DFS PORTION of FCC 47 CFR PART 15 SUBPART E
DFS PORTION of INDUSTRY CANADA RSS-247 ISSUE 2

CERTIFICATION TEST REPORT

FOR

5 GHz FIXED OUTDOOR WIRELESS TRANSCEIVER

MODEL NUMBER: PTP 450b (HIGH-GAIN)

FCC ID: Z8H89FT0042
IC: 109W-0042

REPORT NUMBER: 12338572-E2V1

ISSUE DATE: JULY 5, 2018

Prepared for
CAMBIUM NETWORKS
3800 GOLF ROAD
ROLLING MEADOWS, IL 60008-4023, U.S.A.

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NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	06/05/18	Initial Issue	Henry Lau

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: CAMBIUM NETWORKS
3800 GOLF ROAD
ROLLING MEADOWS, IL 60008-4023, U.S.A.

EUT DESCRIPTION: 5 GHz FIXED OUTDOOR WIRELESS TRANSCEIVER

MODEL: PTP 450b (HIGH-GAIN)

SERIAL NUMBER: 0a-00-3e-7f-ff-f5

DATE TESTED: JUNE 21 to 22, 2018

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
DFS Portion of CFR 47 Part 15 Subpart E	Complies
DFS Portion of INDUSTRY CANADA RSS-247 Issue 2	Complies

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

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

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UL Verification Services Inc.

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with the DFS portion of FCC CFR 47 Part 2, FCC CFR 47 Part 15, FCC 06-96, FCC KDB 789033, KDB 905462 D02 and D03 and RSS-247 Issue 2.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

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

4. CALIBRATION AND UNCERTAINTY

4.1. 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.

4.2. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty level has been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY
Time	± 0.02 %

The Uncertainty figure is valid to a confidence level of 95%.

5. DYNAMIC FREQUENCY SELECTION

5.1. OVERVIEW

5.1.1. LIMITS

INDUSTRY CANADA

IC RSS-247 is closely harmonized with FCC Part 15 DFS rules. The deviations are as follows:

RSS-247 Issue 2

Note: For the band 5600–5650 MHz, no operation is permitted.

Until further notice, devices subject to this annex shall not be capable of transmitting in the band 5600–5650 MHz. This restriction is for the protection of Environment Canada weather radars operating in this band.

FCC

§15.407 (h), FCC KDB 905462 D02 “COMPLIANCE MEASUREMENT PROCEDURES FOR UNLICENSED-NATIONAL INFORMATION INFRASTRUCTURE DEVICES OPERATING IN THE 5250-5350 MHz AND 5470-5725 MHz BANDS INCORPORATING DYNAMIC FREQUENCY SELECTION” and KDB 905462 D03 “U-NII CLIENT DEVICES WITHOUT RADAR DETECTION CAPABILITY”.

Table 1: Applicability of DFS requirements prior to use of a channel

Requirement	Operational Mode		
	Master	Client (without radar detection)	Client (with radar detection)
Non-Occupancy Period	Yes	Not required	Yes
DFS Detection Threshold	Yes	Not required	Yes
Channel Availability Check Time	Yes	Not required	Not required
U-NII Detection Bandwidth	Yes	Not required	Yes

Table 2: Applicability of DFS requirements during normal operation

Requirement	Operational Mode		
	Master	Client **(without DFS)**	Client **(with DFS)**
DFS Detection Threshold	Yes	Not required	Yes
Channel Closing Transmission Time	Yes	Yes	Yes
Channel Move Time	Yes	Yes	Yes
U-NII Detection Bandwidth	Yes	Not required	Yes

Additional requirements for devices with multiple bandwidth modes	Master Device or Client with Radar DFS	Client (without DFS)
U-NII Detection Bandwidth and Statistical Performance Check	All BW modes must be tested	Not required
Channel Move Time and Channel Closing Transmission Time	Test using widest BW mode available	Test using the widest BW mode available for the link
All other tests	Any single BW mode	Not required
Note: Frequencies selected for statistical performance check (Section 7.8.4) should include several frequencies within the radar detection bandwidth and frequencies near the edge of the radar detection bandwidth. For 802.11 devices it is suggested to select frequencies in all 20 MHz channel blocks and a null frequency between the bonded 20 MHz channel blocks.		

Table 3: Interference Threshold values, Master or Client incorporating In-Service Monitoring

Maximum Transmit Power	Value (see notes)
E.I.R.P. ≥ 200 mill watt	-64 dBm
E.I.R.P. < 200 mill watt and power spectral density < 10 dBm/MHz	-62 dBm
E.I.R.P. < 200 mill watt that do not meet power spectral density requirement	-64 dBm

Note 1: This is the level at the input of the receiver assuming a 0 dBi receive antenna
Note 2: Throughout these test procedures an additional 1 dB has been added to the amplitude of the test transmission waveforms to account for variations in measurement equipment. This will ensure that the test signal is at or above the detection threshold level to trigger a DFS response.
Note 3: E.I.R.P. is based on the highest antenna gain. For MIMO devices refer to KDB publication 662911 D01.

Table 4: DFS Response requirement values

Parameter	Value
Non-occupancy period	30 minutes
Channel Availability Check Time	60 seconds
Channel Move Time	10 seconds (See Note 1)
Channel Closing Transmission Time	200 milliseconds + approx. 60 milliseconds over remaining 10 second period. (See Notes 1 and 2)
U-NII Detection Bandwidth	Minimum 100% of the U-NII 99% transmission power bandwidth. (See Note 3)

Note 1: *Channel Move Time* and the *Channel Closing Transmission Time* should be performed with Radar Type 0. The measurement timing begins at the end of the Radar Type 0 burst.
Note 2: The *Channel Closing Transmission Time* is comprised of 200 milliseconds starting at the beginning of the *Channel Move Time* plus any additional intermittent control signals required to facilitate a *Channel* move (an aggregate of 60 milliseconds) during the remainder of the 10 second period. The aggregate duration of control signals will not count quiet periods in between transmissions.
Note 3: During the *U-NII Detection Bandwidth* detection test, radar type 0 should be used. For each frequency step the minimum percentage of detection is 90 percent. Measurements are performed with no data traffic.

Table 5 – Short Pulse Radar Test Waveforms

Radar Type	Pulse Width (usec)	PRI (usec)	Pulses	Minimum Percentage of Successful Detection	Minimum Trials
0	1	1428	18	See Note 1	See Note 1
1	1	Test A: 15 unique PRI values randomly selected from the list of 23 PRI values in table 5a	Roundup: {(1/360) x (19 x 10^6 PRI_{usec})}	60%	30
		Test B: 15 unique PRI values randomly selected within the range of 518-3066 usec. With a minimum increment of 1 usec, excluding PRI values selected in Test A			
2	1-5	150-230	23-29	60%	30
3	6-10	200-500	16-18	60%	30
4	11-20	200-500	12-16	60%	30
Aggregate (Radar Types 1-4)				80%	120

Note 1: Short Pulse Radar Type 0 should be used for the *Detection Bandwidth* test, *Channel Move Time*, and *Channel Closing Time* tests.

Table 6 – Long Pulse Radar Test Signal

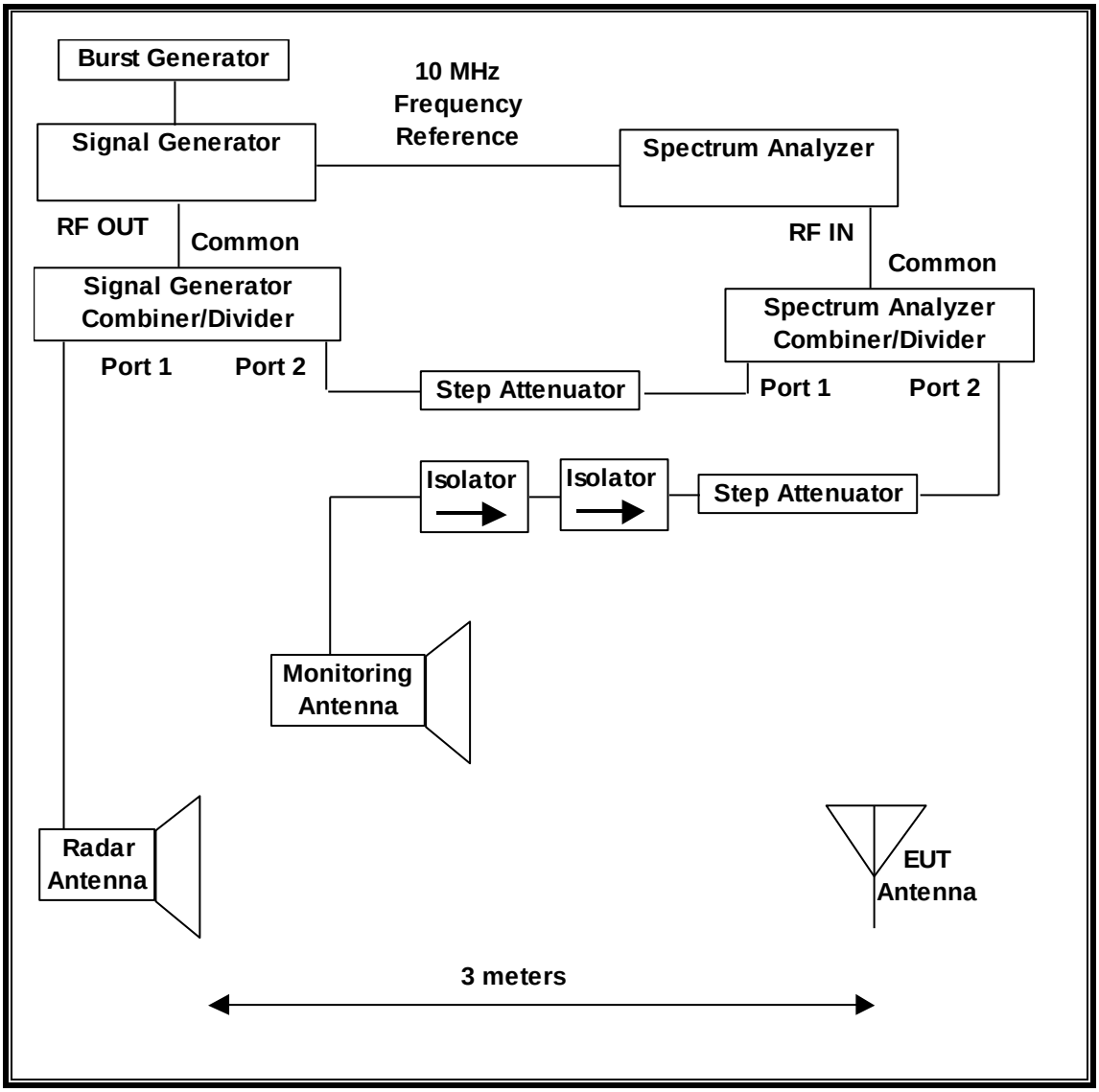
Radar Waveform Type	Pulse Width (µsec)	Chirp Width (MHz)	PRI (µsec)	Pulses per Burst	Number of Bursts	Minimum Percentage of Successful Detection	Minimum Trials
5	50-100	5-20	1000-2000	1-3	8-20	80%	30

Table 7 – Frequency Hopping Radar Test Signal

Radar Waveform Type	Pulse Width (µsec)	PRI (µsec)	Pulses per Hop	Hopping Rate (kHz)	Hopping Sequence Length (msec)	Minimum Percentage of Successful Detection	Minimum Trials
6	1	333	9	0.333	300	70%	30

5.1.2. TEST AND MEASUREMENT SYSTEM

RADIATED METHOD SYSTEM BLOCK DIAGRAM



SYSTEM OVERVIEW

The short pulse and long pulse signal generating system utilizes the NTIA software. The Vector Signal Generator has been validated by the NTIA. The hopping signal generating system utilizes the CCS simulated hopping method and system, which has been validated by the DoD, FCC and NTIA. The software selects waveform parameters from within the bounds of the signal type on a random basis using uniform distribution.

The short pulse types 1, 2, 3 and 4, and the long pulse type 5 parameters are randomized at run-time.

The hopping type 6 pulse parameters are fixed while the hopping sequence is based on the August 2005 NTIA Hopping Frequency List. The initial starting point randomized at run-time and each subsequent starting point is incremented by 475. Each frequency in the 100-length segment is compared to the boundaries of the EUT Detection Bandwidth and the software creates a hopping burst pattern in accordance with Section 7.4.1.3 Method #2 Simulated Frequency Hopping Radar Waveform Generating Subsystem of KDB 905462 D02. The frequency of the signal generator is incremented in 1 MHz steps from F_L to F_H for each successive trial. This incremental sequence is repeated as required to generate a minimum of 30 total trials and to maintain a uniform frequency distribution over the entire Detection Bandwidth.

The signal monitoring equipment consists of a spectrum analyzer. The aggregate ON time is calculated by multiplying the number of bins above a threshold during a particular observation period by the dwell time per bin, with the analyzer set to peak detection and max hold.

SYSTEM CALIBRATION

A 50-ohm load is connected in place of the spectrum analyzer, and the spectrum analyzer is connected to a horn antenna via a coaxial cable, with the reference level offset set to (horn antenna gain – coaxial cable loss). The signal generator is set to CW mode. The amplitude of the signal generator is adjusted to yield a level of –64 dBm as measured on the spectrum analyzer.

Without changing any of the instrument settings, the spectrum analyzer is reconnected to the Common port of the Spectrum Analyzer Combiner/Divider. The Reference Level Offset of the spectrum analyzer is adjusted so that the displayed amplitude of the signal is –64 dBm.

The spectrum analyzer displays the level of the signal generator as received at the antenna ports of the Master Device. The interference detection threshold may be varied from the calibrated value of –64 dBm and the spectrum analyzer will still indicate the level as received by the Master Device.

ADJUSTMENT OF DISPLAYED TRAFFIC LEVEL

A link is established between the Master and Slave and the distance between the units is adjusted as needed to provide a suitable received level at the Master and Slave devices. Traffic that meets or exceeds the minimum requirement is generated using iPerf traffic generator software and streamed from the Master to the Slave radio devices. The monitoring antenna is adjusted so that the WLAN traffic level, as displayed on the spectrum analyzer, is at lower amplitude than the radar detection threshold.

TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the DFS tests documented in this report:

TEST EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**T No.**	**Cal Due**
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight	N9030A	T459	06/30/18
Signal Generator, MXG X-Series RF Vector	Agilent	N5182B	T1134	04/23/19
Arbitrary Waveform Generator	Agilent / HP	33220A	T190	04/23/19

5.1.3. TEST AND MEASUREMENT SOFTWARE

The following test and measurement software was utilized for the tests documented in this report:

TEST SOFTWARE LIST		
Name	**Version**	**Test / Function**
Aggregate Time-PXA	3.1	Channel Loading and Aggregate Closing Time
FCC 2014 Detection Bandwidth-PXA	3.1.1	Detection Bandwidth in 5 MHz Steps
In Service Monitoring-PXA	3.3.4	In-Service Monitoring (Probability of Detection)
PXA Read	3.1	Signal Generator Screen Capture
SGXProject.exe	1.7	Radar Waveform Generation and Download

5.1.4. TEST ROOM ENVIRONMENT

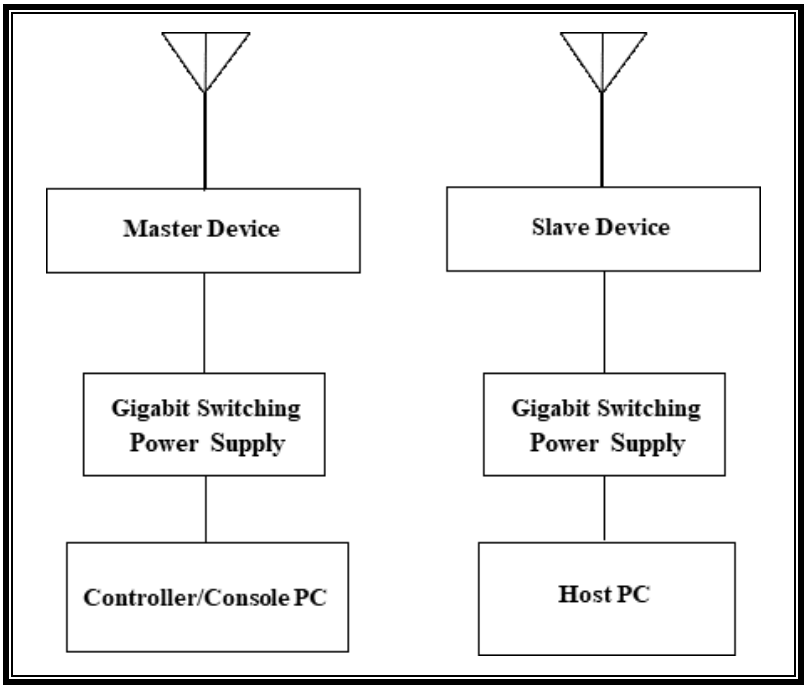
The test room temperature and humidity shall be maintained within normal temperature of 15~35 °C and normal humidity 20~75% (relative humidity).

ENVIRONMENT CONDITION

Parameter	Value
Temperature	25.9 and 26.5 °C
Humidity	32 and 34 %

5.1.5. SETUP OF EUT

RADIATED METHOD EUT TEST SETUP



SUPPORT EQUIPMENT

The following support equipment was utilized for the DFS tests documented in this report:

PERIPHERAL SUPPORT EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
Gigabit Switching Power Supply (EUT)	Phihong	PSA15A-300 (AP)	000868116P0401	DoC
Notebook PC (EUT Controller/Console)	Lenovo	Type 4236-B92	PB-HEXC4 12/05	DoC
AC Adapter (Controller/Console PC)	Lenovo	42T4418	11S42T4418Z1ZGWG 08R90M	DoC
5 GHz Fixed Outdoor Transceiver (Slave Device)	Cambium Networks	PTP 450b (Mid-Gain)	0a-00-3e-70-51-8f	Z8H89FT0032
Gigabit Switching Power Supply (Slave)	Phihong	PSA15A-300 (AP)	0167552117P0401	DoC
Notebook PC (Slave Host)	Lenovo	Type 20B7-S0A200	PF-02JN9J 14/06	DoC
AC Adapter (Host PC)	Lenovo	ADLX65NCC2A	11S45N0263Z1ZSHD 41A5JY	DoC

5.1.6. DESCRIPTION OF EUT

For FCC the EUT operates over the 5250-5350 MHz and 5470-5725 MHz ranges.

For IC the EUT operates over the 5250-5350 MHz and 5470-5725 MHz ranges, excluding the 5600-5650 MHz range.

The EUT is a Master Device.

The manufacturer has declared that the highest power level within these bands is 30 dBm EIRP in the 5250-5350 MHz band and 30 dBm EIRP in the 5470-5725 MHz band.

The EUT utilizes a proprietary protocol. Two nominal channel bandwidths are implemented: 10 MHz and 40 MHz.

The manufacturer has declared that the lowest gain antenna assembly utilized with the EUT has a gain of 2 dBi and the highest gain antenna assembly utilized with the EUT has a gain of 24 dBi.

The rated output power of the Master unit is > 23dBm (EIRP). Therefore the required interference threshold level is –64 dBm. After correction for procedural adjustments, the required radiated threshold at the antenna port is –64 + 1 = -63 dBm.

The calibrated radiated DFS Detection Threshold level is set to –63 dBm.

One integrated antenna array is utilized to meet the diversity and MIMO operational requirements.

The EUT uses one vertically polarized and one horizontally polarized transmitter/receiver chain. During testing the vertical chain is connected to a dipole antenna.

The Slave device associated with the EUT during these tests does not have radar detection capability.

WLAN traffic that meets or exceeds the minimum required loading was generated by transferring a data stream from the Master Device to the Slave Device using iPerf version 2.0.5 software package.

TPC is required since the maximum EIRP is greater than 500 mW (27 dBm).

The software installed in the EUT is Canopy version 15.1.4.

UNIFORM CHANNEL SPREADING

This function is not required per KDB 905462.

5.2. RESULTS FOR 10 MHz BANDWIDTH

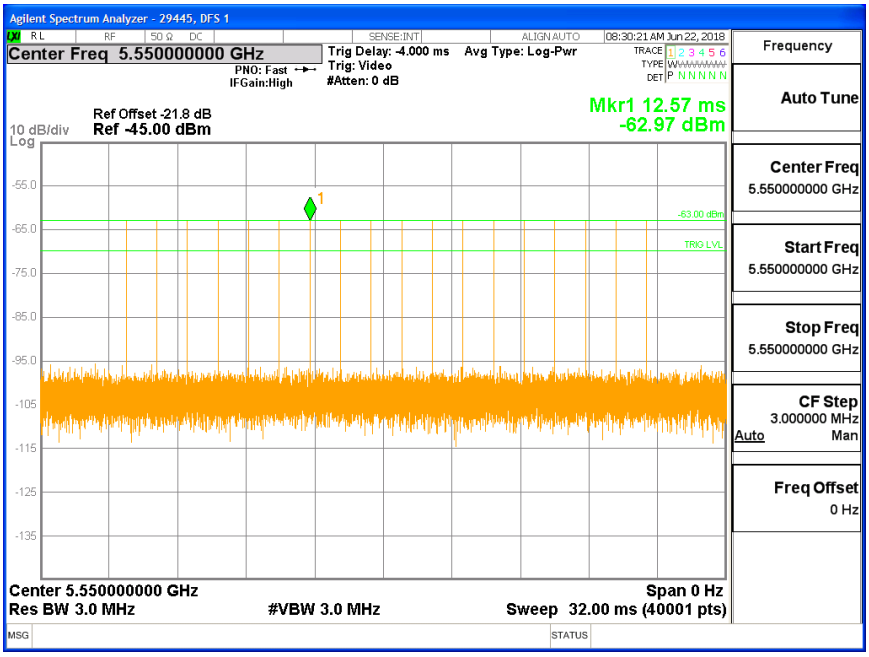
5.2.1. TEST CHANNEL

All tests were performed at a channel center frequency of 5550 MHz.

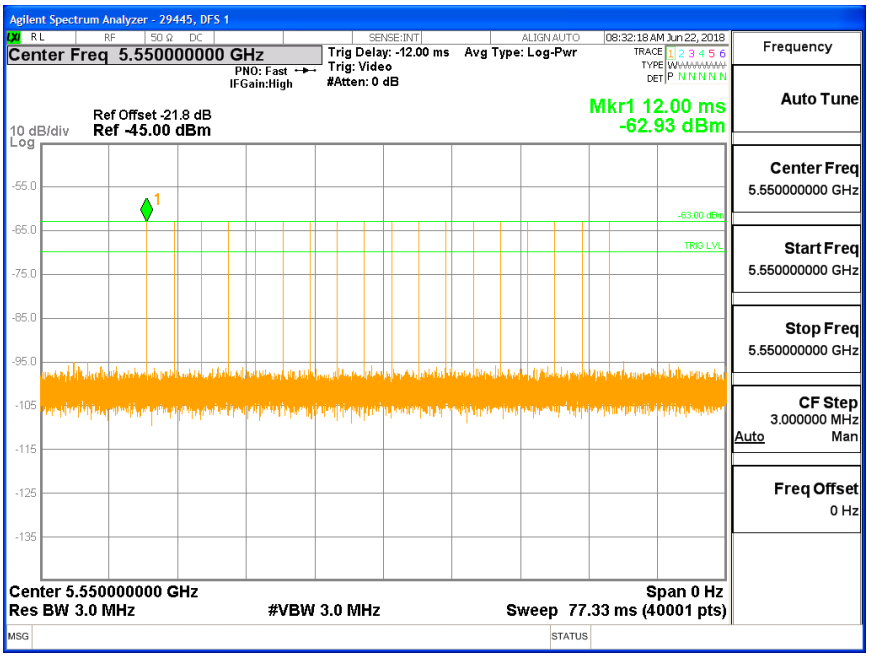
5.2.2. RADAR WAVEFORMS AND TRAFFIC

RADAR WAVEFORMS

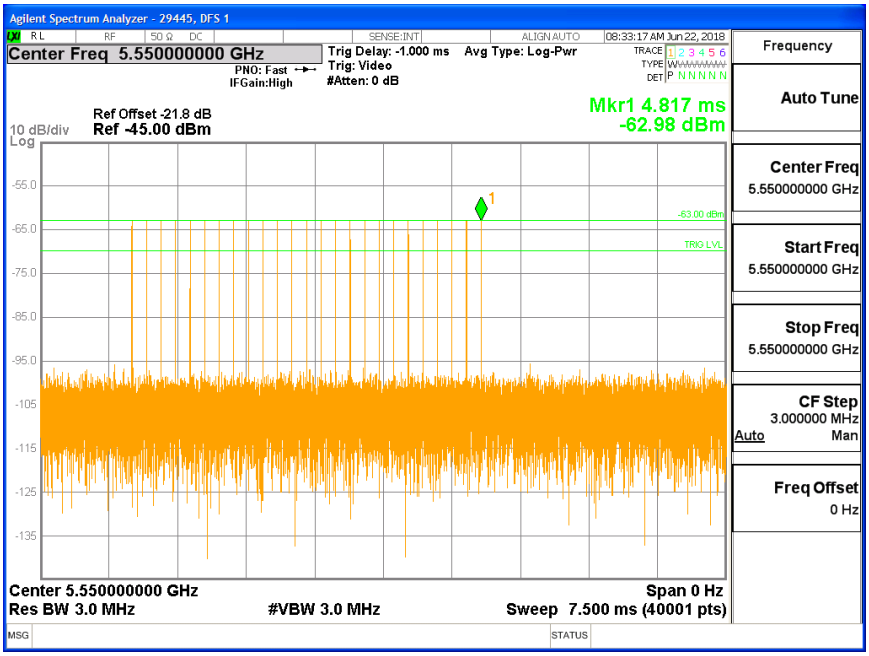
SHORT PULSE RADAR TYPE 0



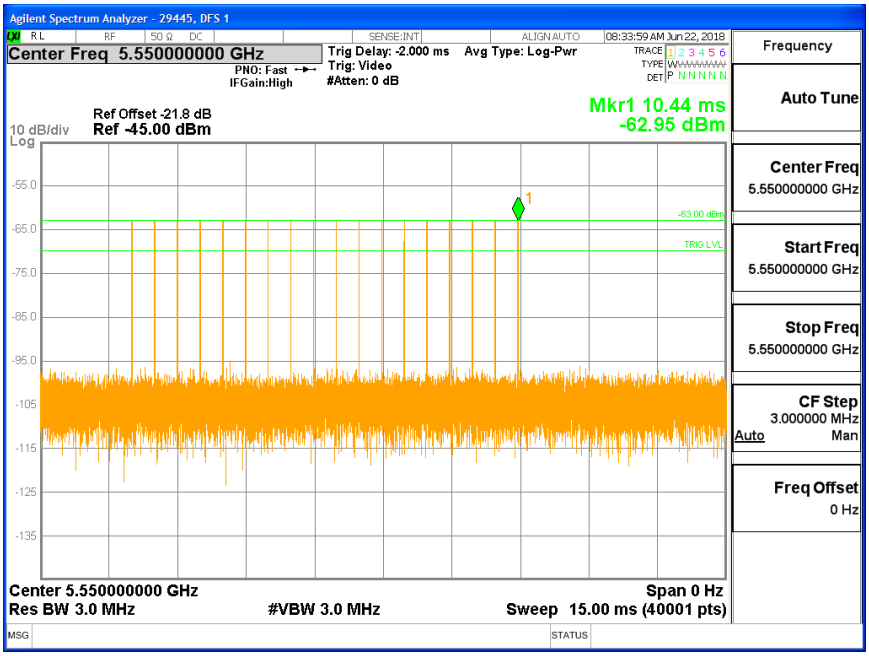
SAMPLE OF RADAR TYPE 1



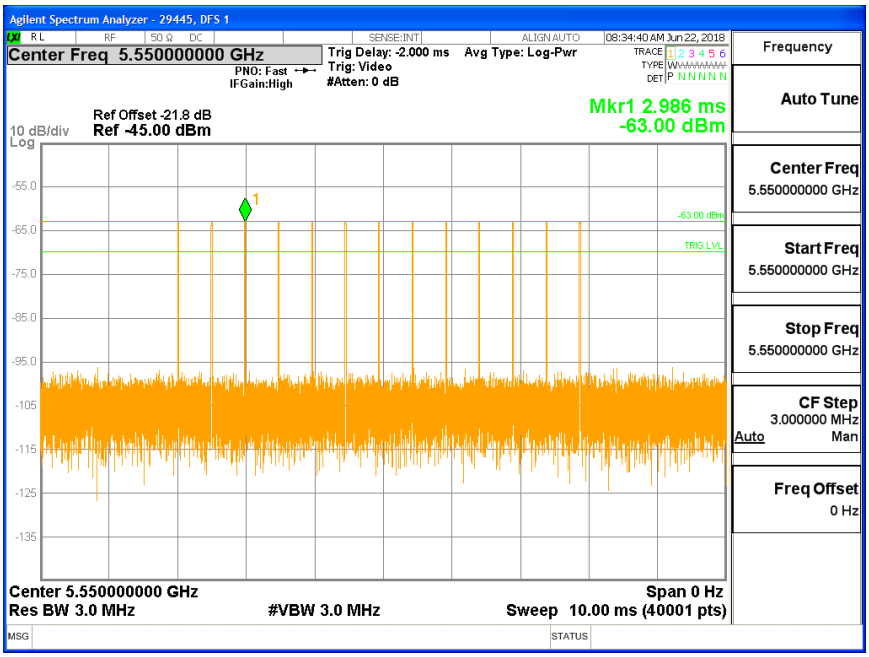
SAMPLE OF RADAR TYPE 2



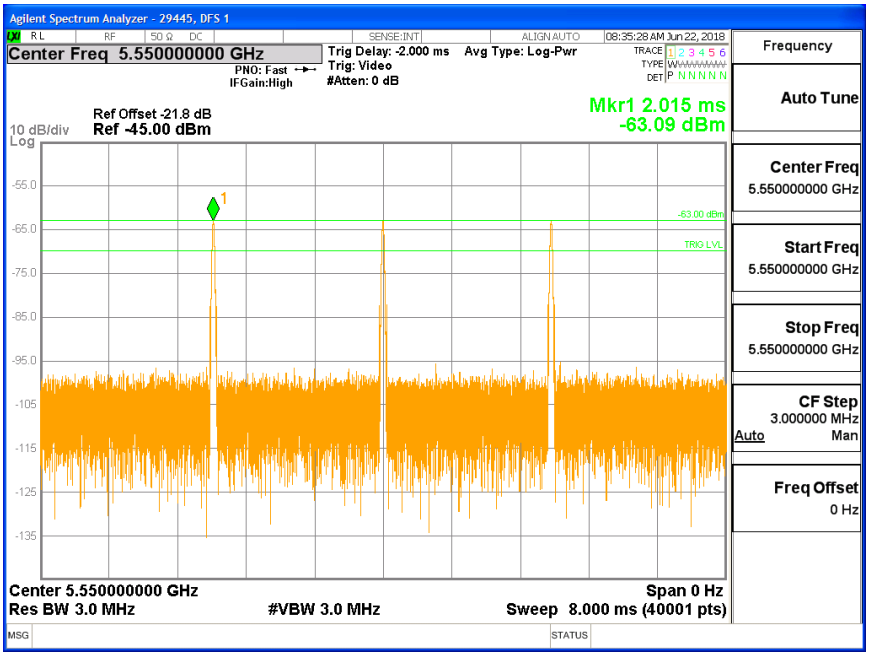
SAMPLE OF RADAR TYPE 3



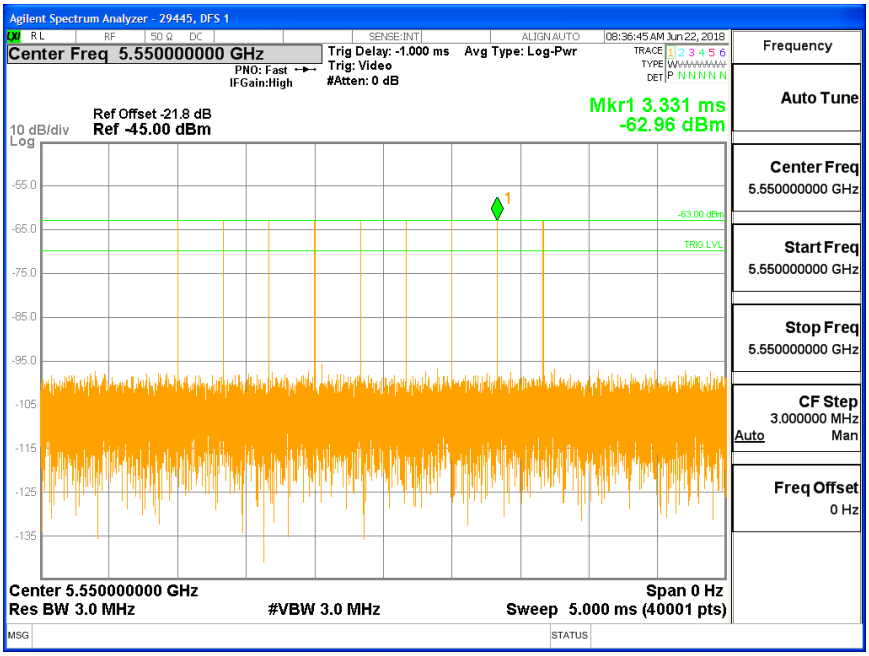
SAMPLE OF RADAR TYPE 4



SAMPLE OF SINGLE BURST OF RADAR TYPE 5

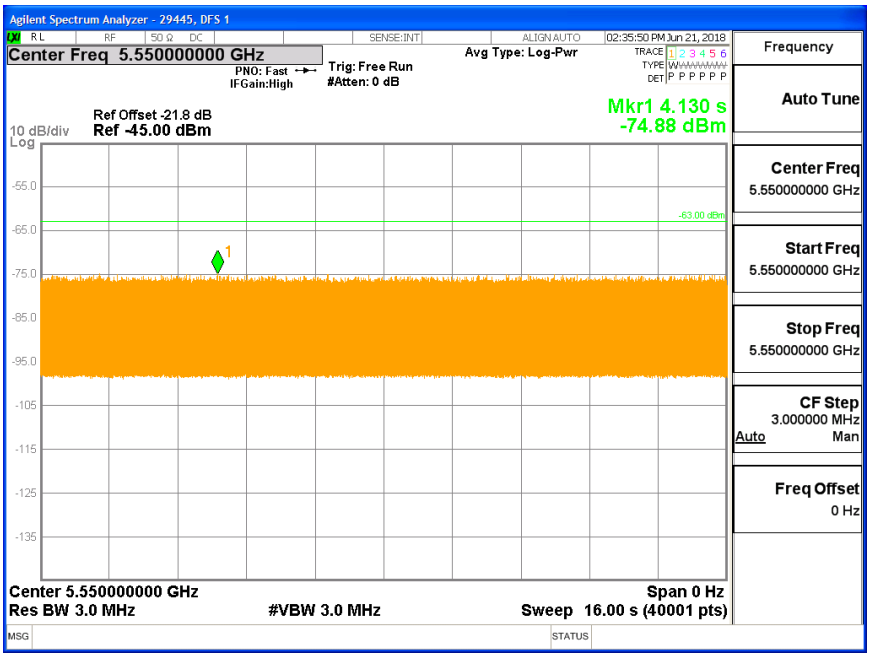


SINGLE BURST OF RADAR TYPE 6

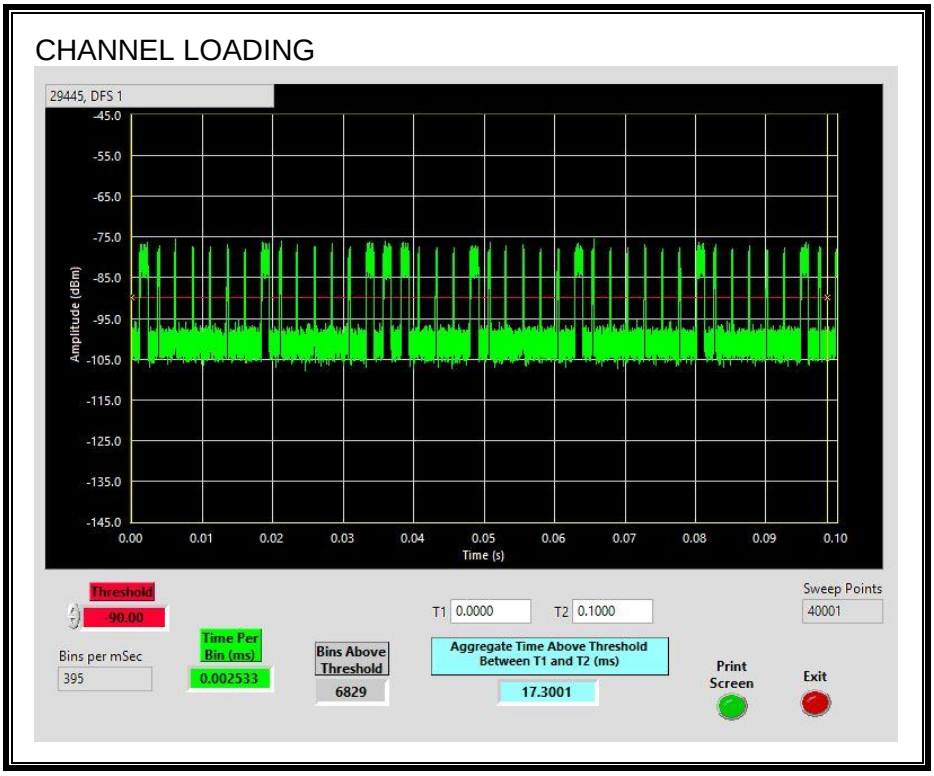


TRAFFIC

TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 17.3%.

5.2.3. CHANNEL AVAILABILITY CHECK TIME

Note: Per table 2 of KDB 905462 D02, this test is only required to be performed at the highest supported channel bandwidth. Therefore, the manufacturer has chosen not to perform this test for 10 MHz channel bandwidth.

5.2.4. OVERLAPPING CHANNEL TESTS

RESULTS

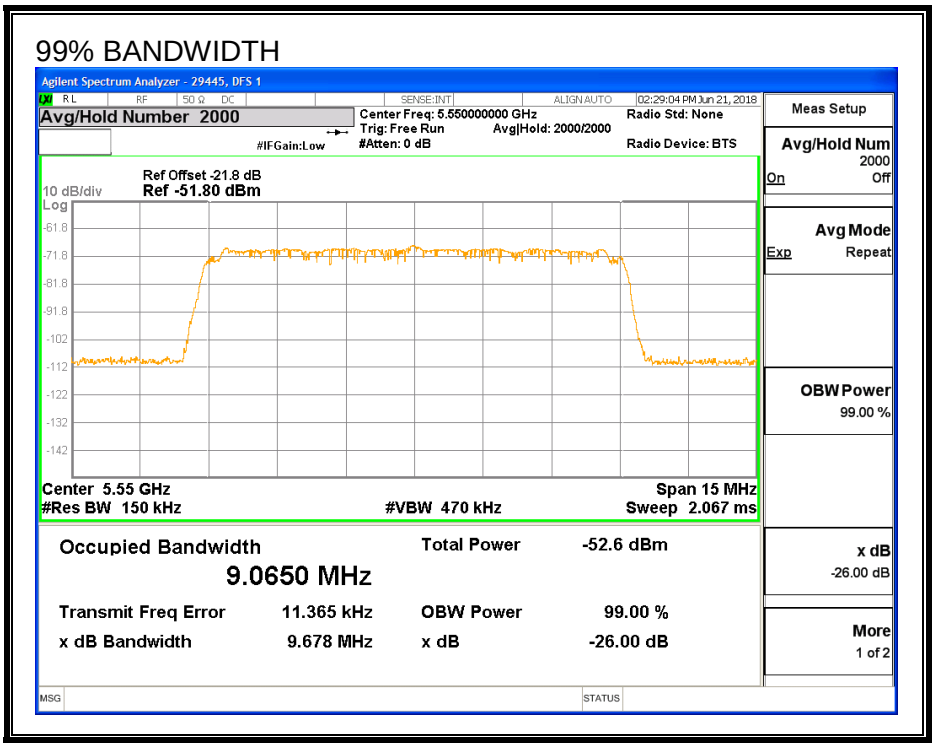
These tests are not applicable. The manufacturer's channel mapping plan prohibits overlapping channel from occurring.

5.2.5. MOVE AND CLOSING TIME

Note: Per table 2 of KDB 905462 D02, this test is only required to be performed at the highest supported channel bandwidth. Therefore, the manufacturer has chosen not to perform this test for 10 MHz channel bandwidth.

5.2.6. DETECTION BANDWIDTH

REFERENCE PLOT OF 99% POWER BANDWIDTH



RESULTS

FL (MHz)	FH (MHz)	Detection Bandwidth (MHz)	99% Power Bandwidth (MHz)	Ratio of Detection BW to 99% Power BW (%)	Minimum Limit (%)
5545.0	5555.0	10.0	9.065	110.3	100

DETECTION BANDWIDTH PROBABILITY

DETECTION BANDWIDTH PROBABILITY RESULTS

Detection Bandwidth Test Results		29445	DFS 1	
FCC Type 0 Waveform: 1 us Pulse Width, 1428 us PRI, 18 Pulses per Burst				
Frequency (MHz)	Number of Trials	Number Detected	Detection (%)	Mark
5545	10	10	100	FL
5550	10	10	100	
5555	10	10	100	FH

5.2.7. IN-SERVICE MONITORING

RESULTS

FCC Radar Test Summary

Signal Type	Number of Trials	Detection (%)	Limit (%)	Pass/Fail	Detection Bandwidth FL	Detection Bandwidth FH	OBW	Test Location	Employee Number	In-Service Monitoring Version
FCC Short Pulse Type 1	30	90.00	60	Pass	5545	5555	9.06	DFS 1	29445	Version 3.3.4
FCC Short Pulse Type 2	30	96.67	60	Pass	5545	5555	9.06	DFS 1	29445	Version 3.3.4
FCC Short Pulse Type 3	30	73.33	60	Pass	5545	5555	9.06	DFS 1	29445	Version 3.3.4
FCC Short Pulse Type 4	30	83.33	60	Pass	5545	5555	9.06	DFS 1	29445	Version 3.3.4
Aggregate		85.83	80	Pass						
FCC Long Pulse Type 5	30	100.00	80	Pass	5545	5555	9.06	DFS 1	29445	Version 3.3.4
FCC Hopping Type 6	33	81.82	70	Pass	5545	5555		DFS 1	29445	Version 3.3.4

TYPE 1 DETECTION PROBABILITY

Data Sheet for FCC Short Pulse Radar Type 1

Waveform	Pulse Width (us)	PRI (us)	Pulses Per Burst	Test (A/B)	Frequency (MHz)	Successful Detection (Yes/No)
1001	1	3066	18	A	5548	Yes
1002	1	558	95	A	5555	Yes
1003	1	538	99	A	5548	Yes
1004	1	818	65	A	5552	Yes
1005	1	898	59	A	5547	Yes
1006	1	718	74	A	5551	Yes
1007	1	598	89	A	5553	Yes
1008	1	878	61	A	5554	Yes
1009	1	578	92	A	5547	Yes
1010	1	678	78	A	5547	Yes
1011	1	938	57	A	5548	Yes
1012	1	918	58	A	5549	Yes
1013	1	618	86	A	5554	Yes
1014	1	798	67	A	5554	Yes
1015	1	838	63	A	5548	Yes
1016	1	1257	42	B	5547	No
1017	1	2955	18	B	5554	Yes
1018	1	1910	28	B	5551	Yes
1019	1	2543	21	B	5552	Yes
1020	1	1628	33	B	5552	Yes
1021	1	2390	23	B	5555	Yes
1022	1	1604	33	B	5549	Yes
1023	1	1301	41	B	5551	Yes
1024	1	1998	27	B	5555	No
1025	1	3019	18	B	5555	Yes
1026	1	2652	20	B	5553	Yes
1027	1	2608	21	B	5554	Yes
1028	1	1016	52	B	5549	Yes
1029	1	2454	22	B	5552	No
1030	1	2346	23	B	5550	Yes

TYPE 2 DETECTION PROBABILITY

Data Sheet for FCC Short Pulse Radar Type 2					
Waveform	Pulse Width (us)	PRI (us)	Pulses Per Burst	Frequency (MHz)	Successful Detection (Yes/No)
2001	1.4	159	25	5553	Yes
2002	2.5	200	24	5551	Yes
2003	3.3	213	23	5553	Yes
2004	2.6	177	27	5546	Yes
2005	3.6	195	27	5552	Yes
2006	3.2	163	27	5549	Yes
2007	2.5	227	27	5546	Yes
2008	2.2	199	28	5552	Yes
2009	1.7	187	25	5546	Yes
2010	3.9	168	27	5553	Yes
2011	1.7	160	28	5553	Yes
2012	4	183	23	5554	Yes
2013	2	222	24	5552	Yes
2014	4.6	212	23	5554	Yes
2015	2.8	174	24	5554	Yes
2016	1.7	168	24	5555	Yes
2017	4.2	215	23	5546	Yes
2018	1.2	174	29	5552	Yes
2019	2	188	28	5545	Yes
2020	1.3	152	25	5550	No
2021	2.3	169	24	5554	Yes
2022	1.9	218	25	5550	Yes
2023	1.2	202	25	5545	Yes
2024	3.1	217	26	5548	Yes
2025	2.6	161	23	5547	Yes
2026	2.6	224	25	5551	Yes
2027	4.5	215	26	5551	Yes
2028	2.7	158	27	5550	Yes
2029	4.8	197	29	5546	Yes
2030	3.3	186	28	5549	Yes

TYPE 3 DETECTION PROBABILITY

Data Sheet for FCC Short Pulse Radar Type 3					
Waveform	Pulse Width (us)	PRI (us)	Pulses Per Burst	Frequency (MHz)	Successful Detection (Yes/No)
3001	8.7	496	18	5551	Yes
3002	9.5	477	18	5551	Yes
3003	7.9	372	18	5546	Yes
3004	7.1	499	17	5550	Yes
3005	9.8	288	17	5554	Yes
3006	9.1	428	16	5545	No
3007	6	481	17	5551	No
3008	7.8	383	16	5550	Yes
3009	9	331	17	5551	Yes
3010	6.8	379	16	5550	Yes
3011	6.3	340	18	5547	Yes
3012	8.5	400	18	5552	Yes
3013	8.2	374	16	5551	Yes
3014	6.4	329	17	5546	Yes
3015	8.5	316	17	5551	Yes
3016	9.2	284	17	5552	Yes
3017	7.4	417	17	5554	Yes
3018	8.2	398	17	5552	Yes
3019	6.6	426	17	5545	No
3020	9.9	419	16	5547	No
3021	8.5	460	16	5552	Yes
3022	7.8	348	18	5548	Yes
3023	6.9	402	16	5555	No
3024	6.5	436	18	5546	Yes
3025	7.7	252	16	5548	Yes
3026	9.6	299	18	5554	Yes
3027	9.1	261	17	5555	No
3028	7.2	321	16	5555	No
3029	6.9	295	18	5553	Yes
3030	9.2	250	16	5555	No

TYPE 4 DETECTION PROBABILITY

Data Sheet for FCC Short Pulse Radar Type 4					
Waveform	Pulse Width (us)	PRI (us)	Pulses Per Burst	Frequency (MHz)	Successful Detection (Yes/No)
4001	13.8	488	13	5554	No
4002	15.2	456	12	5551	Yes
4003	11.2	338	13	5551	Yes
4004	13.1	318	13	5546	Yes
4005	18.7	346	12	5553	Yes
4006	16.8	340	14	5553	Yes
4007	18.5	381	14	5549	Yes
4008	12.3	269	14	5554	Yes
4009	19.3	323	16	5555	No
4010	18.3	357	14	5553	Yes
4011	11.9	423	16	5552	Yes
4012	16.2	471	14	5555	No
4013	15.1	432	15	5552	Yes
4014	19.9	492	16	5552	No
4015	19.2	466	14	5549	Yes
4016	15.4	421	13	5552	No
4017	20	408	16	5548	Yes
4018	12.4	376	15	5548	Yes
4019	17.4	258	12	5549	Yes
4020	19.4	372	14	5547	Yes
4021	15.8	267	15	5549	Yes
4022	13.9	394	13	5550	Yes
4023	15.6	301	12	5551	Yes
4024	14.2	441	15	5554	Yes
4025	16.4	494	14	5552	Yes
4026	15.5	278	12	5549	Yes
4027	13.8	344	15	5546	Yes
4028	13.4	391	15	5546	Yes
4029	12.2	353	13	5552	Yes
4030	17	413	14	5552	Yes

TYPE 5 DETECTION PROBABILITY

Data Sheet for FCC Long Pulse Radar Type 5		
Trial	Frequency (MHz)	Successful Detection (Yes/No)
1	5550	Yes
2	5550	Yes
3	5550	Yes
4	5550	Yes
5	5550	Yes
6	5550	Yes
7	5550	Yes
8	5550	Yes
9	5550	Yes
10	5550	Yes
11	5552	Yes
12	5552	Yes
13	5554	Yes
14	5549	Yes
15	5551	Yes
16	5548	Yes
17	5549	Yes
18	5554	Yes
19	5549	Yes
20	5554	Yes
21	5551	Yes
22	5547	Yes
23	5551	Yes
24	5547	Yes
25	5551	Yes
26	5547	Yes
27	5551	Yes
28	5547	Yes
29	5551	Yes
30	5547	Yes

Note: The Type 5 randomized parameters tested are shown in a separate document.

TYPE 6 DETECTION PROBABILITY

Data Sheet for FCC Hopping Radar Type 6				
1 us Pulse Width, 333 us PRI, 9 Pulses per Burst, 1 Burst per Hop				
NTIA August 2005 Hopping Sequence				
Trial	Starting Index Within Sequence	Signal Generator Frequency (MHz)	Hops within Detection BW	Successful Detection (Yes/No)
1	278	5545	2	Yes
2	753	5546	2	Yes
3	1228	5547	2	Yes
4	1703	5548	3	Yes
5	2178	5549	2	Yes
6	2653	5550	2	Yes
7	3128	5551	1	No
8	3603	5552	1	No
9	4553	5553	4	Yes
10	5028	5554	3	Yes
11	5503	5555	3	Yes
12	5978	5545	4	Yes
13	6453	5546	2	No
14	7403	5547	2	Yes
15	7878	5548	4	Yes
16	8353	5549	1	Yes
17	8828	5550	2	Yes
18	9778	5551	1	No
19	10253	5552	4	Yes
20	11678	5553	1	Yes
21	12153	5554	1	Yes
22	12628	5555	1	Yes
23	13103	5545	3	Yes
24	13578	5546	3	Yes
25	14053	5547	3	Yes
26	14528	5548	3	Yes
27	15003	5549	1	Yes
28	15478	5550	1	No
29	15953	5551	2	No
30	16428	5552	3	Yes
31	16903	5553	3	Yes
32	17378	5554	2	Yes
33	17853	5555	3	Yes

5.3. RESULTS FOR 40 MHz BANDWIDTH

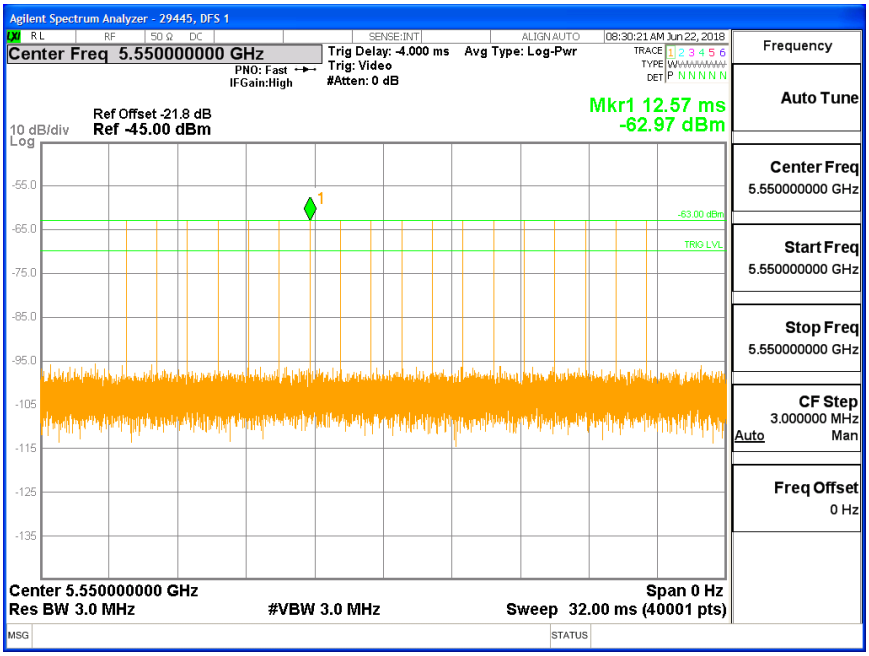
5.3.1. TEST CHANNEL

All tests were performed at a channel center frequency of 5550 MHz.

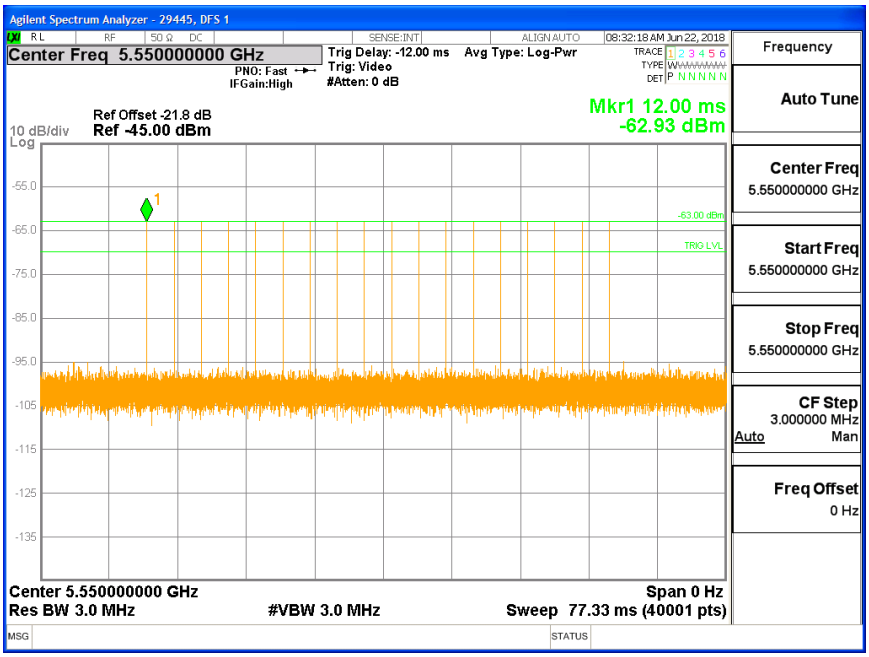
5.3.2. RADAR WAVEFORMS AND TRAFFIC

RADAR WAVEFORMS

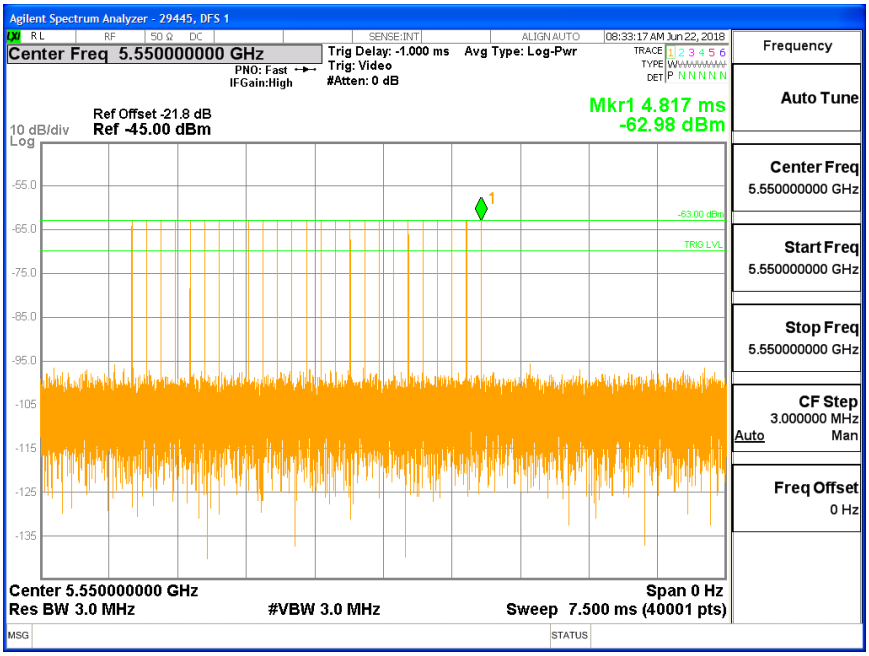
SHORT PULSE RADAR TYPE 0



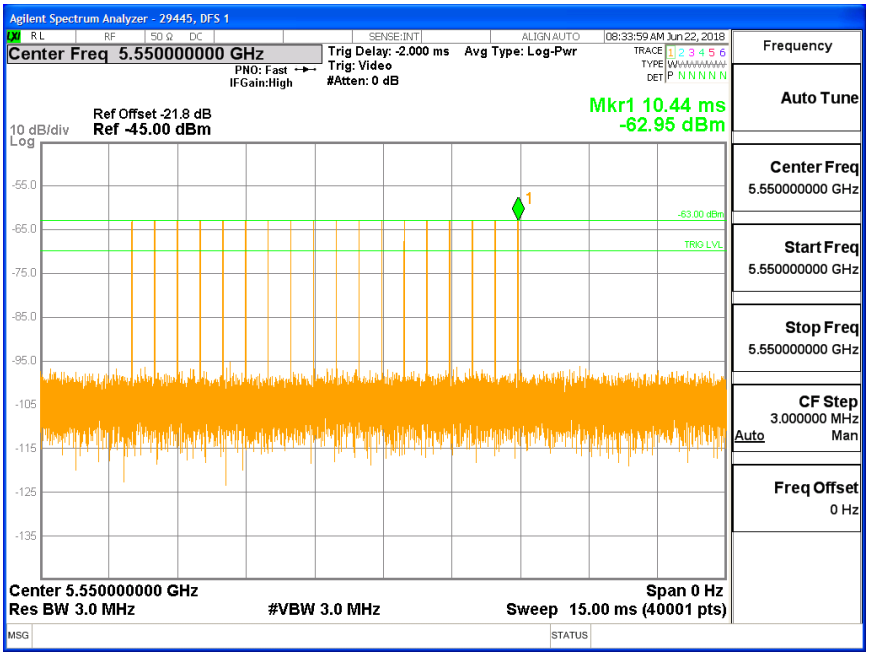
SAMPLE OF RADAR TYPE 1



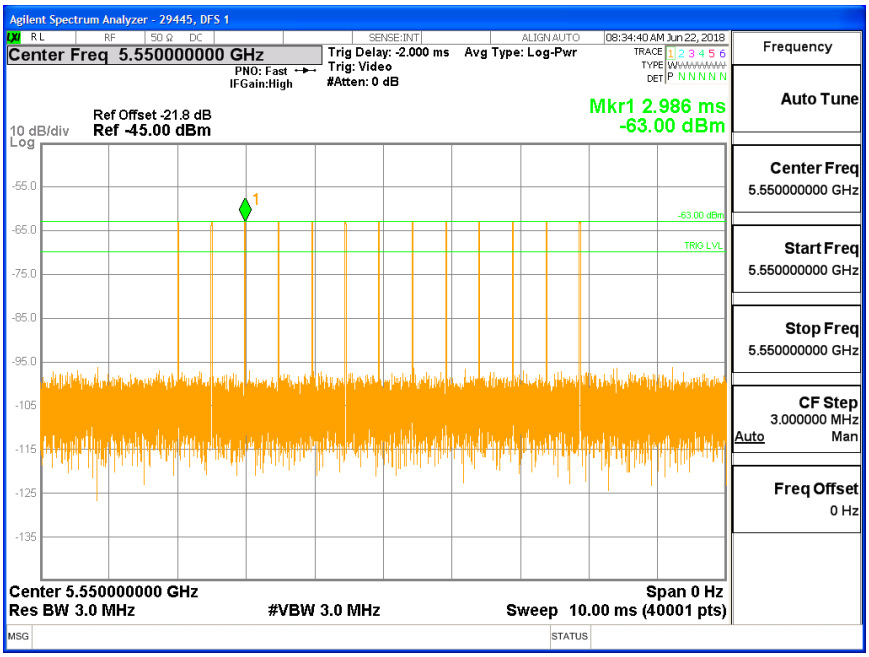
SAMPLE OF RADAR TYPE 2



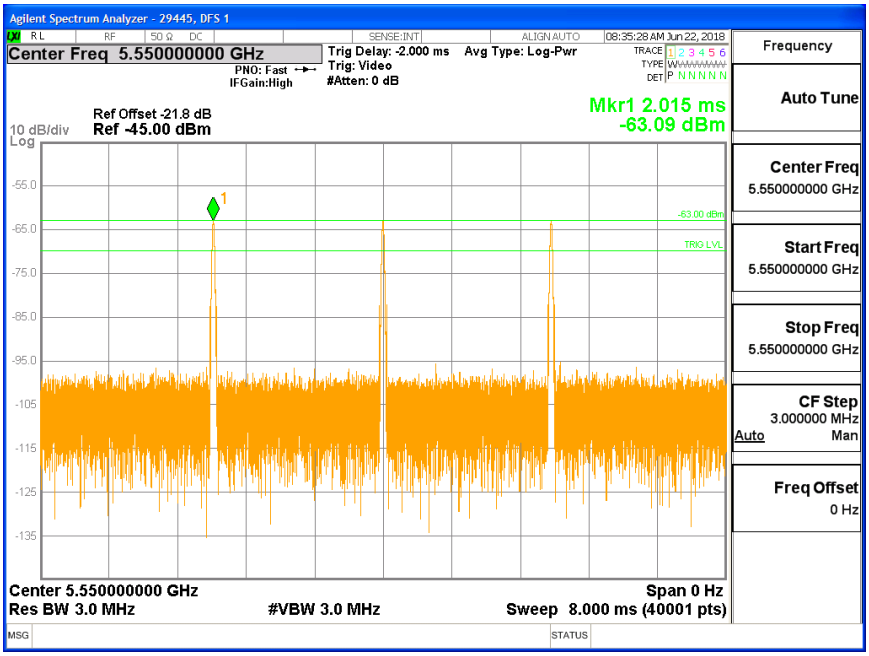
SAMPLE OF RADAR TYPE 3



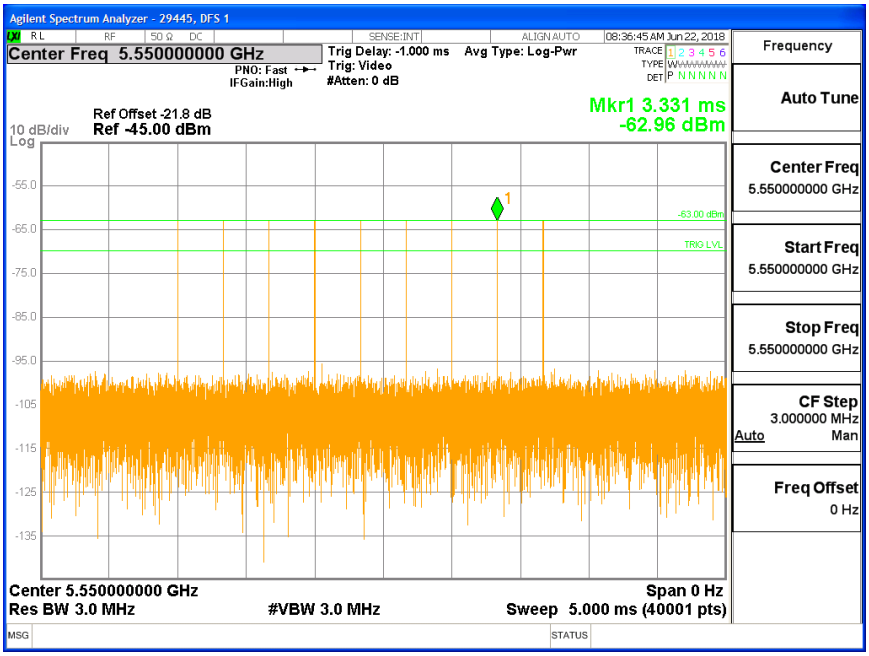
SAMPLE OF RADAR TYPE 4



SAMPLE OF SINGLE BURST OF RADAR TYPE 5

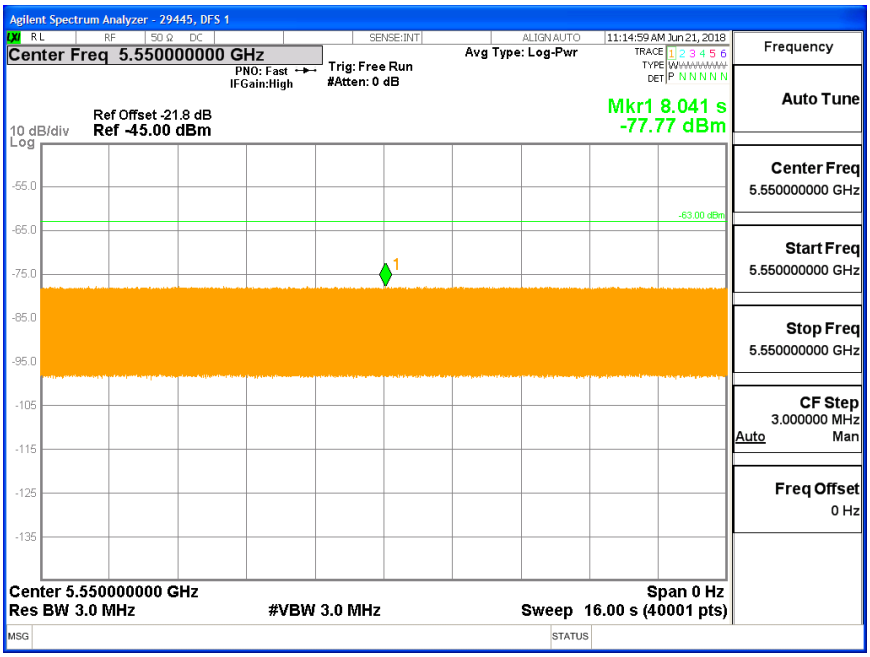


SINGLE BURST OF RADAR TYPE 6

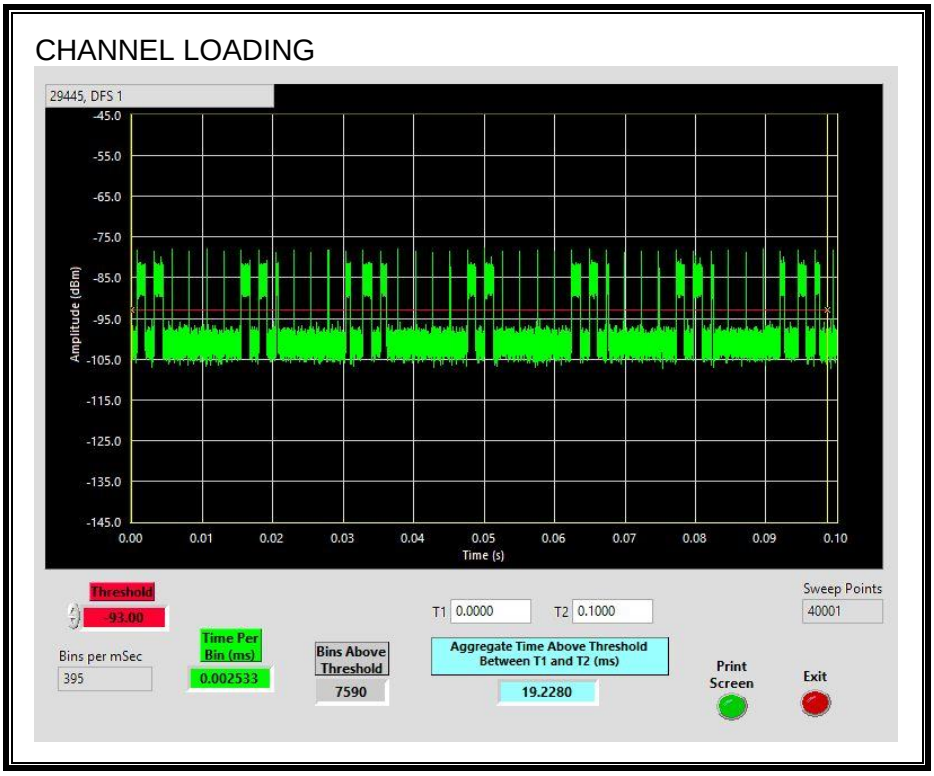


TRAFFIC

TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 19.22%.

5.3.3. CHANNEL AVAILABILITY CHECK TIME

PROCEDURE TO DETERMINE INITIAL POWER-UP CYCLE TIME

A link was established on channel then a software reset command was issued to the EUT. The time from the cessation of traffic to the re-initialization of traffic was measured as the time required for the EUT to complete the total power-up cycle. The time to complete the initial power-up period is 60 seconds less than this total power-up time.

PROCEDURE FOR TIMING OF RADAR BURST

With a link established on channel, the EUT was reset. A radar signal was triggered within 0 to 6 seconds after the initial power-up period, and transmissions on the channel were monitored on the spectrum analyzer.

The Non-Occupancy list was cleared. With a link established on channel, the EUT was reset. A radar signal was triggered within 54 to 60 seconds after the initial power-up period, and transmissions on the channel were monitored on the spectrum analyzer.

QUANTITATIVE RESULTS

No Radar Triggered

Timing of Reset (sec)	Timing of Start of Traffic (sec)	Total Reset and CAC Cycle Time (sec)	Initial Reset Cycle Time (sec)
32.9	153.2	120.3	60.3

Radar Near Beginning of CAC

Timing of Reset (sec)	Timing of Radar Burst (sec)	Radar Relative to Reset (sec)	Radar Relative to Start of CAC (sec)
32.47	96.7	64.2	3.9

Radar Near End of CAC

Timing of Reset (sec)	Timing of Radar Burst (sec)	Radar Relative to Reset (sec)	Radar Relative to Start of CAC (sec)
32.92	150.8	117.9	57.6

QUALITATIVE RESULTS

Timing of Radar Burst	Display on Control Computer	Spectrum Analyzer Display
No Radar Triggered	EUT marks Channel as active	Transmissions begin on channel after completion of the initial reset and the CAC
Within 0 to 6 second window	EUT indicates radar detected	No transmissions on channel
Within 54 to 60 second window	EUT indicates radar detected	No transmissions on channel

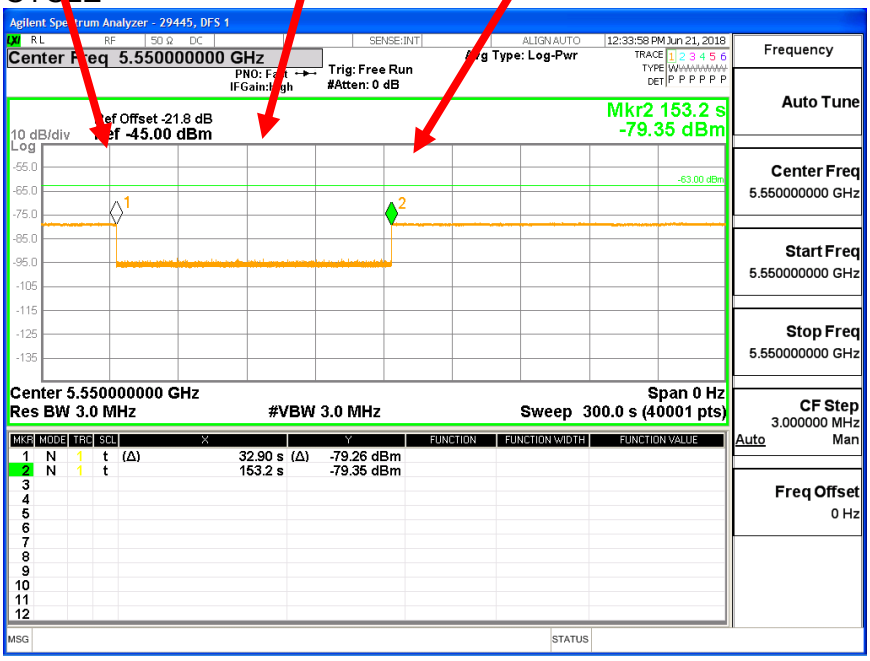
TIMING WITHOUT RADAR DURING CAC

Software Reset Command Issued
Traffic ceases
Start of Initial Reset cycle

End of Initial Reset cycle
Start of CAC

End of CAC
Traffic is Initiated

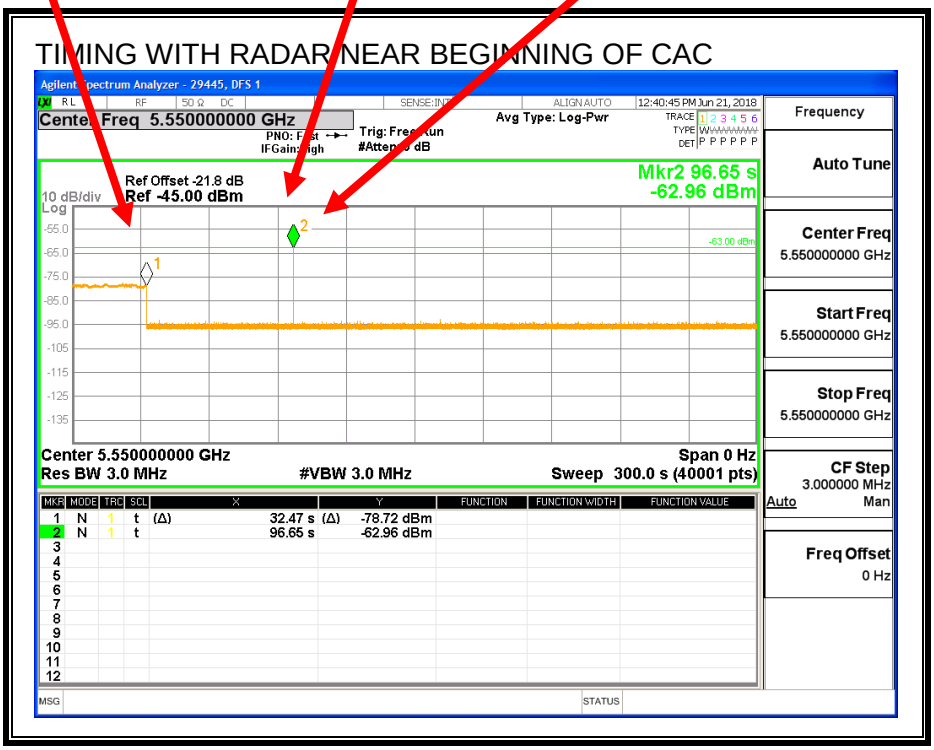
TIMING WITHOUT RADAR – NORMAL RESET AND CAC CYCLE



Transmissions begin on channel after completion of the initial reset cycle and the CAC.

TIMING WITH RADAR NEAR BEGINNING OF CAC

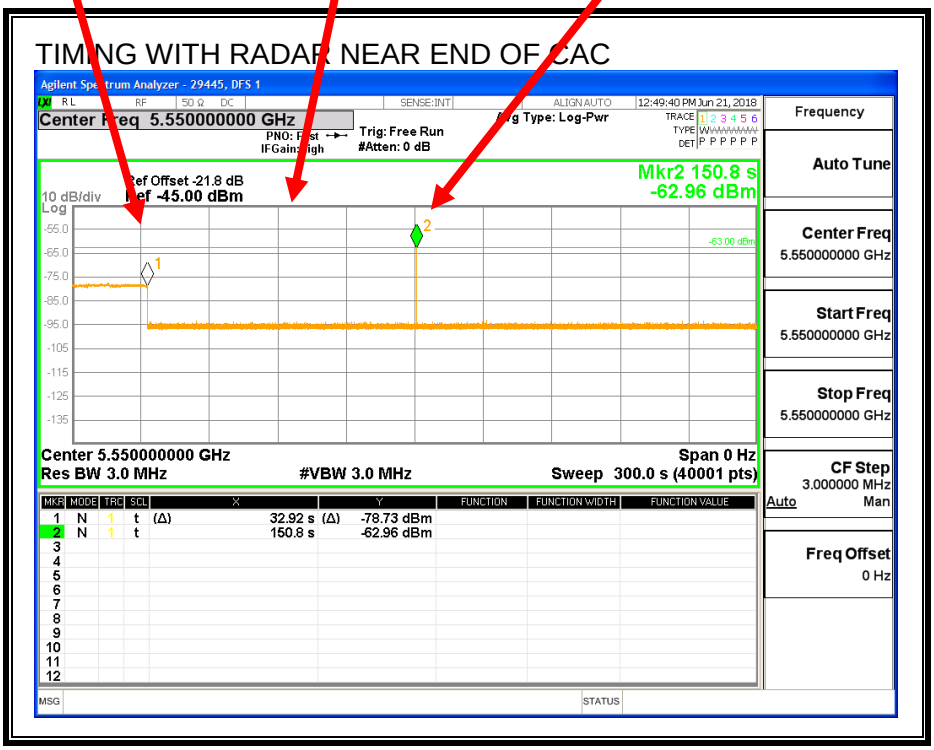
Software Reset Command Issued
Traffic ceases
Start of Initial Reset cycle
End of Initial Reset cycle
Start of CAC
Radar Signal Applied



No EUT transmissions were observed after the radar signal.

TIMING WITH RADAR NEAR END OF CAC

Software Reset Command Issued
Traffic ceases
Start of Initial Reset cycle
End of Initial Reset cycle
Start of CAC
Radar Signal Applied



No EUT transmissions were observed after the radar signal.

5.3.4. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable. The manufacturer's channel mapping plan prohibits overlapping channel from occurring.

5.3.5. MOVE AND CLOSING TIME

REPORTING NOTES

The reference marker is set at the end of last radar pulse.

The delta marker is set at the end of the last WLAN transmission following the radar pulse. This delta is the channel move time.

The aggregate channel closing transmission time is calculated as follows:

Aggregate Transmission Time =
(Number of analyzer bins showing transmission) * (dwell time per bin)

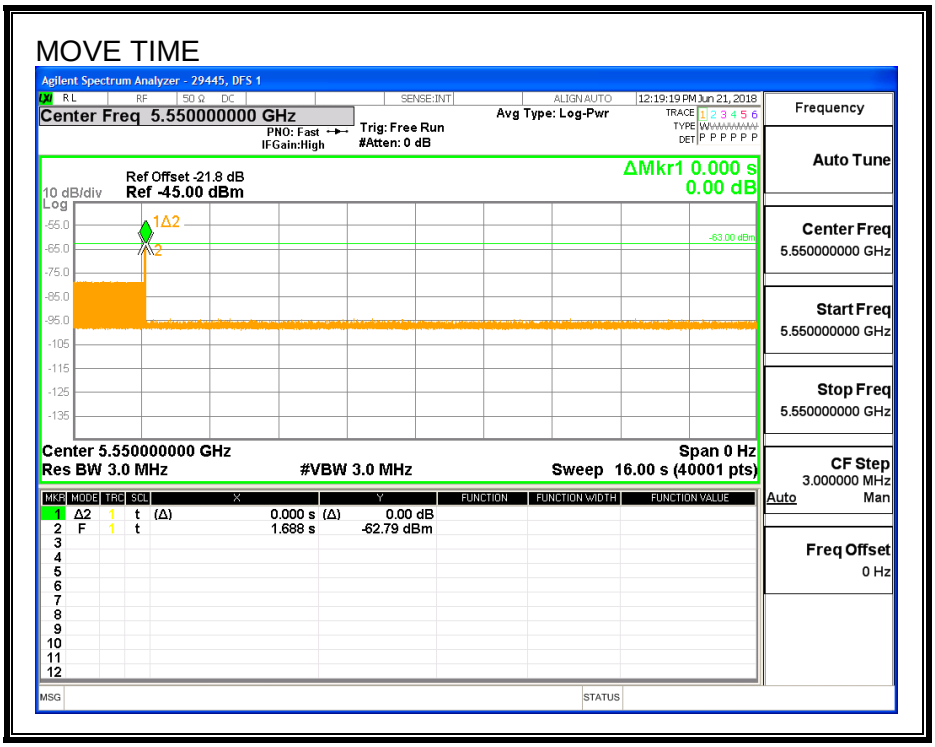
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

Channel Move Time (sec)	Limit (sec)
0.000	10

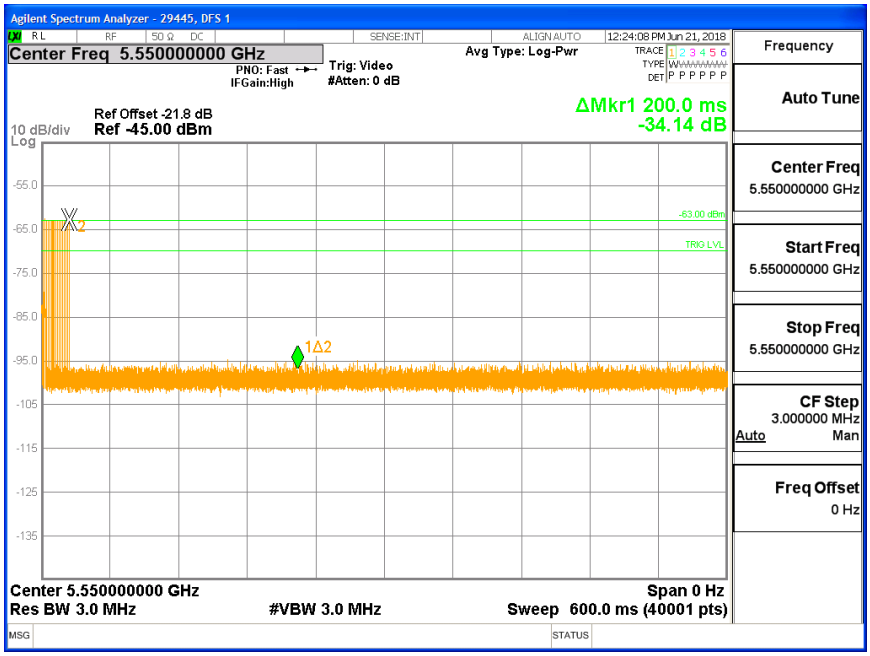
Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
0.0	60

MOVE TIME



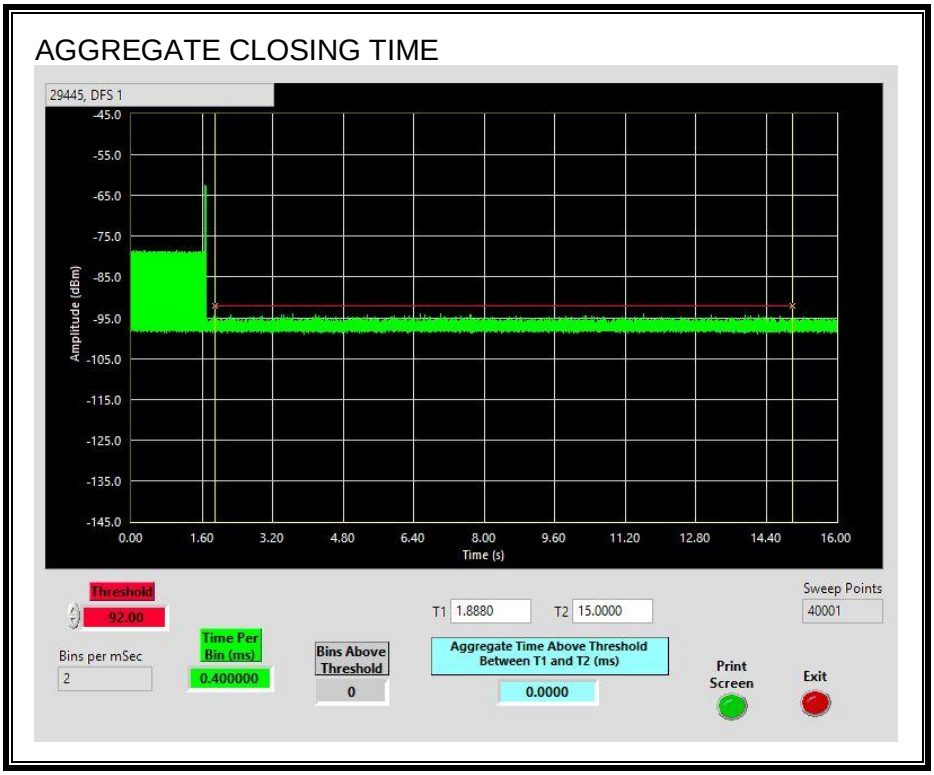
CHANNEL CLOSING TIME

CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

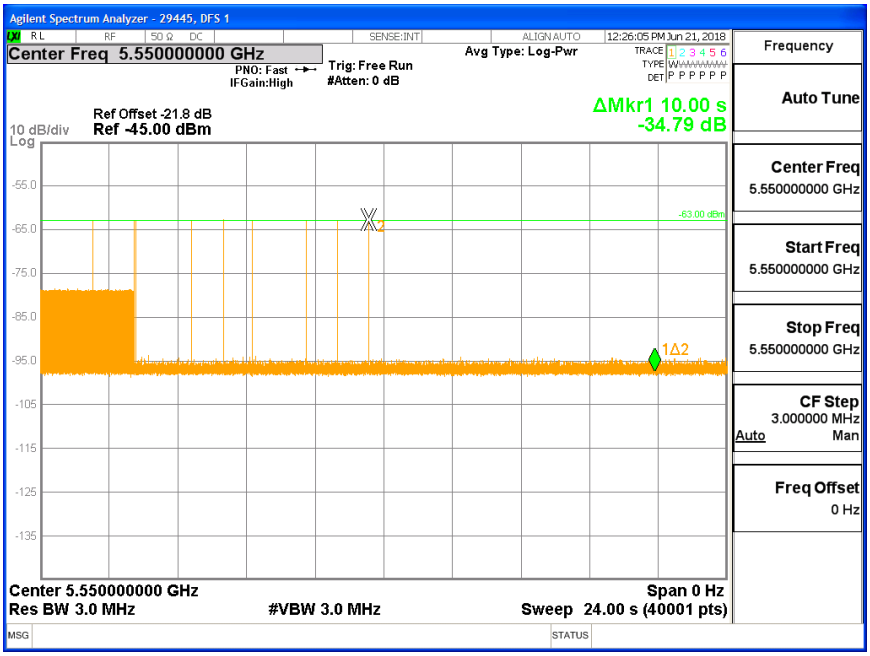
No transmissions are observed during the aggregate monitoring period.



LONG PULSE CHANNEL MOVE TIME

The traffic ceases prior to 10 seconds after the end of the radar waveform.

MOVE TIME FOR LONG PULSE RADAR

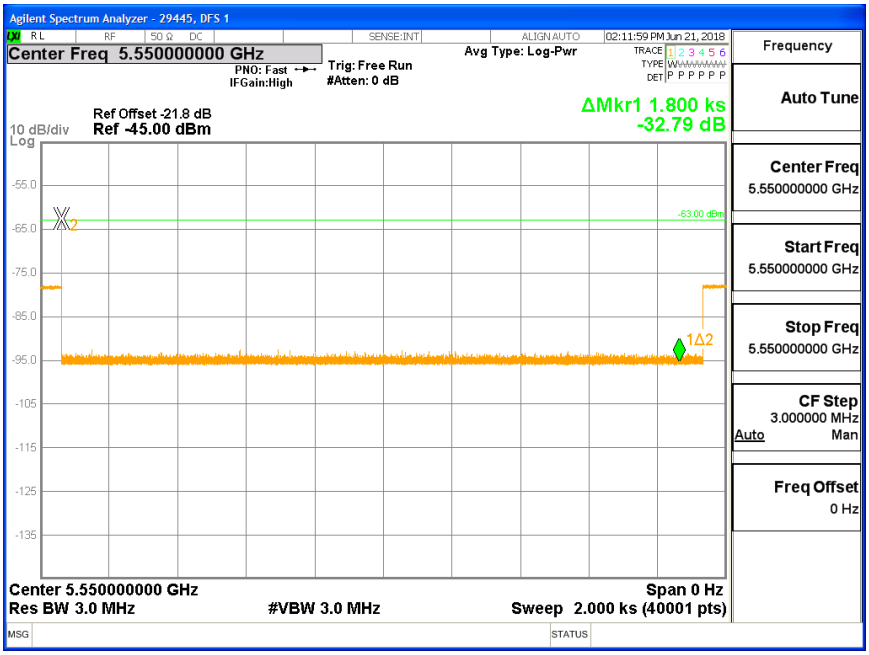


5.3.6. NON-OCCUPANCY PERIOD

RESULTS

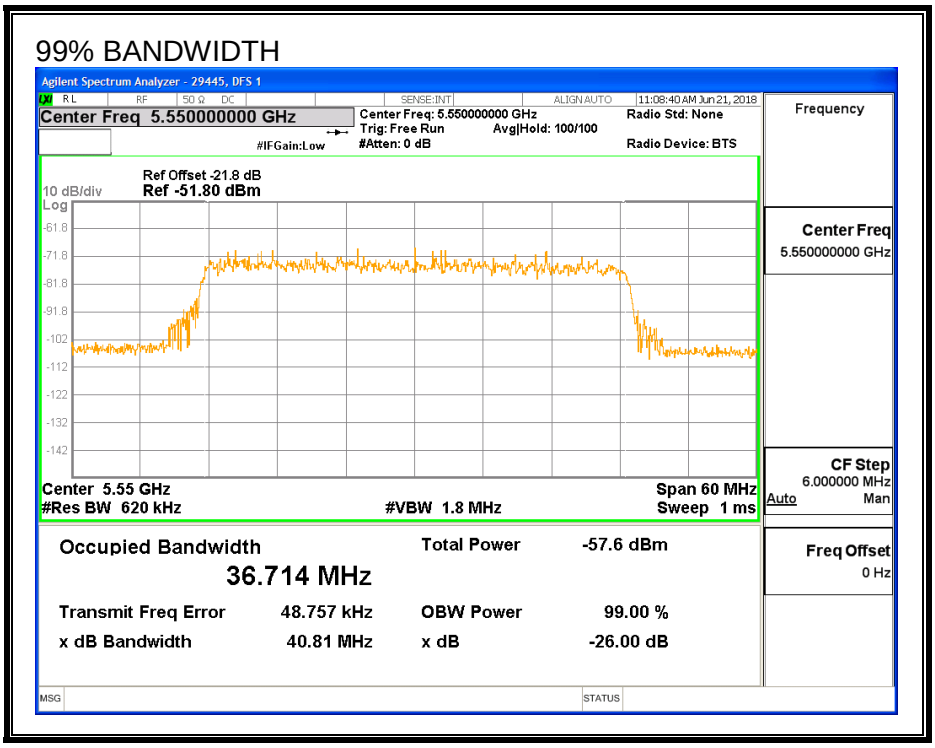
No EUT transmissions were observed on the test channel during the 30-minute observation time. After the 30-minute non-occupancy period the EUT performed a new CAC, then resumed transmissions upon detecting no radar during this CAC period.

NON-OCCUPANCY PERIOD



5.3.7. DETECTION BANDWIDTH

REFERENCE PLOT OF 99% POWER BANDWIDTH



RESULTS

FL (MHz)	FH (MHz)	Detection Bandwidth (MHz)	99% Power Bandwidth (MHz)	Ratio of Detection BW to 99% Power BW (%)	Minimum Limit (%)
5530	5570	40	36.714	109.0	100

DETECTION BANDWIDTH PROBABILITY

DETECTION BANDWIDTH PROBABILITY RESULTS

Detection Bandwidth Test Results		29445	DFS 1	
FCC Type 0 Waveform: 1 us Pulse Width, 1428 us PRI, 18 Pulses per Burst				
Frequency (MHz)	Number of Trials	Number Detected	Detection (%)	Mark
5530	10	10	100	FL
5535	10	10	100	
5540	10	10	100	
5545	10	10	100	
5550	10	10	100	
5555	10	10	100	
5560	10	10	100	
5565	10	10	100	
5570	10	10	100	FH

5.3.8. IN-SERVICE MONITORING

RESULTS

FCC Radar Test Summary

Signal Type	Number of Trials	Detection (%)	Limit (%)	Pass/Fail	Detection Bandwidth FL	Detection Bandwidth FH	OBW	Test Location	Employee Number	In-Service Monitoring Version
FCC Short Pulse Type 1	30	93.33	60	Pass	5530	5570	36.71	DFS 1	29445	Version 3.3.4
FCC Short Pulse Type 2	30	100.00	60	Pass	5530	5570	36.71	DFS 1	29445	Version 3.3.4
FCC Short Pulse Type 3	30	96.67	60	Pass	5530	5570	36.71	DFS 1	29445	Version 3.3.4
FCC Short Pulse Type 4	30	96.67	60	Pass	5530	5570	36.71	DFS 1	29445	Version 3.3.4
Aggregate		96.67	80	Pass						
FCC Long Pulse Type 5	30	100.00	80	Pass	5530	5570	36.71	DFS 1	29445	Version 3.3.4
FCC Hopping Type 6	41	100.00	70	Pass	5530	5570		DFS 1	29445	Version 3.3.4

TYPE 1 DETECTION PROBABILITY

Data Sheet for FCC Short Pulse Radar Type 1

Waveform	Pulse Width (us)	PRI (us)	Pulses Per Burst	Test (A/B)	Frequency (MHz)	Successful Detection (Yes/No)
1001	1	3066	18	A	5531	Yes
1002	1	558	95	A	5554	Yes
1003	1	538	99	A	5535	Yes
1004	1	818	65	A	5556	Yes
1005	1	898	59	A	5551	Yes
1006	1	718	74	A	5545	Yes
1007	1	598	89	A	5549	Yes
1008	1	878	61	A	5540	Yes
1009	1	578	92	A	5537	Yes
1010	1	678	78	A	5530	Yes
1011	1	938	57	A	5540	Yes
1012	1	918	58	A	5535	Yes
1013	1	618	86	A	5569	Yes
1014	1	798	67	A	5552	Yes
1015	1	838	63	A	5538	Yes
1016	1	1257	42	B	5540	Yes
1017	1	2955	18	B	5556	Yes
1018	1	1910	28	B	5540	Yes
1019	1	2543	21	B	5555	No
1020	1	1628	33	B	5533	Yes
1021	1	2390	23	B	5563	Yes
1022	1	1604	33	B	5566	Yes
1023	1	1301	41	B	5547	Yes
1024	1	1998	27	B	5544	Yes
1025	1	3019	18	B	5562	Yes
1026	1	2652	20	B	5536	Yes
1027	1	2608	21	B	5536	Yes
1028	1	1016	52	B	5559	Yes
1029	1	2454	22	B	5546	No
1030	1	2346	23	B	5542	Yes

TYPE 2 DETECTION PROBABILITY

Data Sheet for FCC Short Pulse Radar Type 2					
Waveform	Pulse Width (us)	PRI (us)	Pulses Per Burst	Frequency (MHz)	Successful Detection (Yes/No)
2001	1.4	159	25	5534	Yes
2002	2.5	200	24	5548	Yes
2003	3.3	213	23	5533	Yes
2004	2.6	177	27	5549	Yes
2005	3.6	195	27	5566	Yes
2006	3.2	163	27	5560	Yes
2007	2.5	227	27	5544	Yes
2008	2.2	199	28	5534	Yes
2009	1.7	187	25	5532	Yes
2010	3.9	168	27	5554	Yes
2011	1.7	160	28	5561	Yes
2012	4	183	23	5544	Yes
2013	2	222	24	5565	Yes
2014	4.6	212	23	5541	Yes
2015	2.8	174	24	5567	Yes
2016	1.7	168	24	5534	Yes
2017	4.2	215	23	5568	Yes
2018	1.2	174	29	5531	Yes
2019	2	188	28	5568	Yes
2020	1.3	152	25	5559	Yes
2021	2.3	169	24	5553	Yes
2022	1.9	218	25	5539	Yes
2023	1.2	202	25	5567	Yes
2024	3.1	217	26	5563	Yes
2025	2.6	161	23	5536	Yes
2026	2.6	224	25	5549	Yes
2027	4.5	215	26	5543	Yes
2028	2.7	158	27	5540	Yes
2029	4.8	197	29	5548	Yes
2030	3.3	186	28	5548	Yes

TYPE 3 DETECTION PROBABILITY

Data Sheet for FCC Short Pulse Radar Type 3					
Waveform	Pulse Width (us)	PRI (us)	Pulses Per Burst	Frequency (MHz)	Successful Detection (Yes/No)
3001	8.7	496	18	5564	Yes
3002	9.5	477	18	5538	Yes
3003	7.9	372	18	5534	Yes
3004	7.1	499	17	5533	Yes
3005	9.8	288	17	5532	Yes
3006	9.1	428	16	5559	Yes
3007	6	481	17	5534	Yes
3008	7.8	383	16	5543	Yes
3009	9	331	17	5534	Yes
3010	6.8	379	16	5548	Yes
3011	6.3	340	18	5565	Yes
3012	8.5	400	18	5536	Yes
3013	8.2	374	16	5544	Yes
3014	6.4	329	17	5569	Yes
3015	8.5	316	17	5567	Yes
3016	9.2	284	17	5533	Yes
3017	7.4	417	17	5534	Yes
3018	8.2	398	17	5556	Yes
3019	6.6	426	17	5568	Yes
3020	9.9	419	16	5555	No
3021	8.5	460	16	5534	Yes
3022	7.8	348	18	5538	Yes
3023	6.9	402	16	5559	Yes
3024	6.5	436	18	5545	Yes
3025	7.7	252	16	5542	Yes
3026	9.6	299	18	5555	Yes
3027	9.1	261	17	5540	Yes
3028	7.2	321	16	5561	Yes
3029	6.9	295	18	5536	Yes
3030	9.2	250	16	5531	Yes

TYPE 4 DETECTION PROBABILITY

Data Sheet for FCC Short Pulse Radar Type 4

Waveform	Pulse Width (us)	PRI (us)	Pulses Per Burst	Frequency (MHz)	Successful Detection (Yes/No)
4001	13.8	488	13	5541	Yes
4002	15.2	456	12	5544	Yes
4003	11.2	338	13	5566	Yes
4004	13.1	318	13	5568	Yes
4005	18.7	346	12	5551	Yes
4006	16.8	340	14	5555	Yes
4007	18.5	381	14	5552	Yes
4008	12.3	269	14	5536	Yes
4009	19.3	323	16	5545	Yes
4010	18.3	357	14	5554	Yes
4011	11.9	423	16	5538	Yes
4012	16.2	471	14	5569	Yes
4013	15.1	432	15	5545	Yes
4014	19.9	492	16	5544	Yes
4015	19.2	466	14	5543	Yes
4016	15.4	421	13	5541	Yes
4017	20	408	16	5564	Yes
4018	12.4	376	15	5553	Yes
4019	17.4	258	12	5542	Yes
4020	19.4	372	14	5562	Yes
4021	15.8	267	15	5568	Yes
4022	13.9	394	13	5537	Yes
4023	15.6	301	12	5549	Yes
4024	14.2	441	15	5547	Yes
4025	16.4	494	14	5563	No
4026	15.5	278	12	5557	Yes
4027	13.8	344	15	5551	Yes
4028	13.4	391	15	5553	Yes
4029	12.2	353	13	5536	Yes
4030	17	413	14	5566	Yes

TYPE 5 DETECTION PROBABILITY

Data Sheet for FCC Long Pulse Radar Type 5		
Trial	Frequency (MHz)	Successful Detection (Yes/No)
1	5550	Yes
2	5550	Yes
3	5550	Yes
4	5550	Yes
5	5550	Yes
6	5550	Yes
7	5550	Yes
8	5550	Yes
9	5550	Yes
10	5550	Yes
11	5538	Yes
12	5539	Yes
13	5540	Yes
14	5535	Yes
15	5537	Yes
16	5534	Yes
17	5535	Yes
18	5540	Yes
19	5535	Yes
20	5540	Yes
21	5565	Yes
22	5560	Yes
23	5565	Yes
24	5560	Yes
25	5565	Yes
26	5560	Yes
27	5565	Yes
28	5560	Yes
29	5565	Yes
30	5560	Yes

Note: The Type 5 randomized parameters tested are shown in a separate document.

TYPE 6 DETECTION PROBABILITY

Data Sheet for FCC Hopping Radar Type 6				
1 us Pulse Width, 333 us PRI, 9 Pulses per Burst, 1 Burst per Hop				
NTIA August 2005 Hopping Sequence				
Trial	Starting Index Within Sequence	Signal Generator Frequency (MHz)	Hops within Detection BW	Successful Detection (Yes/No)
1	56	5530	8	Yes
2	531	5531	11	Yes
3	1006	5532	11	Yes
4	1481	5533	7	Yes
5	1956	5534	8	Yes
6	2431	5535	11	Yes
7	2906	5536	9	Yes
8	3381	5537	12	Yes
9	3856	5538	10	Yes
10	4331	5539	6	Yes
11	4806	5540	8	Yes
12	5281	5541	9	Yes
13	5756	5542	13	Yes
14	6231	5543	10	Yes
15	6706	5544	5	Yes
16	7181	5545	7	Yes
17	7656	5546	5	Yes
18	8131	5547	13	Yes
19	8606	5548	6	Yes
20	9081	5549	5	Yes
21	9556	5550	10	Yes
22	10031	5551	10	Yes
23	10506	5552	9	Yes
24	10981	5553	11	Yes
25	11456	5554	9	Yes
26	11931	5555	6	Yes
27	12406	5556	7	Yes
28	12881	5557	9	Yes
29	13356	5558	9	Yes
30	13831	5559	10	Yes
31	14306	5560	5	Yes
32	14781	5561	9	Yes
33	15256	5562	8	Yes
34	15731	5563	9	Yes
35	16206	5564	5	Yes
36	16681	5565	10	Yes
37	17156	5566	7	Yes
38	17631	5567	6	Yes
39	18106	5568	9	Yes
40	18581	5569	8	Yes
41	19056	5570	8	Yes

5.4. BRIDGE MODE RESULTS

Per KDB 905462, Section 5.1 (footnote 1):

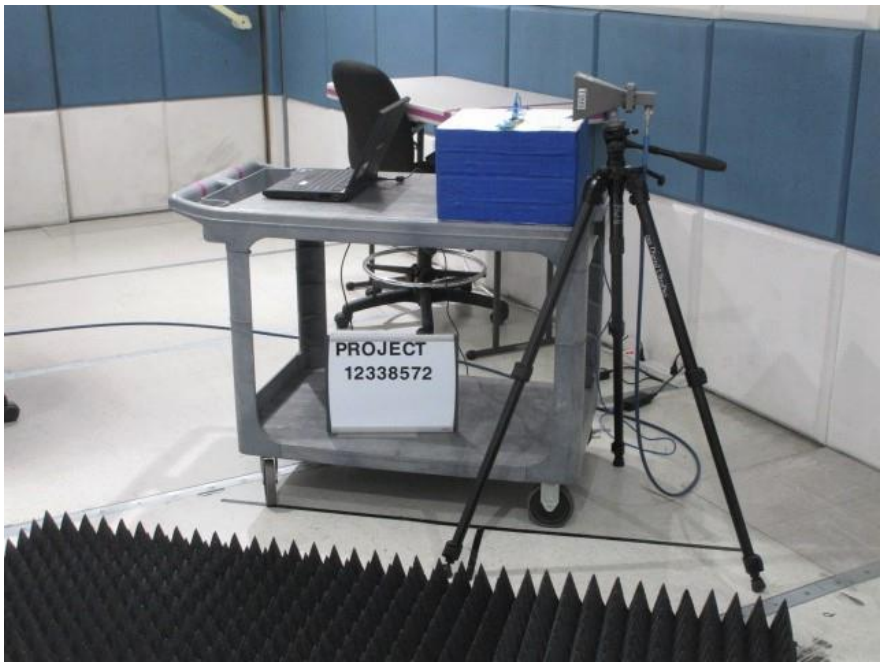
Networks Access Points with Bridge and/or MESH modes of operation are permitted to operate in the DFS bands but must employ a DFS function. The functionality of the Bridge mode as specified in §15.403(a) must be validated in the DFS test report. Devices operating as relays must also employ DFS function. The method used to validate the functionality must be documented and validation data must be documented. Bridge mode can be validated by performing a test statistical performance check (Section 7.8.4) on any one of the radar types. This is an abbreviated test to verify DFS functionality. MESH mode operational methodology must be submitted in the application for certification for evaluation by the FCC.

This device does not support Bridge Mode therefore this test was not performed.

6. SETUP PHOTOS

DYNAMIC FREQUENCY SELECTION MEASUREMENT SETUP

DFS FRONT PHOTO



DFS BACK PHOTO

END OF REPORT