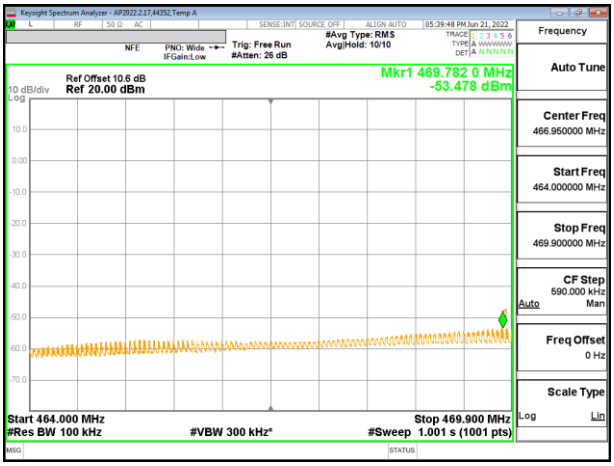
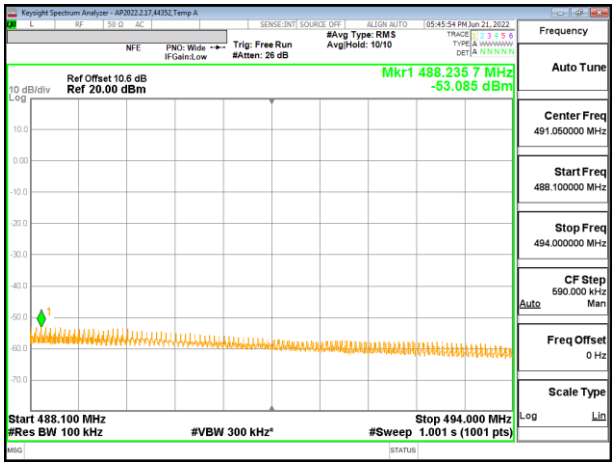
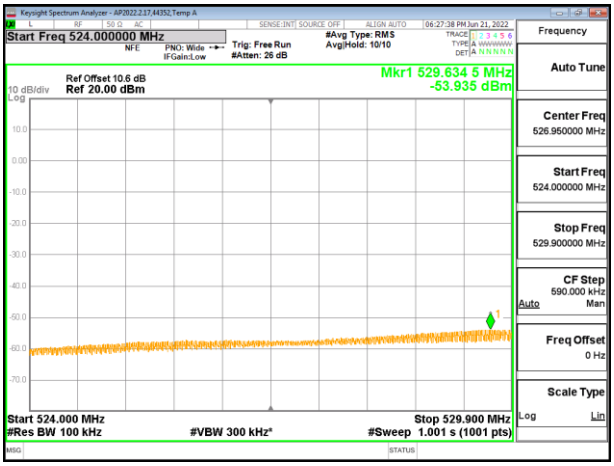


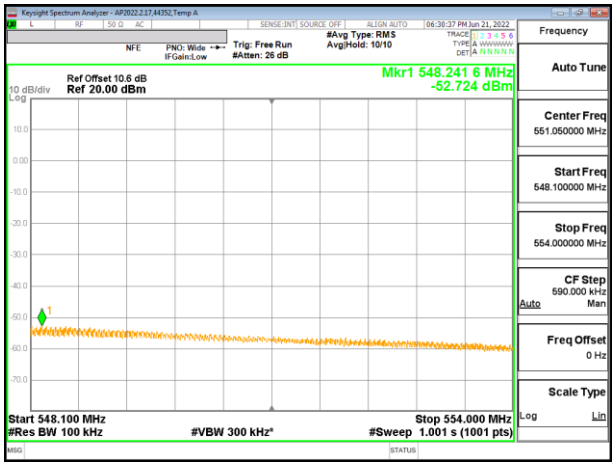
LOW CHANNEL Antenna 2 Lower Edge



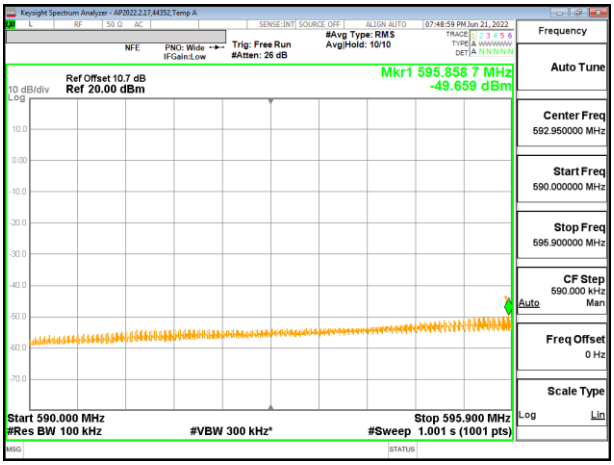
LOW CHANNEL Antenna 2 Upper Edge



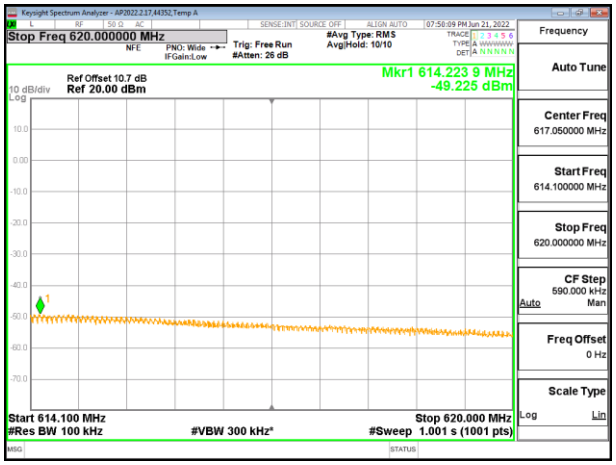
MID CHANNEL Antenna 2 Lower Edge



MID CHANNEL Antenna 2 Upper Edge



HIGH CHANNEL Antenna 2 Lower Edge



HIGH CHANNEL Antenna 2 Upper Edge

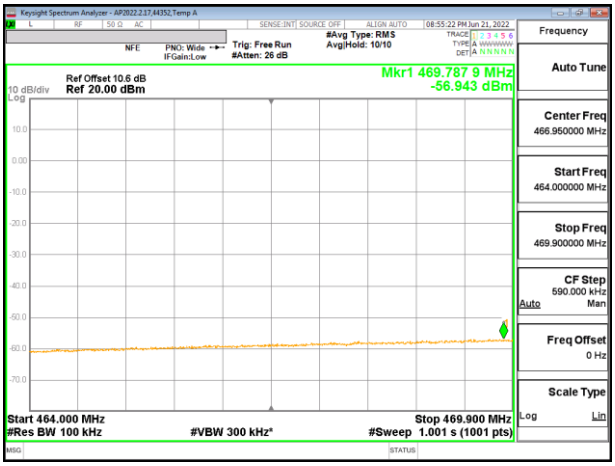
10.3.4. UHF BAND -2TX 24MHz - Antenna 1+2

Lower Adjacent Channel Emissions

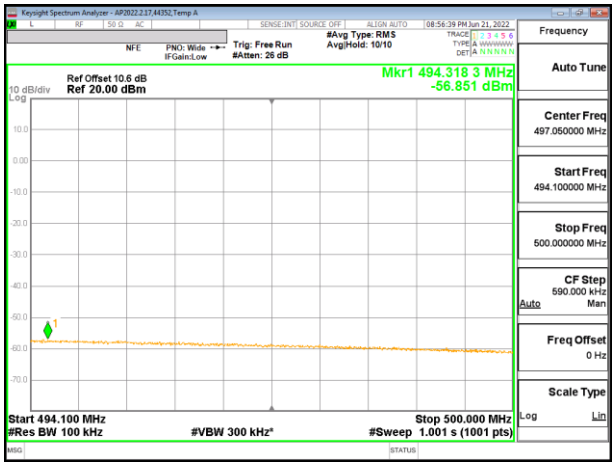
Channel	Frequency (MHz)	Measured Emission Antenna 1 (dBm)	Measured Emission Antenna 2 (dBm)	Measured Total Emission (dBm)	Emissions Limit (dBm)	Worst Case Margin (dBm)
Low	482	-56.94	-56.95	-53.94	-44.8	-9.14
Mid	542	-56.70	-56.64	-53.66	-44.8	-8.86
High	602	-52.36	-54.67	-50.35	-44.8	-5.55

Upper Adjacent Channel Emissions

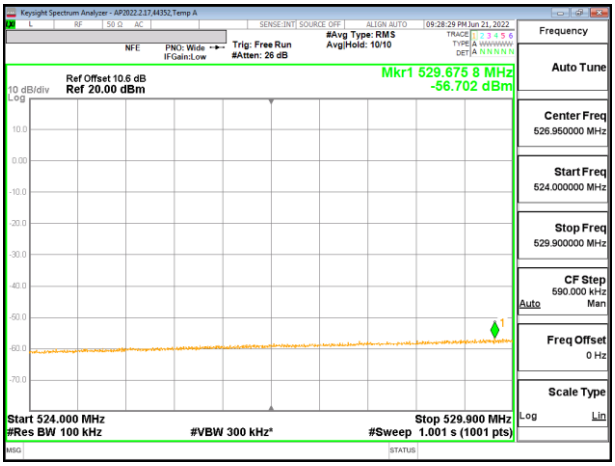
Channel	Frequency (MHz)	Measured Emission Antenna 1 (dBm)	Measured Emission Antenna 2 (dBm)	Measured Total Emission (dBm)	Emissions Limit (dBm)	Worst Case Margin (dBm)
Low	482	-56.85	-57.21	-54.02	-44.8	-9.22
Mid	542	-54.39	-54.96	-51.65	-44.8	-6.85
High	602	-49.75	-51.67	-47.59	-44.8	-2.79



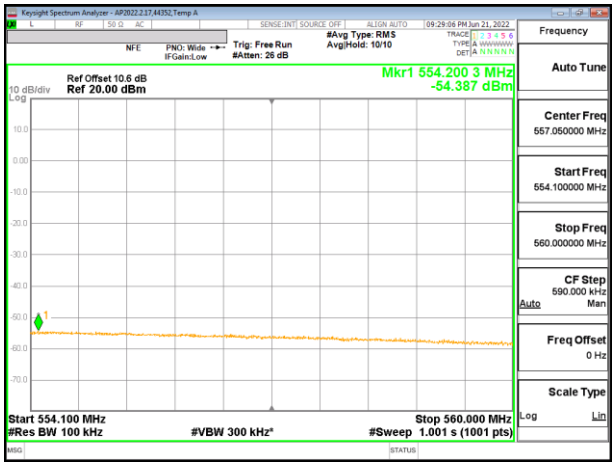
LOW CHANNEL Antenna 1 Lower Edge



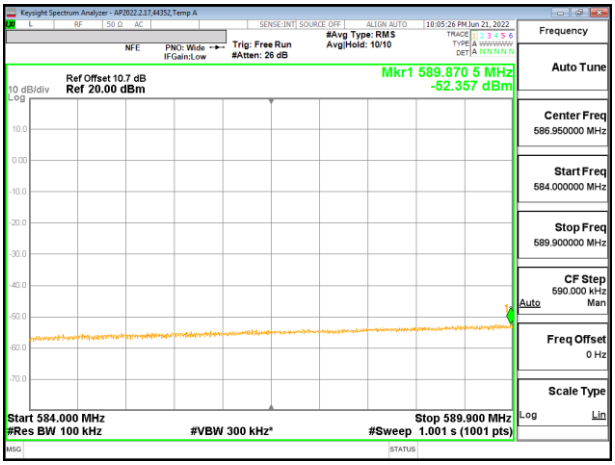
LOW CHANNEL Antenna 1 Upper Edge



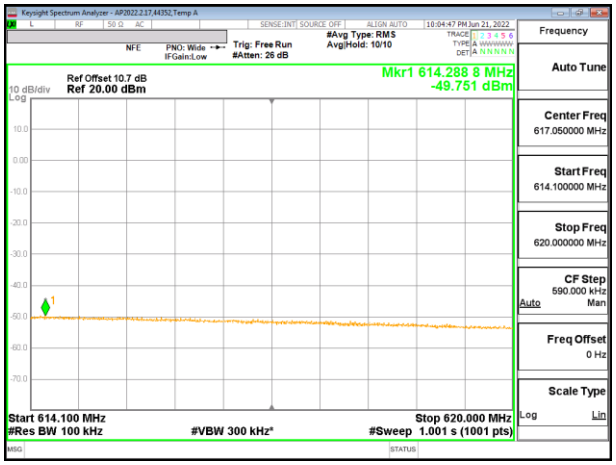
MID CHANNEL Antenna 1 Lower Edge



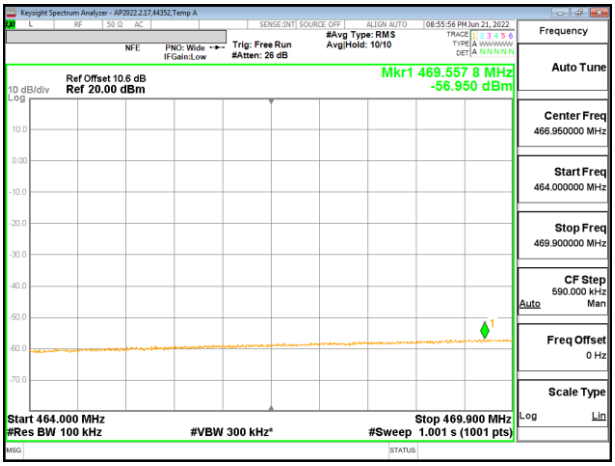
MID CHANNEL Antenna 1 Upper Edge



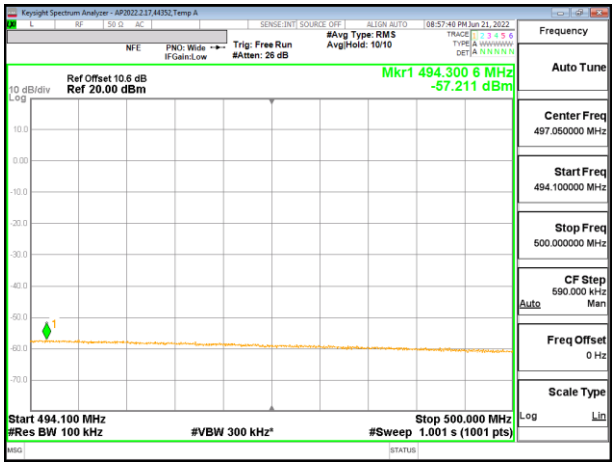
HIGH CHANNEL Antenna 1 Lower Edge



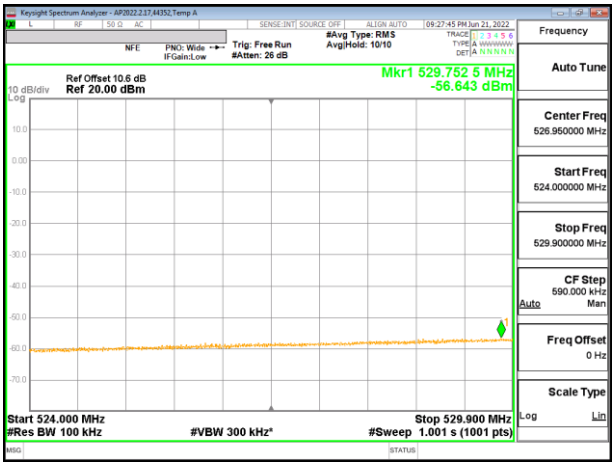
HIGH CHANNEL Antenna 1 Upper Edge



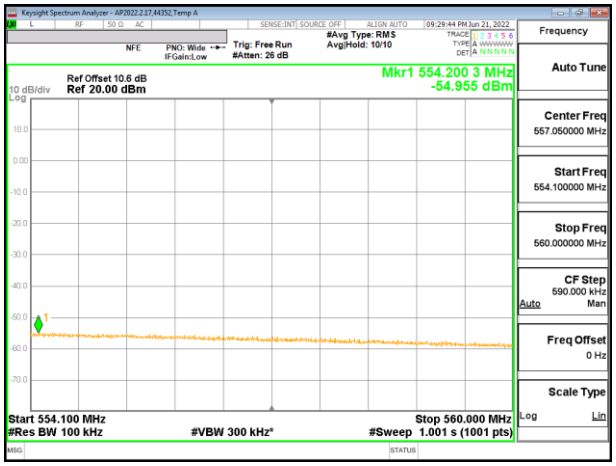
LOW CHANNEL Antenna 2 Lower Edge



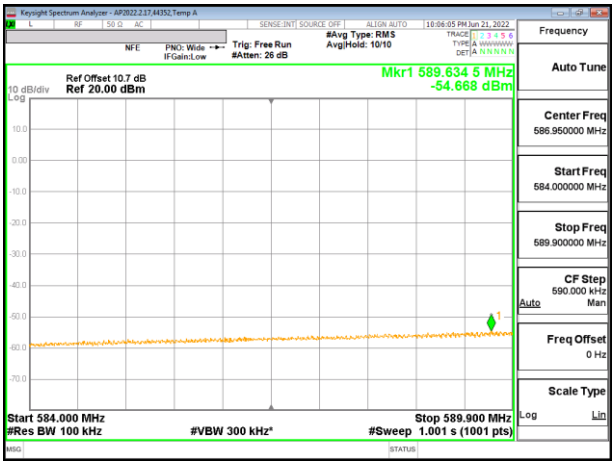
LOW CHANNEL Antenna 2 Upper Edge



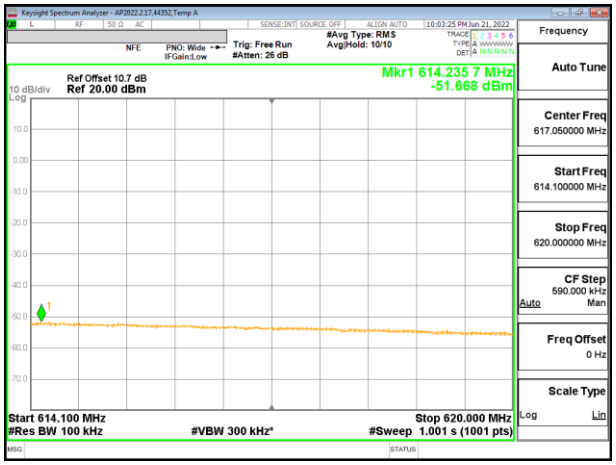
MID CHANNEL Antenna 2 Lower Edge



MID CHANNEL Antenna 2 Upper Edge



HIGH CHANNEL Antenna 2 Lower Edge



HIGH CHANNEL Antenna 2 Upper Edge

11. 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.

§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.

The EUT is fixed to a pole and placed 80 cm above the ground plane for measurement below 1GHz and Above 1GHz. For Above 1GHz, the antenna bore sight is at 1m.
The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.10.
The EUT is set to transmit in a continuous mode.

For measurements below 1 GHz the resolution bandwidth is set to 100 kHz for peak detection measurements or 120 kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

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. Blue color trace on plots:Parallel orientation. Green color trace on plots:Perpendicular orientation.

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.

UL VERIFICATION SERVICES INC.
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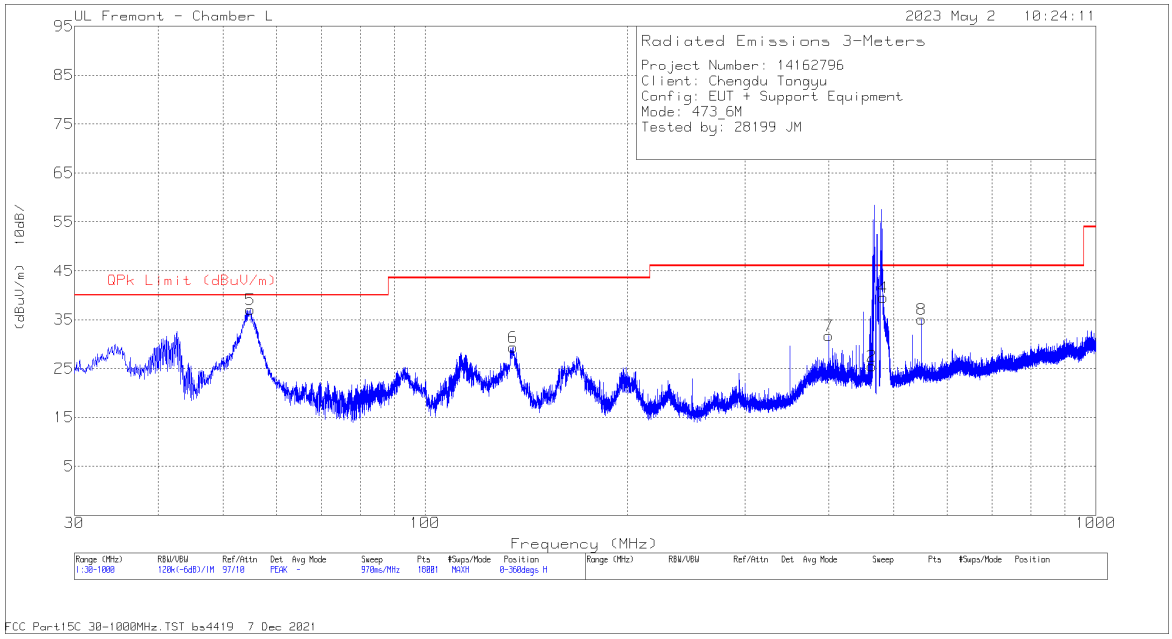
11.1. TRANSMITTER BELOW 1GHz

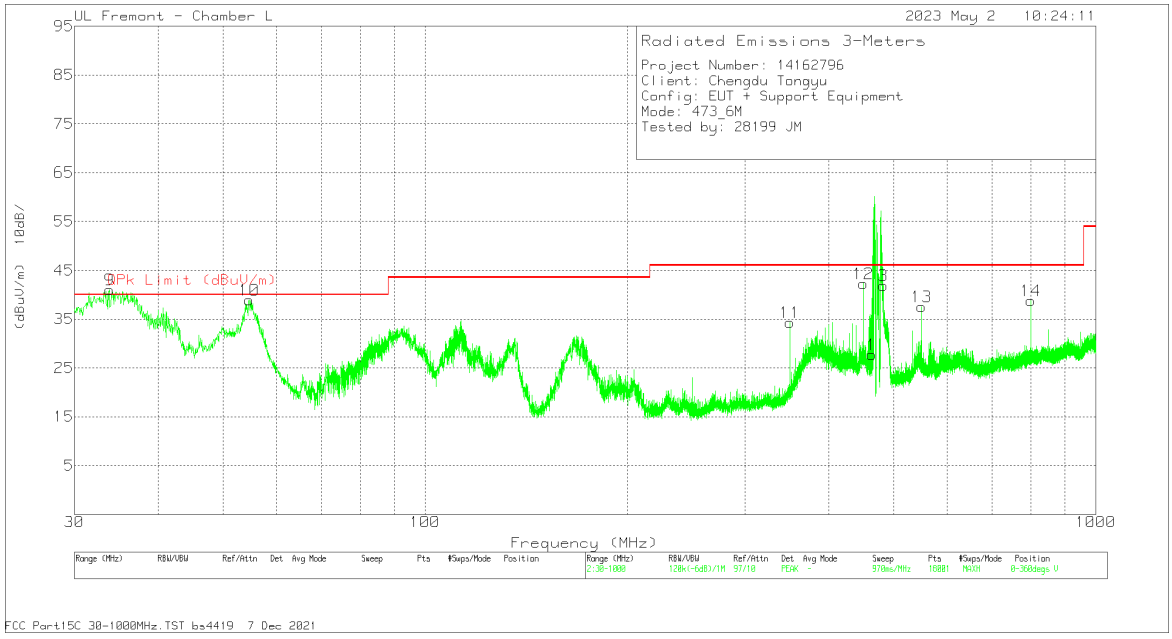
11.1.1. UHF BAND

BEYOND ADJACENT CHANNEL (LOW CHANNEL)

HORIZONTAL PLOT



VERTICAL PLOT



LOW CHANNEL DATA

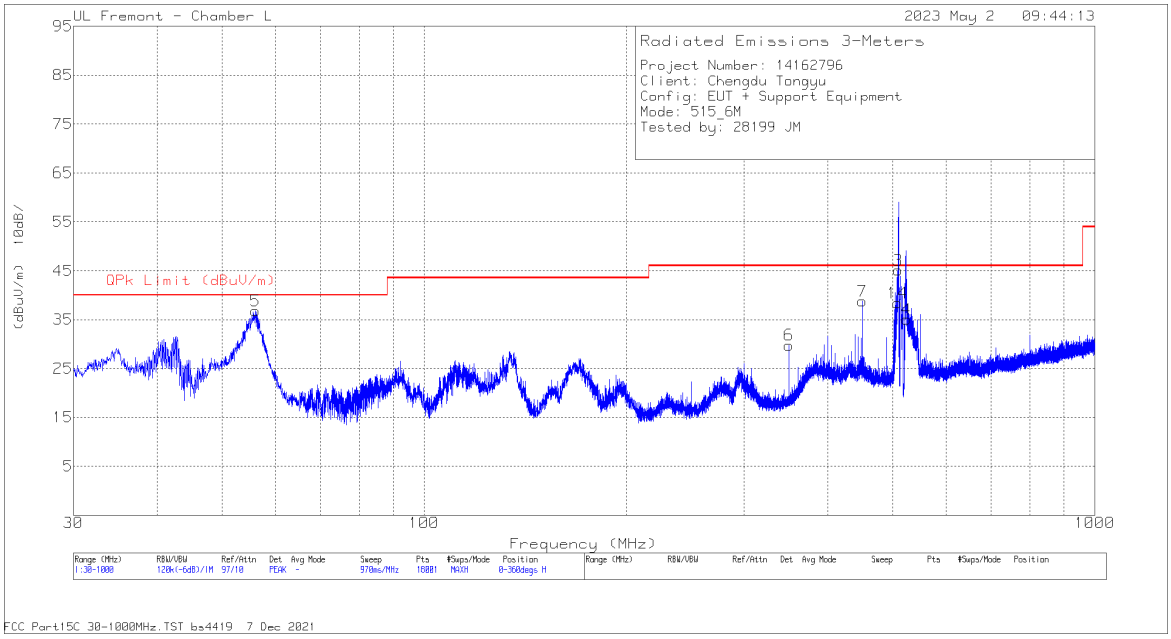
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	174374 ANSI ACF 10 m H UL_	CBL/AMP	80460 Filter	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	463.968	30.83	Pk	23.2	-28.5	0.2	25.73	46.02	-20.29	0-360	198	H
4	482.236	44.19	Pk	23.7	-28.4	0.2	39.69	46.02	-6.33	0-360	198	H
5	54.4159	52.96	Qp	13.2	-30.9	0.2	35.46	40	-4.54	342	367	H
6	135.245	40.2	Pk	19.3	-30.1	0.2	29.6	43.52	-13.92	0-360	198	H
7	400.056	39	Pk	21.5	-28.8	0.2	31.9	46.02	-14.12	0-360	99	H
8	549.975	39.05	Pk	24.2	-28.2	0.2	35.25	46.02	-10.77	0-360	198	H
1	463.968	33.03	Pk	23.2	-28.5	0.2	27.93	46.02	-18.09	0-360	198	V
3	481.967	46.62	Pk	23.7	-28.4	0.2	42.12	-	-	0-360	101	V
9	40.456	46.77	Qp	19.4	-31	0.2	35.37	40	-4.63	261	141	V
10	54.4267	53.66	Qp	13.2	-30.9	0.2	36.16	40	-3.84	90	152	V
11	349.993	43.08	Pk	20.2	-29	0.2	34.48	46.02	-11.54	0-360	101	V
12	450.001	50.61	Qp	22.8	-28.5	0.2	45.11	46.02	-0.91	150	104	V
13	550.029	41.58	Pk	24.2	-28.2	0.2	37.78	46.02	-8.24	0-360	101	V
14	800.02	39.21	Pk	27	-27.4	0.4	39.21	46.02	-6.81	0-360	101	V

Pk - Peak detector
Qp - Quasi-Peak detector

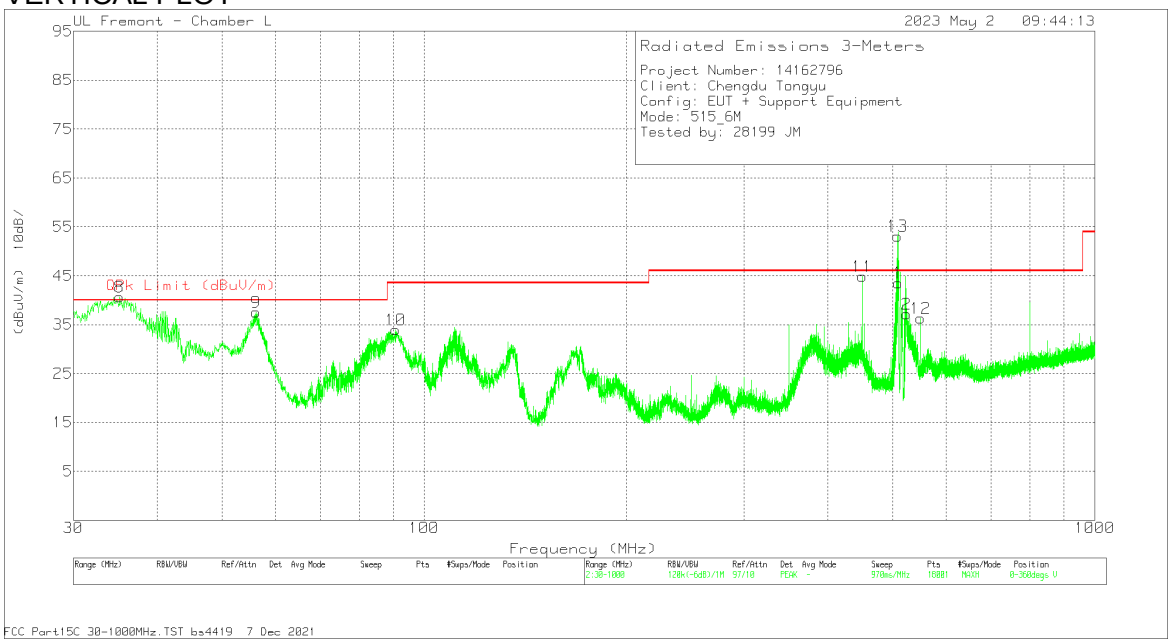
Note Only emissions beyond 464 MHz and 482 MHz from the center of 473 MHz were considered.

BEYOND ADJACENT CHANNEL (MID CHANNEL)

HORIZONTAL PLOT



VERTICAL PLOT



MID CHANNEL DATA

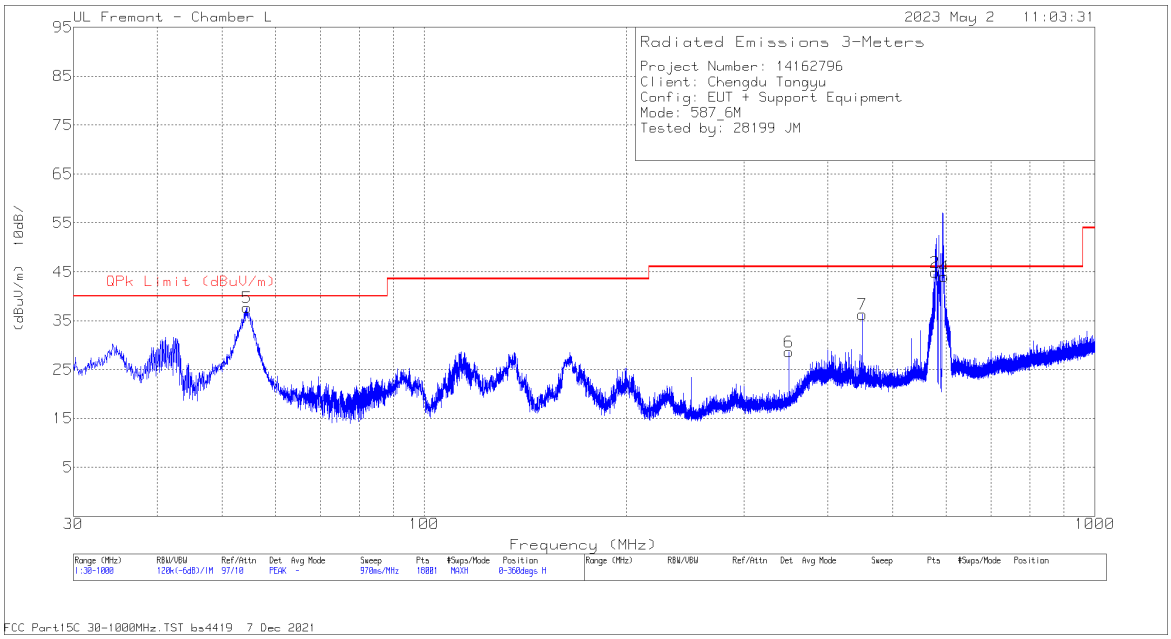
Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	174374 ANSI ACF 10 m H UL_	CBL/AMP	80459 Filter	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
3	509.127	49.74	Pk	23.7	-28.3	5	50.14	-	-	0-360	101	H
4	524.27	39.5	Pk	23.8	-28.2	1	36.1	46.02	-9.92	0-360	101	H
5	56.1448	51.79	Qp	13.2	-30.9	.2	34.29	40	-5.71	2	375	H
6	349.993	38.59	Pk	20.2	-29	1	30.79	46.02	-15.23	0-360	398	H
7	450.011	44.53	Pk	22.8	-28.5	.2	39.03	46.02	-6.99	0-360	101	H
14	507.888	43.05	Pk	23.7	-28.3	2	40.45	-	-	0-360	198	H
1	509.127	48.17	Pk	23.7	-28.3	5	48.57	-	-	0-360	198	V
2	524.27	41.6	Pk	23.8	-28.2	1	38.2	46.02	-7.82	0-360	101	V
8	36.6277	45.92	Qp	22	-31.1	.2	37.02	40	-2.98	263	110	V
9	56.0904	52.71	Qp	13.2	-30.9	.2	35.21	40	-4.79	69	142	V
10	90.7329	50.59	Pk	13.9	-30.5	1	34.99	43.52	-8.53	0-360	198	V
11	449.998	50.42	Qp	22.8	-28.5	.2	44.92	46.02	-1.1	155	106	V
12	549.975	40.3	Pk	24.2	-28.2	1	37.3	46.02	-8.72	0-360	101	V
13	507.888	57.73	Pk	23.7	-28.3	2	55.13	-	-	0-360	101	V

Pk - Peak detector
Qp - Quasi-Peak detector

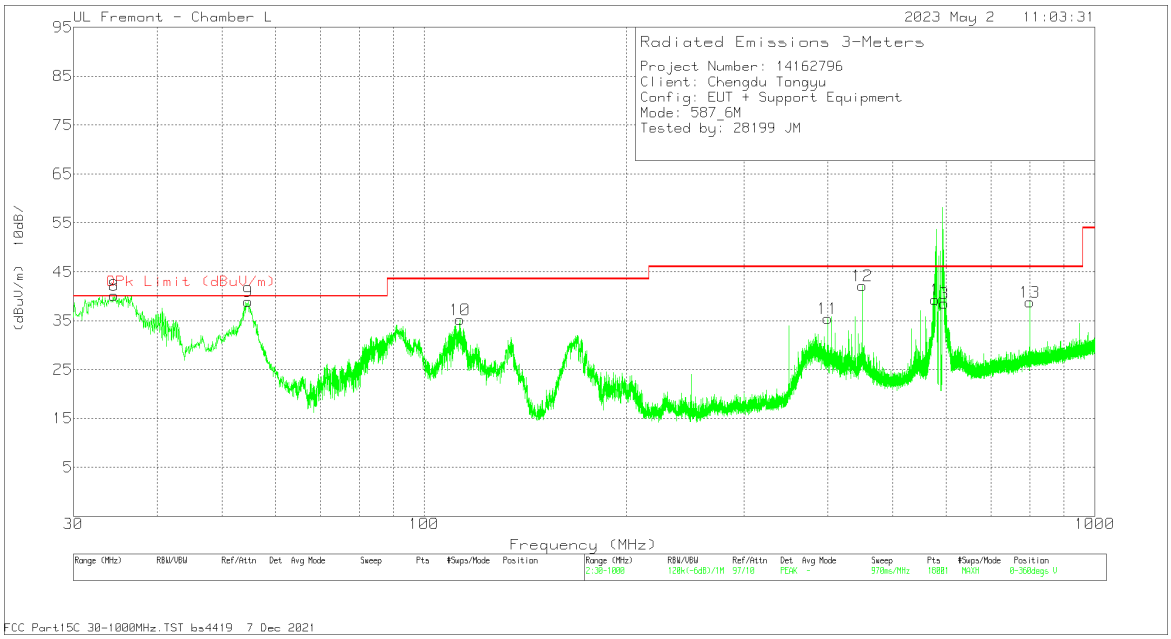
Note Only emissions beyond 506 MHz and 524 MHz from the center of 515 MHz were considered.

BEYOND ADJACENT CHANNEL (HIGH CHANNEL)

HORIZONTAL PLOT



VERTICAL PLOT



HIGH CHANNEL DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	174374 ANSI ACF 10 m H UL_	CBL/AMP	Filter 80457	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
2	577.864	41.76	Qp	24.6	-28.2	1	39.16	46.02	-6.86	291	120	H
4	596.913	40.61	Qp	24.4	-28	1	38.01	46.02	-8.01	292	155	H
5	54.2053	52.91	Qp	13.2	-30.9	0.1	35.31	40	-4.69	351	385	H
6	349.993	37.46	Pk	20.2	-29	0.1	28.76	46.02	-17.26	0-360	399	H
7	449.957	41.95	Pk	22.8	-28.5	0.1	36.35	46.02	-9.67	0-360	98	H
1	577.957	45.02	Qp	24.6	-28.2	1	42.42	46.02	-3.6	289	153	V
3	596.05	42.13	Pk	24.4	-28	1	39.53	46.02	-6.49	0-360	100	V
8	36.1416	44.06	Qp	22.3	-31.1	0.1	35.36	40	-4.64	278	145	V
9	54.419	54.96	Qp	13.2	-30.9	0.1	37.36	40	-2.64	88	114	V
10	113.151	46.6	Pk	18.9	-30.3	0.3	35.5	43.52	-8.02	0-360	100	V
11	400.002	42.71	Pk	21.5	-28.8	0.1	35.51	46.02	-10.51	0-360	100	V
12	449.997	47.21	Qp	22.8	-28.5	0.1	41.61	46.02	-4.41	147	105	V
13	800.02	39.15	Pk	27	-27.4	0.2	38.95	46.02	-7.07	0-360	100	V

Pk - Peak detector
Qp - Quasi-Peak detector

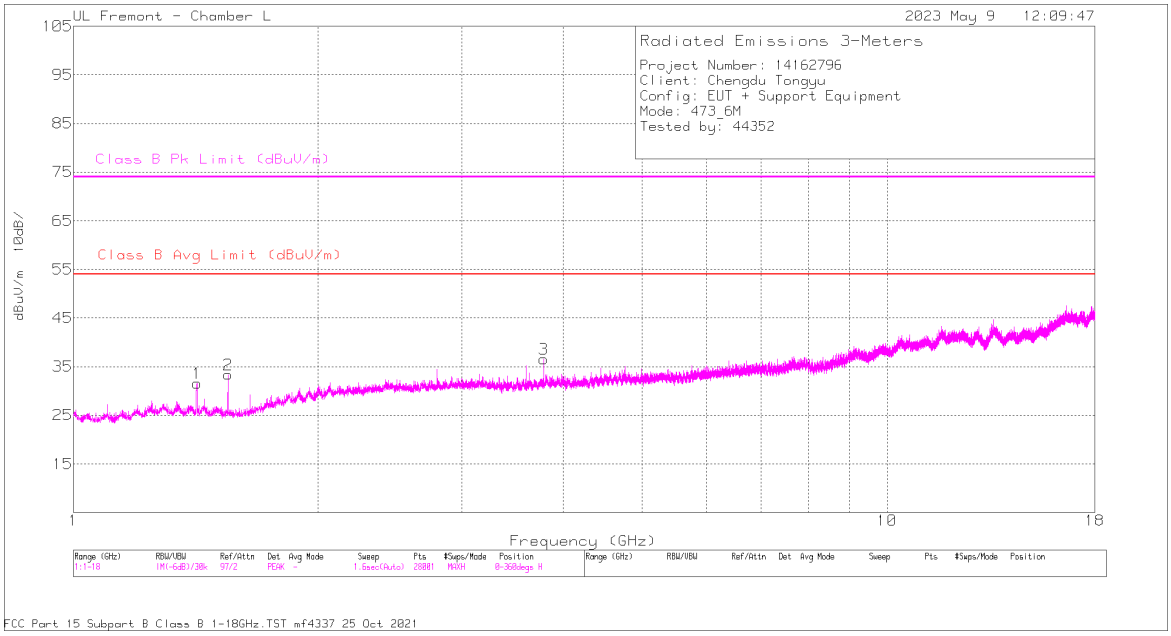
Note Only emissions beyond 578 MHz and 596 MHz from the center of 587 MHz were considered.

11.2. TRANSMITTER ABOVE 1GHz

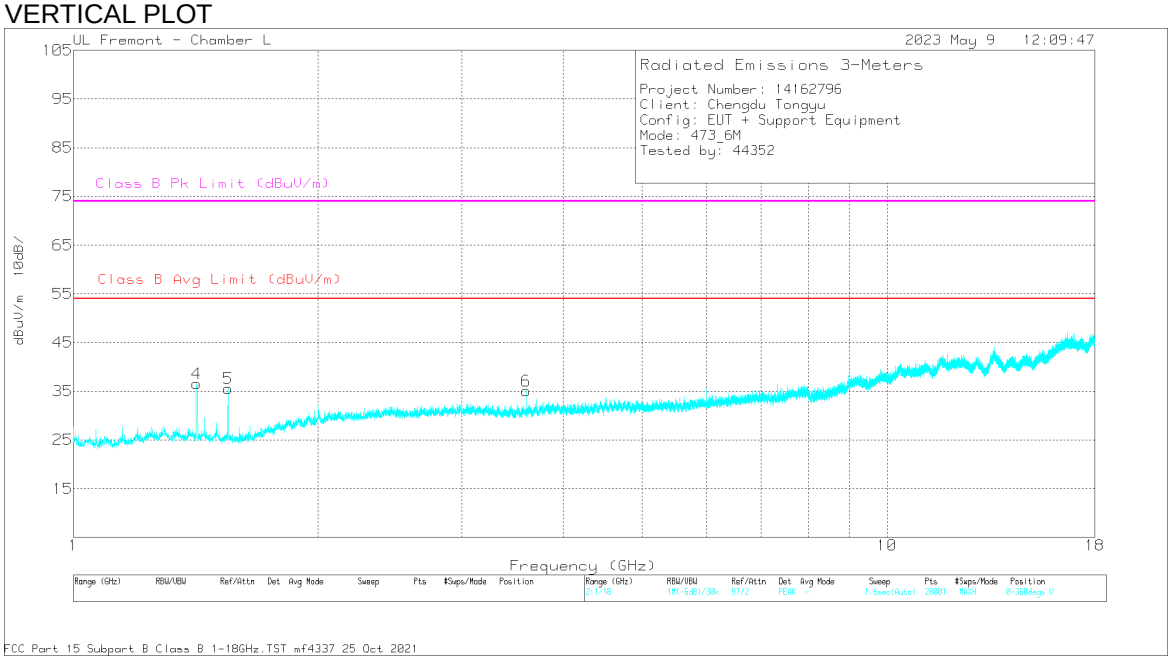
11.2.1. HARMONICS AND SPURIOUS EMISSIONS IN THE UHF BAND

LOW CHANNEL

HORIZONTAL PLOT



VERTICAL PLOT



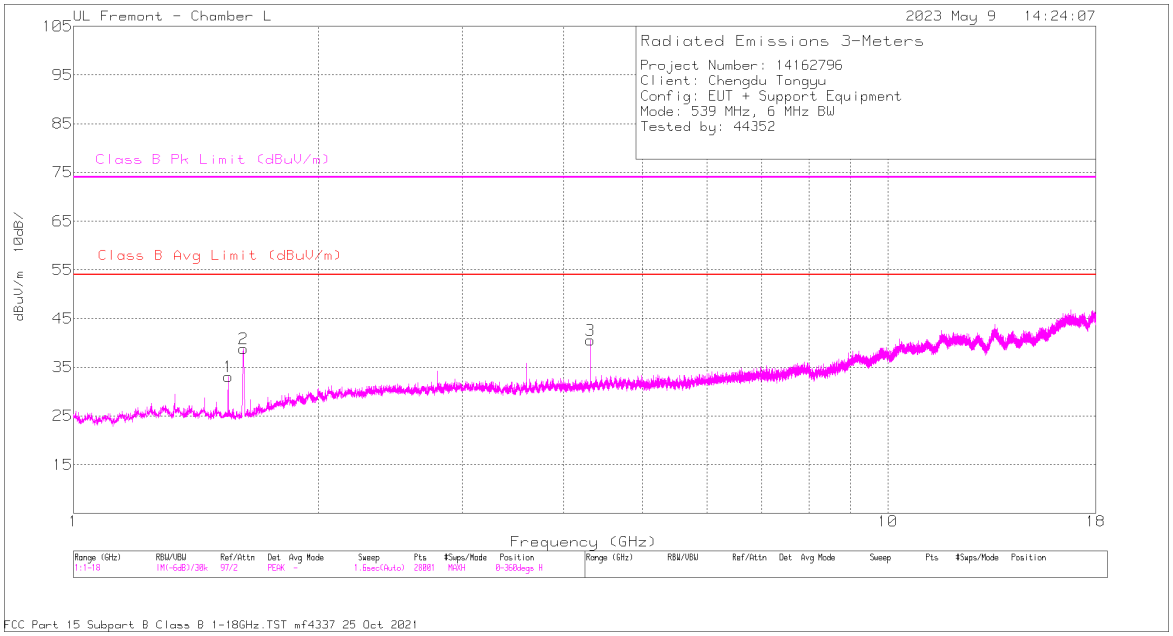
LOW CHANNEL DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206806 ACF (dB) 3mH	AMP/CBL	191812 Filter	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	1.419449	48.82	Pk	28.6	-31.4	1	47.02	54	-6.98	74	-26.98	227	198	H
	1.419449	35.93	RMS	28.6	-31.4	1	34.13	54	-19.87	74	-39.87	227	198	H
2	1.549935	43.34	Pk	27.9	-31.1	1	41.14	54	-12.86	74	-32.86	209	268	H
	1.549935	37.18	RMS	27.9	-31.1	1	34.98	54	-19.02	74	-39.02	209	268	H
3	3.784089	35.37	Pk	33.3	-26.9	1	42.77	54	-11.23	74	-31.23	223	392	H
	3.784089	25.54	RMS	33.3	-26.9	1	32.94	54	-21.06	74	-41.06	223	392	H
4	1.419255	50.81	Pk	28.6	-31.4	1	49.01	54	-4.99	74	-24.99	211	105	V
	1.419255	38.2	RMS	28.6	-31.4	1	36.4	54	-17.6	74	-37.6	211	105	V
5	1.549967	44.68	Pk	27.9	-31.1	1	42.48	54	-11.52	74	-31.52	147	135	V
	1.549967	39.58	RMS	27.9	-31.1	1	37.38	54	-16.62	74	-36.62	147	135	V
6	3.599917	37.01	Pk	32.9	-27.2	1	43.71	54	-10.29	74	-30.29	188	123	V
	3.599918	28.82	RMS	32.9	-27.2	1	35.52	54	-18.48	74	-38.48	188	123	V

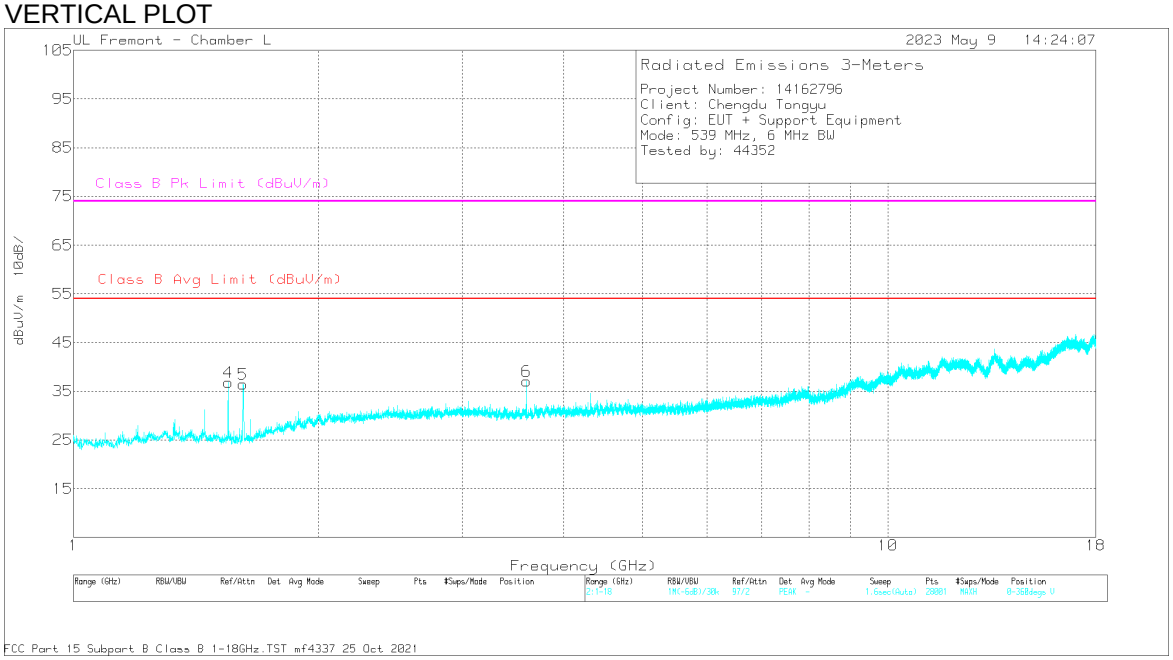
Pk - Peak detector
RMS - RMS detection

MID CHANNEL

HORIZONTAL PLOT



VERTICAL PLOT



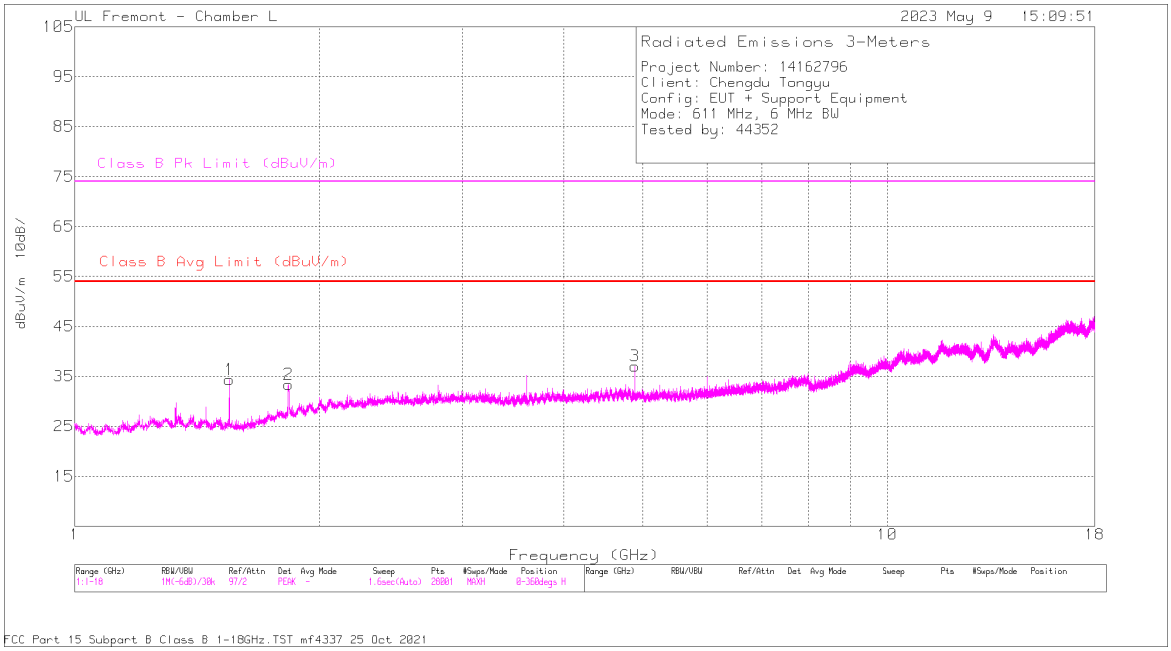
MID CHANNEL DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206806 ACF (dB) 3mH	AMP/CBL	191812 Filter	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	1.549958	43.65	Pk	27.9	-31.1	1	41.45	54	-12.55	74	-32.55	207	271	H
	1.549958	37.38	RMS	27.9	-31.1	1	35.18	54	-18.82	74	-38.82	207	271	H
2	1.616102	54.84	Pk	27.8	-31	1	52.64	54	-1.36	74	-21.36	227	316	H
	1.616102	40.49	RMS	27.8	-31	1	38.29	54	-15.71	74	-35.71	227	316	H
3	4.311901	39.33	Pk	33.4	-26.5	1	47.23	54	-6.77	74	-26.77	241	102	H
	4.311901	32.46	RMS	33.4	-26.5	1	40.36	54	-13.64	74	-33.64	241	102	H
4	1.549939	43.98	Pk	27.9	-31.1	1	41.78	54	-12.22	74	-32.22	151	111	V
	1.549939	39.23	RMS	27.9	-31.1	1	37.03	54	-16.97	74	-36.97	151	111	V
5	1.616175	49.21	Pk	27.8	-31	1	47.01	54	-6.99	74	-26.99	179	365	V
	1.616175	34.04	RMS	27.8	-31	1	31.84	54	-22.16	74	-42.16	179	365	V
6	3.600031	37.01	Pk	32.9	-27.2	1	43.71	54	-10.29	74	-30.29	200	207	V
	3.600031	29.29	RMS	32.9	-27.2	1	35.99	54	-18.01	74	-38.01	200	207	V

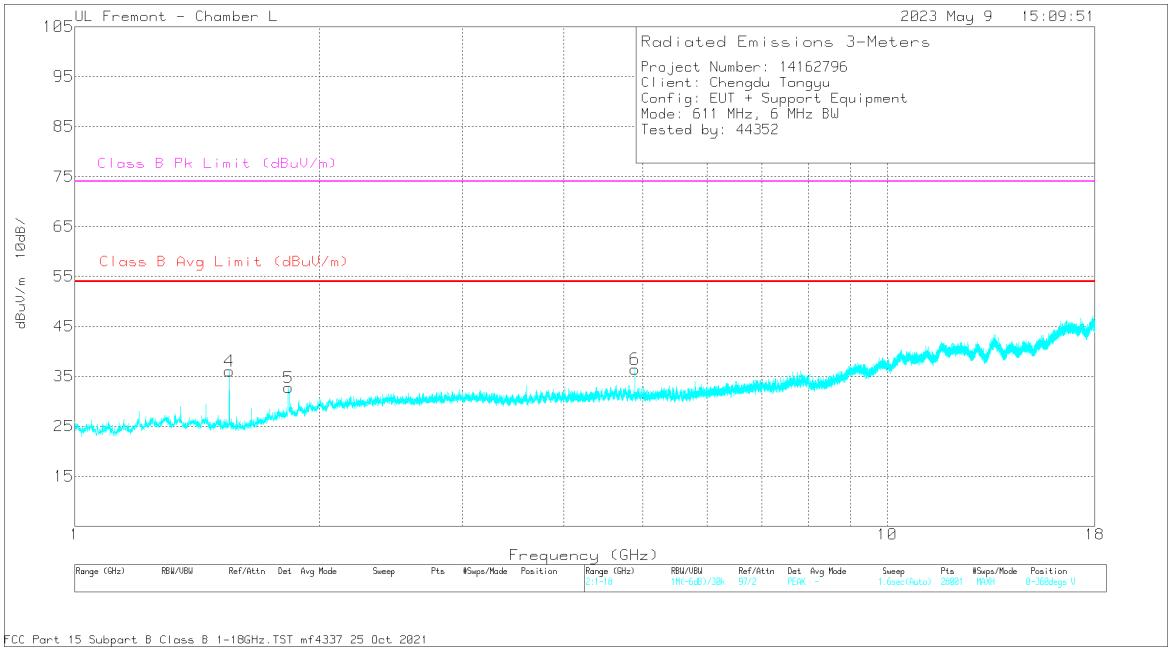
Pk - Peak detector
RMS - RMS detection

HIGH CHANNEL

HORIZONTAL PLOT



VERTICAL PLOT



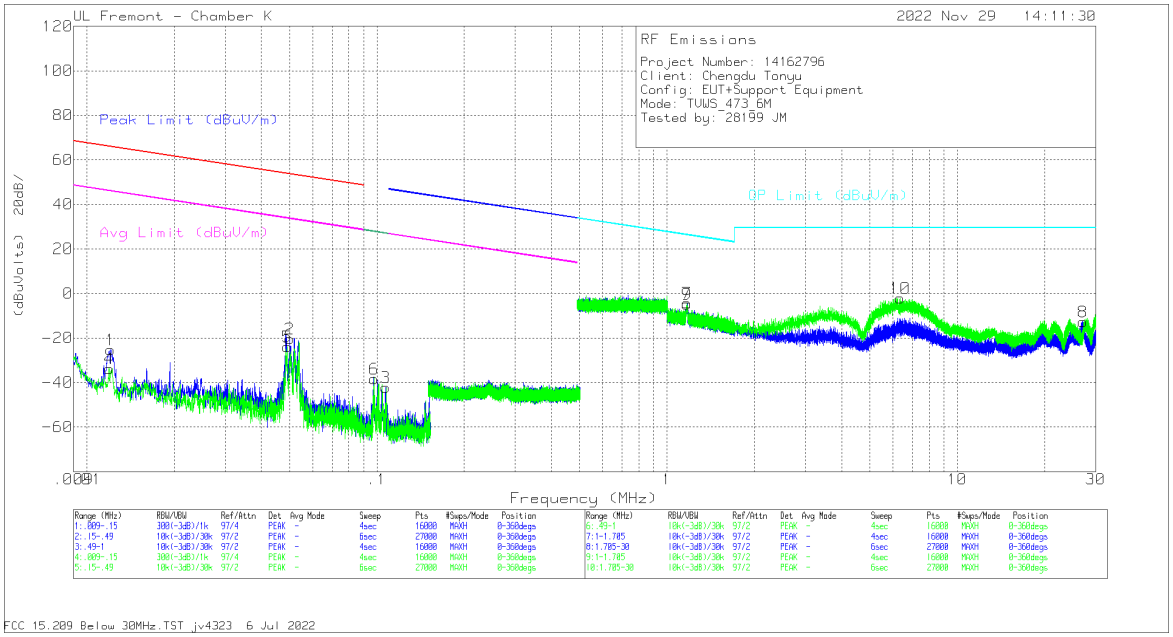
HIGH CHANNEL DATA

Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	206806 ACF (dB) 3mH	AMP/CBL	191812 Filter	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
2	1.833659	40.32	Pk	30.4	-30.2	1	41.52	54	-12.48	74	-32.48	218	141	H
	1.833659	27	RMS	30.4	-30.2	1	28.2	54	-25.8	74	-45.8	218	141	H
3	4.888082	36.55	Pk	33.9	-25.8	1	45.65	54	-8.35	74	-28.35	240	102	H
	4.888082	30.97	RMS	33.9	-25.8	1	40.07	54	-13.93	74	-33.93	240	102	H
1	1.550011	42.81	Pk	27.9	-31.1	1	40.61	54	-13.39	74	-33.39	212	177	H
	1.550011	36.25	RMS	27.9	-31.1	1	34.05	54	-19.95	74	-39.95	212	177	H
4	1.550171	43.76	Pk	27.9	-31.1	1	41.56	54	-12.44	74	-32.44	169	140	V
	1.550171	37.19	RMS	27.9	-31.1	1	34.99	54	-19.01	74	-39.01	169	140	V
5	1.832849	46.29	Pk	30.4	-30.3	1	47.39	54	-6.61	74	-26.61	166	289	V
	1.832849	29.27	RMS	30.4	-30.3	1	30.37	54	-23.63	74	-43.63	166	289	V
6	4.887908	34.93	Pk	33.9	-25.8	1	44.03	54	-9.97	74	-29.97	192	108	V
	4.887908	25.77	RMS	33.9	-25.8	1	34.87	54	-19.13	74	-39.13	192	108	V

Pk - Peak detector
RMS - RMS detection

11.3. WORST-CASE TRANSMITTER BELOW 30MHz

FACE ON PLOT



Blue Trace is Face On
Green Trace is Face Off

DATA

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna E (ACF)	Amp/Cbl (dB)	Dist Corr 300m	Corrected Reading (dBuVolts)	Peak Limit (dBuV/m)	Margin (dB)	Avg Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Face
1	.0121	25.77	Pk	60	-31	-80	-25.23	65.93	-91.16	45.93	-71.16	0-360	On
2	.0501	34.76	Pk	57.1	-32.2	-80	-20.34	53.58	-73.92	33.58	-53.92	0-360	On
3	.1075	14.46	Pk	55.6	-32.2	-80	-42.14	27	-69.14	-	-	0-360	On
4	.0119	17.28	Pk	60	-31	-80	-33.72	66.04	-99.76	46.04	-79.76	0-360	Off
5	.0492	31.12	Pk	57.1	-32.2	-80	-23.98	53.75	-77.73	33.75	-57.73	0-360	Off
6	.098	18.15	Pk	55.6	-32.2	-80	-38.45	27.78	-66.23	-	-	0-360	Off

Pk - Peak detector

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	Loop Antenna E (ACF)	Amp/Cbl (dB)	Dist Corr 30m (dB) 40Log	Corrected Reading (dBuVolts)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Face
7	1.1688	21.75	Pk	46	-32.1	-40	-4.35	26.27	-30.62	0-360	On
8	27.053	25.65	Pk	33.2	-31.5	-40	-12.65	29.5	-42.15	0-360	On
9	1.1682	21.34	Pk	46	-32.1	-40	-4.76	26.28	-31.04	0-360	Off
10	6.3602	34.79	Pk	35.1	-31.9	-40	-2.01	29.5	-31.51	0-360	Off

Pk - Peak detector

Note: Used 473MHz Notch filter (80460)
Worst case filter loss Is 0.03 dB from 9KHz to 30MHz

Note: there is no difference for in test result for transmitter and receiver for Below 30MHz

12. AC MAINS LINE CONDUCTED EMISSIONS

LIMITS

FCC §15.709 (c)(4) White space devices connected to the AC power line are required to comply with the conducted limits set forth in § 15.207.

FCC §15.207 (a)

Frequency range (MHz)	Limits (dBµV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46 66
0.50 to 5	56	46
0.50 to 30	60	50
Note: The lower limit shall apply at the transition frequencies		

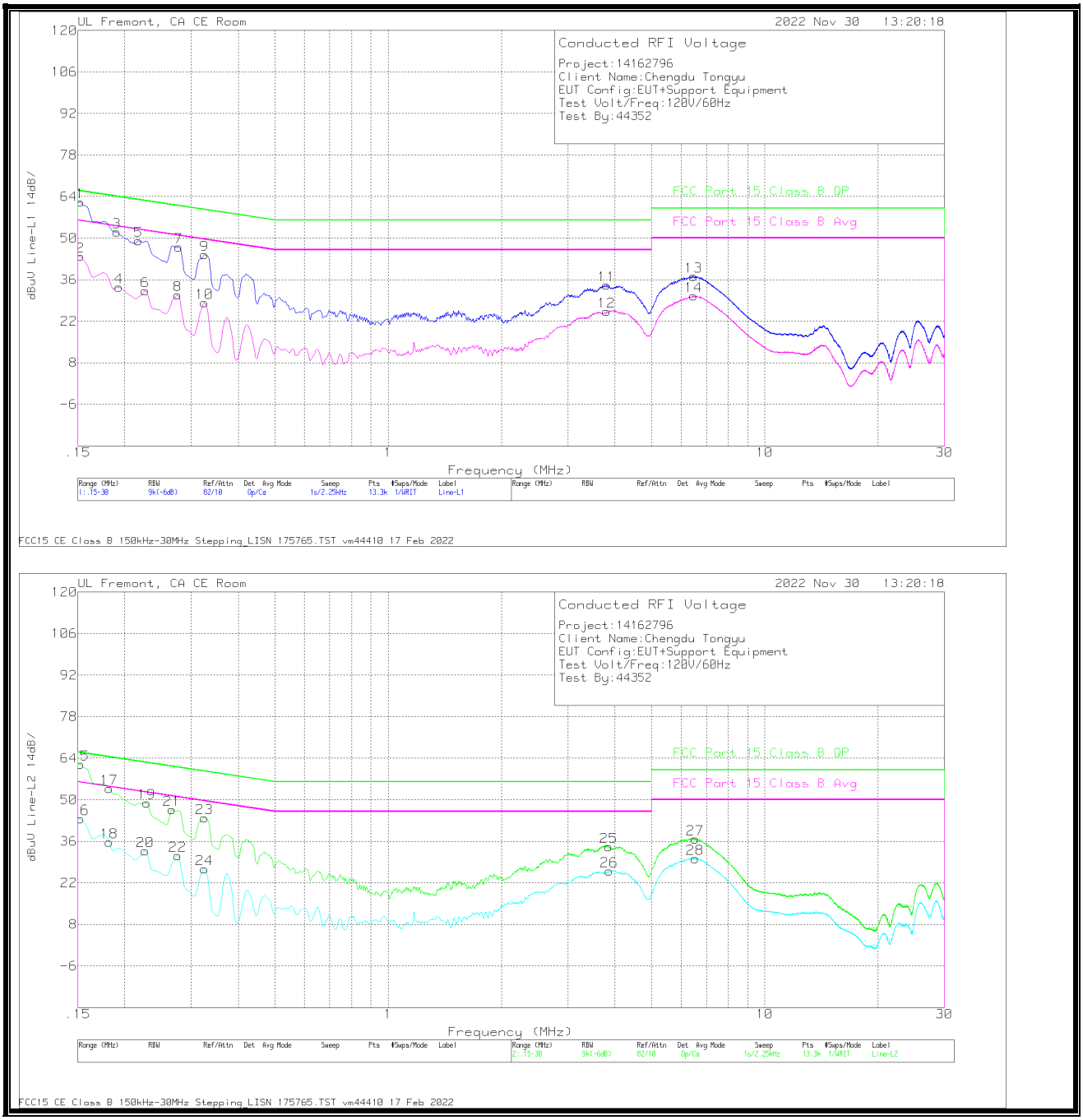
TEST PROCEDURE

ANSI C63.4-2009.

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

12.1. UHF MODE

12.1.1. LINE 1 & 2 RESULTS



DATA

Range 1: Line-L1 .15 - 30MHz

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	175765 LISN L1	C1&C3 cable path loss	207996 Limiter with short cabl	Corrected Reading dBuV	FCC Part 15 Class B QP	QP Margin (dB)	FCC Part 15 Class B Avg	Av(CISPR)Margin (dB)
2	.1523	34.44	Ca	.1	0	9.4	43.94	-	-	55.88	-11.94
4	.1928	24	Ca	.1	0	9.4	33.5	-	-	53.92	-20.42
6	.2265	22.99	Ca	0	0	9.3	32.29	-	-	52.58	-20.29
8	.276	21.5	Ca	0	0	9.3	30.8	-	-	50.94	-20.14
10	.3255	18.97	Ca	0	0	9.3	28.27	-	-	49.57	-21.3
12	3.8063	15.92	Ca	0	.1	9.3	25.32	-	-	46	-20.68
14	6.4691	21.13	Ca	0	.1	9.3	30.53	-	-	50	-19.47
1	.1523	52.72	Qp	.1	0	9.4	62.22	65.88	-3.66	-	-
3	.1905	42.57	Qp	.1	0	9.4	52.07	64.01	-11.94	-	-
5	.2175	39.81	Qp	0	0	9.3	49.11	62.91	-13.8	-	-
7	.2783	37.8	Qp	0	0	9.3	47.1	60.87	-13.77	-	-
9	.3255	35.08	Qp	0	0	9.3	44.38	59.57	-15.19	-	-
11	3.8063	24.82	Qp	0	.1	9.3	34.22	56	-21.78	-	-
13	6.4826	27.71	Qp	0	.1	9.3	37.11	60	-22.89	-	-

Range 2: Line-L2 .15 - 30MHz

Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	175765 LISN L2	C2&C3 cable path loss	207996 Limiter with short cabl	Corrected Reading dBuV	FCC Part 15 Class B QP	QP Margin (dB)	FCC Part 15 Class B Avg	Av(CISPR)Margin (dB)
16	.1523	34.15	Ca	.1	0	9.4	43.65	-	-	55.88	-12.23
18	.1815	26.17	Ca	.1	0	9.4	35.67	-	-	54.42	-18.75
20	.2265	23.43	Ca	0	0	9.3	32.73	-	-	52.58	-19.85
22	.276	21.95	Ca	0	0	9.3	31.25	-	-	50.94	-19.69
24	.3255	17.45	Ca	0	0	9.3	26.75	-	-	49.57	-22.82
26	3.858	16.61	Ca	0	.1	9.3	26.01	-	-	46	-19.99
28	6.5288	20.83	Ca	0	.1	9.3	30.23	-	-	50	-19.77
15	.1523	52.43	Qp	.1	0	9.4	61.93	65.88	-3.95	-	-
17	.1815	44.29	Qp	.1	0	9.4	53.79	64.42	-10.63	-	-
19	.2288	39.62	Qp	0	0	9.3	48.92	62.49	-13.57	-	-
21	.267	37.43	Qp	0	0	9.3	46.73	61.21	-14.48	-	-
23	.3255	34.6	Qp	0	0	9.3	43.9	59.57	-15.67	-	-
25	3.8513	24.84	Qp	0	.1	9.3	34.24	56	-21.76	-	-
27	6.5288	27.37	Qp	0	.1	9.3	36.77	60	-23.23	-	-

Qp - Quasi-Peak detector
Ca - CISPR average detection

13. FIXED BASE STATION DATABASE CERTIFICATION TESTS

Test Procedure

The test requirements were done on the base except for a few scenarios where client was also tested.

The test requirements were done on the base connected to DB through TVWS application on Host PC and on client connected to DB through the base. The TVWS application acts as a proxy relaying messages from the base to the WSDB server.

13.1. 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.

    - 1. FCC ID
    - 2. Serial Number
    - 3. Contact information (Device owner and device contact)
    - 4. Location Coordinates
    - 5. Location uncertainty with 95% accuracy
    - 6. Antenna Height AGL (must not be > 30 m)

    Confirm that antenna HAAT exceeding 250 m generally, or 500 m in less congested areas receives no list of available channels

    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

Client to provide pre-registration method if available

Ie. 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 site is selected as the initial transmitting channel. This channel will be the initial “listening” channel for the Remote Station.

13.1.1. SUCCESSFUL REGISTRATION

TEST PROCEDURE

1. Configure the base EUT with correct registration information:

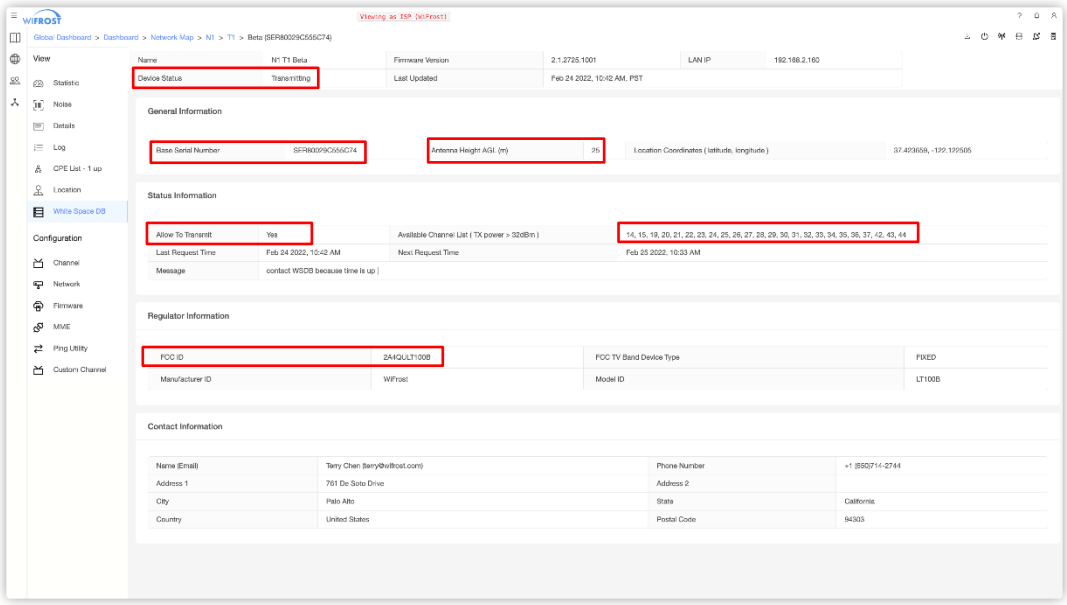
    a. The FCC ID and serial number are permanently programmed to the device and cannot be modified.
    b. Known acceptable geographic coordinates, antenna height AGL and contact information were entered into the EUT.
2. The base EUT automatically contacts the TVWS Database to perform device registration.
3. Upon successful registration, the base EUT automatically contacts the TVWS Database to retrieve device channel list.
4. Selects a channel from the channel list returned from the TVWS Database and start normal radio operation on the selected channel.
5. Verify base output signal on the selected channel on the spectrum analyzer.
6. Repeat Steps 1-3 for client EUT

RESULTS

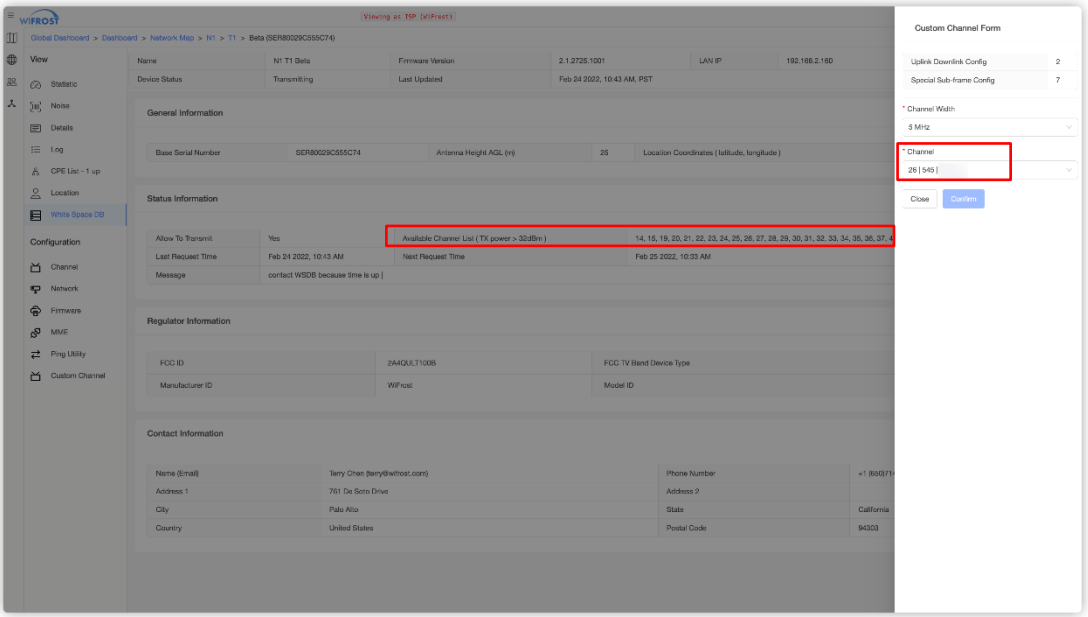
The EUT successfully registered when correct registration information was submitted to the TVWS Database. The EUT transmission was observed on the spectrum analyzer on the selected TV channel from the returned channel list from the TVWS Database. FCC ID and serial # information were obtained.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	16080ZS	2/24/22

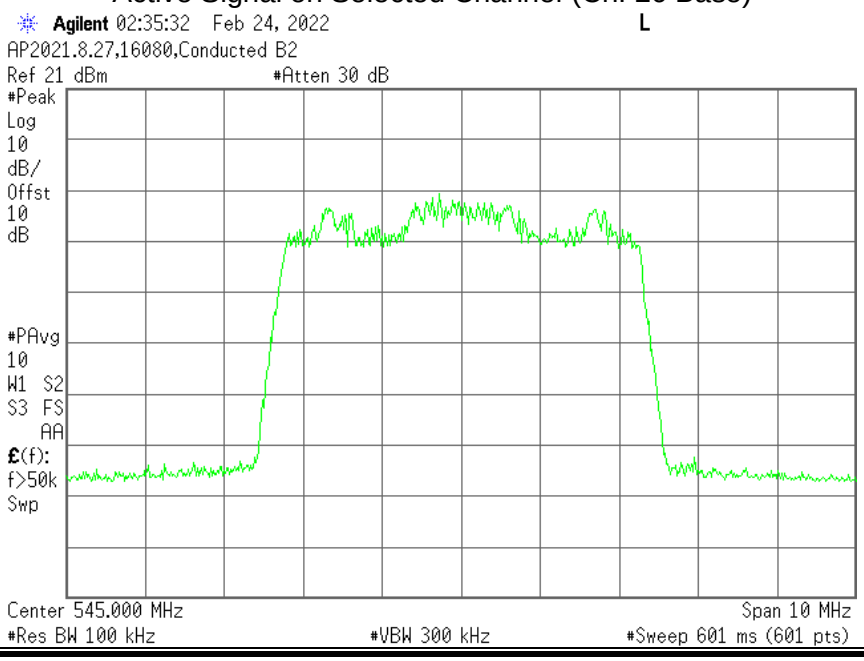
Successful Device Registration with Database, SN & FCC ID cannot be altered (Base)



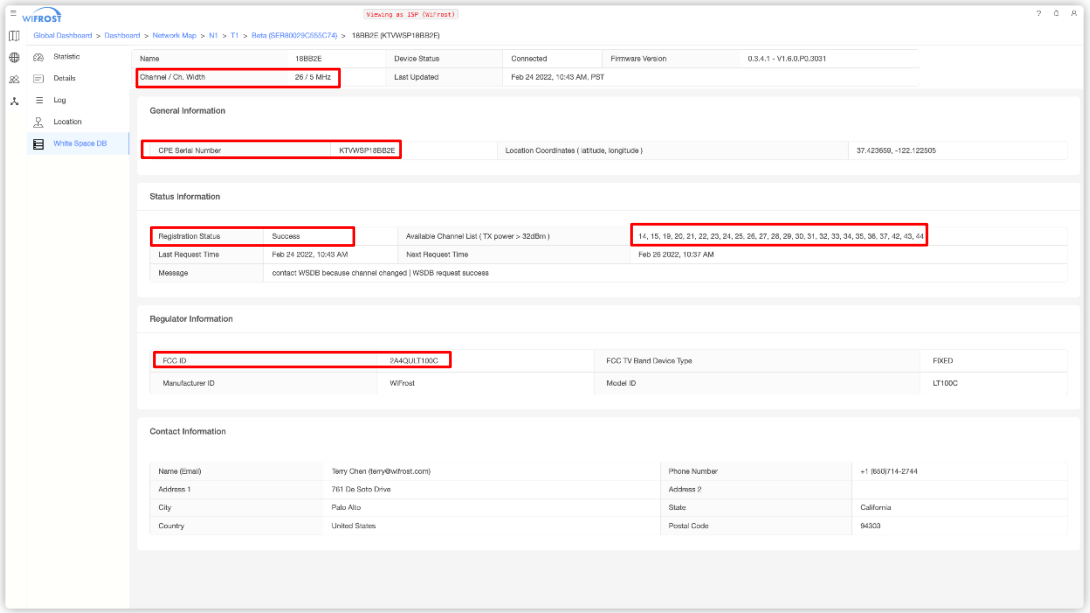
Channel selection from Database (Ch. 26 Base)



Active Signal on Selected Channel (Ch. 26 Base)



Channel selection from Client, Successful Registration, SN and FCC ID cannot be altered (Ch. 26 Client)



13.1.2. FAILED REGISTRATION – LOCATION COORDINATES

TEST PROCEDURE

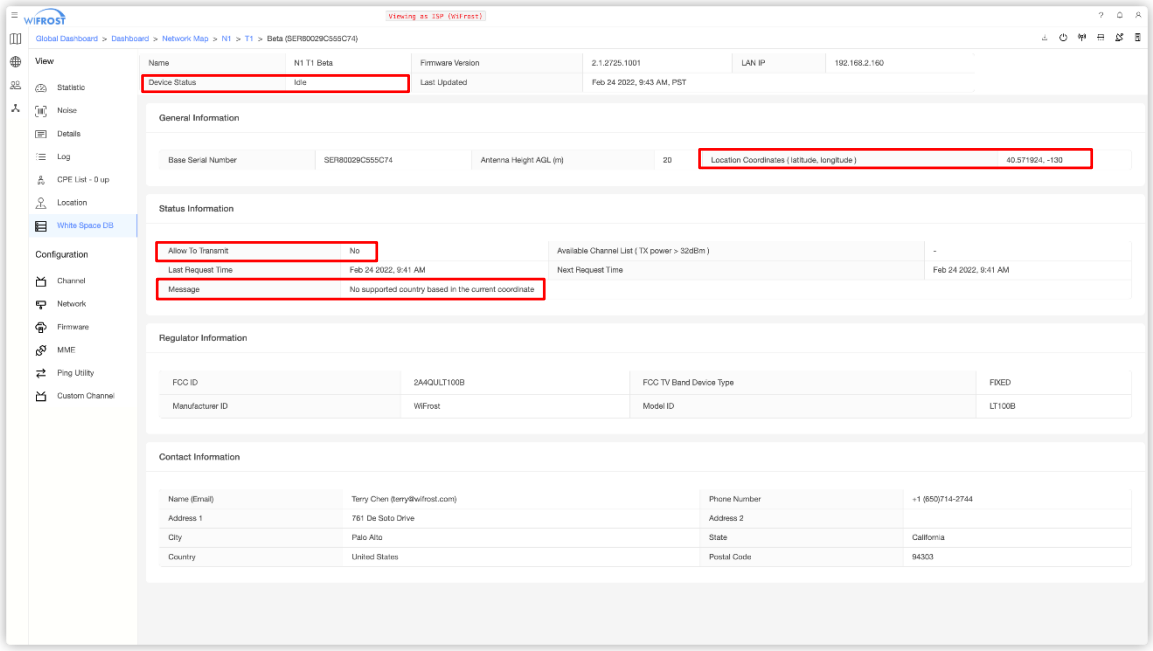
- Configure the EUT with restricted coordinates: LAT=40° 34' 18.9264" (40.571924), LNG=-130° 0' 0" (-130), which is a location that is prohibited to transmit
- Observe the base EUT registration failure indicated by the database message

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	2/24/22

Failed Registration



13.1.3. FAILED REGISTRATION –CONTACT INFORMATION

TEST PROCEDURE

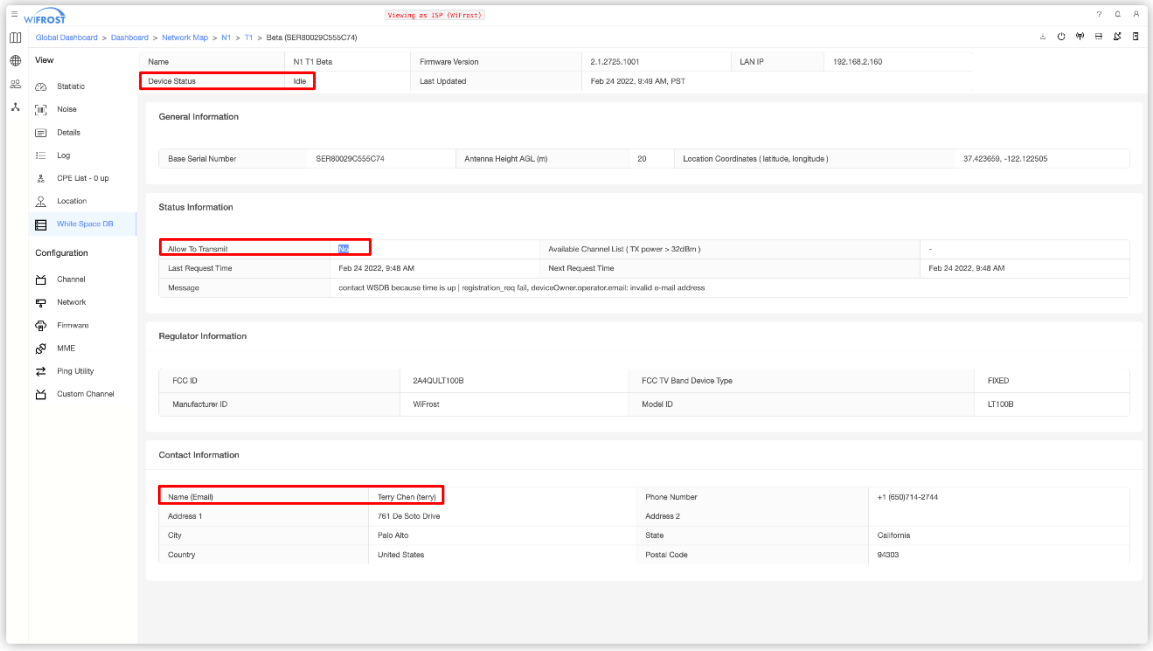
- Configure the base EUT with missing contact information, e.g. email.
- The device software cannot proceed with registration and prompts user to enter the missing information.

RESULTS

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

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	16080ZS	2/24/22

Contact information missing field – Email address removed from Name (Email) field



13.1.4. FAILED REGISTRATION – ANTENNA HEIGHT AGL

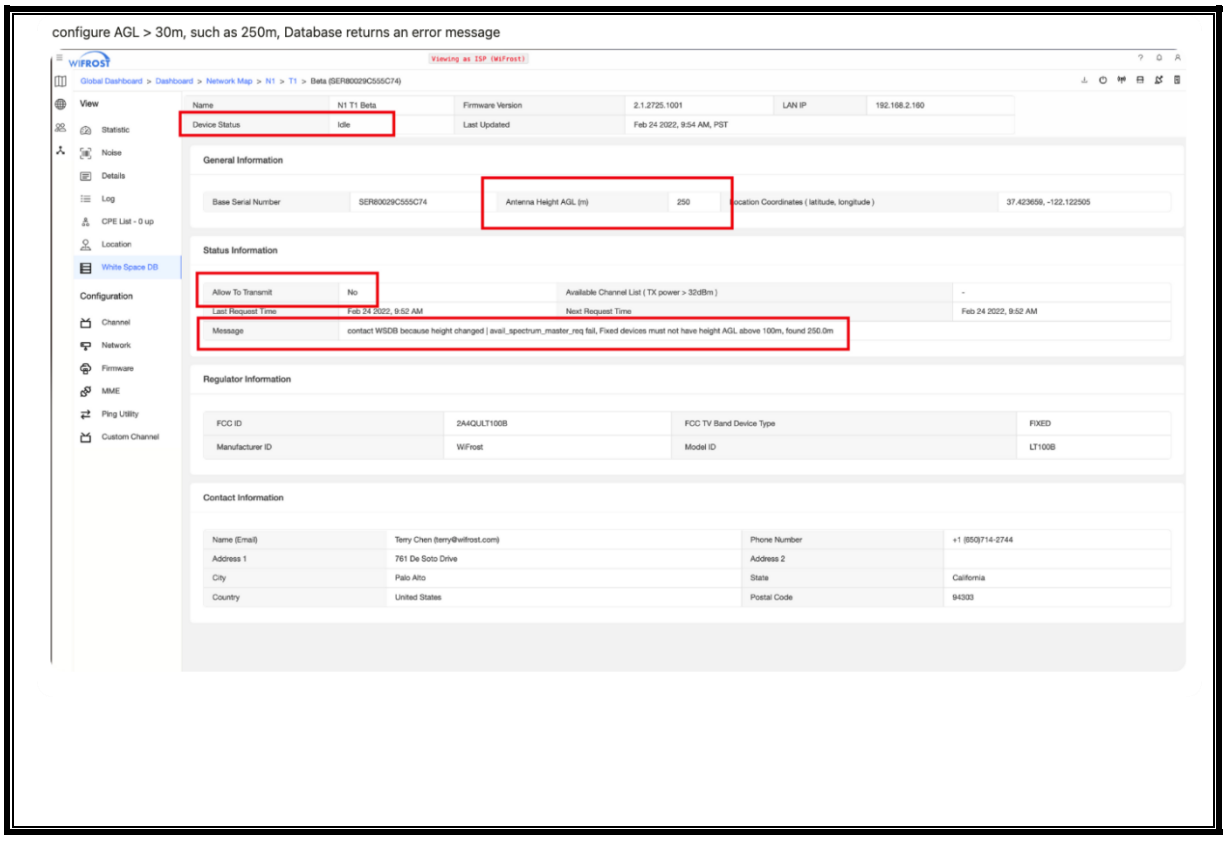
TEST PROCEDURE

- 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	2/24/22



13.2. 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

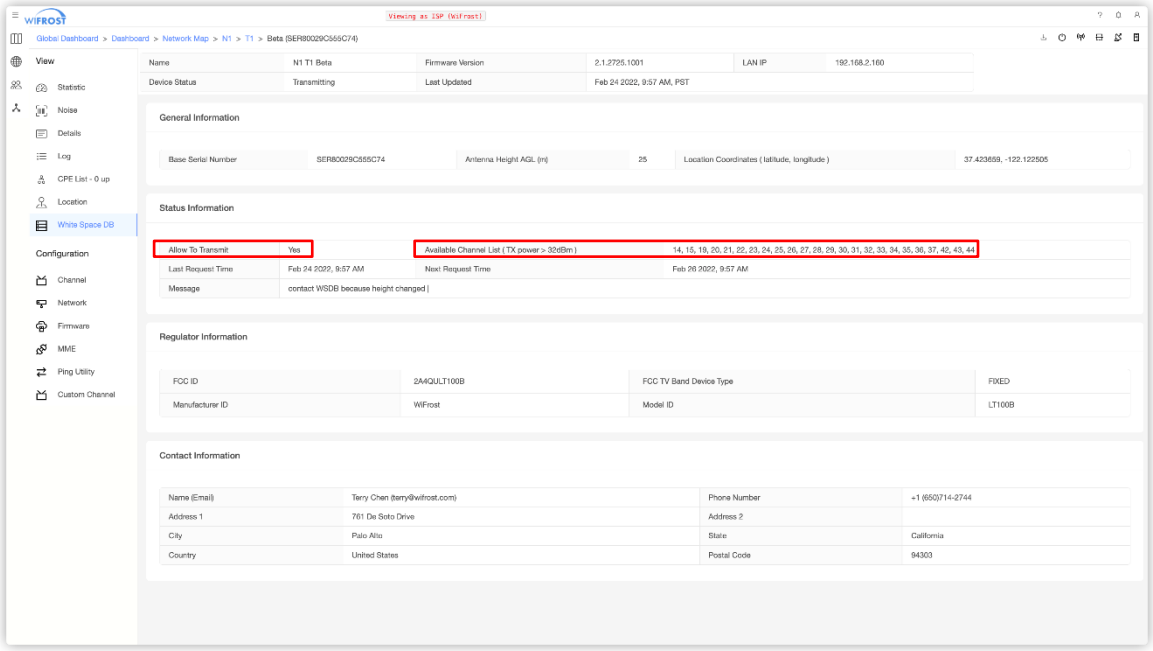
- The base EUT geographic coordinates are entered at registration time and stored in the device. The device channel list request uses the same coordinates established at registration time. No separate coordinates can be entered for channel list request.
- The device requires professional installation 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	2/24/22

Channel list after successful registration



13.3. FIXED TVDB Database Re-Check

CLAUSES

- §15.711(h)(1)

REQUIREMENT

(i) A device that has been in a powered-on state shall access the white space database at least once every 60 minutes to verify that the operating channel(s) and associated maximum power levels continue to be available at its location. Devices shall adjust their channel usage in accordance with the most recent channel availability schedule information provided by the white space database for the two-hour period beginning at the time of the device last accessed the database for a list of available channels.

(ii) If a device fails to successfully contact the white space database, it may continue to operate until no longer than 120 minutes after the last successful contact, at which time it must cease operations until it reestablishes contact with the white space database and re-verifies its list of available channels and associated maximum power levels.

(2)(i)A device that has been in a powered-on state shall access the database at least once a day to verify that the operating channel(s) and associated maximum power levels continue to be available at its location.

(2)(ii) If a device 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 and corresponding power levels.

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 the base EUT access the white space database after 60 minutes.
- Observe that there is no output signal after 120 minutes from last successful contact.

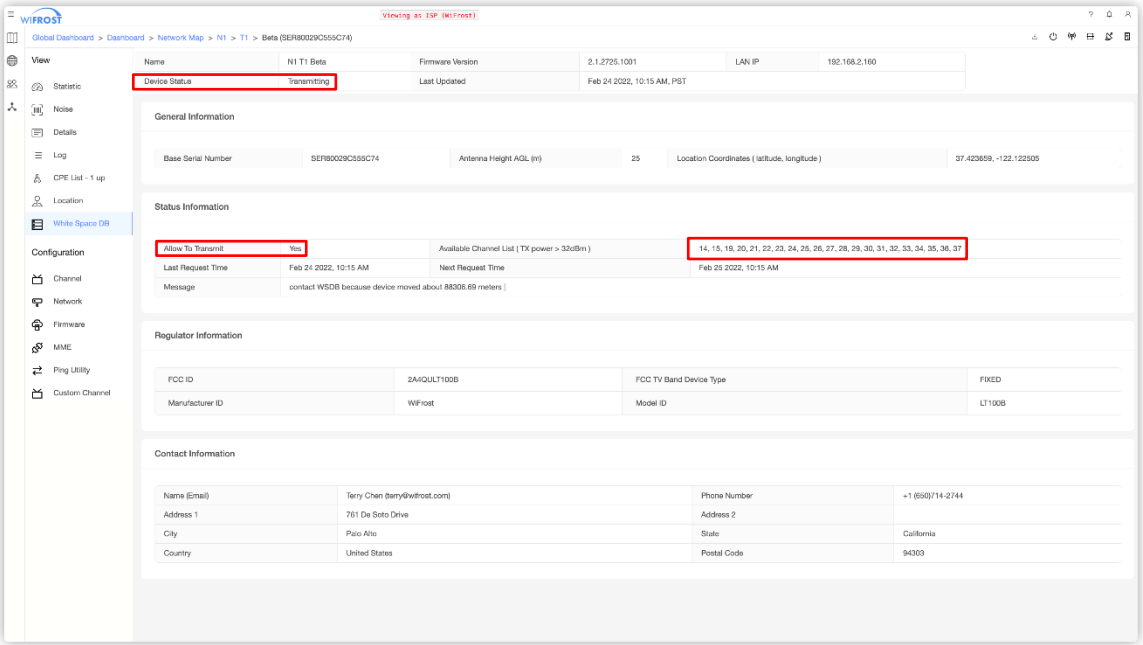
RESULTS

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.

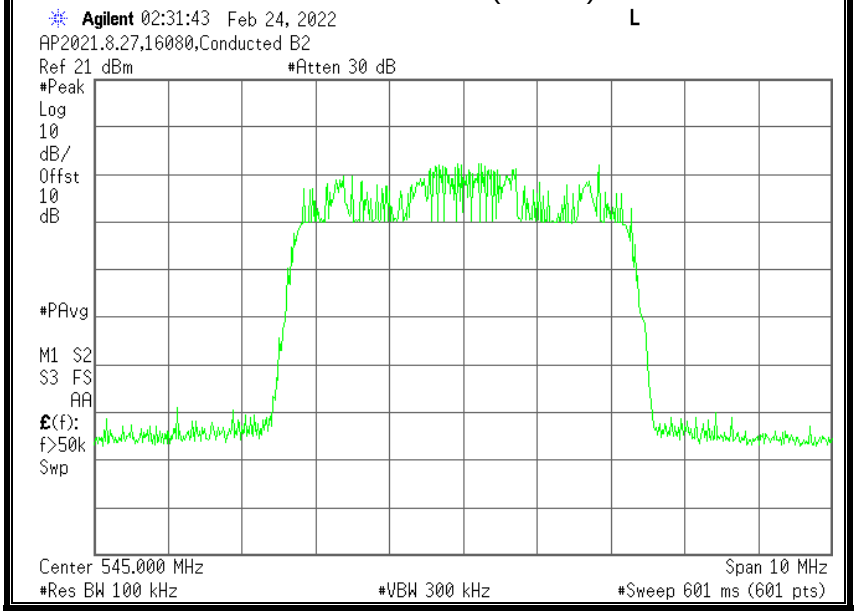
Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	16080ZS	2/24/22

Successful registration & Selected Channel from list (Ch. 26)

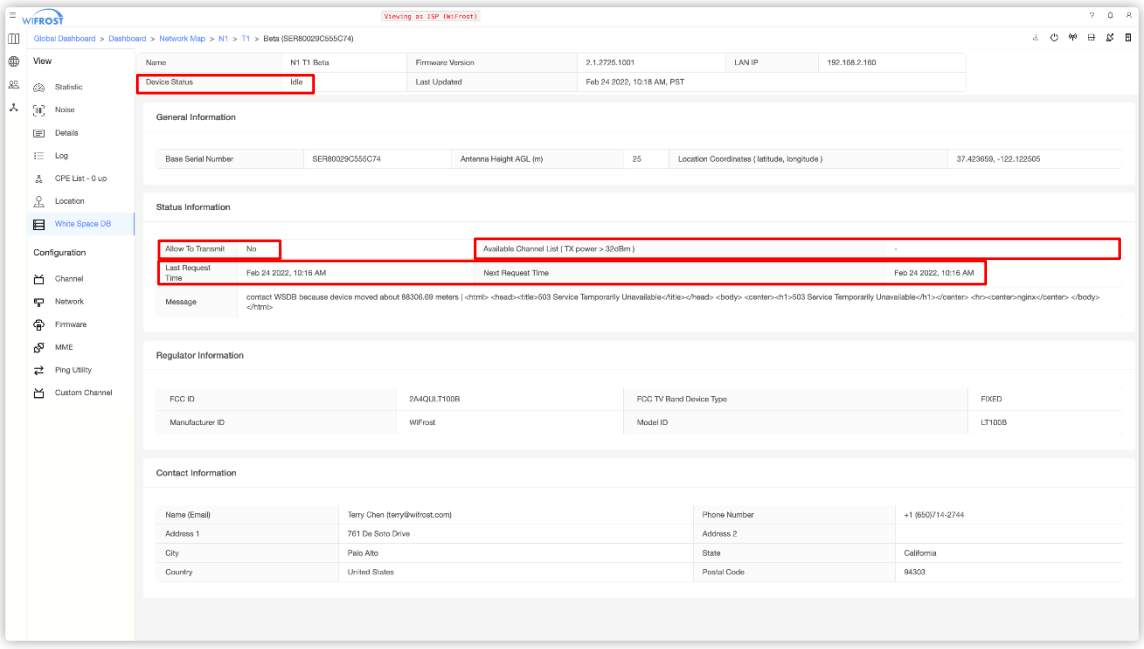
Transmission enabled on Ch. 26



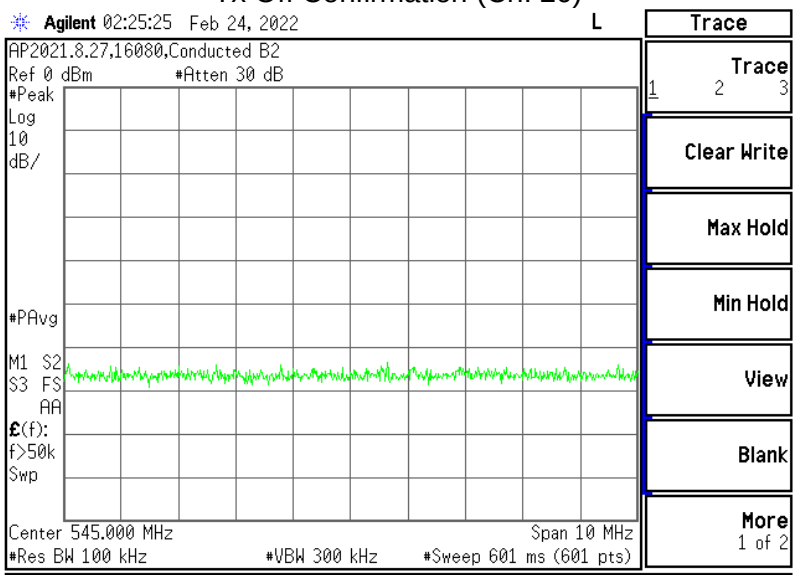
Tx Confirmation (Ch. 26)



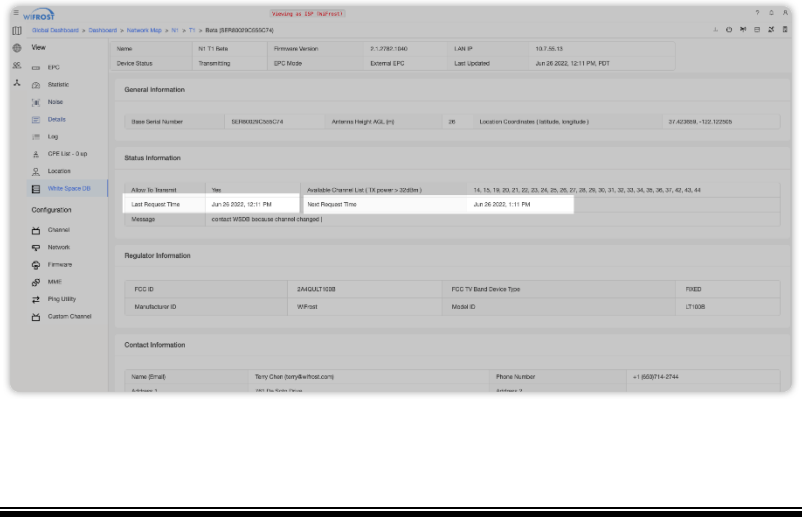
Router blocking – Program used to stop the micro server which caused database connection to be lost. Simulated by changing time/date and transmission stopped and channel list became unavailable



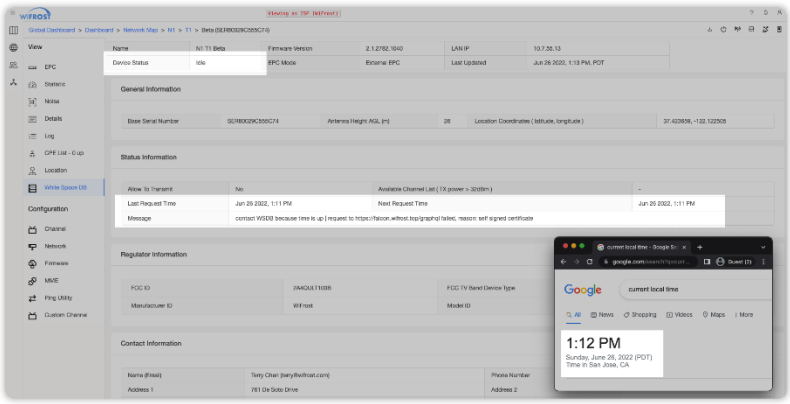
Tx Off Confirmation (Ch. 26)



Base contacts database every 60 mins



Base stop transmission when it fails to contact database



13.4. 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. The fixed device's registration information shall be updated if the geographic coordinates reported to the database differ by more than ±50 meters from the previously registered coordinates.

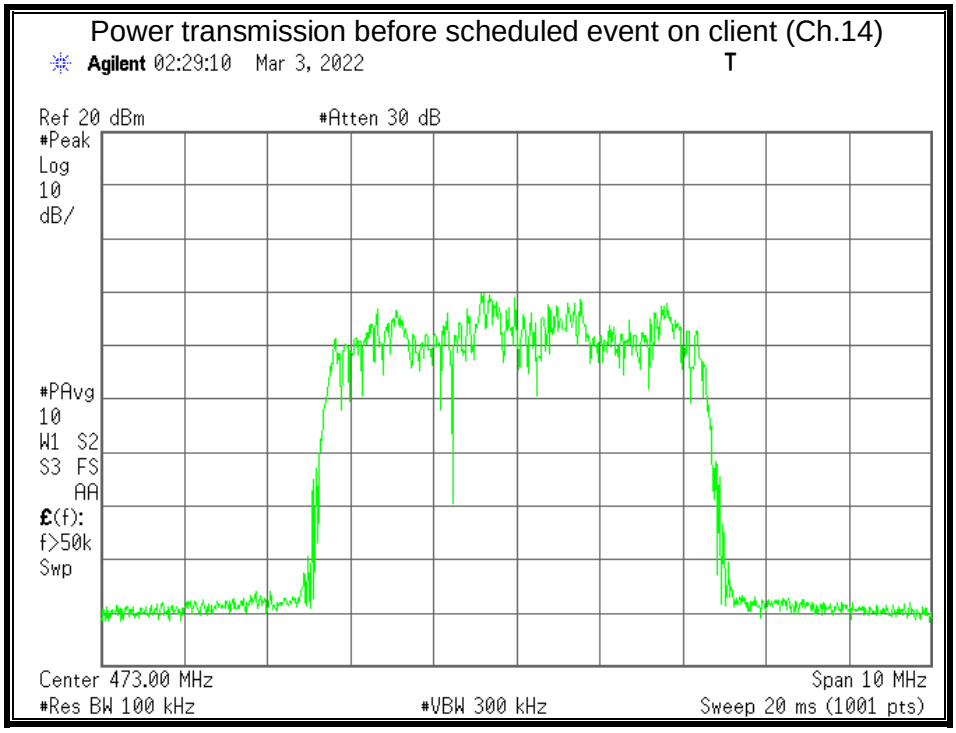
After receiving an available channel list, register a low-power auxiliary device on the WSD operating channel to operate on an available channel and in the upcoming time period when the device will be tested. Repeat the available channel request after the update interval and in the time period when the 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

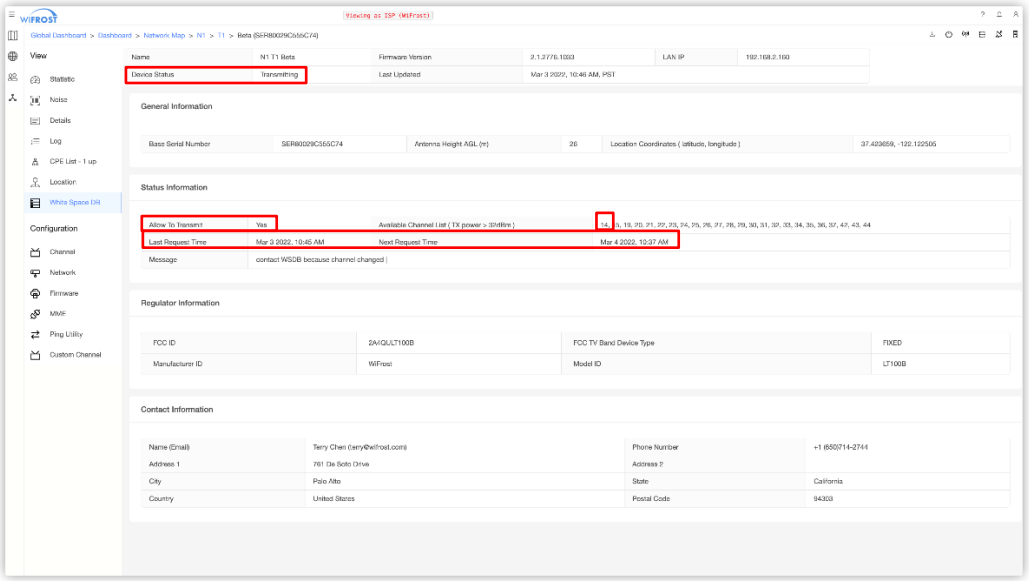
1. A lower power auxiliary devices are registered and scheduled for protection at both base and client locations
2. Allow the base and client EUT to enter normal operations prior to testing
3. Upon channel list request to the TVWS Database, the base EUT obtains the channel list expiration time reflecting 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**
☒	☐	16080ZS	3/3/2022

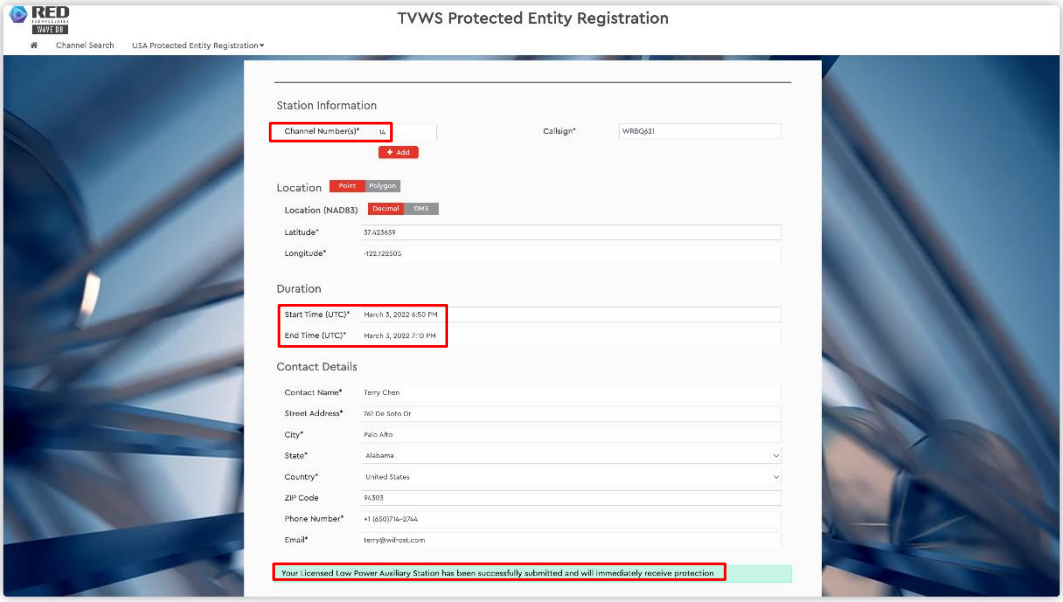
13.4.1. RESULTS FOR BASE



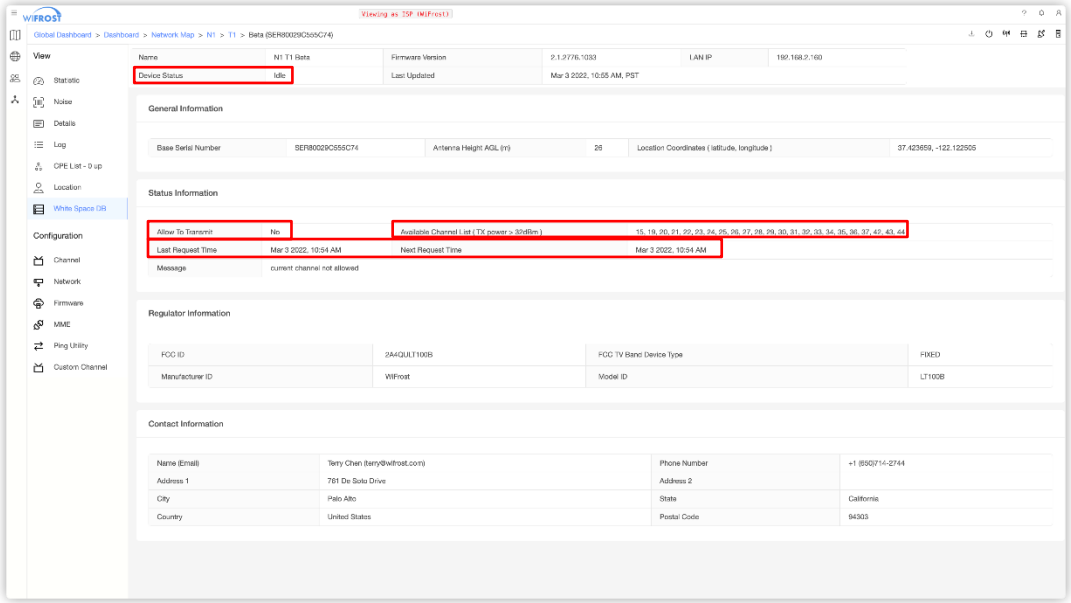
Successful Registration on Ch. 14



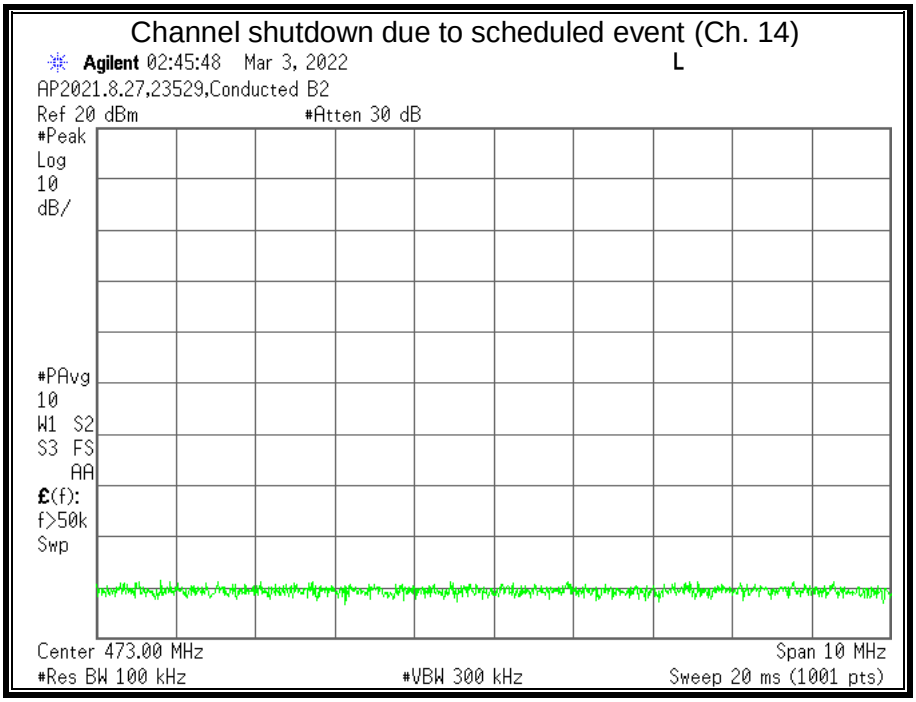
Scheduled Event



Radio shutdown, no longer to transmit. Ch.14 missing from list, device not able to transmit

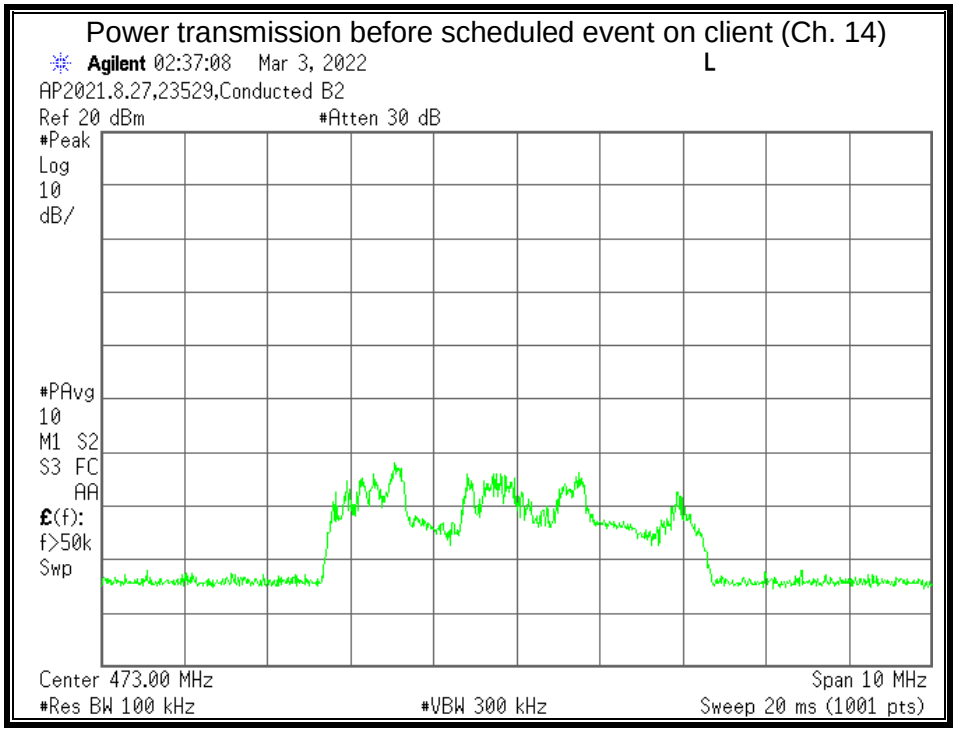


Channel shutdown due to scheduled event (Ch. 14)

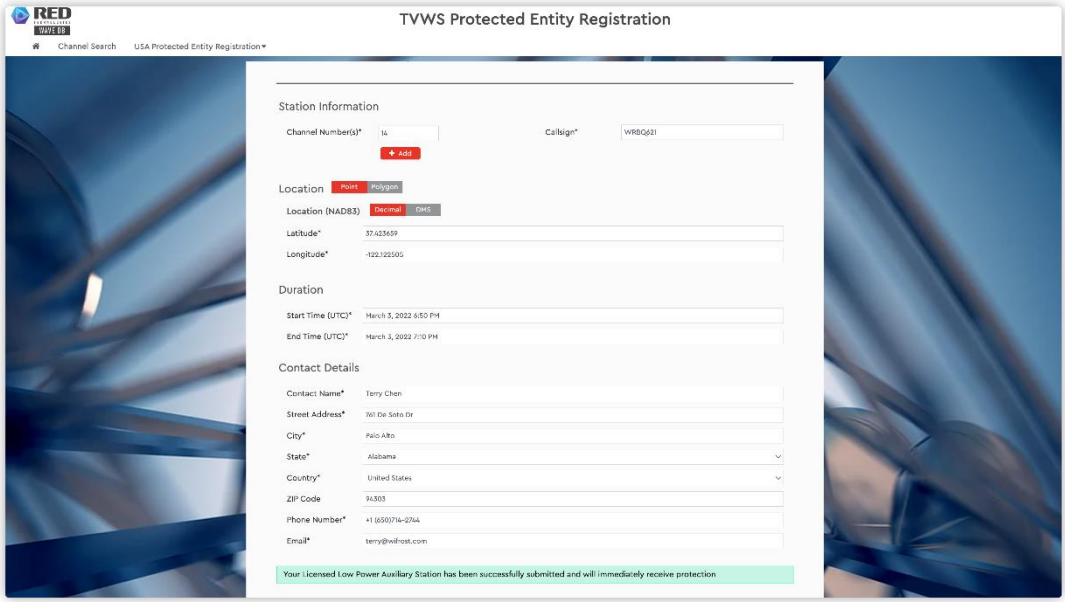


13.4.2. RESULTS FOR CLIENT

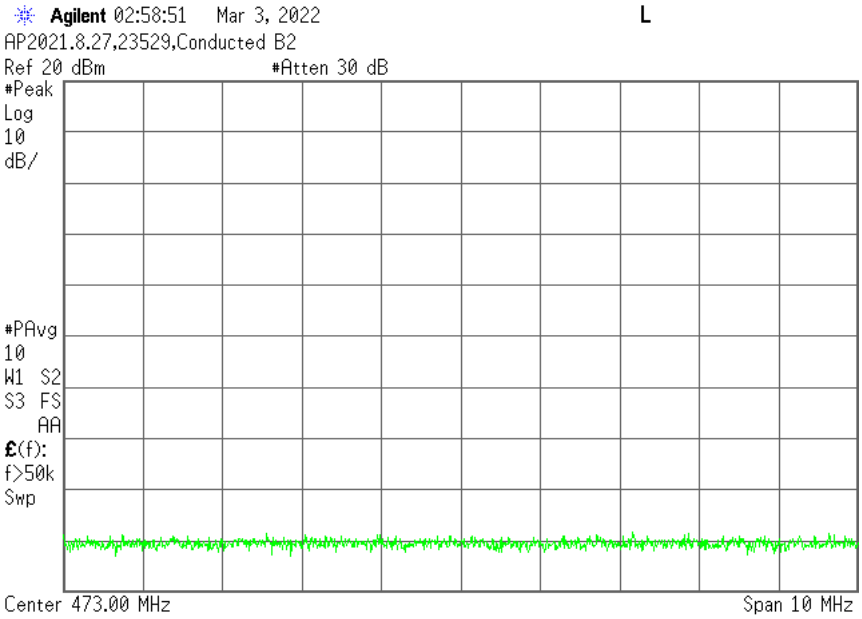
Power transmission before scheduled event on client (Ch. 14)



Scheduled event, Channel transmission shutting down



Channel shutdown due to scheduled event (when base stops transmitting, client also stops due to scheduled event on Ch. 14)



13.5. 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

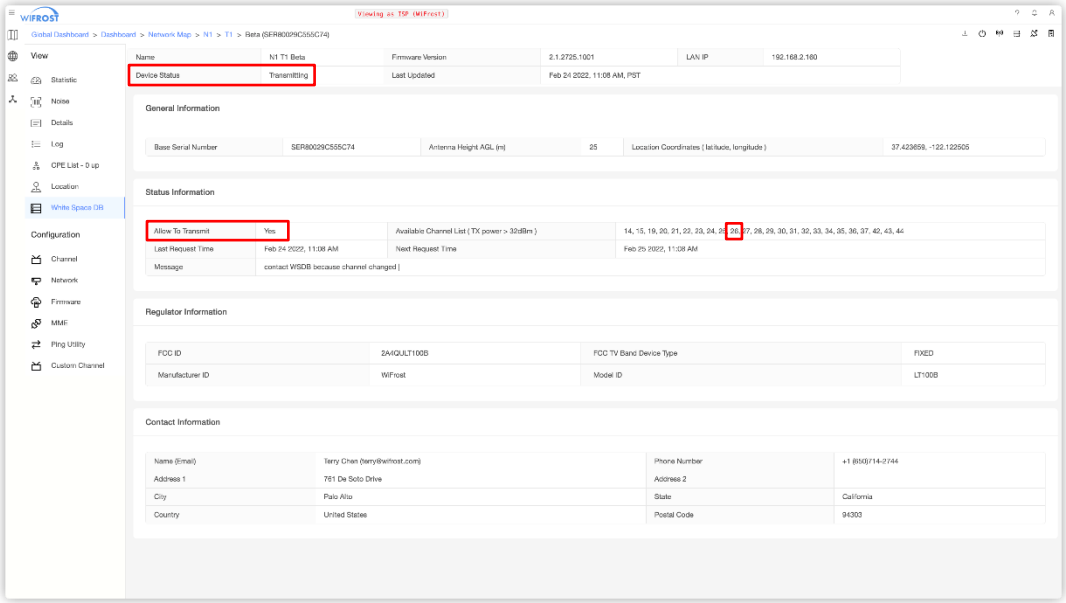
- Configure the base EUT with correct registration information.
- The base EUT automatically contacts the TVWS Database to perform device registration.
- Upon successful registration, base automatically contacts the TVWS Database to retrieve device channels.
- Confirm the base EUT software only allows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

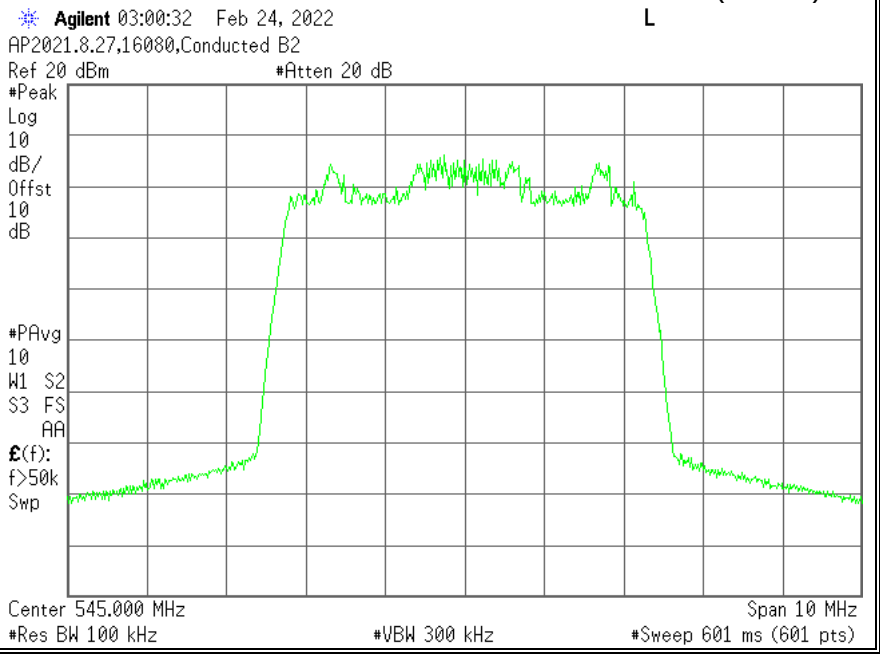
The EUT operates on a channel from the authorized channel list and at the authorized power level. The EUT cannot select and operate on any channel other than those within the authorized channel list returned from the TVWS Database, which are within the device operating frequency range.

Test Results			
Pass	**Fail**	**Tested By**	**Test Date**
☒	☐	16080ZS	2/24/22

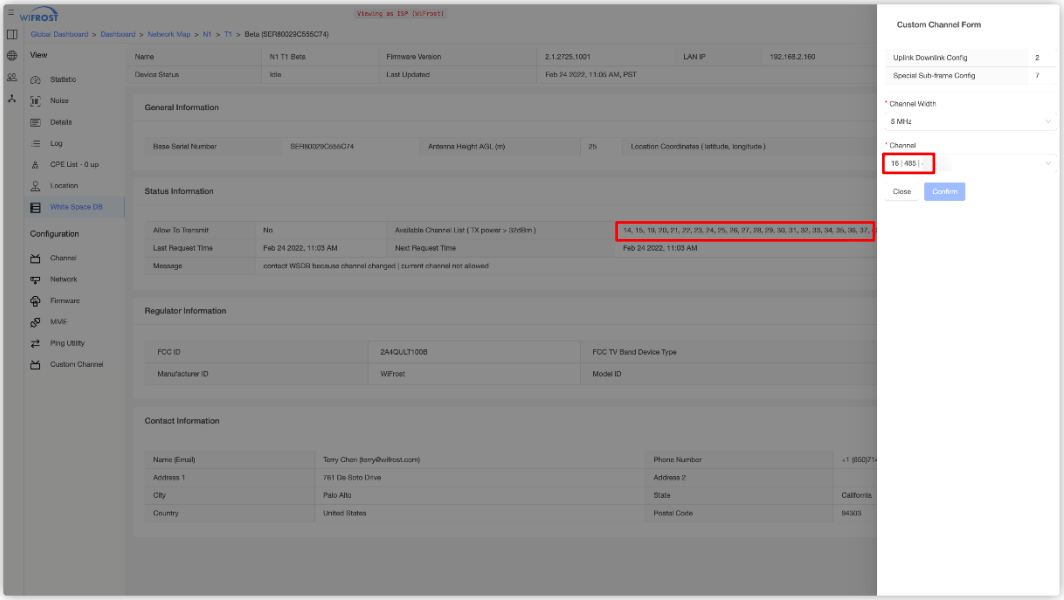
Successful Device Registration with Database (Ch. 26 selected for transmission)



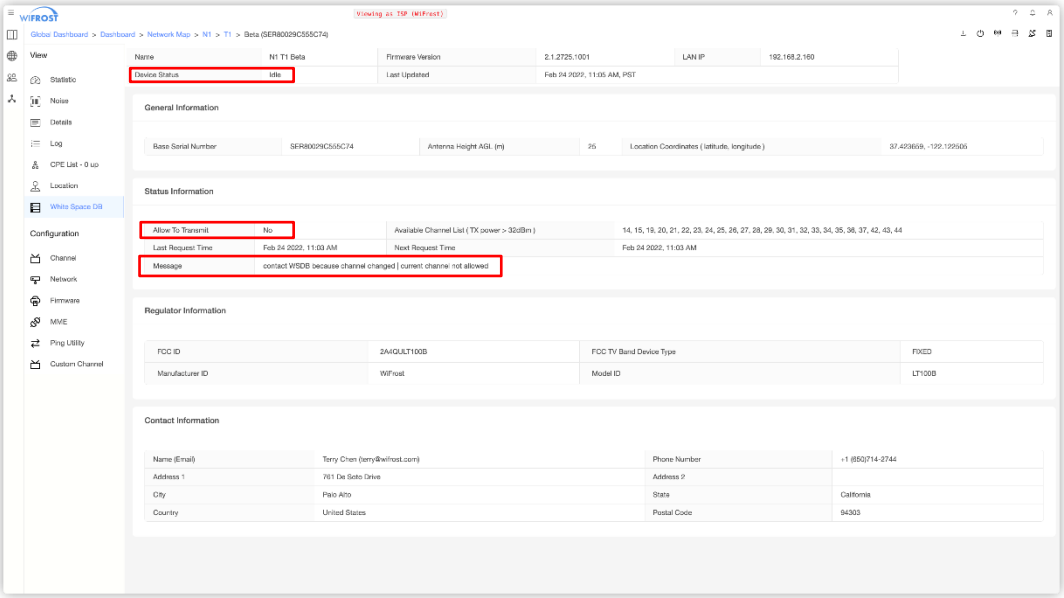
Power Transmission on allowed database channel (Ch. 26)



Ch. 16 Selected which is not an authorized channel



Due to selecting an unauthorized channel, the device will not operate



13.6. 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?
Hypertext Transfer Protocol Secure (HTTPS)

ii. How are communications initiated?
Every time device push data to the WiFrost Cloud Software, cloud will decide to communicate with the database based on the next contact time and the device information update (coordinate change more than 50m, Antenna Height AGL change, channel change, etc.) When the time is up or the device information updated, cloud will communicate with the right database provider based on the device coordinates.

iii. How does the WSD validate messages from the database?
Database will respond with the JSON message. WSD will first check the status field. Then it will check certain fields in the data payload, such as available spectrum list, next contact time, database message field.

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

Device will stop transmitting immediately when it fails to communicate or authenticate the database.

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

Database follow REST API Response format, device must send data in JSON format. Each type of the request has some field check in the JSON message.

vi. What encryption method is used?

SSL/TLS and RSA encryption

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

Database will generate unique license token and access token for each registered device.

13.7. PUSH NOTIFICATION TO FIXED

CLAUSES

- §15.711(i)

REQUIREMENT

Push notifications. Device manufacturers and database administrators may implement a system that pushes updated channel availability information from the database to white space devices. However, the use of such systems is not mandatory, and the requirements for white space devices to validate the operating channel and to cease operation in accordance with paragraph (h) of this section continue to apply if such a system is used.

Requirements for §15.711(h) apply instead, see section 13.3.

13.8. LOCATION ACCURACY

CLAUSES

- §15.711(b)

REQUIREMENT

(b) Geo-location -
(1) Accuracy. Fixed white space devices that incorporate a geo-location capability and Mode II devices shall determine their location and their geo-location uncertainty (in meters), with a confidence level of 95%.

(2) Reference datum. All geographic coordinates shall be referenced to the North American Datum of 1983 (NAD 83).

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

13.9. INTERFERENCE PROTECTION REQUIREMENT - FIXED

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

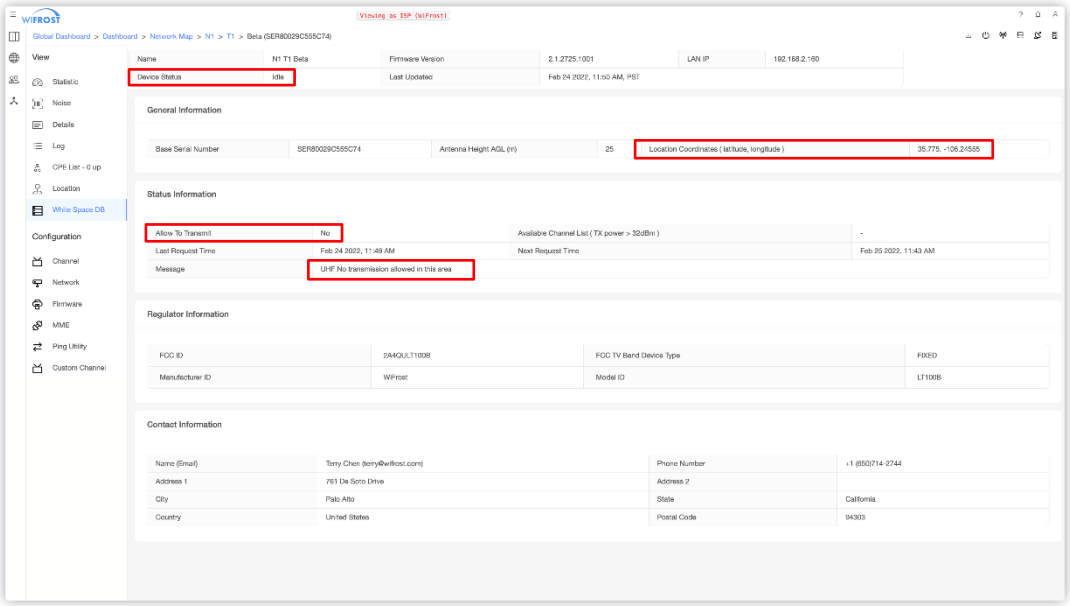
a) Digital television stations, and digital and analog Class A TV, low power TV, TV translator and TV booster stations
b) TV translator, Low power TV (including Class A) and Multi-channel Video Programming Distributor (MVPD)
c) Fixed Broadcast Auxiliary Service (BAS) links
d) PLMR/CMRS operations
e)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

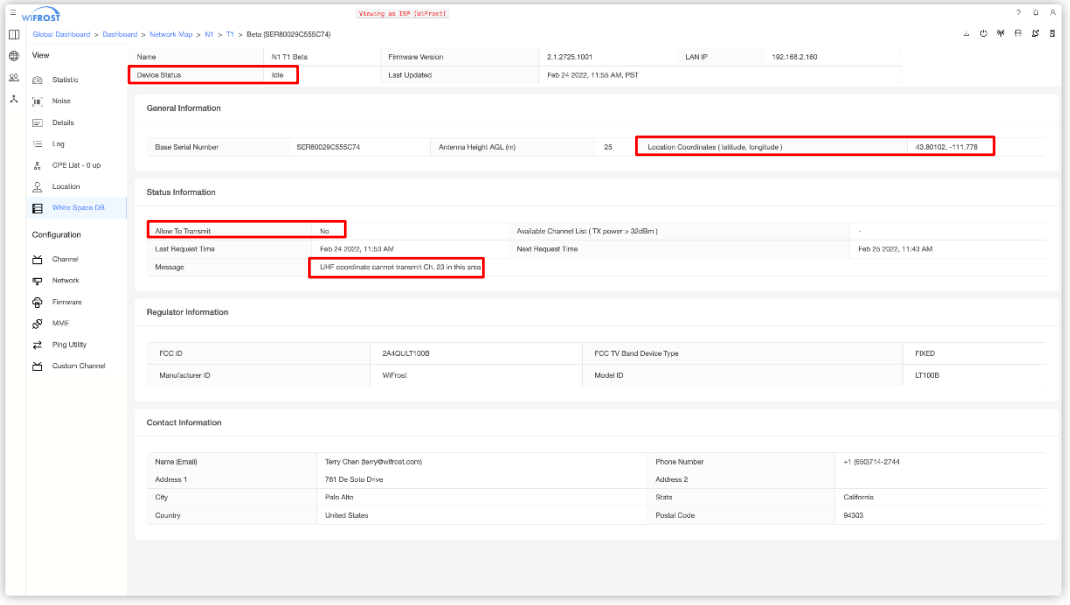
Scenario		Coordinate	Note
a	Digital television stations, and digital and analog Class A TV, low power TV, TV translator and TV booster stations	38.73829, -108.887 (VHF) 35.775, -106.24555 (UHF)	UHF No transmission allowed VHF coordinate cannot transmit on Ch. 13
b	TV translator, Low power TV(including 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	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 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	19.7071, -155.0885	Cannot transmit on Ch. 17

Test Results			
Pass	Fail	Tested By	Test Date
☒	☐	16080ZS	2/24/22

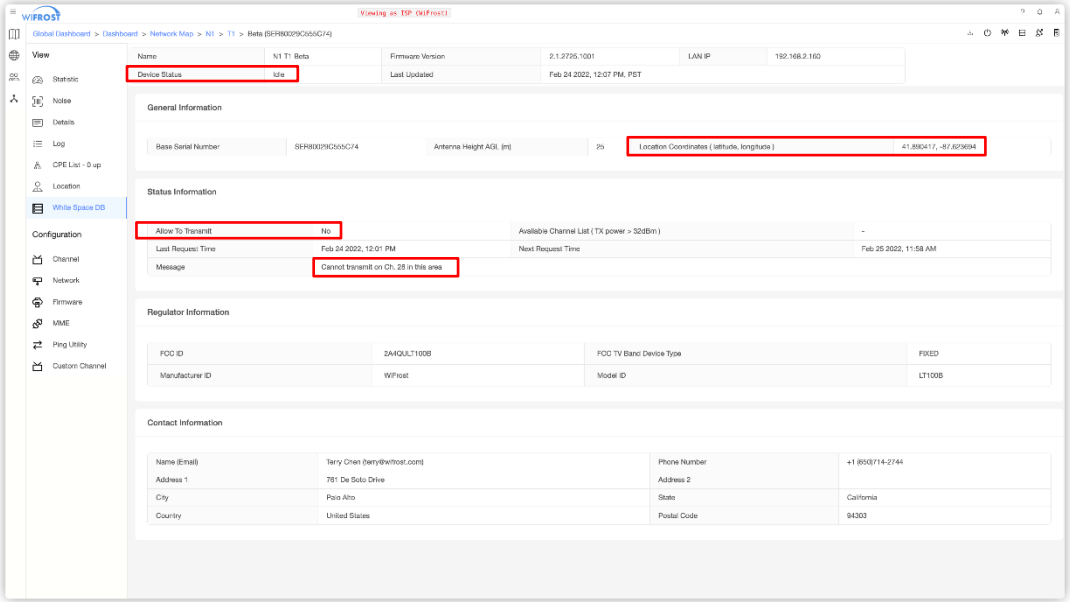
Scenario A UHF



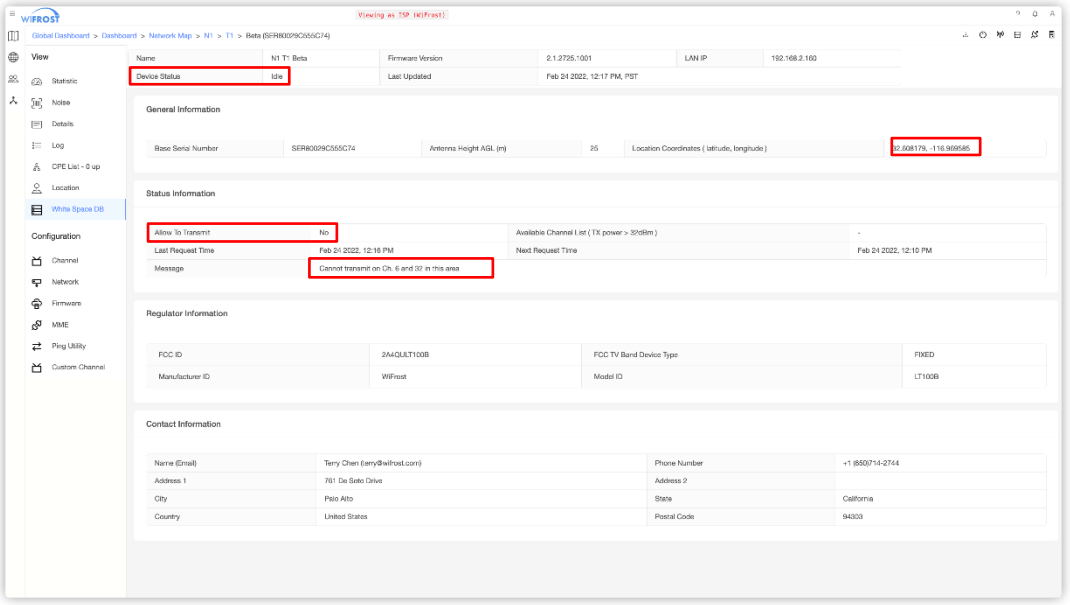
Scenario B (UHF) (cannot select channel 23)



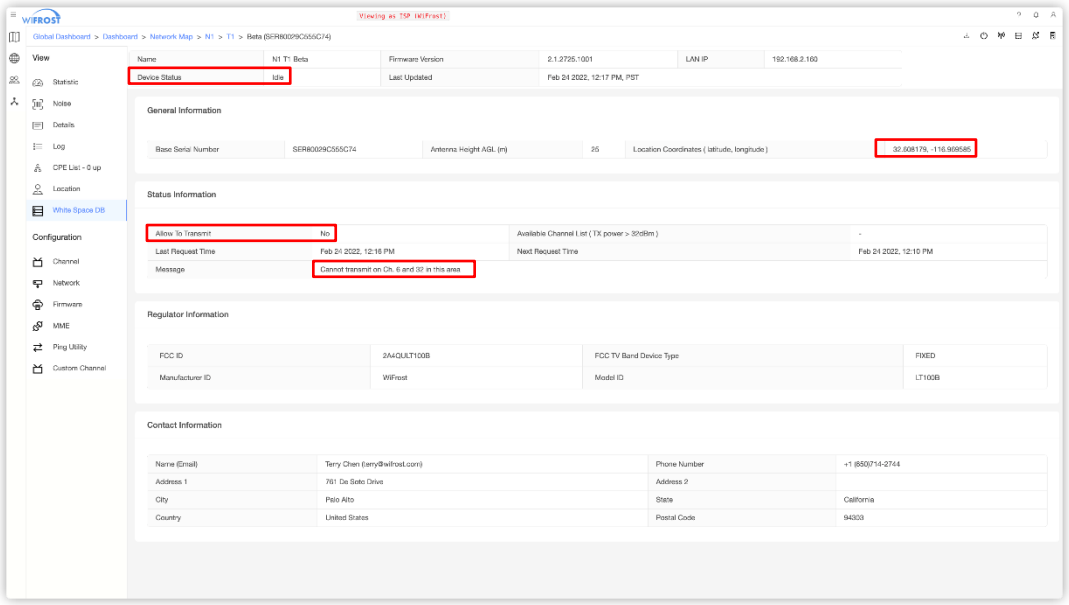
Scenario C (channel 28 missing)



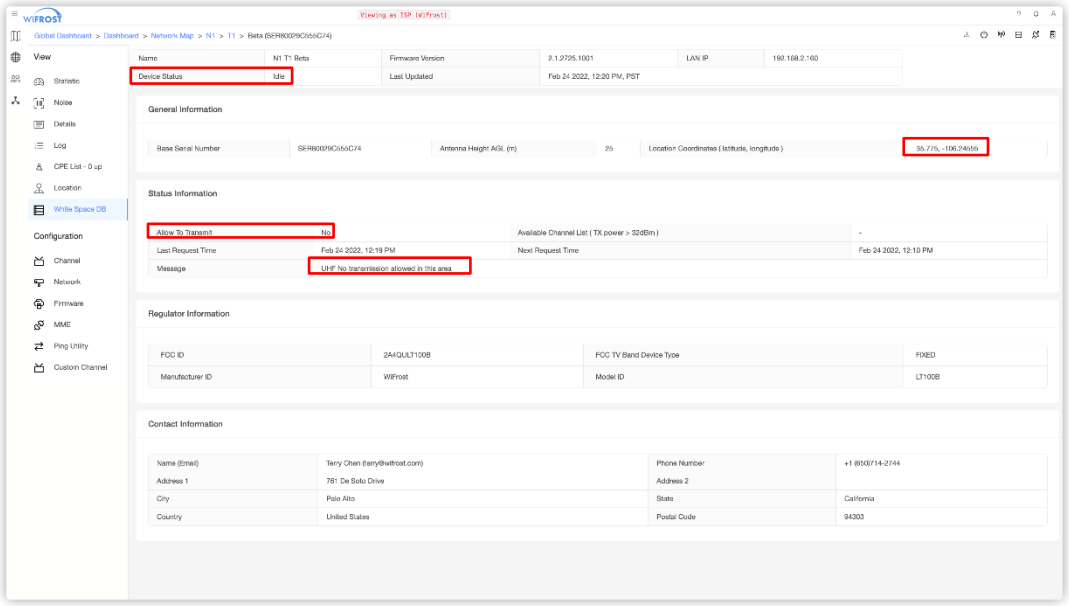
Scenario D/E (cannot transmit on channel 17 nor 18)



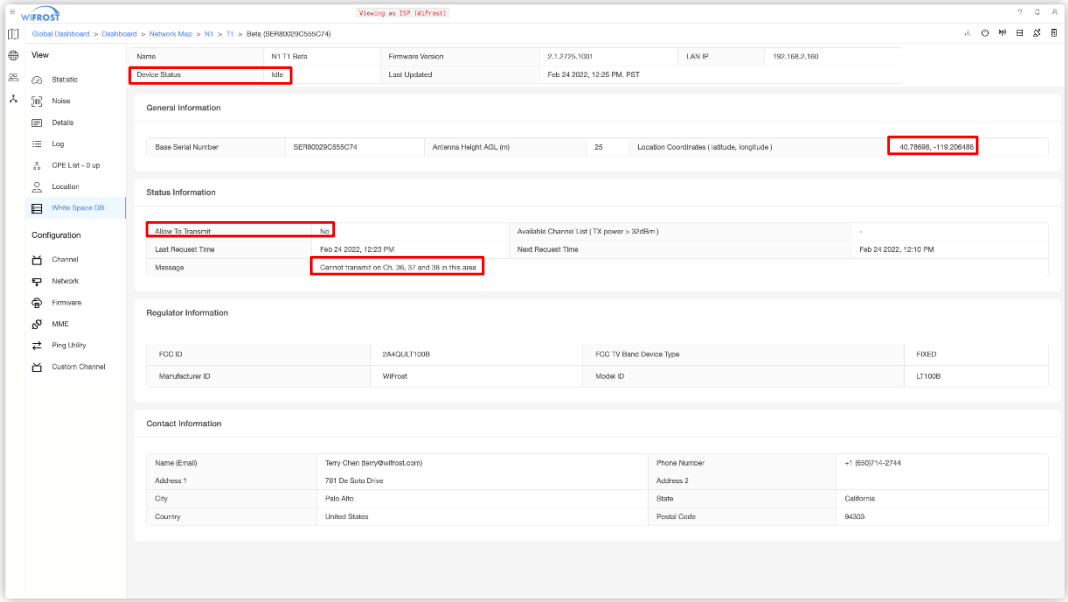
Scenario G (cannot transmit on channel 6 nor 32)



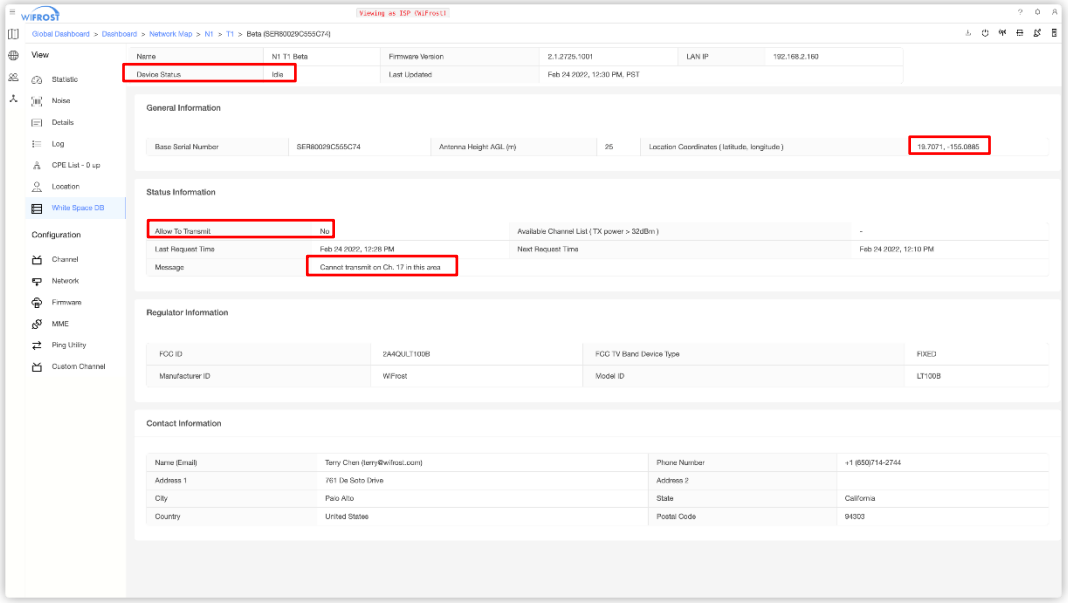
Scenario H (No channels available)



Scenario I (cannot transmit on channel 36/37/38)



Scenario K (cannot transmit on channel 17)



13.10. POWER LEVEL REDUCTION - FIXED

CLAUSES

- §15.711(c)(2)(ii), (d)(3)
- §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.

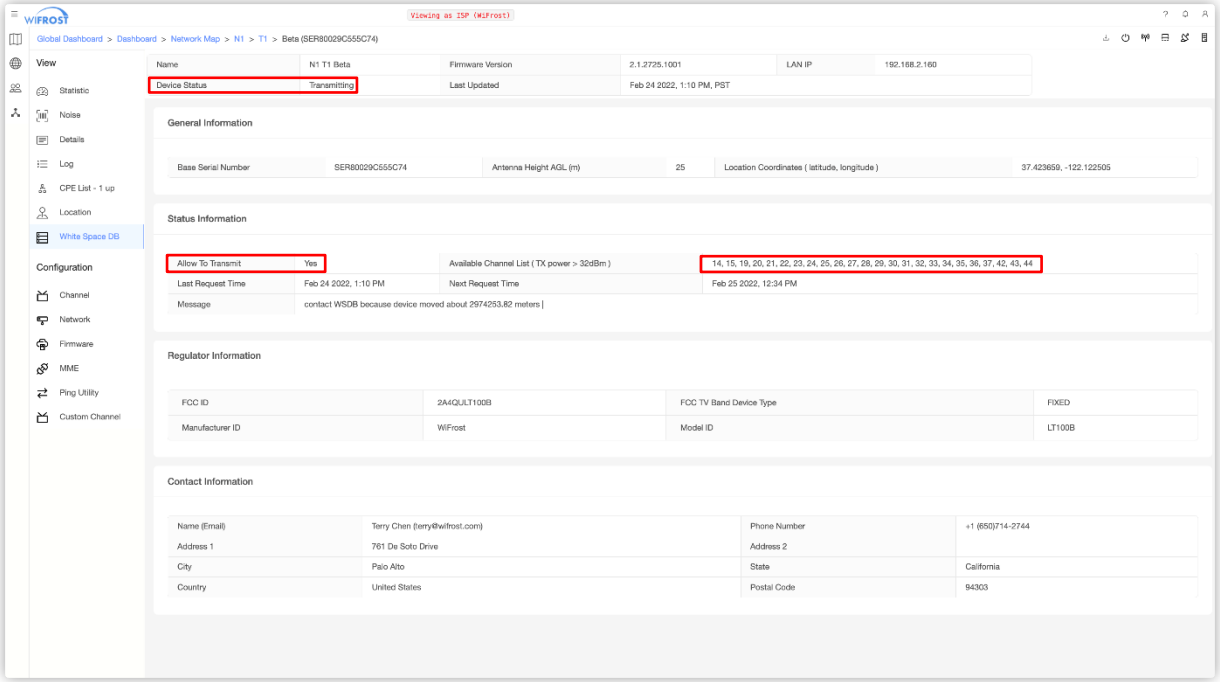
TEST PROCEDURE

- 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	2/24/22

Successful registration, Channel availability and maximum allowed Power level



Max TX Power is 20.77 dBm. Setting a higher value will revert back to 20.77 dBm