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: PMP 450b

FCC ID: Z8H89FT0032
IC: 109W-0032

REPORT NUMBER: 12234490-E2V1

ISSUE DATE: APRIL 25, 2018

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

Prepared by
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET
FREMONT, CA 94538, U.S.A.
TEL: (510) 771-1000
FAX: (510) 661-0888

NVLAP TESTING
NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	04/25/18	Initial Issue	Henry Lau

UL VERIFICATION SERVICES INC. FORM NO: CCSUP4701J
47173 BENICIA STREET, FREMONT, CA 94538, USA TEL: (510) 771-1000 FAX: (510) 661-0888
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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: PMP 450b

SERIAL NUMBER: 0A-003e-70-2a-9d

DATE TESTED: APRIL 04 to 05, 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.

Approved & Released For
UL Verification Services Inc. By:

HENRY LAU
TEST ENGINEER
UL Verification Services Inc.

Prepared By:

DOUG ANDERSON
EMC ENGINEER
UL Verification Services Inc.

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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. The full scope of accreditation can be viewed at http://ts.nist.gov/standards/scopes/2000650.htm.

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%.

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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”.

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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.		

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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.

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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

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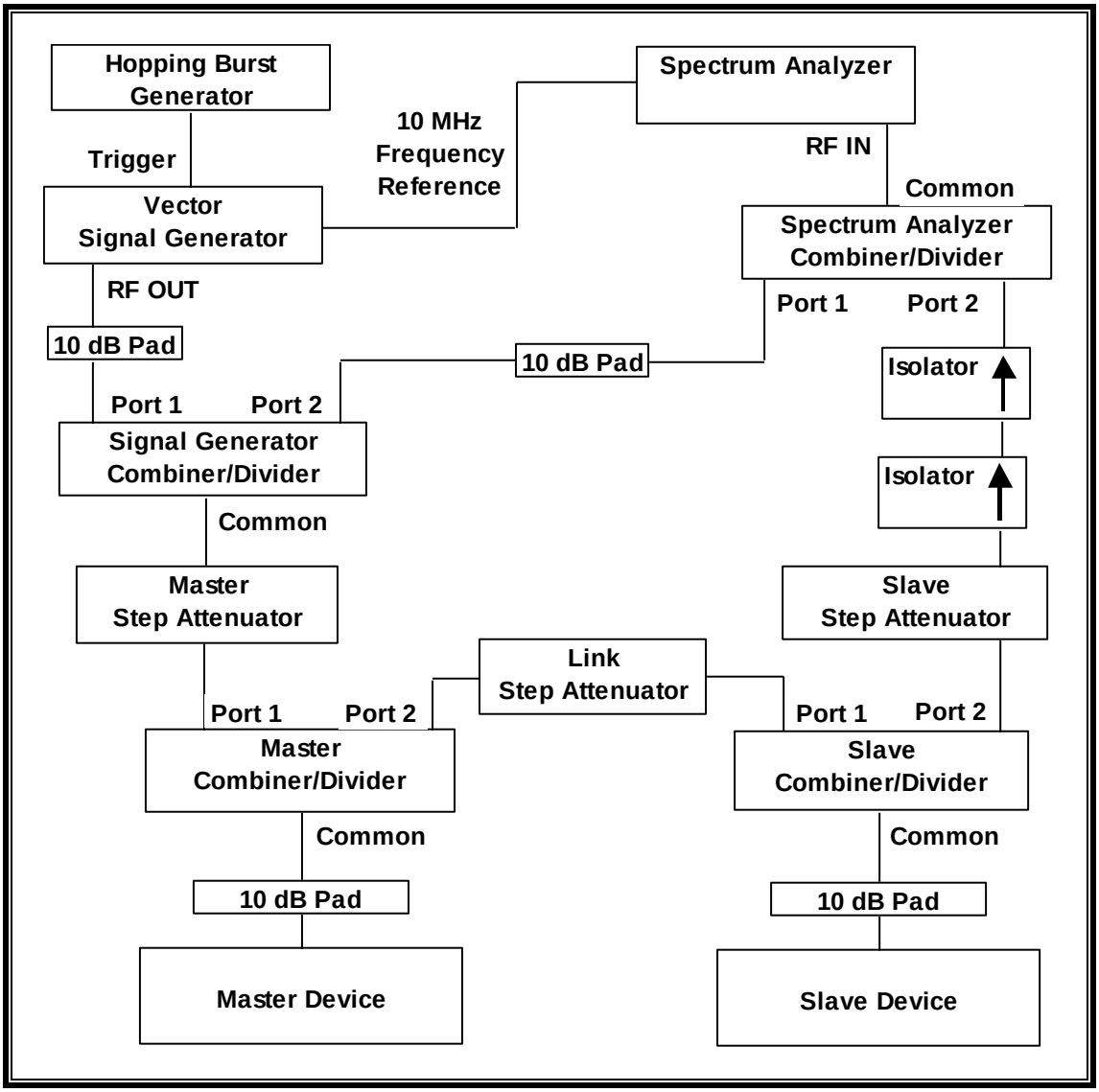
5.1.2. TEST AND MEASUREMENT SYSTEM

CONDUCTED METHOD SYSTEM BLOCK DIAGRAM



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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.

Should multiple RF ports be utilized for the Master and/or Slave devices (for example, for diversity or MIMO implementations), additional combiner/dividers are inserted between the Master Combiner/Divider and the pad connected to the Master Device (and/or between the Slave Combiner/Divider and the pad connected to the Slave Device). Additional pads may be utilized such that there is one pad at each RF port on each EUT.

SYSTEM CALIBRATION

A 50-ohm load is connected in place of the spectrum analyzer, and the spectrum analyzer is connected in place of the master device. 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.

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ADJUSTMENT OF DISPLAYED TRAFFIC LEVEL

A link is established between the Master and Slave and the Link Step Attenuator between the units is adjusted as needed to provide a suitable received level at the Master and Slave devices. The video test file is streamed to generate WLAN traffic. The WLAN traffic level, as displayed on the spectrum analyzer, is confirmed to be at lower amplitude than the radar detection threshold and is confirmed to be the Radar Detection Device rather than the associated device. If a different setting of the Master Step Attenuator is required to meet the above conditions, a new System Calibration is performed for the new Master Step Attenuator setting.

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	06/22/18
Signal Generator, MXG X-Series RF Vector	Agilent	N5182B	T1134	04/21/18
Arbitrary Waveform Generator	Agilent / HP	33220A	T190	04/06/18

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	3.0	Channel Loading and Aggregate Closing Time
FCC 2006 Detection Bandwidth-PXA	3.0	Detection Bandwidth in 1 MHz Steps
FCC 2014 Detection Bandwidth-PXA	3.0	Detection Bandwidth in 5 MHz Steps
In Service Monitoring-PXA	3.0	In-Service Monitoring (Probability of Detection)
PXA Read	3.0.0.9	Signal Generator Screen Capture
SGXProject.exe	1.7	Radar Waveform Generation and Download

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 26.3 °C
Humidity	27 and 27 %

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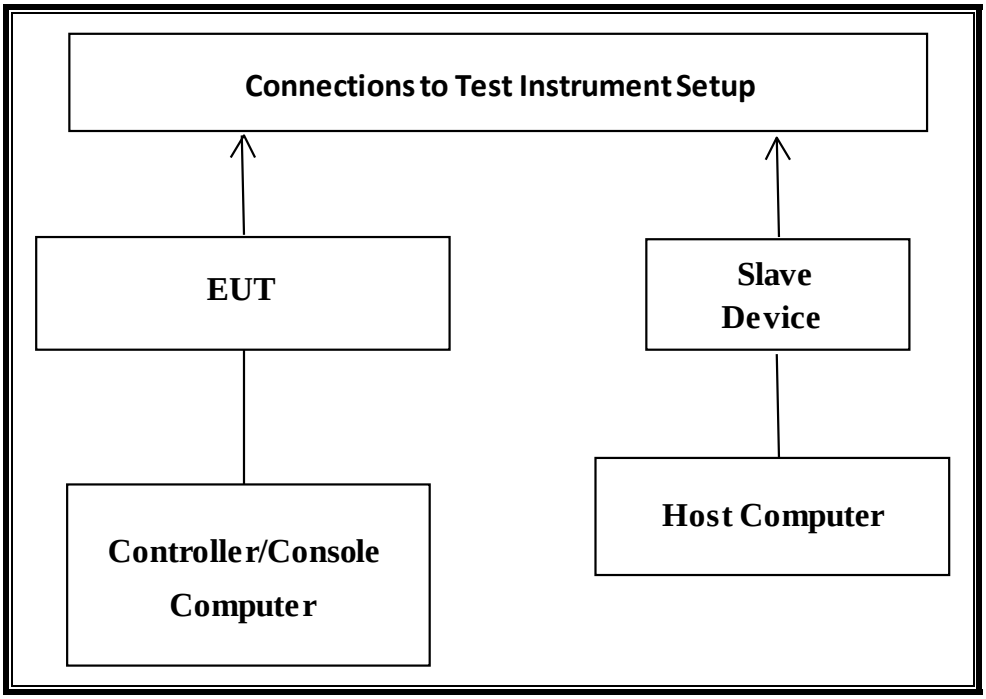
5.1.4. SETUP OF EUT

CONDUCTED 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**
P.O.E.Injector (EUT)	Phihong	PSA15A-300 (AP)	0444582117P0401	DoC
Notebook PC (EUT Controller/Console)	Lenovo	Type 20B7-S0A200	PF-02JN9J 14/06	DoC
AC Adapter (Controller/Console PC)	Lenovo	ADLX65NCC2A	11S45N0263Z1ZSH D41A5JY	DoC
5 GHz Fixed Outdoor Transceiver (Slave Device)	Cambium Networks	PMP 450b	0a:00:3e:70:51:8f	Z8HFT0032
P.O.E.Injector (Slave)	Phihong	PSA15A-300 (AP)	0443642117P0401	DoC
Notebook PC (Slave Host)	Lenovo	TP00001A	None	DoC
AC Adapter (Host PC)	Lenovo	ADLX65NCT2A	11S45N0323Z1ZLZH 3925TJ	DoC

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5.1.5. 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 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 as declared by manufacturer.

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

For 10 MHz channel bandwidth the only antenna assembly utilized with the EUT has a gain of 16 dBi.

For 10 MHz channel bandwidth the rated output power of the Master unit is > 23dBm (EIRP). Therefore the required interference threshold level is –64 dBm. After correction for antenna gain and procedural adjustments, the required conducted threshold at the antenna port is –64 + 16 + 1 = -47 dBm.

For 10 MHz channel bandwidth the calibrated conducted DFS Detection Threshold level is set to –47 dBm.

For 40 MHz channel bandwidth the highest gain antenna assembly utilized with the EUT has a gain of 16 dBi in the 5250-5350 MHz band and 16 dBi in the 5470-5725 MHz band. The lowest gain antenna assembly utilized with the EUT has a gain of 0 dBi in the 5250-5350 MHz band and 0 dBi in the 5470-5725 MHz band.

For 40 MHz channel bandwidth the EUT was tested with a client declared worst-case gain of 0 dBi.

For 40 MHz channel bandwidth the rated output power of the Master unit is > 23dBm (EIRP). Therefore the required interference threshold level is –64 dBm. After correction for antenna gain and procedural adjustments, the required conducted threshold at the antenna port is –64 + 0 + 1 = -63 dBm.

For 40 MHz channel bandwidth the calibrated conducted DFS Detection Threshold level is set to –63 dBm.

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

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The EUT uses one vertically polarized and one horizontally polarized transmitter/receiver chain. During testing the vertical chain is connected to a 50-ohm coaxial antenna port while the horizontal chain is terminated with a 50-ohm load. The vertical antenna port is connected to the test system via a power divider to perform conducted tests.

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 1.4.

UNIFORM CHANNEL SPREADING

This function is not required per KDB 905462.

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5.2. RESULTS FOR 10 MHz BANDWIDTH

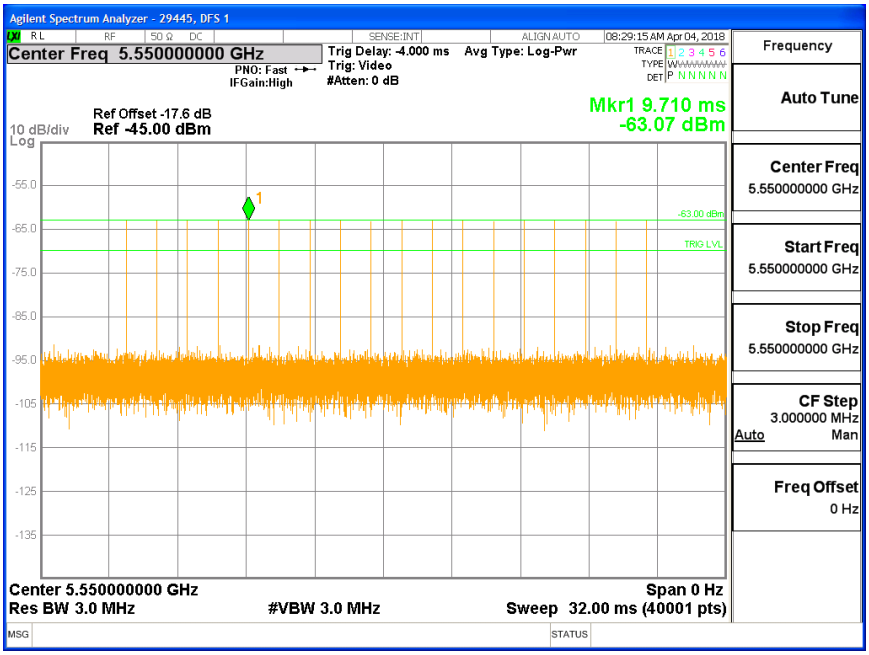
5.2.1. TEST CHANNEL

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



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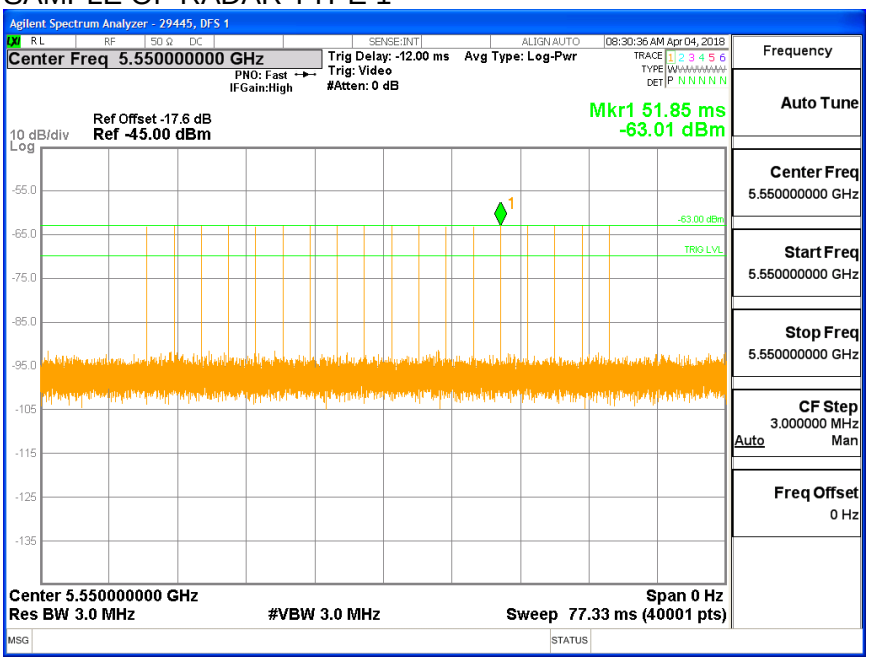
SAMPLE OF RADAR TYPE 1



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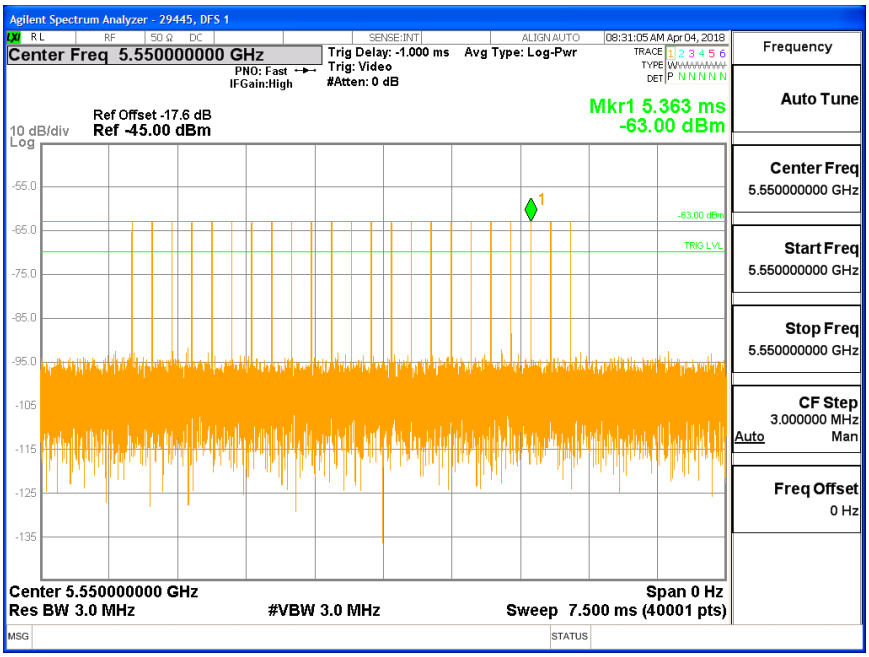
SAMPLE OF RADAR TYPE 2



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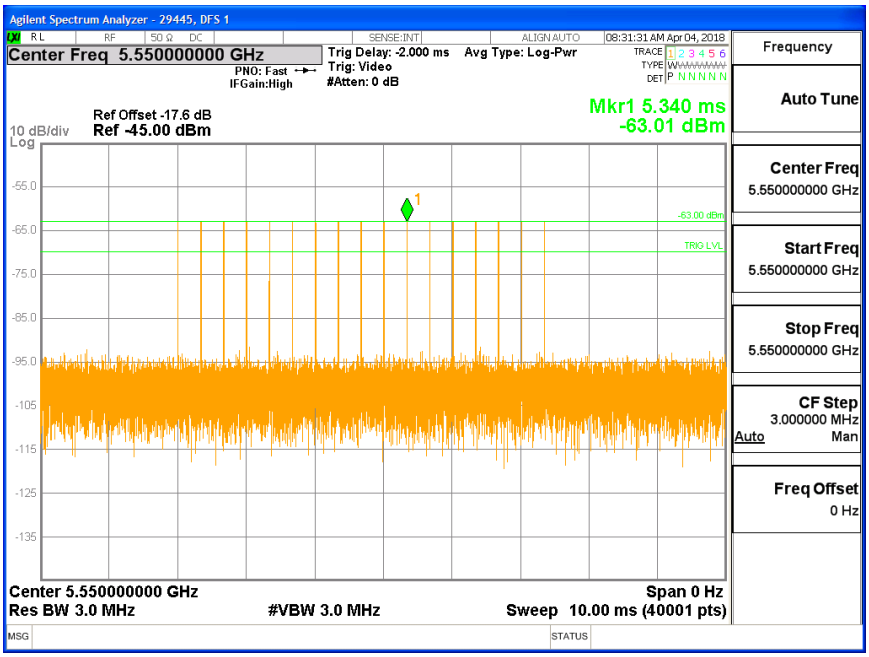
SAMPLE OF RADAR TYPE 3



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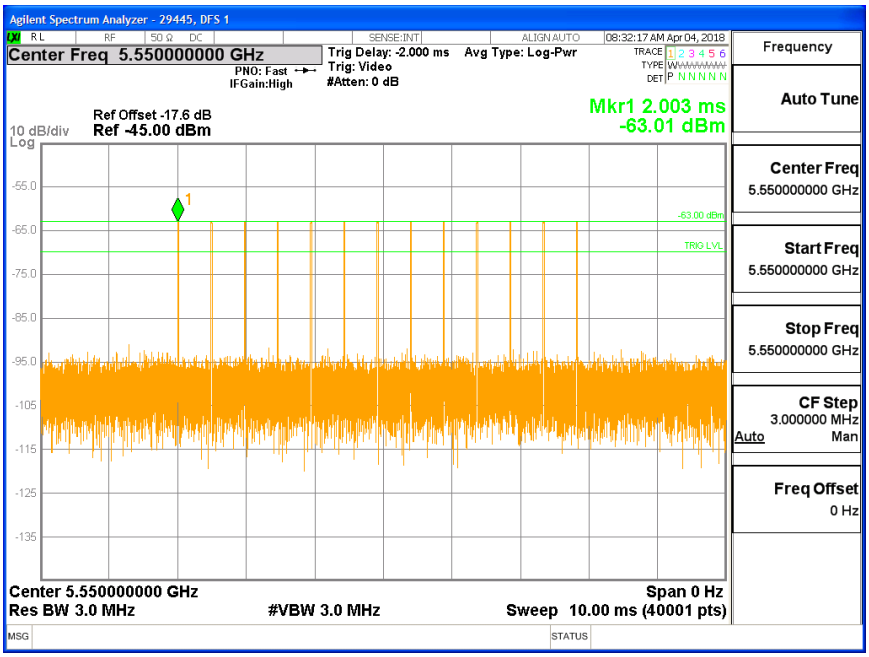
SAMPLE OF RADAR TYPE 4



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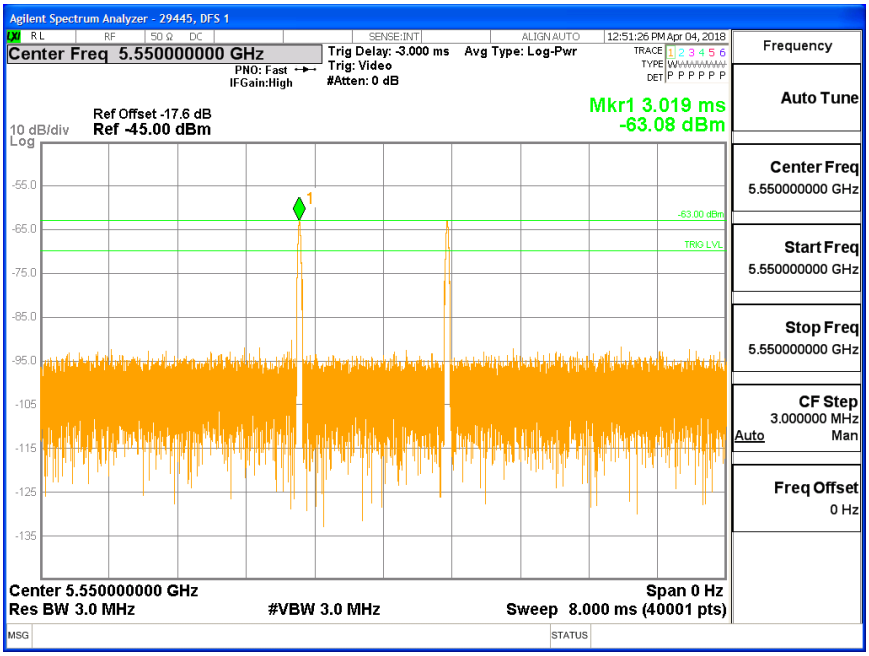
SAMPLE OF SINGLE BURST OF RADAR TYPE 5



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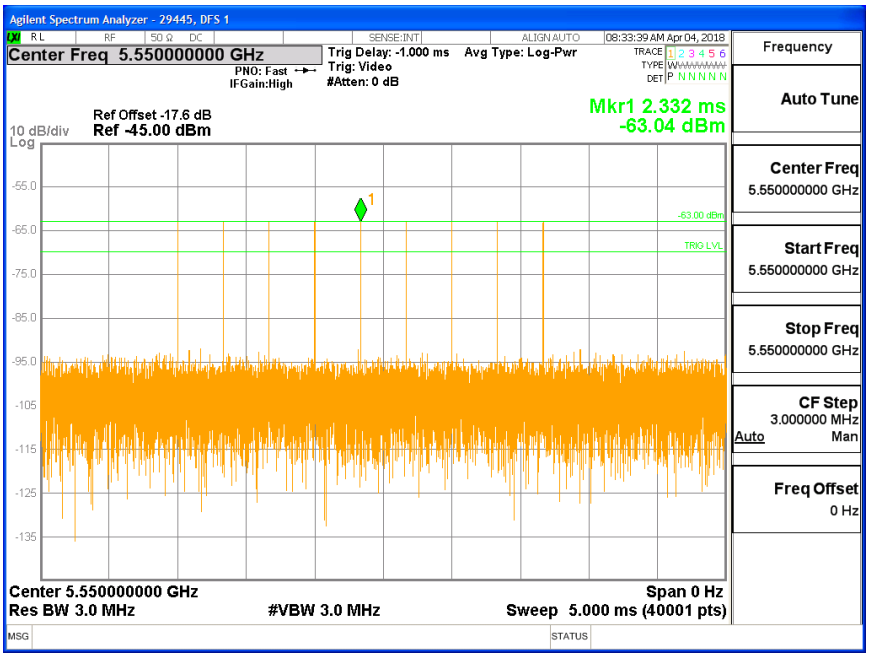
SINGLE BURST OF RADAR TYPE 6



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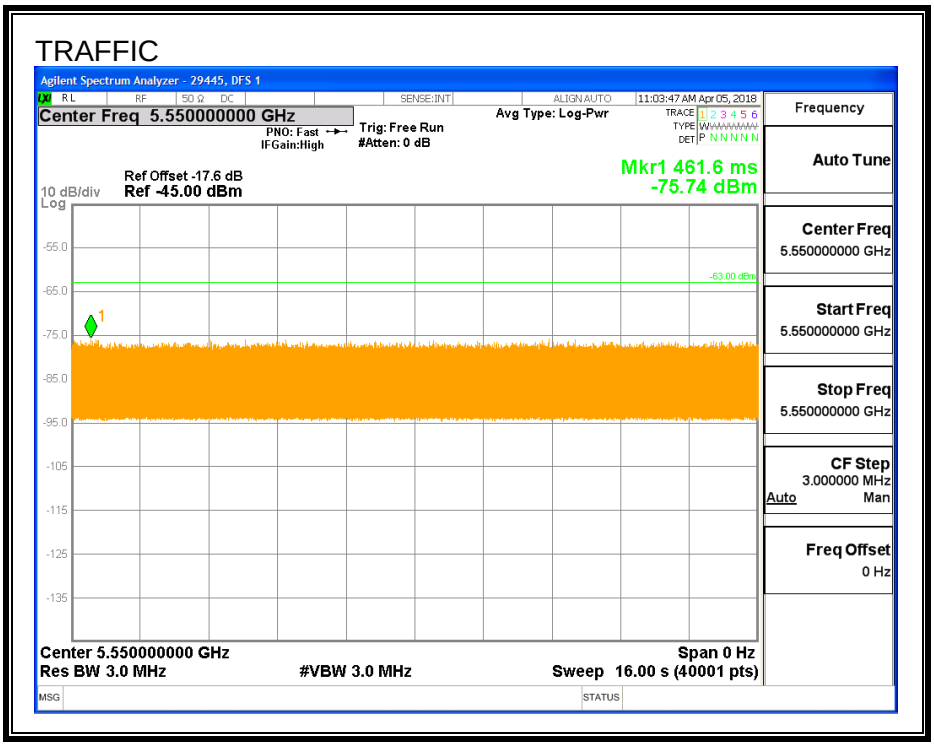
TRAFFIC



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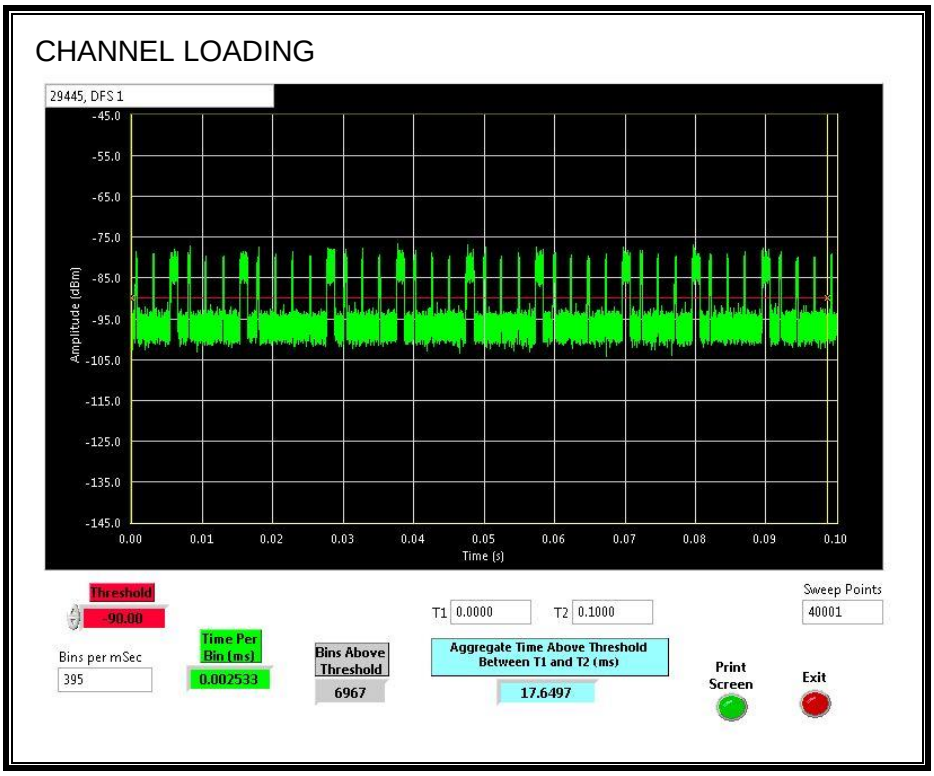
CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 17.649%

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5.2.3. CHANNEL AVAILABILITY CHECK TIME

This test is not required for this channel bandwidth per table two, page six of KDB 905462 D02, therefore it has not been performed.

5.2.4. OVERLAPPING CHANNEL TESTS

RESULTS

The channel spacing is not less than the channel bandwidth therefore the EUT does not have an overlapping channel plan.

5.2.5. MOVE AND CLOSING TIME

This test is not required for this channel bandwidth per table two, page six of KDB 905462 D02, therefore it has not been performed.

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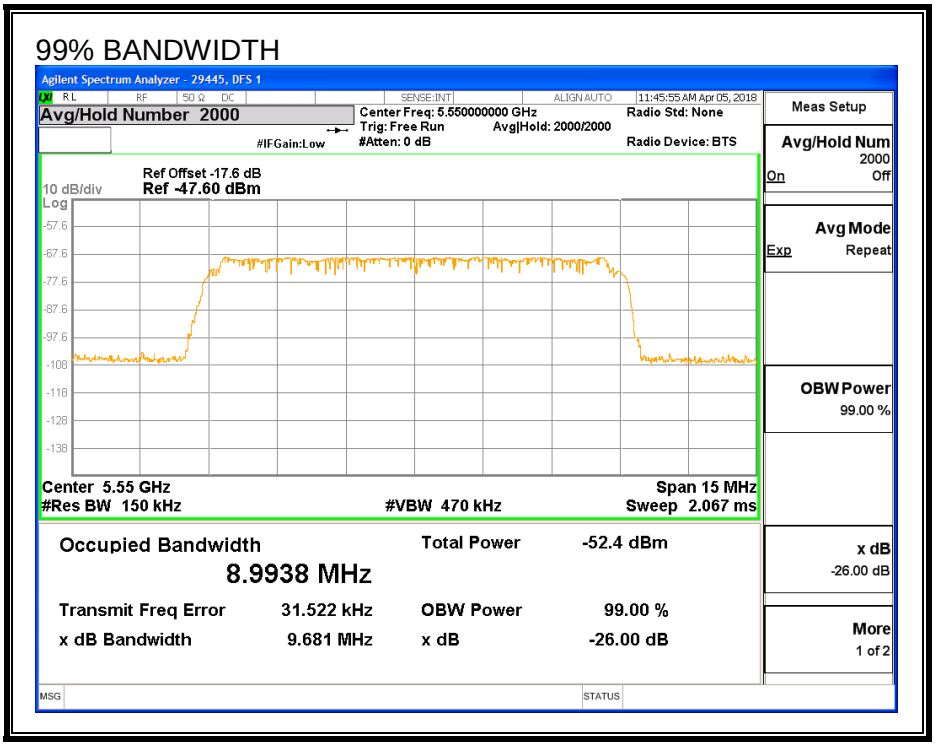
5.2.6. DETECTION BANDWIDTH

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 (%)
5545.5	5554.5	9	8.9938	100.1	100

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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
5545.5	10	10	100	FL
5546	10	9	90	
5547	10	10	100	
5548	10	10	100	
5549	20	18	90	
5550	10	10	100	
5551	10	9	90	
5552	10	10	100	
5553	10	10	100	
5554	10	10	100	
5554.5	10	10	100	FH

Note: The above results confirm that the EUT has a Detection Bandwidth of at least 100% of the 99% Occupied Power Bandwidth. Given that the center frequency of the channel can be set by the manufacturer when the EUT is configured at the factory, it demonstrates that the 1 MHz Detection Bandwidth step increment is divided in half for the current configured center frequency. Therefore the 1 MHz step increment ratio is maintained in accordance with KDB 905462 D02.

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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	86.67	60	Pass	5545.5	5554.5	8.99	DFS 1	29445	Version 3.0
FCC Short Pulse Type 2	30	90.00	60	Pass	5545.5	5554.5	8.99	DFS 1	29445	Version 3.0
FCC Short Pulse Type 3	30	73.33	60	Pass	5545.5	5554.5	8.99	DFS 1	29445	Version 3.0
FCC Short Pulse Type 4	30	93.33	60	Pass	5545.5	5554.5	8.99	DFS 1	29445	Version 3.0
Aggregate		85.83	80	Pass						
FCC Long Pulse Type 5	30	100.00	80	Pass	5545.5	5554.5	8.99	DFS 1	29445	Version 3.0
FCC Hopping Type 6	40	70.00	70	Pass	5545.5	5554.5		DFS 1	29445	Version 3.0

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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	5550	Yes
1002	1	678	78	A	5548	Yes
1003	1	938	57	A	5549	Yes
1004	1	738	72	A	5548	Yes
1005	1	598	89	A	5551	Yes
1006	1	858	62	A	5551	Yes
1007	1	578	92	A	5553	Yes
1008	1	698	76	A	5552	Yes
1009	1	798	67	A	5551	Yes
1010	1	518	102	A	5550	Yes
1011	1	638	83	A	5548	Yes
1012	1	538	99	A	5550	Yes
1013	1	918	58	A	5552	Yes
1014	1	758	70	A	5547	Yes
1015	1	618	86	A	5545	Yes
1016	1	2642	20	B	5546	Yes
1017	1	727	73	B	5553	No
1018	1	2360	23	B	5547	Yes
1019	1	574	92	B	5554	No
1020	1	2336	23	B	5551	Yes
1021	1	2033	26	B	5553	Yes
1022	1	2730	20	B	5551	Yes
1023	1	1203	44	B	5547	Yes
1024	1	836	64	B	5553	Yes
1025	1	792	67	B	5545	No
1026	1	553	96	B	5553	No
1027	1	639	83	B	5548	Yes
1028	1	530	100	B	5549	Yes
1029	1	2098	26	B	5548	Yes
1030	1	2119	25	B	5549	Yes

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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	4.2	218	23	5548	Yes
2002	3.9	152	24	5546	Yes
2003	3.4	220	28	5546	Yes
2004	1.5	159	23	5551	Yes
2005	1.2	150	27	5546	No
2006	1.6	217	25	5551	Yes
2007	1.5	175	27	5548	Yes
2008	2.2	164	29	5547	Yes
2009	4.5	164	27	5550	Yes
2010	1.2	201	27	5553	Yes
2011	1.8	167	29	5549	Yes
2012	2.9	208	25	5552	Yes
2013	3.7	178	24	5547	Yes
2014	3	185	28	5553	Yes
2015	4	202	27	5549	Yes
2016	3.6	171	24	5554	Yes
2017	2.9	154	28	5545	No
2018	2.6	207	29	5546	Yes
2019	2.1	195	26	5553	Yes
2020	4.3	214	27	5548	Yes
2021	2.1	168	25	5552	Yes
2022	4.4	191	23	5548	Yes
2023	2.4	230	25	5551	Yes
2024	5	220	23	5553	Yes
2025	3.2	182	25	5549	No
2026	4	175	24	5548	Yes
2027	4.6	222	23	5548	Yes
2028	1.6	182	23	5550	Yes
2029	2.4	195	29	5550	Yes
2030	1.7	159	26	5552	Yes

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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	7.7	334	17	5552	No
3002	7.3	486	17	5553	Yes
3003	6.6	435	17	5549	Yes
3004	6.3	349	17	5551	Yes
3005	9.9	310	16	5553	Yes
3006	8	253	17	5547	Yes
3007	9.9	478	17	5547	Yes
3008	8.1	300	18	5549	Yes
3009	6.1	420	18	5552	No
3010	8.7	388	18	5551	Yes
3011	6.9	270	16	5547	No
3012	9.9	250	18	5553	Yes
3013	8.3	396	18	5550	Yes
3014	9.4	272	18	5550	Yes
3015	6.1	313	17	5552	No
3016	9.5	452	16	5552	Yes
3017	6.4	255	16	5549	No
3018	6	407	16	5547	No
3019	9.4	355	16	5549	Yes
3020	7.2	403	16	5545	No
3021	6.7	482	18	5548	Yes
3022	6.7	424	16	5550	Yes
3023	8.6	398	16	5548	Yes
3024	6.8	471	17	5550	Yes
3025	8.9	340	17	5546	Yes
3026	7.4	308	17	5547	Yes
3027	7.8	441	18	5551	Yes
3028	8.6	422	17	5552	No
3029	7	317	17	5545	Yes
3030	6.2	443	17	5547	Yes

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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	17.4	484	13	5550	Yes
4002	16	373	16	5552	Yes
4003	18.2	426	13	5550	Yes
4004	13	327	16	5550	Yes
4005	15.6	276	13	5550	Yes
4006	20	323	16	5549	Yes
4007	18.8	285	14	5552	Yes
4008	14.6	345	15	5554	Yes
4009	13.9	319	16	5546	Yes
4010	19.1	274	12	5548	Yes
4011	14.6	261	13	5554	Yes
4012	16.1	480	12	5545	No
4013	12.1	362	14	5553	Yes
4014	14	342	13	5548	Yes
4015	19.5	371	12	5546	Yes
4016	17.7	364	12	5550	Yes
4017	14.5	405	16	5553	Yes
4018	13.2	293	14	5552	Yes
4019	11.1	347	16	5550	Yes
4020	19.2	381	14	5549	Yes
4021	12.8	448	12	5548	Yes
4022	17.1	495	15	5550	Yes
4023	16	456	13	5550	Yes
4024	11.7	265	16	5551	Yes
4025	11	491	14	5551	Yes
4026	16.3	446	16	5552	Yes
4027	11.8	433	12	5549	Yes
4028	13.2	400	16	5554	No
4029	18.3	282	12	5550	Yes
4030	11.1	263	13	5550	Yes

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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	5554	Yes
12	5551	Yes
13	5550	Yes
14	5551	Yes
15	5548	Yes
16	5550	Yes
17	5549	Yes
18	5554	Yes
19	5550	Yes
20	5551	Yes
21	5552	Yes
22	5549	Yes
23	5552	Yes
24	5549	Yes
25	5552	Yes
26	5549	Yes
27	5552	Yes
28	5549	Yes
29	5552	Yes
30	5549	Yes

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

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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	257	5545	3	No
2	732	5546	1	Yes
3	1207	5547	2	No
4	1682	5548	2	Yes
5	2157	5549	3	Yes
6	2632	5550	1	Yes
7	3107	5551	1	No
8	4532	5552	2	Yes
9	5007	5553	3	Yes
10	5482	5554	3	Yes
11	5957	5545	3	No
12	6432	5546	2	Yes
13	7382	5547	1	Yes
14	7857	5548	4	Yes
15	8332	5549	1	No
16	8807	5550	4	Yes
17	9757	5551	1	No
18	10232	5552	1	Yes
19	10707	5553	1	No
20	11182	5554	2	No
21	11657	5545	2	Yes
22	12607	5546	2	Yes
23	13082	5547	2	Yes
24	13557	5548	3	No
25	14032	5549	4	Yes
26	14507	5550	3	Yes
27	14982	5551	1	Yes
28	15457	5552	1	Yes
29	15932	5553	2	No
30	16407	5554	1	Yes
31	16882	5545	4	Yes
32	17357	5546	1	Yes
33	17832	5547	3	Yes
34	18307	5548	1	No
35	18782	5549	3	Yes
36	19257	5550	1	Yes
37	19732	5551	1	Yes
38	20207	5552	2	Yes
39	20682	5553	4	Yes
40	21157	5554	2	No

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5.3. RESULTS FOR 40 MHz BANDWIDTH

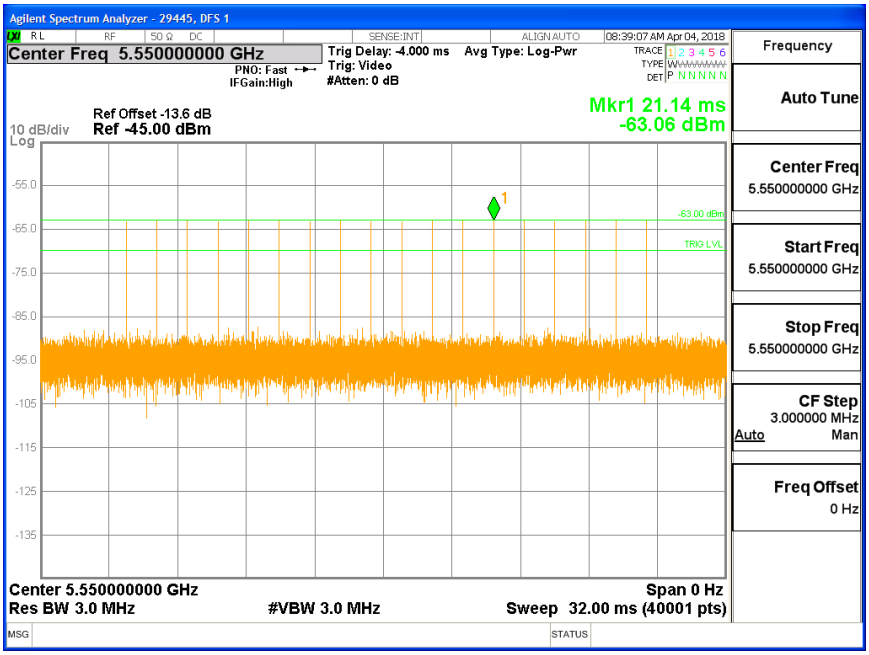
5.3.1. TEST CHANNEL

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



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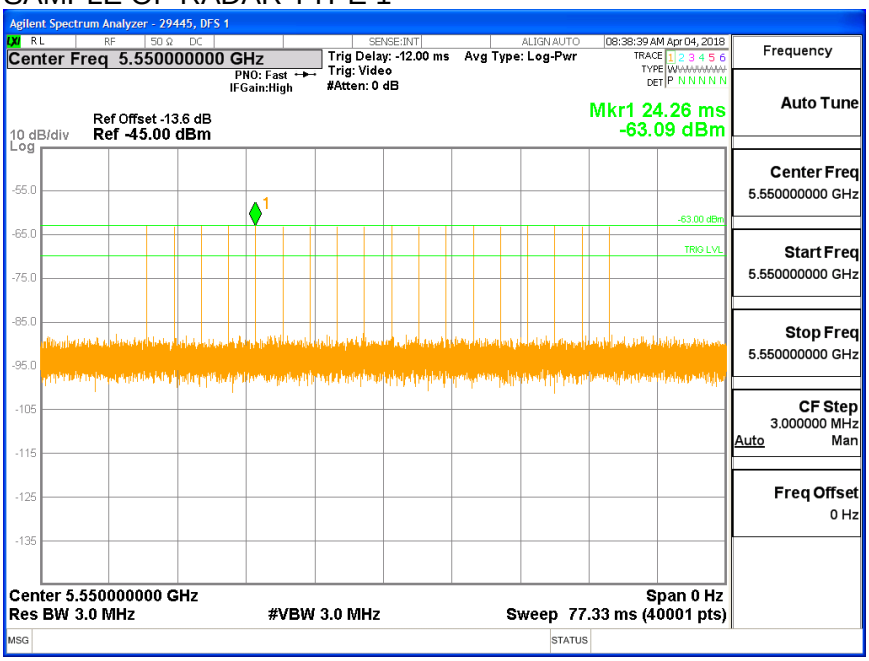
SAMPLE OF RADAR TYPE 1



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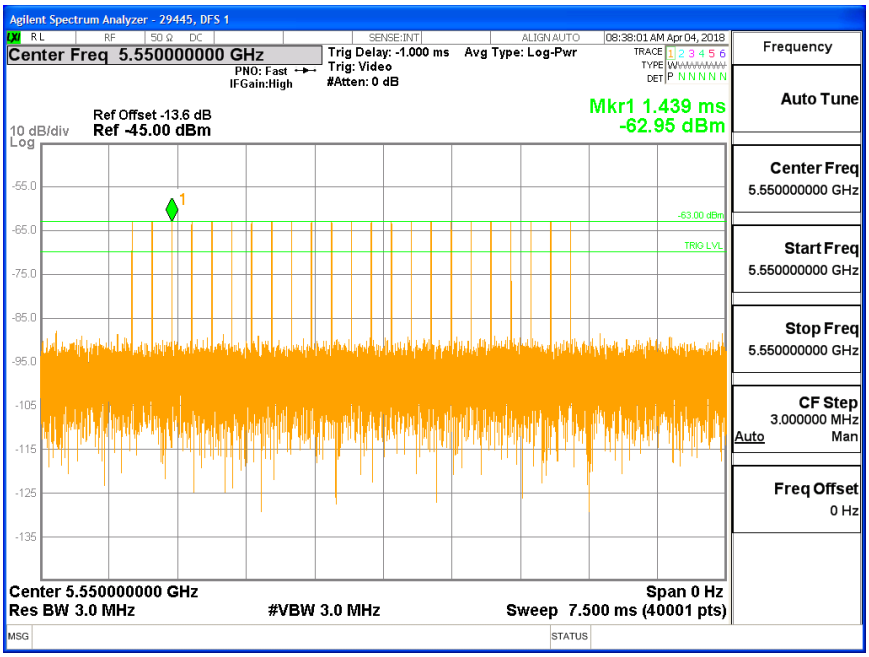
SAMPLE OF RADAR TYPE 2



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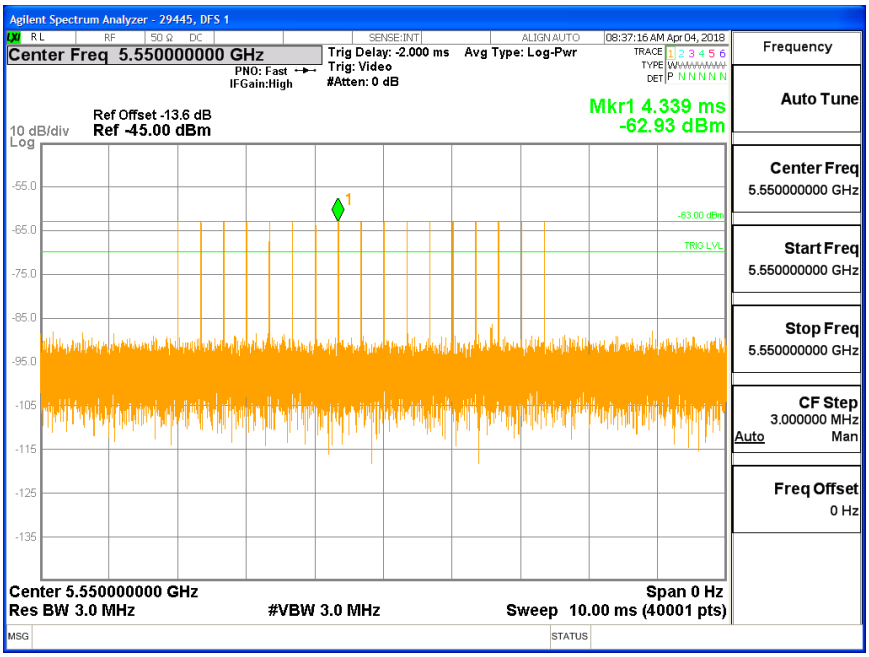
SAMPLE OF RADAR TYPE 3



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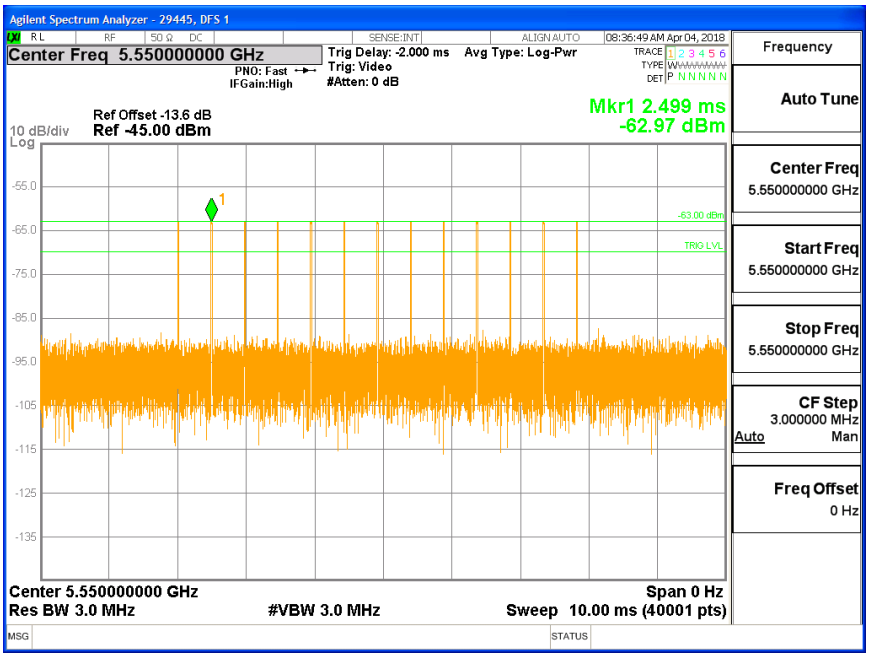
SAMPLE OF RADAR TYPE 4



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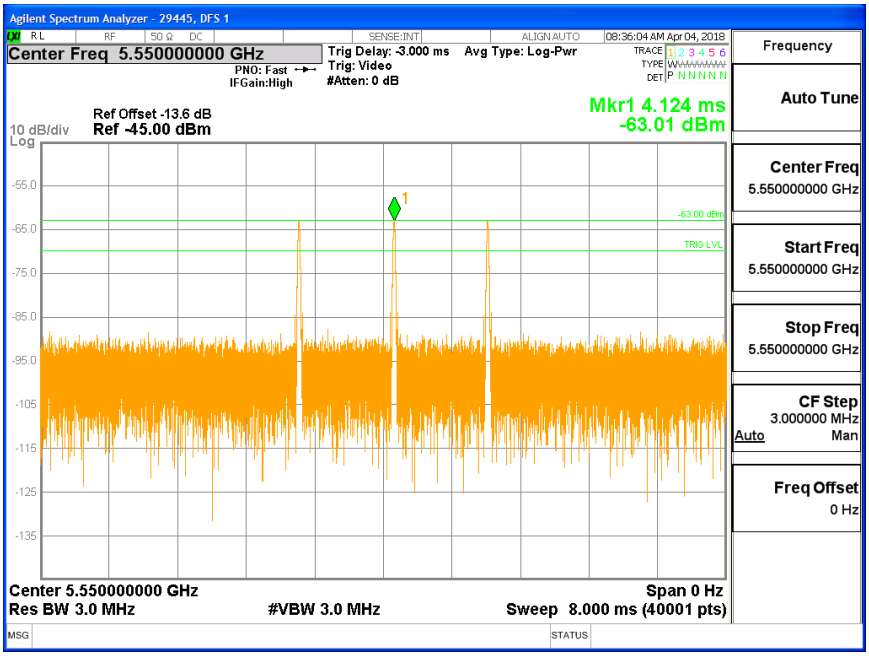
SAMPLE OF SINGLE BURST OF RADAR TYPE 5



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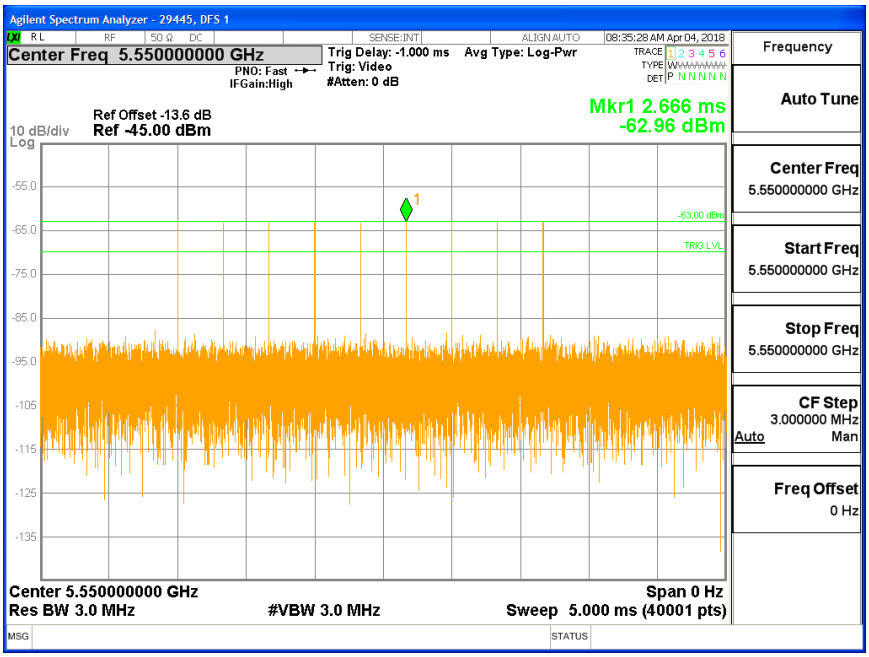
SINGLE BURST OF RADAR TYPE 6



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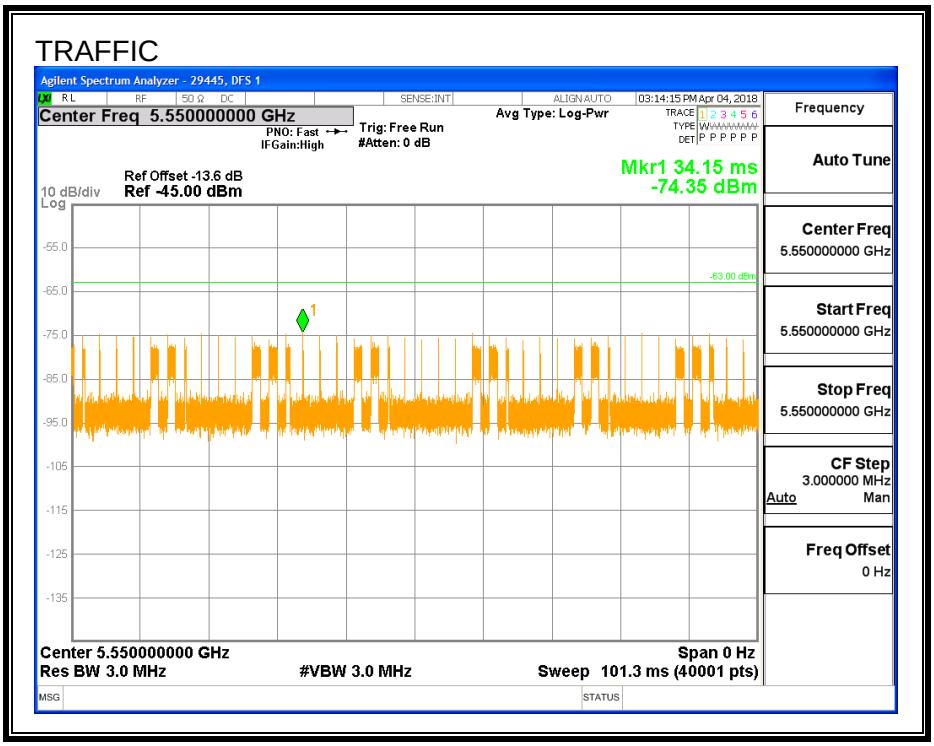
TRAFFIC



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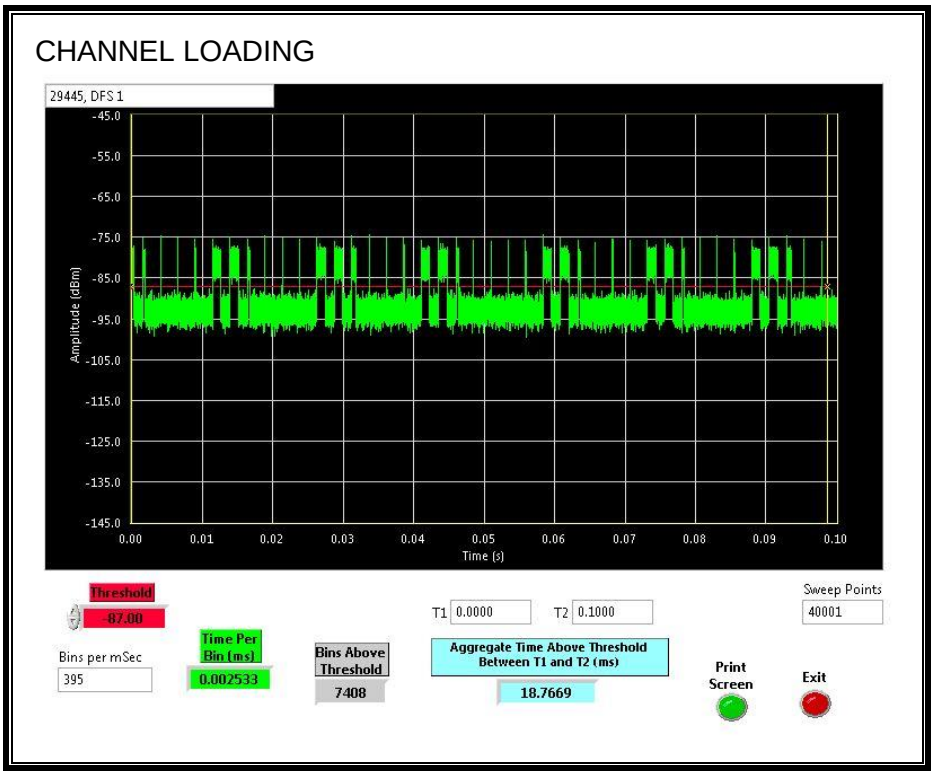
CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 18.766%

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5.3.3. CHANNEL AVAILABILITY CHECK TIME

PROCEDURE TO DETERMINE INITIAL POWER-UP CYCLE TIME

A link was established on channel then the EUT was rebooted. 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 rebooted. 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 rebooted. 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.

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QUANTITATIVE RESULTS

No Radar Triggered

Timing of Reboot (sec)	Timing of Start of Traffic (sec)	Total Power-up Cycle Time (sec)	Initial Power-up Cycle Time (sec)
30.59	135.5	104.9	44.9

Radar Near Beginning of CAC

Timing of Reboot (sec)	Timing of Radar Burst (sec)	Radar Relative to Reboot (sec)	Radar Relative to Start of CAC (sec)
30.08	79.4	49.3	4.4

Radar Near End of CAC

Timing of Reboot (sec)	Timing of Radar Burst (sec)	Radar Relative to Reboot (sec)	Radar Relative to Start of CAC (sec)
30.27	133.2	102.9	58.0

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 power-up cycle 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

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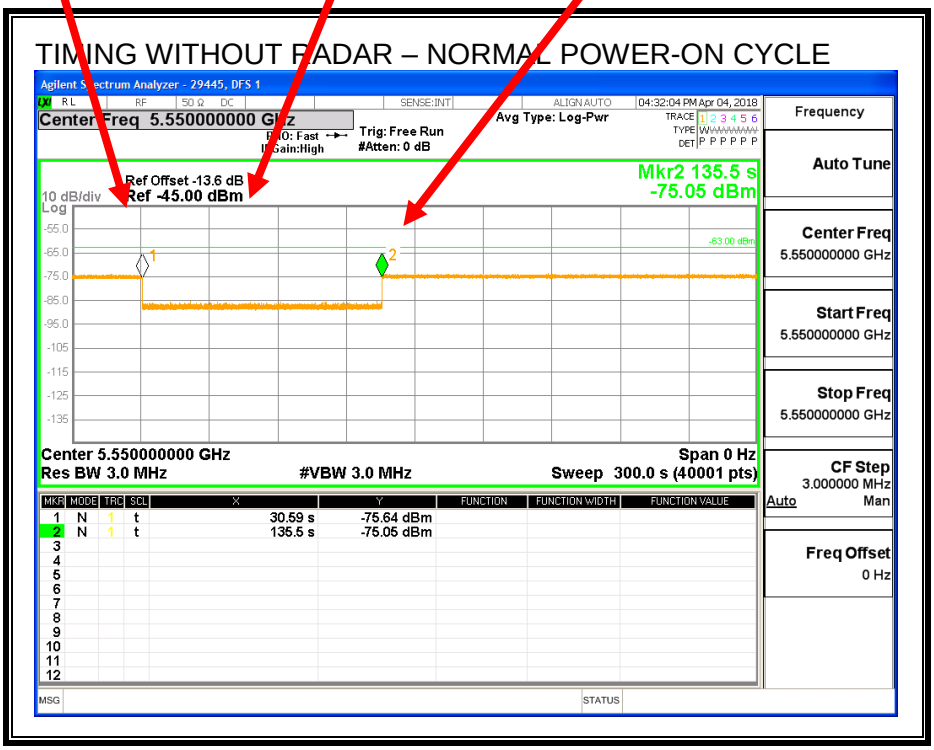
TIMING WITHOUT RADAR DURING CAC

AP is rebooted
Traffic ceases
Start of Initial Power-up cycle

End of Initial Power-up cycle
Start of CAC

End of CAC
Traffic is Initiated



Transmissions begin on channel after completion of the initial power-up cycle and the CAC.

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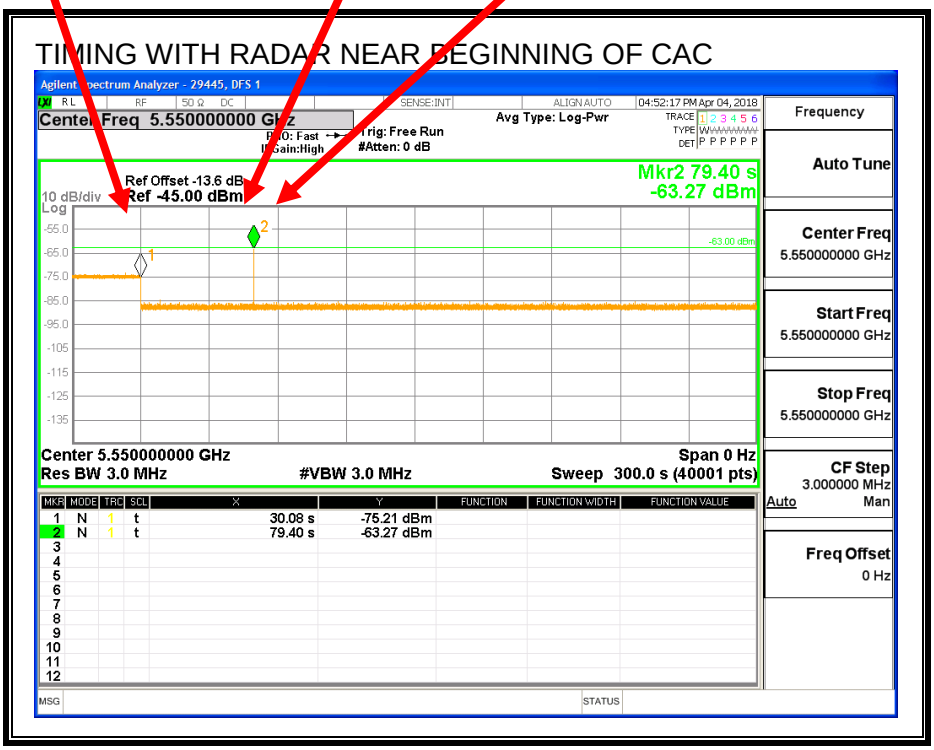
TIMING WITH RADAR NEAR BEGINNING OF CAC

AP is rebooted
Traffic ceases
Start of Initial Power-up cycle

End of Initial Power-up cycle
Start of CAC

Radar Signal Applied



No EUT transmissions were observed after the radar signal.

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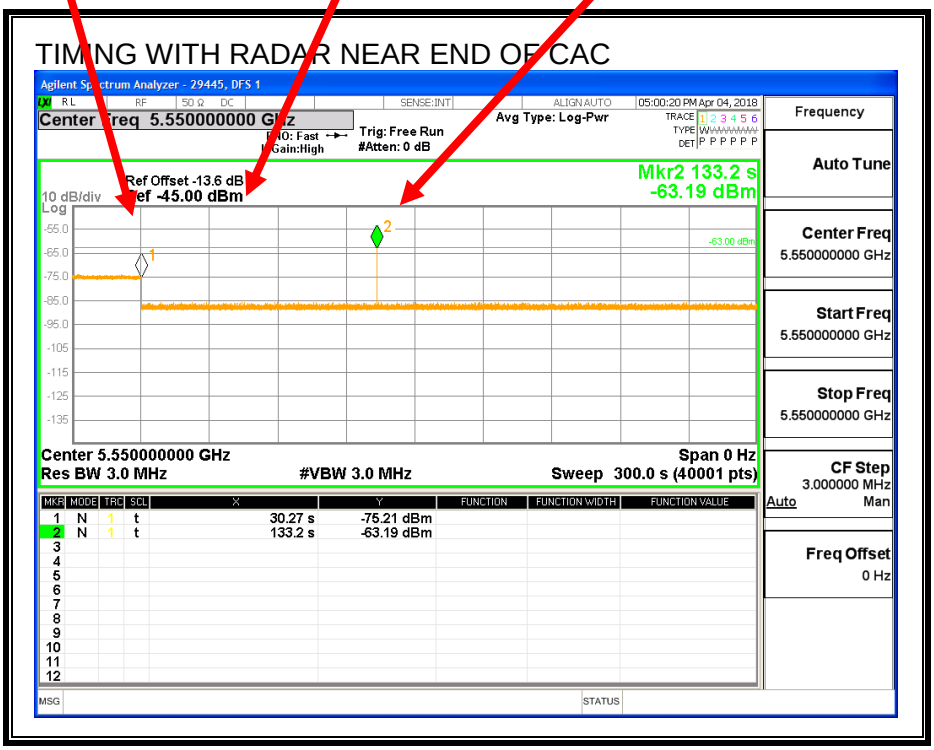
TIMING WITH RADAR NEAR END OF CAC

AP is rebooted
Traffic ceases
Start of Initial Power-up cycle

End of Initial Power-up cycle
Start of CAC

Radar Signal Applied



No EUT transmissions were observed after the radar signal.

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5.3.1. OVERLAPPING CHANNEL TESTS

RESULTS

The channel spacing is not less than the channel bandwidth therefore the EUT does not have an overlapping channel plan.

5.3.2. 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

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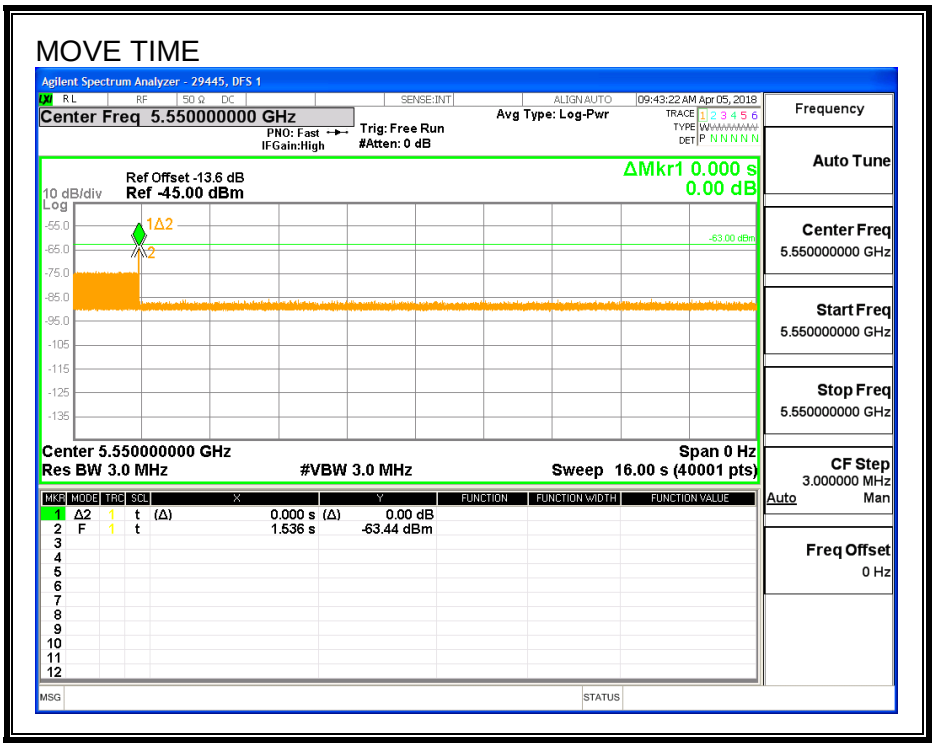
MOVE TIME



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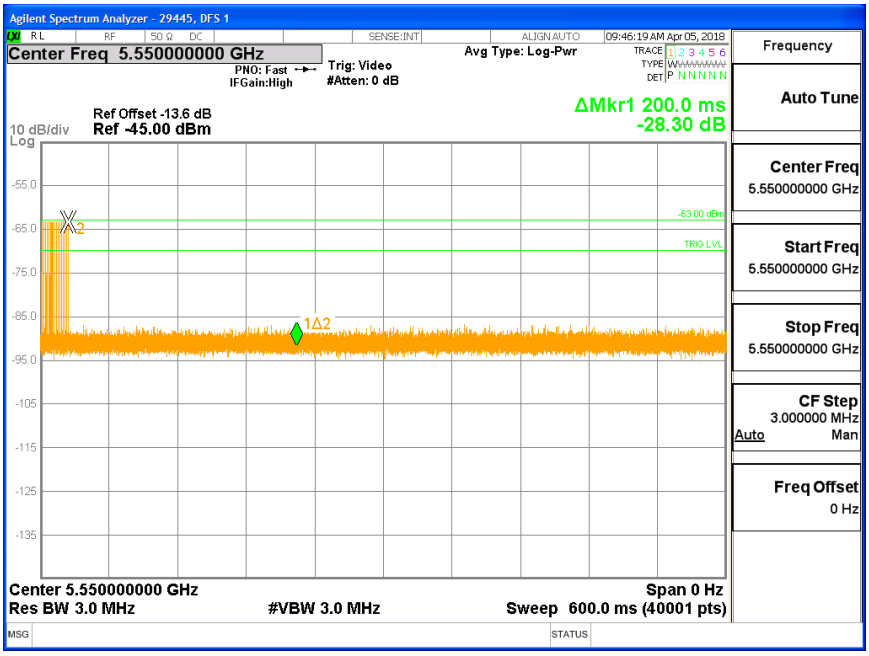
CHANNEL CLOSING TIME

CLOSING TIME



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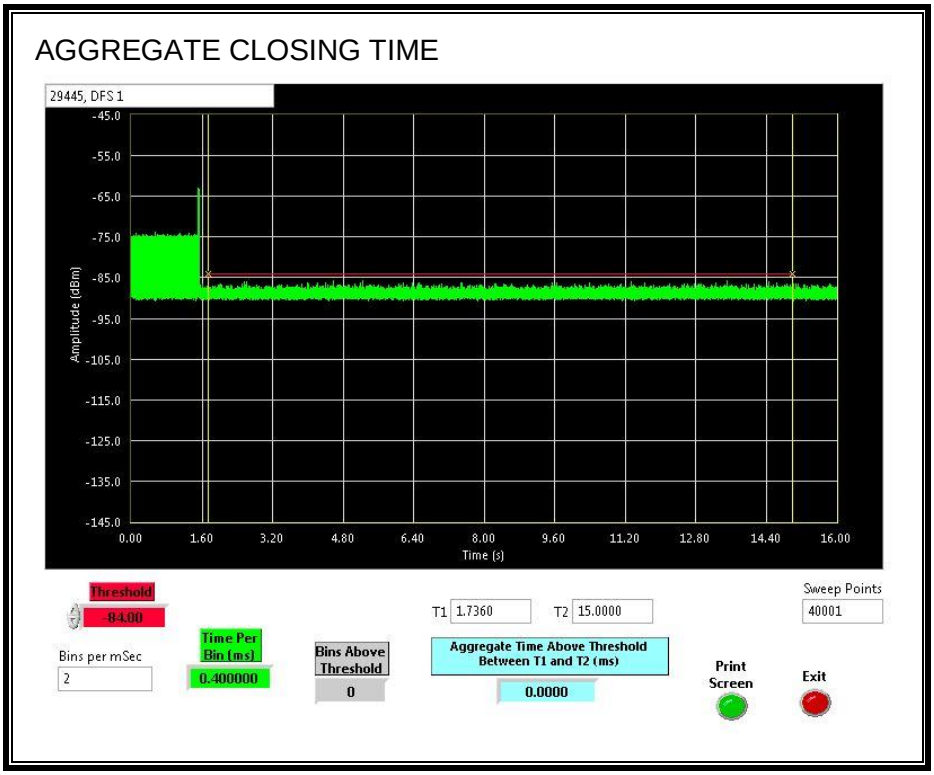
AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

No transmissions are observed during the aggregate monitoring period.



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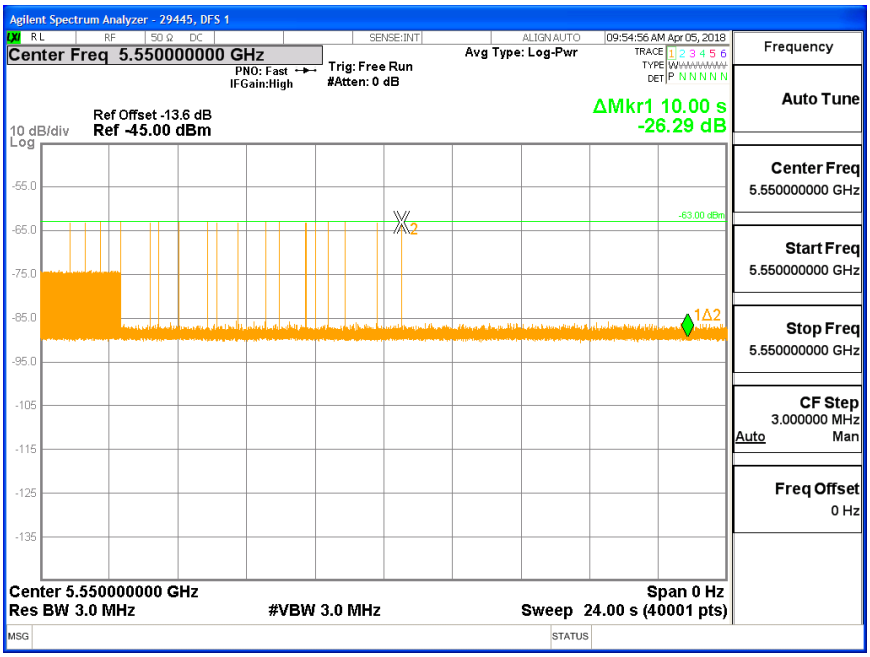
LONG PULSE CHANNEL MOVE TIME

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

MOVE TIME FOR LONG PULSE RADAR



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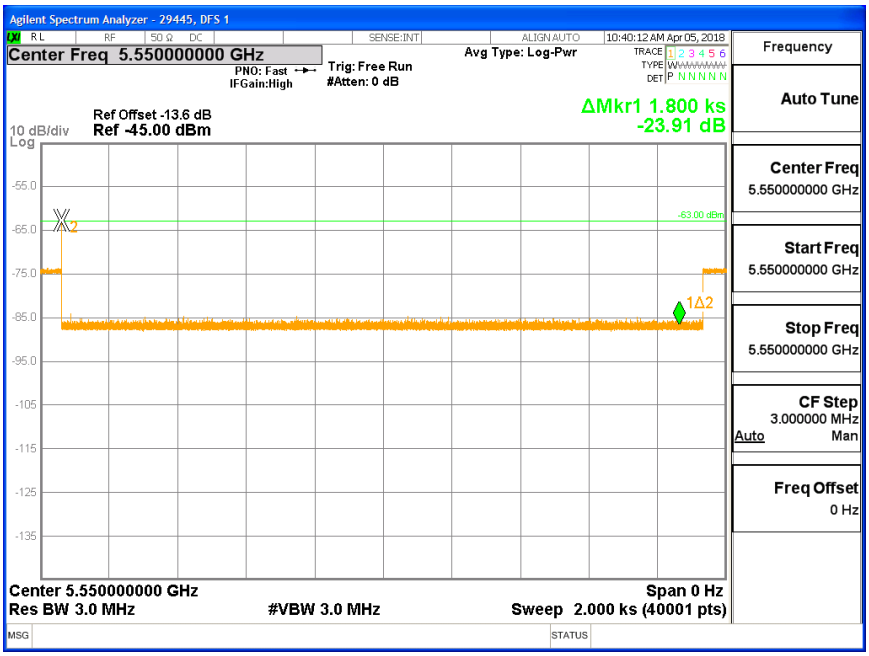
5.3.1. NON-OCCUPANCY PERIOD

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



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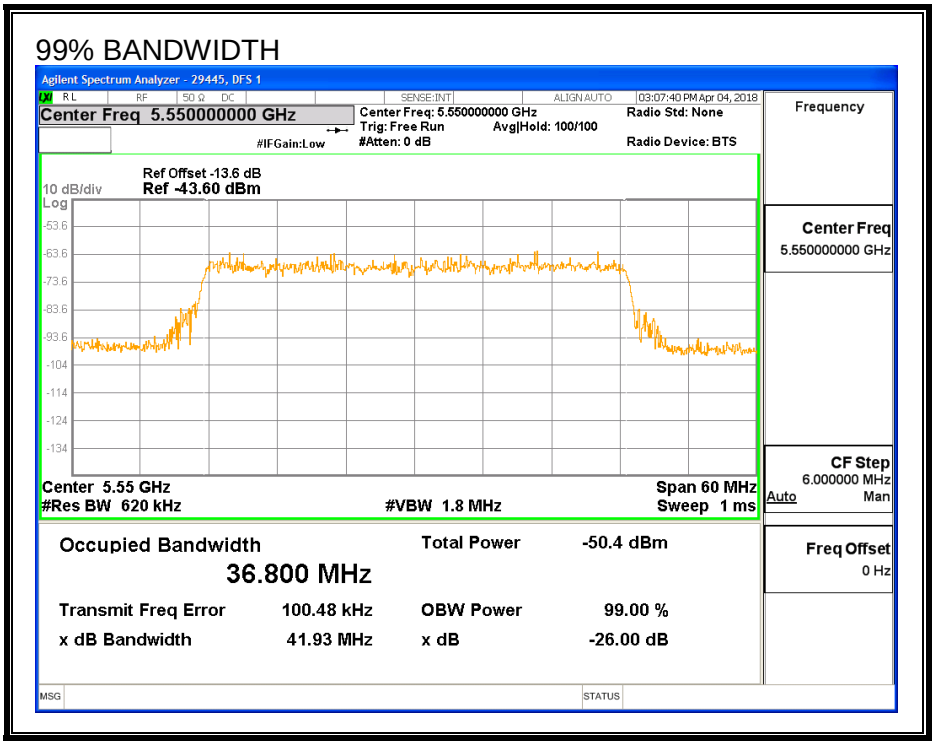
5.3.2. DETECTION BANDWIDTH

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	36.800	108.7	100

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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	9	90	
5565	10	10	100	
5570	10	10	100	FH

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5.3.3. 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	100.00	60	Pass	5530	5570	36.8	DFS 1	29445	Version 3.0
FCC Short Pulse Type 2	30	96.67	60	Pass	5530	5570	36.8	DFS 1	29445	Version 3.0
FCC Short Pulse Type 3	30	100.00	60	Pass	5530	5570	36.8	DFS 1	29445	Version 3.0
FCC Short Pulse Type 4	30	100.00	60	Pass	5530	5570	36.8	DFS 1	29445	Version 3.0
Aggregate		99.17	80	Pass						
FCC Long Pulse Type 5	30	100.00	80	Pass	5530	5570	36.8	DFS 1	29445	Version 3.0
FCC Hopping Type 6	41	100.00	70	Pass	5530	5570		DFS 1	29445	Version 3.0

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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	678	78	A	5567	Yes
1003	1	938	57	A	5533	Yes
1004	1	738	72	A	5568	Yes
1005	1	598	89	A	5551	Yes
1006	1	858	62	A	5568	Yes
1007	1	578	92	A	5543	Yes
1008	1	698	76	A	5546	Yes
1009	1	798	67	A	5533	Yes
1010	1	518	102	A	5566	Yes
1011	1	638	83	A	5534	Yes
1012	1	538	99	A	5546	Yes
1013	1	918	58	A	5567	Yes
1014	1	758	70	A	5567	Yes
1015	1	618	86	A	5544	Yes
1016	1	2642	20	B	5568	Yes
1017	1	727	73	B	5563	Yes
1018	1	2360	23	B	5565	Yes
1019	1	574	92	B	5542	Yes
1020	1	2336	23	B	5553	Yes
1021	1	2033	26	B	5560	Yes
1022	1	2730	20	B	5533	Yes
1023	1	1203	44	B	5564	Yes
1024	1	836	64	B	5531	Yes
1025	1	792	67	B	5530	Yes
1026	1	553	96	B	5569	Yes
1027	1	639	83	B	5548	Yes
1028	1	530	100	B	5541	Yes
1029	1	2098	26	B	5546	Yes
1030	1	2119	25	B	5530	Yes

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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	4.2	218	23	5568	Yes
2002	3.9	152	24	5560	Yes
2003	3.4	220	28	5570	Yes
2004	1.5	159	23	5553	Yes
2005	1.2	150	27	5538	No
2006	1.6	217	25	5554	Yes
2007	1.5	175	27	5568	Yes
2008	2.2	164	29	5559	Yes
2009	4.5	164	27	5559	Yes
2010	1.2	201	27	5537	Yes
2011	1.8	167	29	5537	Yes
2012	2.9	208	25	5540	Yes
2013	3.7	178	24	5568	Yes
2014	3	185	28	5538	Yes
2015	4	202	27	5534	Yes
2016	3.6	171	24	5539	Yes
2017	2.9	154	28	5557	Yes
2018	2.6	207	29	5556	Yes
2019	2.1	195	26	5533	Yes
2020	4.3	214	27	5547	Yes
2021	2.1	168	25	5539	Yes
2022	4.4	191	23	5534	Yes
2023	2.4	230	25	5564	Yes
2024	5	220	23	5550	Yes
2025	3.2	182	25	5541	Yes
2026	4	175	24	5536	Yes
2027	4.6	222	23	5540	Yes
2028	1.6	182	23	5556	Yes
2029	2.4	195	29	5556	Yes
2030	1.7	159	26	5555	Yes

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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	7.7	334	17	5566	Yes
3002	7.3	486	17	5548	Yes
3003	6.6	435	17	5556	Yes
3004	6.3	349	17	5566	Yes
3005	9.9	310	16	5539	Yes
3006	8	253	17	5535	Yes
3007	9.9	478	17	5562	Yes
3008	8.1	300	18	5539	Yes
3009	6.1	420	18	5547	Yes
3010	8.7	388	18	5548	Yes
3011	6.9	270	16	5532	Yes
3012	9.9	250	18	5553	Yes
3013	8.3	396	18	5537	Yes
3014	9.4	272	18	5557	Yes
3015	6.1	313	17	5534	Yes
3016	9.5	452	16	5541	Yes
3017	6.4	255	16	5537	Yes
3018	6	407	16	5567	Yes
3019	9.4	355	16	5562	Yes
3020	7.2	403	16	5563	Yes
3021	6.7	482	18	5537	Yes
3022	6.7	424	16	5564	Yes
3023	8.6	398	16	5531	Yes
3024	6.8	471	17	5546	Yes
3025	8.9	340	17	5536	Yes
3026	7.4	308	17	5532	Yes
3027	7.8	441	18	5563	Yes
3028	8.6	422	17	5562	Yes
3029	7	317	17	5536	Yes
3030	6.2	443	17	5535	Yes

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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	17.4	484	13	5555	Yes
4002	16	373	16	5556	Yes
4003	18.2	426	13	5559	Yes
4004	13	327	16	5568	Yes
4005	15.6	276	13	5549	Yes
4006	20	323	16	5560	Yes
4007	18.8	285	14	5563	Yes
4008	14.6	345	15	5559	Yes
4009	13.9	319	16	5565	Yes
4010	19.1	274	12	5547	Yes
4011	14.6	261	13	5563	Yes
4012	16.1	480	12	5537	Yes
4013	12.1	362	14	5562	Yes
4014	14	342	13	5531	Yes
4015	19.5	371	12	5564	Yes
4016	17.7	364	12	5540	Yes
4017	14.5	405	16	5543	Yes
4018	13.2	293	14	5565	Yes
4019	11.1	347	16	5554	Yes
4020	19.2	381	14	5551	Yes
4021	12.8	448	12	5538	Yes
4022	17.1	495	15	5552	Yes
4023	16	456	13	5530	Yes
4024	11.7	265	16	5563	Yes
4025	11	491	14	5541	Yes
4026	16.3	446	16	5556	Yes
4027	11.8	433	12	5558	Yes
4028	13.2	400	16	5538	Yes
4029	18.3	282	12	5532	Yes
4030	11.1	263	13	5568	Yes

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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	5540	Yes
12	5537	Yes
13	5536	Yes
14	5537	Yes
15	5534	Yes
16	5536	Yes
17	5535	Yes
18	5540	Yes
19	5536	Yes
20	5537	Yes
21	5566	Yes
22	5563	Yes
23	5566	Yes
24	5563	Yes
25	5566	Yes
26	5563	Yes
27	5566	Yes
28	5563	Yes
29	5566	Yes
30	5563	Yes

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

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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	347	5530	6	Yes
2	822	5531	11	Yes
3	1297	5532	11	Yes
4	1772	5533	12	Yes
5	2247	5534	12	Yes
6	2722	5535	8	Yes
7	3197	5536	6	Yes
8	3672	5537	3	Yes
9	4147	5538	11	Yes
10	4622	5539	12	Yes
11	5097	5540	8	Yes
12	5572	5541	8	Yes
13	6047	5542	6	Yes
14	6522	5543	9	Yes
15	6997	5544	8	Yes
16	7472	5545	7	Yes
17	7947	5546	11	Yes
18	8422	5547	8	Yes
19	8897	5548	14	Yes
20	9372	5549	5	Yes
21	9847	5550	6	Yes
22	10322	5551	14	Yes
23	10797	5552	10	Yes
24	11272	5553	6	Yes
25	11747	5554	8	Yes
26	12222	5555	6	Yes
27	12697	5556	12	Yes
28	13172	5557	9	Yes
29	13647	5558	4	Yes
30	14122	5559	7	Yes
31	14597	5560	4	Yes
32	15072	5561	6	Yes
33	15547	5562	7	Yes
34	16022	5563	10	Yes
35	16497	5564	9	Yes
36	16972	5565	4	Yes
37	17447	5566	6	Yes
38	17922	5567	12	Yes
39	18397	5568	9	Yes
40	18872	5569	8	Yes
41	19347	5570	11	Yes

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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.

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6. SETUP PHOTOS

DYNAMIC FREQUENCY SELECTION MEASUREMENT SETUP

DFS PHOTO

END OF REPORT

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