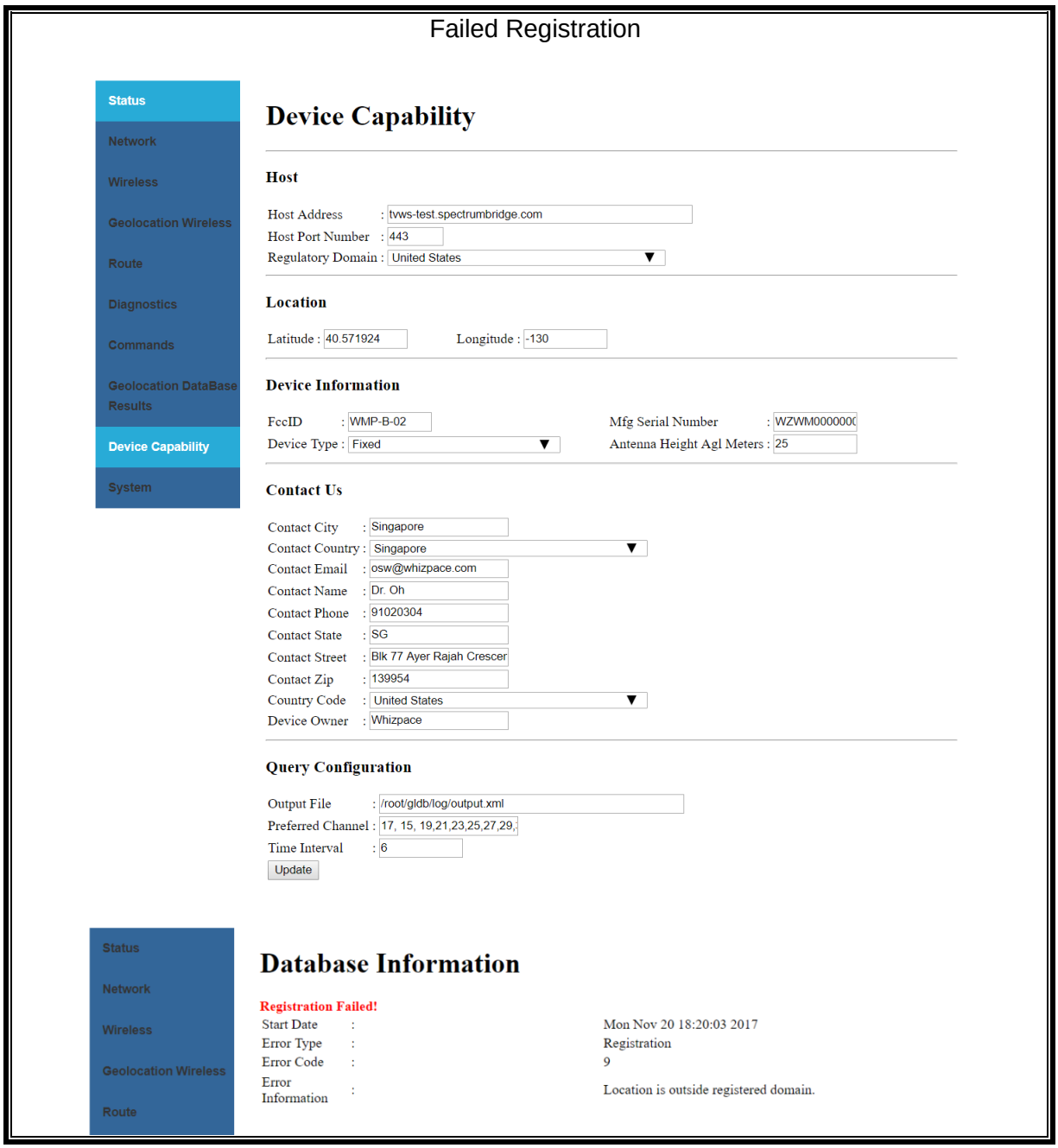
- Configure the EUT with restricted coordinates: LAT=40° 34' 18.9264" (40.571924), LNG=-130° 0' 0" (-130) which is a location that is prohibited to transmit
- Observe the base EUT registration failure indicated by the database message

RESULT

The base EUT failed to register when restricted coordinates information were submitted to the TVWS Database.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	37699 CS	11/20/17

Failed Registration



12.1.3. FAILED REGISTRATION – ANTENNA HEIGHT AGL

TEST PROCEDURE

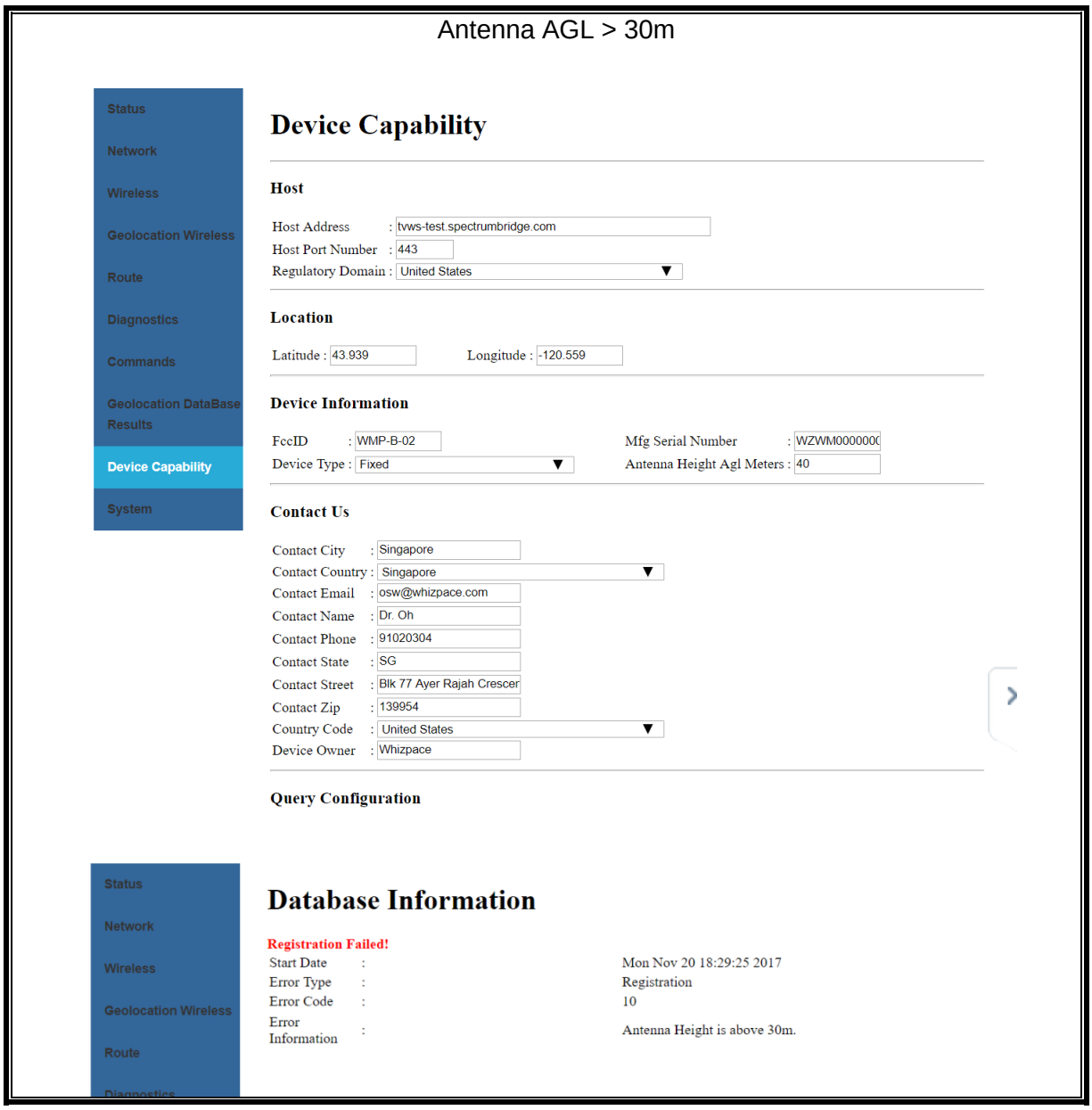
- Configure the EUT with antenna height Above Ground Level (AGL) > 30 meters.
- Observe the base registration failure indicated by the database message.

RESULTS

The base EUT failed to register when it is set to a location with antenna AGL above the limit.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	37699 CS	11/20/17

Antenna AGL > 30m



12.1.4. FAILED REGISTRATION –CONTACT INFORMATION

TEST PROCEDURE

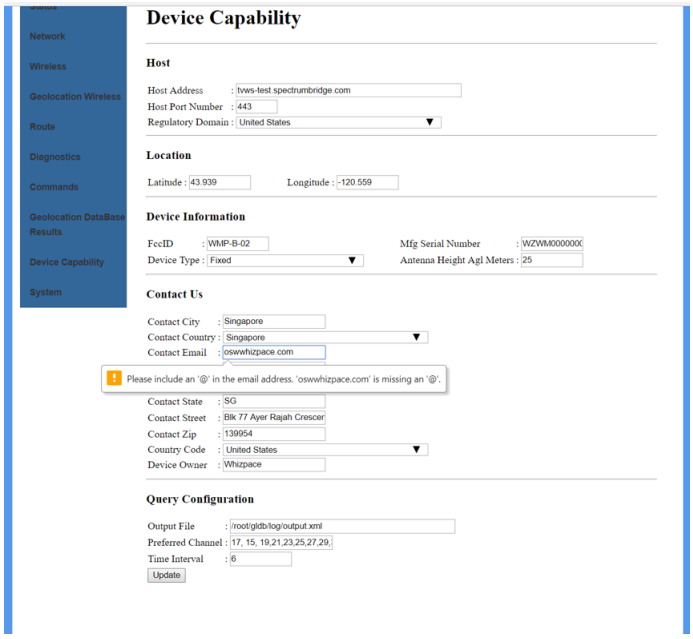
- Configure the base EUT with missing contact information, e.g. email.
- The device software cannot proceed with registration and prompts user to enter the missing information.

RESULTS

Software didn't proceed with registration when contact information fields are missing.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	37699 CS	11/20/17

Contact information missing field



12.2. FIXED WSD CHANNELS OF OPERATION

CLAUSES

- §15.711(c)(2)(ii)

REQUIREMENT

Confirm that the device only operates on channels provided by the database

TEST PROCEDURE

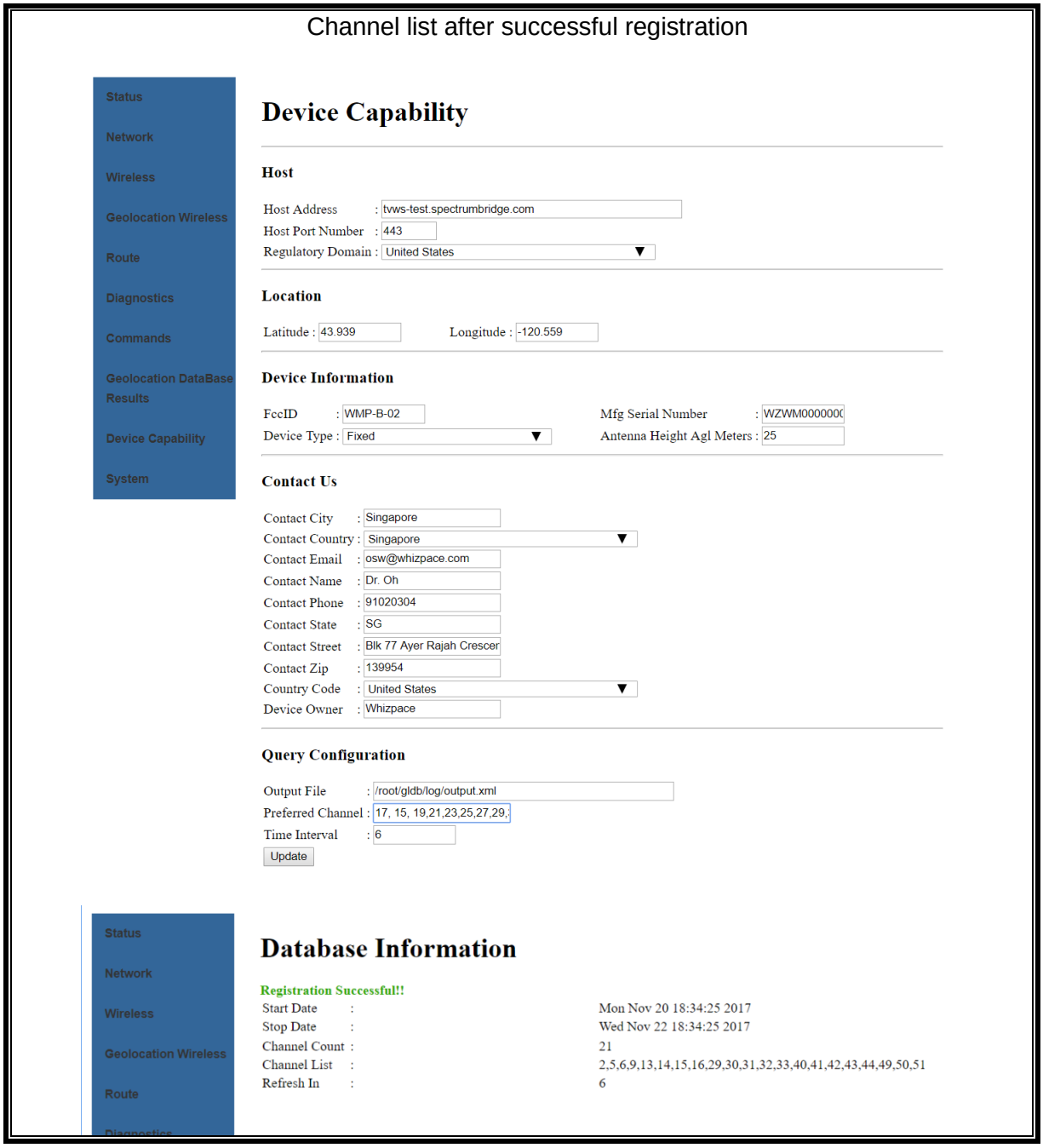
- The base EUT geographic coordinates are entered at registration time and stored in the device. The device channel list request uses the same coordinates established at registration time. No separate coordinates can be entered for channel list request.
- The device requires professional installation and device registration information including device location will be entered by the professional installer.
- Once the registration is complete, upon power cycling the device will use the stored registration location for channel list request.

RESULTS

The device only uses its registered location for channel list request. The device registered location will be established at installation time by a professional installer and cannot be altered after installation

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	37699 CS	11/20/17

Channel list after successful registration



12.3. FIXED TVDB DATABASE UPDATE

CLAUSES

- §15.711(h)

REQUIREMENT

If a fixed or Mode II personal/portable TVBD fails to successfully contact the white space database during any given day, it may continue to operate until 11:59 p.m. of the following day at which time it must cease operations until it re-establishes contact with the white space database and re-verifies its list of available channels.

To simulate that the device fails to successfully contact the database, block access to the database from the WSD by removing connection to the database. All other radio functions, including internet connectivity should be maintained. Confirm that the WSD ceases operation by 11:59PM on the following day

TEST PROCEDURE

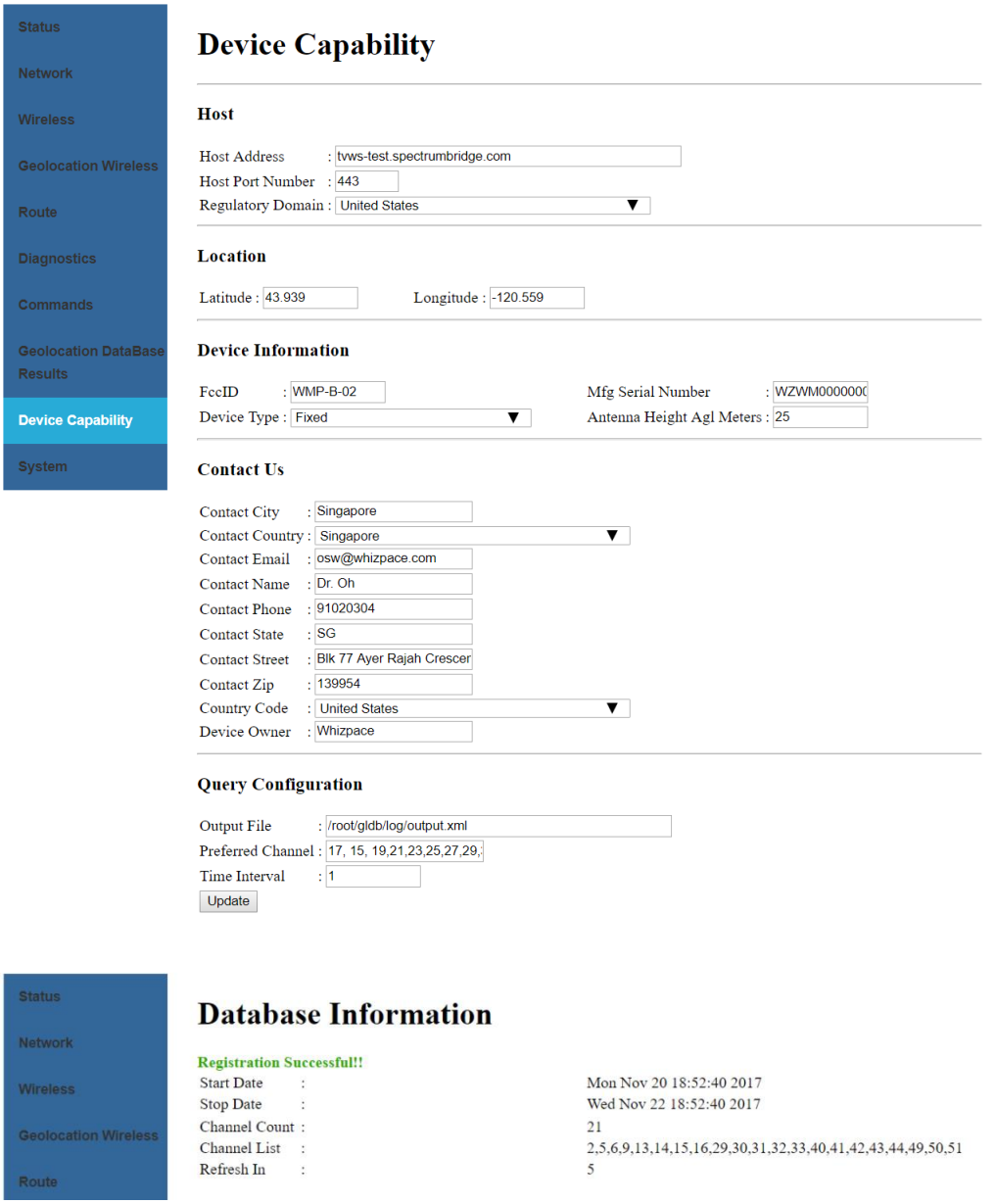
- Set the base EUT to normal operation mode:
  - Enter proper registration information on the base.
  - Base contacts the TVWS to perform registration.
  - Base contacts the TVWS to retrieve channel list.
  - Select an operating channel from returned channel list.
  - Enable base transmission.
- Observe the base EUT output signal on the spectrum analyzer.
- Use a programmable router to block the database URL.
- Observe that there is no output signal from the base after 11:59 PM on the following day.

RESULTS

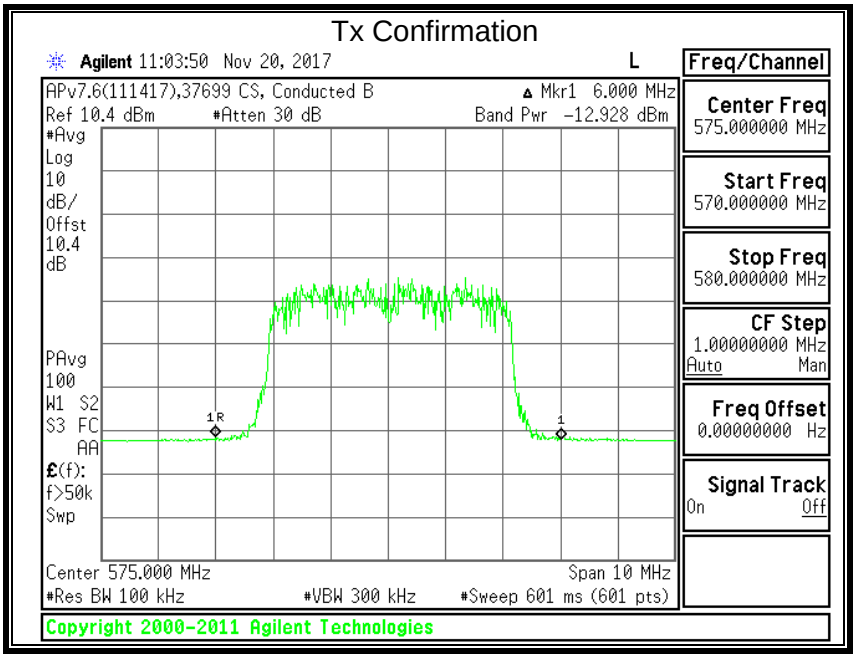
During normal operation, the base and client channel lists are updated periodically by sending channel list requests to the TVWS Database. For test purposes this time period was shortened. After the database access was blocked, the next channel list requests failed and the EUTs stopped transmission immediately.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	37699 CS	05/03/17

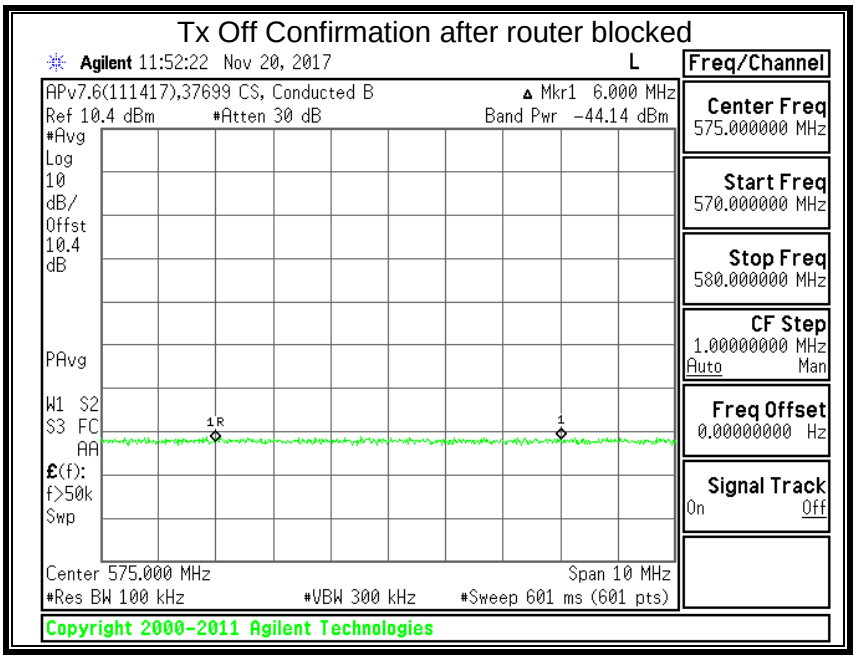
Successful registration



Tx Confirmation



Tx Off Confirmation after router blocked



12.4. 48 HOUR CHANNEL SCHEDULING

CLAUSES

- FCC §15.711(c)(2)(iii)
- FCC §15.713(a)(1)

REQUIREMENT

Each fixed whitespace device shall access the database at least once a day to verify that the operating channels continue to remain available. Each fixed white space device must adjust its use of channels in accordance with channel availability schedule information provided by its database for the 48-hour period beginning at the time the device last accessed the database for a list of available channels.

After receiving an available channel list, register a low-power auxiliary device on the WSD operating channel to operate on an available channel and in the upcoming time period when the device will be tested. Repeat the available channel request after the update interval and in the time period when the low-power auxiliary device is scheduled to operate, and confirm that the low-power device is accounted for in the schedule. Using the system management software, confirm that the device changes channels at the scheduled time.

TEST PROCEDURE

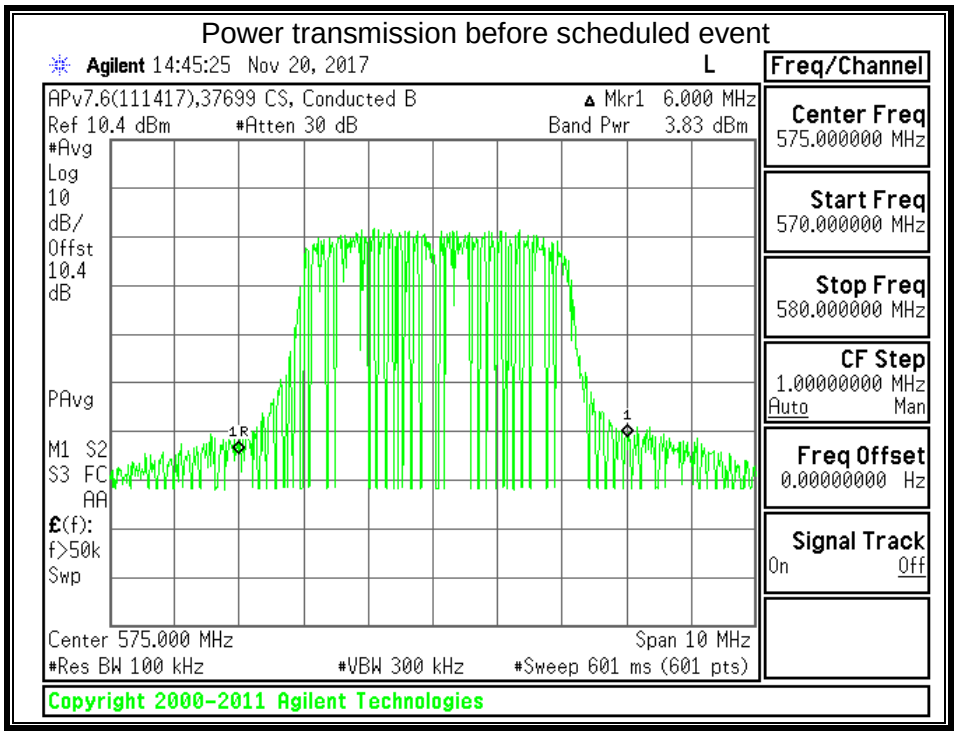
1. A lower power auxiliary devices are registered and scheduled for protection at both base and client locations
2. Allow the base and client EUT to enter normal operations prior to testing
3. Upon channel list request to the TVWS Database, the base EUT obtains the channel list expiration time reflecting the low power auxillary device's registered protection period
4. The base EUT requests new channel list upon the channel list expiration time and the base EUT's current operation channel is no longer in the returned channel list
5. The base EUT ceases transmission on the protected channel immediately
6. Steps 3-5 were repeated for client EUT

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	37699 CS	11/20/17 – 11/21/17

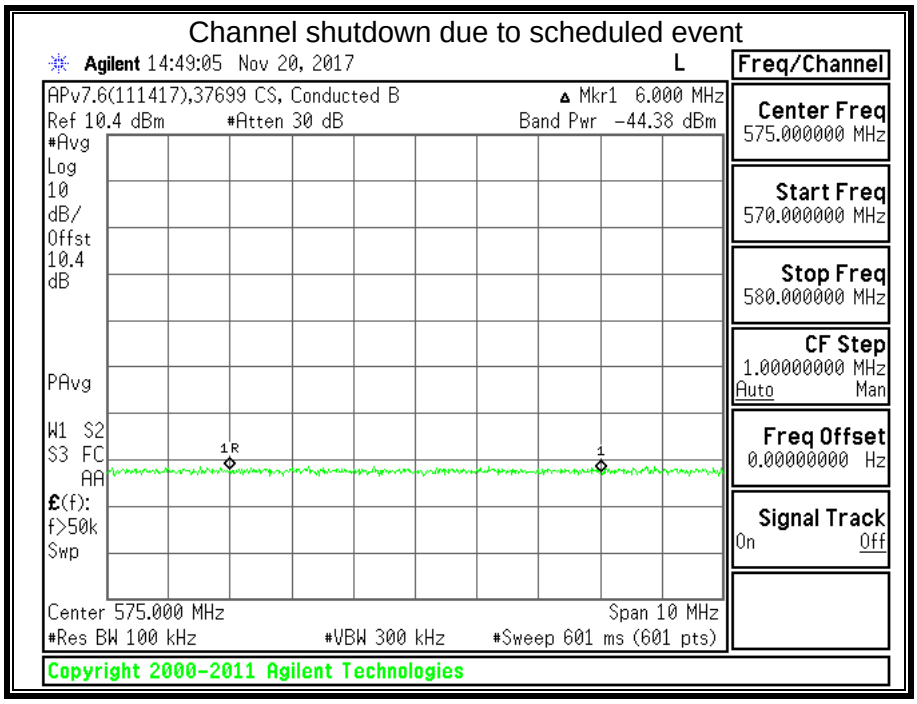
12.4.1. RESULTS FOR BASE

Successful registration

Power transmission before scheduled event

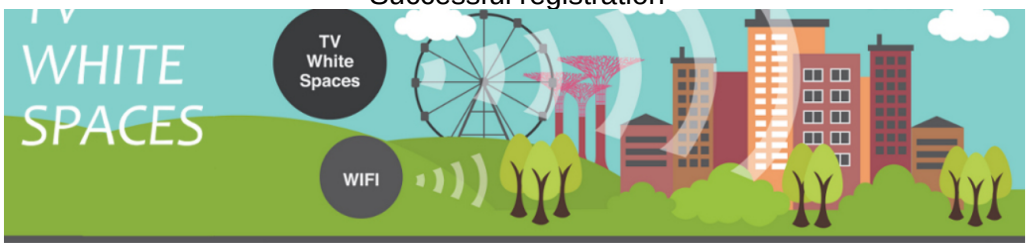


Channel shutdown due to scheduled event



12.4.2. RESULTS FOR CLIENT

Successful registration



Status
Network
Wireless
Geolocation Wireless
Route
Diagnostics
Commands
Geolocation DataBase Results
Device Capability
System

Device Capability

Host

Host Address : tvws-test.spectrumbridge.com
Host Port Number : 443
Regulatory Domain : United States

Location

Latitude : 43.939 Longitude : -120.559

Device Information

FccID : WMP-ID6-01 Mfg Serial Number : WZWM0000000
Device Type : Fixed Antenna Height Agl Meters : 25

Contact Us

Contact City : Singapore
Contact Country : Singapore
Contact Email : osw@whizpace.com
Contact Name : Dr. Oh
Contact Phone : +6591020304
Contact State : SG
Contact Street : Blk 77 Ayer Rajah Crescer
Contact Zip : 139954
Country Code : United States
Device Owner : Whizpace

Query Configuration

Output File : /root/gldb/log/output.xml
Preferred Channel : 17, 15, 19,21,23,25,27,29,
Time Interval : 1
Update

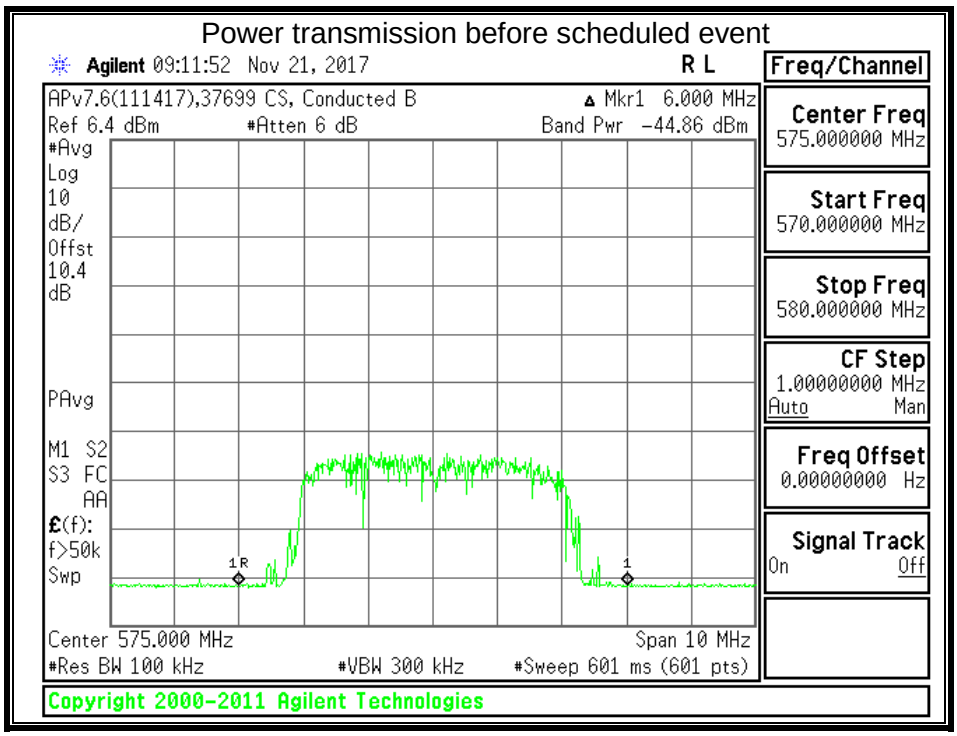
Status
Network
Wireless
Geolocation Wireless
Route

Database Information

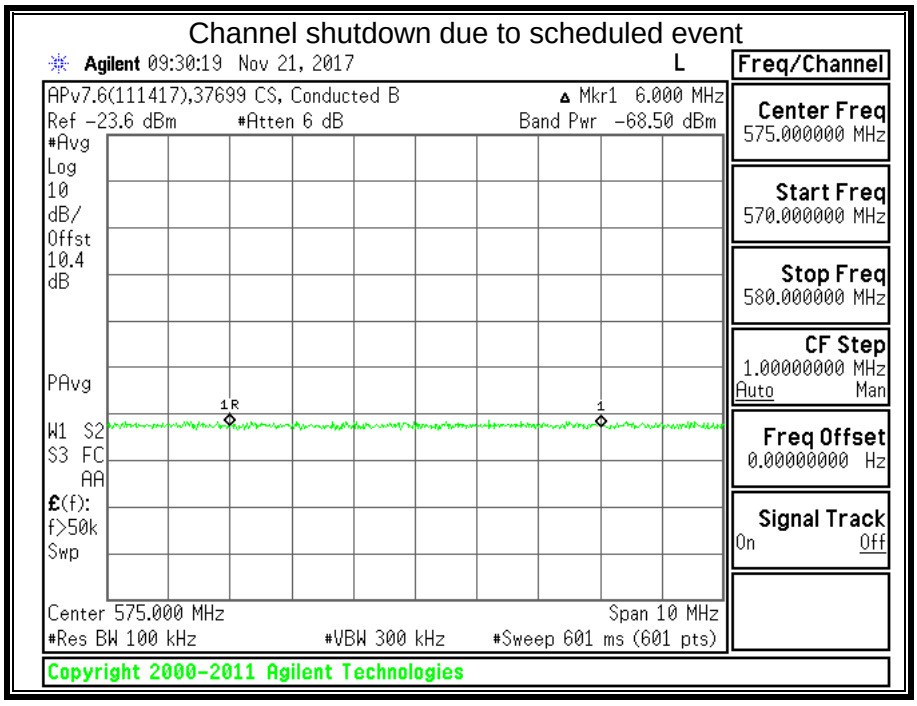
Registration Successful!!

Start Date : Tue Nov 21 17:03:20 2017
Stop Date : Thu Nov 23 17:03:20 2017
Channel Count : 21
Channel List : 2,5,6,9,13,14,15,16,29,30,31,32,33,40,41,42,43,44,49,50,51
Refresh In : 1

Power transmission before scheduled event



Channel shutdown due to scheduled event



12.5. WSD CHANNEL AVAILABILITY

CLAUSES

- FCC §15.707
- FCC §15.711(c)
- FCC §15.712

REQUIREMENT

Confirm that WSD properly identifies itself as fixed or personal/portable to the database by comparing the channel list provided by the database with those allowable to the class of WSD under test. Confirm that the WSD is operating on a channel or channels from the list at the authorized power and cannot be made to operate on an unauthorized channel.

TEST PROCEDURE

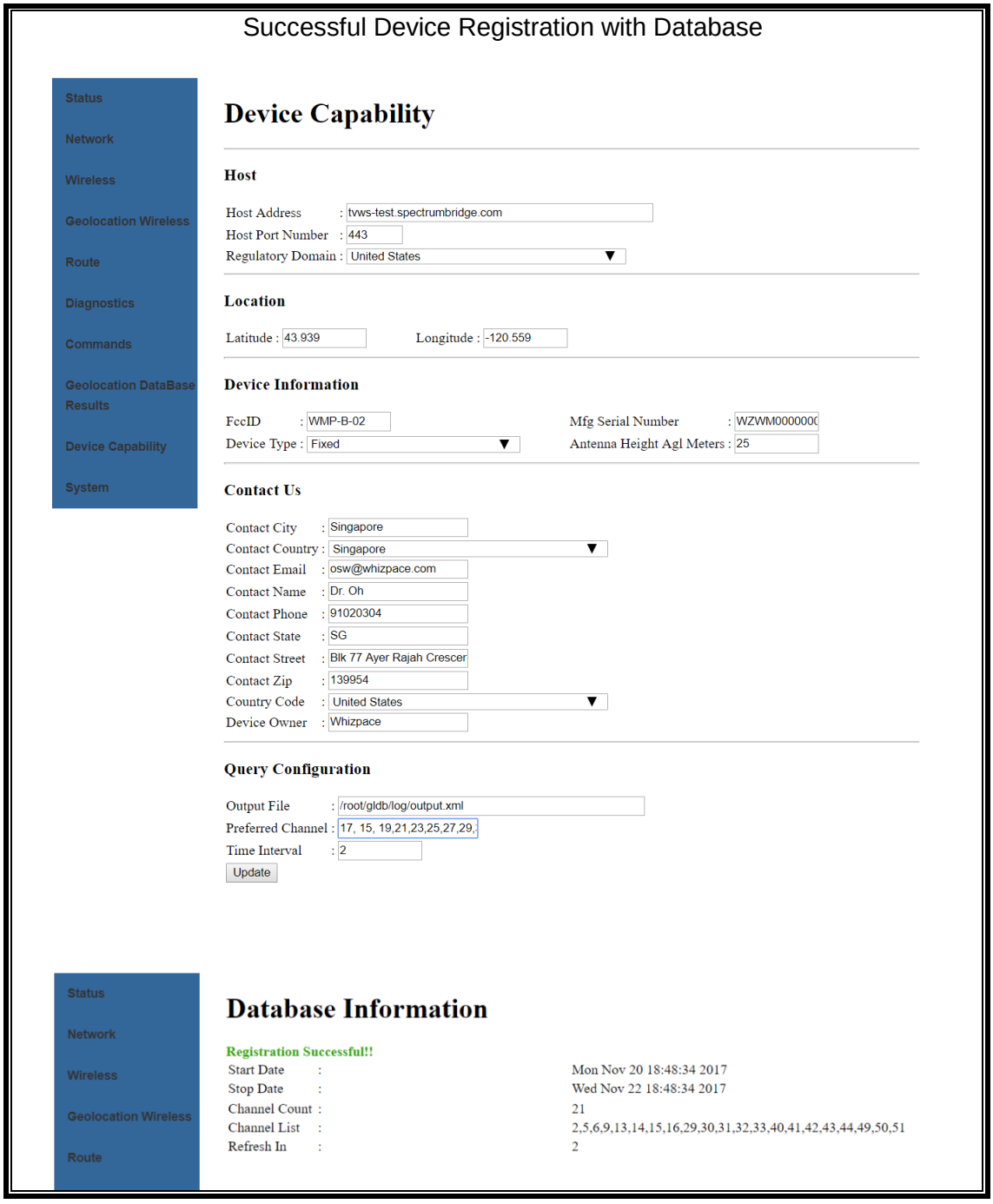
- Configure the base EUT with correct registration information.
- The base EUT automatically contacts the TVWS Database to perform device registration.
- Upon successful registration, base automatically contacts the TVWS Database to retrieve device channels.
- Confirm the base EUT software only allows the user to select a channel from the channel list returned from the database which are within the device operating frequency range
- Upon successful registration the database returns the allowable power according to the device type.
- Verify on the spectrum analyzer that the base EUT is operating on the selected channel

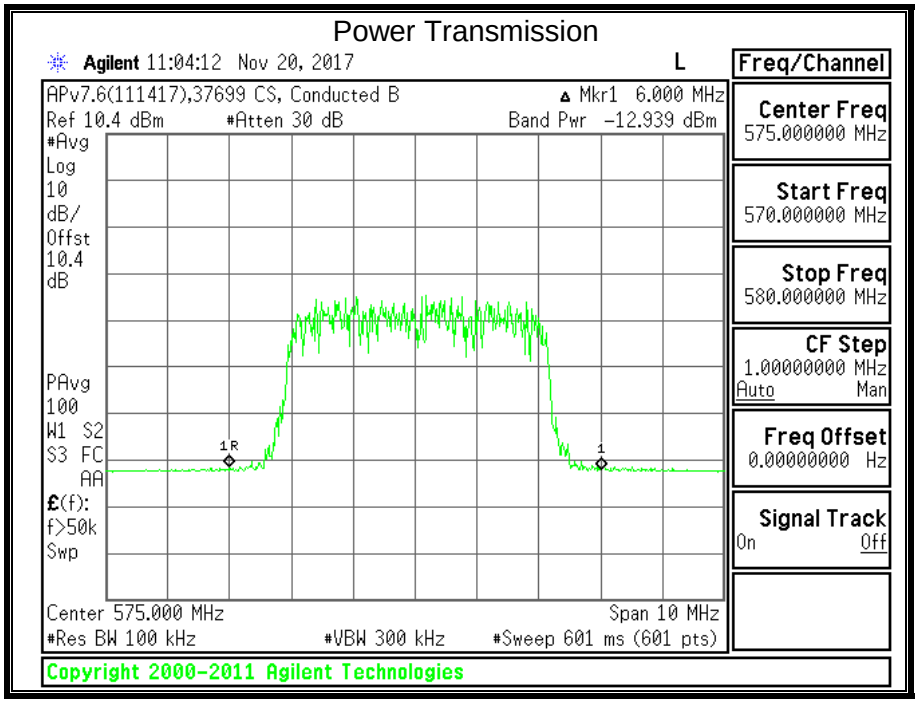
RESULTS

The EUT operates on a channel from the authorized channel list and at the authorized power level. The EUT cannot select and operate on any channel other than those within the authorized channel list returned from the TVWS Database, which are within the device operating frequency range.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	37699 CS	11/20/17

Successful Device Registration with Database





Note 575MHz corresponds to Channel 31. Seen on the allowed list of operating channels.

12.6. SECURITY

CLAUSES

- §15.715(f)
- §15.713(i)
- §15.711(j)

REQUIREMENT

The device operations procedures must include documentation with a detailed explanation of the following for each database the device is expected to work with:

i. What communication protocol is used between the database and the WSD?
ii. How are communications initiated?
iii. How does the WSD validate messages from the database?
iv. How does the device handle failure to communicate or authenticate the database?
v. How does the database validate messages from a WSD?
vi. What encryption method is used?
vii. How does the database ensure secure registration of protected devices?

ANSWERS

i. What communication protocol is used between the database and the WSD?

HTTPS is the communication protocol used between the database and the WSD.

ii. How are communications initiated?

The TV white space device will first initiate the communication by sending a registration request. The request consists of information of the location, contact and device. Once the database will validate the registration request and send a successful registration response to the device. The device will then proceed to send a channel availability request to the database, the database will reply with a corresponding channel availability response

iii. How does the WSD validate messages from the database?

The TV white space device will first check for the HTTP response code. If the 200 code is not received, the device will continue to try again. If the 200 code is received, the device will proceed to check if the response from the database in correct XML format and if it is using the format that is specified by the database. As the communication is done using HTTPS protocol, the messages will be encrypted, hence it will ensure the confidentiality and integrity of data

iv. How does the device handle failure to communicate or authenticate the database?

The device will stop its transmission immediately if it failed to communicate or authenticate with the database

v. How does the database validate messages from a WSD?

The database requires the WSD to be pre-enrolled before it will send any response to request. Hence, it will first check to see if device has been pre-enrolled. Next the database will validate the message received to see if it conforms to the specification of the request definition on whether that field is mandatory or optional field. Lastly, it will validate the message content.

vi. What encryption method is used?

TLS is used as a support layer to HTTPS, SSLV2

vii. How does the database ensure secure registration of protected devices?

The database has different administrative rights for different account holders. The TV white space device is not a protected device; therefore it has different portal from the protected devices. The registration of the protected devices can only be done by an authorized account holder with access rights to protected devices portal.

12.7. PUSH NOTIFICATION

CLAUSES

- §15.711(i)

REQUIREMENT

Confirm that the WSD device changes channels (or cease operation) when it receives 'push' notification from the database.

Using system management software, register the device at (specific coordinates) and wait for the database to send a push notification. Confirm that, once the notification is received, the device responds to the new channel availability list provided by the database, which would include ceasing operation on a channel no longer available, or ceases operation.

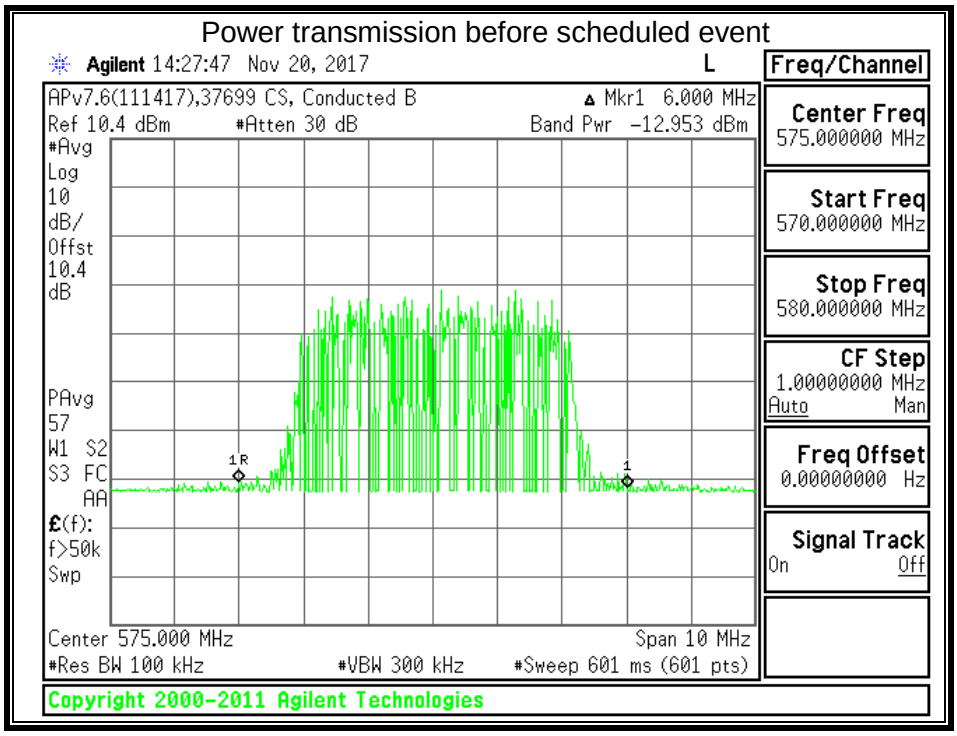
TEST PROCEDURE

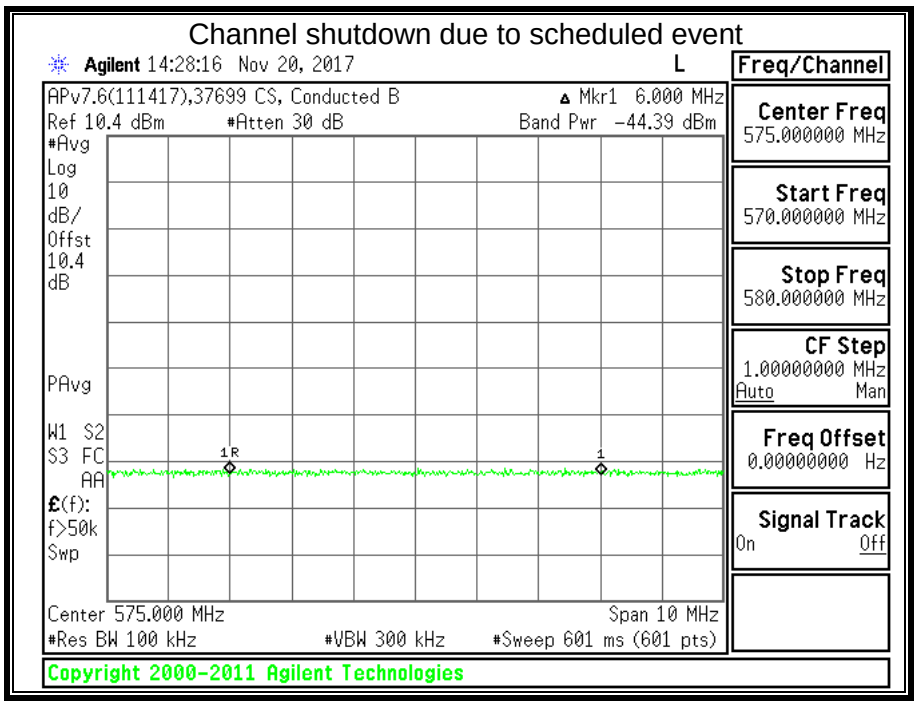
- Obtain a successful registration to the database.
- Transmit on desired channel
- Wait for database to send a push notification to cease operation on desired channel
- Confirm that once the push notification is received, a new channel availability list is provided and the desired channel ceases operation.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	37699 CS	11/20/17 – 11/21/17

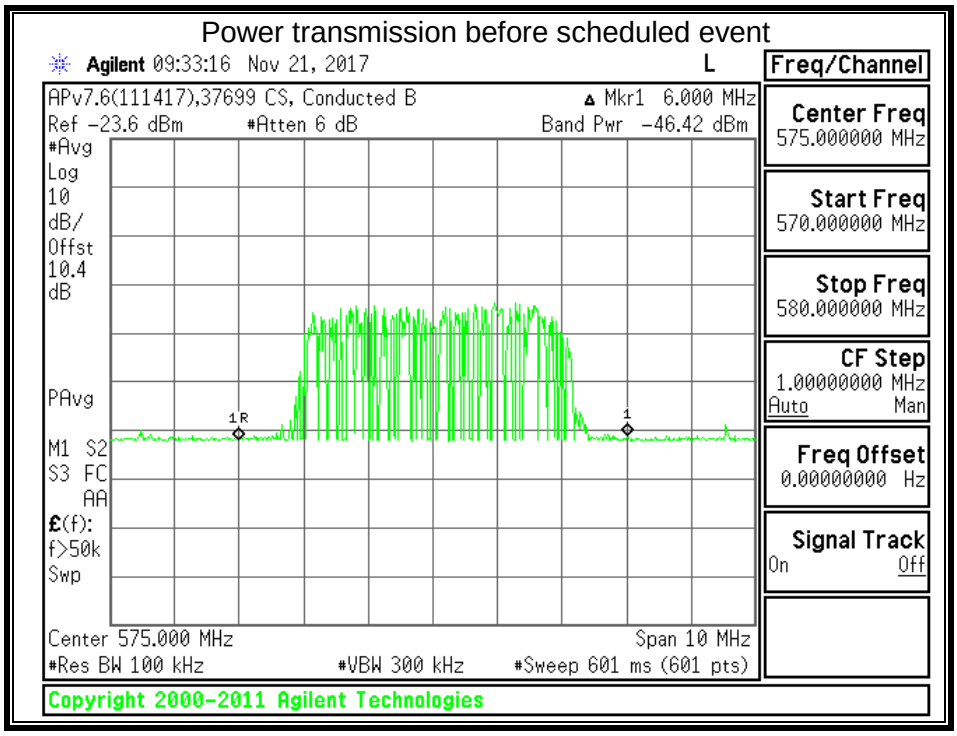
Due to the push notification and 48hr channel scheduling only differing in time scheduled. The same event from the 48hr channel scheduling test was used to cover this requirement.

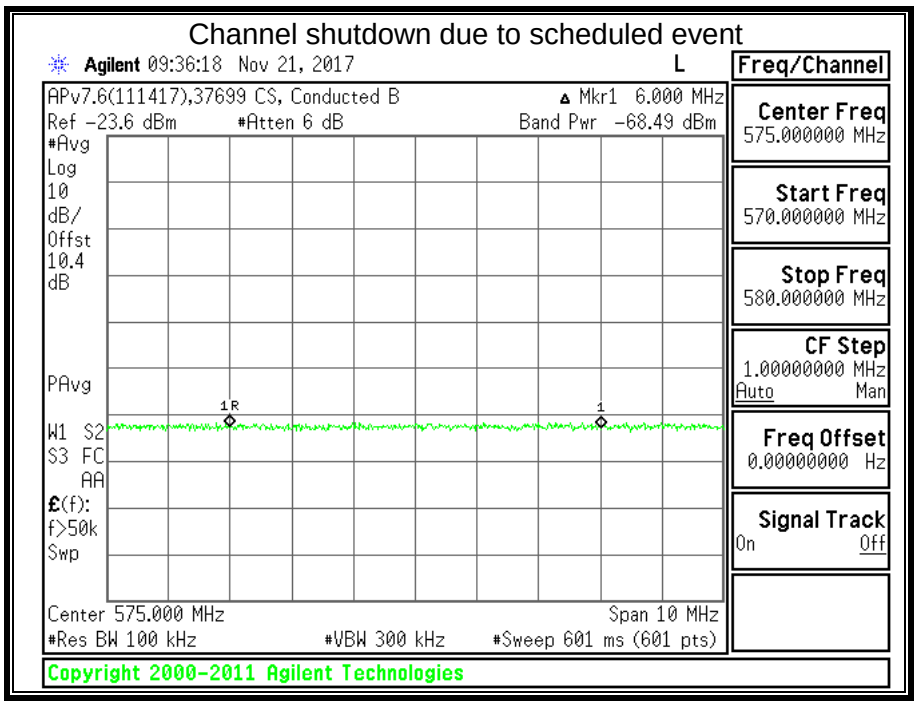
12.7.1. RESULTS FOR BASE





12.7.1. RESULTS FOR CLIENT





12.8. Location accuracy

CLAUSES

- §15.711(b)

REQUIREMENT

For Fixed and Mode II devices, provide details regarding the technologies used by the device to determine its location and how, in case of other than GPS technology, the location uncertainty is calculated with a 95% confidence level

RESULTS

See theory of operations for details on Location accuracy

12.9. Interference protection requirement

CLAUSES

- §15.712

REQUIREMENT

Using system management software or database, provide different location (coordinates) so that compliance with operating channel and power level is shown under each of the scenarios outlines in §15.712. Include a sample scan showing the total channel power and adjacent channel emission settings for test coordinates.

TEST PROCEDURE

For the scenarios listed below confirm there is no allowance of transmission on specific channels according to that particular location

Scenarios

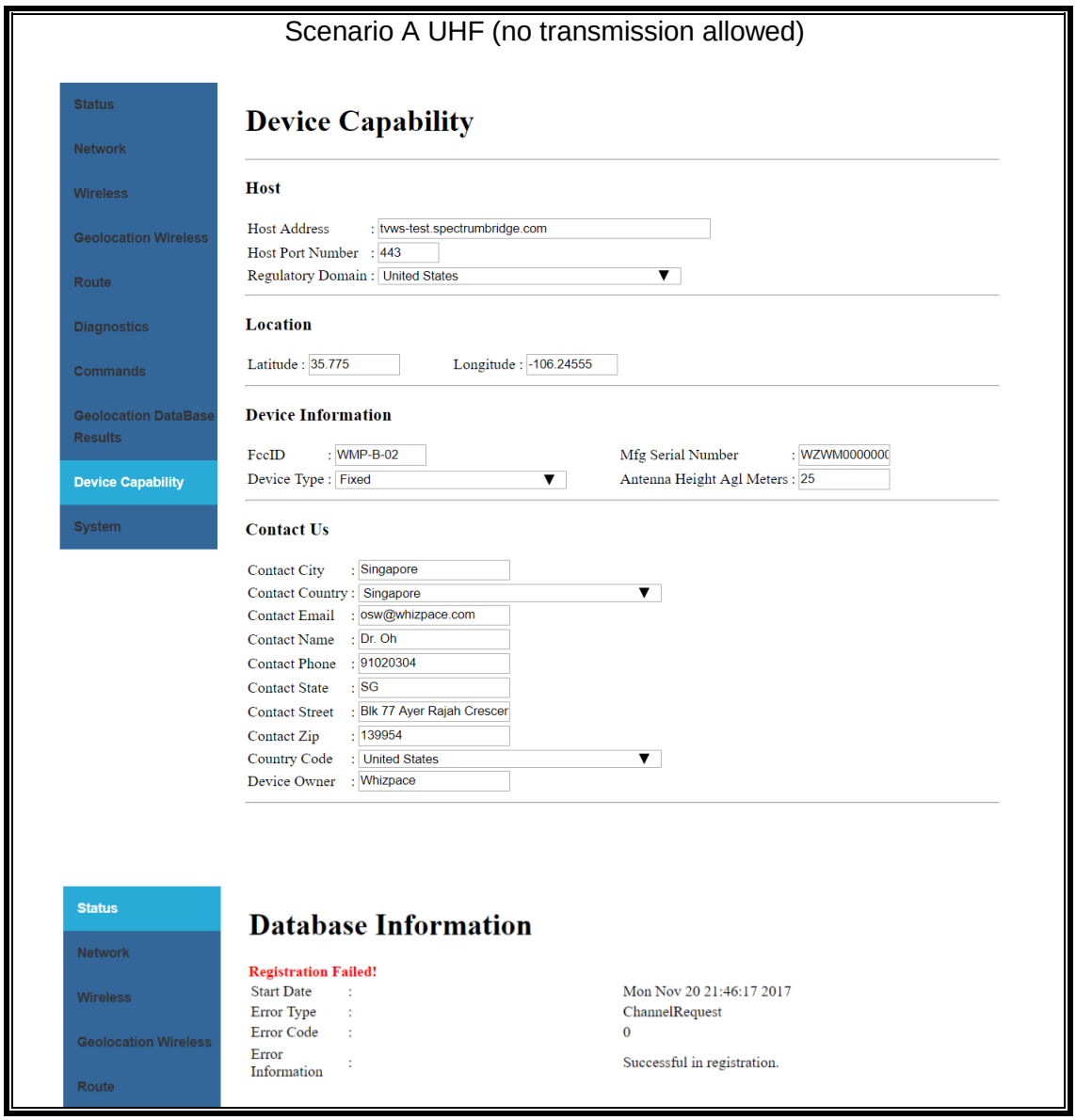
a) Digital television stations, and digital and analog Class A TV, low power TV, TV translator and TV booster stations
b) TV translator, Low power TV(including Class A) and Multi-channel Video Programming Distributor (MVPD)
c) Fixed Broadcast Auxiliary Service (BAS) links
d) PLMR/CMRS operations
e) Offshore Radiotelephone Service
f) Low power auxiliary services including wireless microphones
g) Border areas near Canada and Mexico
h) Radio astronomy services
i) 600 Mhz service band
j) Wireless Medical Telemetry Service
k) 488-494 MHz band in Hawaii

RESULTS

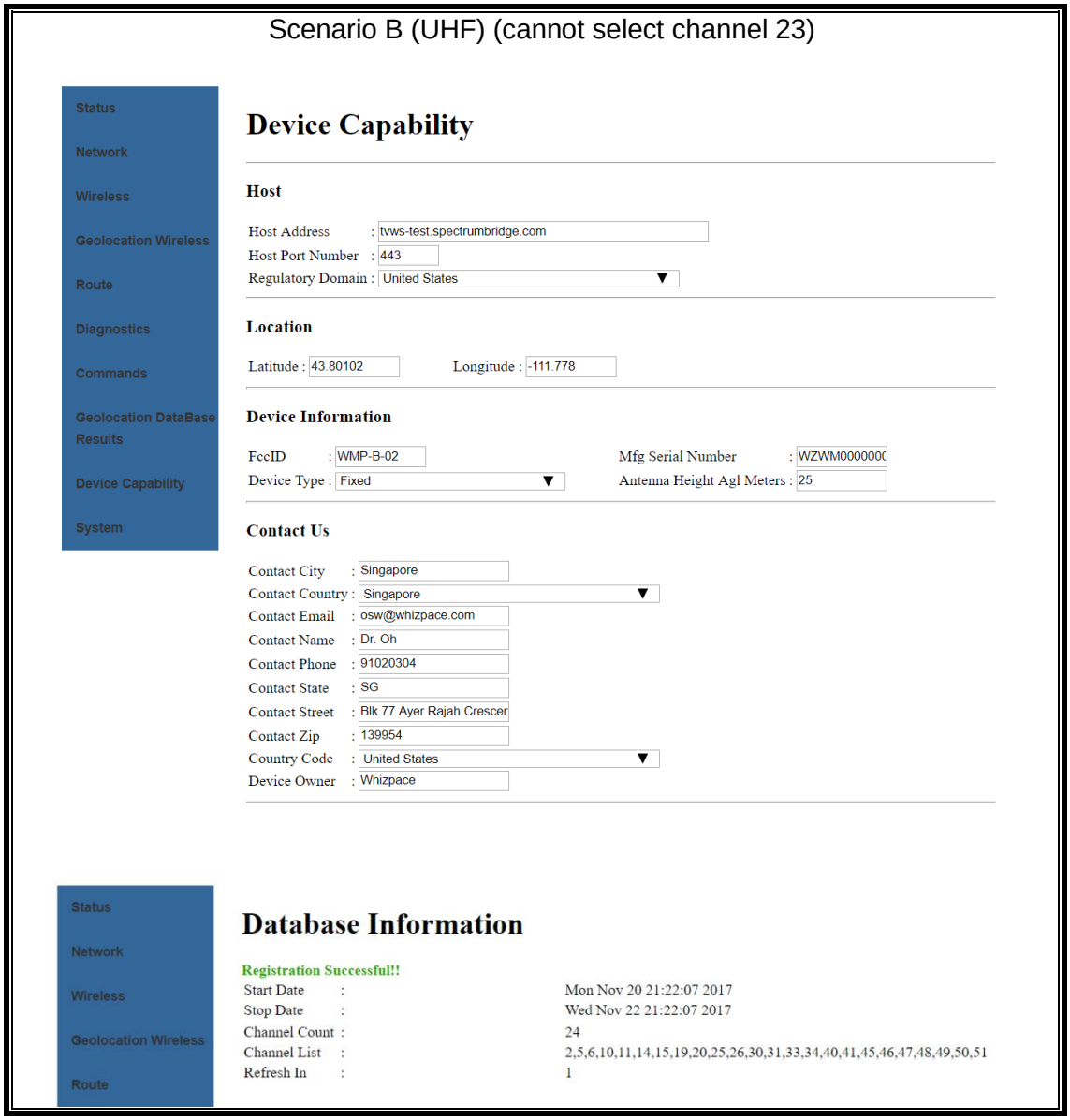
Scenario		Coordinate	Note
a	Digital television stations, and digital and analog Class A TV, low power TV, TV translator and TV booster stations	35.775, -106.24555 (UHF)	UHF No transmission allowed
b	TV translator, Low power TV(including Class A) and Multi-channel Video Programming Distributor (MVPD)	43.80102, -111.778 (UHF)	UHF coordinate cannot transmit Ch. 23
c	Fixed Broadcast Auxiliary Service (BAS) links	41.890417, -87.623694	Cannot transmit on Ch. 28
d	PLMR/CMRS operations	18.954722, -77.004722	Cannot transmit on Ch. 17 and 18
e	Offshore Radio telephone Service	18.954722, -77.004722	Cannot transmit on Ch. 17 and 18
f	Low power auxiliary services including wireless microphones	N/A	48 hour channel scheduling requirement was based off this scenario
g	Border areas near Canada and Mexico	32.608179, -116.969585	Cannot transmit on Ch. 6 and 32
h	Radio astronomy services	35.775, -106.24555	No channels available
i	600 MHz service band	40.78698, -119.206486	Cannot transmit on Ch. 36, 37 and 38
j	Wireless Medical Telemetry Service	N/A	EUT does not support transmission in this frequency band
k	488-494 MHz band in Hawaii	20.88, -156.678611	Cannot transmit on Ch. 17

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	37699 CS	11/20/17

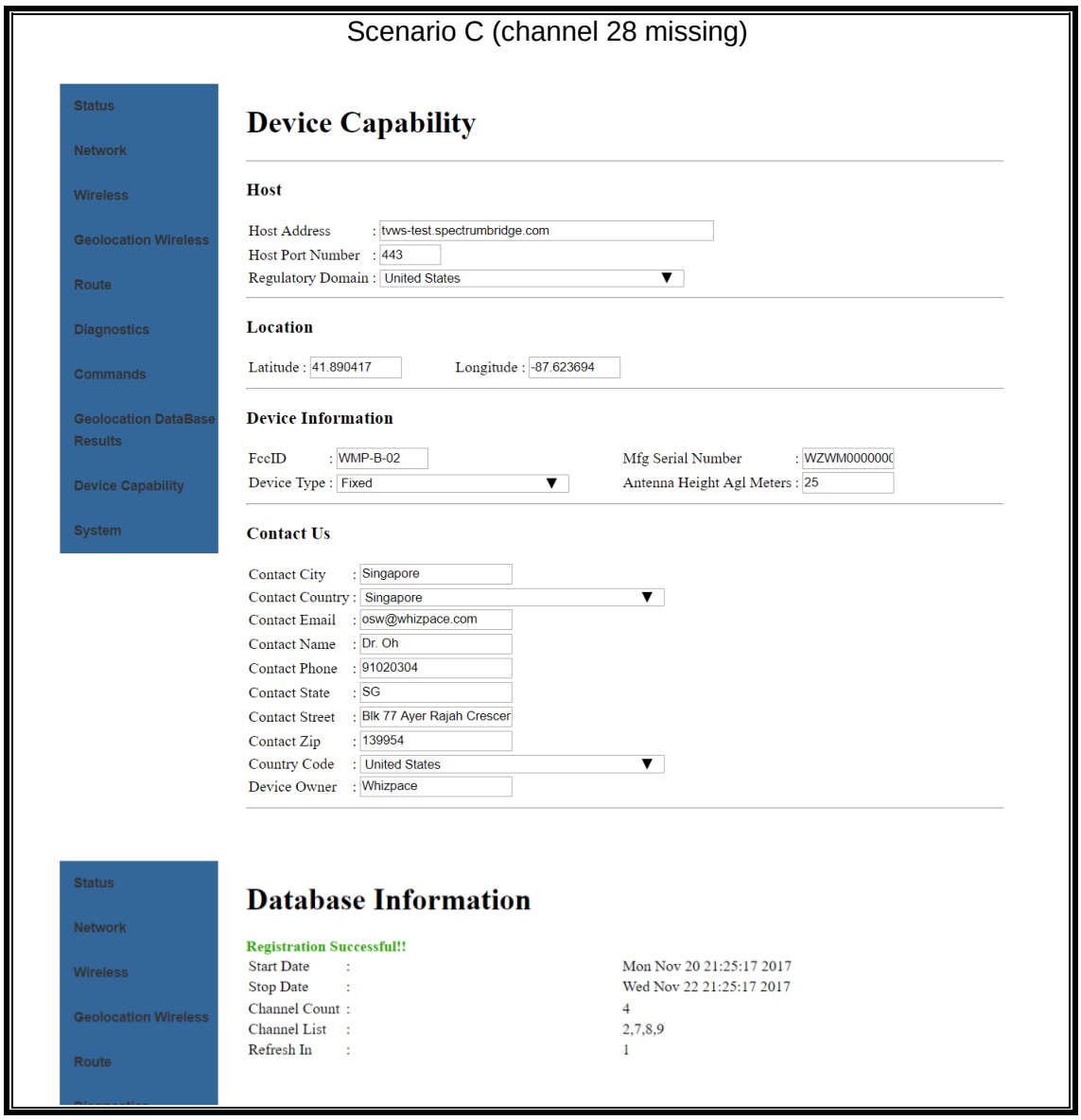
Scenario A UHF (no transmission allowed)



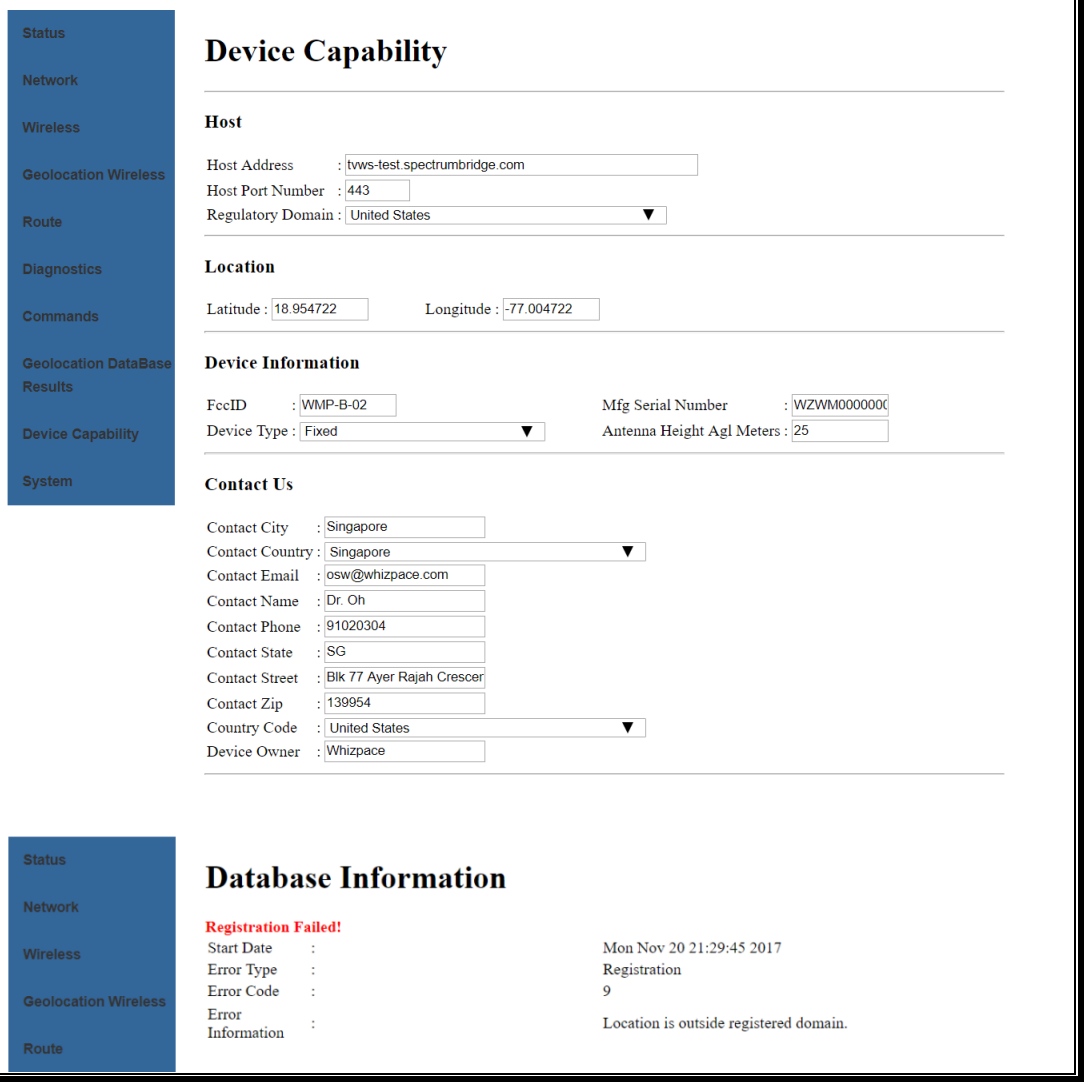
Scenario B (UHF) (cannot select channel 23)



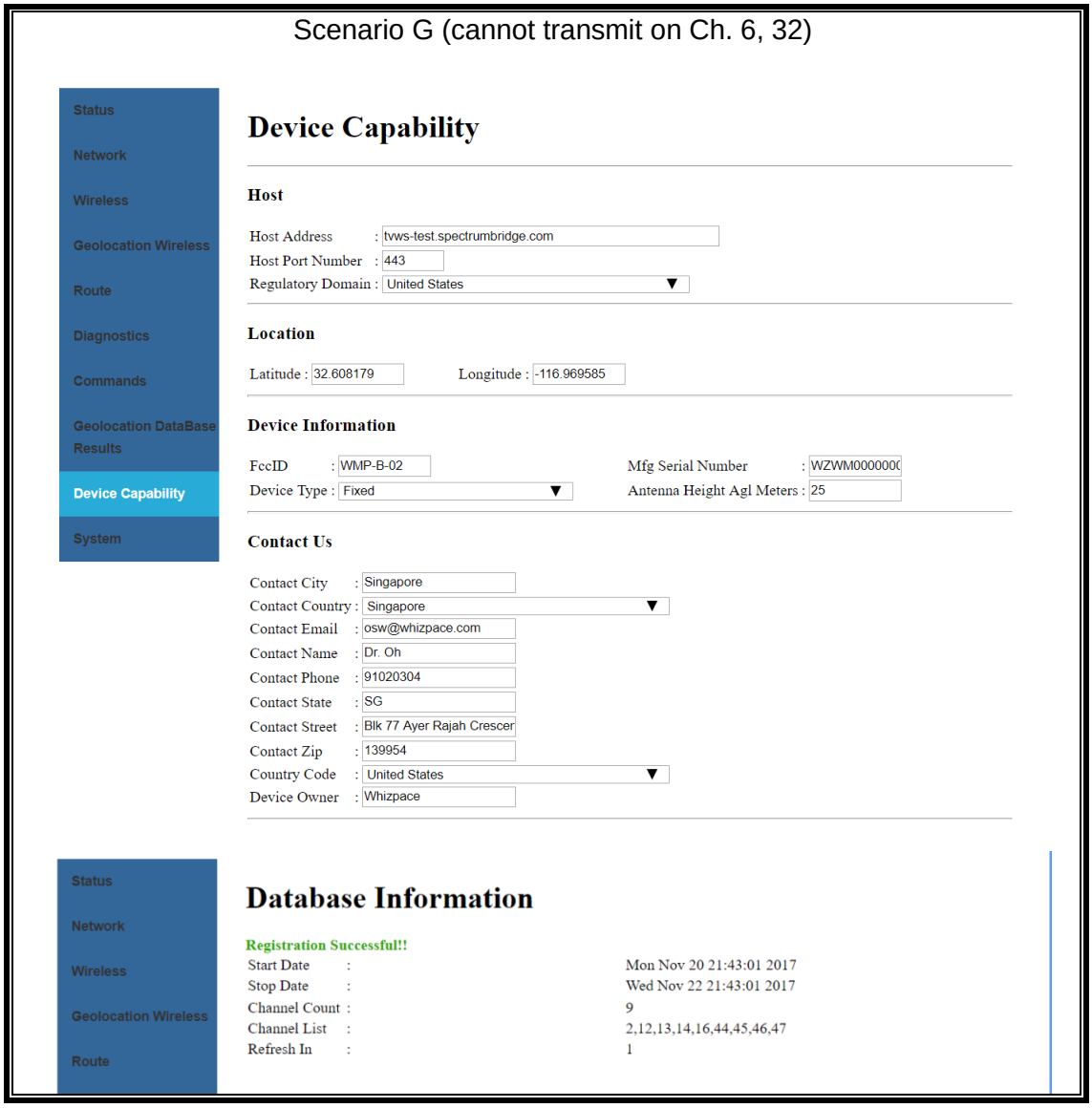
Scenario C (channel 28 missing)



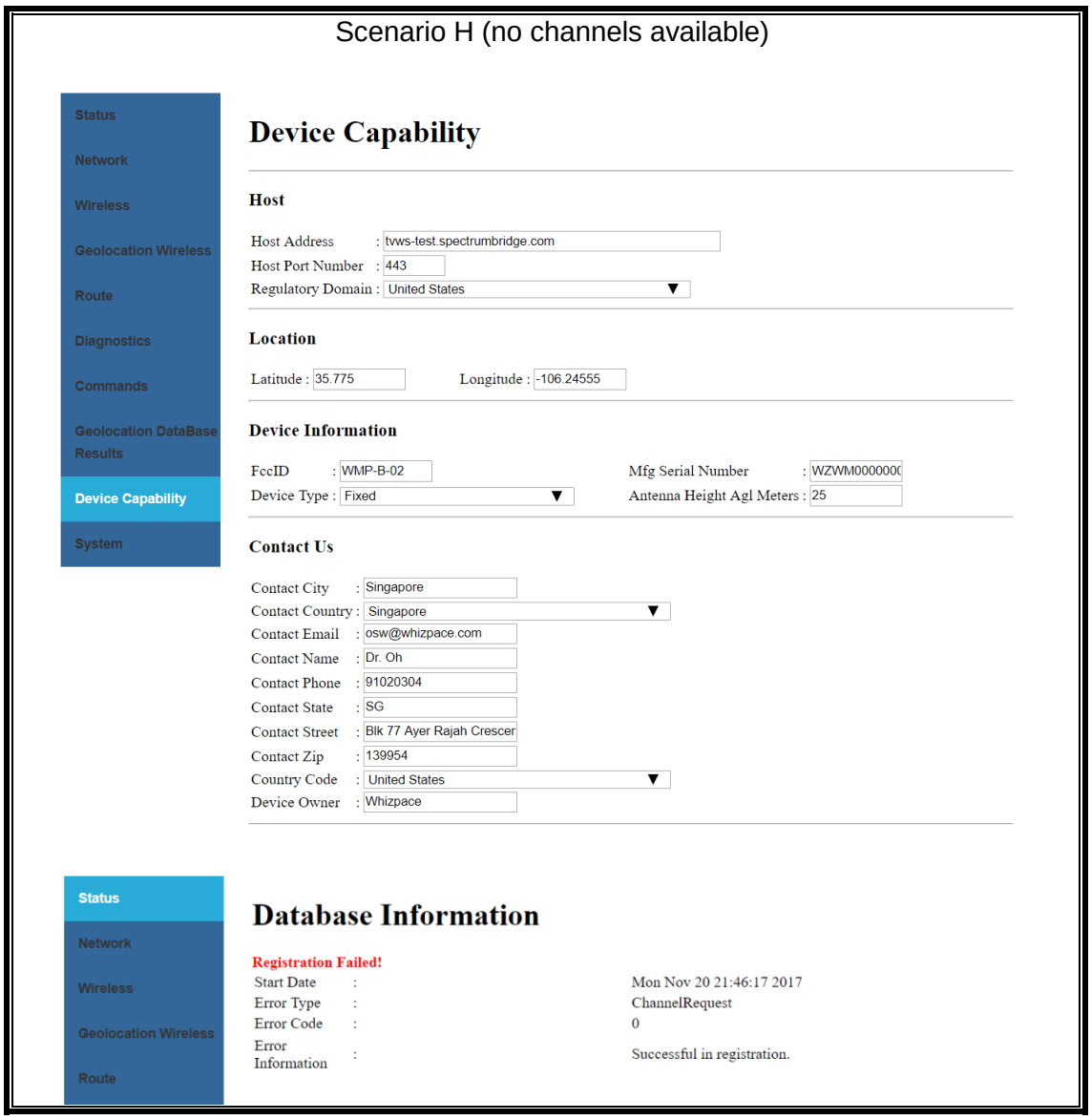
Scenario D/E (cannot transmit on Ch. 17 and Ch. 18)



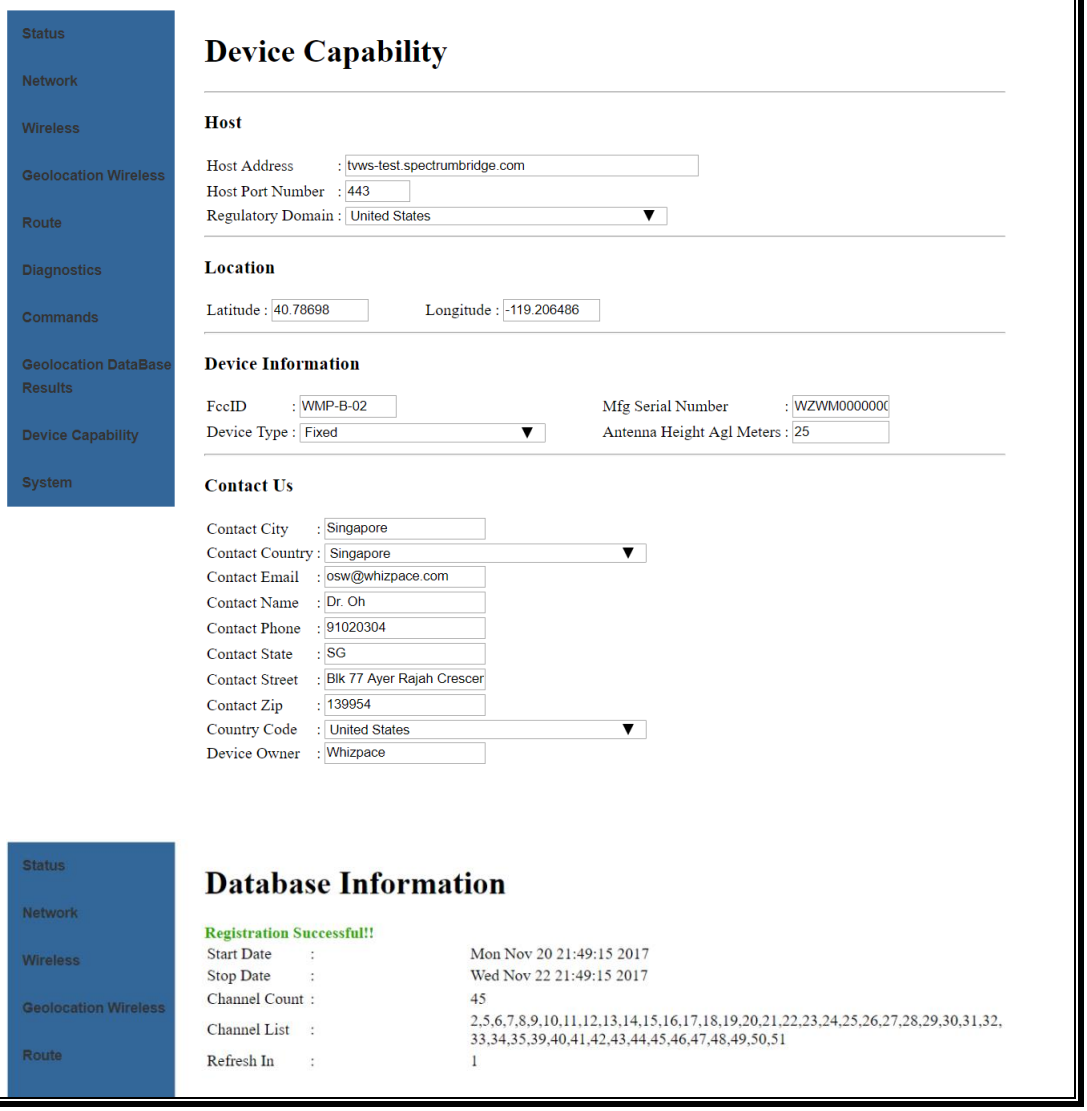
Scenario G (cannot transmit on Ch. 6, 32)



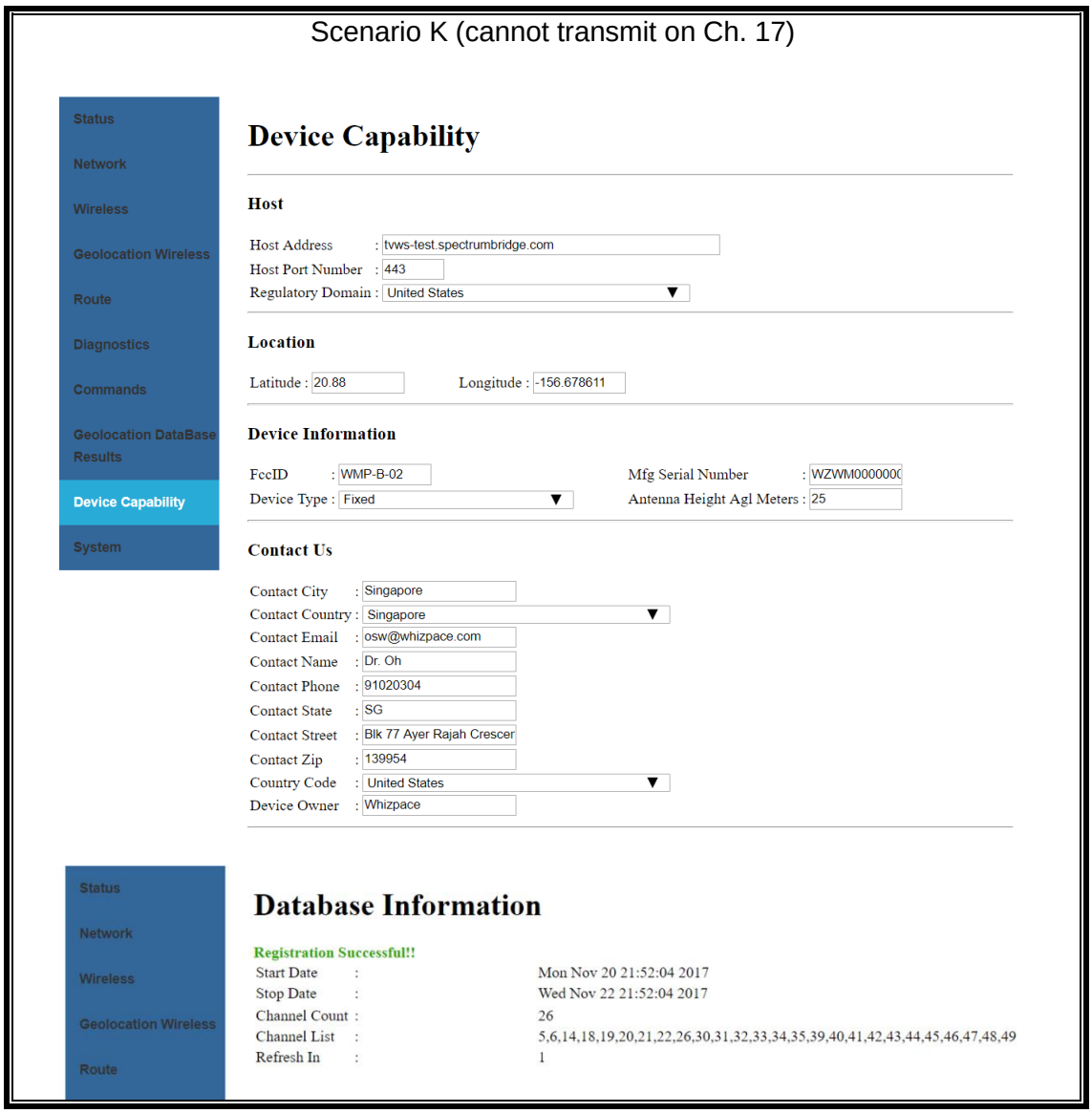
Scenario H (no channels available)



Scenario I (cannot transmit 36, 37, 38)



Scenario K (cannot transmit on Ch. 17)



12.10. Fixed Power level reduction

CLAUSES

- §15.711(c)(2)(ii)
- §15.715(e)

REQUIREMENT

Using system management software, make a channel availability request to the database. Using the spectrum analyzer, confirm that the WSD operates at no more than the maximum power level indicated by the database and that the power level cannot be set to a higher level than indicated by the database at that specific location. If the device cannot reduce power, it must cease operation.

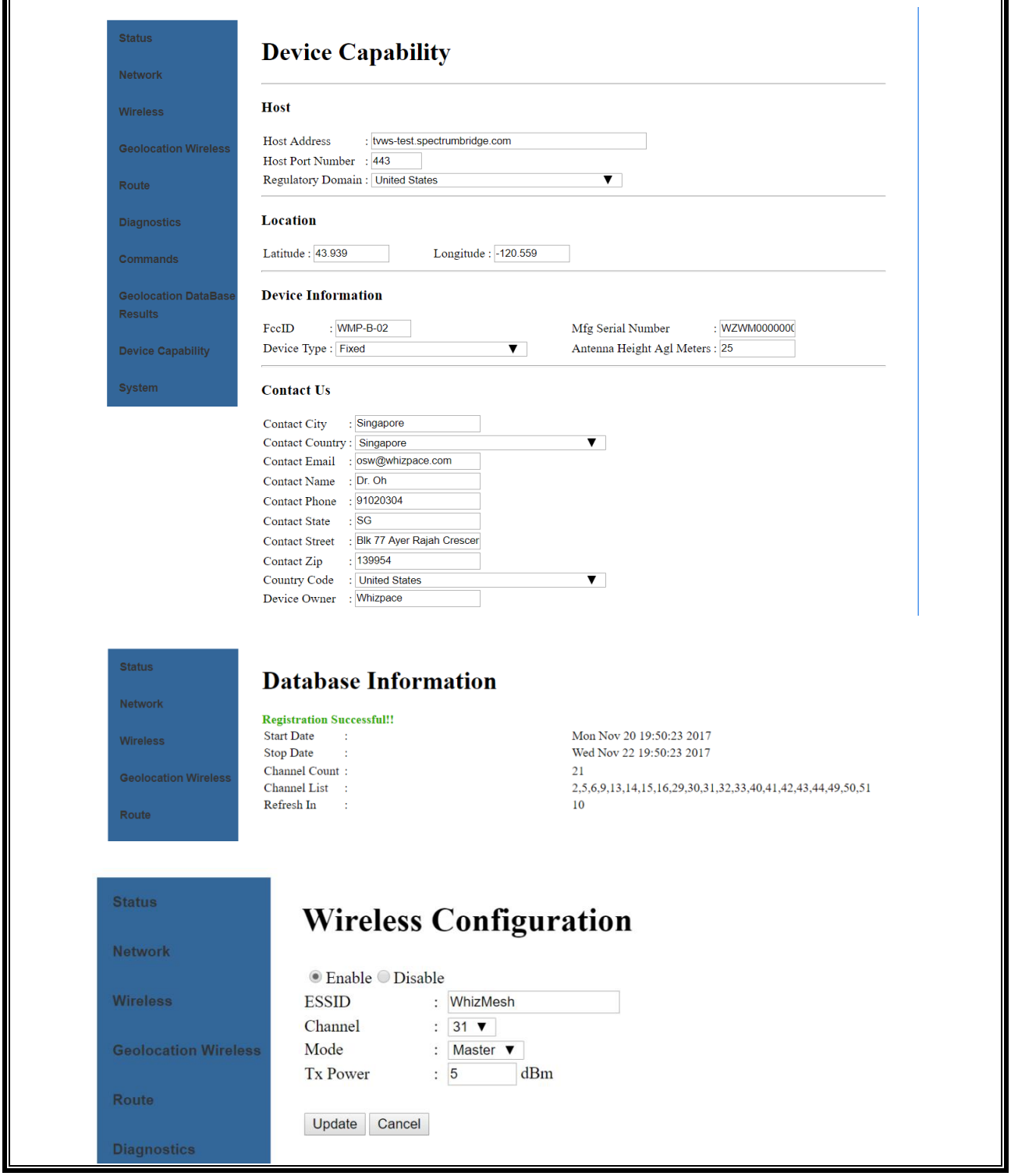
TEST PROCEDURE

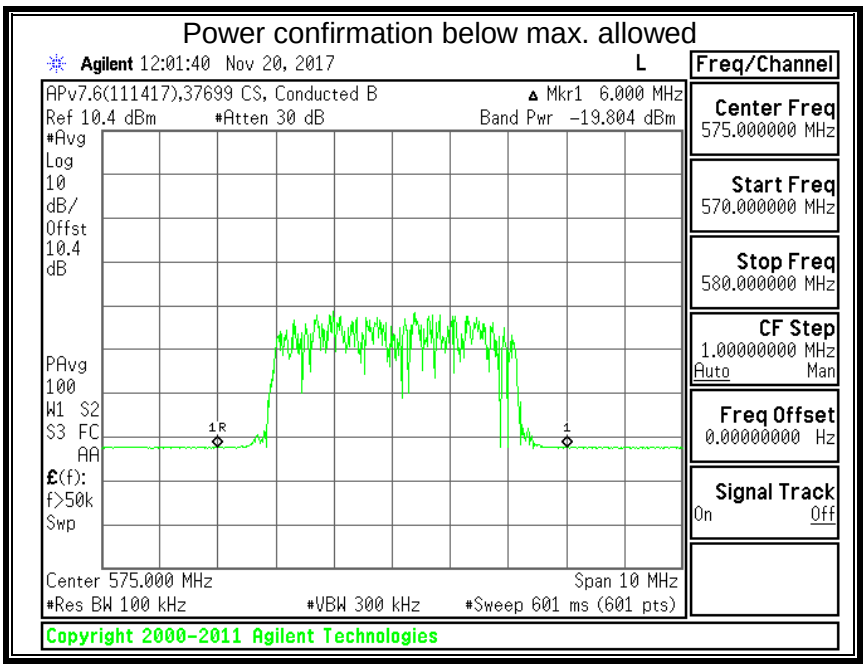
- Create a successful registration with the database
- Transmit at desired channel
- Confirm with spectrum analyzer that the EUT does not operate more than the max power level indicated by the database.
- Confirm power level cannot be set higher than the level indicated by the database

RESULTS

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	37699 CS	11/20/17

Successful registration, Channel availability and maximum allowed Power level





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