TEST REPORT

Report Number : 12749689-E2V3

Applicant	:	Huwomobility, Inc. 920 Hillview Court #260 Milpitas, CA 95035 United States
Model	:	HL3210
FCC ID	:	2ATD7-HL3210F
EUT Description	:	Fixed TVWS Device
Test Standard(s)	:	FCC 47 CFR PART 15 SUBPART H

Date of Issue:
Friday, January 10, 2020

Prepared by:
UL Verification Services Inc.
47173 Benicia Street
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NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	12/27/2019	Initial release	---
V2	01/07/2020	Section 6.2 updated per TCB comment	F. de Anda
V3	01/10/2020	Section 10 updated per TCB comment	F. de Anda

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: Huwomobility, Inc.
920 Hillview Court #260
Milpitas, CA 95035 United States

EUT DESCRIPTION: TVWS Device

MODEL: HL3210

SERIAL NUMBER: 0300220000011005, 0300220000011007 and 0300011000022074

DATE TESTED: September 18, 2019 – December 20, 2019

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. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

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.

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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, ANSI C63.4-2009.

4. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, and 47658 Kato Road, 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	47658 Kato Rd
☒ Chamber A	☐ Chamber D	☒ Chamber I
☐ Chamber B	☐ Chamber E	☐ Chamber J
☐ Chamber C	☐ Chamber F	☐ Chamber K
	☐ Chamber G	☐ Chamber L
	☐ Chamber H	☐ Chamber M

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

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

RADIATED EMISSIONS
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

MAINS CONDUCTED EMISSIONS
Where relevant, the following sample calculation is provided:
Final Voltage (dBuV) = Measured Voltage (dBuV) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss.
36.5 dBuV + 0 dB +10.1 dB+ 0 dB = 46.6 dBuV

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	2.52 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	4.88 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.24 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.37 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.17 dB

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

6. EQUIPMENT UNDER TEST

6.1. DESCRIPTION OF EUT

The EUT is a fixed TVWS device. Both base and CPE units use the same hardware and SW.

6.2. MAXIMUM OUTPUT POWER

The transmitter has a maximum power as follows;

		Conducted		EIRP	
BAND	Frequency Range (MHz)	Output Power (dBm)	Output Power (mW)	Output Power (dBm)	Output Power (mW)
UHF	470 -608, 618-698	25.18	329.61	38.18	6576.58

6.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio can be configured with the following antenna types, and highest gain for each type:

Type	Band	Gain
Bowtie Antenna	UHF	13 dBi

6.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT for RF tests was V100R002C01B01_1386 Date: Jul 26, 2019

The firmware installed in the EUT for DB tests was V100R002C01B03_1430 Date: Dec 17, 2019

6.5. WORST-CASE CONFIGURATION AND MODE

For below 30MHz 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.

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

All final radiated testing was performed with the EUT in the X (Flatbed) orientation.

6.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List			
Description	Manufacturer	Model	Serial Number
Laptop	Lenovo	T61P	L3-D4858
AC Adapter	Lenovo	42T4430	11S42T4430Z1ZGWE17FAFJ
EUT (second unit)	HuWo Mobility	PROTO#2	300011000022074
POE(second unit)	Ubiquiti Networks	GP-C500-120G	1744-0004095
Router	HP	J9793A	CN20FQ6DNV

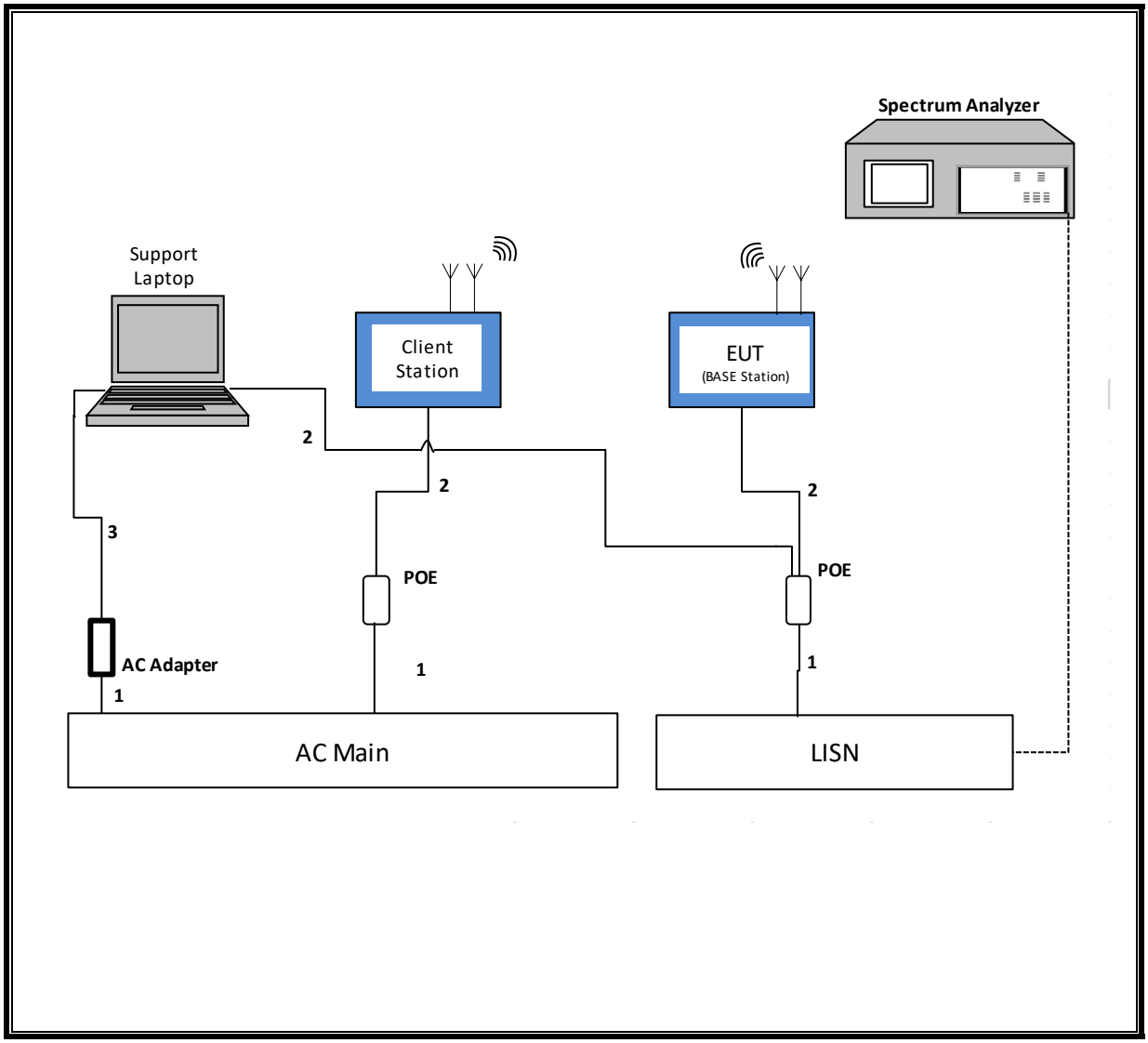
I/O CABLES

I/O CABLE LIST						
Cable No.	Port	No. of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC	1	AC	Un-shield	0.2	to AC/DC adaptor
2	Ethernet	3	RJ45	Un-shield	1.2	POE to Laptop and EUT
3	DC	1	DC	Un-shield	0.8	AC/DC adaptor to Laptop
4	DC	1	DC	Un-shield	0.8	AC/DC adaptor to Router
5	SMA	2	Coaxial	Un-shield	2.5	EUT to Antenna
6	Ethernet	1	RJ45	Un-shield	6	Laptop to EUT

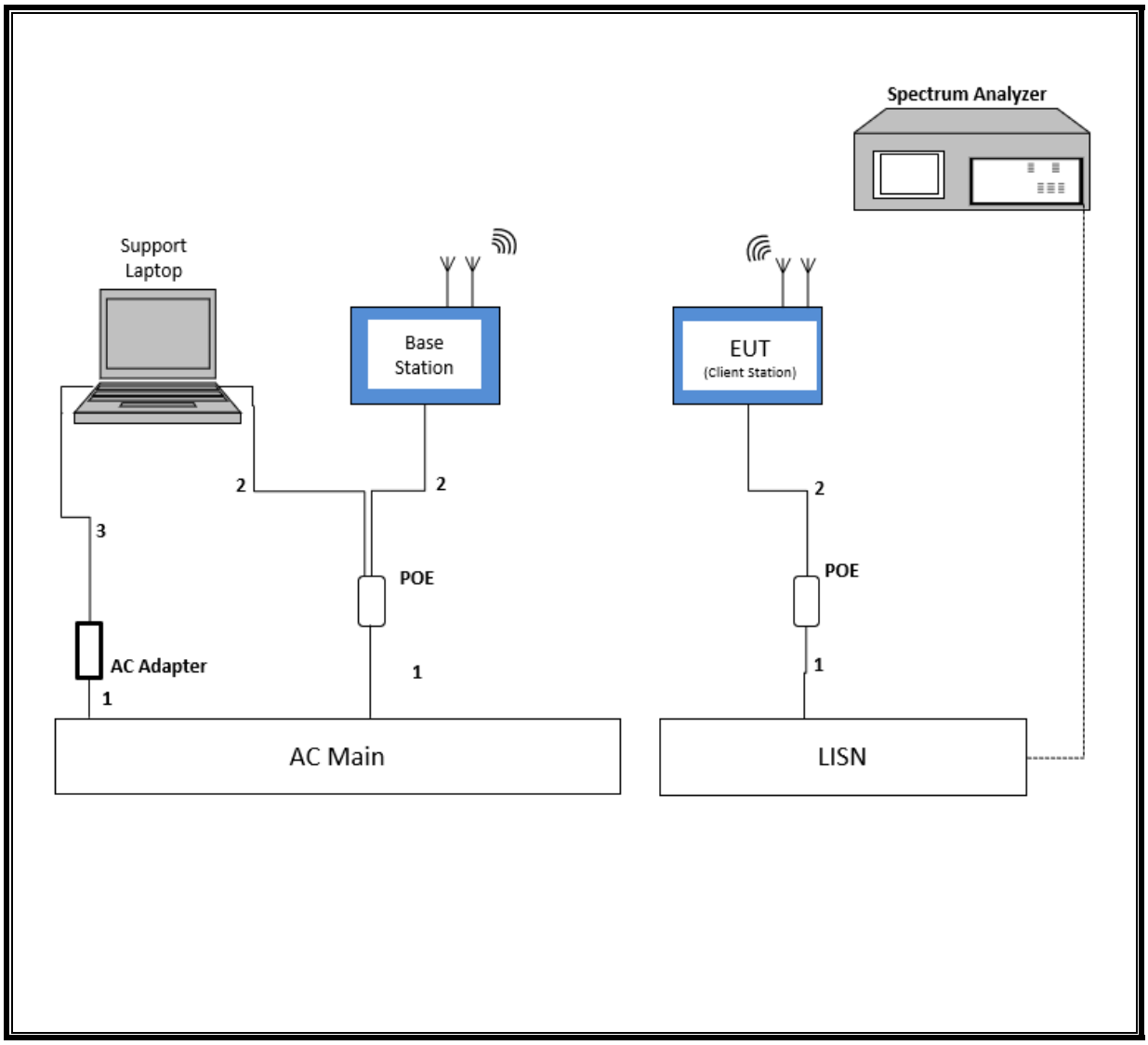
TEST SETUP

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

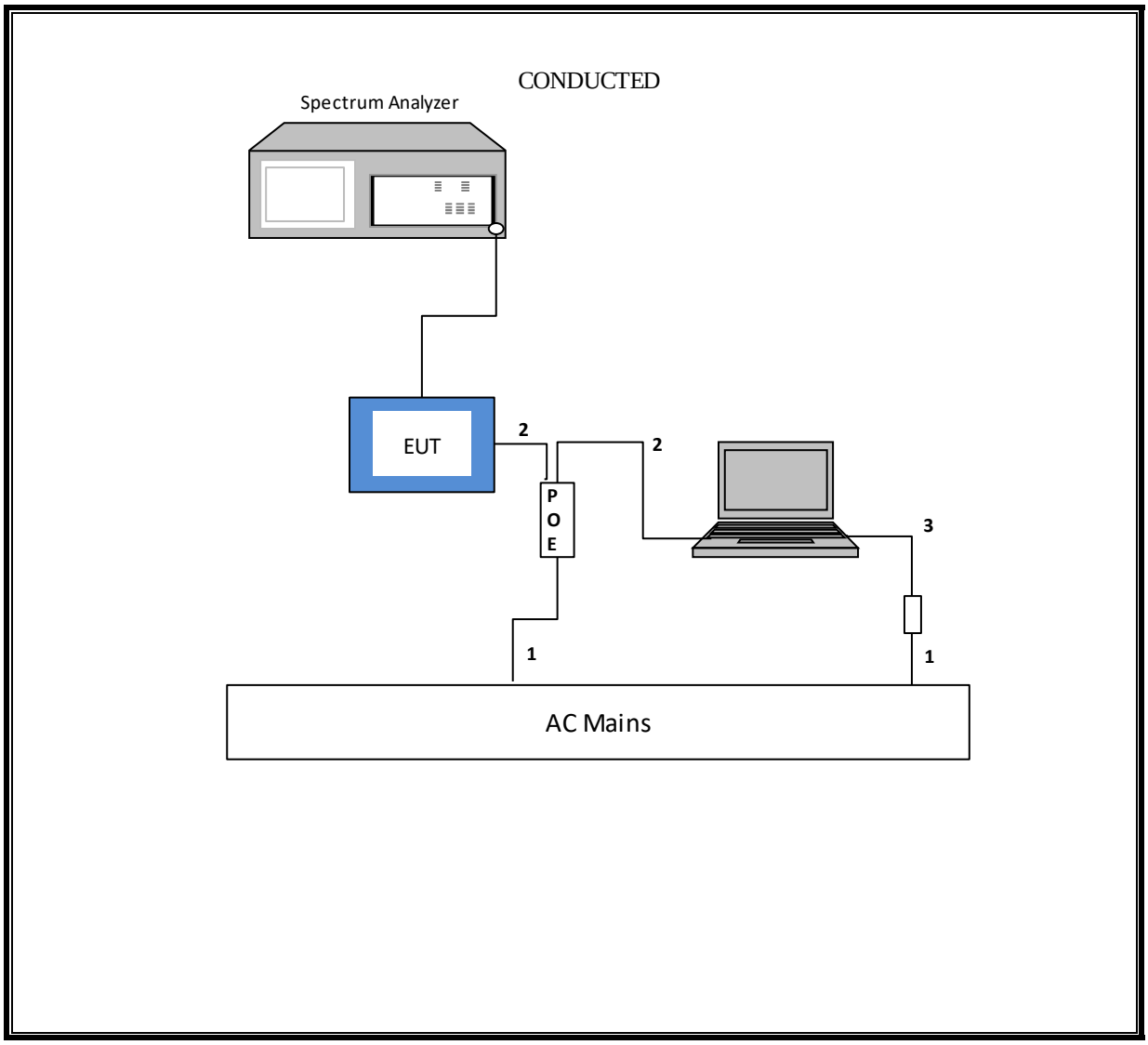
SETUP DIAGRAM AC LINE CONDUCTED TESTS - BASE



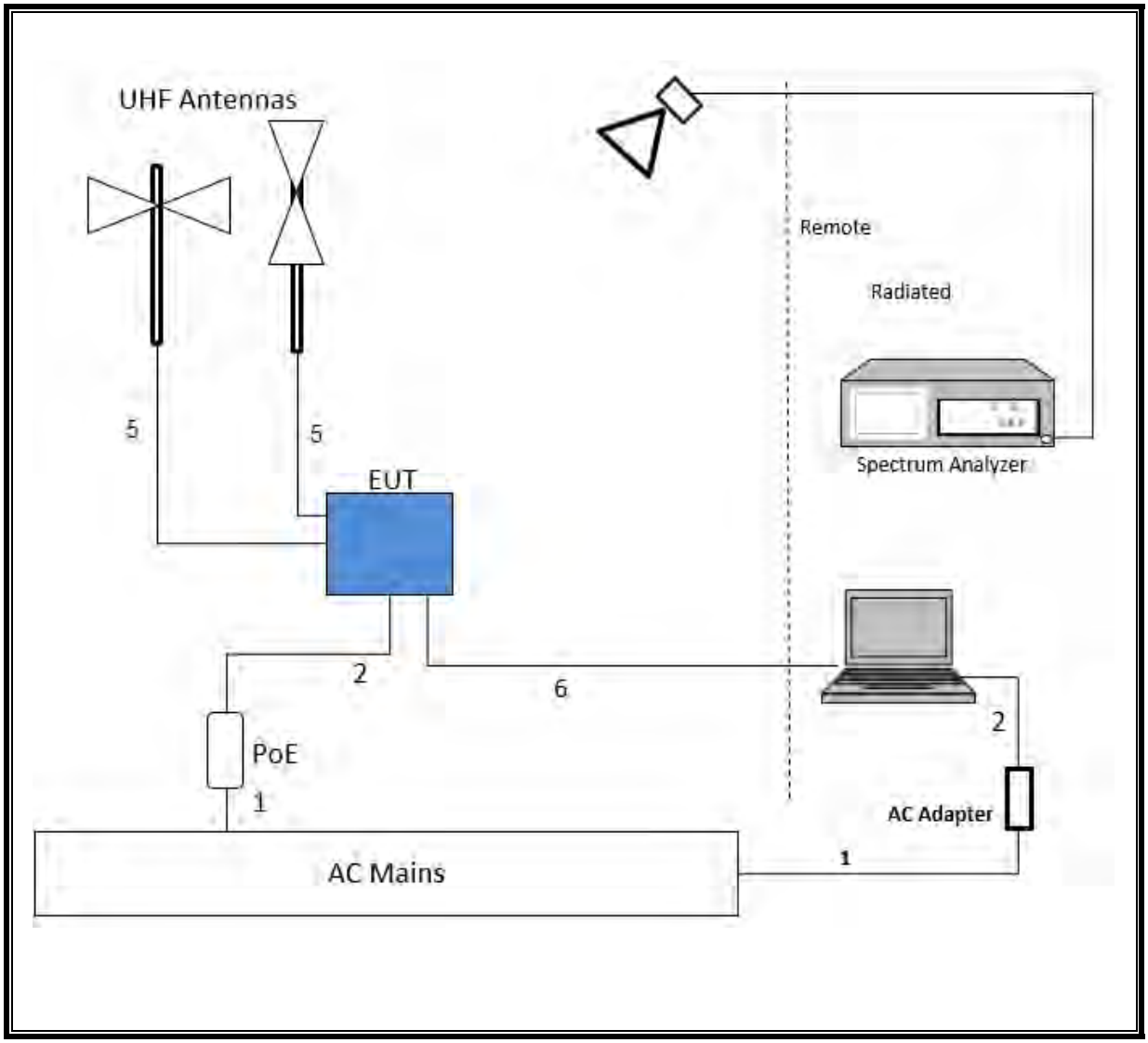
SETUP DIAGRAM AC LINE CONDUCTED TESTS - CLIENT



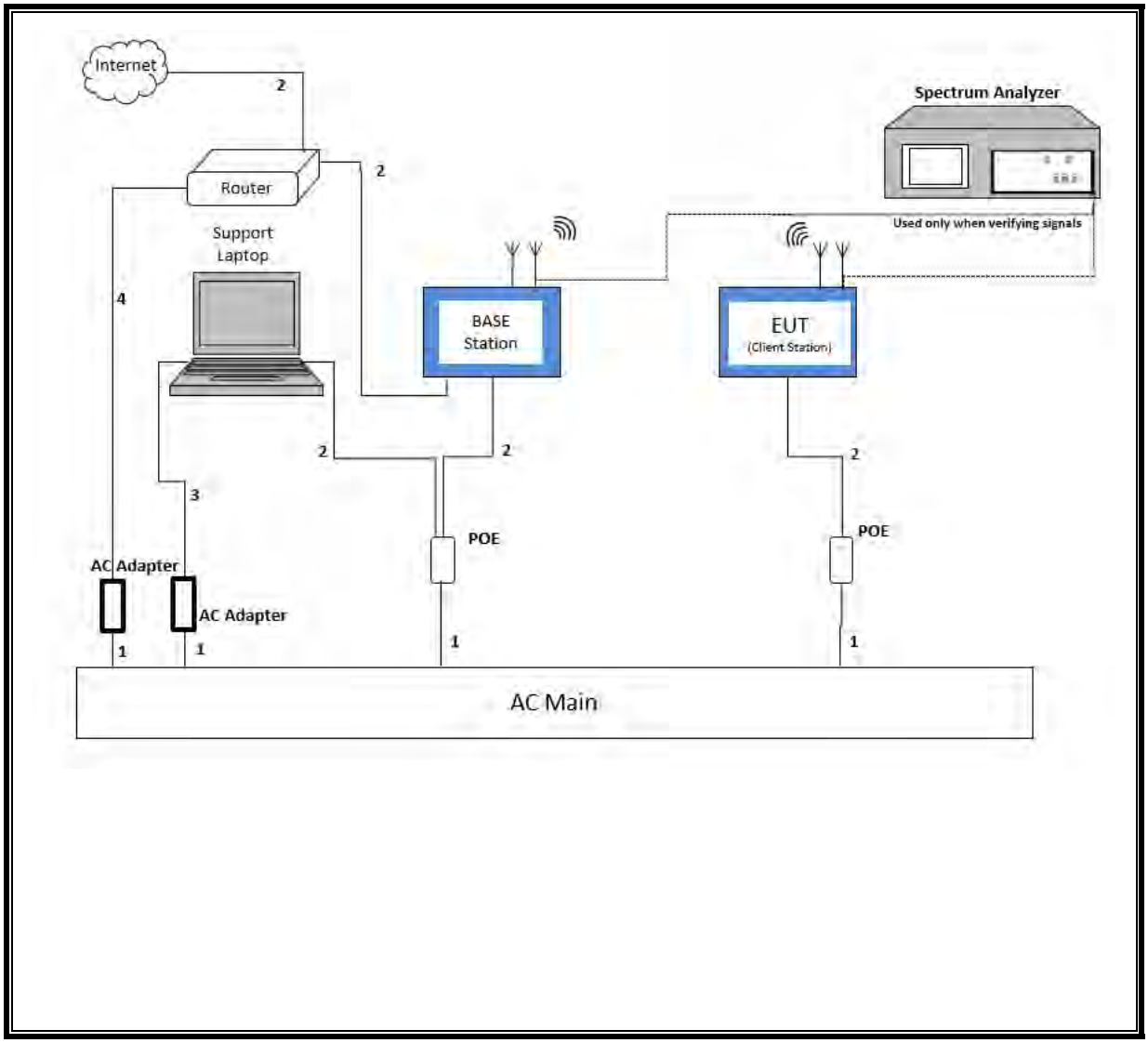
SETUP DIAGRAM ANTENNA PORT CONDUCTED TESTS



SETUP DIAGRAM FOR RADIATED 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:

TEST EQUIPMENT LIST					
Description	**Manufacturer**	**Model**	**ID Num**	**Cal Due**	**Last Cal**
Antenna, Active Loop 9KHz ro 30MHz	COM-POWER	AL-130R	PRE0165308	04/11/2020	04/11/2019
Horn Antenna	ETS-Lindgren	3117	T346	05/14/2020	05/14/2019
Amplifier, 1 to18GHz	MITEQ	AFS42-00101800-25-S-42	T1165	06/24/2020	06/24/2019
Antenna, Broadband Hybrid, 30MHz to 3GHz	Sunol Sciences Corp.	JB3	PRE0181575	09/05/2020	09/05/2019
Amplifier, 9kHz to 1GHz, 32 dB	Keysight Technologies	8447D	T15	11/26/2020	11/26/2019
Spectrum Analyzer, PXA, 3Hz to 26.5GHz	Agilent (Keysight) Technologies	N9030A	T917	01/24/2020	01/24/2019
Spectrum Analyzer, PSA, 3Hz to 26.5GHz	Agilent (Keysight) Technologies	E4440A	T146	1/29/2020	1/29/2019
Spectrum Analyzer, PSA, 3Hz to 26.5GHz	Agilent (Keysight) Technologies	E4440A	T198	1/29/2020	1/29/2019
692 MHz Notch Filter	EWT	EWT-14-0559	PRE0164927	08/07/2020	08/07/2019
515MHz Notch Filter	EWT	EWT-14-0348	T241	08/07/2020	08/07/2019
473MHz Notch Filter	EWT	EWT-14-0337	T232	08/07/2020	08/07/2019
1GHz High Pass Filter	Micro-Tronics	HPM50115	PRE0182589	09/04/2020	09/04/2019
AC Line Conducted					
EMI Receiver	Rohde & Schwarz	ESR	T1436	02/14/2020	02/14/2019
LISN for Conducted Emissions CISPR-16	FCC INC.	FCC LISN 50/250	T1310	01/24/2020	01/24/2019
Transient Limiter	Com-Power Co.	Lit 930	PRE0129246	01/24/2020	01/24/2019
Test Software List					
Radiated Software	UL	UL EMC		Ver 9.5, June 15, 2019	
Antenna Port Software	UL	UL RF		Ver 2019.10.3	
AC Line Conducted Software	UL	UL EMC		Ver 9.5, May 26, 2015	

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

The TX chains are uncorrelated and the antenna gain is the same for each chain. The directional gain is equal to the antenna gain.

RESULTS

9.1.1. UHF BAND

Tested By:	23653 DC
Test Date:	10/4/2019

Antenna Gain (dBi)	13.00

Output Power Results

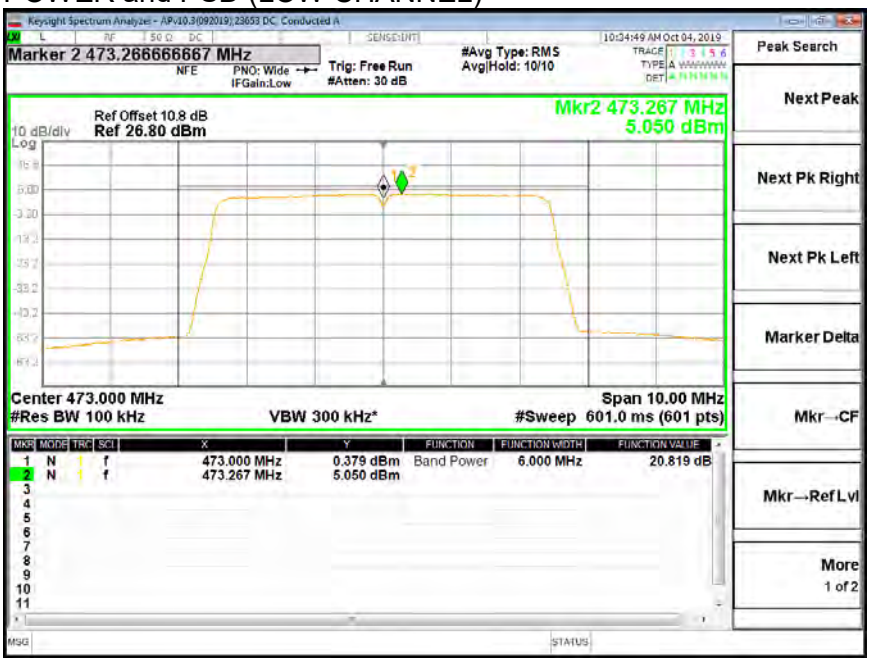
Channel	Frequency (MHz)	Measured Output Power Chain 0 (dBm)	Measured Output Power Chain 1 (dBm)	Measured Total Output Power (dBm)	Measured Total EIRP (dBm)	Conducted Power Limit (dBm)	Margin (dBm)
Low	473	20.82	20.99	23.92	36.92	27.00	-3.08
Mid	587	22.36	21.96	25.18	38.18	27.00	-1.82
High	695	20.26	20.99	23.65	36.65	27.00	-3.35

PSD Results

Channel	Frequency (MHz)	Measured Output PSD Chain 0 (dBm)	Measured Output PSD Chain 1 (dBm)	Measured Total PSD Power (dBm)	Conducted PSD Limit (dBm)	Margin (dBm)
Low	473	5.05	5.67	8.38	9.60	-1.22
Mid	587	6.58	6.12	9.36	9.60	-0.24
High	695	4.41	5.49	7.99	9.60	-1.61

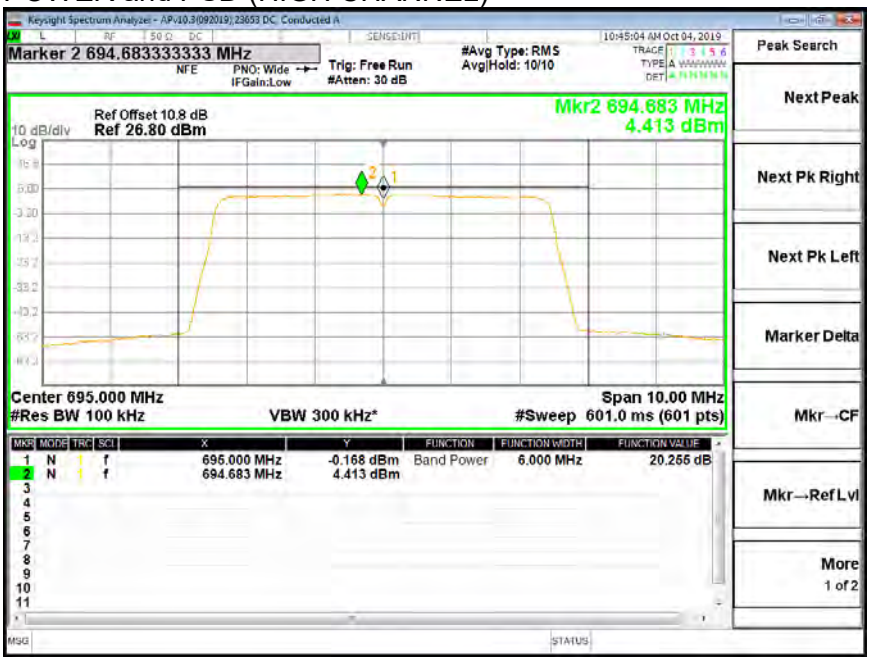
Chain 0

POWER and PSD (LOW CHANNEL)



POWER and PSD (MID CHANNEL)

POWER and PSD (HIGH CHANNEL)



Chain 1

POWER and PSD (LOW CHANNEL)

POWER and PSD (MID CHANNEL)

POWER and PSD (HIGH CHANNEL)

9.2. BAND-EDGE

LIMITS

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

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

(d) Emission limits.(1) The adjacent channel emission limits shown in the tables in paragraphs (b)(1) and (2) of this section apply in 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.

(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.

(3) Emission measurements in the adjacent bands shall be performed using a minimum resolution bandwidth of 100 kHz with an average detector. A narrower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 100 kHz.

Conducted Band edge limits for this Fixed WS device are:−45.8 dBm/100 kHz

RESULTS

9.2.1. UHF BAND

Chain 0+1

Tested By:	23653 DC
Test Date:	10/4/19

Lower Band-Edge Emissions

Channel	Frequency (MHz)	Measured Emission Chain 0 (dBm)	Measured Emission Chain 1 (dBm)	Measured Total Emission (dBm)	Emissions Limit (dBm)	Worst Case Margin (dBm)
Low	473	-51.45	-51.24	-48.33	-45.8	-2.53
Mid	587	-49.33	-51.82	-47.39	-45.8	-1.59
High	695	-52.18	-52.17	-49.16	-45.8	-3.36

Upper Band-Edge Emissions

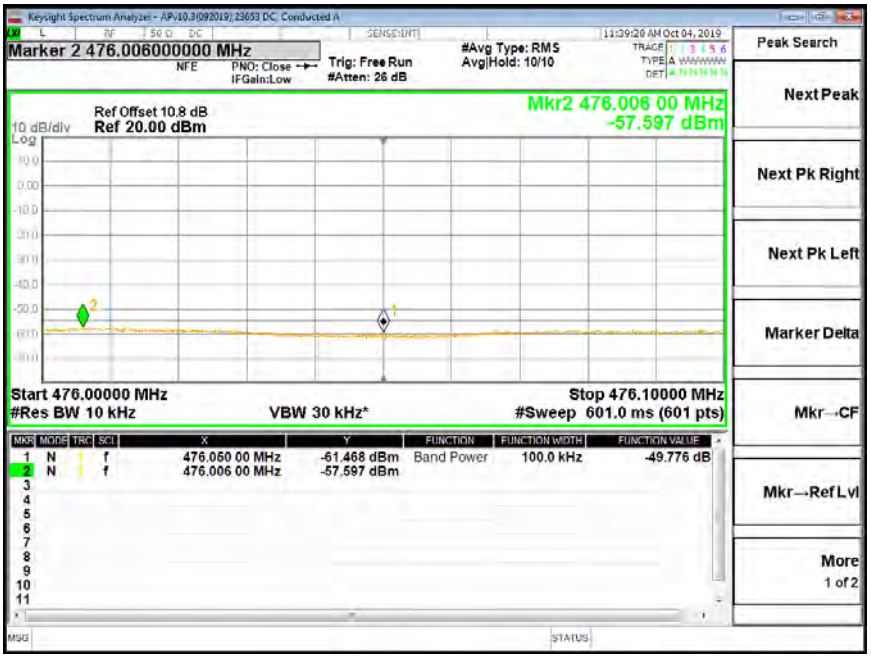
Channel	Frequency (MHz)	Measured Emission Chain 0 (dBm)	Measured Emission Chain 1 (dBm)	Measured Total Emission (dBm)	Emissions Limit (dBm)	Worst Case Margin (dBm)
Low	473	-49.78	-48.93	-46.32	-45.8	-0.52
Mid	587	-51.60	-53.61	-49.48	-45.8	-3.68
High	695	-50.45	-51.72	-48.03	-45.8	-2.23

CHAIN 0

LOW CHANNEL

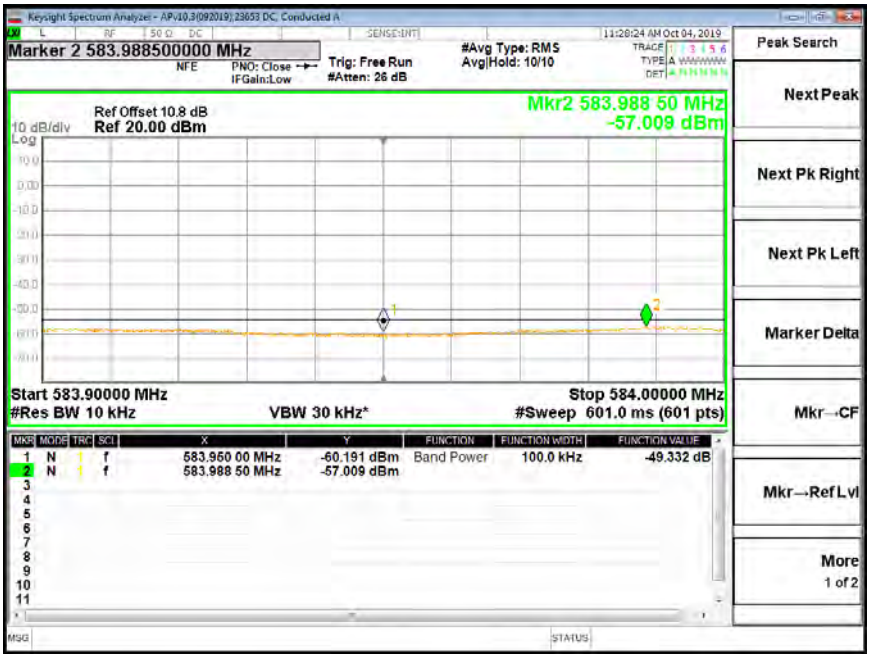
LOWER BAND-EDGE

UPPER BAND-EDGE

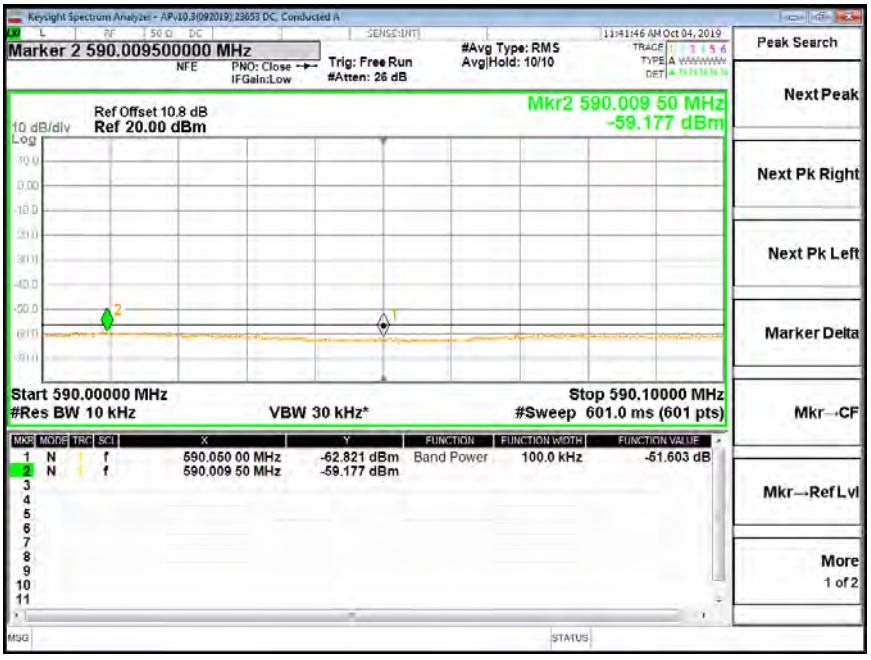


MID CHANNEL

LOWER BAND-EDGE



UPPER BAND-EDGE



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HIGH CHANNEL

LOWER BAND-EDGE

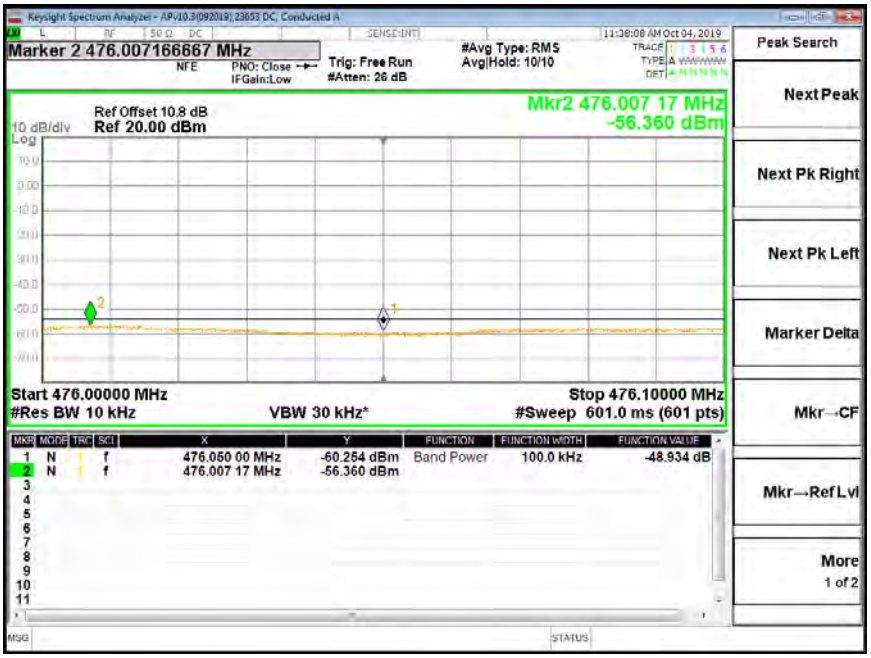
UPPER BAND-EDGE

Chain 1

LOW CHANNEL

LOWER BAND-EDGE

UPPER BAND-EDGE



MID CHANNEL

LOWER BAND-EDGE

UPPER BAND-EDGE

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HIGH CHANNEL

LOWER BAND-EDGE

UPPER BAND-EDGE

9.3. ADJACENT CHANNEL EMISSIONS

LIMITS

§15.709 Fixed White Space Device

(d) Emission limits.(1) The adjacent channel emission limits shown in the tables in paragraphs (b)(1) and (2) of this section apply in 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.

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

(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.

(3) Emission measurements in the adjacent bands shall be performed using a minimum resolution bandwidth of 100 kHz with an average detector. A narrower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 100 kHz.

Adjacent channel emission limits for this Fixed WS device are: −45.8 dBm/100 kHz

RESULTS

9.3.1. UHF BAND

Chain 0+1

Tested By:	23653 DC
Test Date:	10/4/19

Lower Adjacent Channel Emissions

Channel	Frequency (MHz)	Measured Emission Chain 0 (dBm)	Measured Emission Chain 1 (dBm)	Measured Total Emission (dBm)	Emissions Limit (dBm)	Worst Case Margin (dBm)
Low	473	-50.94	-50.35	-47.62	-45.8	-1.82
Mid	587	-49.64	-51.57	-47.49	-45.8	-1.69
High	695	-52.19	-52.24	-49.21	-45.8	-3.41

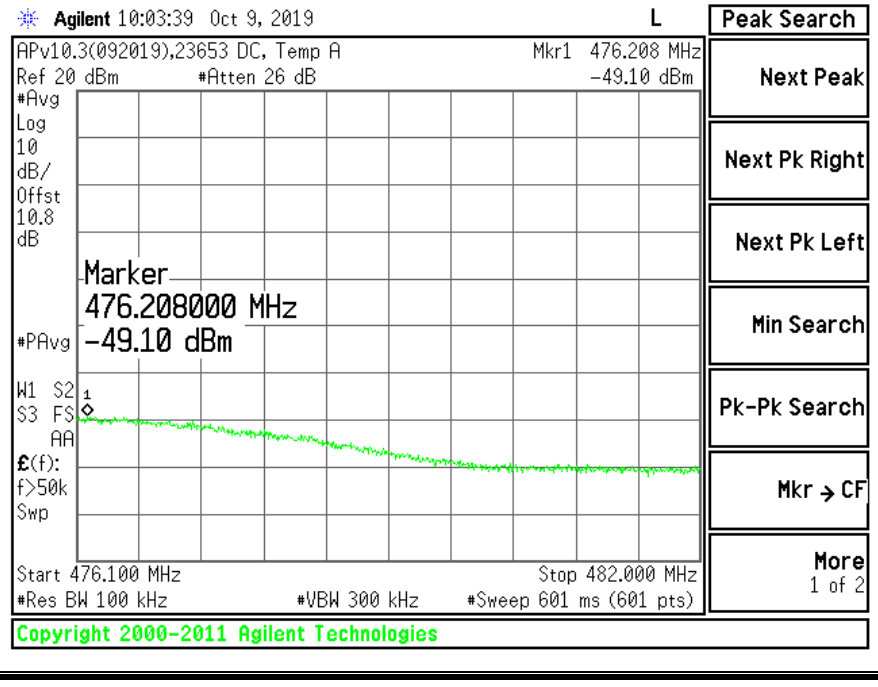
Upper Adjacent Channel Emissions

Channel	Frequency (MHz)	Measured Emission Chain 0 (dBm)	Measured Emission Chain 1 (dBm)	Measured Total Emission (dBm)	Emissions Limit (dBm)	Worst Case Margin (dBm)
Low	473	-49.10	-48.61	-45.84	-45.8	-0.04
Mid	587	-51.68	-51.57	-48.61	-45.8	-2.81
High	695	-48.18	-49.09	-45.60	-45.8	0.20

LOW CHANNEL

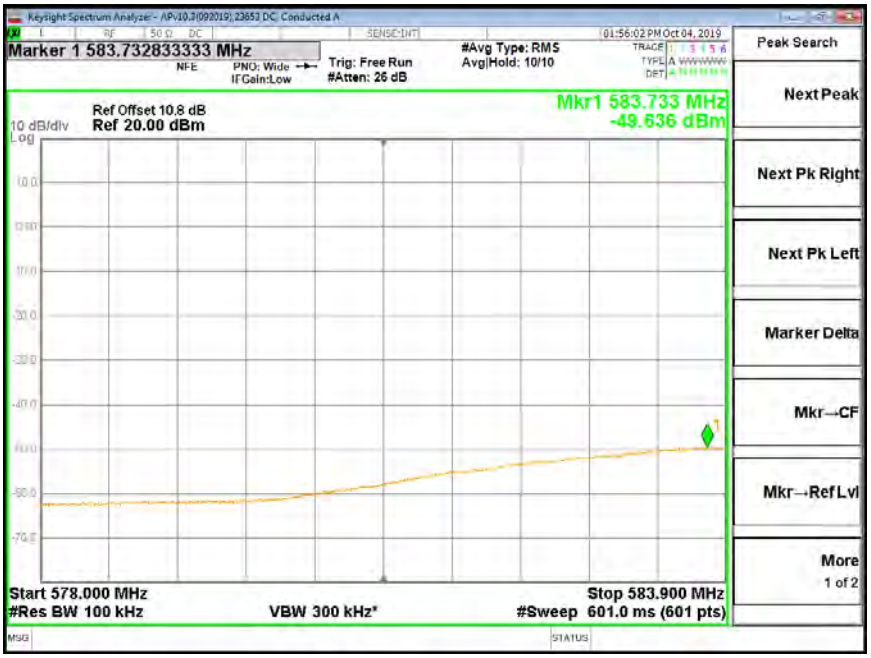
LOWER ADJACENT EMISSION

UPPER ADJACENT EMISSION

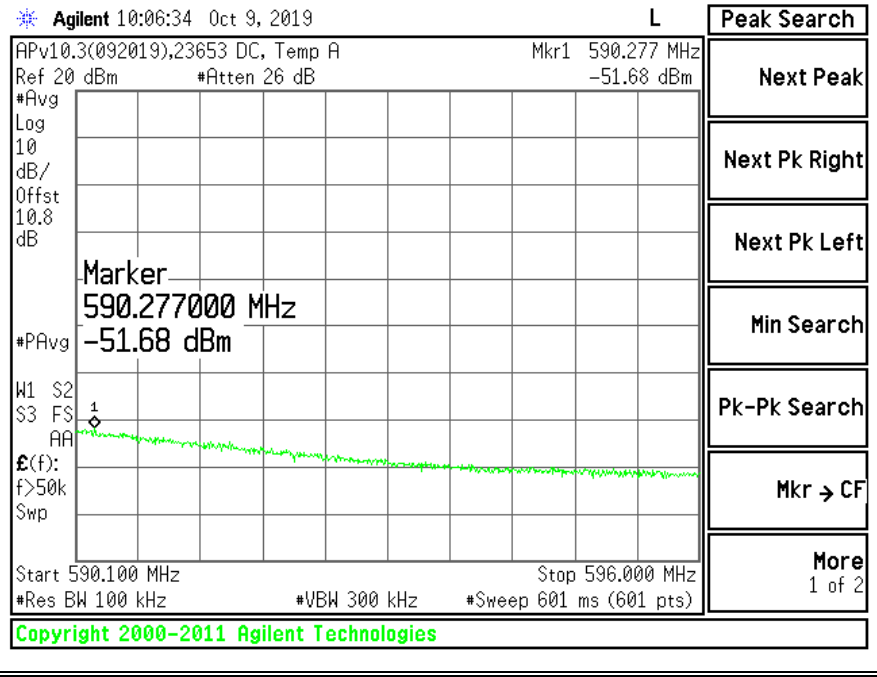


MID CHANNEL

LOWER ADJACENT EMISSION

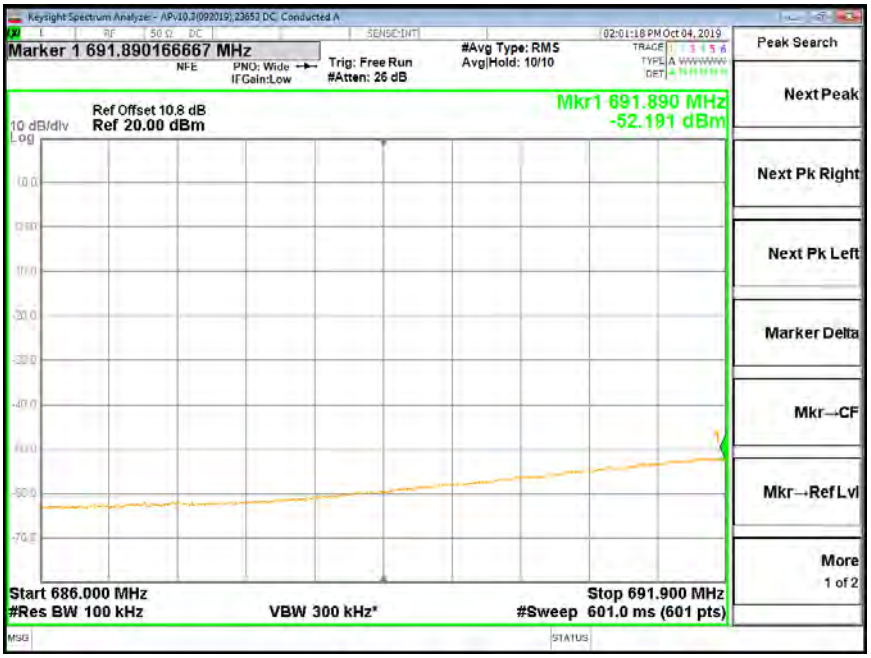


UPPER ADJACENT EMISSION

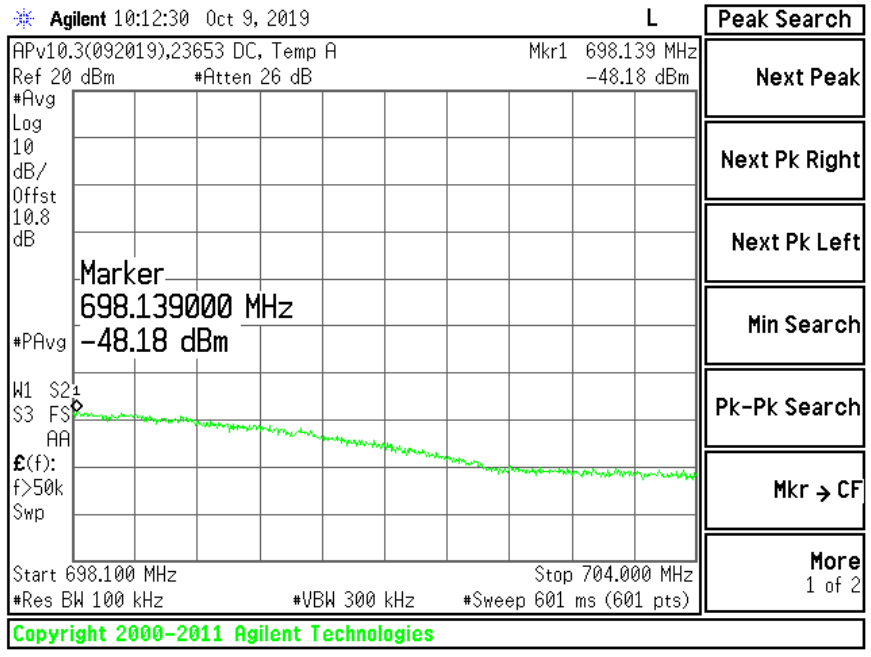


HIGH CHANNEL

LOWER ADJACENT EMISSION



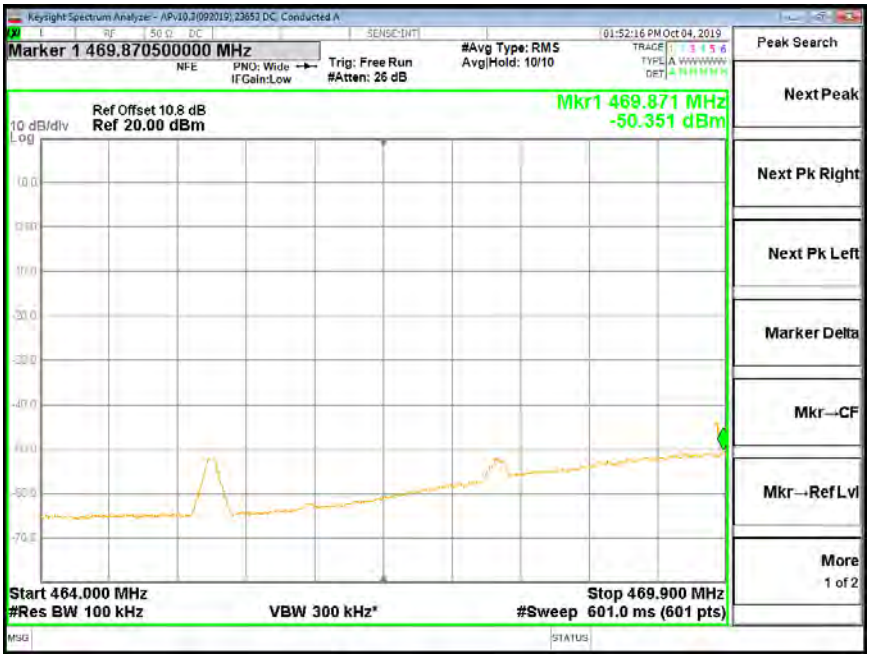
UPPER ADJACENT EMISSION



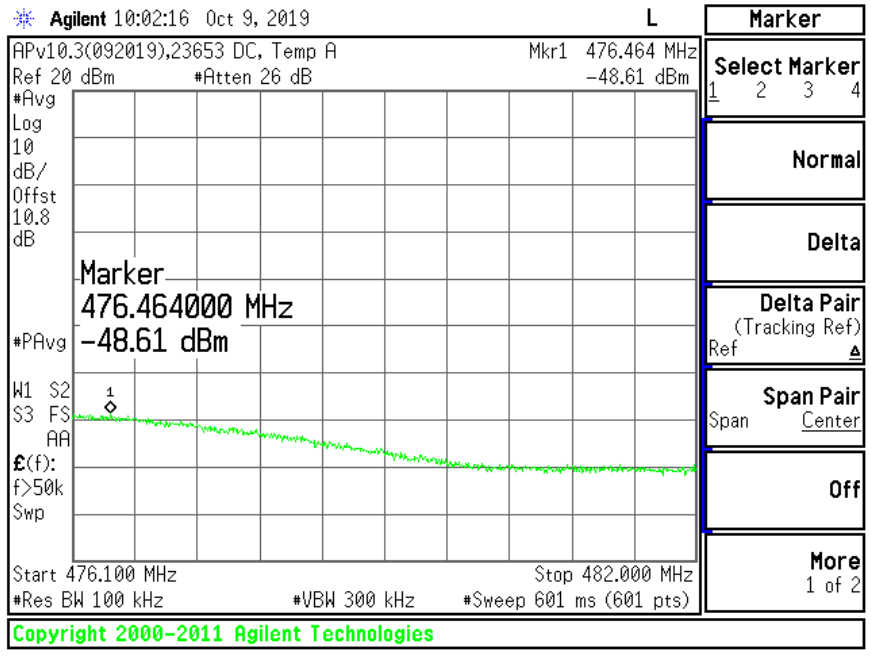
Chain 1

LOW CHANNEL

LOWER ADJACENT EMISSION

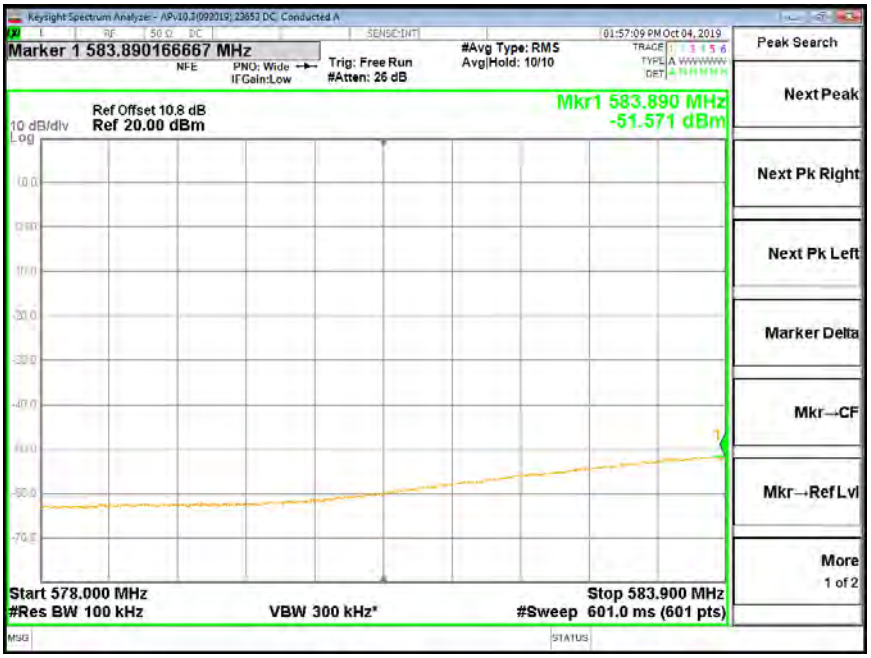


UPPER ADJACENT EMISSION

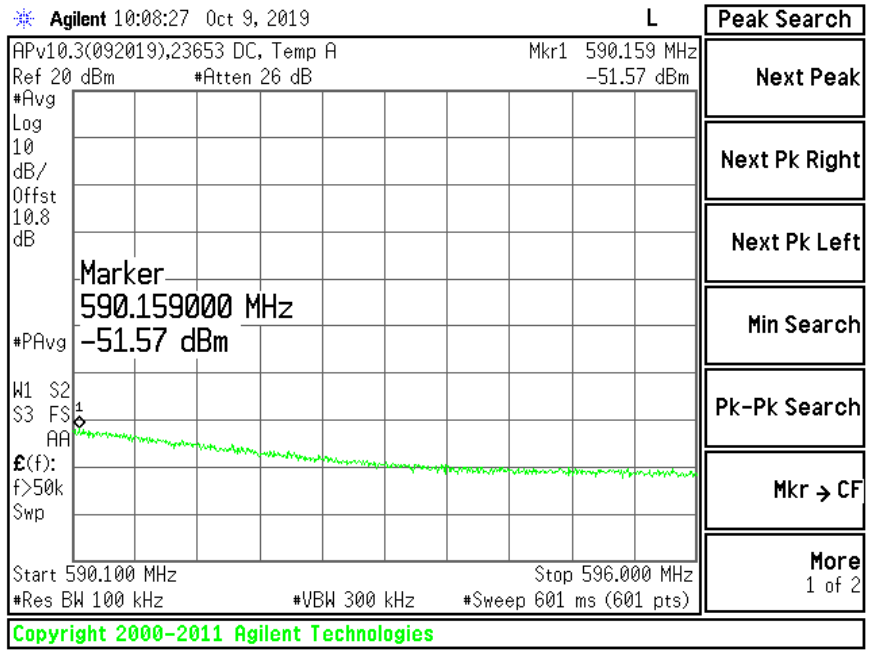


MID CHANNEL

LOWER ADJACENT EMISSION

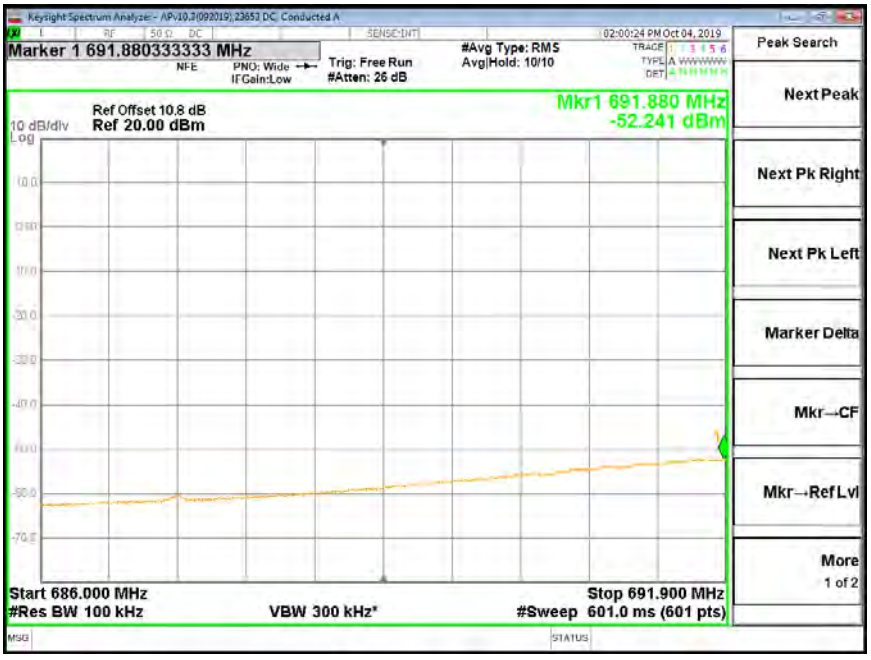


UPPER ADJACENT EMISSION

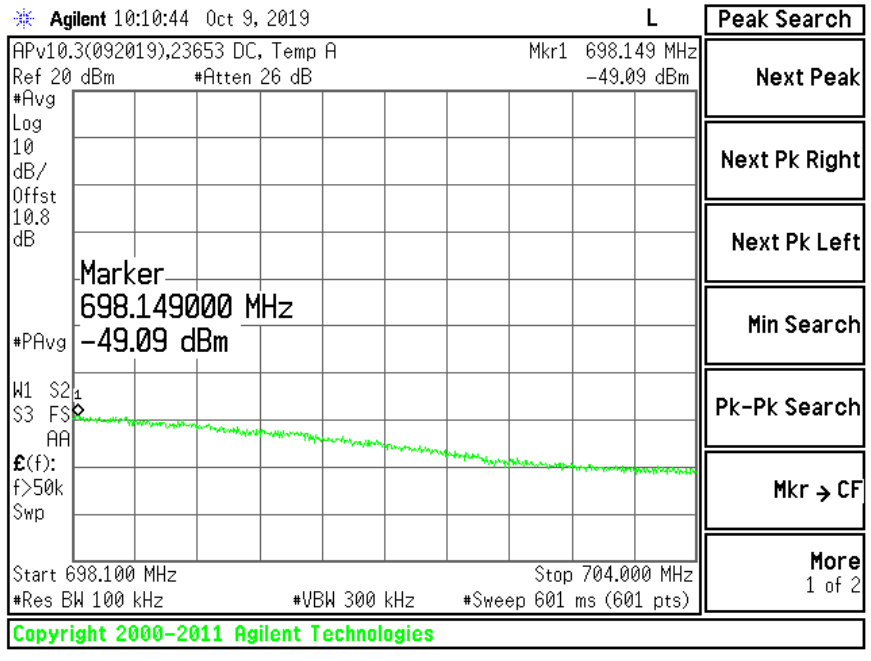


HIGH CHANNEL

LOWER ADJACENT EMISSION



UPPER ADJACENT EMISSION



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 3m	Measurement distance (m)
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.

2D antenna use - For below 30MHz testing, investigation was done on three antenna orientations (parallel, perpendicular, and ground-parallel), parallel and perpendicular are the worst orientations, therefore testing was performed on these two orientations only.

KDB 414788 Open Field Site(OFS) and Chamber Correlation Justification

Base 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.

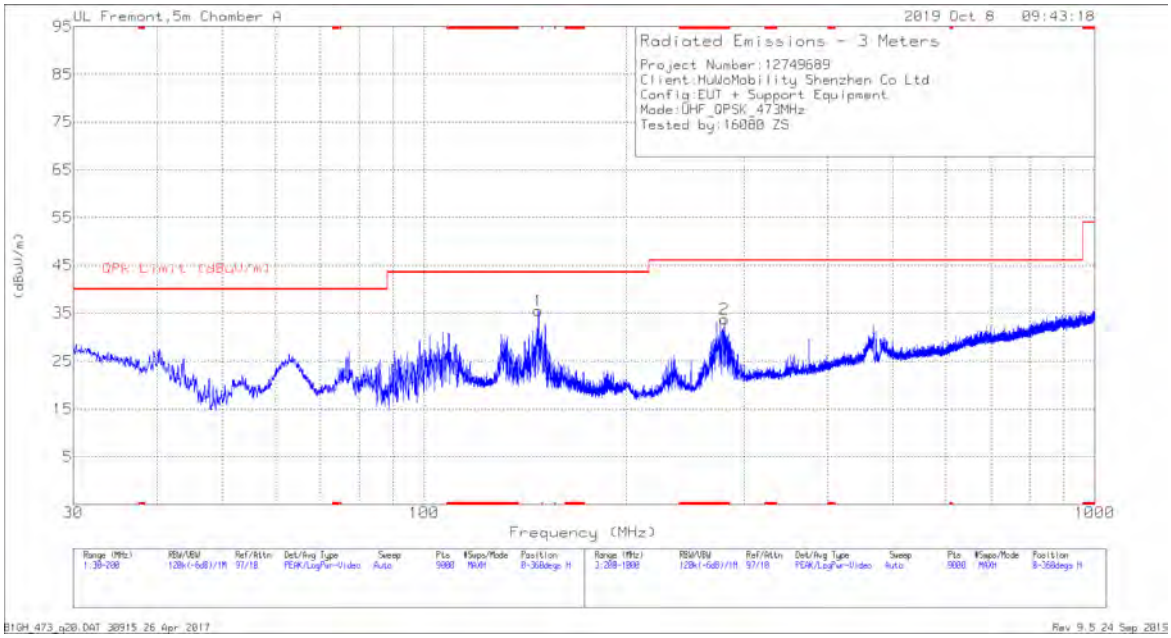
OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

10.1. TRANSMITTER BELOW 1GHz

10.1.1. UHF BAND

BEYOND ADJACENT CHANNEL (LOW CHANNEL)

HORIZONTAL PLOT



VERTICAL PLOT

LOW CHANNEL DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0181575 (dB)	Amp/Cbl (dB/m)	Fltr (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	* 280.6314	38.78	Pk	19.2	-24.4	.1	33.68	46	-12.32	0-360	100	H
3	63.371	51.84	Pk	13.6	-26.8	.1	38.74	40	-1.26	0-360	100	V
1	148.1065	42.72	Pk	18.4	-25.7	.1	35.52	43.5	-7.98	0-360	200	H
4	462.9632	42.39	Pk	23	-24.8	.1	40.69	46	-5.31	0-360	100	V
7	468.0305	46.16	Pk	23.2	-25	.1	44.46	46	-1.54	0-360	100	V
8	478.6095	47.43	Pk	23.6	-25	.1	46.13	-	-	0-360	100	V
5	483.9434	46.52	Pk	23.6	-25	.1	45.22	46	-.78	0-360	100	V
6	650.5401	43.81	Pk	25.7	-24.4	.1	45.21	46	-.79	0-360	100	V

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

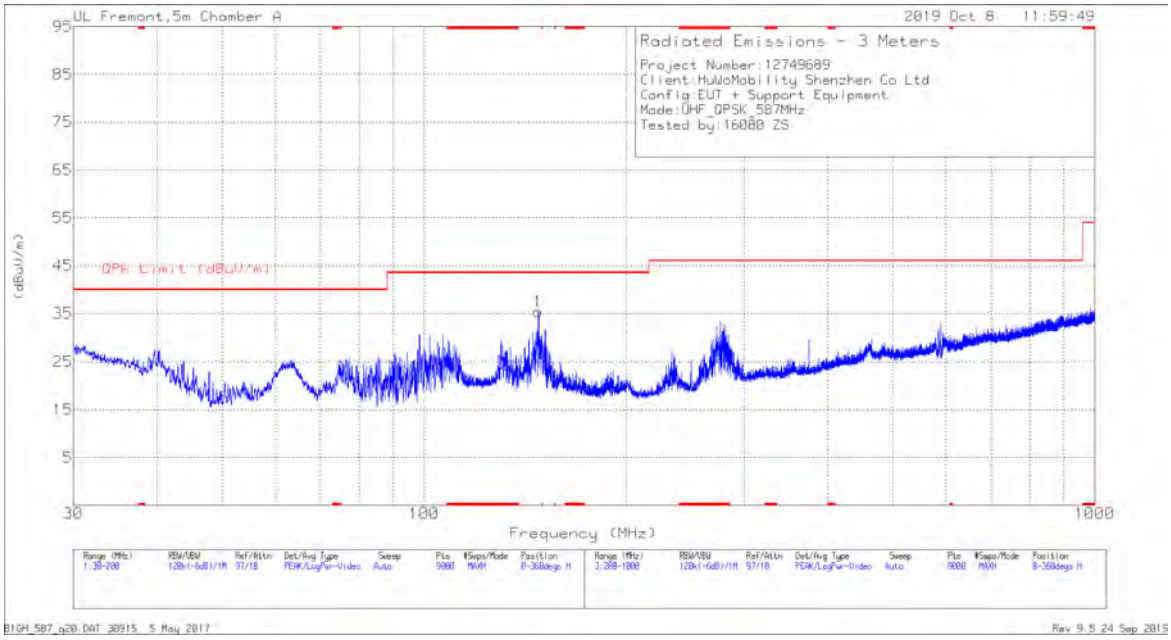
Radiated Emissions

Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0181575 (dB)	Amp/Cbl (dB/m)	Fltr (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
62.992	45.64	Qp	13.6	-26.8	.1	32.54	40	-7.46	117	108	V
462.6592	37.33	Qp	23	-24.8	.1	35.63	46	-10.37	133	192	V
467.8337	34.42	Av	23.2	-25	.1	32.72	46	-13.28	137	174	V
478.9625	32.85	Av	23.6	-25	.1	31.55	46	-14.45	176	167	V
484.2974	37.28	Qp	23.6	-25	.1	35.98	46	-10.02	174	156	V
650.3541	35.26	Qp	25.7	-24.4	.1	36.66	46	-9.34	182	112	V

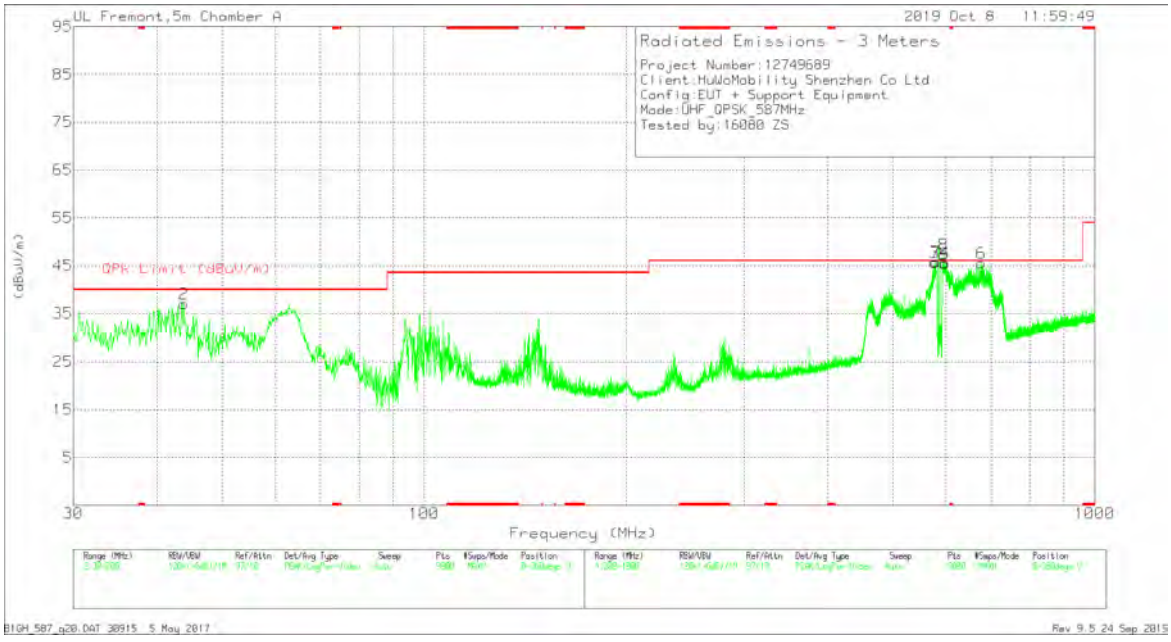
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Qp - Quasi-Peak detector
Av - Average detection

BEYOND ADJACENT CHANNEL (MID CHANNEL)

HORIZONTAL PLOT



VERTICAL PLOT



MID CHANNEL DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0181575 (dB)	Amp/Cbl (dB/m)	Fltr (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	43.7904	47	Pk	16.8	-27	.2	37	40	-3	0-360	100	V
1	148.1065	42.44	Pk	18.4	-25.7	.2	35.34	43.5	-8.16	0-360	199	H
3	577.3763	45.75	Pk	24.5	-24.8	.2	45.65	46	-.35	0-360	200	V
7	579.0653	45.77	Pk	24.6	-24.8	.2	45.77	46	-.23	0-360	100	V
8	595.245	47.6	Pk	24.2	-24.7	.2	47.3	-	-	0-360	200	V
4	597.3785	45.93	Pk	24.2	-24.7	.2	45.63	46	-.37	0-360	200	V
5	598.0897	45.65	Pk	24.3	-24.7	.2	45.45	46	-.55	0-360	100	V
6	676.5875	43.81	Pk	25.7	-24.2	.2	45.51	46	-.49	0-360	100	V

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

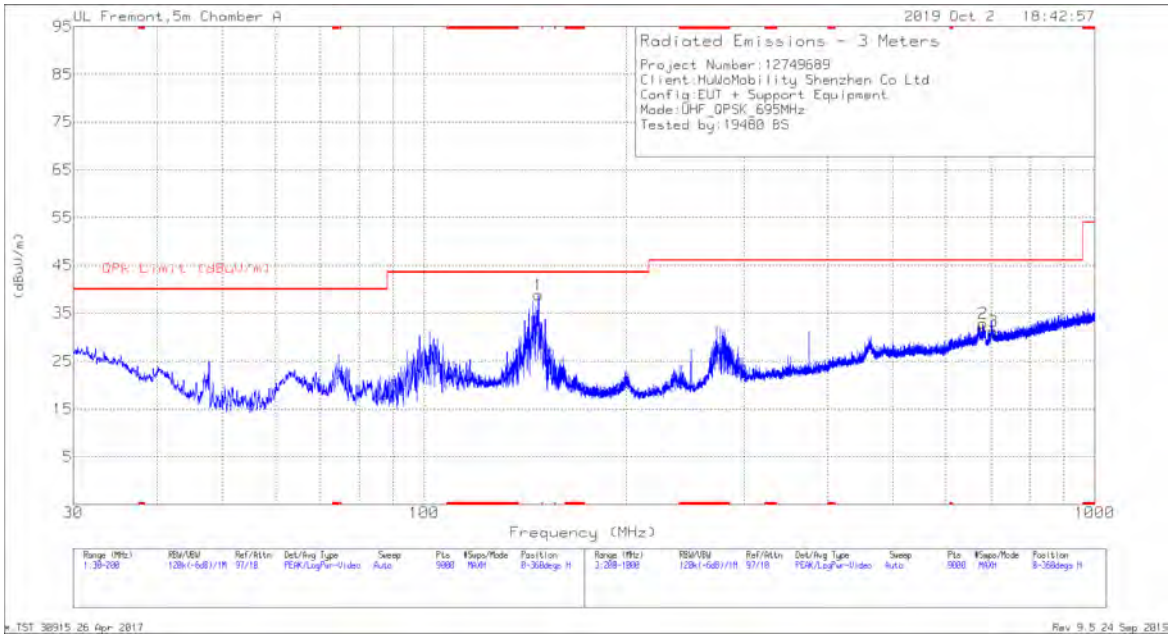
Radiated Emissions

Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0181575 (dB)	Amp/Cbl (dB/m)	Fltr (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
43.8184	44.73	Qp	16.8	-27	.2	34.73	40	-5.27	86	106	V
577.7063	41.37	Qp	24.6	-24.8	.2	41.37	46	-4.63	185	145	V
579.3283	34.81	Av	24.6	-24.8	.2	34.81	46	-11.19	185	131	V
595.713	34.51	Av	24.2	-24.7	.2	34.21	46	-11.69	213	136	V
597.8465	39.85	Qp	24.3	-24.7	.2	39.65	46	-6.35	181	130	V
598.4517	39.65	Qp	24.3	-24.7	.2	39.45	46	-6.55	181	127	V
676.7125	36.37	Qp	25.7	-24.2	.2	38.07	46	-7.93	185	114	V

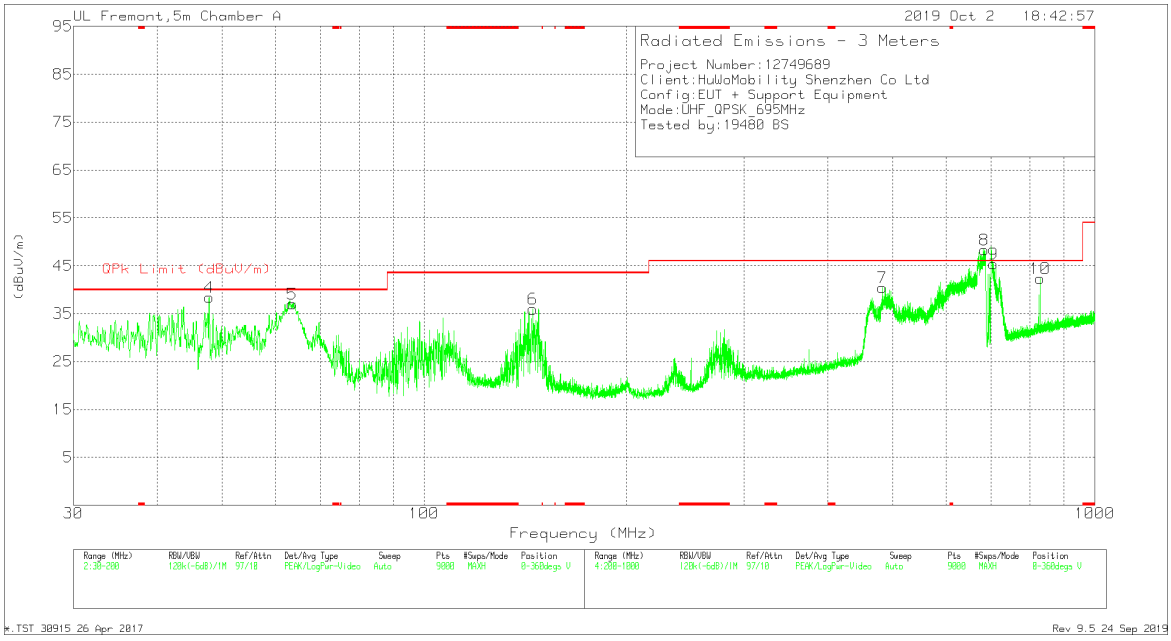
* - indicates frequency in CFR47 Pt 15 / IC RSS-Restricted Band
Qp - Quasi-Peak detector
Av - Average detection

BEYOND ADJACENT CHANNEL (HIGH CHANNEL)

HORIZONTAL PLOT



VERTICAL PLOT



HIGH CHANNEL DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0181575 (dB)	Amp/Cbl (dB/m)	Fltr (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	47.7953	50.79	Pk	14.6	-27	0.2	38.59	40	-1.41	0-360	100	V
5	63.5693	50.28	Pk	13.6	-26.8	0.2	37.28	40	-2.72	0-360	100	V
6	145.254	43.25	Pk	18.5	-25.8	0.2	36.15	43.5	-7.35	0-360	100	V
1	148.1065	46.16	Pk	18.4	-25.7	0.2	39.06	43.5	-4.44	0-360	200	H
7	482.521	41.9	Pk	23.6	-25	0.2	40.7	46	-5.3	0-360	100	V
2	681.8326	31.15	Pk	25.8	-24.1	0.2	33.05	46	-12.95	0-360	200	H
8	684.0551	46.63	Pk	25.8	-24.1	0.2	48.53	-	-	0-360	100	V
3	705.3908	28.96	Pk	26.2	-24	0.2	31.36	46	-14.64	0-360	400	H
9	705.3908	43.23	Pk	26.2	-24	0.2	45.63	46	-0.37	0-360	100	V
10	828.9604	37.7	Pk	27.7	-23.1	0.2	42.5	46	-3.5	0-360	400	V

Pk - Peak detector

Radiated Emissions

Frequency (MHz)	Meter Reading (dBuV)	Det	AF PRE0181575 (dB)	Amp/Cbl (dB/m)	Fltr (dB)	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
47.8006	44.5	Qp	14.6	-27	0.2	32.3	40	-7.7	33	146	V
47.8169	45.94	Qp	14.6	-27	0.2	33.74	40	-6.26	7	107	V
63.4061	46.45	Qp	13.6	-26.8	0.2	33.45	40	-6.55	114	104	V
145.253	40.88	Qp	18.5	-25.8	0.2	33.78	43.5	-9.72	266	106	V
148.1267	45.58	Qp	18.4	-25.7	0.2	38.48	43.5	-5.02	137	246	H
482.5277	36.99	Qp	23.6	-25	0.2	35.79	46	-10.21	207	171	V
681.7827	27.92	Qp	25.8	-24.1	0.2	29.82	46	-16.18	196	223	H
683.8919	44.02	Qp	25.8	-24.1	0.2	45.92	46	-0.08	205	114	V
705.4758	39.83	Qp	26.2	-24	0.2	42.23	46	-3.77	209	101	V
705.4926	24.49	Qp	26.2	-24	0.2	26.89	46	-19.11	191	368	H
829.1726	22.22	Qp	27.7	-23.1	0.2	27.02	46	-17.98	192	363	V

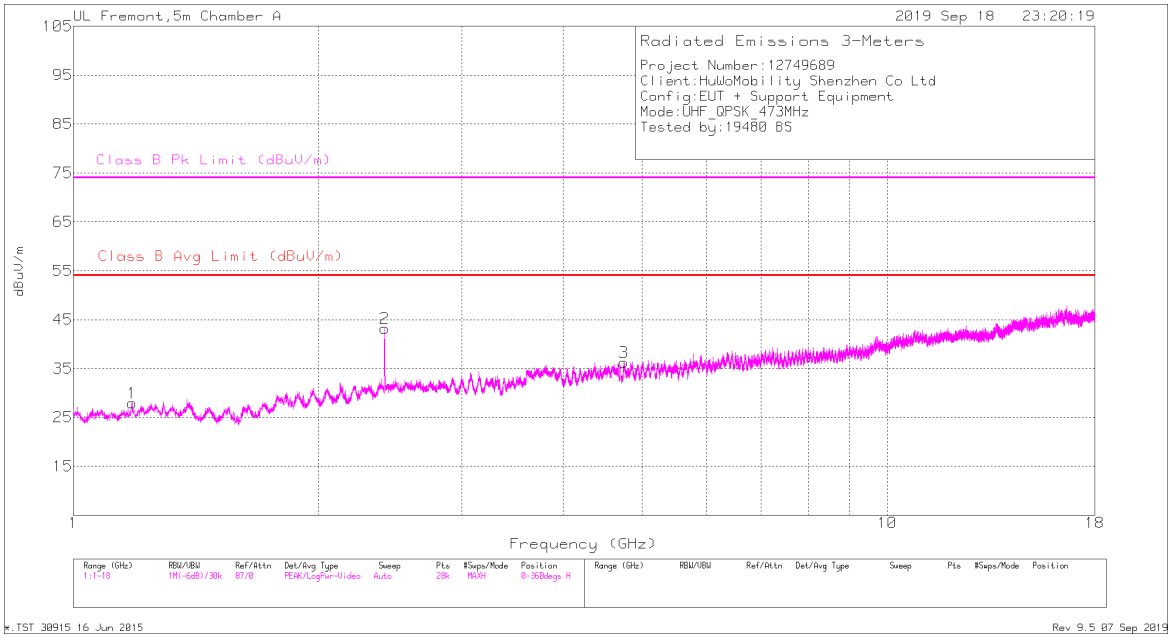
Qp - Quasi-Peak detector

10.2. TRANSMITTER ABOVE 1GHz

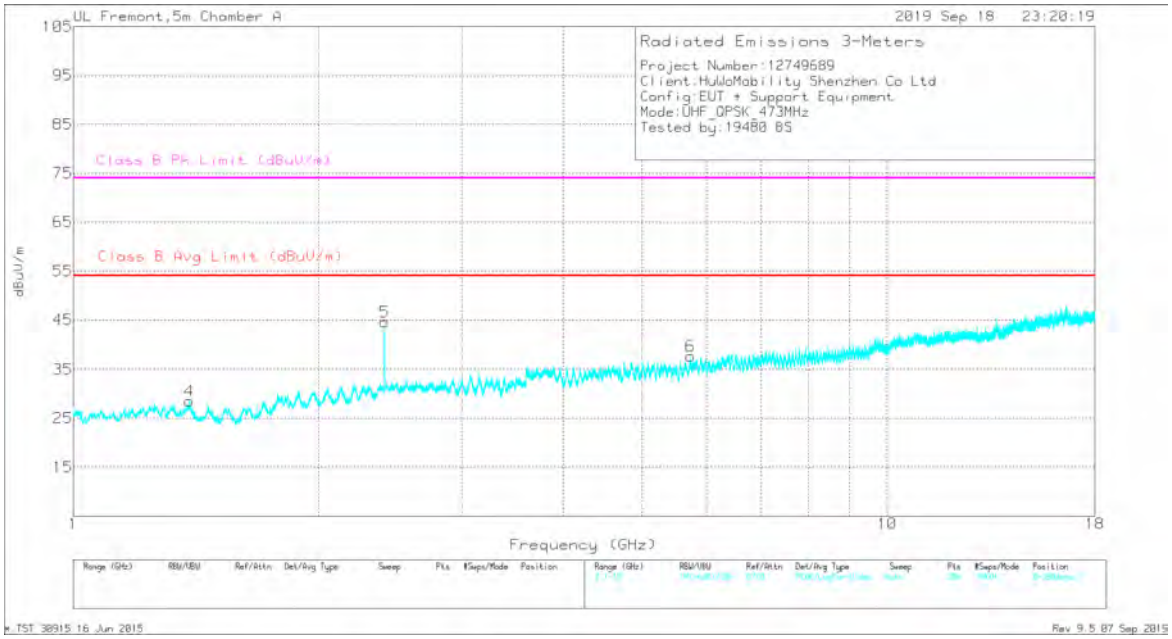
10.2.1. HARMONICS AND SPURIOUS EMISSIONS IN THE UHF BAND

LOW CHANNEL

HORIZONTAL PLOT



VERTICAL PLOT



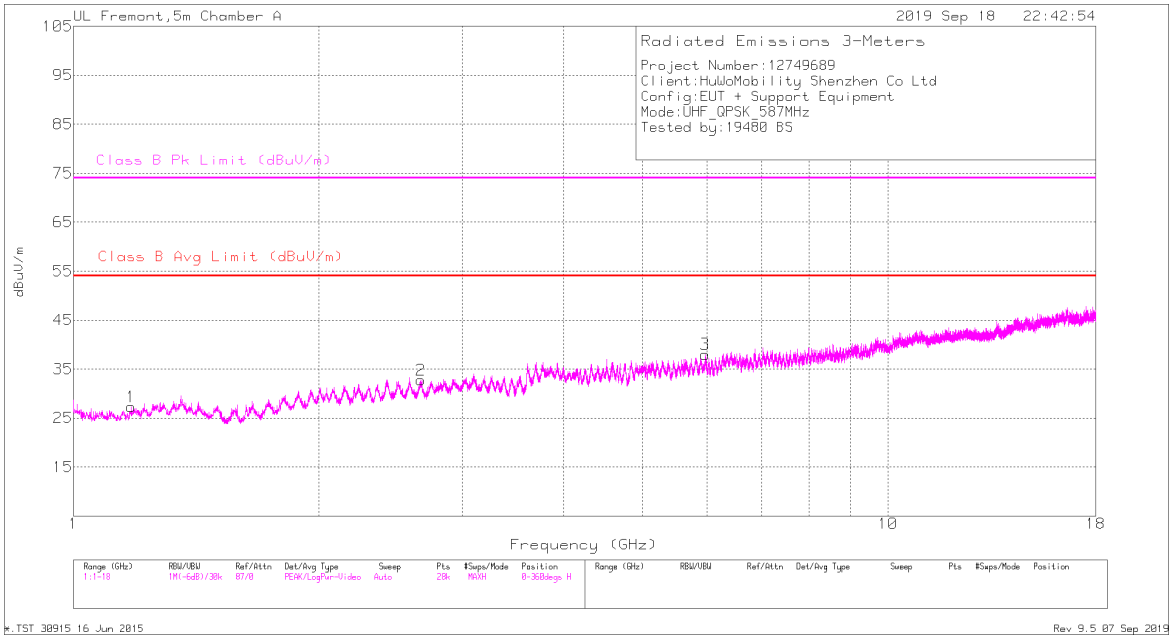
LOW CHANNEL DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl (dB)	Fltr (dB)	Corrected Reading dBuV/m	Class B Avg Limit (dBuV/m)	Margin (dB)	Class B Pk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	1.17878	40.46	Pk	28	-32.5	1	36.96	-	-	74	-37.04	353	175	H
	1.17878	26.99	Av	28	-32.5	1	23.49	54	-30.51	-	-	353	175	H
4	1.38943	39.39	Pk	29	-32	1	37.39	-	-	74	-36.61	223	190	V
	1.38943	26.29	Av	29	-32	1	24.29	54	-29.71	-	-	223	190	V
2	2.41253	51.23	Pk	32.4	-30.4	1	54.23	-	-	74	-19.77	226	163	V
	2.41253	39.75	Av	32.4	-30.4	1	42.75	54	-11.25	-	-	226	163	V
5	2.41264	49.84	Pk	32.4	-30.4	1	52.84	-	-	74	-21.16	188	366	H
	2.41264	38.15	Av	32.4	-30.4	1	41.15	54	-12.85	-	-	188	366	H
3	4.75088	37.85	Pk	34.2	-27.6	1	45.45	-	-	74	-28.55	48	175	H
	4.75088	25.46	Av	34.2	-27.6	1	33.06	54	-20.94	-	-	48	175	H
6	5.73239	35.96	Pk	34.9	-26.6	1	45.26	-	-	74	-28.74	295	218	V
	5.73239	23.6	Av	34.9	-26.6	1	32.9	54	-21.1	-	-	295	218	V

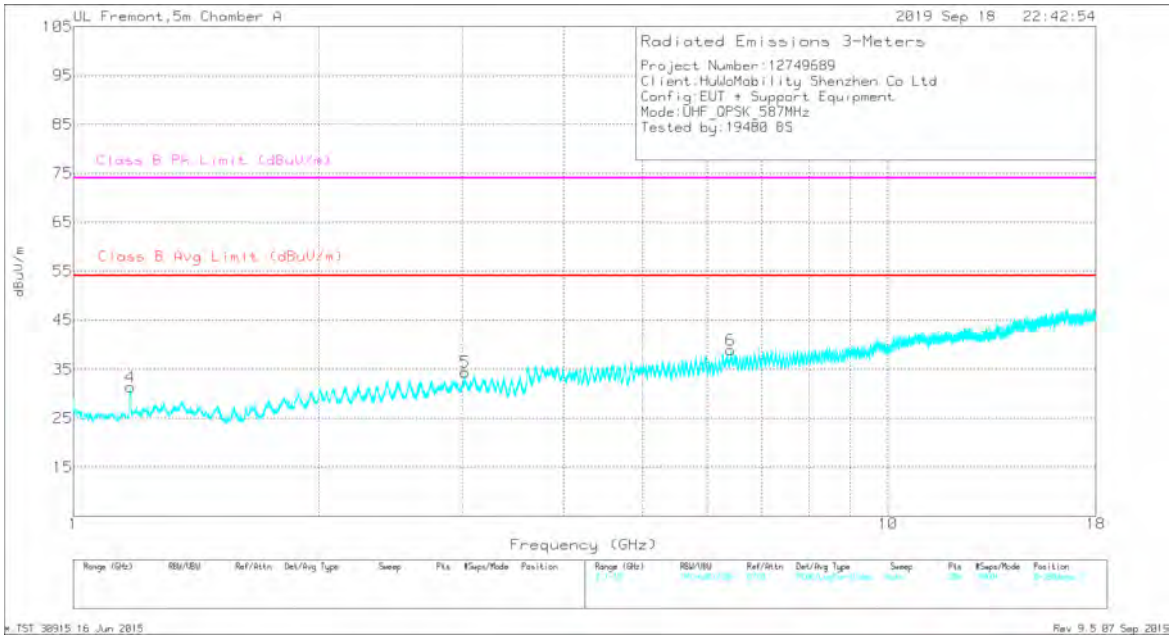
Pk - Peak detector
Av - Average detection

MID CHANNEL

HORIZONTAL PLOT



VERTICAL PLOT



UL VERIFICATION SERVICES INC.
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 319-4000 FAX: (510) 661-0888

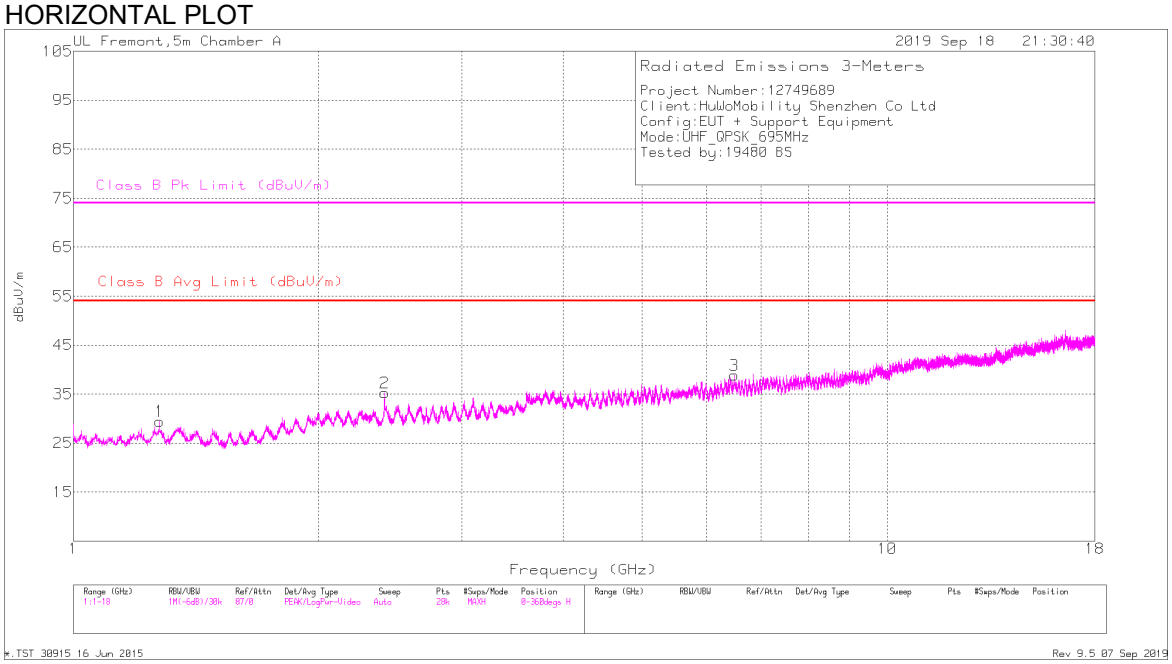
MID CHANNEL DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl (dB)	Fltr (dB)	Corrected Reading dBuV/m	Class B Avg Limit (dBuV/m)	Margin (dB)	Class B Pk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	1.17581	48.59	Pk	27.9	-32.5	1	44.99	-	-	74	-29.01	322	164	V
	1.17581	33.03	Av	27.9	-32.5	1	29.43	54	-24.57	-	-	322	164	V
1	1.17625	40.23	Pk	27.9	-32.5	1	36.63	-	-	74	-37.37	43	199	H
	1.17625	26.65	Av	27.9	-32.5	1	23.05	54	-30.95	-	-	43	199	H
2	2.67128	38.83	Pk	32.4	-30.2	1	42.03	-	-	74	-31.97	146	146	H
	2.67128	25.76	Av	32.4	-30.2	1	28.96	54	-25.04	-	-	146	146	H
5	3.02436	39.02	Pk	33	-29.8	1	43.22	-	-	74	-30.78	241	103	V
	3.02436	25.43	Av	33	-29.8	1	29.63	54	-24.37	-	-	241	103	V
3	5.96789	36.35	Pk	35.4	-26.2	1	46.55	-	-	74	-27.45	76	163	H
	5.96789	23.63	Av	35.4	-26.2	1	33.83	54	-20.17	-	-	76	163	H
6	6.41458	35.63	Pk	35.8	-25.2	1	47.23	-	-	74	-26.77	351	250	V
	6.41458	23.07	Av	35.8	-25.2	1	34.67	54	-29.33	-	-	351	250	V

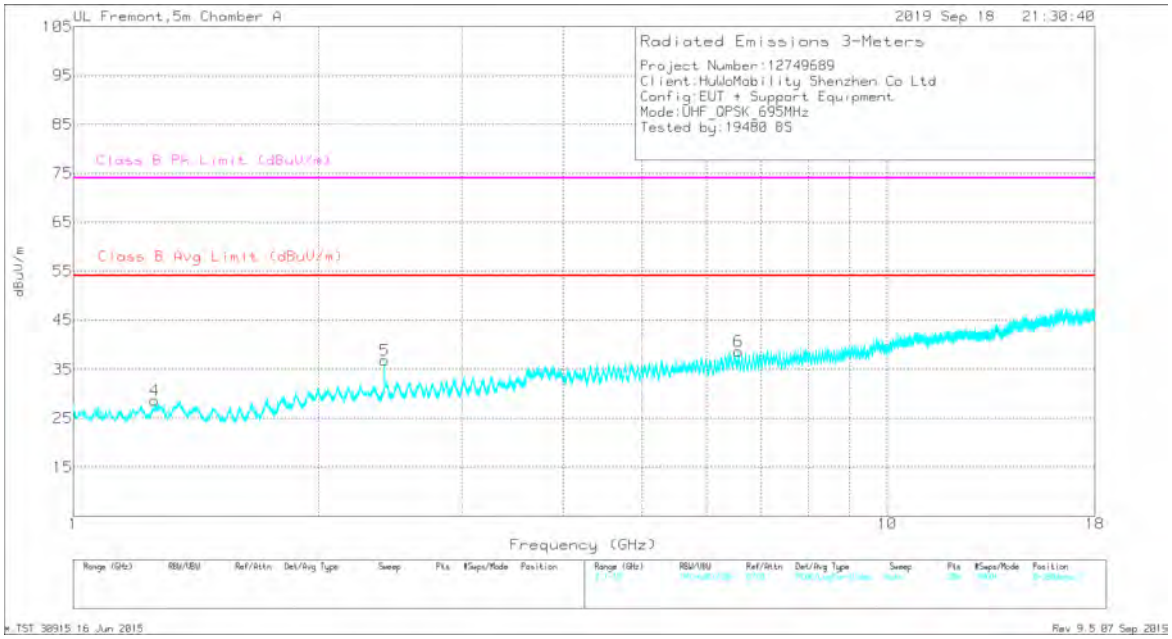
Pk - Peak detector
Av - Average detection

HIGH CHANNEL

HORIZONTAL PLOT



VERTICAL PLOT



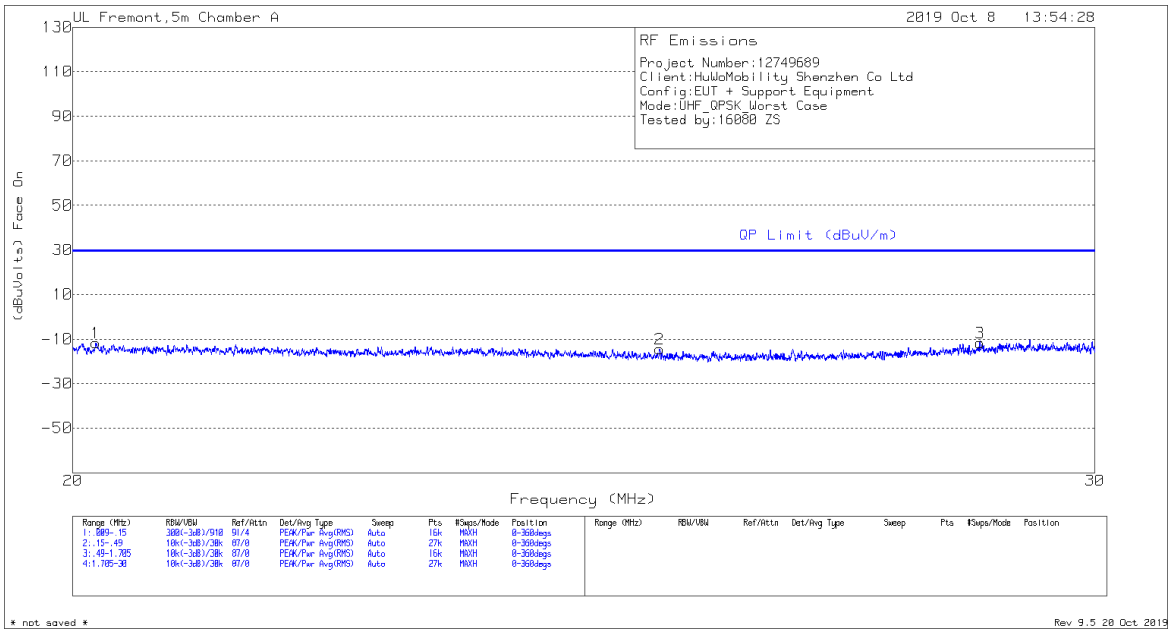
HIGH CHANNEL DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AF T346 (dB/m)	Amp/Cbl (dB)	Fltr (dB)	Corrected Reading dBuV/m	Class B Avg Limit (dBuV/m)	Margin (dB)	Class B Pk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
4	1.25951	40.22	Pk	28.9	-32.3	1	37.82	-	-	74	-36.18	325	160	V
	1.25951	26.67	Av	28.9	-32.3	1	24.27	54	-29.73	-	-	325	160	V
1	1.27571	39.95	Pk	29.1	-32.3	1	37.75	-	-	74	-36.25	149	142	H
	1.27571	26.72	Av	29.1	-32.3	1	24.52	54	-29.48	-	-	149	142	H
2	2.41156	46.74	Pk	32.4	-30.4	1	49.74	-	-	74	-24.26	188	253	H
	2.41156	34.9	Av	32.4	-30.4	1	37.9	54	-16.1	-	-	188	253	H
5	2.4117	44.09	Pk	32.4	-30.4	1	47.09	-	-	74	-26.91	255	122	V
	2.4117	32.03	Av	32.4	-30.4	1	35.03	54	-18.97	-	-	255	122	V
3	6.4899	35.94	Pk	35.8	-25.2	1	47.54	-	-	74	-26.46	235	195	H
	6.4899	22.83	Av	35.8	-25.2	1	34.43	54	-19.57	-	-	235	195	H
6	6.5704	35.28	Pk	35.8	-25.1	1	46.98	-	-	74	-27.02	43	128	V
	6.5704	22.59	Av	35.8	-25.1	1	34.29	54	-19.71	-	-	43	128	V

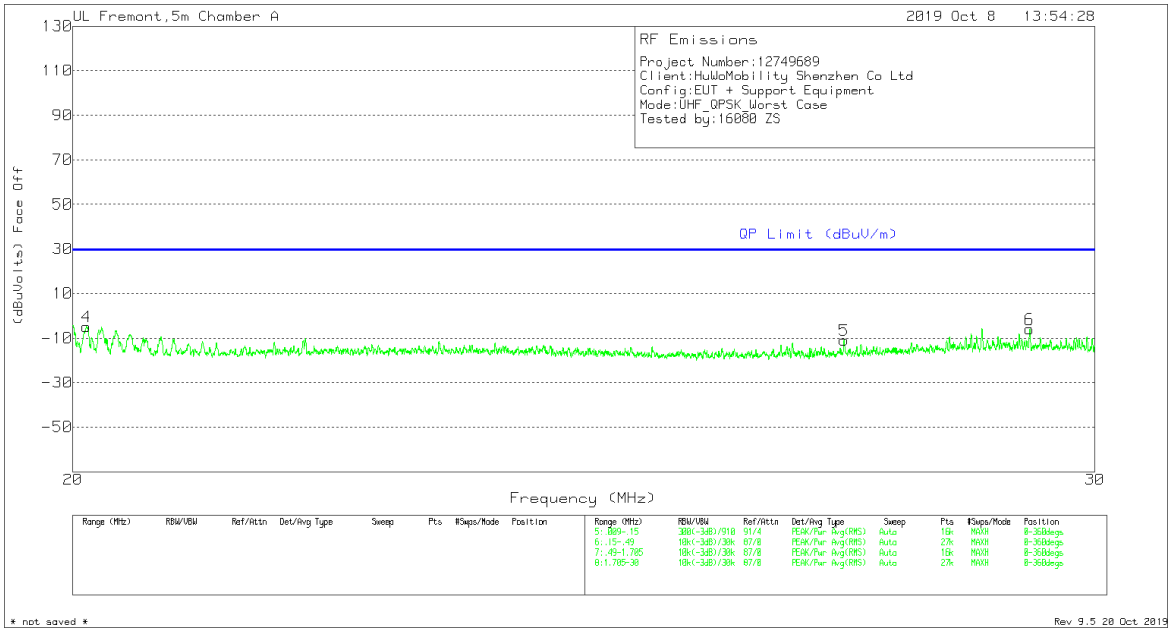
Pk - Peak detector
Av - Average detection

10.3. WORST-CASE TRANSMITTER BELOW 30MHz

FACE ON PLOT



FACE OFF PLOT



DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna (dB/m)	Cables (dB)	Dist Corr 30m	Corrected Reading (dBuVolts)	QP Limit (dBuV/m)	Margin (dB)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)
4	20.10631	20.01	Pk	14.6	.6	-40	-4.79	30	-34.79	29.5	-34.29	0-360
1	20.18334	13.06	Pk	14.6	.6	-40	-11.74	30	-41.74	29.5	-41.24	0-360
2	25.2436	12.14	Pk	12.7	.7	-40	-14.46	30	-44.46	29.5	-43.96	0-360
5	27.15778	15.59	Pk	12.8	.7	-40	-10.91	30	-40.91	29.5	-40.41	0-360
3	28.6648	14.66	Pk	12.9	.7	-40	-11.74	30	-41.74	29.5	-41.24	0-360
6	29.23282	20.38	Pk	12.9	.7	-40	-6.02	30	-36.02	29.5	-35.52	0-360

Pk - Peak detector

11. AC MAINS LINE CONDUCTED EMISSIONS

LIMITS

FCC §15.207 (a)

Frequency range (MHz)	Limits (dBµV)	
	Quasi-peak	Average
0.15 to 0.50	79	66
0.50 to 30	73	60
Note: The lower limit shall apply at the transition frequencies		

TEST PROCEDURE

ANSI C63.10-2013

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

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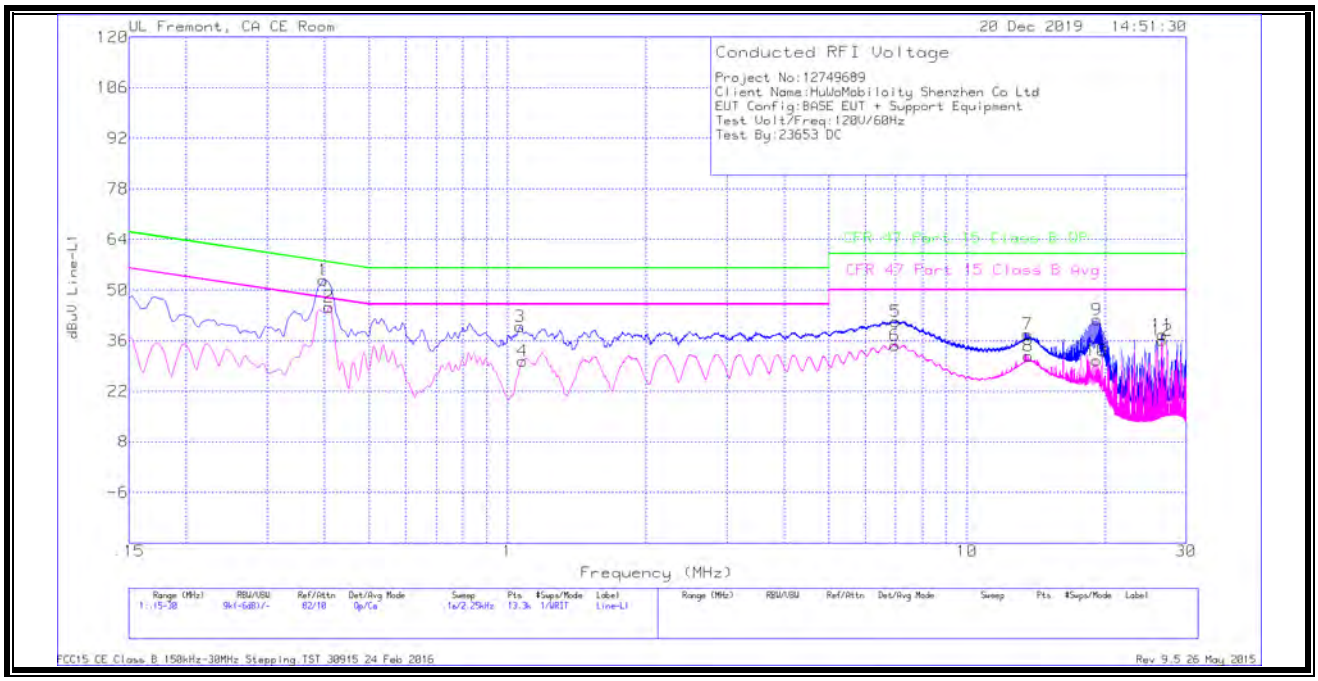
11.1. UHF MODE

11.1.1. LINE 1 RESULTS - BASE



DATA

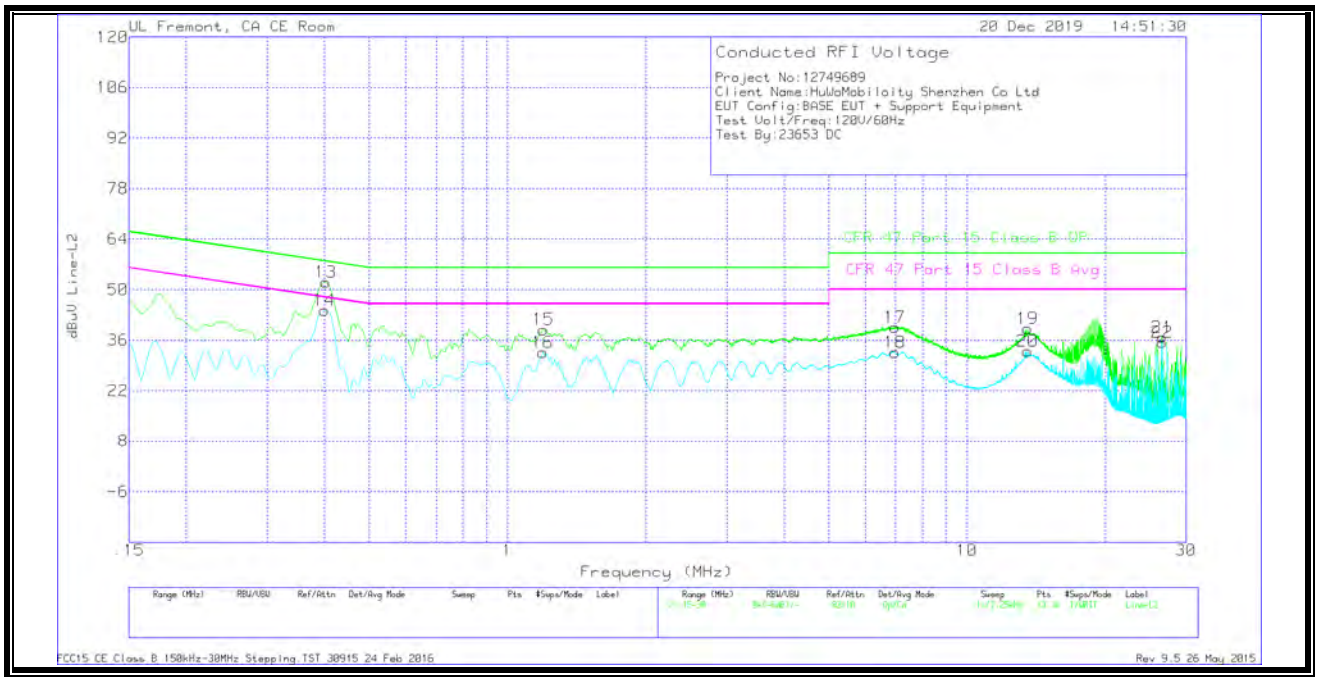
Range 1: Line-L1 .15 - 30MHz

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	.3975	42.64	Qp	0	0	10.1	52.74	57.91	-5.17	-	-
2	.40875	35.29	Ca	0	0	10.1	45.39	-	-	47.67	-2.28
3	1.0635	29.79	Qp	0	.1	10.1	39.99	56	-16.01	-	-
4	1.07925	20.15	Ca	0	.1	10.1	30.35	-	-	46	-15.65
5	6.99	30.95	Qp	0	.2	10.2	41.35	60	-18.65	-	-
6	6.97763	24.36	Ca	0	.2	10.2	34.76	-	-	50	-15.24
7	13.56	27.29	Qp	.1	.2	10.2	37.79	60	-22.21	-	-
8	13.60275	21.29	Ca	.1	.2	10.2	31.79	-	-	50	-18.21
9	19.15125	31.19	Qp	.1	.3	10.3	41.89	60	-18.11	-	-
10	19.158	19.81	Ca	.1	.3	10.3	30.51	-	-	50	-19.49
11	26.61	26.8	Qp	.1	.3	10.5	37.7	60	-22.3	-	-
12	26.61	25.17	Ca	.1	.3	10.5	36.07	-	-	50	-13.93

Qp - Quasi-Peak detector

Ca - CISPR average detection

11.1.2. LINE 2 RESULTS - BASE



DATA

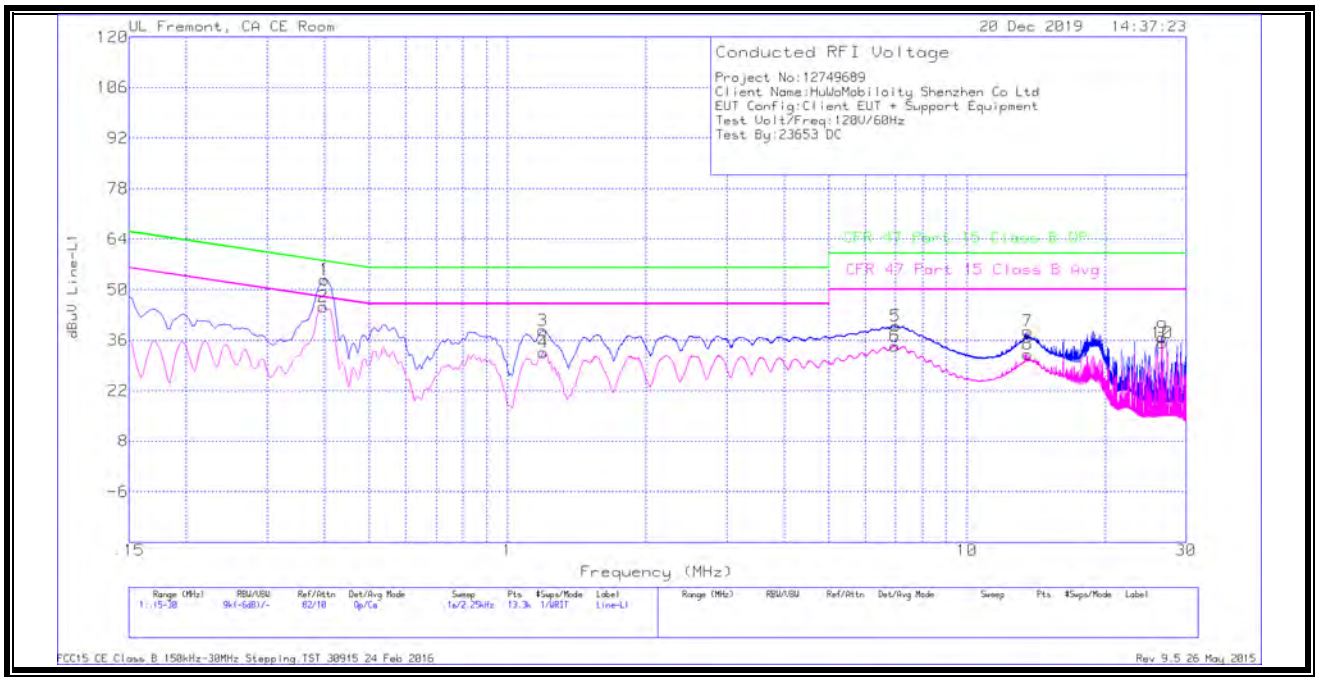
Range 2: Line-L2 .15 - 30MHz

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	.402	41.98	Qp	0	0	10.1	52.08	57.81	-5.73	-	-
14	.39975	34.24	Ca	0	0	10.1	44.34	-	-	47.86	-3.52
15	1.19625	28.76	Qp	0	.1	10.1	38.96	56	-17.04	-	-
16	1.194	22.38	Ca	0	.1	10.1	32.58	-	-	46	-13.42
17	6.96525	29.16	Qp	0	.2	10.2	39.56	60	-20.44	-	-
18	6.96525	22.27	Ca	0	.2	10.2	32.67	-	-	50	-17.33
19	13.56	28.76	Qp	.1	.2	10.2	39.26	60	-20.74	-	-
20	13.56	22.49	Ca	.1	.2	10.2	32.99	-	-	50	-17.01
21	26.61	25.95	Qp	.1	.3	10.5	36.85	60	-23.15	-	-
22	26.61	24.46	Ca	.1	.3	10.5	35.36	-	-	50	-14.64

Qp - Quasi-Peak detector

Ca - CISPR average detection

11.1.3. LINE 1 RESULTS - CLIENT



DATA

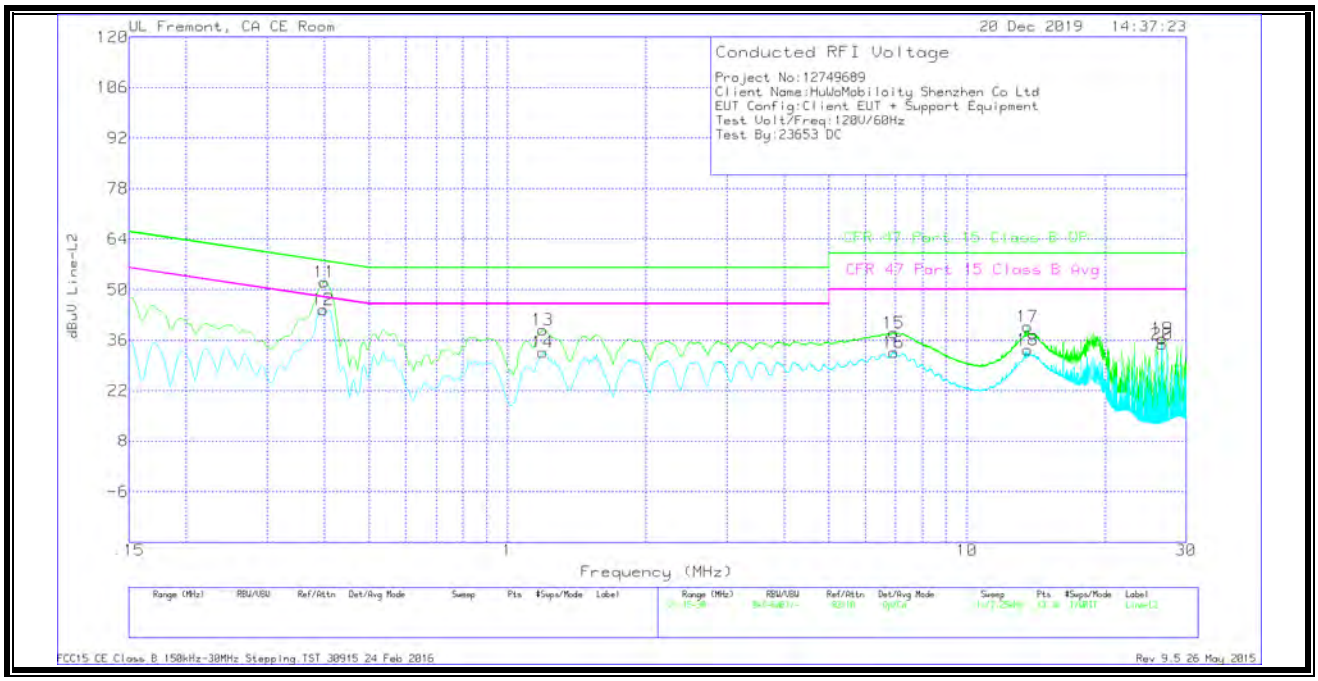
Range 1: Line-L1 .15 - 30MHz

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	.39975	42.67	Qp	0	0	10.1	52.77	57.86	-5.09	-	-
2	.3975	35.19	Ca	0	0	10.1	45.29	-	-	47.91	-2.62
3	1.194	28.48	Qp	0	.1	10.1	38.68	56	-17.32	-	-
4	1.19625	22.48	Ca	0	.1	10.1	32.68	-	-	46	-13.32
5	6.981	29.51	Qp	0	.2	10.2	39.91	60	-20.09	-	-
6	6.96075	24.04	Ca	0	.2	10.2	34.44	-	-	50	-15.56
7	13.56	27.99	Qp	.1	.2	10.2	38.49	60	-21.51	-	-
8	13.56	21.68	Ca	.1	.2	10.2	32.18	-	-	50	-17.82
9	26.61	25.92	Qp	.1	.3	10.5	36.82	60	-23.18	-	-
10	26.61	24.35	Ca	.1	.3	10.5	35.25	-	-	50	-14.75

Qp - Quasi-Peak detector

Ca - CISPR average detection

11.1.4. LINE 2 RESULTS - CLIENT



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)
11	.39975	42	Qp	0	0	10.1	52.1	57.86	-5.76	-	-
12	.3975	34.33	Ca	0	0	10.1	44.43	-	-	47.91	-3.48
13	1.194	28.61	Qp	0	.1	10.1	38.81	56	-17.19	-	-
14	1.194	22.48	Ca	0	.1	10.1	32.68	-	-	46	-13.32
15	6.9225	27.67	Qp	0	.2	10.2	38.07	60	-21.93	-	-
16	6.91913	22.19	Ca	0	.2	10.2	32.59	-	-	50	-17.41
17	13.56	29.28	Qp	.1	.2	10.2	39.78	60	-20.22	-	-
18	13.56	22.75	Ca	.1	.2	10.2	33.25	-	-	50	-16.75
19	26.61	25.5	Qp	.1	.3	10.5	36.4	60	-23.6	-	-
20	26.61	24.03	Ca	.1	.3	10.5	34.93	-	-	50	-15.07

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.

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 3.8 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

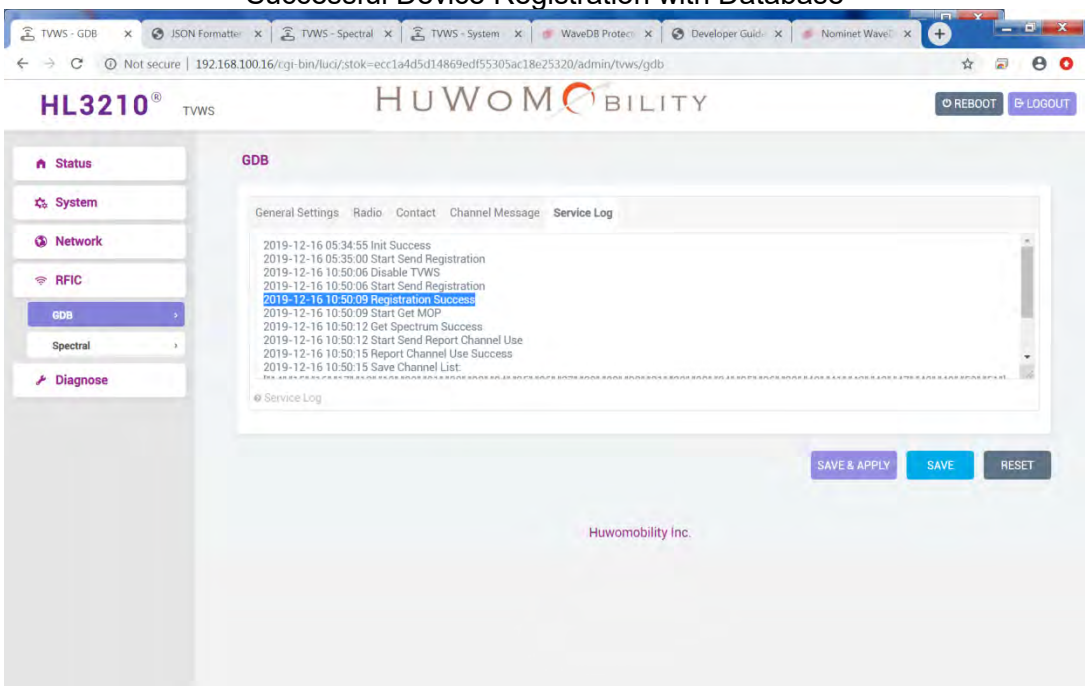
- Configure the base EUT with correct registration information:
    - The FCC ID and serial number are permanently programmed to the device and cannot be modified.
    - Known acceptable geographic coordinates, antenna height AGL and contact information were entered into the EUT.
- The base EUT automatically 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

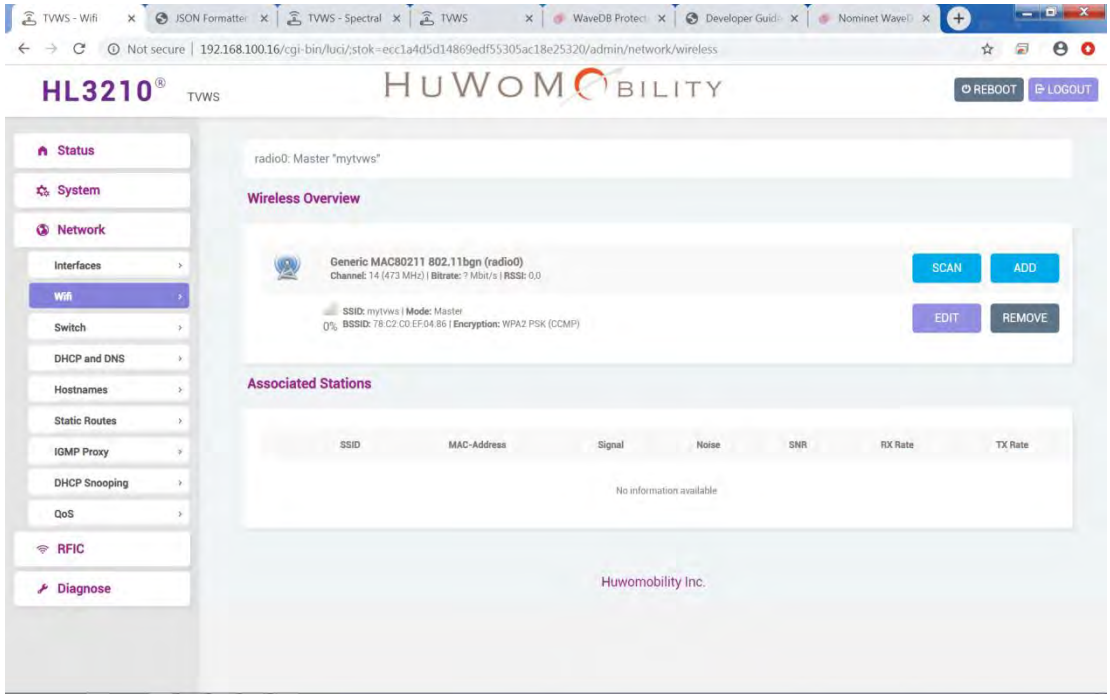
The EUT successfully registered when correct registration information was submitted to the TVWS Database. The EUT transmission was observed on the spectrum analyzer on the selected TV channel from the returned channel list from the TVWS Database.

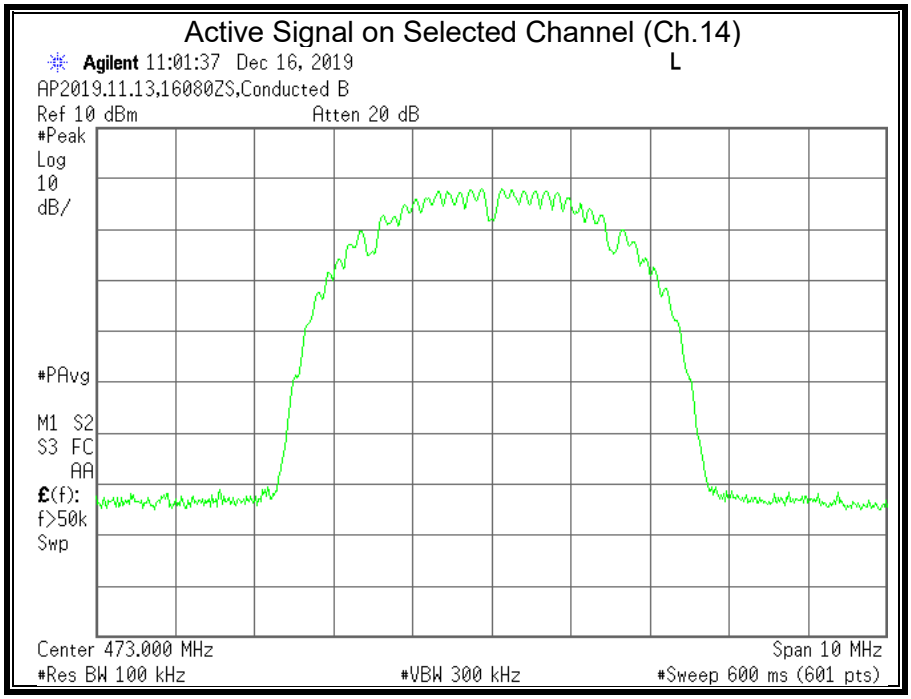
Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	16080ZS	12/16/2019

Successful Device Registration with Database



Channel selection from Database





12.1.2. FAILED REGISTRATION – Location Coordinates

TEST PROCEDURE

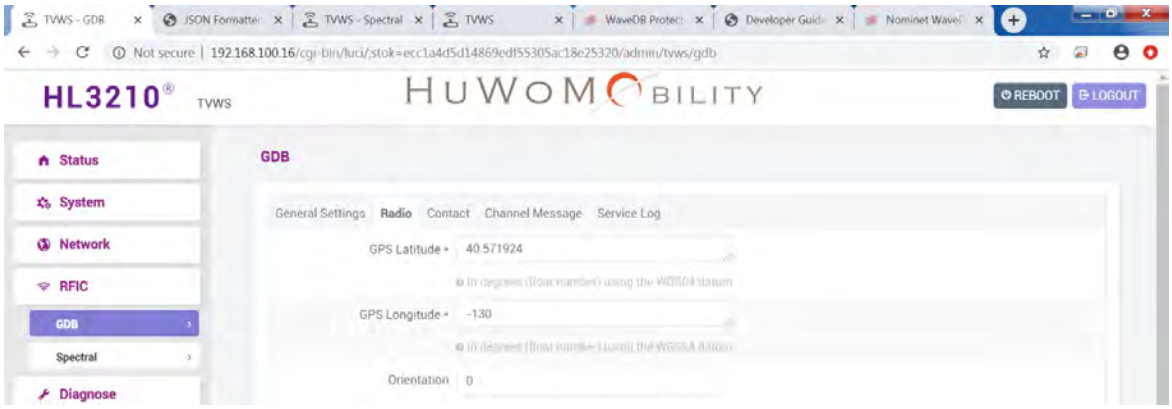
- Configure the EUT with restricted coordinates: LAT=40° 34' 18.9264" (40.571924), LNG=-130° 0' 0" (-130) which is a location that is prohibited to transmit
- Observe the base EUT registration failure indicated by the database message

RESULT

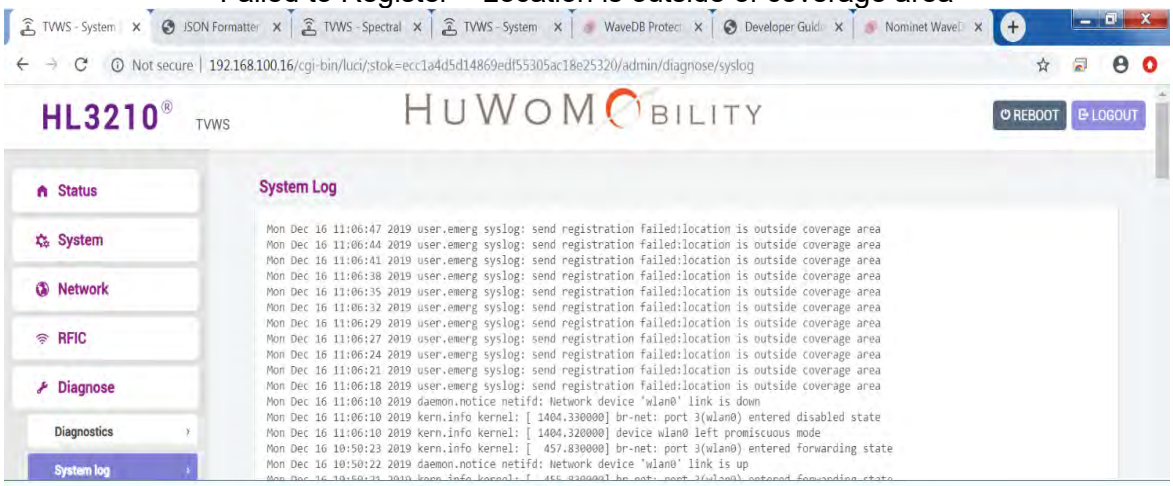
The base EUT failed to register when restricted coordinates information were submitted to the TVWS Database.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	16080ZS	12/16/2019

Failed Registration Coordinates



Failed to Register – Location is outside of coverage area



12.1.3. FAILED REGISTRATION – ANTENNA HEIGHT AGL

TEST PROCEDURE

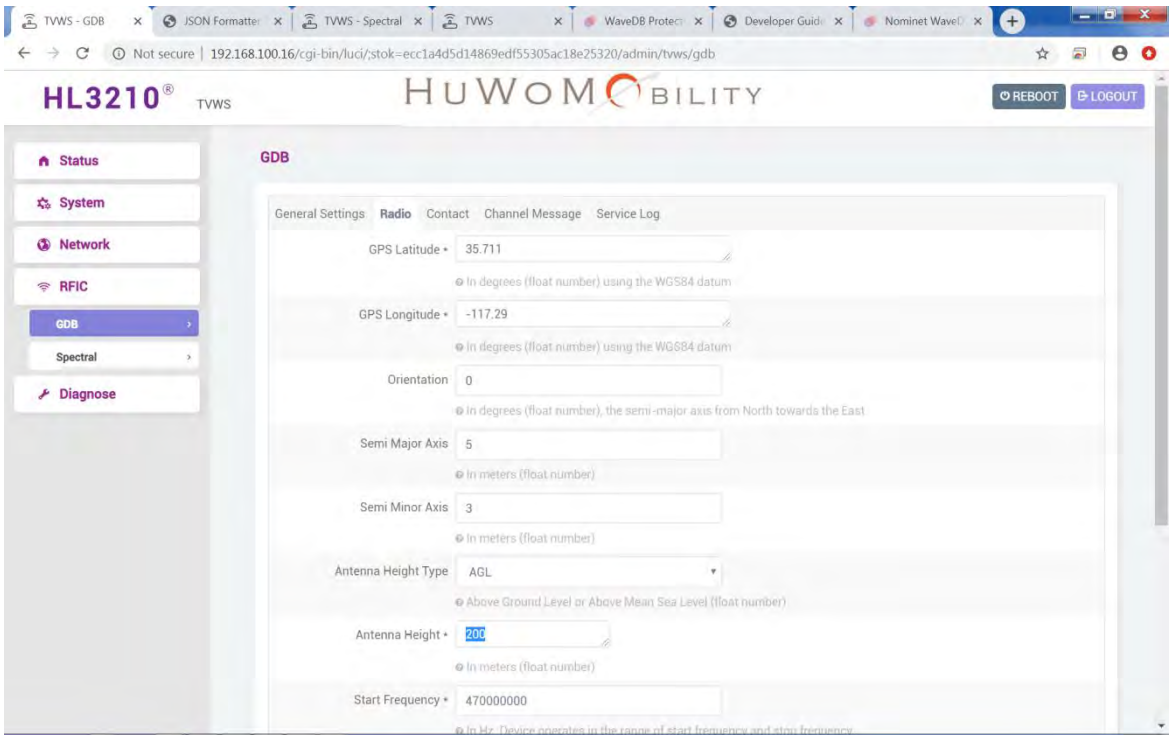
- Configure the EUT with antenna height Above Ground Level (AGL) > 30 meters.
- Observe the base registration failure indicated by the database message.

RESULTS

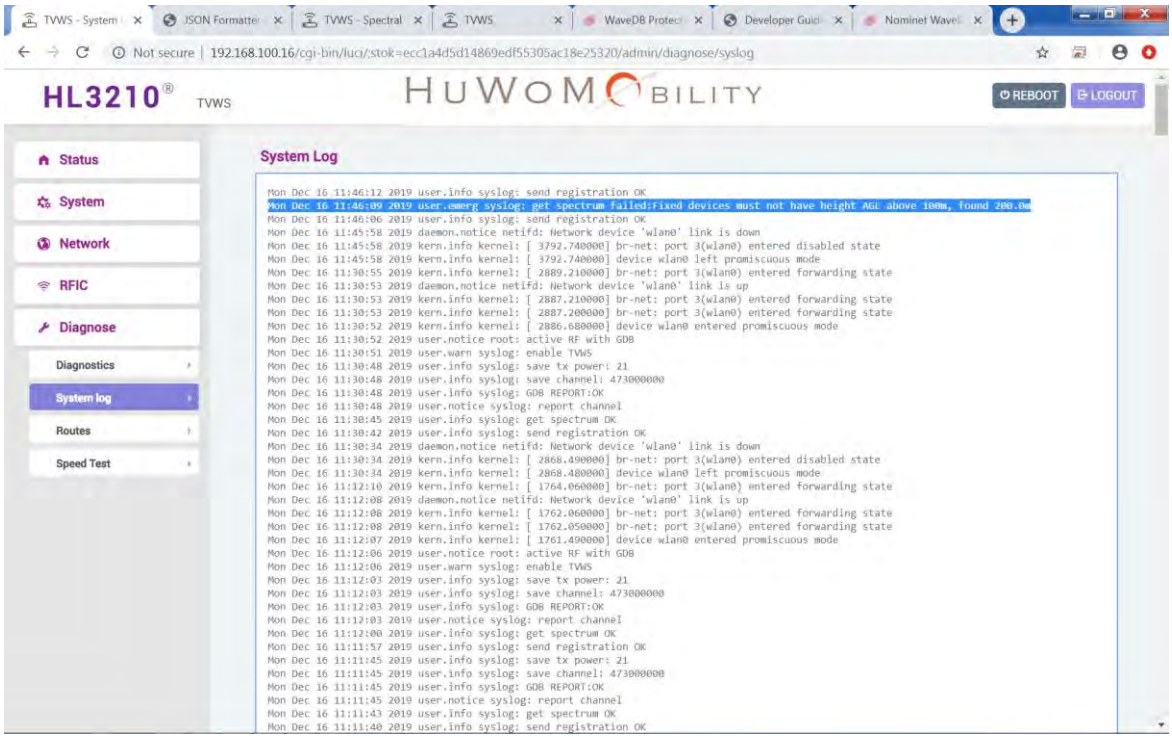
The base EUT failed to register when it is set to a location with antenna AGL above the limit.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	16080ZS	12/16/2019

Antenna AGL Set > 30m (200m)



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



12.1.4. FAILED REGISTRATION –CONTACT INFORMATION

TEST PROCEDURE

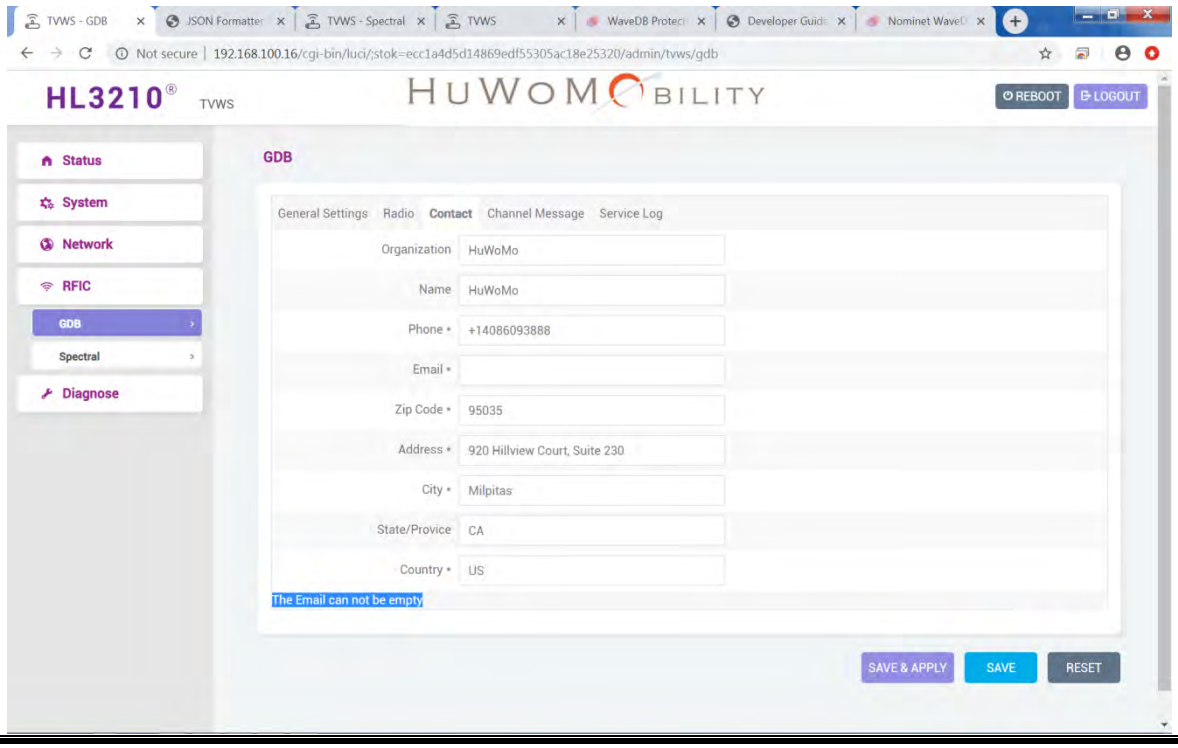
- Configure the base EUT with missing contact information, e.g. email.
- The device software cannot proceed with registration and prompts user to enter the missing information.

RESULTS

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

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	16080ZS	12/16/2019

Contact information missing field
(Email cannot be empty)



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

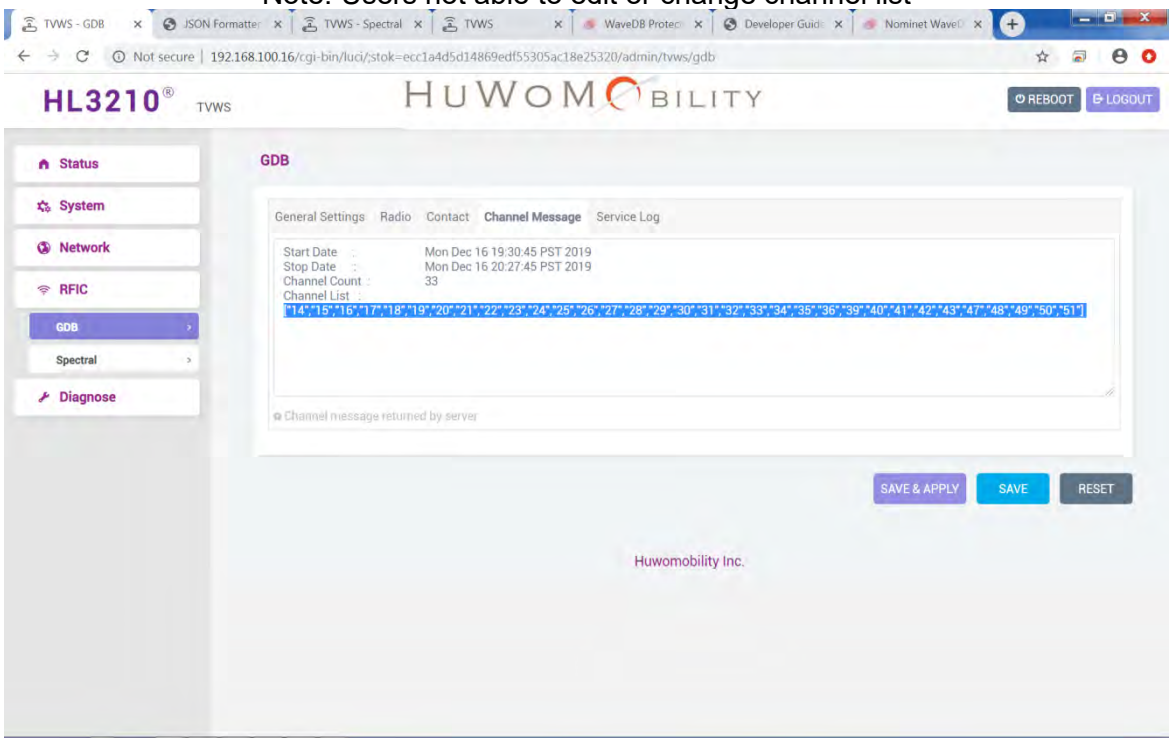
- The base EUT geographic coordinates are entered at registration time and stored in the device. The device channel list request uses the same coordinates established at registration time. No separate coordinates can be entered for channel list request.
- The device requires professional installation 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**
☒	☐	16080ZS	12/16/2019

Channel list after successful registration
Note: Users not able to edit or change channel list



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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

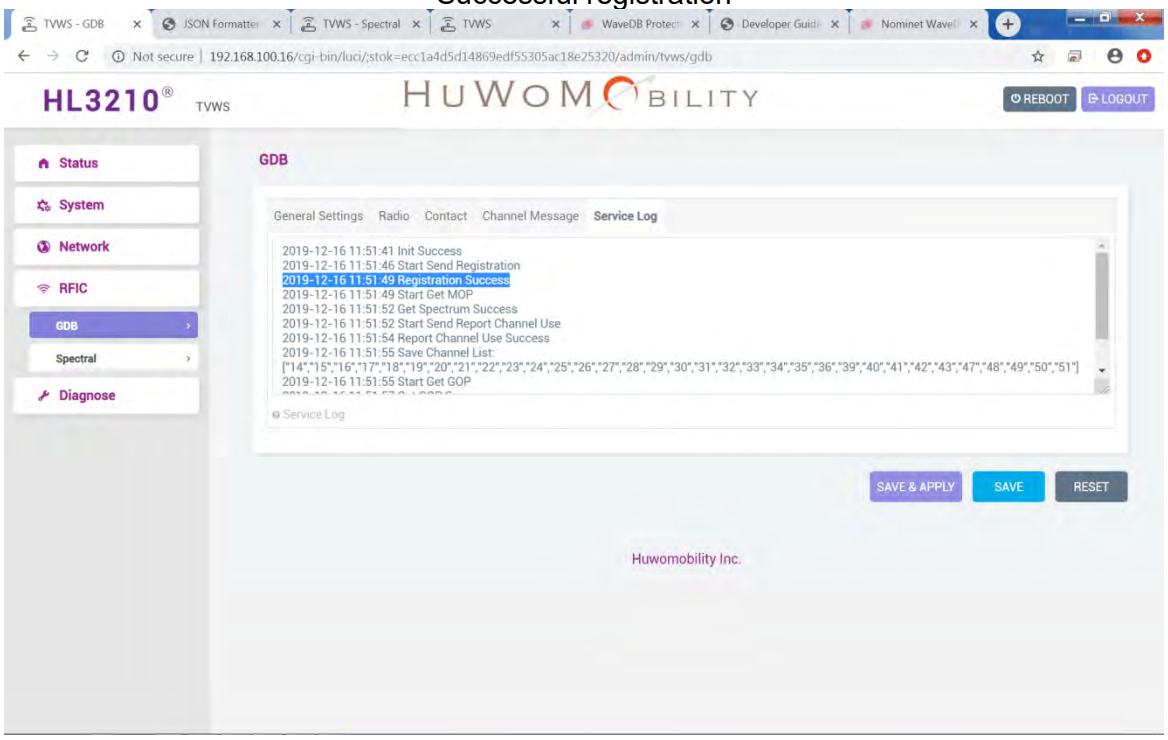
- Set the base EUT to normal operation mode:
  - Enter proper registration information on the base.
  - Base contacts the TVWS to perform registration.
  - Base contacts the TVWS to retrieve channel list.
  - Select an operating channel from returned channel list.
  - Enable base transmission.
- Observe 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

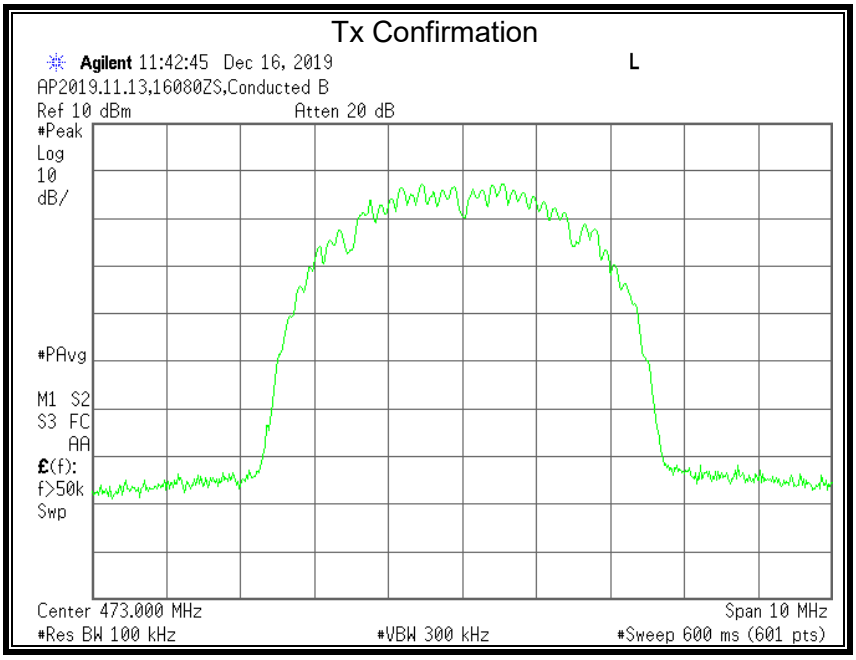
During normal operation, the base and client channel lists are updated periodically by sending channel list requests to the TVWS Database. For test purposes this time period was shortened. After the database access was blocked, the next channel list requests failed and the EUTs stopped transmission immediately.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	16080ZS	12/16/2019

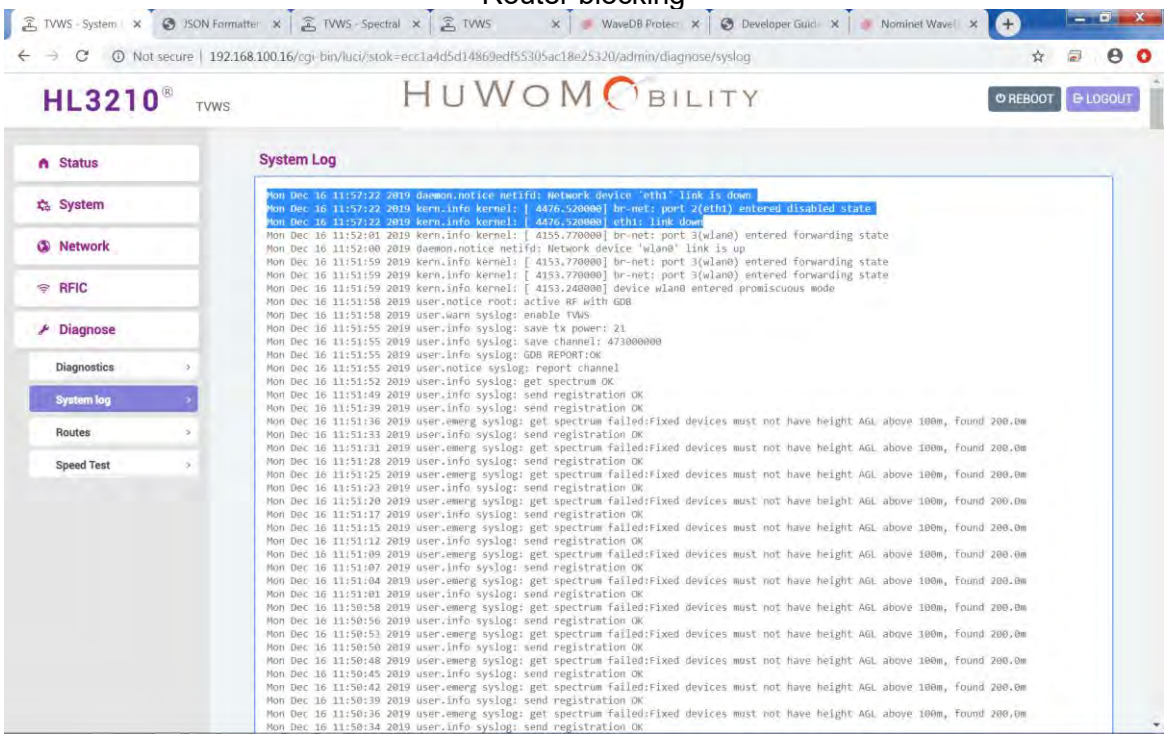
Successful registration



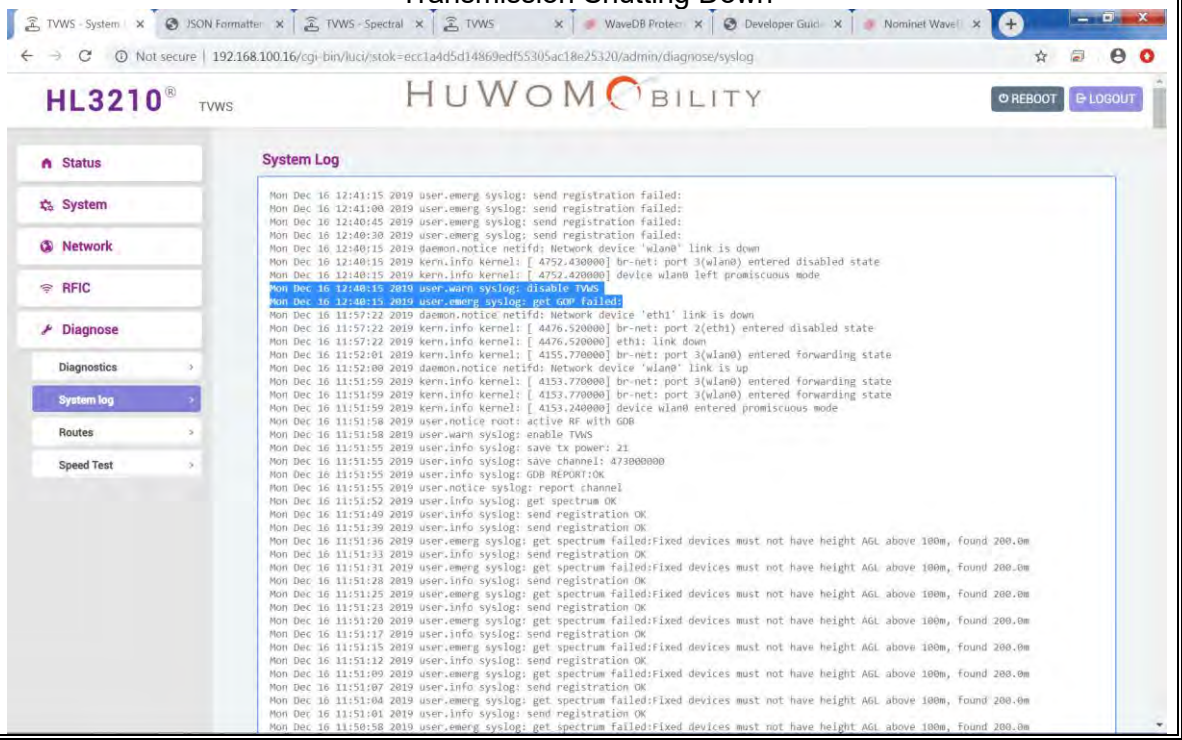
Tx Confirmation



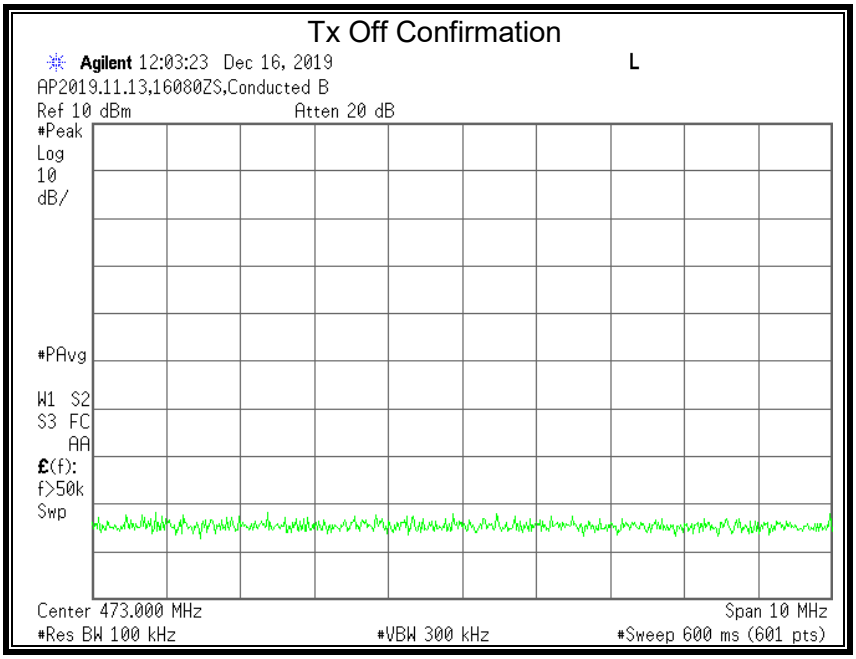
Router blocking



Transmission Shutting Down



Tx Off Confirmation



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.

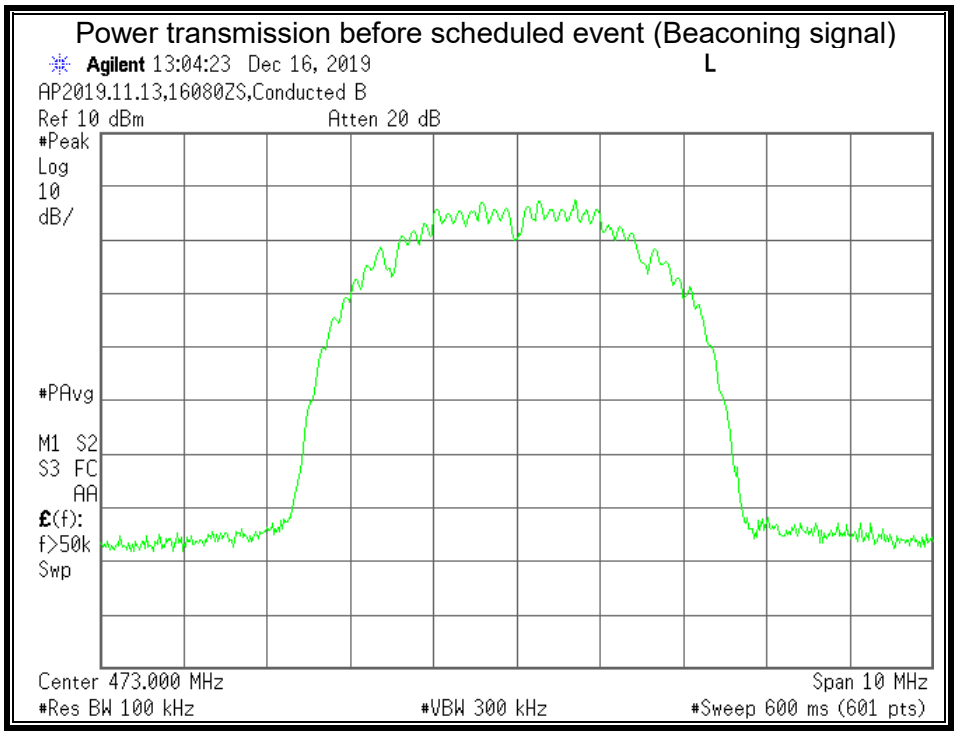
TEST PROCEDURE

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 auxiliary 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

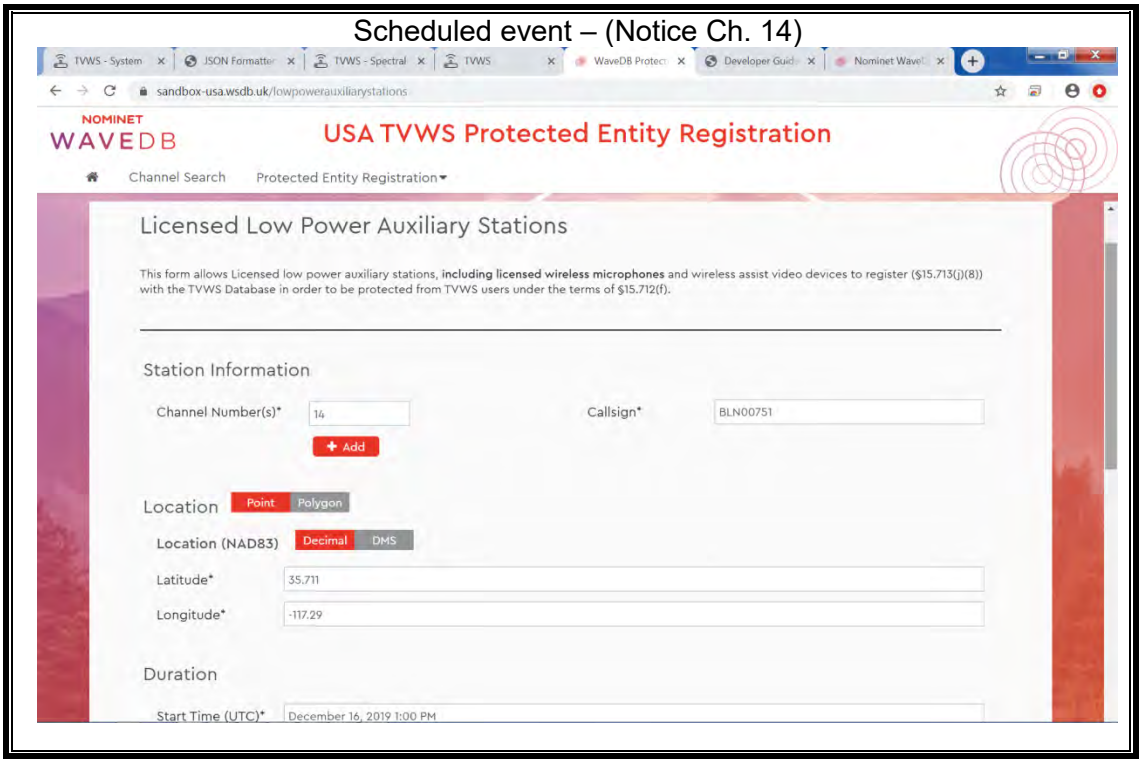
Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	16080ZS	12/16/2019

12.4.1. RESULTS FOR BASE

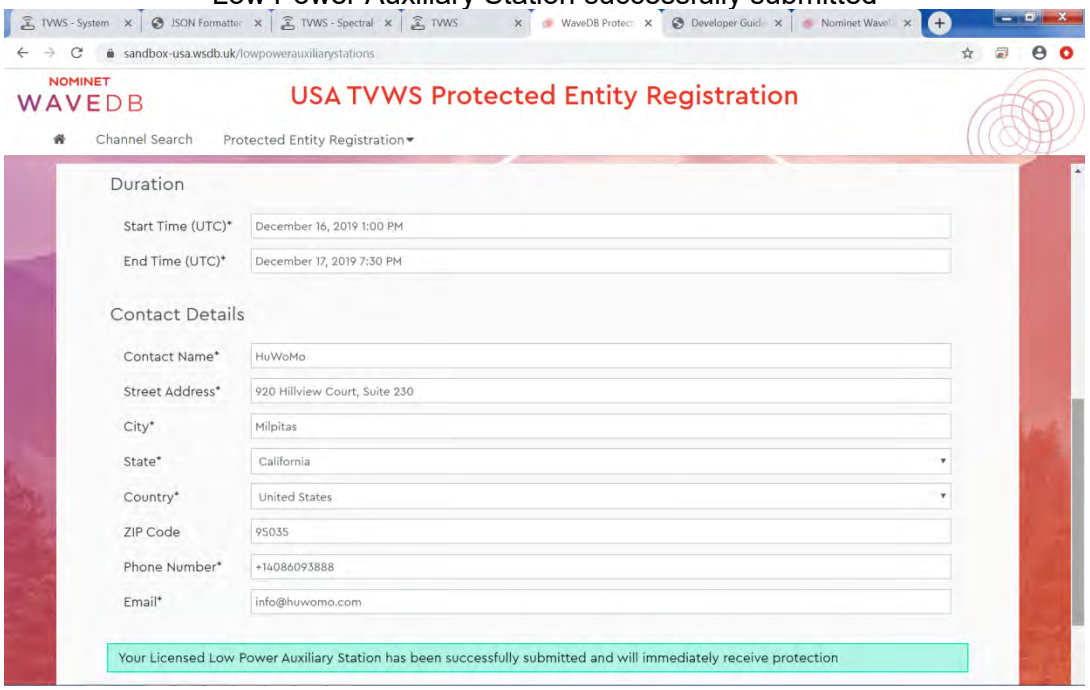
Power transmission before scheduled event (Beaconing signal)



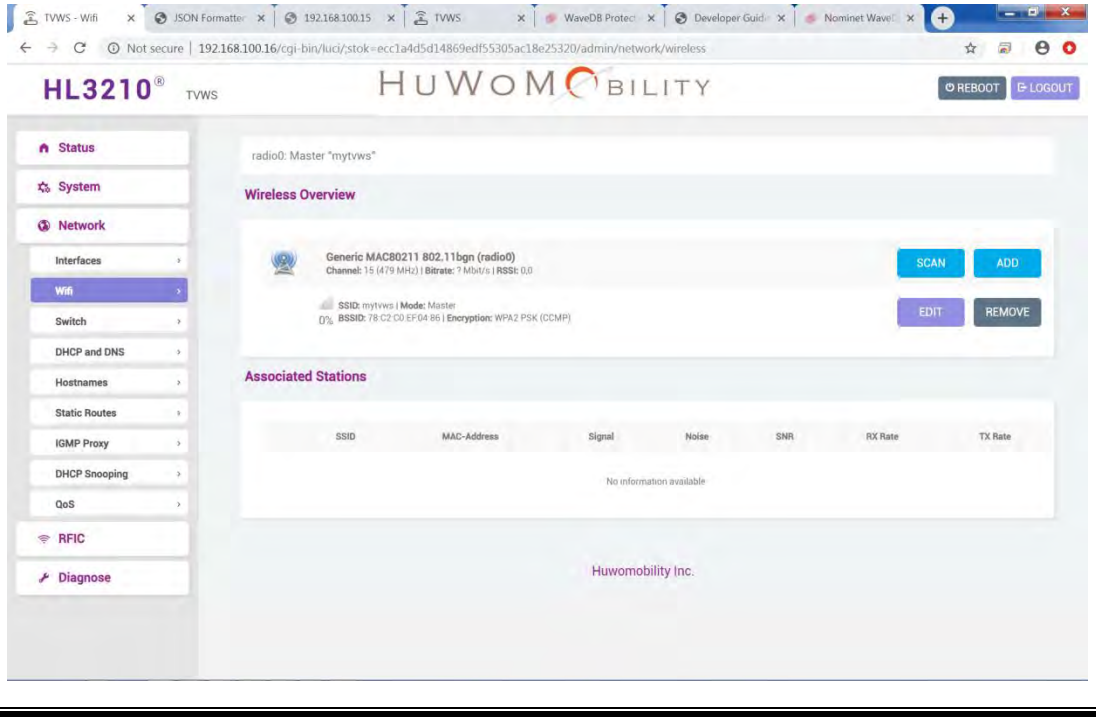
Scheduled event – (Notice Ch. 14)

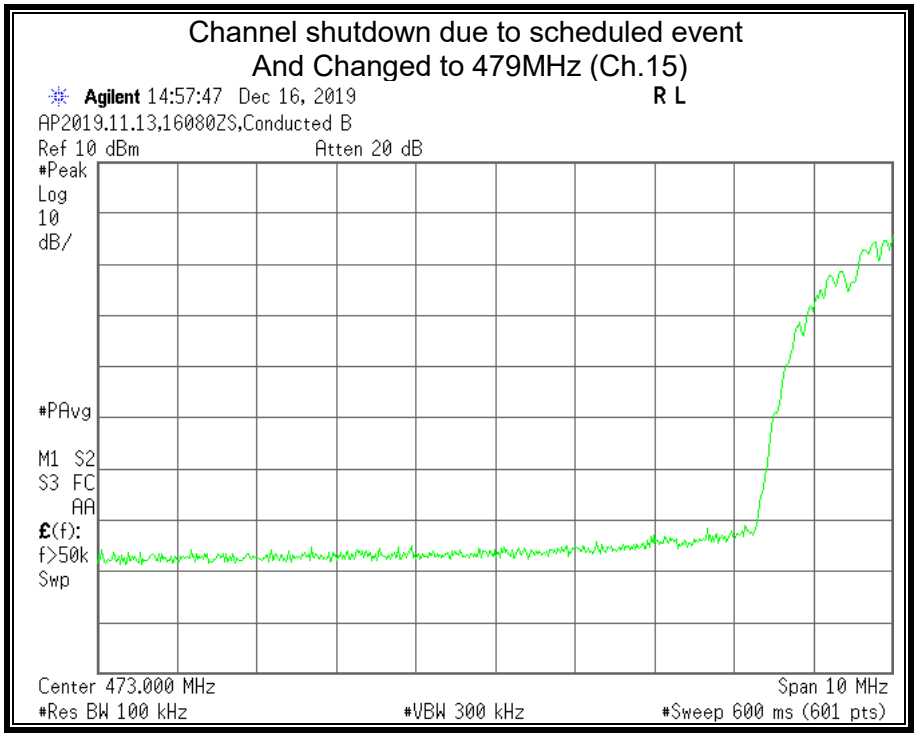


Low Power Auxiliary Station successfully submitted



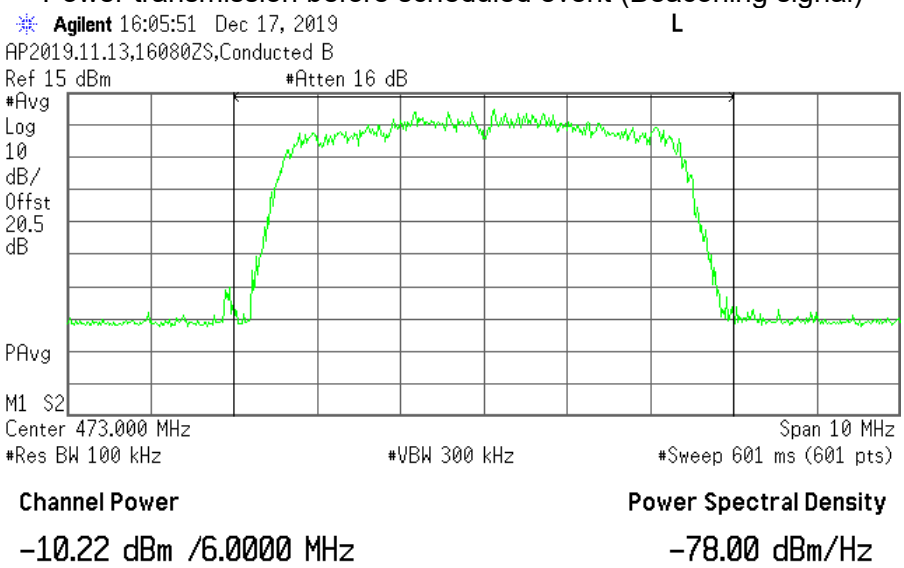
Channel 15 now selected



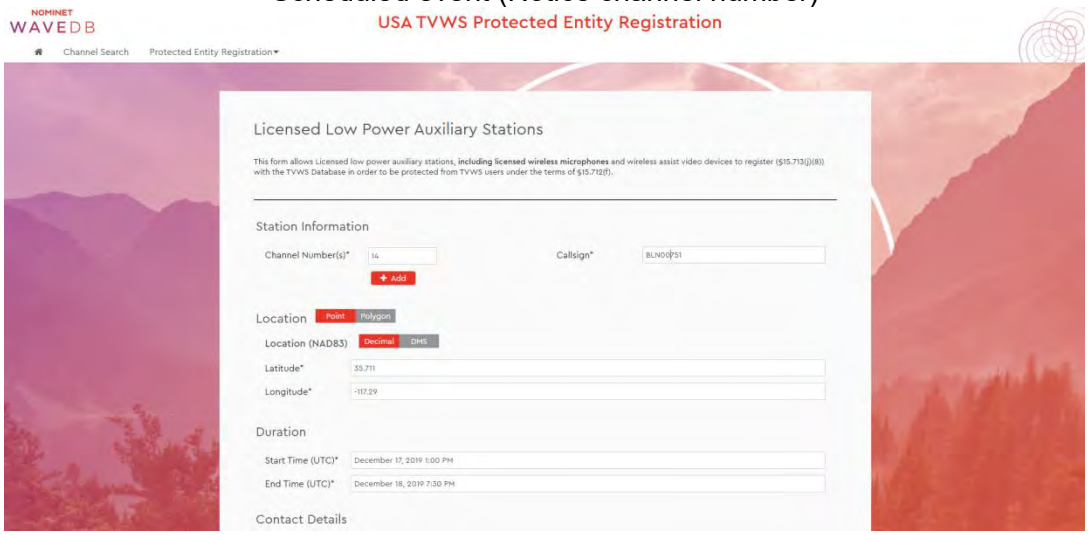


12.4.2. RESULTS FOR CLIENT

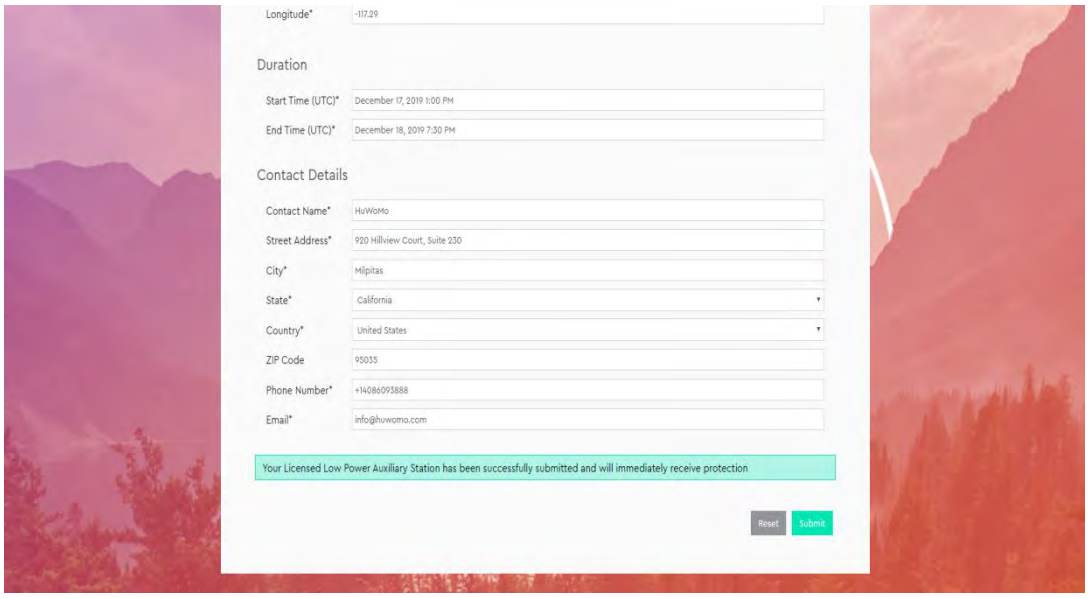
Power transmission before scheduled event (Beaconing signal)



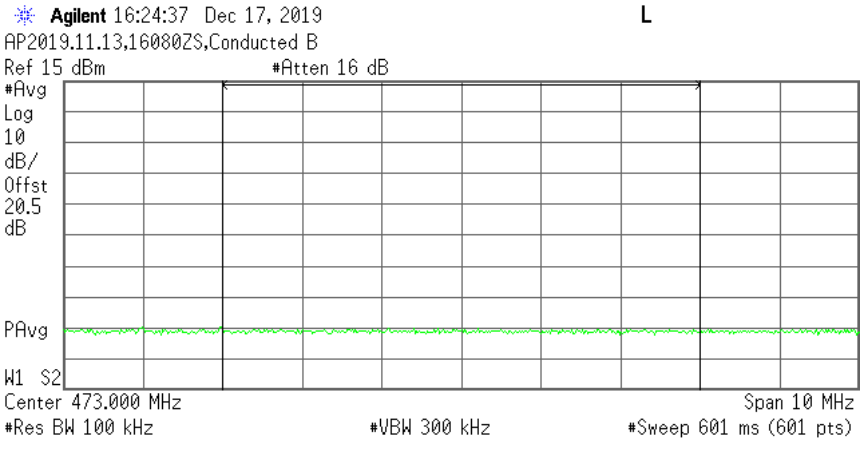
Scheduled event (Notice channel number)



Low Power Auxiliary Station successfully submitted



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

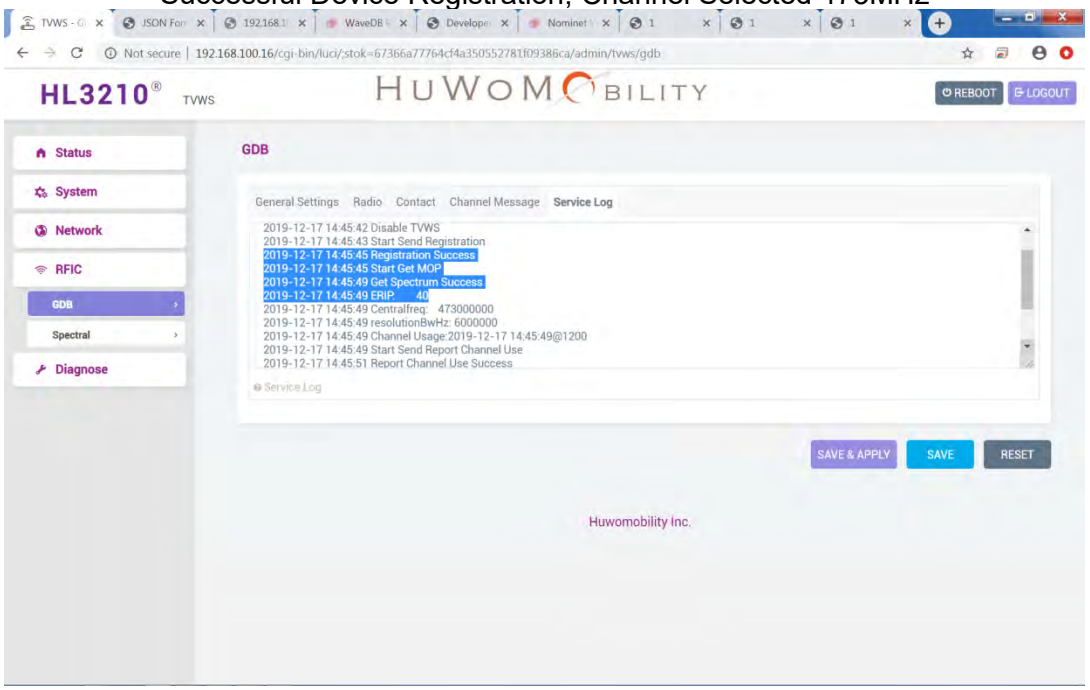
- Configure the base EUT with correct registration information.
- The base EUT automatically contacts the TVWS Database to perform device registration.
- Upon successful registration, base automatically contacts the TVWS Database to retrieve device channels.
- Confirm the base EUT software only allows 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

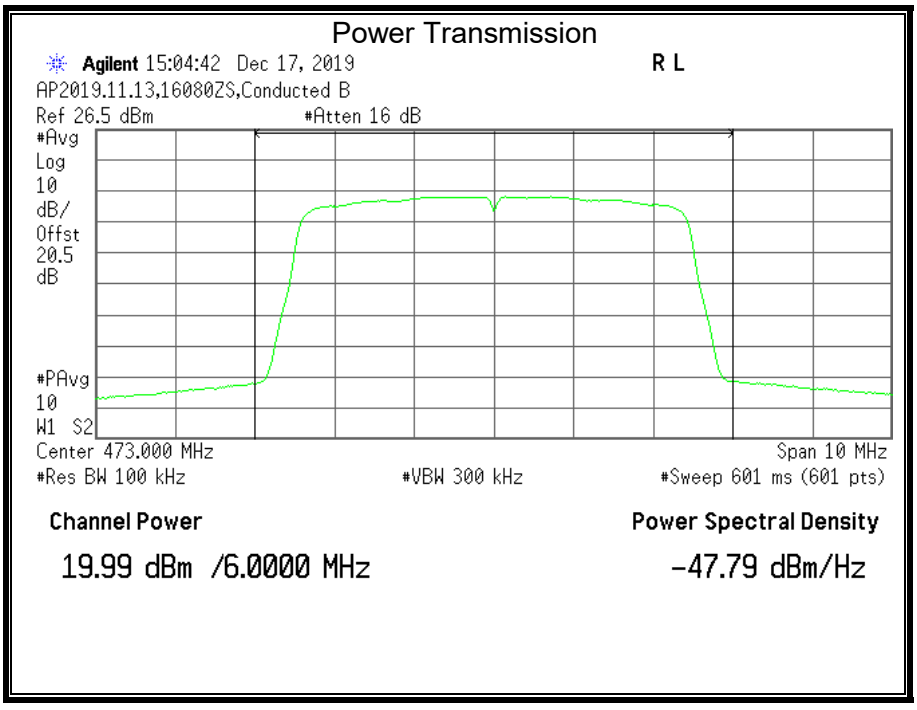
The EUT operates on a channel from the authorized channel list and at the authorized power level. The EUT cannot select and operate on any channel other than those within the authorized channel list returned from the TVWS Database, which are within the device operating frequency range.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	16080ZS	12/16/2019

Successful Device Registration, Channel Selected 473MHz



Power Transmission



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?

The Fixed WSD (WSD) supports Nominet database; which is certified by the FCC. The IETF PAWS protocol is used to transmit data between WSD and the database; via HTTPS over SSL/TLS.

ii. How are communications initiated?

The WSD initiates secure communication with the Nominet database by initially sending an INIT_REQ message containing a Device Descriptor. The Device Descriptor element contains the following:

- Device serial number
- Manufacturer ID
- Model ID
- FCC ID

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

The identity of the Nominet database is validated through verification of the Nominet SSL/TLS certificate through standard third-party certificate authority mechanisms; ensuring communications are secure and authenticated between the WSD and the database.

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

The radio will not be turn on until the WSD has successfully authenticated, communicated and obtained available channel(s) that can be operated on. After it, the WSD periodically maintains the communication with the database. If the device fails to communicate with the database for a number of times consecutively, the radio will be turned off. And the device will re-try to communicate and authenticate the database periodically.

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

A unique database token installed in the radio during manufacturing is required to validate the exchange. Only devices that have a valid database token can receive communications from the database. The database validates the token against the provided serial number, manufacturer name, model ID and FCC ID. The list of valid serial numbers is communicated from device manufacturer to Nominet via a separate web dashboard where authorized (by Nominet) parties can generate tokens for specific devices

vi. What encryption method is used?

The standard SSL/TLS encryption is used to encrypt packets sent between the WSD and the database.

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

Protected devices are entities authorized by the rules for protection from WSD transmissions. Nominet provides a secure public interface to register protected devices in the database web tool by authorized entities.

12.7. Push notification to Fixed

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**
☒	☐	16080ZS	12/16/2019

12.7.1. RESULTS FOR BASE AND CLIENT

As per the waiver DA-19-960A1 issued by FCC on September 25, 2019, this test is waived till March 31, 2020 for base and client units

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

EUT uses GPS technology for determining location.
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

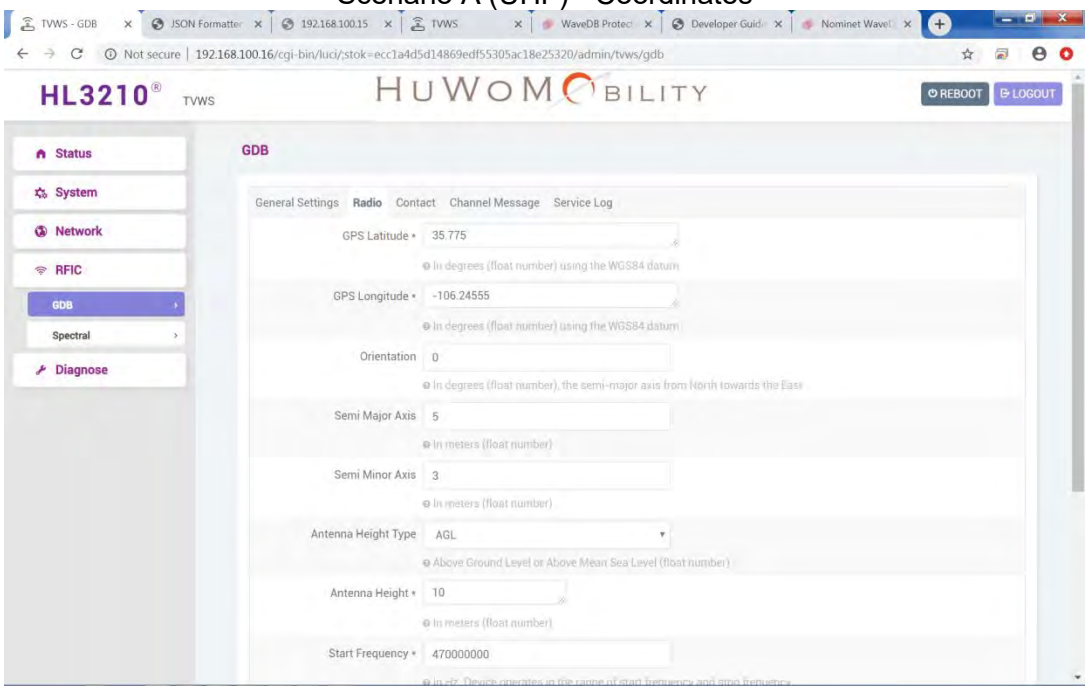
a) Digital television stations, and digital and analog Class A TV, low power TV, TV translator and TV booster stations
b) TV translator, Low power TV(including Class A) and Multi-channel Video Programming Distributor (MVPD)
c) Fixed Broadcast Auxiliary Service (BAS) links
d) PLMR/CMRS operations
e) Offshore 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

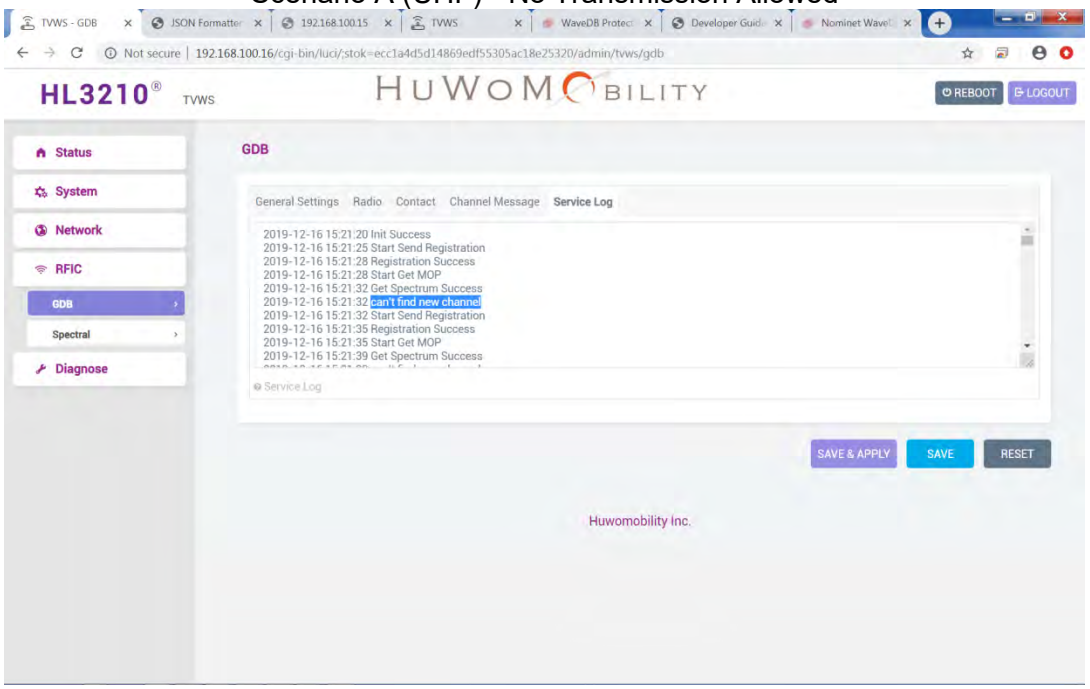
Scenario		Coordinate	Note
a	Digital television stations, and digital and analog Class A TV, low power TV, TV translator and TV booster stations	38.73829, -108.887 (VHF) 35.775, -106.24555 (UHF)	UHF No transmission allowed VHF coordinate cannot transmit on Ch. 13
b	TV translator, Low power TV(including Class A) and Multi-channel Video Programming Distributor (MVPD)	43.80102, -111.778 (UHF) 35.66218, -117.604 (VHF)	UHF coordinate cannot transmit Ch. 23 VHF coordinate cannot transmit Ch. 11
c	Fixed Broadcast Auxiliary Service (BAS) links	41.890417, -87.623694	Cannot transmit on Ch. 28
d	PLMR/CMRS operations	38.954722, -77.004722	Cannot transmit on Ch. 17 and 18
e	Offshore Radio telephone Service	38.954722, -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
☒	☐	16080ZS	12/16/2019

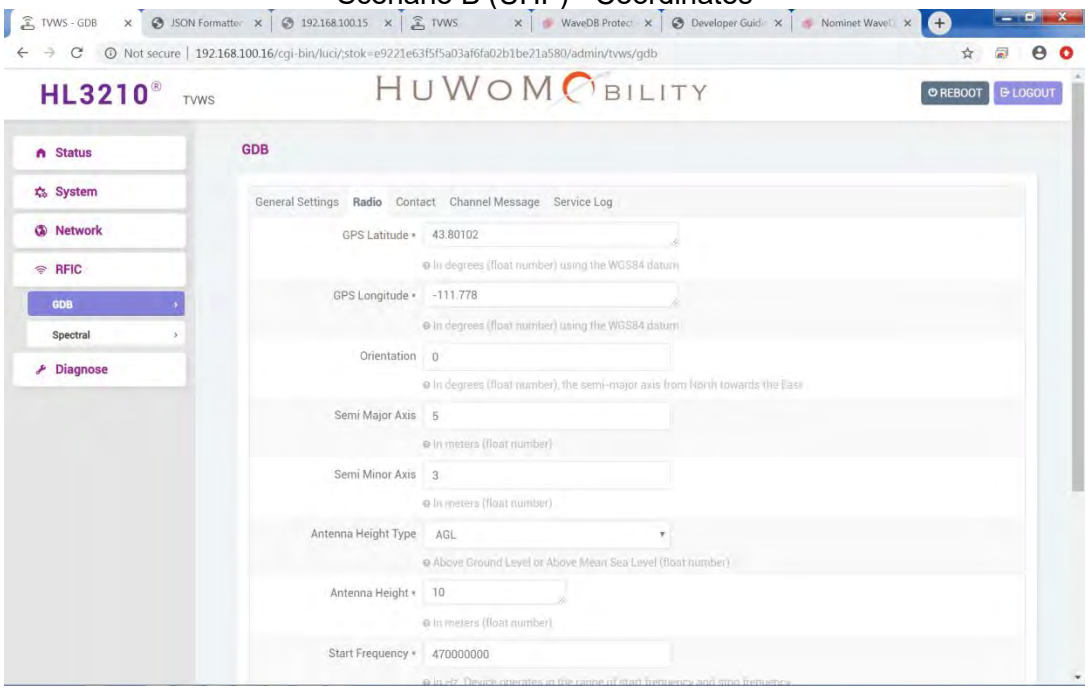
Scenario A (UHF) - Coordinates



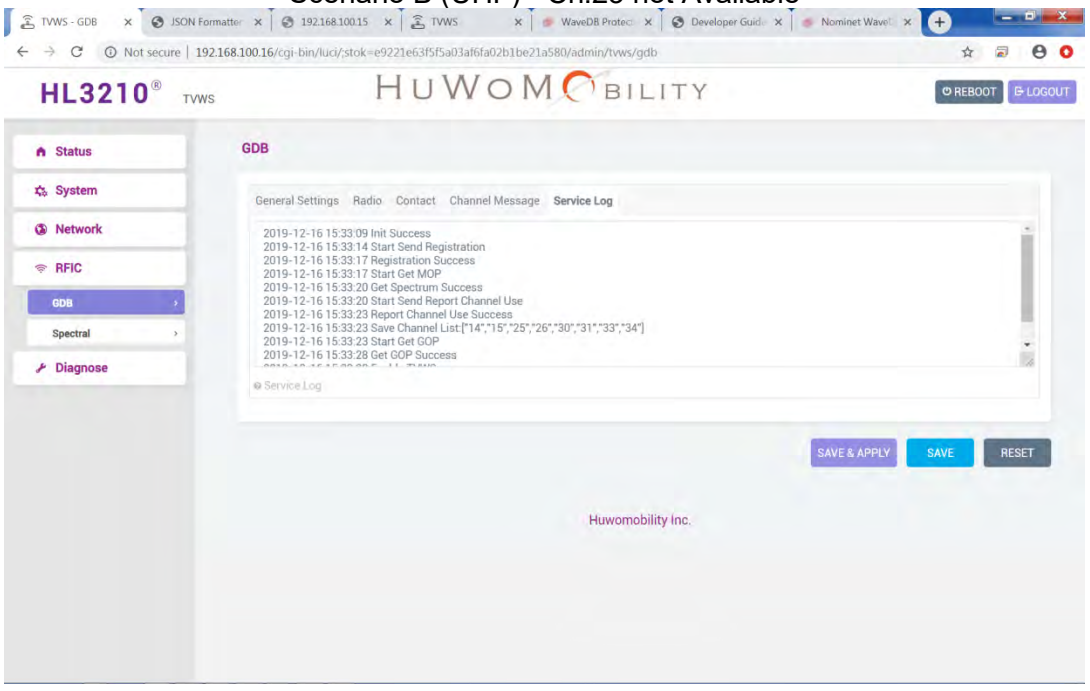
Scenario A (UHF) - No Transmission Allowed



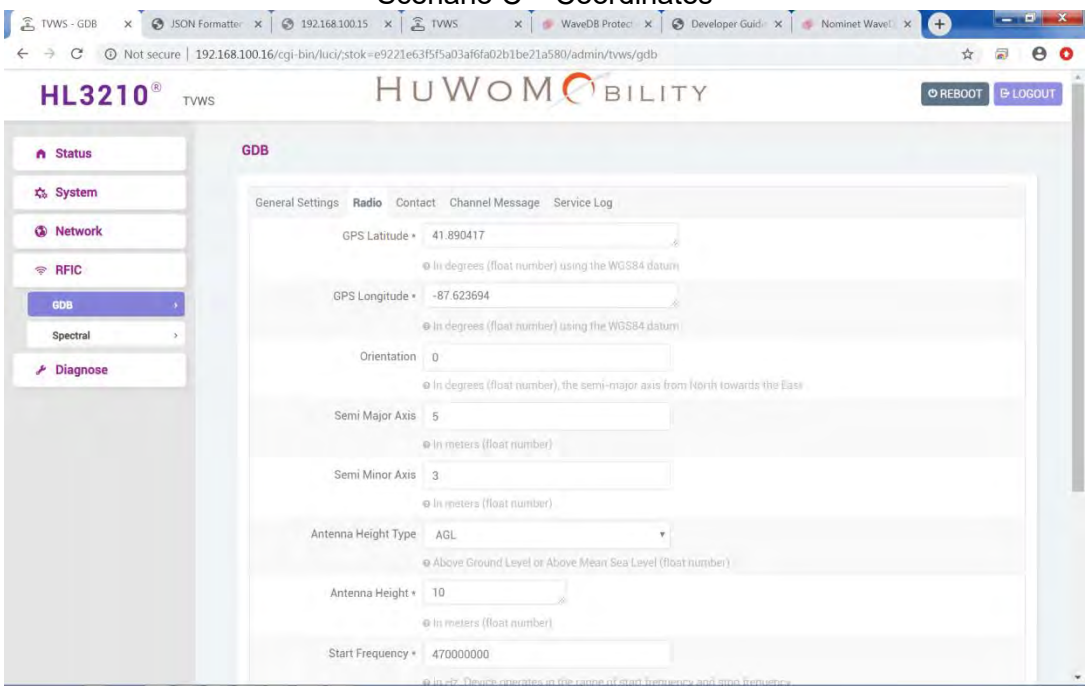
Scenario B (UHF) - Coordinates



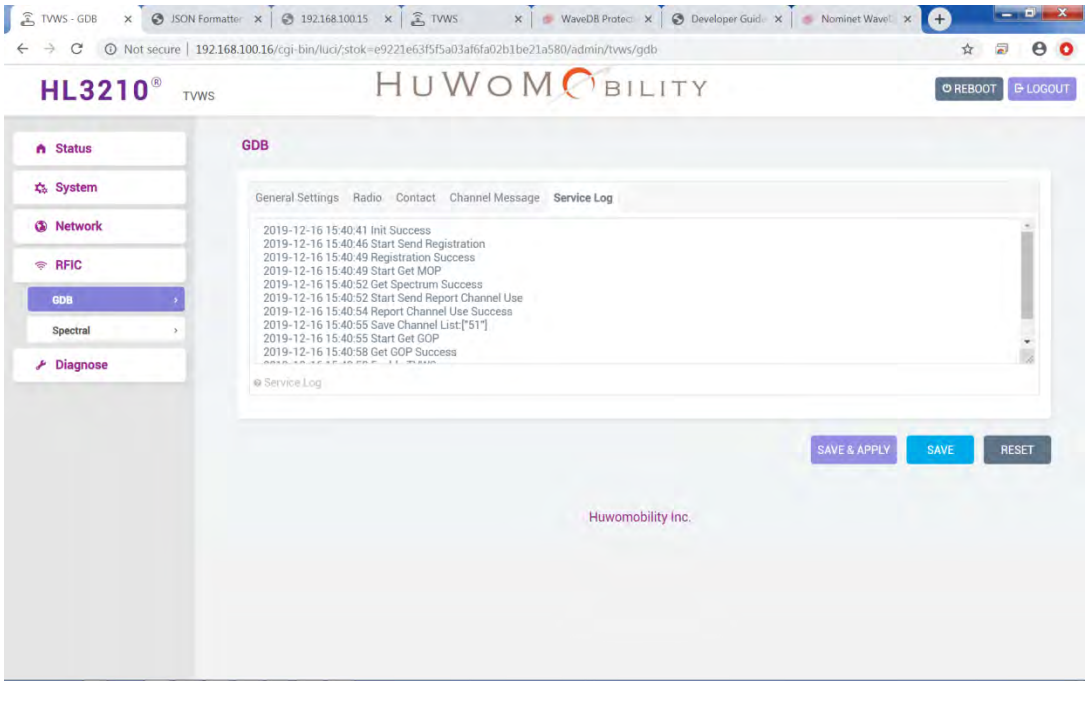
Scenario B (UHF) - Ch.23 not Available



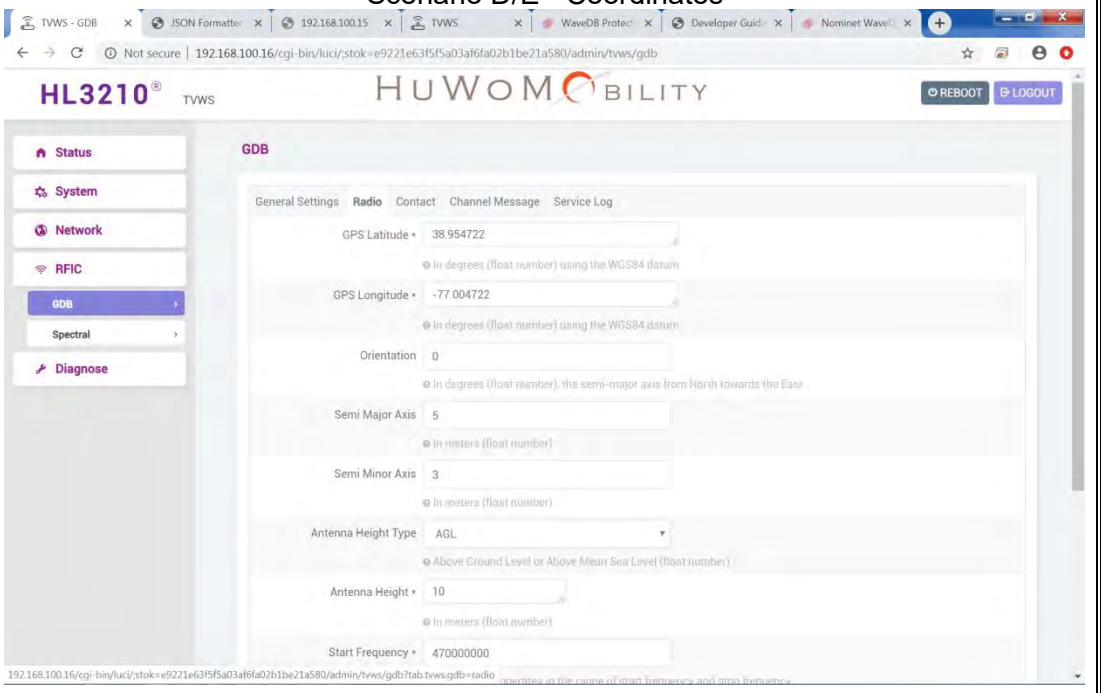
Scenario C – Coordinates



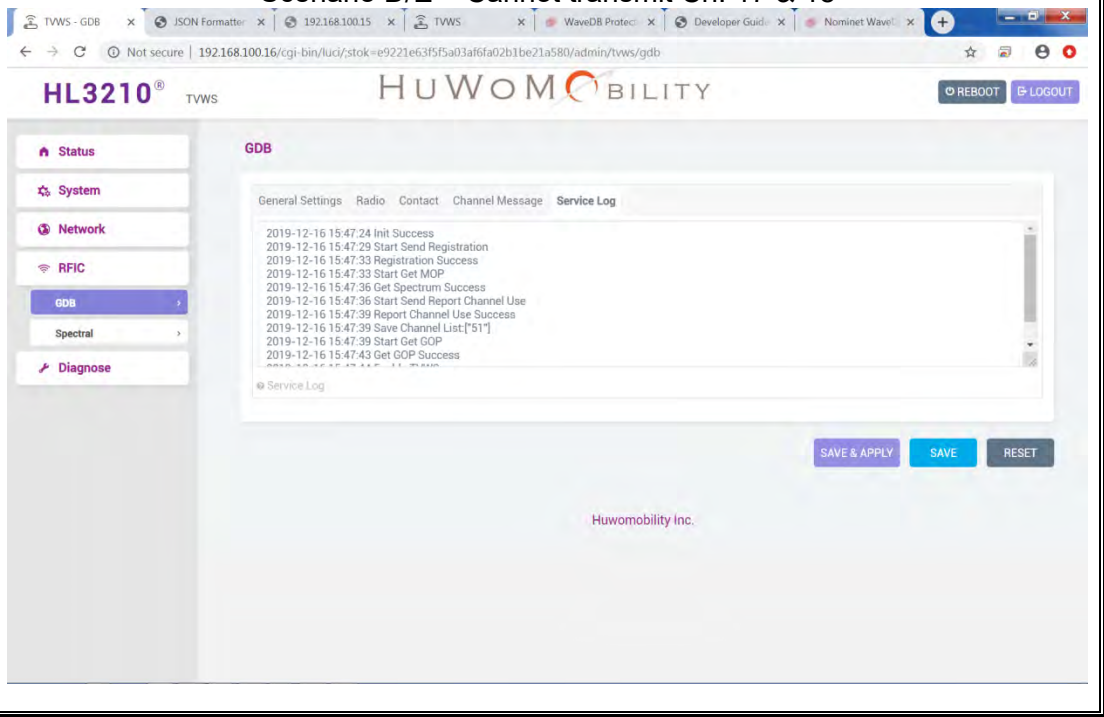
Scenario C – Ch. 28 not allowed



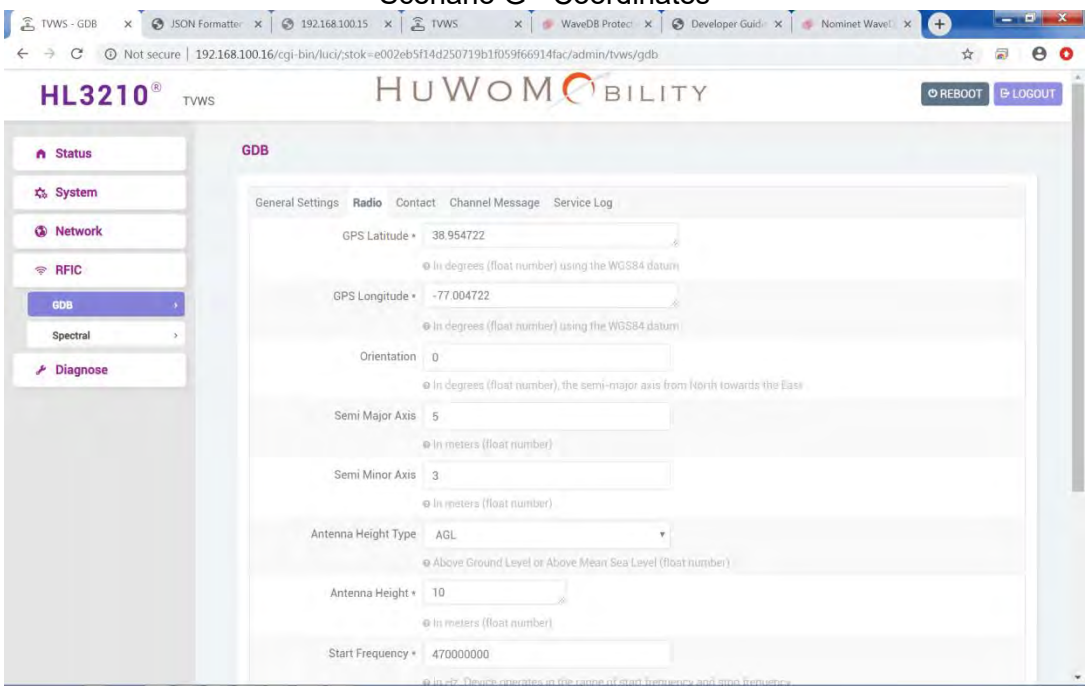
Scenario D/E - Coordinates



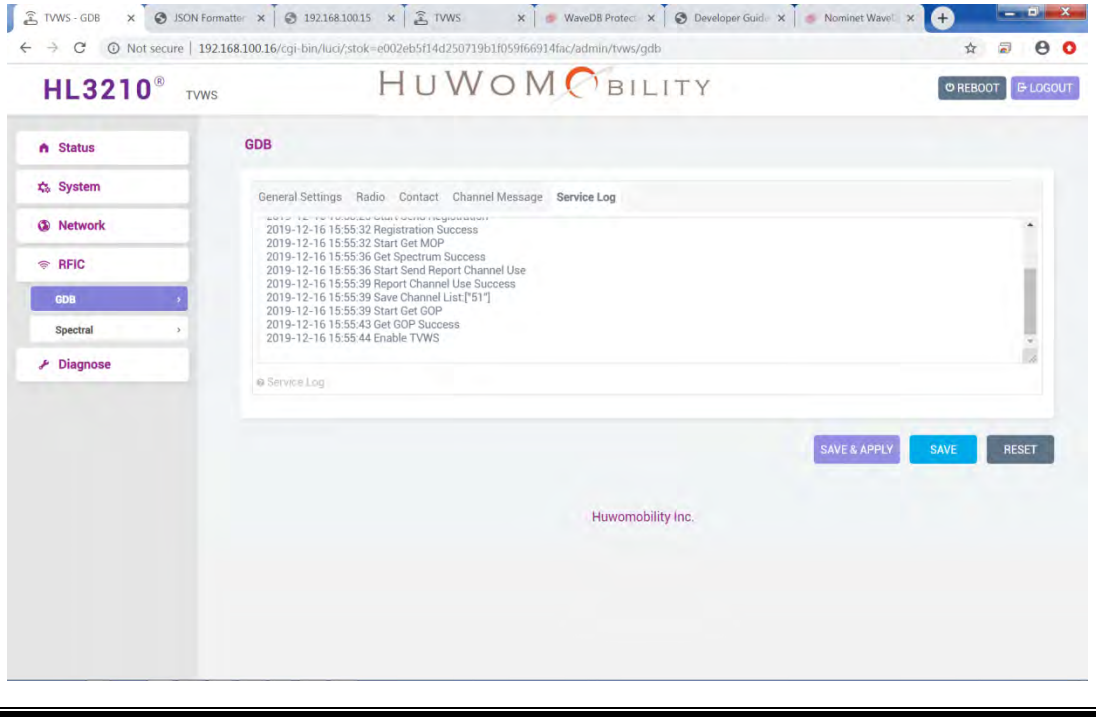
Scenario D/E – Cannot transmit Ch. 17 & 18



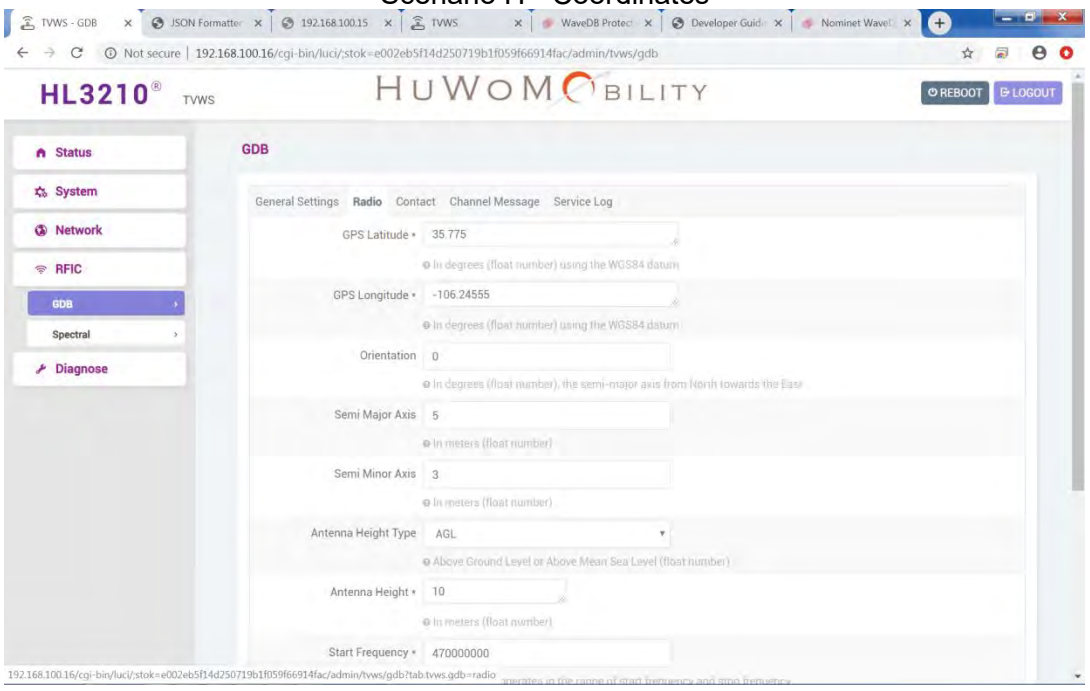
Scenario G - Coordinates



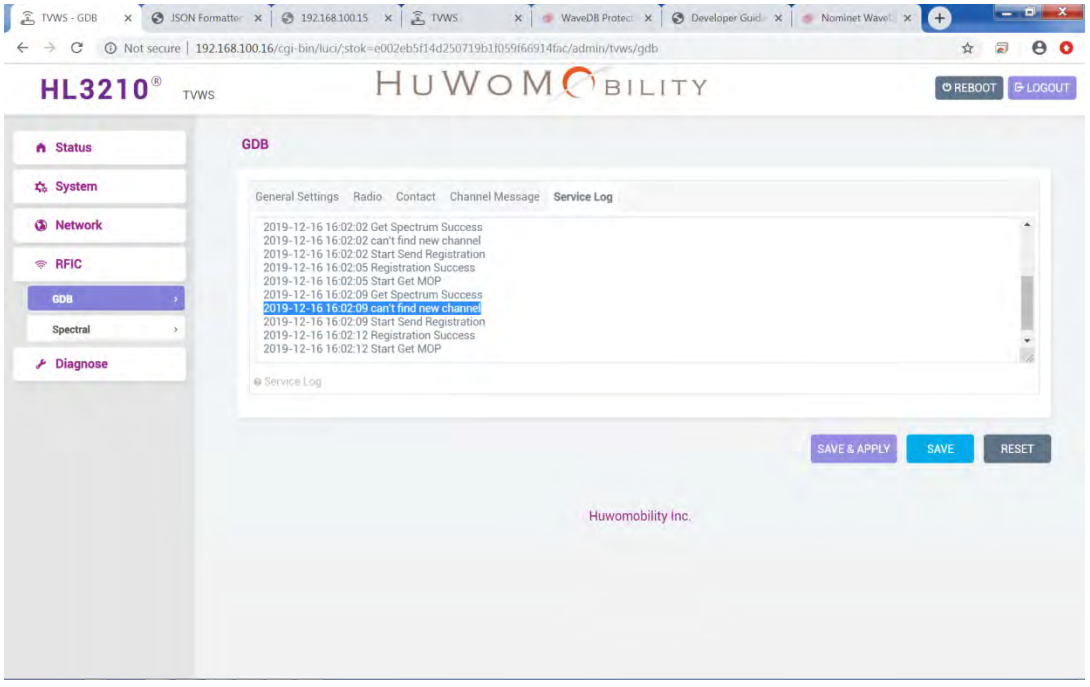
Scenario G – Cannot transmit on Ch.6 & Ch.32



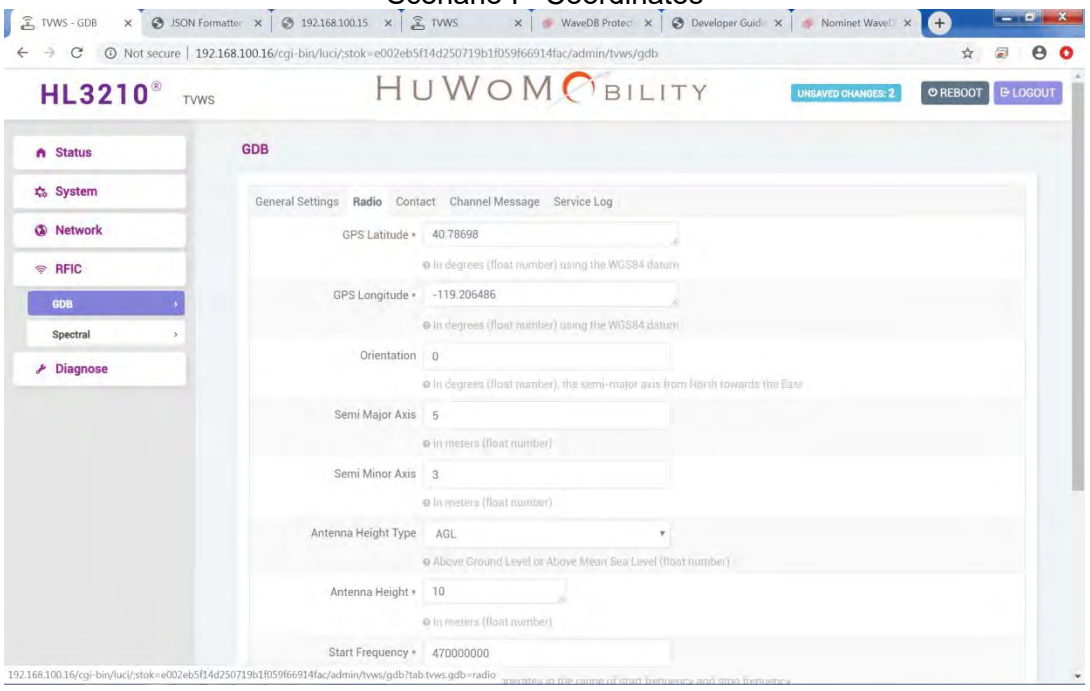
Scenario H - Coordinates



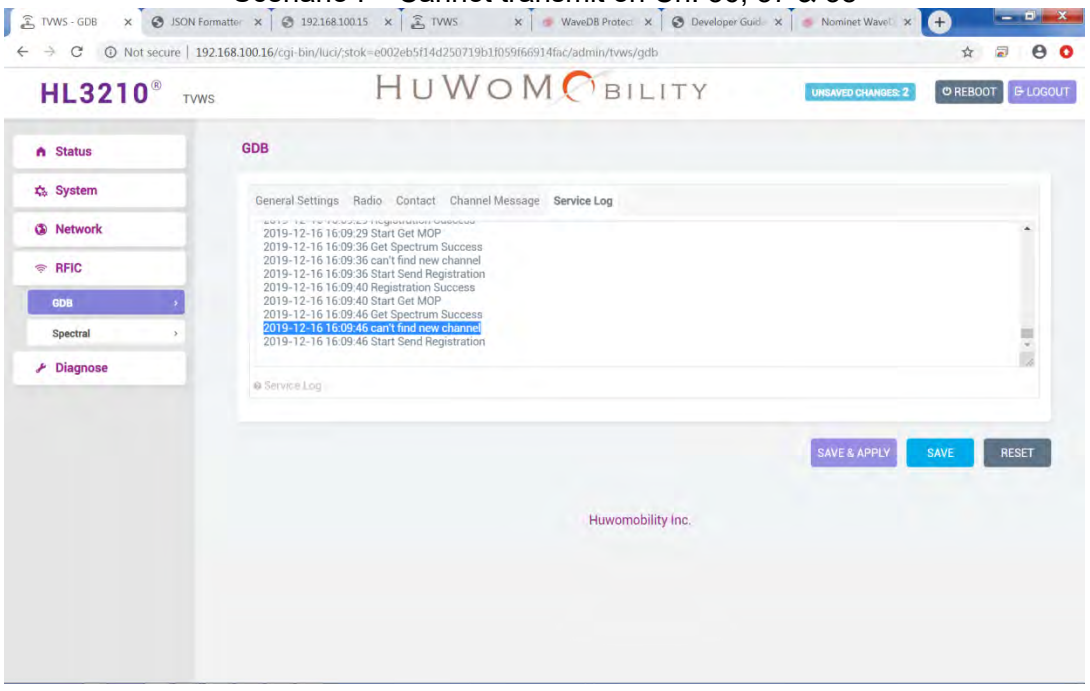
Scenario H – No Channels Available



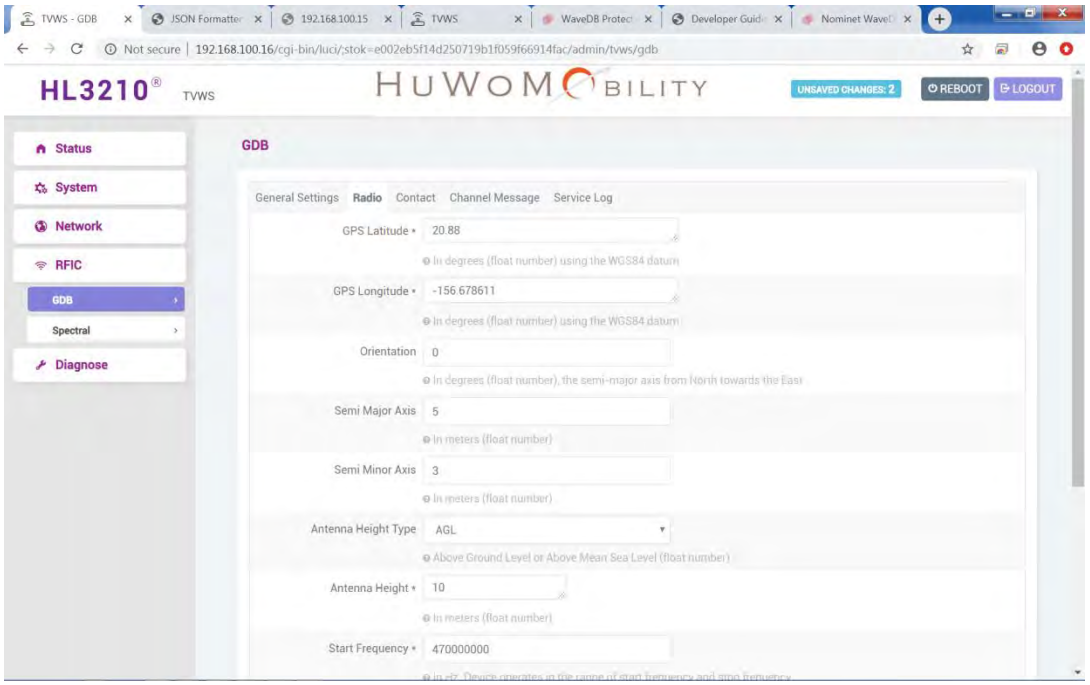
Scenario I - Coordinates



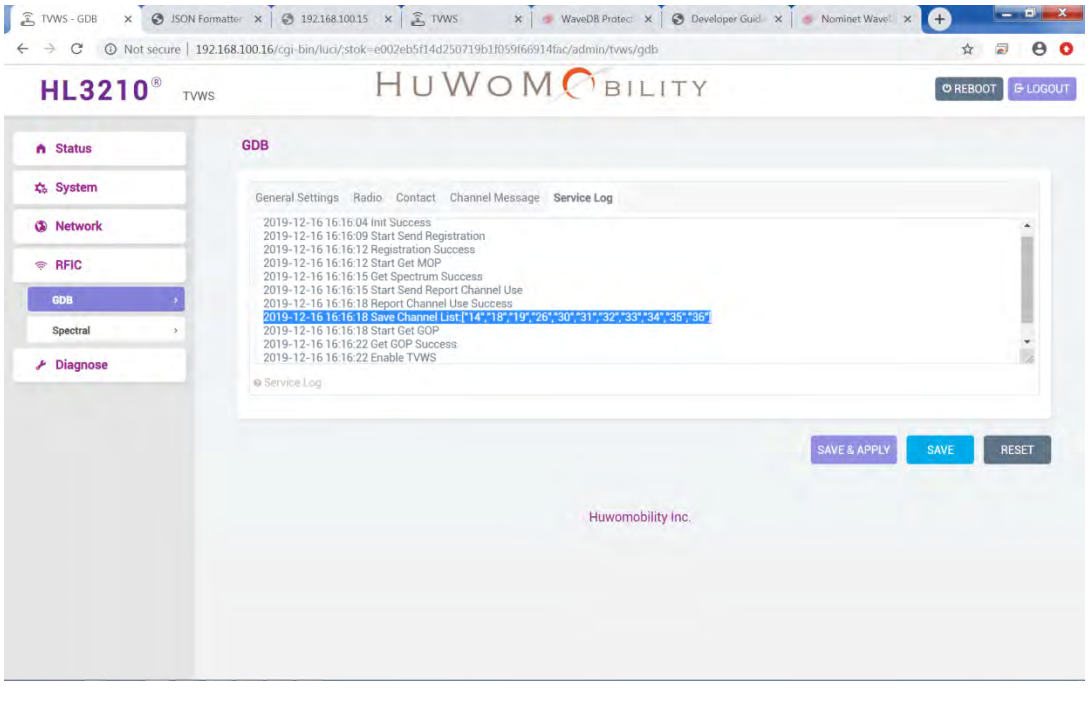
Scenario I – Cannot transmit on Ch. 36, 37 & 38



Scenario K - Coordinates



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.

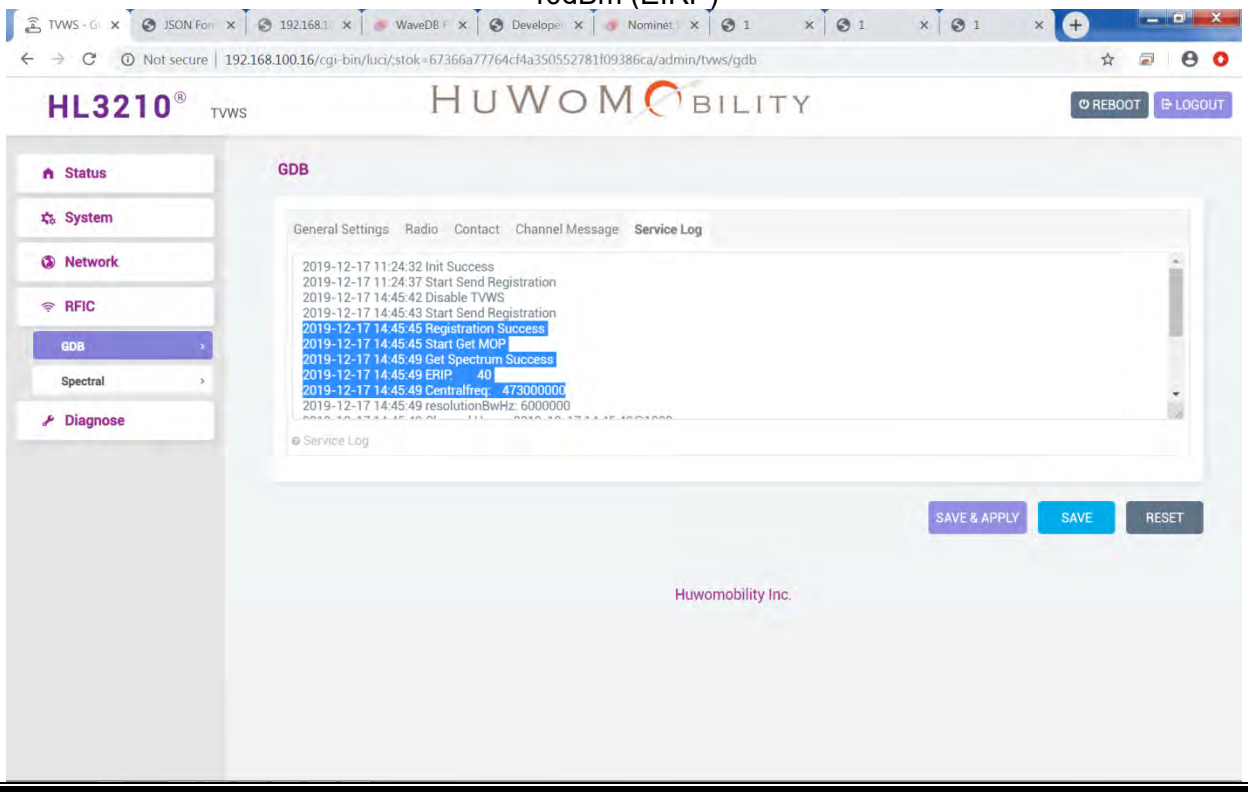
TEST PROCEDURE

- 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**
☒	☐	16080ZS	12/17/2019

Successful registration, Channel availability 473MHz and maximum allowed Power level 40dBm (EIRP)



Power confirmation below max. allowed
User not able to change to higher power (EIRP limit 40dBm)