



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

CERTIFICATION TEST REPORT

FOR

SMARTPHONE

MODEL NUMBER: A2296

**FCC ID: BCG-E3501A
IC: 579C-E3501A**

REPORT NUMBER: 13018918-E13V2

ISSUE DATE: MARCH 25, 2020

Prepared for
APPLE, INC.
1 APPLE PARK WAY
CUPERTINO, CA 95014, U.S.A.

Prepared by
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET
FREMONT, CA 94538, U.S.A.
TEL: (510) 319-4000
FAX: (510) 661-0888



NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	03/23/20	Initial Issue	Doug Anderson
V2	03/25/20	Address TCB's Questions	Doug Anderson

TABLE OF CONTENTS

1. ATTESTATION OF TEST RESULTS	6
2. TEST METHODOLOGY	7
3. REFERENCE DOCUMENTS	7
4. FACILITIES AND ACCREDITATION	7
5. CALIBRATION AND UNCERTAINTY	7
5.1. MEASURING INSTRUMENT CALIBRATION	7
5.2. SAMPLE CALCULATION	7
5.3. MEASUREMENT UNCERTAINTY	7
6. DYNAMIC FREQUENCY SELECTION	8
6.1. OVERVIEW	8
6.1.1. LIMITS	8
6.1.2. TEST AND MEASUREMENT SYSTEM	12
6.1.3. TEST AND MEASUREMENT SOFTWARE	14
6.1.4. TEST ROOM ENVIRONMENT	14
6.1.5. SETUP OF EUT (CLIENT MODE)	15
6.1.6. SETUP OF EUT (CLIENT-TO-CLIENT COMMUNICATIONS MODE)	16
6.1.7. SETUP OF EUT (PEER TO PEER MODE)	17
6.1.8. DESCRIPTION OF EUT	19
6.2. CLIENT MODE RESULTS FOR 20 MHz BANDWIDTH	22
6.2.1. TEST CHANNEL	22
6.2.2. RADAR WAVEFORM AND TRAFFIC	22
6.2.3. OVERLAPPING CHANNEL TESTS	25
6.2.4. MOVE AND CLOSING TIME	25
6.3. CLIENT MODE RESULTS FOR 40 MHz BANDWIDTH	29
6.3.1. TEST CHANNEL	29
6.3.2. RADAR WAVEFORM AND TRAFFIC	29
6.3.3. OVERLAPPING CHANNEL TESTS	32
6.3.4. MOVE AND CLOSING TIME	32
6.4. CLIENT MODE RESULTS FOR 80 MHz BANDWIDTH	36
6.4.1. TEST CHANNEL	36
6.4.2. RADAR WAVEFORM AND TRAFFIC	36
6.4.3. OVERLAPPING CHANNEL TESTS	39
6.4.4. MOVE AND CLOSING TIME	39
6.4.5. 30-MINUTE NON-OCCUPANCY PERIOD	43
6.5. CLIENT-TO-CLIENT COMMUNICATIONS MODE RESULTS FOR 20 MHz BANDWIDTH	44
6.5.1. TEST CHANNEL	44
6.5.2. RADAR WAVEFORM AND TRAFFIC	44
6.5.3. OVERLAPPING CHANNEL TESTS	47
6.5.4. MOVE AND CLOSING TIME	47

6.6.	CLIENT-TO-CLIENT COMMUNICATIONS MODE RESULTS FOR 40 MHz	
	BANDWIDTH.....	51
6.6.1.	TEST CHANNEL	51
6.6.2.	RADAR WAVEFORM AND TRAFFIC	51
6.6.3.	OVERLAPPING CHANNEL TESTS	54
6.6.4.	MOVE AND CLOSING TIME	54
6.7.	CLIENT-TO-CLIENT COMMUNICATIONS MODE RESULTS FOR 80 MHz	
	BANDWIDTH.....	58
6.7.1.	TEST CHANNEL	58
6.7.2.	RADAR WAVEFORM AND TRAFFIC	58
6.7.3.	OVERLAPPING CHANNEL TESTS	61
6.7.4.	MOVE AND CLOSING TIME	61
6.7.5.	30-MINUTE NON-OCCUPANCY PERIOD	65
6.8.	PEER TO PEER MODE EUT RESULTS FOR 20 MHz BANDWIDTH.....	66
6.8.1.	TEST CHANNEL	66
6.8.2.	RADAR WAVEFORM AND TRAFFIC	66
6.8.3.	OVERLAPPING CHANNEL TESTS	69
6.8.4.	MOVE AND CLOSING TIME	69
6.9.	PEER TO PEER MODE EUT RESULTS FOR 40 MHz BANDWIDTH.....	73
6.9.1.	TEST CHANNEL	73
6.9.2.	RADAR WAVEFORM AND TRAFFIC	73
6.9.3.	OVERLAPPING CHANNEL TESTS	76
6.9.4.	MOVE AND CLOSING TIME	76
6.10.	PEER TO PEER MODE EUT RESULTS FOR 80 MHz BANDWIDTH	80
6.10.1.	TEST CHANNEL	80
6.10.2.	RADAR WAVEFORM AND TRAFFIC	80
6.10.3.	OVERLAPPING CHANNEL TESTS	83
6.10.4.	MOVE AND CLOSING TIME.....	83
6.10.5.	30-MINUTE NON-OCCUPANCY PERIOD	87
6.11.	PEER TO PEER MODE PEER SLAVE DEVICE RESULTS FOR 20 MHz	
	BANDWIDTH.....	88
6.11.1.	TEST CHANNEL	88
6.11.2.	RADAR WAVEFORM AND TRAFFIC	88
6.11.3.	OVERLAPPING CHANNEL TESTS	91
6.11.4.	MOVE AND CLOSING TIME.....	91
6.12.	PEER TO PEER MODE PEER SLAVE DEVICE RESULTS FOR 40 MHz	
	BANDWIDTH.....	95
6.12.1.	TEST CHANNEL	95
6.12.2.	RADAR WAVEFORM AND TRAFFIC	95
6.12.3.	OVERLAPPING CHANNEL TESTS	98
6.12.4.	MOVE AND CLOSING TIME.....	98
6.13.	PEER TO PEER MODE PEER SLAVE DEVICE RESULTS FOR 80 MHz	
	BANDWIDTH.....	102
6.13.1.	TEST CHANNEL	102
6.13.2.	RADAR WAVEFORM AND TRAFFIC	102
6.13.3.	OVERLAPPING CHANNEL TESTS	105
6.13.4.	MOVE AND CLOSING TIME.....	105
6.13.5.	30-MINUTE NON-OCCUPANCY PERIOD	109

7. SETUP PHOTOS.....110

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: APPLE, INC.
1 APPLE PARK WAY
CUPERTINO, CA 95014, U.S.A.

EUT DESCRIPTION: SMARTPHONE

MODEL: A2296

SERIAL NUMBER: FFMZ003P3C0 and FFMZF064P397

DATE TESTED: OCTOBER 23 to 25, 2019

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

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

This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of the U.S. government.

Approved & Released For
UL Verification Services Inc. By:



Edgard Rincand
Operations Leader
CONSUMER TECHNOLOGY DIVISION
UL Verification Services Inc.

Prepared By:



DOUG ANDERSON
Test Engineer
CONSUMER TECHNOLOGY DIVISION
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 KDB 789033, KDB 905462 D02 and D03 and RSS-247 Issue 2.

3. REFERENCE DOCUMENTS

Measurements of transmitter parameters as referenced in this report are documented in UL Verification Services report number 13018918-E4V2 and 13018918-E5V2.

4. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, and 47658 Kato Road, Fremont, California, USA. Specific facilities are also identified in the test results sections.

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers above are covered under Industry Canada company address and respective code: 2324A.

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

5. CALIBRATION AND UNCERTAINTY

5.1. MEASURING INSTRUMENT CALIBRATION

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

5.2. SAMPLE CALCULATION

Where relevant, the following sample calculation is provided:

$$\begin{aligned} \text{Field Strength (dBuV/m)} &= \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \\ &\text{Cable Loss (dB)} - \text{Preamp Gain (dB)} \\ 36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} &= 28.9 \text{ dBuV/m} \end{aligned}$$

5.3. 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%.

6. DYNAMIC FREQUENCY SELECTION

6.1. OVERVIEW

6.1.1. 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)
<i>U-NII Detection Bandwidth and Statistical Performance Check</i>	All BW modes must be tested	Not required
<i>Channel Move Time and Channel Closing Transmission Time</i>	Test using widest BW mode available	Test using the widest BW mode available for the link
<i>All other tests</i>	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. $\geq$ 200 milliwatt	-64 dBm
E.I.R.P. $<$ 200 milliwatt and power spectral density $<$ 10 dBm/MHz	-62 dBm
E.I.R.P. $<$ 200 milliwatt 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
<i>Non-occupancy period</i>	30 minutes
<i>Channel Availability Check Time</i>	60 seconds
<i>Channel Move Time</i>	10 seconds (See Note 1)
<i>Channel Closing Transmission Time</i>	200 milliseconds + approx. 60 milliseconds over remaining 10 second period. (See Notes 1 and 2)
<i>U-NII Detection Bandwidth</i>	Minimum 100% of the U- NII 99% transmission power bandwidth. (See Note 3)
Note 1: <i>Channel Move Time</i> and the <i>Channel Closing Transmission Time</i> should be performed with Radar Type 0. The measurement timing begins at the end of the Radar Type 0 burst. Note 2: The <i>Channel Closing Transmission Time</i> is comprised of 200 milliseconds starting at the beginning of the <i>Channel Move Time</i> plus any additional intermittent control signals required to facilitate a <i>Channel</i> 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 <i>U-NII Detection Bandwidth</i> 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: $\{(1/360) \times (19 \times 10^6 \text{ PRI}_{\text{usec}})\}$	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 <i>Detection Bandwidth</i> test, <i>Channel Move Time</i> , and <i>Channel Closing Time</i> tests.					

Table 6 – Long Pulse Radar Test Signal

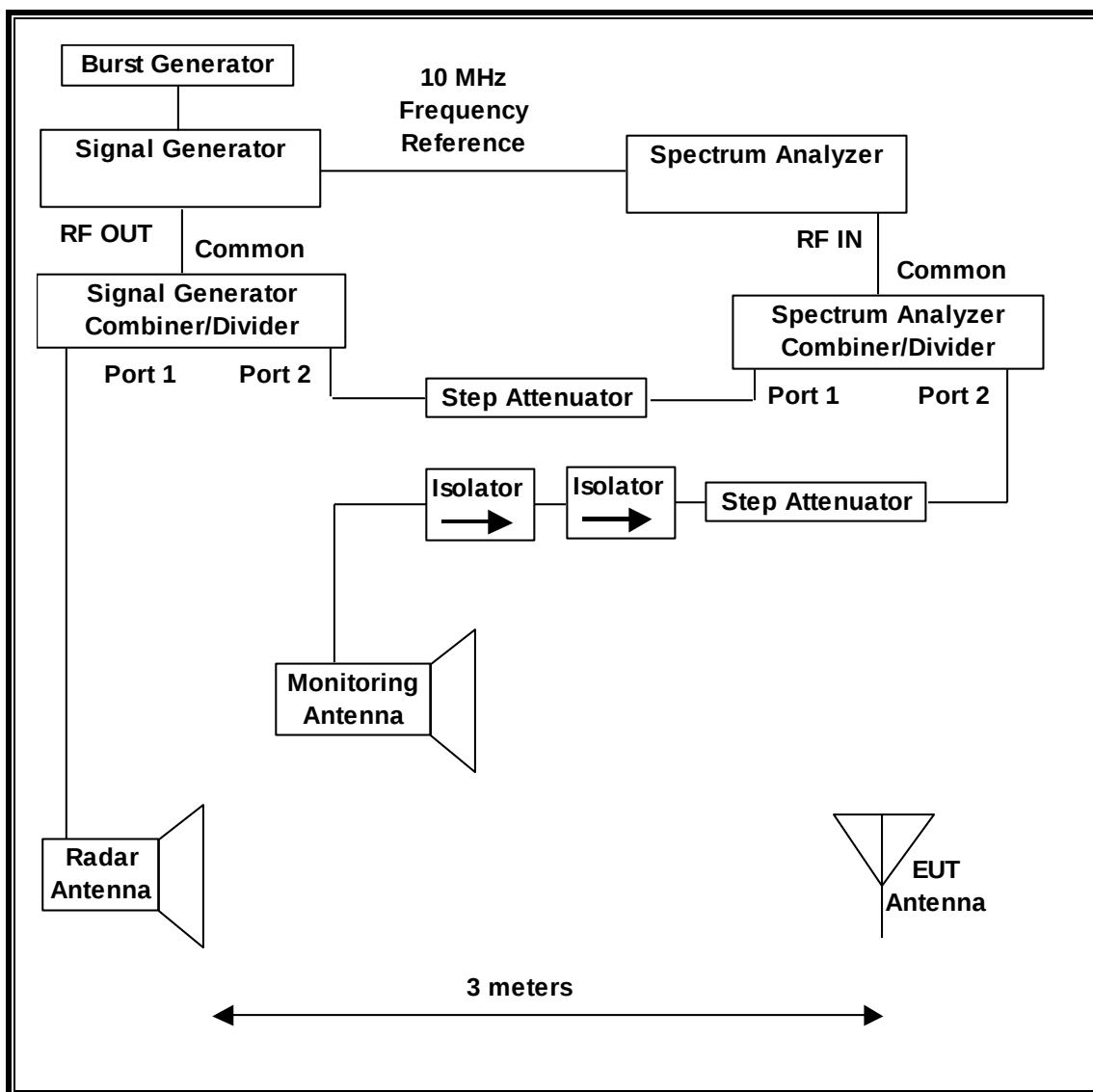
Radar Waveform Type	Pulse Width (μsec)	Chirp Width (MHz)	PRI (μsec)	Pulses per Burst	Number of Bursts	Minimum Percentage of Successful Detection	Minimum Trials
5	50-100	5-20	1000-2000	1-3	8-20	80%	30

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

6.1.2. 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 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. The video test file is streamed to generate WLAN traffic. 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 tests documented in this report:

TEST EQUIPMENT LIST				
Description	Manufacturer	Model	ID No.	Cal Due
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight	N9030A	T459	01/24/20
Signal Generator, MXG X-Series RF Vector	Agilent	N5182B	T1633	02/08/20

6.1.3. 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
PXA Read	3.1	Signal Generator Screen Capture
SGXProject.exe	1.7	Radar Waveform Generation and Download

6.1.4. TEST ROOM ENVIRONMENT

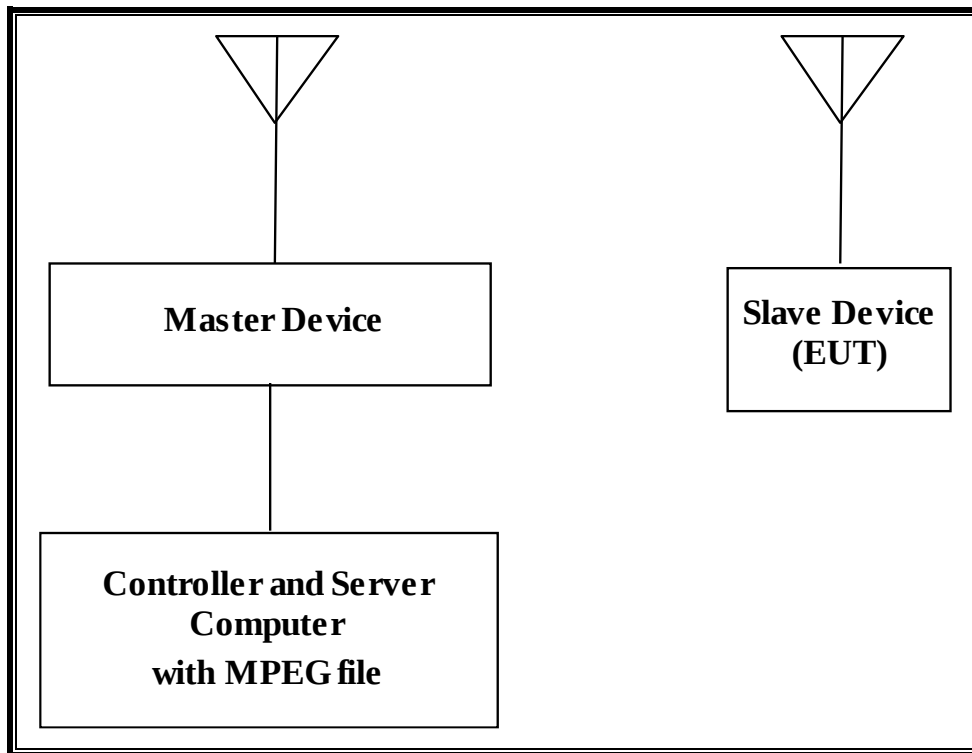
The test room temperature and humidity shall be maintained within normal temperature of 15~35 °C and normal humidity 20~75% (relative humidity).

ENVIRONMENT CONDITION

Parameter	Value
Temperature	24.3, 24.2 and 23.5 °C
Humidity	43, 32 and 27 %

6.1.5. SETUP OF EUT (CLIENT MODE)

RADIATED METHOD EUT TEST SETUP



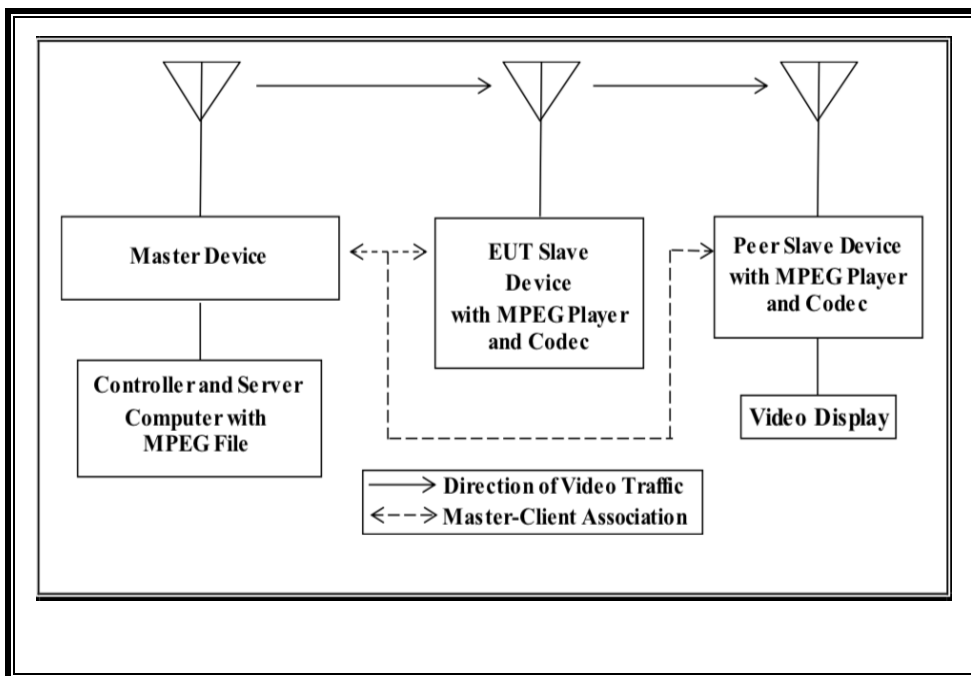
SUPPORT EQUIPMENT

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

PERIPHERAL SUPPORT EQUIPMENT LIST				
Description	Manufacturer	Model	Serial Number	FCC ID
802.11a/b/g/n/ac Wireless Router (Master Device)	Apple	A1521	C86L3BA8FJ1R	BCGA1521
Notebook PC (Controller/Server)	Apple	A1466	C02P52H6G085	DoC
AC Adapter (Notebook PC)	Apple	A1435	C0455332SNAG6HKAW	DoC

6.1.6. SETUP OF EUT (CLIENT-TO-CLIENT COMMUNICATIONS MODE)

RADIATED METHOD EUT TEST SETUP



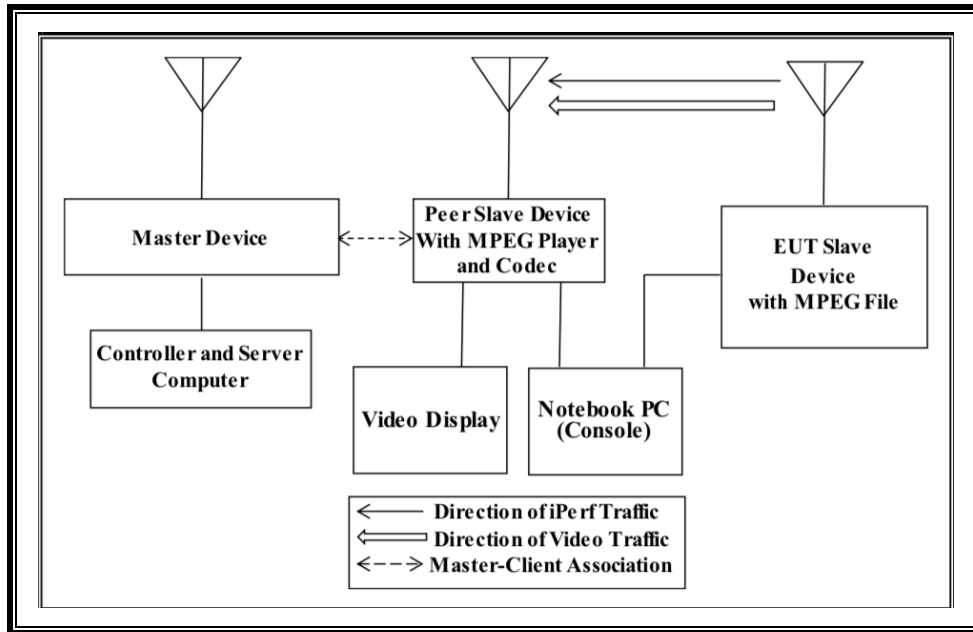
SUPPORT EQUIPMENT

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

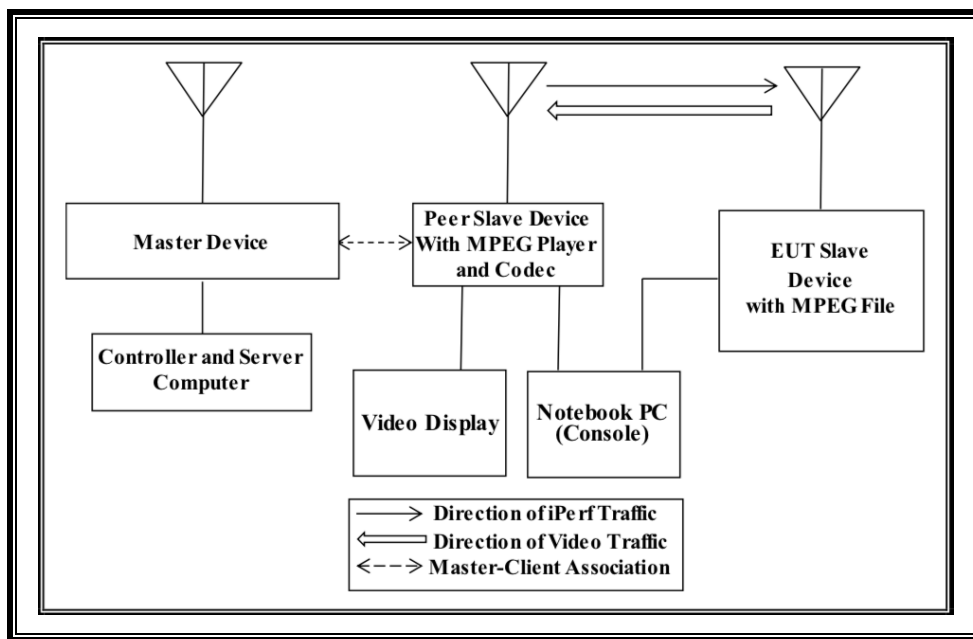
PERIPHERAL SUPPORT EQUIPMENT LIST				
Description	Manufacturer	Model	Serial Number	FCC ID
802.11a/b/g/n/ac Wireless Router (Master Device)	Apple	A1521	C86L3BA8FJ1R	BCGA1521
Notebook PC (Controller/Server)	Apple	A1466	C02P52H6G085	DoC
AC Adapter (Notebook PC)	Apple	A1435	C0455332SNAG6HKAW	DoC
Apple TV (Peer Slave Device)	Apple	A1842	C0HW3DN4J1WF	BCGA1842
15" LCD TV (Video Display)	Polaroid	TLX-01511C	02006	DoC

6.1.7. SETUP OF EUT (PEER TO PEER MODE)

RADIATED METHOD EUT TEST SETUP WHEN MONITORING THE EUT



RADIATED METHOD EUT TEST SETUP WHEN MONITORING THE PEER SLAVE DEVICE



SUPPORT EQUIPMENT

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

PERIPHERAL SUPPORT EQUIPMENT LIST				
Description	Manufacturer	Model	Serial Number	FCC ID
802.11a/b/g/n/ac Wireless Router (Master Device)	Apple	A1521	C86L3BA8FJ1R	BCGA1521
Notebook PC (Controller/Server)	Apple	A1466	C02P52H6G085	DoC
AC Adapter (Notebook PC)	Apple	A1435	C0455332SNAG6HKAW	DoC
Apple TV (Peer Slave Device)	Apple	A1842	C0HW3DN4J1WF	BCGA1842
Notebook PC (Peer Console)	Apple	A1466	C02P41RZG086	DoC
AC Adapter (Console PC)	Apple	A1424	C06503504AXG6P4A3	DoC
15" LCD TV (Video Display)	Polaroid	TLX-01511C	02006	DoC

6.1.8. DESCRIPTION OF EUT

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

The EUT is a Slave Device without Radar Detection.

Slave EUT EIRP, maximum conducted output power, antenna assembly gain and TPC information can be found in the RF report referenced in section 3 of this report.

For FCC the highest power level within these bands is 19.67 dBm EIRP in the 5250-5350 MHz band and 20.76 dBm EIRP in the 5470-5725 MHz band.

For IC the highest power level within these bands is 19.46 dBm EIRP in the 5250-5350 MHz band and 20.76 dBm EIRP in the 5470-5725 MHz band.

The only antenna assembly utilized with the EUT is constructed using two antennas with respective gains of -1.2 dBi and -3.5 dBi in the 5250-5350 MHz band and -0.1 dBi and -2.6 dBi in the 5470-5725 MHz band.

Two antennas are utilized to meet the diversity and MIMO operational requirements.

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 -64 dBm. The tested level is lower than the required level hence it provides a margin to the limit.

The EUT uses two transmitter/receiver chains, each connected to an antenna to perform radiated tests.

In **Standard Client Mode** WLAN traffic that meets or exceeds the minimum required loading was generated by streaming the compressed version of the video test file "6 ½ Magic Hours" from the Master to the Slave using OPlayer Lite media player.

In **Client to Client mode** WLAN traffic is generated by streaming the compressed version of the video test file "6 ½ Magic Hours" from the Master to the Slave and then on to the peer slave device in full motion video mode using OPlayer Lite media player and embedded proprietary AirPlay software.

In **Peer to Peer mode while monitoring the EUT**, WLAN traffic is generated with the combination of streaming the compressed version of the video test file "6 ½ Magic Hours" from the EUT to the Peer Slave Device in full motion video mode using OPlayer HD media player and embedded proprietary AirPlay software and Iperf from the EUT to the Peer Slave Device.

In **Peer to Peer mode while monitoring the Peer Slave Device**, WLAN traffic is generated with the combination of streaming the compressed version of the video test file “6 ½ Magic Hours” from the EUT to the Peer Slave Device in full motion video mode using OPlayer HD media player and embedded proprietary AirPlay software and Iperf from the Peer Slave Device to the EUT.

While performing **Peer to Peer Mode** testing only the Peer Slave Device is associated to the Master Device.

Peer to Peer Mode has been reviewed and approved as compliant with the DFS requirements for client devices by the FCC via KDB inquiry. The inquiry confirmed that the test cases used adequately demonstrate compliance with DFS requirements for client devices.

TPC is not required since the maximum EIRP is less than 500 mW (27 dBm).

The EUT utilizes the 802.11ax architecture. Three nominal channel bandwidths are implemented: 20 MHz, 40 MHz and 80 MHz.

The software installed in the EUT is version 13.2.2 (17E160).

The software installed in the access point is revision 7.7.9.

UNIFORM CHANNEL SPREADING

This function is not required per KDB 905462.

OVERVIEW OF MASTER DEVICE WITH RESPECT TO §15.407 (h) REQUIREMENTS

The Master Device is an Apple, Inc. Access Point, FCC ID: BCGA1521. The minimum antenna gain for the Master Device is 1.4 dBi.

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

The calibrated radiated DFS Detection Threshold level is set to -64 dBm . The tested level is lower than the required level hence it provides a margin to the limit.

The software installed in the access point is revision 7.7.9.

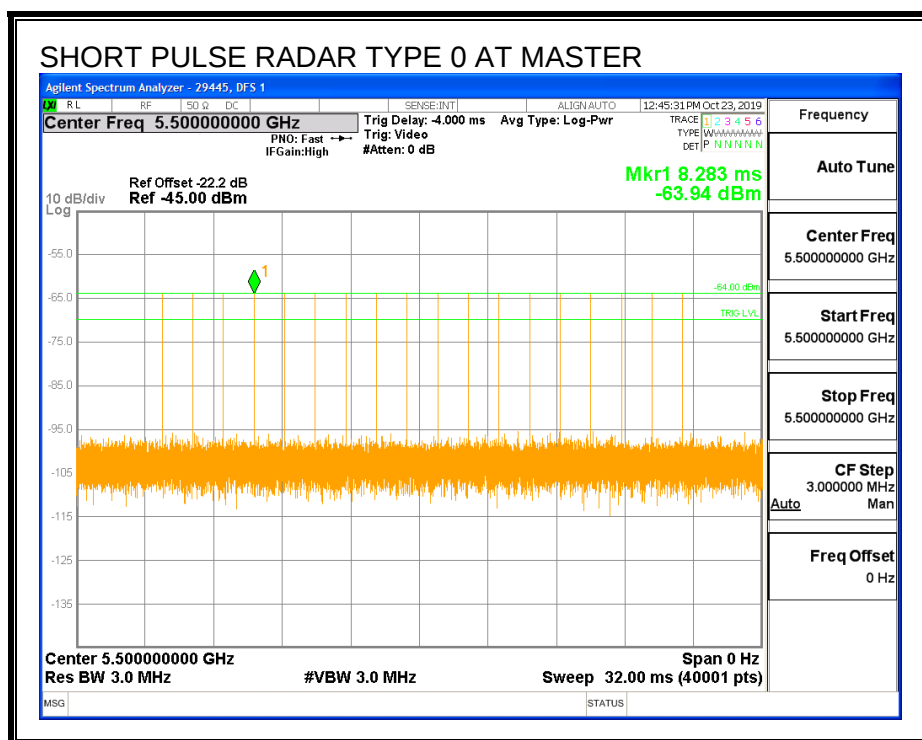
6.2. CLIENT MODE RESULTS FOR 20 MHz BANDWIDTH

6.2.1. TEST CHANNEL

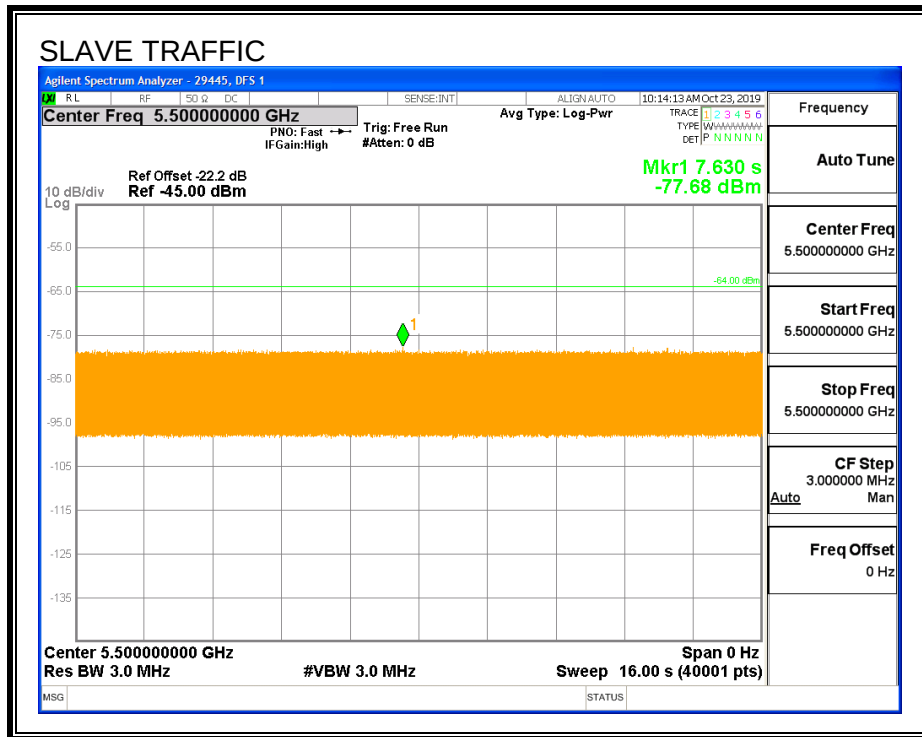
All tests were performed at a channel center frequency of 5500 MHz.

6.2.2. RADAR WAVEFORM AND TRAFFIC

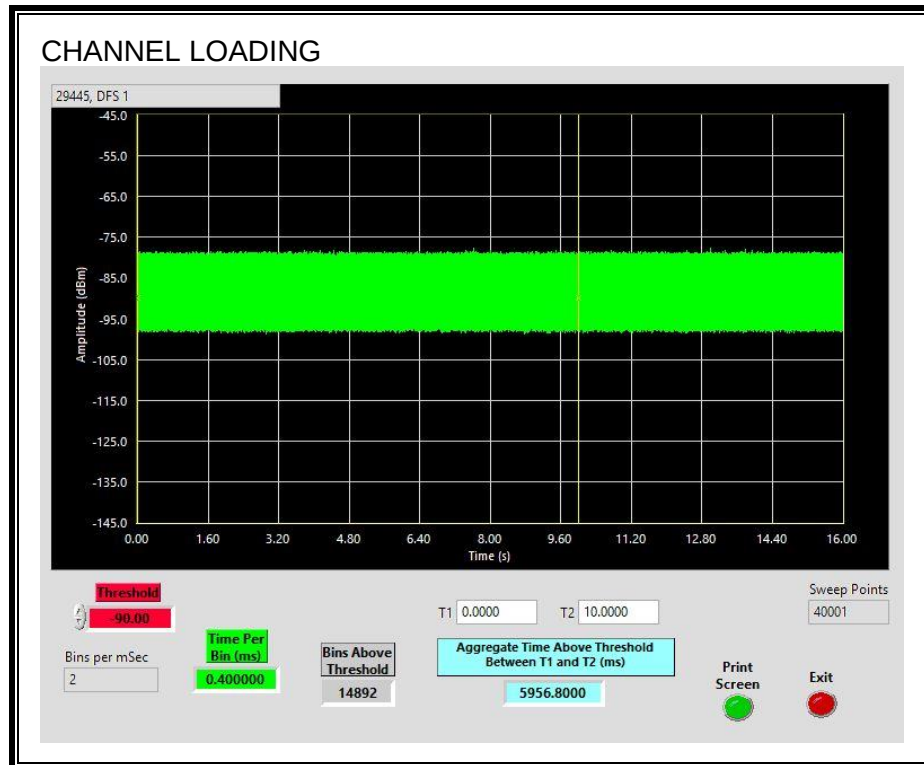
RADAR WAVEFORM



TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 59.56%

6.2.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.2.4. 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)

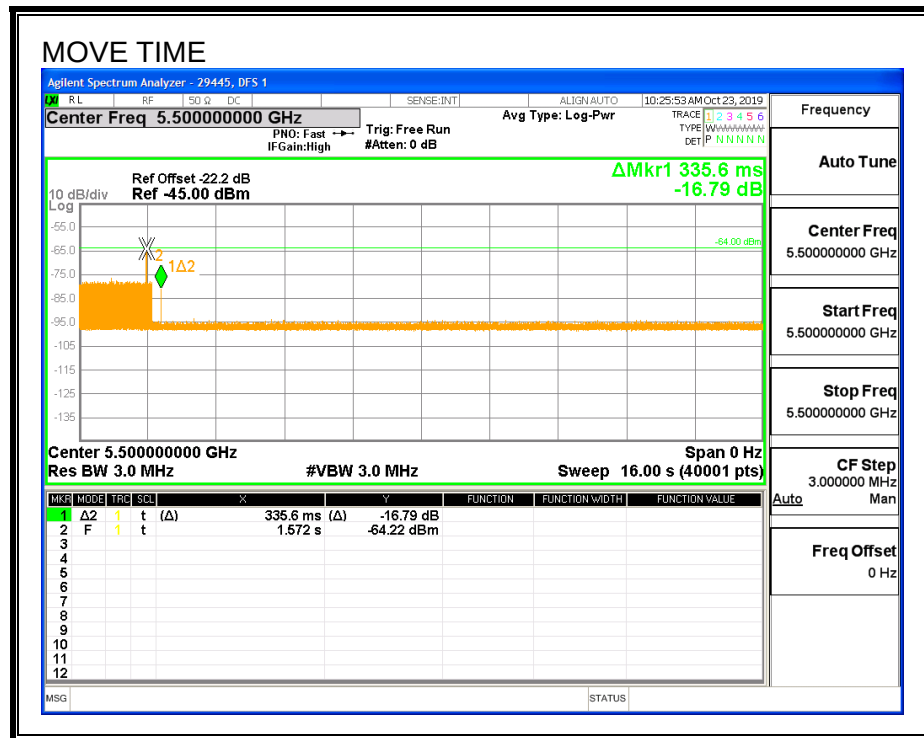
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

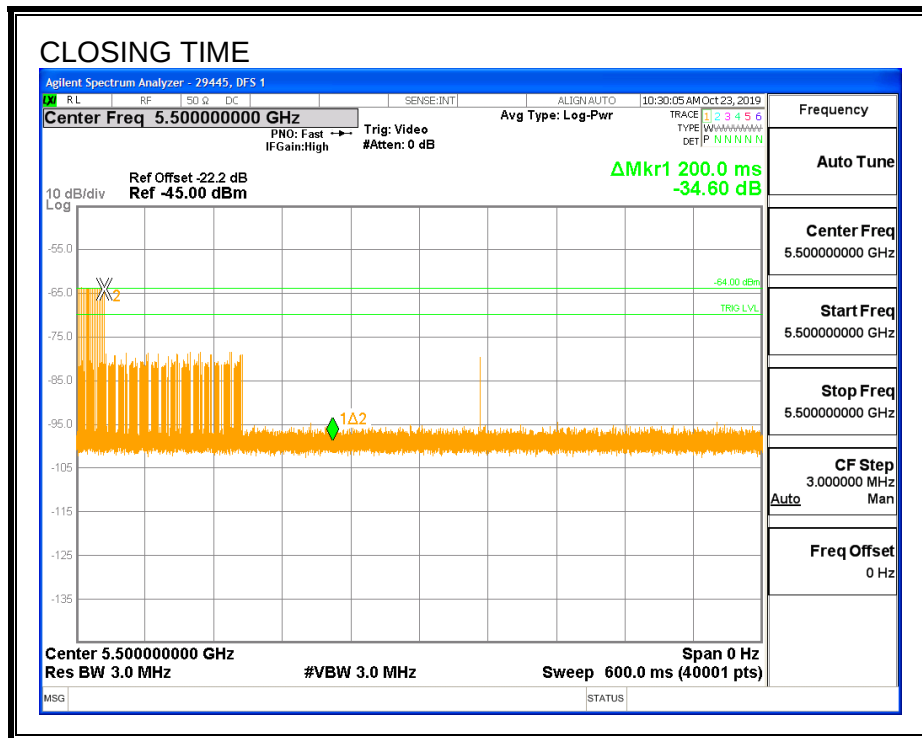
Channel Move Time (sec)	Limit (sec)
0.3356	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
0.40	60

MOVE TIME

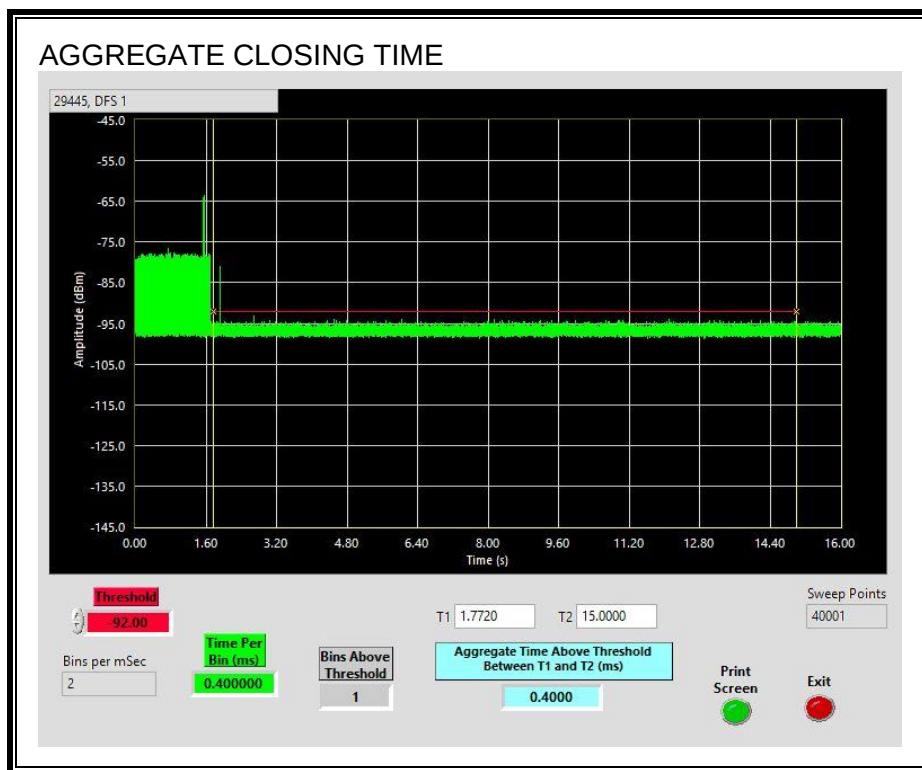


CHANNEL CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

Only intermittent transmissions are observed during the aggregate monitoring period.



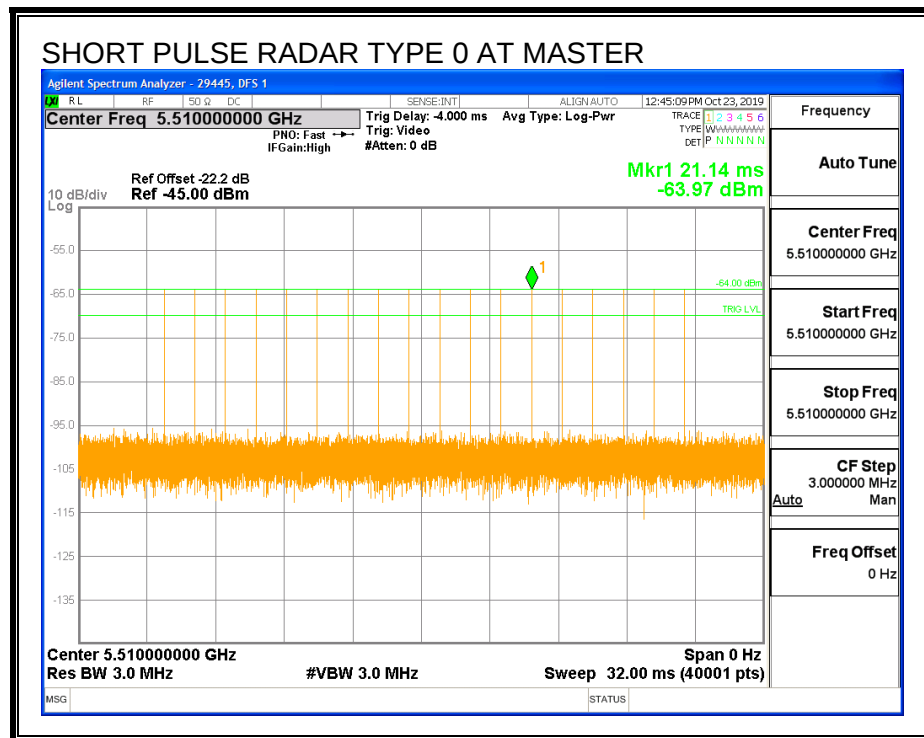
6.3. CLIENT MODE RESULTS FOR 40 MHz BANDWIDTH

6.3.1. TEST CHANNEL

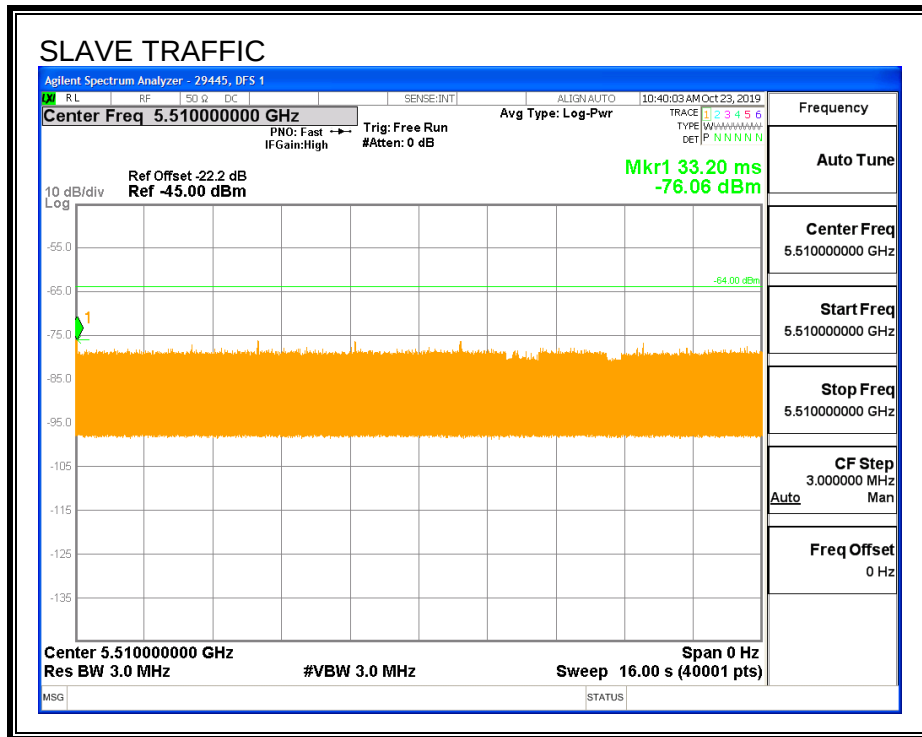
All tests were performed at a channel center frequency of 5510 MHz.

6.3.2. RADAR WAVEFORM AND TRAFFIC

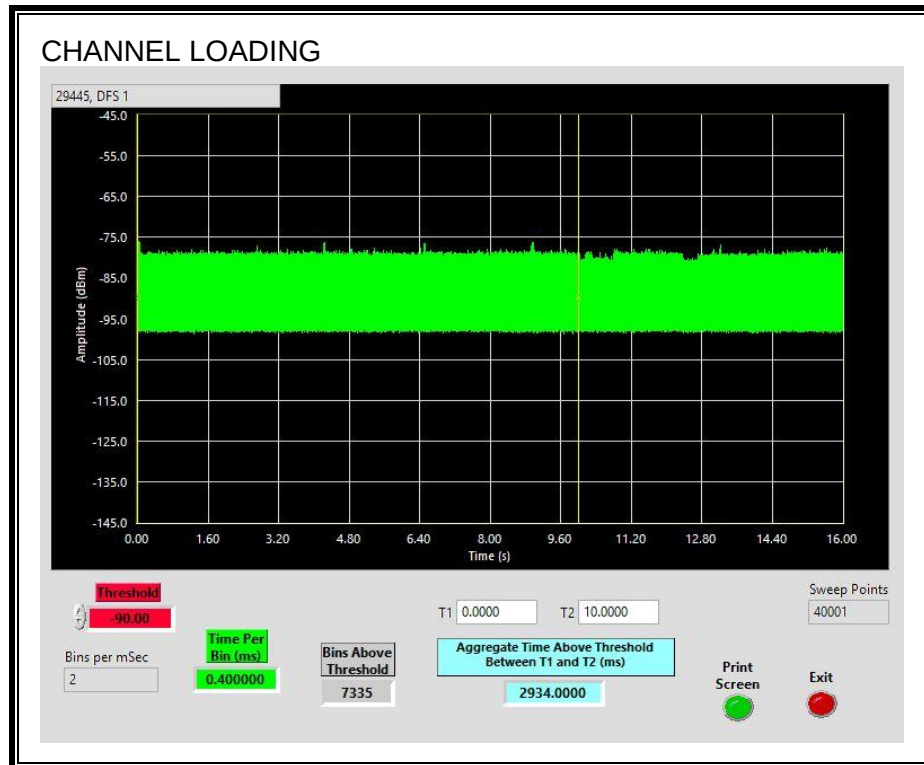
RADAR WAVEFORM



TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 29.34%

6.3.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.3.4. 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)

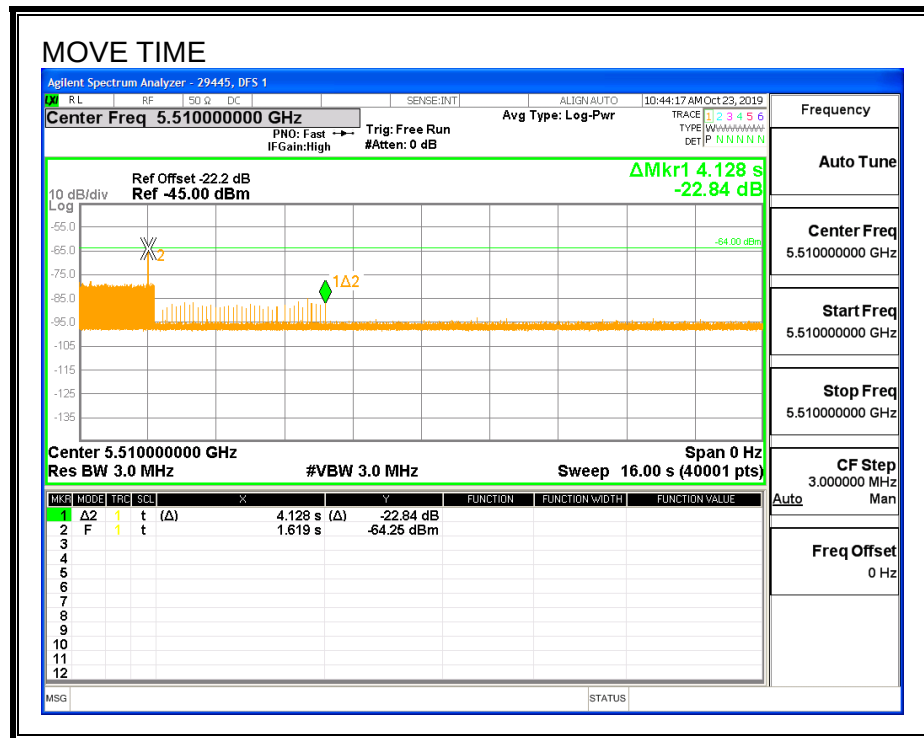
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

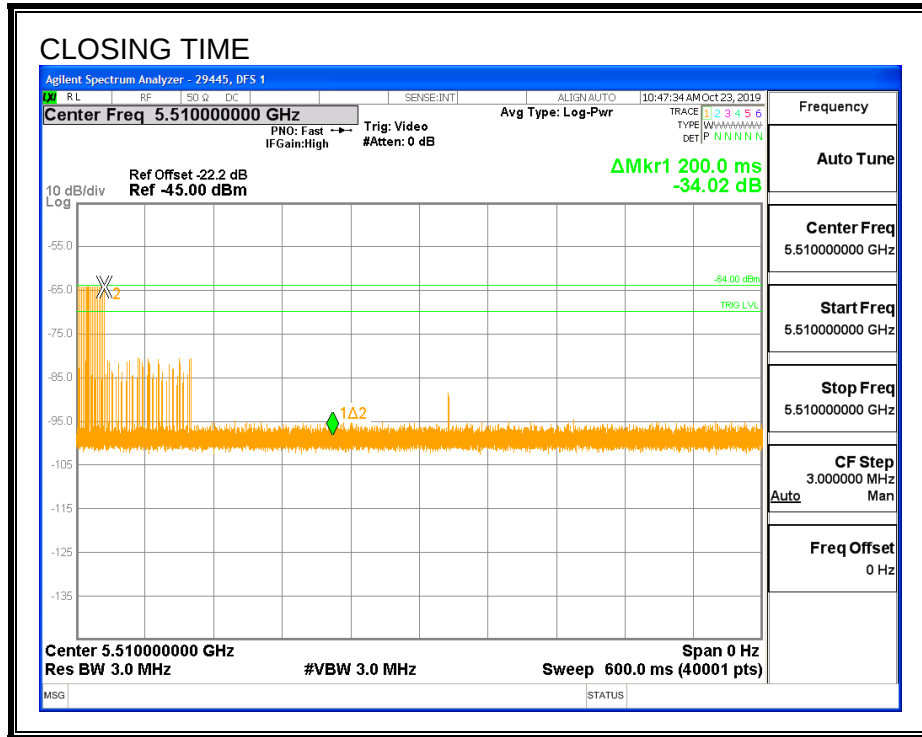
Channel Move Time (sec)	Limit (sec)
4.128	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
14.8	60

MOVE TIME



CHANNEL CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

Only intermittent transmissions are observed during the aggregate monitoring period.



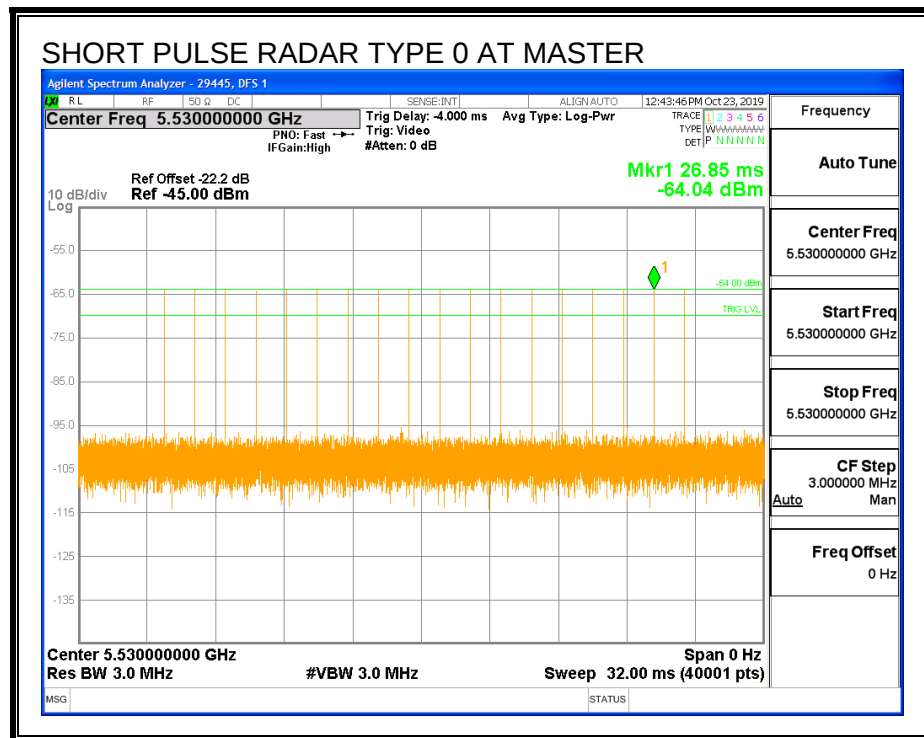
6.4. CLIENT MODE RESULTS FOR 80 MHz BANDWIDTH

6.4.1. TEST CHANNEL

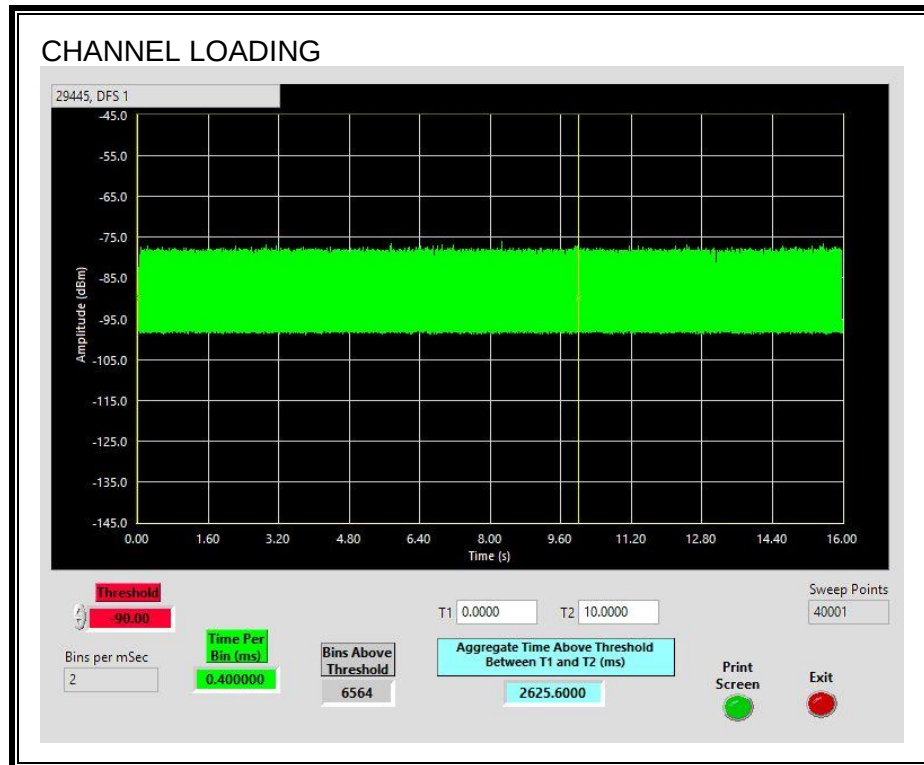
All tests were performed at a channel center frequency of 5530 MHz.

6.4.2. RADAR WAVEFORM AND TRAFFIC

RADAR WAVEFORM



CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 26.25%

6.4.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.4.4. 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)

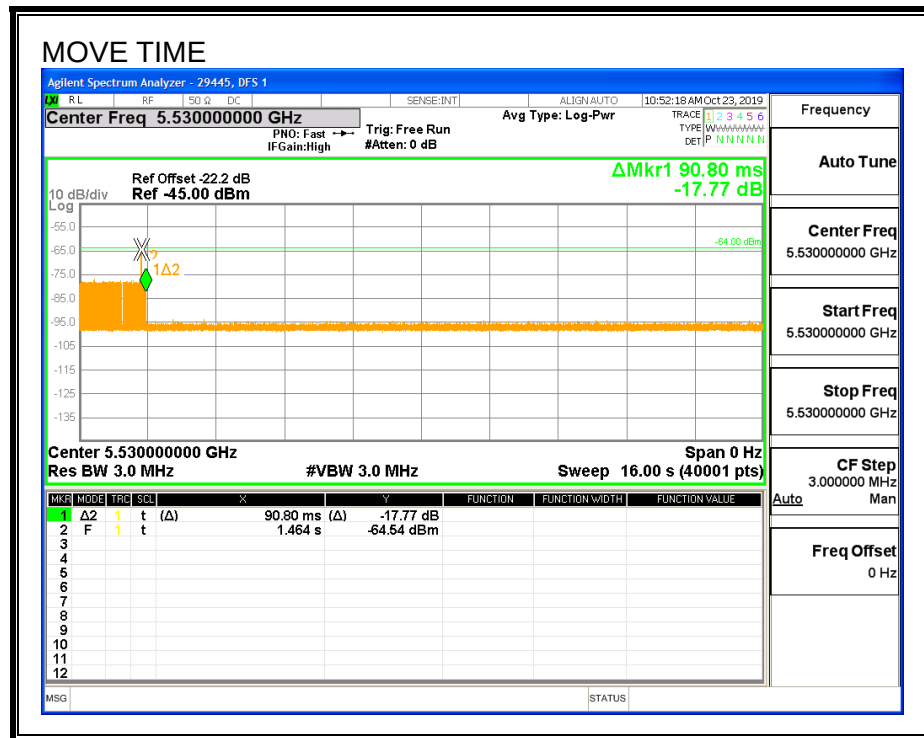
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

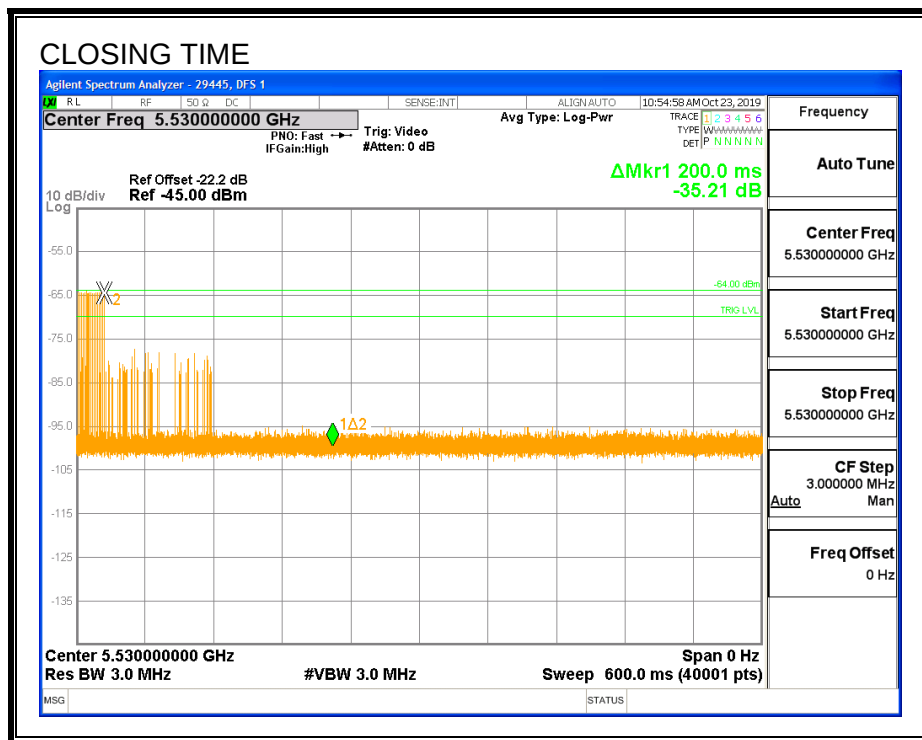
Channel Move Time (sec)	Limit (sec)
0.0908	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
0	60

MOVE TIME

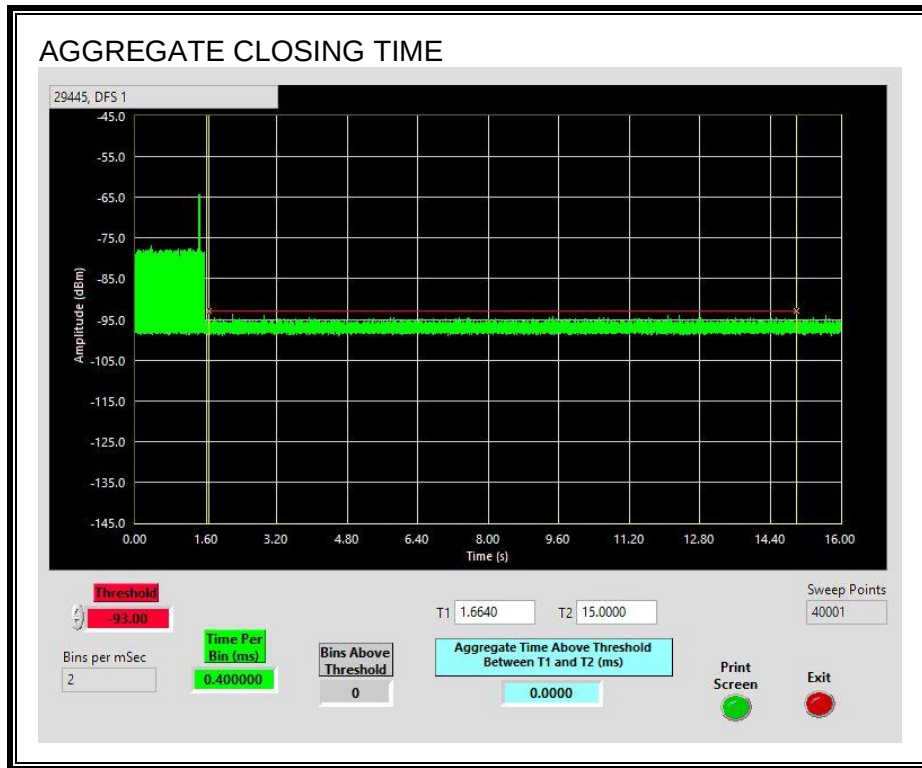


CHANNEL CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

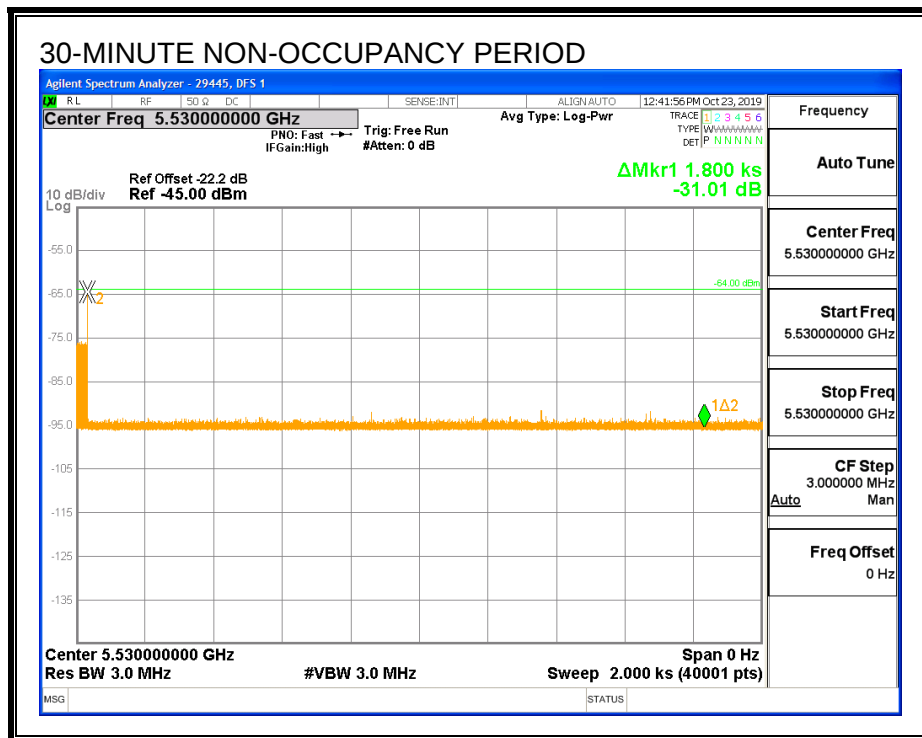
No transmissions are observed during the aggregate monitoring period.



6.4.5. 30-MINUTE NON-OCCUPANCY PERIOD

RESULTS

No EUT transmissions were observed on the test channel during the 30-minute observation time.



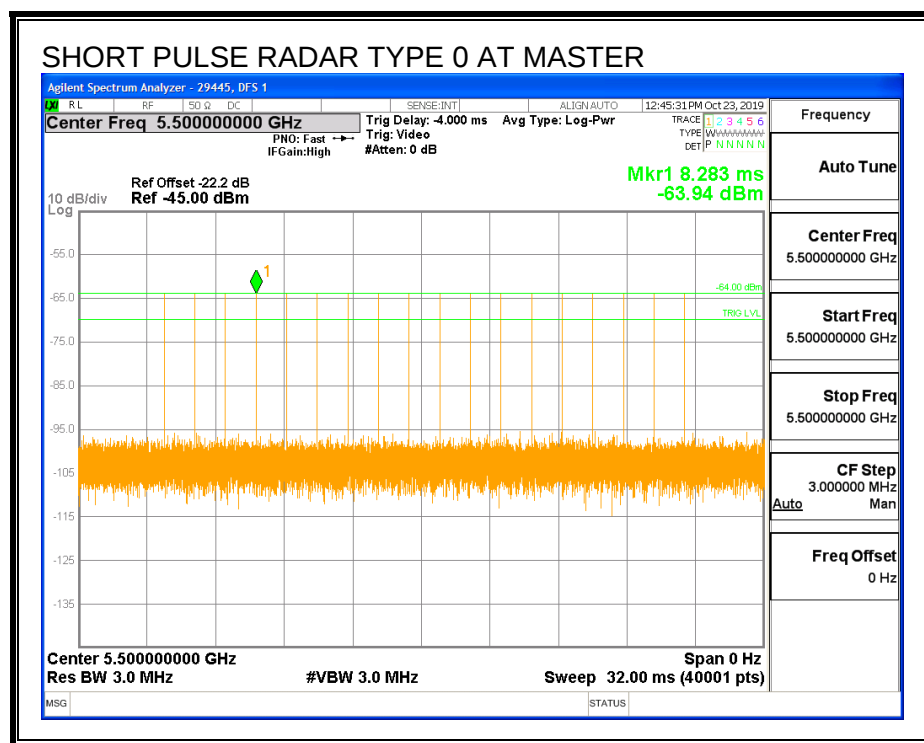
6.5. CLIENT-TO-CLIENT COMMUNICATIONS MODE RESULTS FOR 20 MHz BANDWIDTH

6.5.1. TEST CHANNEL

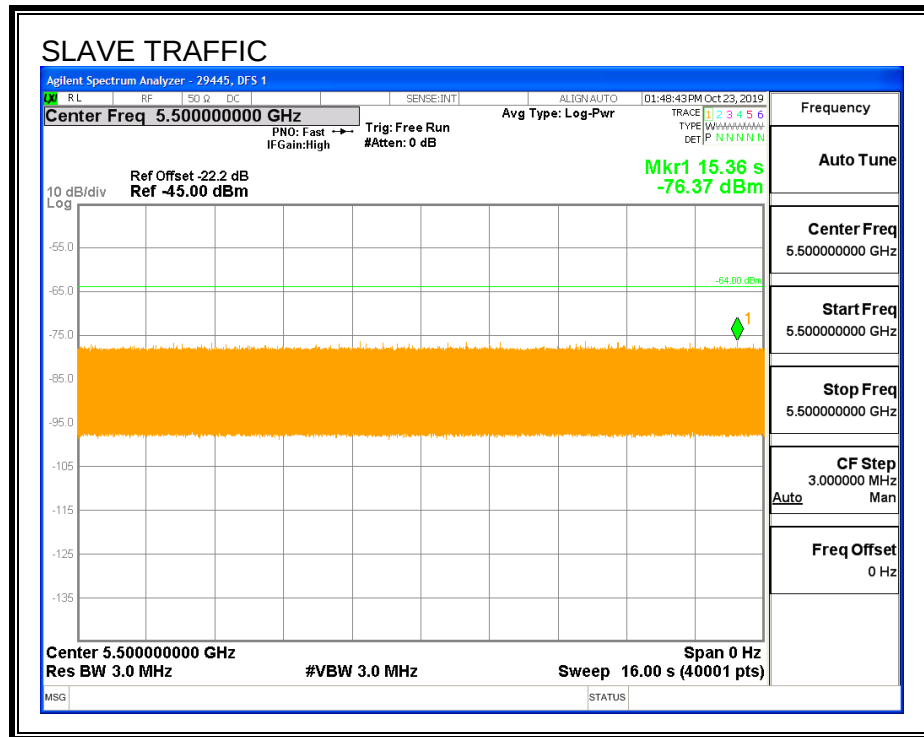
All tests were performed at a channel center frequency of 5500 MHz.

6.5.2. RADAR WAVEFORM AND TRAFFIC

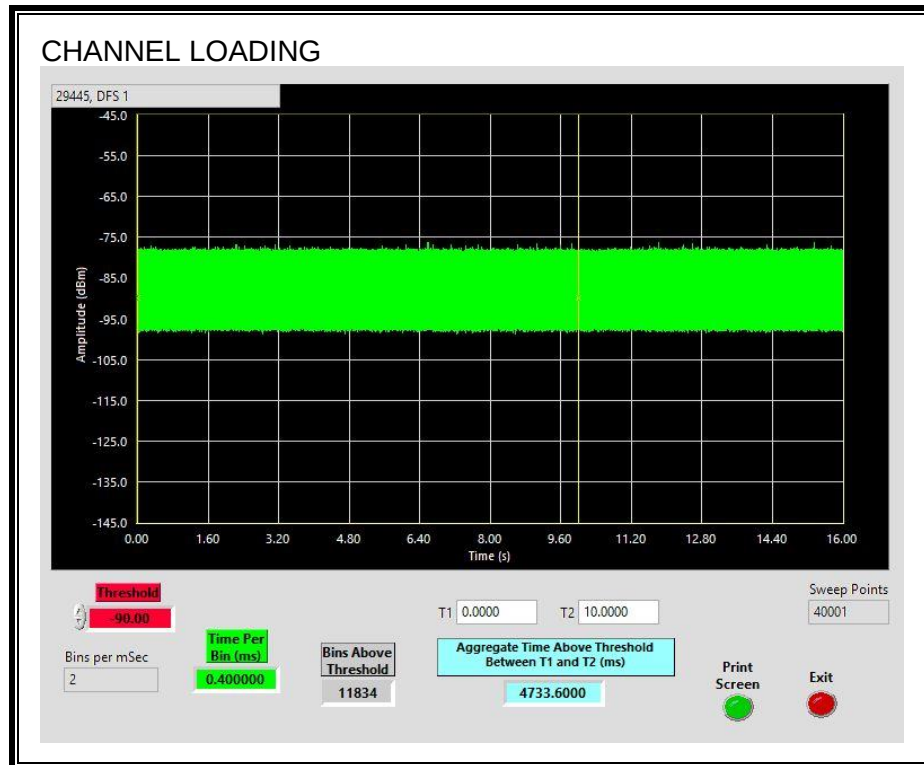
RADAR WAVEFORM



TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 47.33%

6.5.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.5.4. 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)

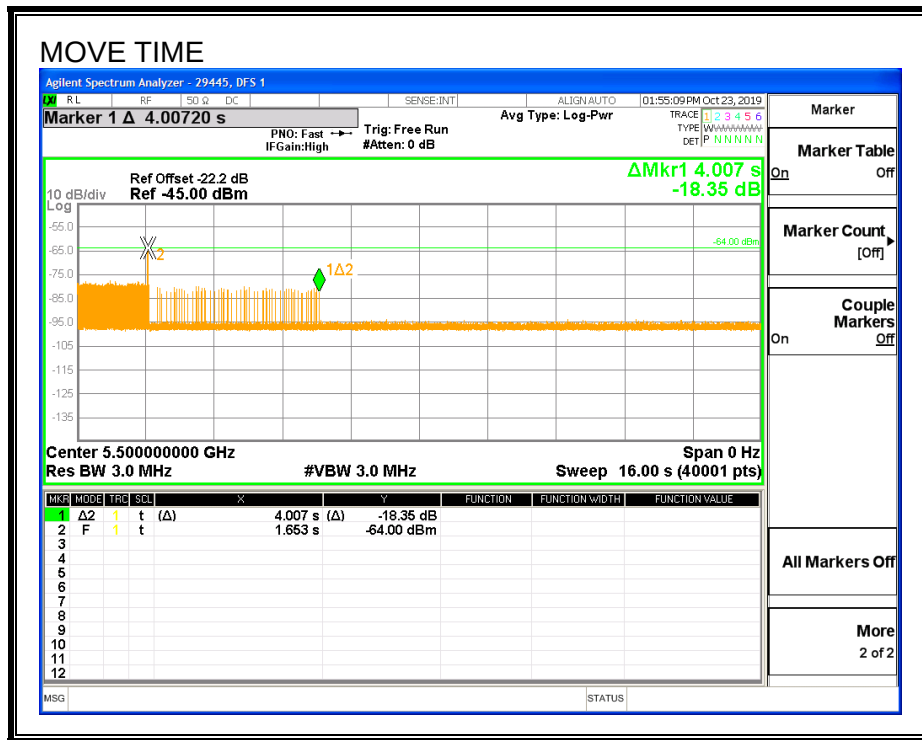
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

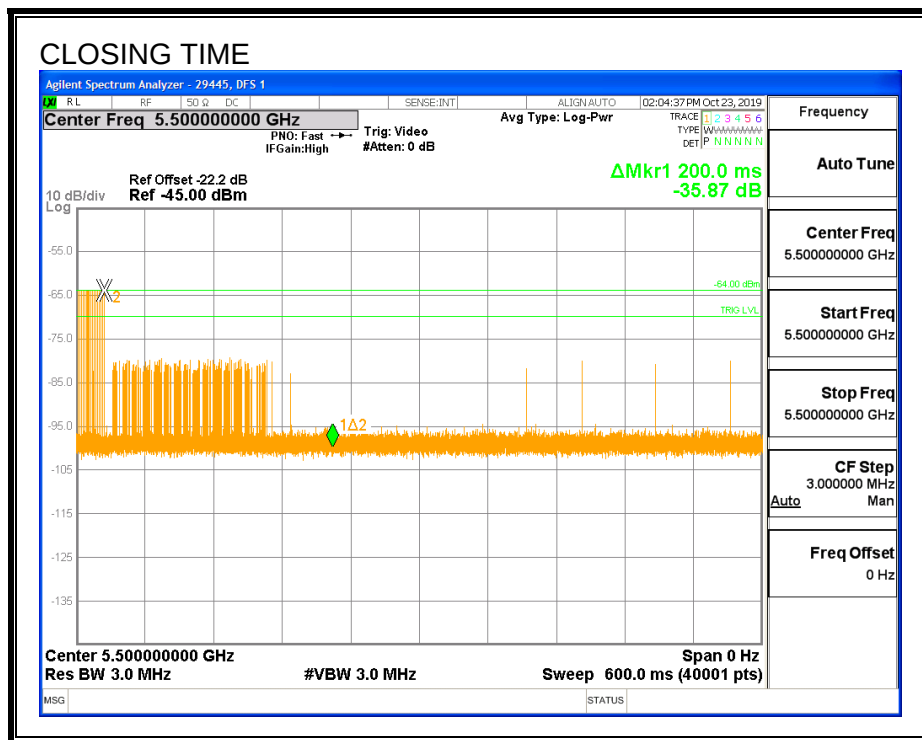
Channel Move Time (sec)	Limit (sec)
4.007	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
38.0	60

MOVE TIME



CHANNEL CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

Only intermittent transmissions are observed during the aggregate monitoring period.



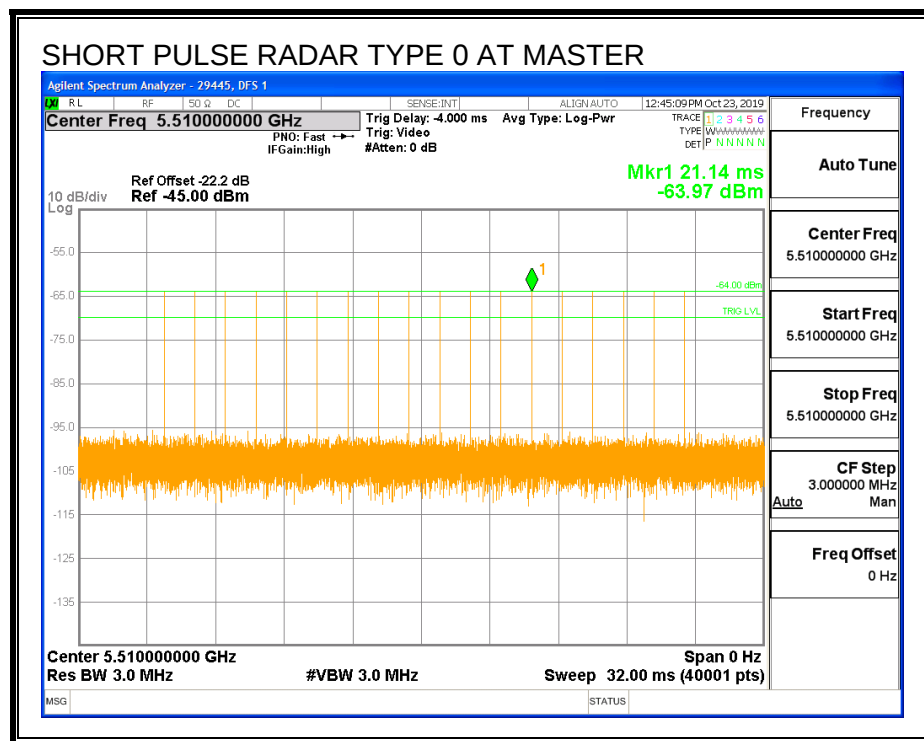
6.6. CLIENT-TO-CLIENT COMMUNICATIONS MODE RESULTS FOR 40 MHz BANDWIDTH

6.6.1. TEST CHANNEL

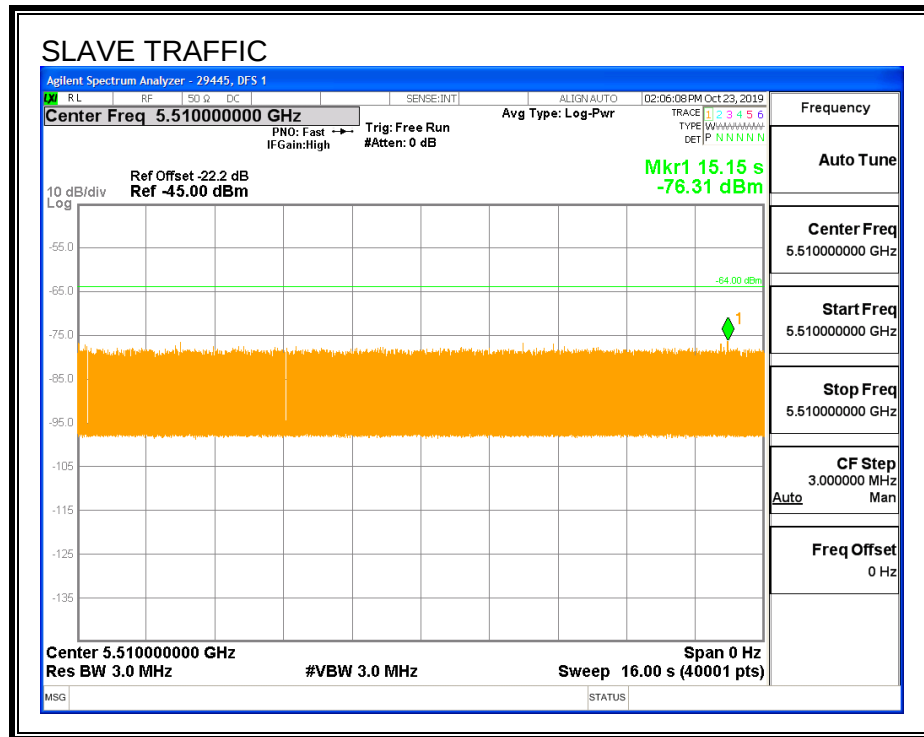
All tests were performed at a channel center frequency of 5510 MHz.

6.6.2. RADAR WAVEFORM AND TRAFFIC

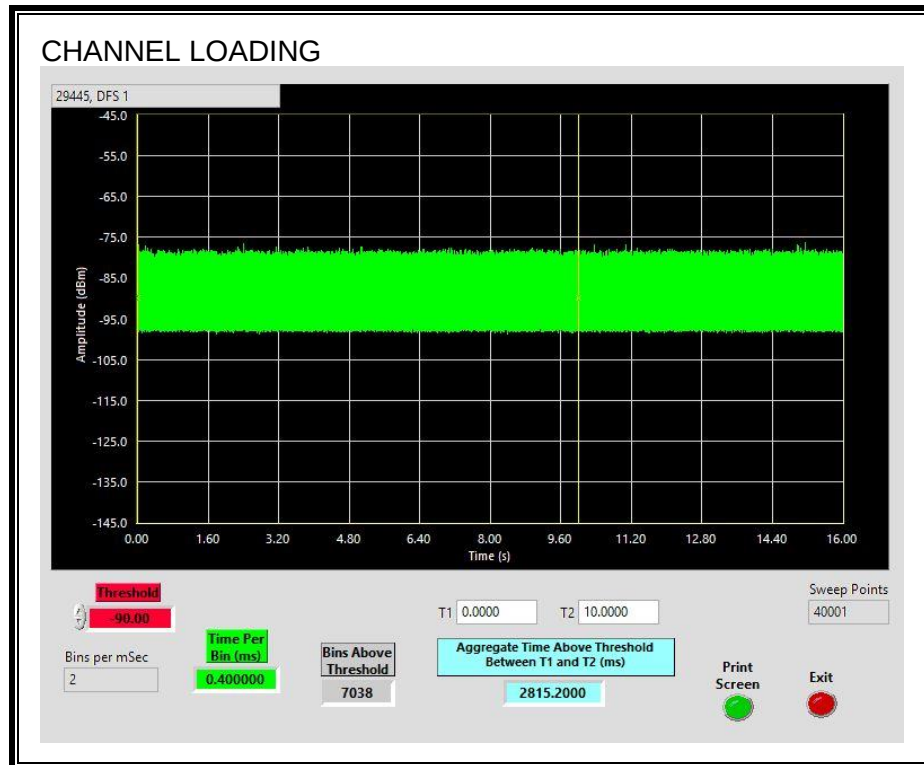
RADAR WAVEFORM



TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 28.15%

6.6.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.6.4. 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)

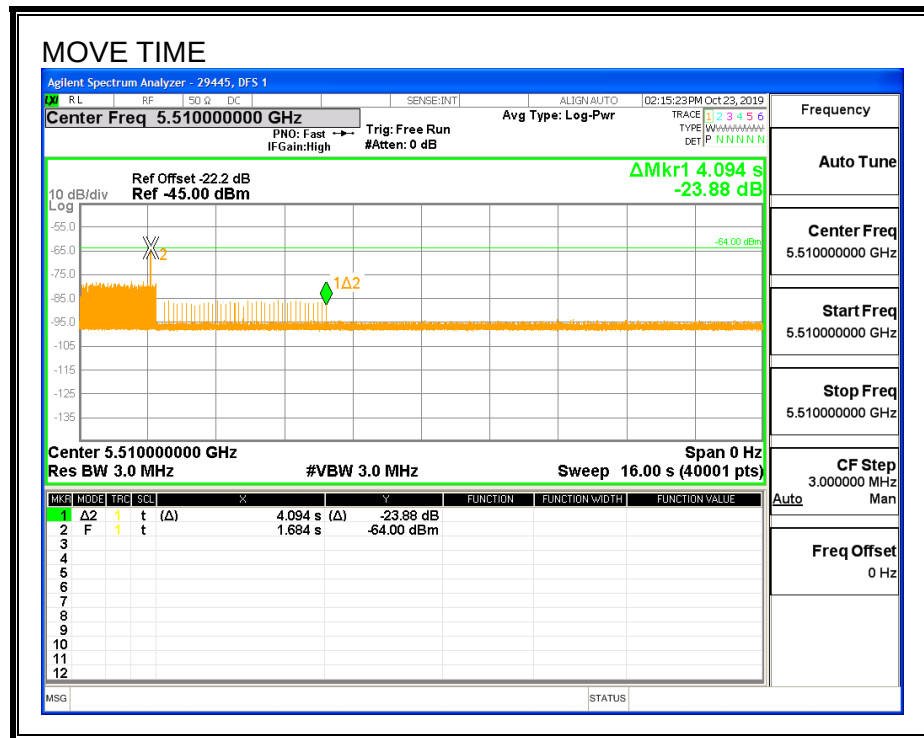
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

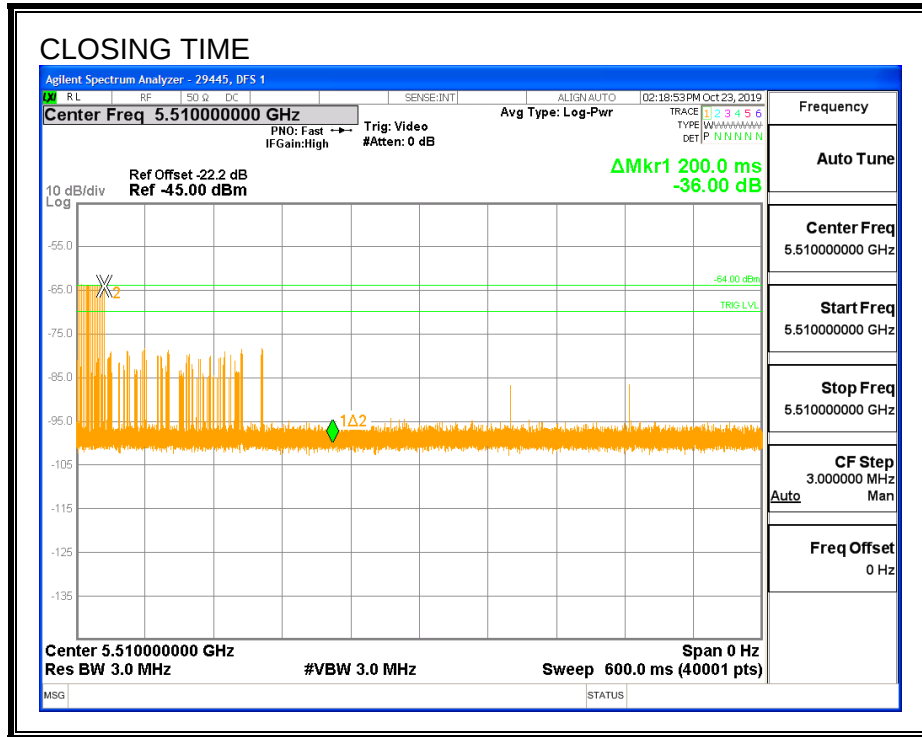
Channel Move Time (sec)	Limit (sec)
4.094	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
15.6	60

MOVE TIME

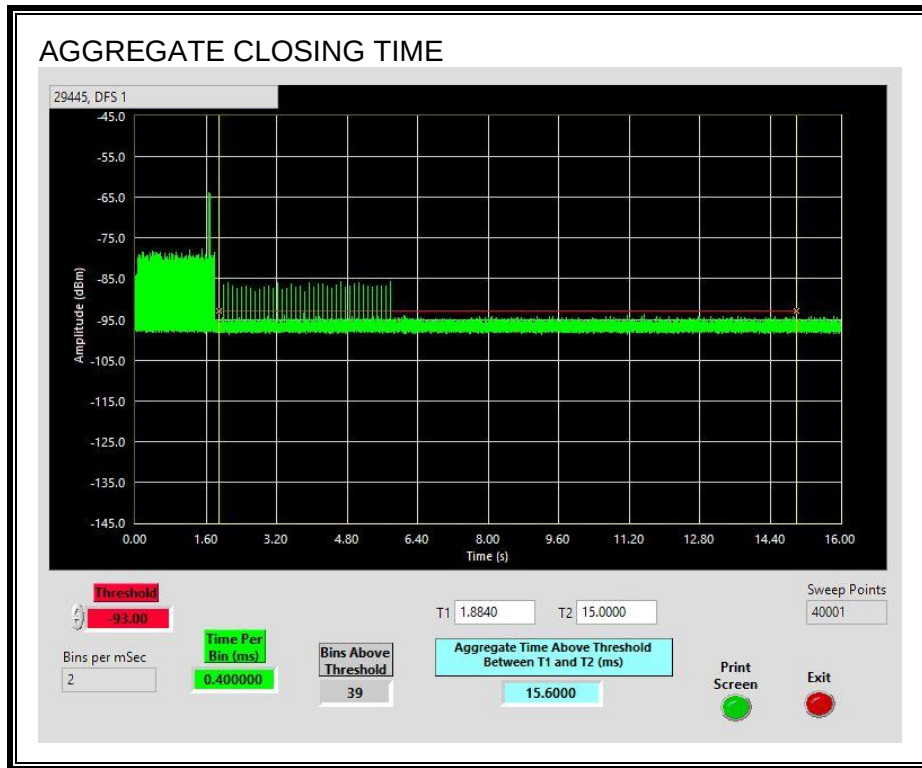


CHANNEL CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

Only intermittent transmissions are observed during the aggregate monitoring period.



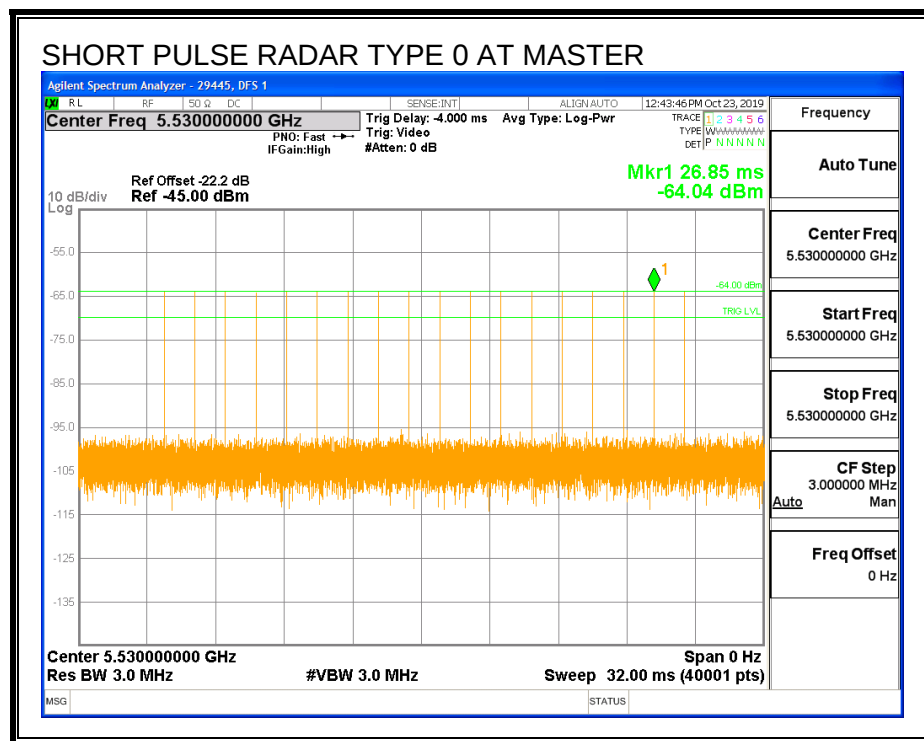
6.7. CLIENT-TO-CLIENT COMMUNICATIONS MODE RESULTS FOR 80 MHz BANDWIDTH

6.7.1. TEST CHANNEL

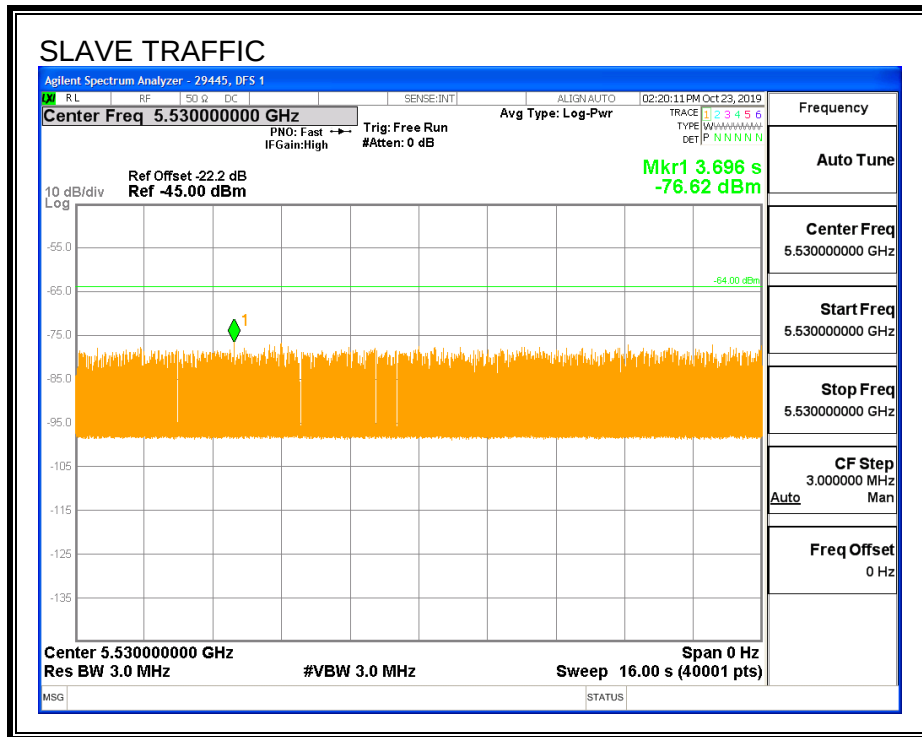
All tests were performed at a channel center frequency of 5530 MHz.

6.7.2. RADAR WAVEFORM AND TRAFFIC

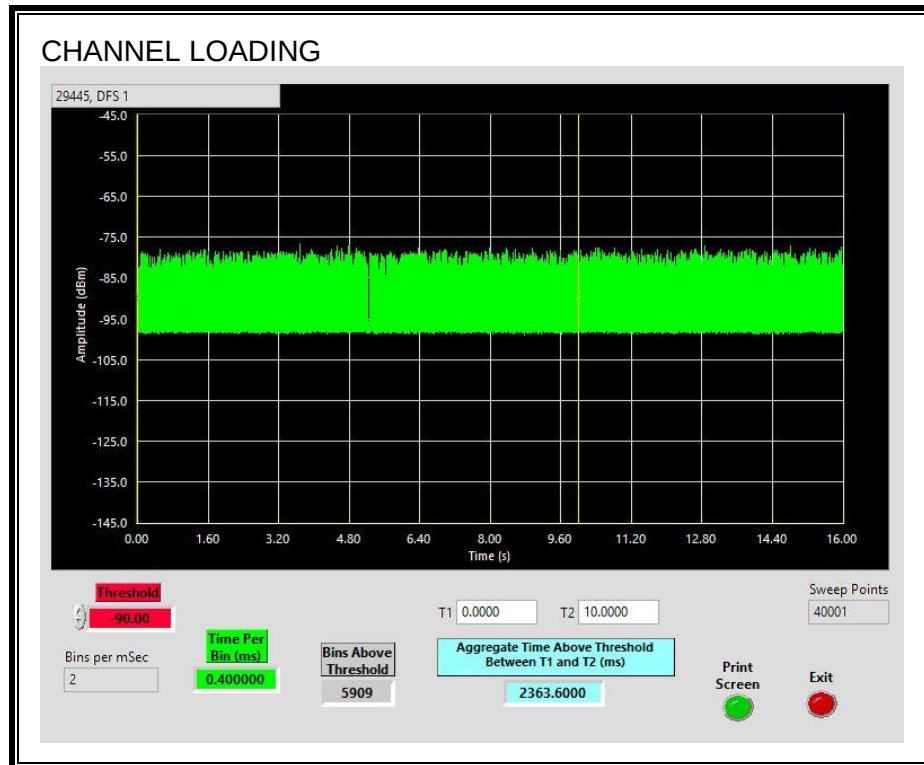
RADAR WAVEFORM



TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 23.63%

6.7.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.7.4. 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)

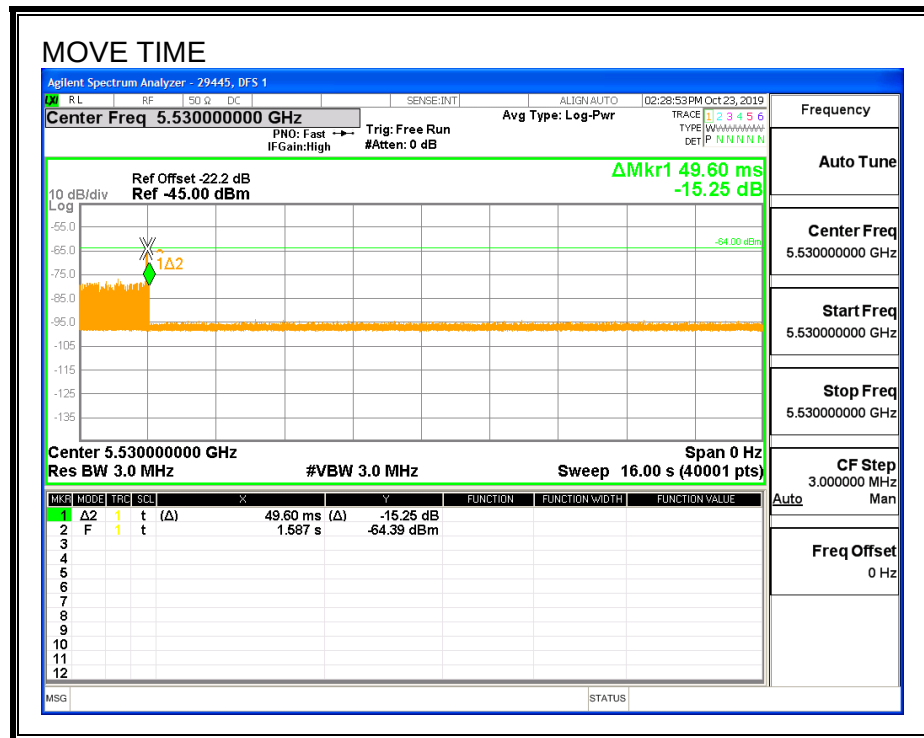
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

Channel Move Time (sec)	Limit (sec)
0.0496	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
0	60

MOVE TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

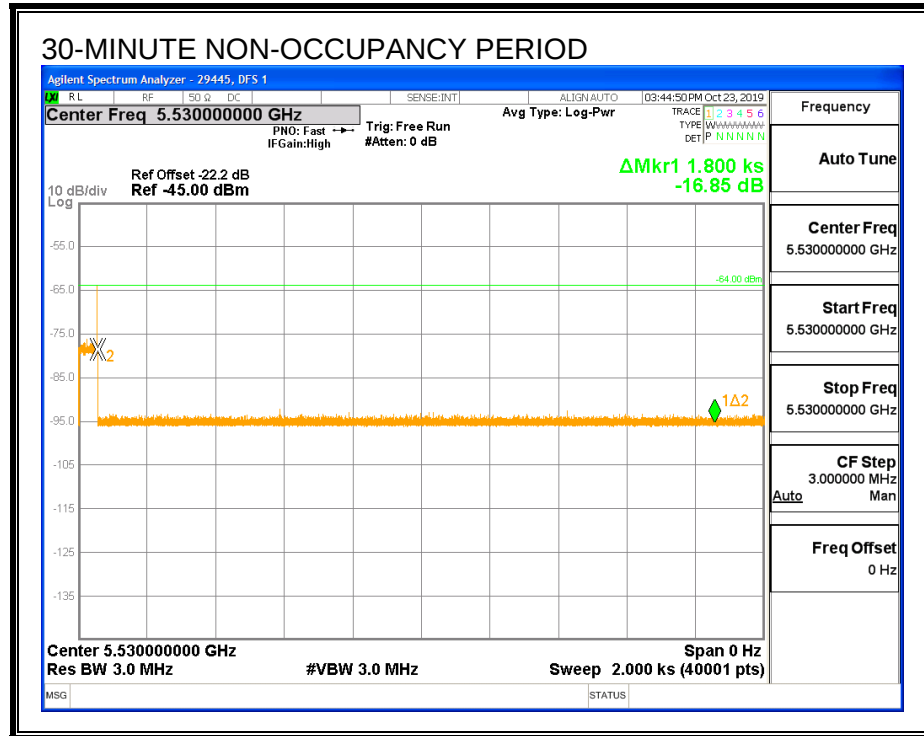
No transmissions are observed during the aggregate monitoring period.



6.7.5. 30-MINUTE NON-OCCUPANCY PERIOD

RESULTS

No EUT transmissions were observed on the test channel during the 30-minute observation time.



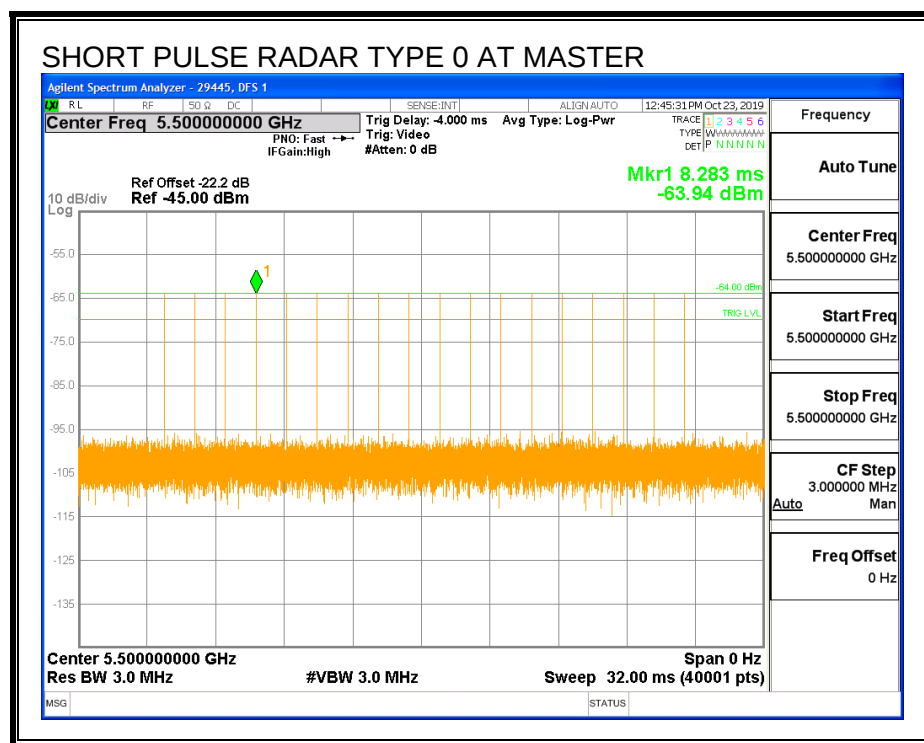
6.8. PEER TO PEER MODE EUT RESULTS FOR 20 MHz BANDWIDTH

6.8.1. TEST CHANNEL

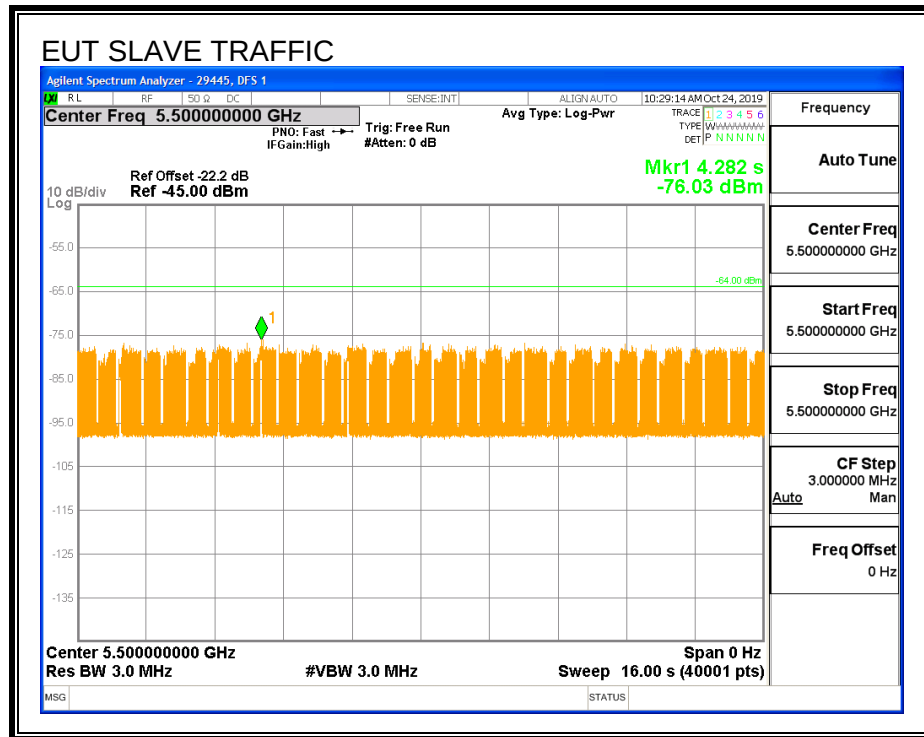
All tests were performed at a channel center frequency of 5500 MHz.

6.8.2. RADAR WAVEFORM AND TRAFFIC

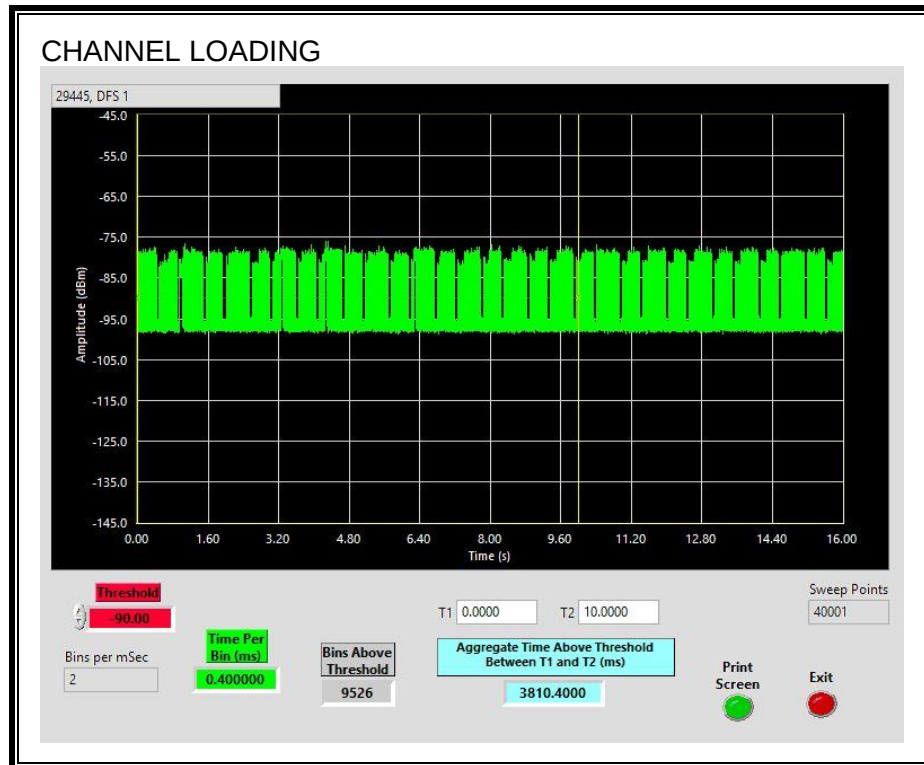
RADAR WAVEFORM



TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 38.1%

6.8.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.8.4. 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)

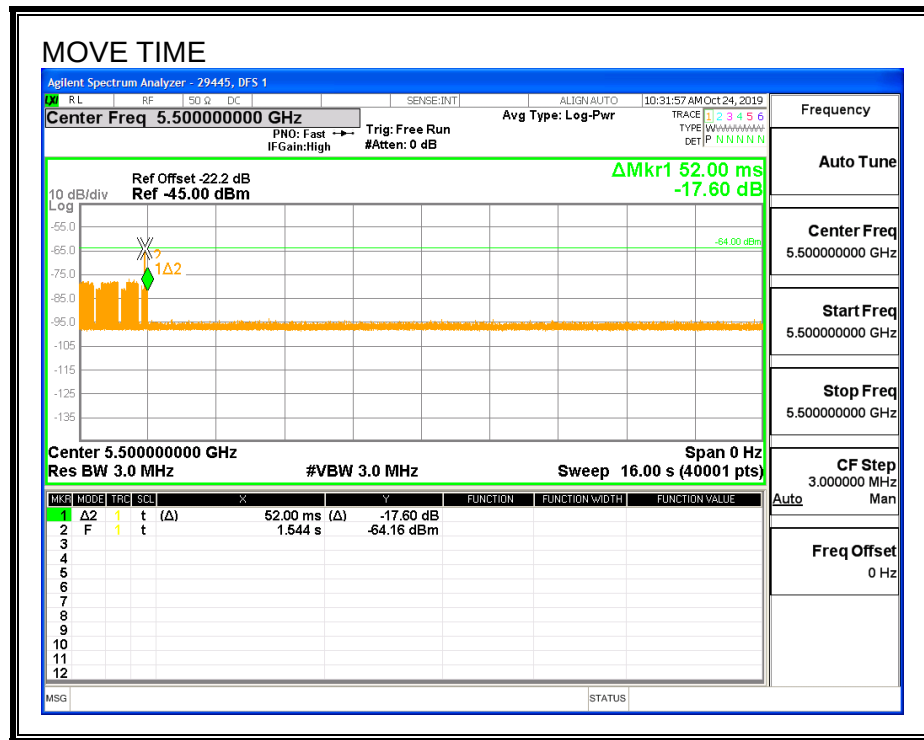
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

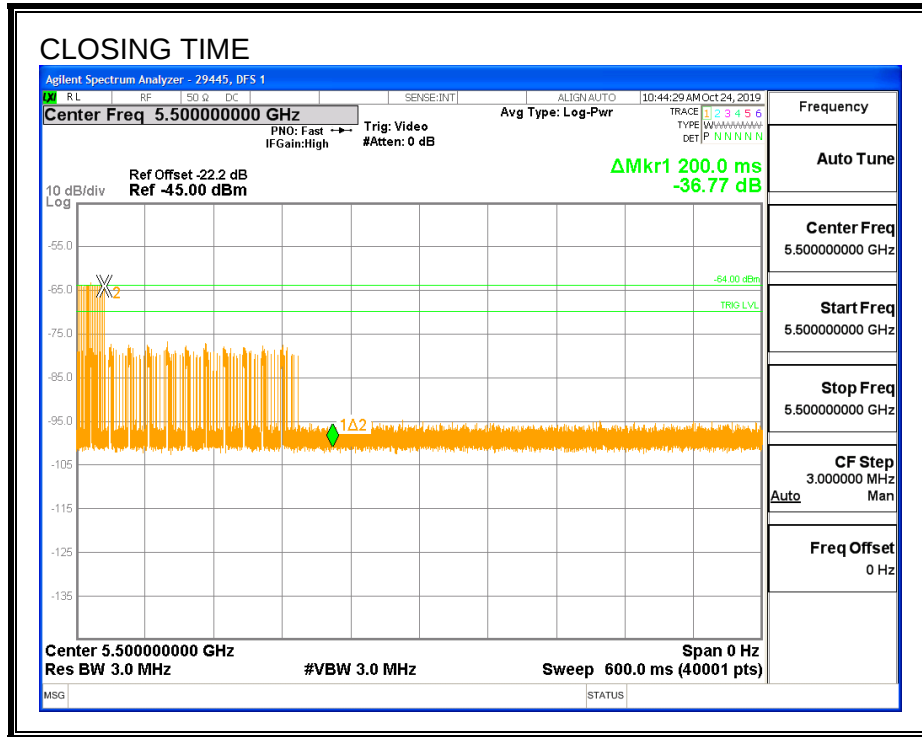
Channel Move Time (sec)	Limit (sec)
0.0520	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
0	60

MOVE TIME



CHANNEL CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

No transmissions are observed during the aggregate monitoring period.



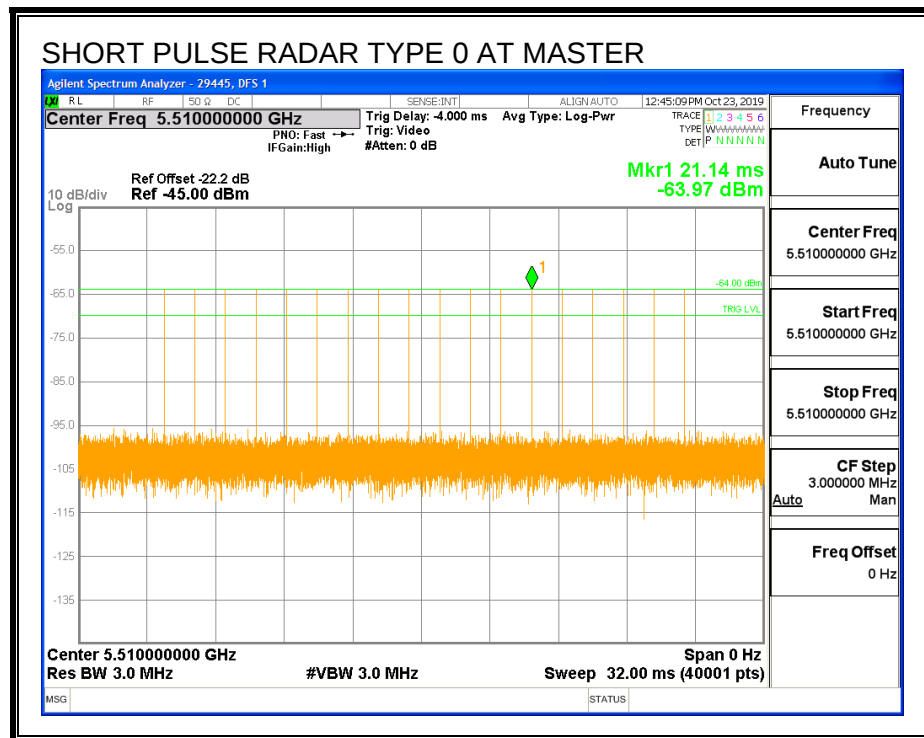
6.9. PEER TO PEER MODE EUT RESULTS FOR 40 MHz BANDWIDTH

6.9.1. TEST CHANNEL

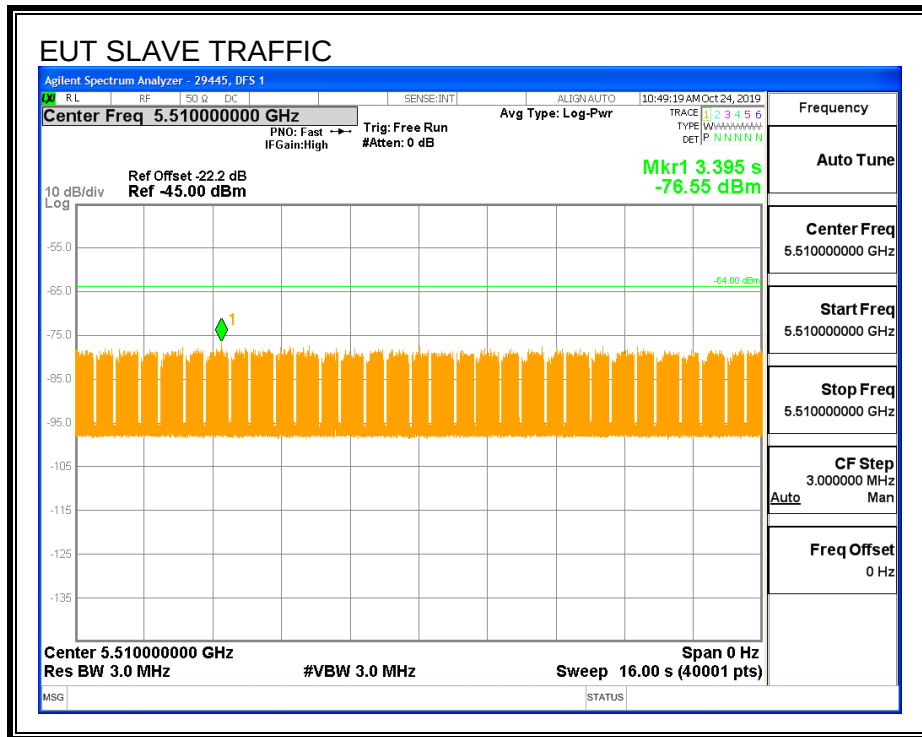
All tests were performed at a channel center frequency of 5510 MHz.

6.9.2. RADAR WAVEFORM AND TRAFFIC

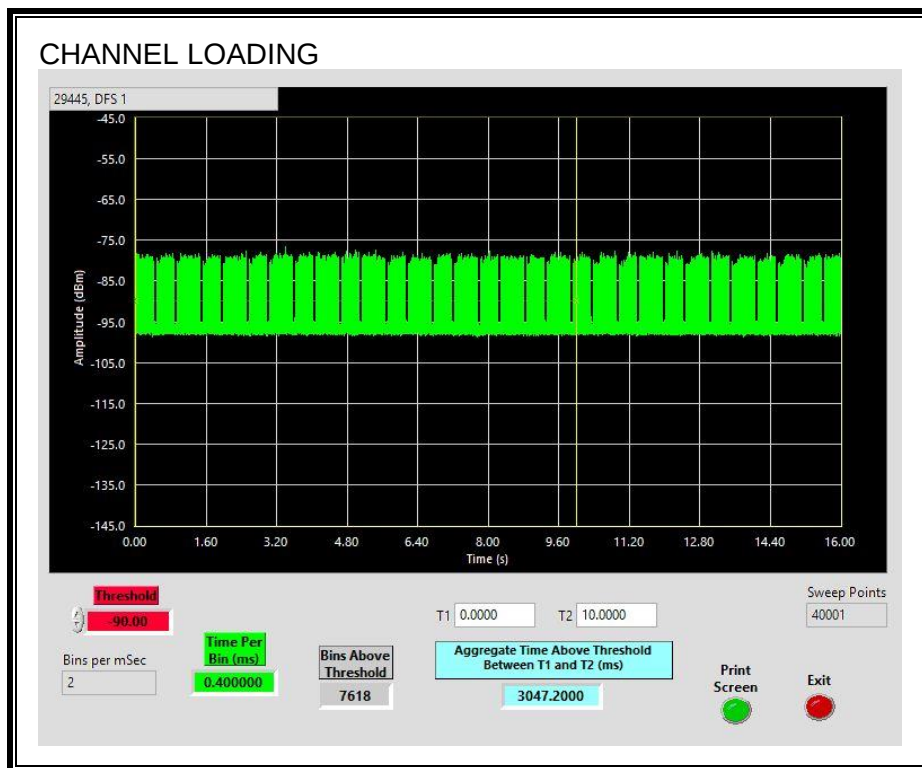
RADAR WAVEFORM



TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 30.47%

6.9.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.9.4. 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)

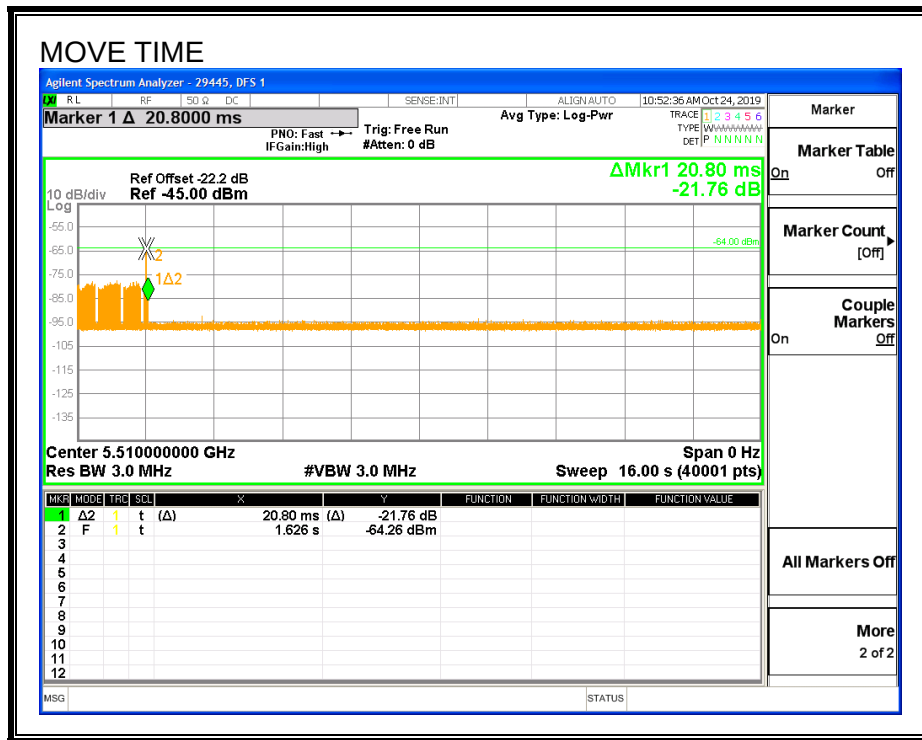
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

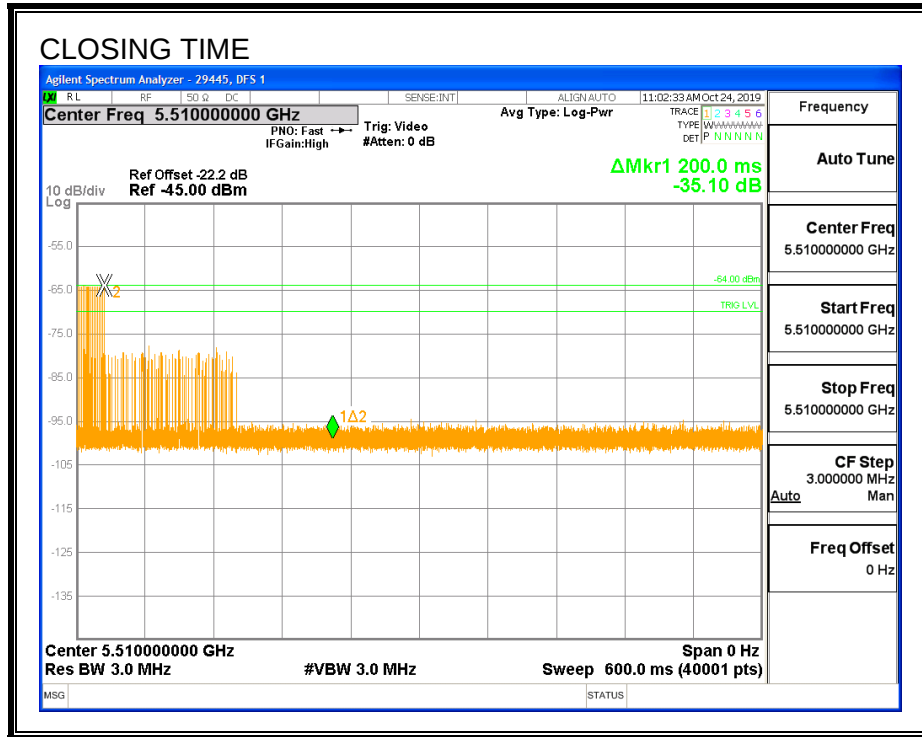
Channel Move Time (sec)	Limit (sec)
0.0208	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
0	60

MOVE TIME



CHANNEL CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

No transmissions are observed during the aggregate monitoring period.



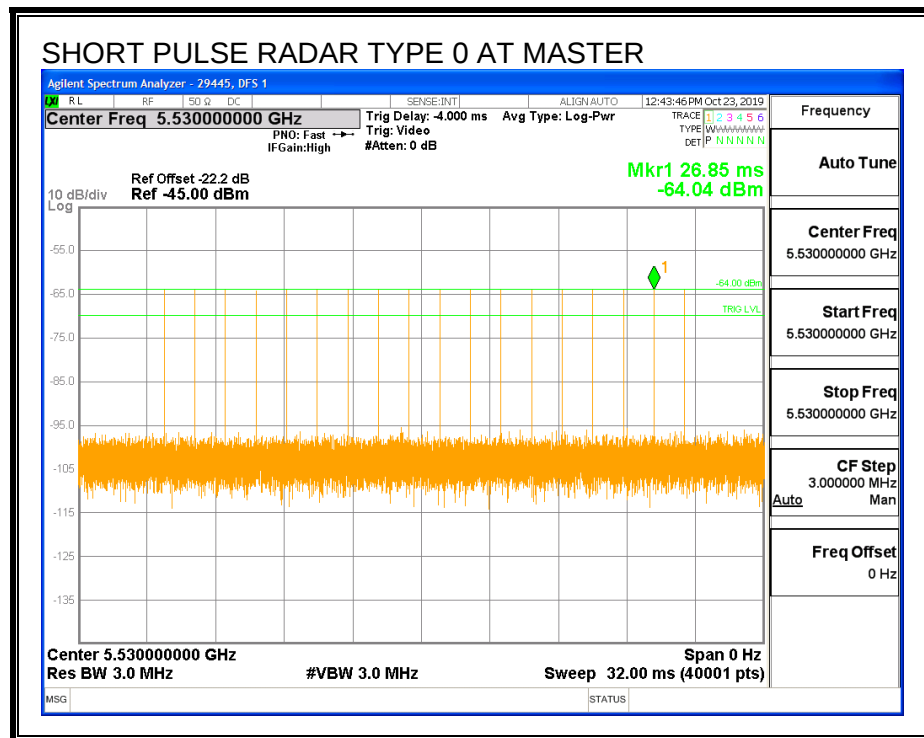
6.10. PEER TO PEER MODE EUT RESULTS FOR 80 MHz BANDWIDTH

6.10.1. TEST CHANNEL

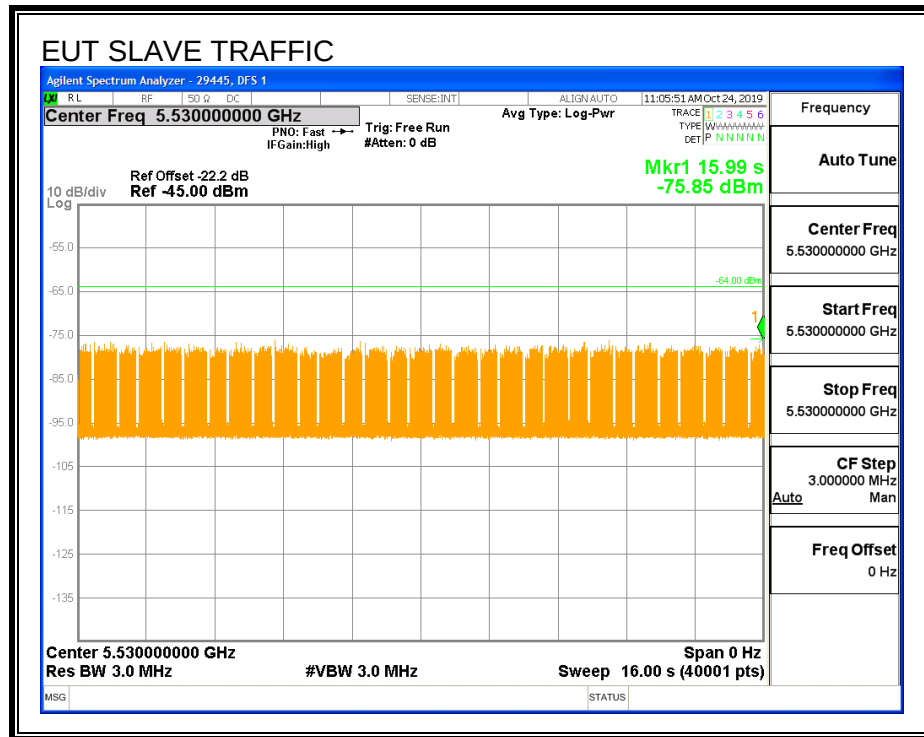
All tests were performed at a channel center frequency of 5530 MHz.

6.10.2. RADAR WAVEFORM AND TRAFFIC

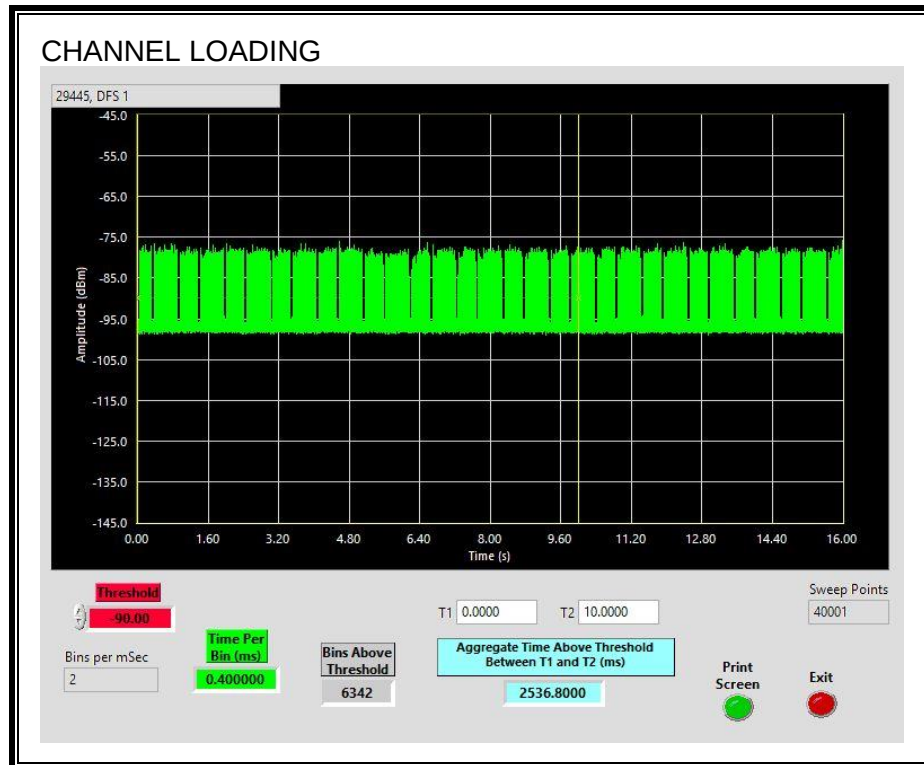
RADAR WAVEFORM



TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the EUT is 25.36%

6.10.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.10.4. 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)

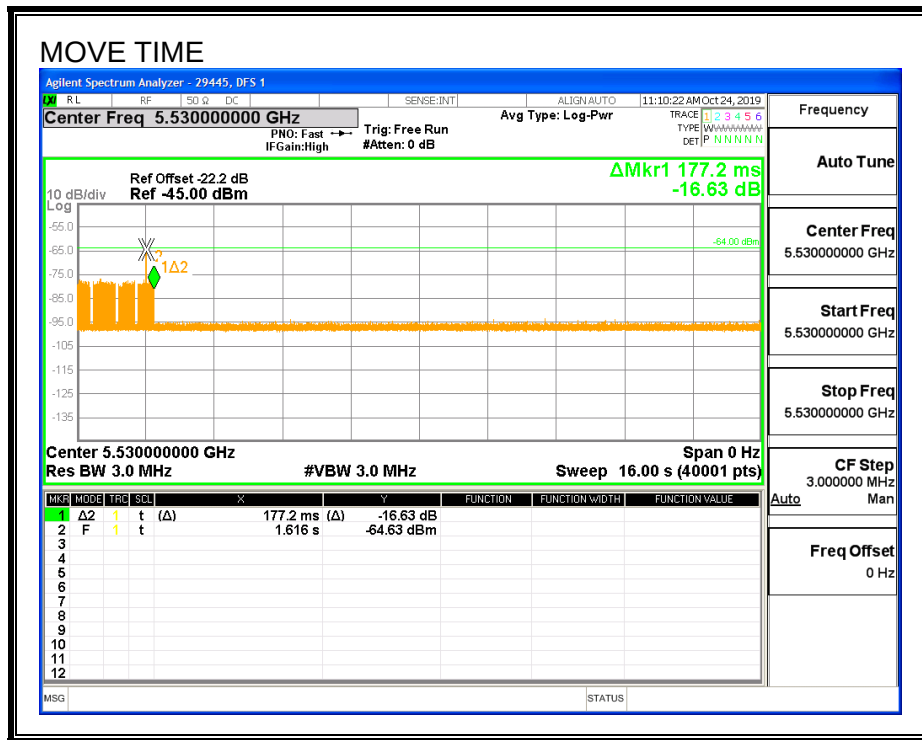
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

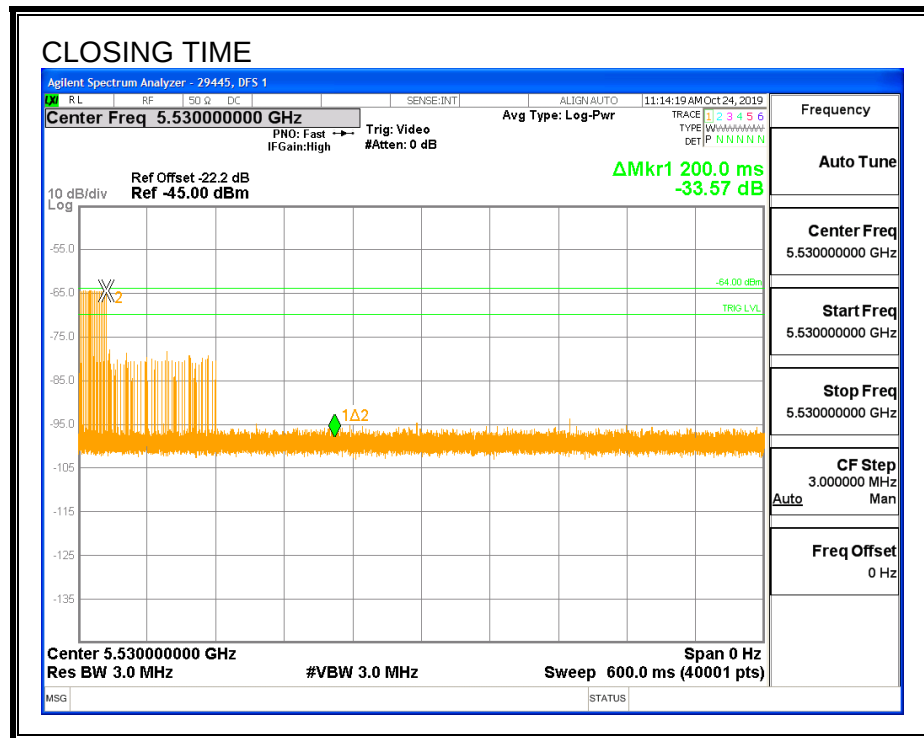
Channel Move Time (sec)	Limit (sec)
0.1772	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
0	60

MOVE TIME



CHANNEL CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

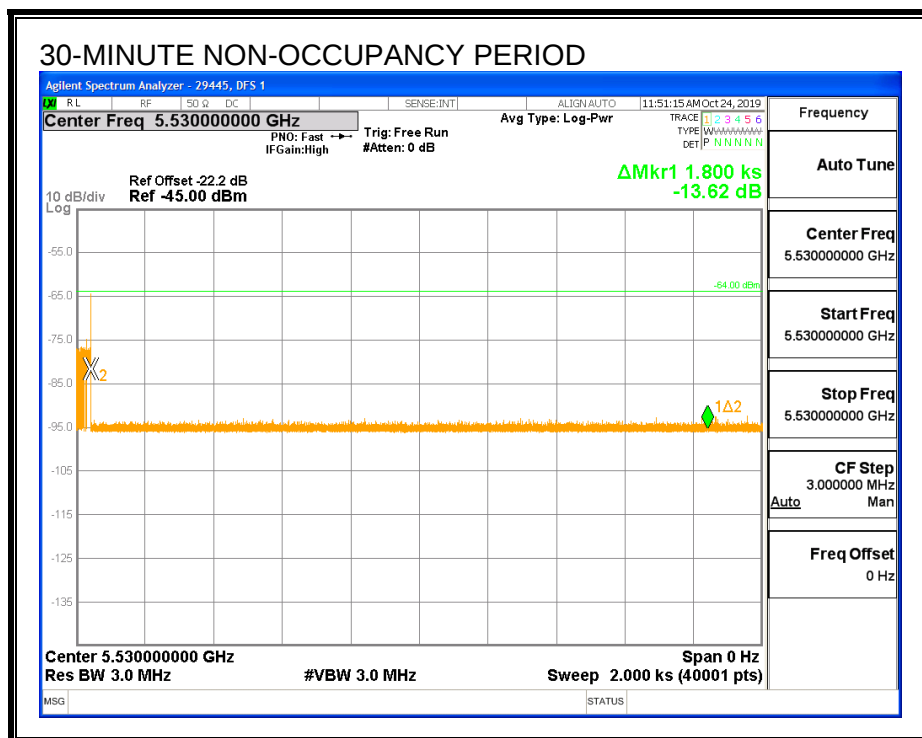
No transmissions are observed during the aggregate monitoring period.



6.10.5. 30-MINUTE NON-OCCUPANCY PERIOD

RESULTS

No EUT transmissions were observed on the test channel during the 30-minute observation time.



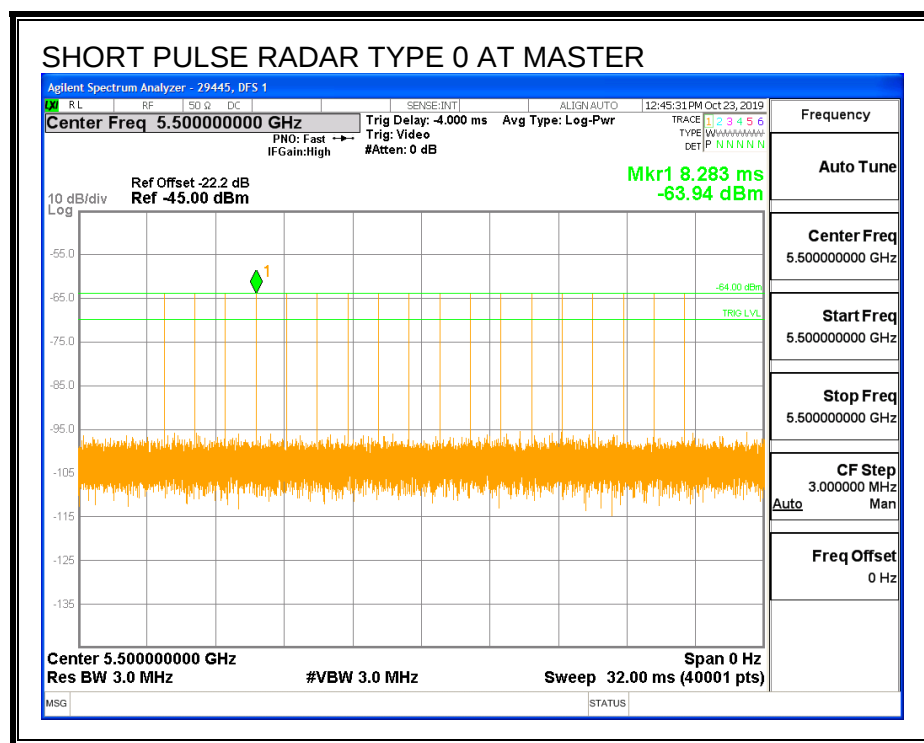
6.11. PEER TO PEER MODE PEER SLAVE DEVICE RESULTS FOR 20 MHz BANDWIDTH

6.11.1. TEST CHANNEL

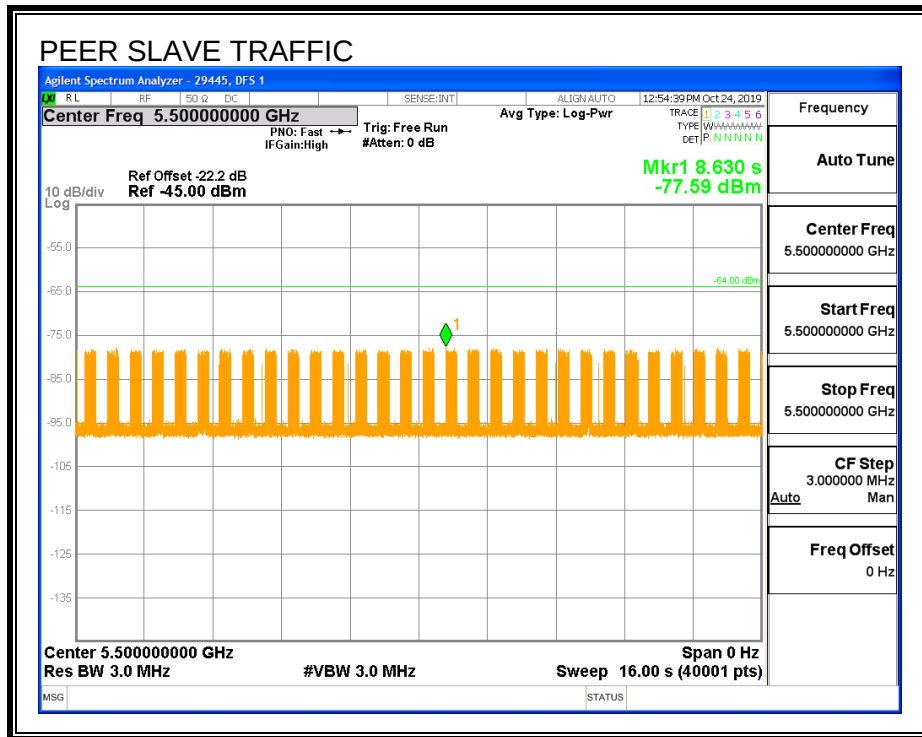
All tests were performed at a channel center frequency of 5500 MHz.

6.11.2. RADAR WAVEFORM AND TRAFFIC

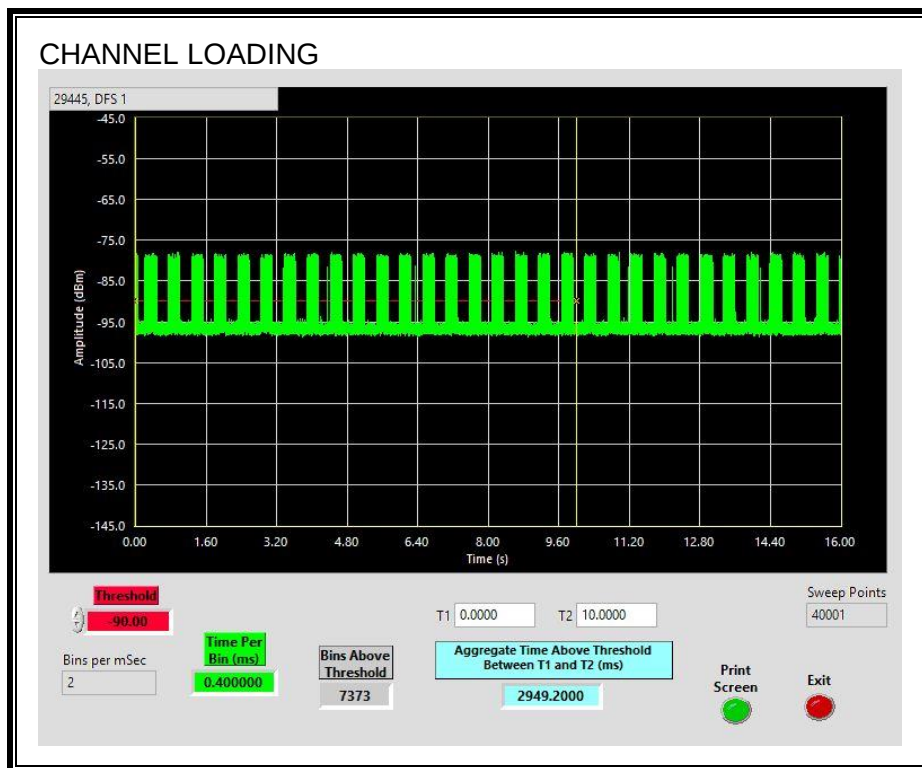
RADAR WAVEFORM



TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the Peer Slave is 29.49%

6.11.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.11.4. 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)

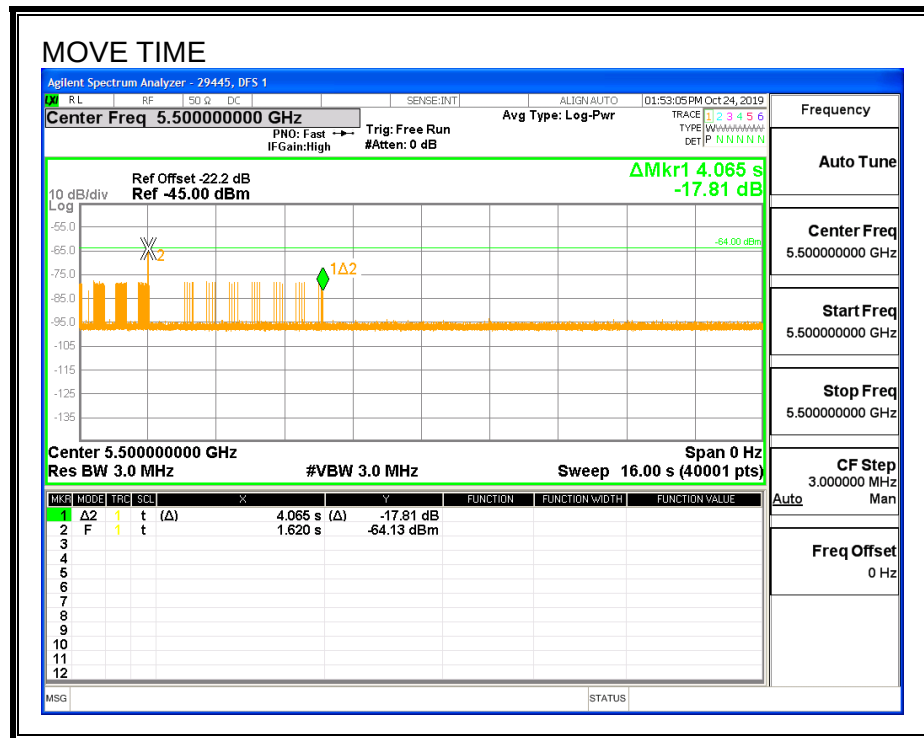
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

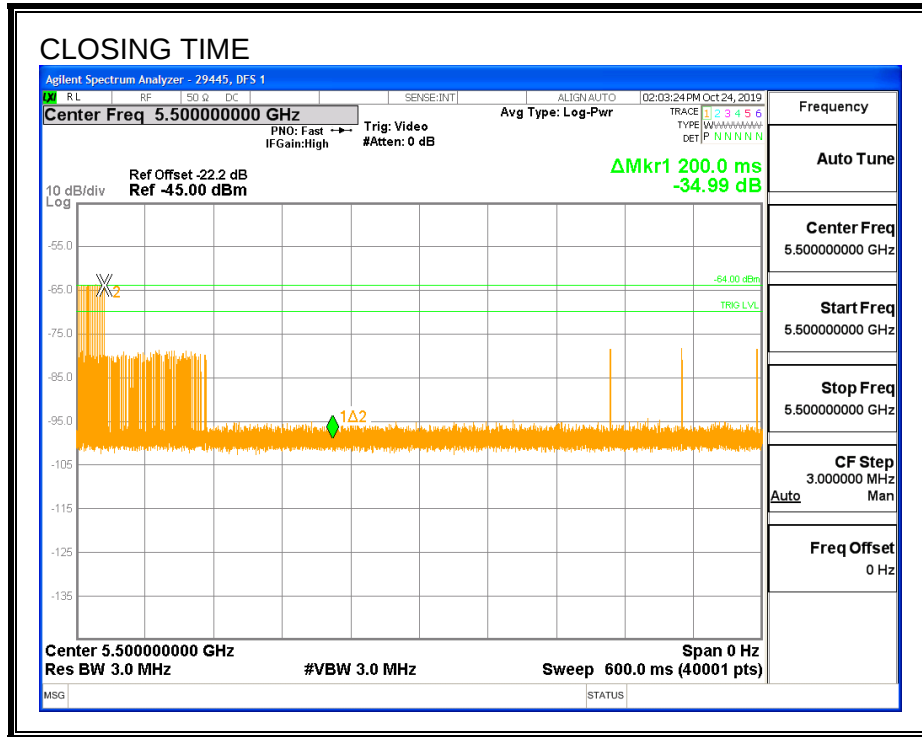
Channel Move Time (sec)	Limit (sec)
4.065	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
43.2	60

MOVE TIME

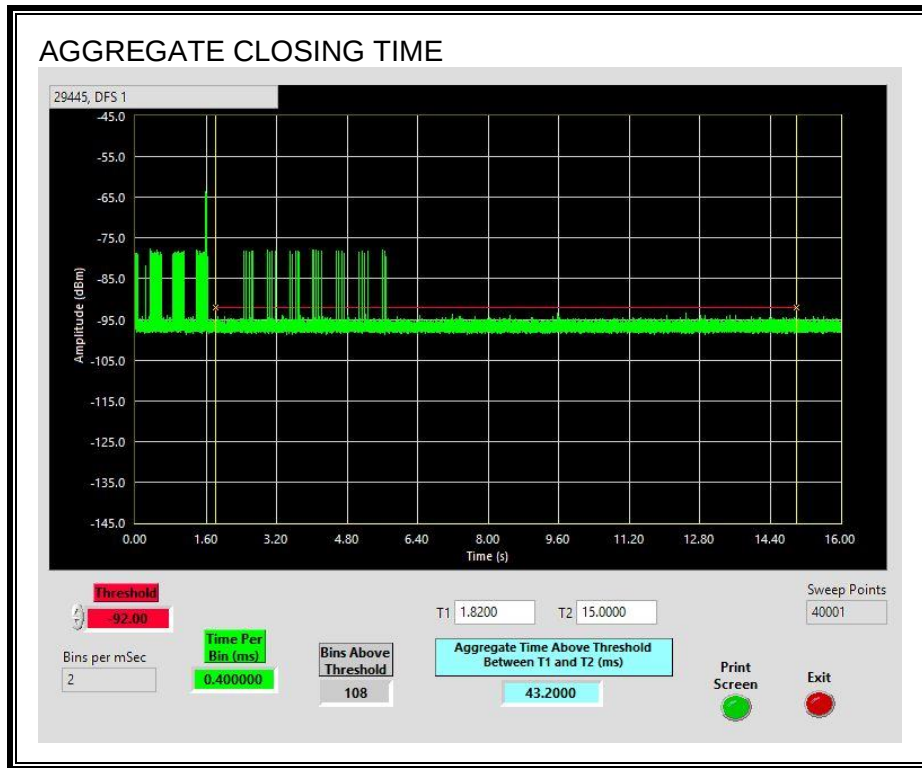


CHANNEL CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

Only intermittent transmissions are observed during the aggregate monitoring period.



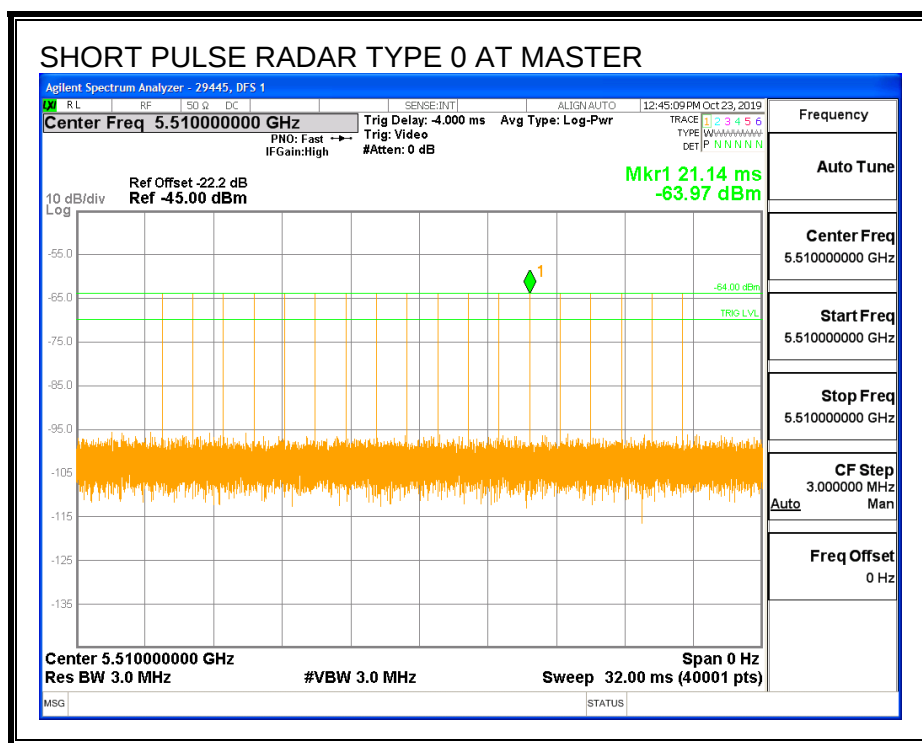
6.12. PEER TO PEER MODE PEER SLAVE DEVICE RESULTS FOR 40 MHz BANDWIDTH

6.12.1. TEST CHANNEL

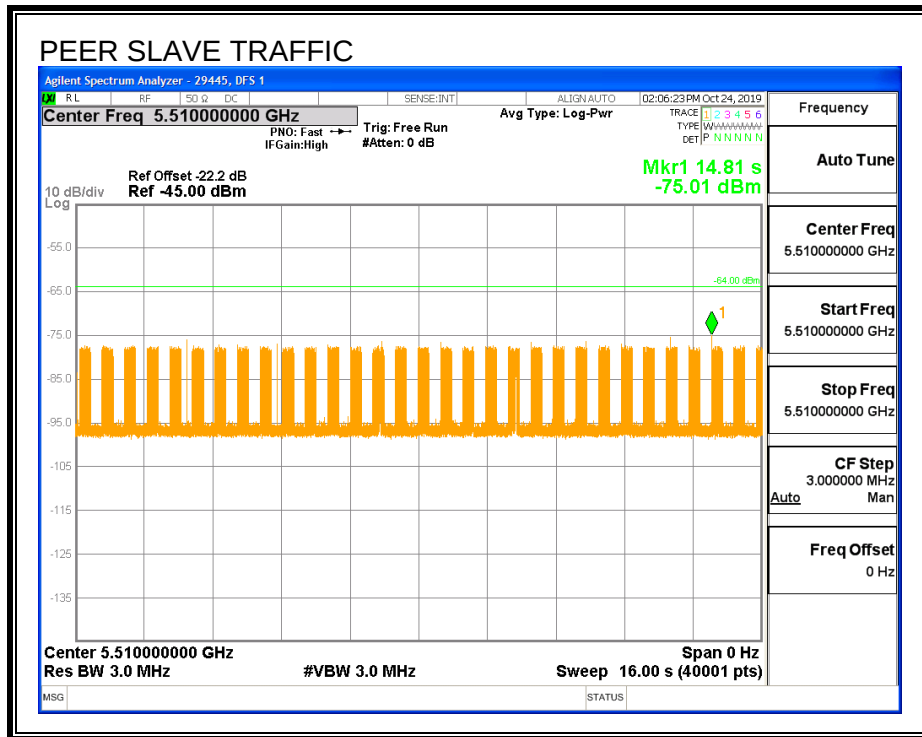
All tests were performed at a channel center frequency of 5510 MHz.

6.12.2. RADAR WAVEFORM AND TRAFFIC

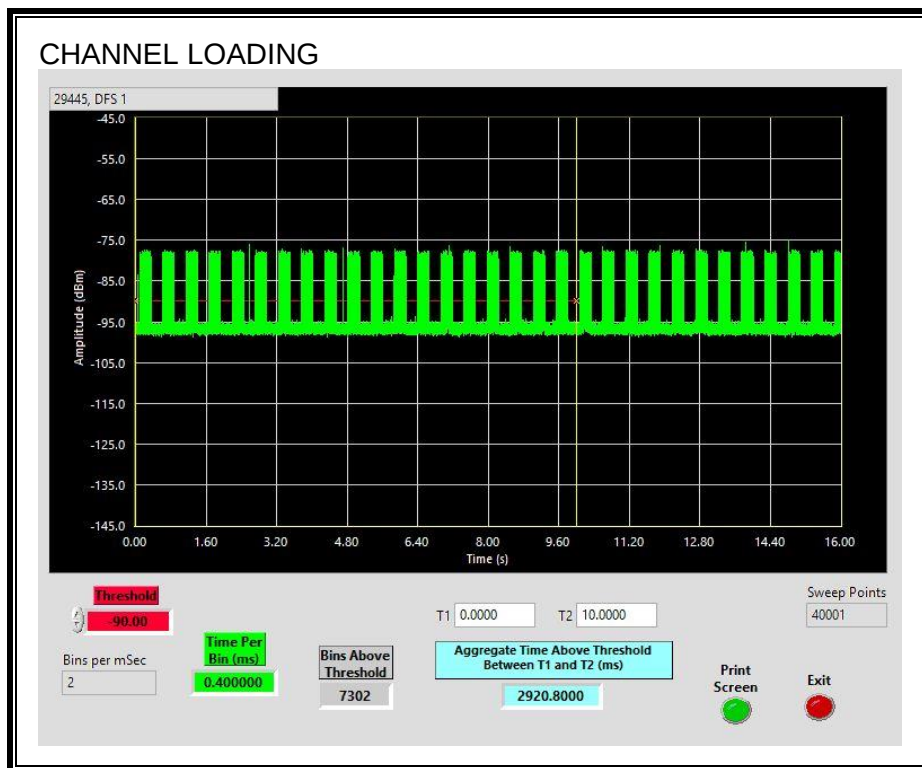
RADAR WAVEFORM



TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the Peer Slave is 29.2%

6.12.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.12.4. 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)

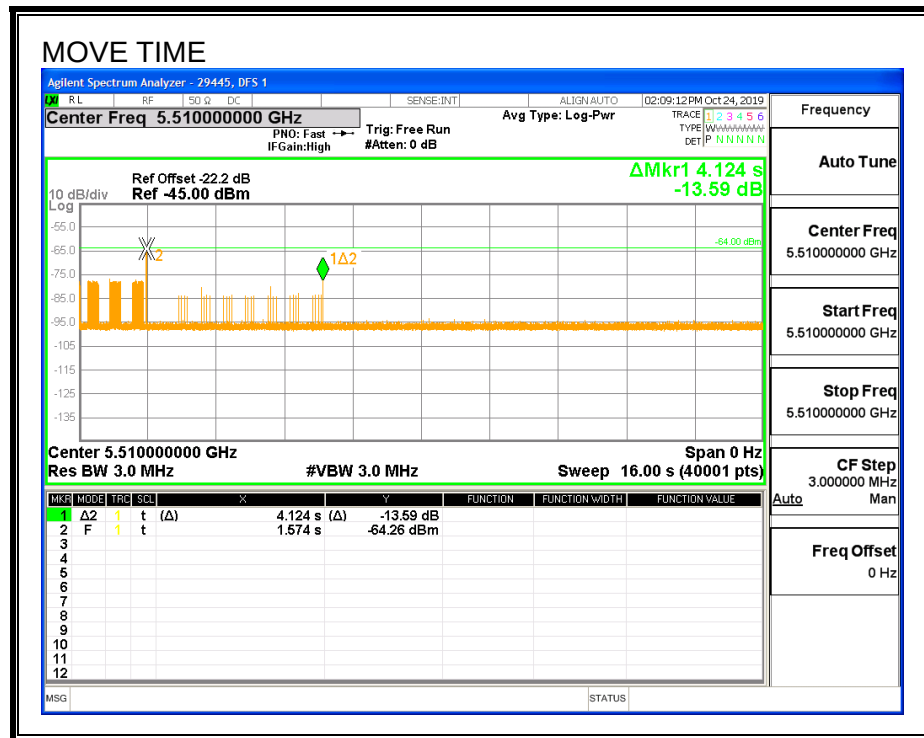
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

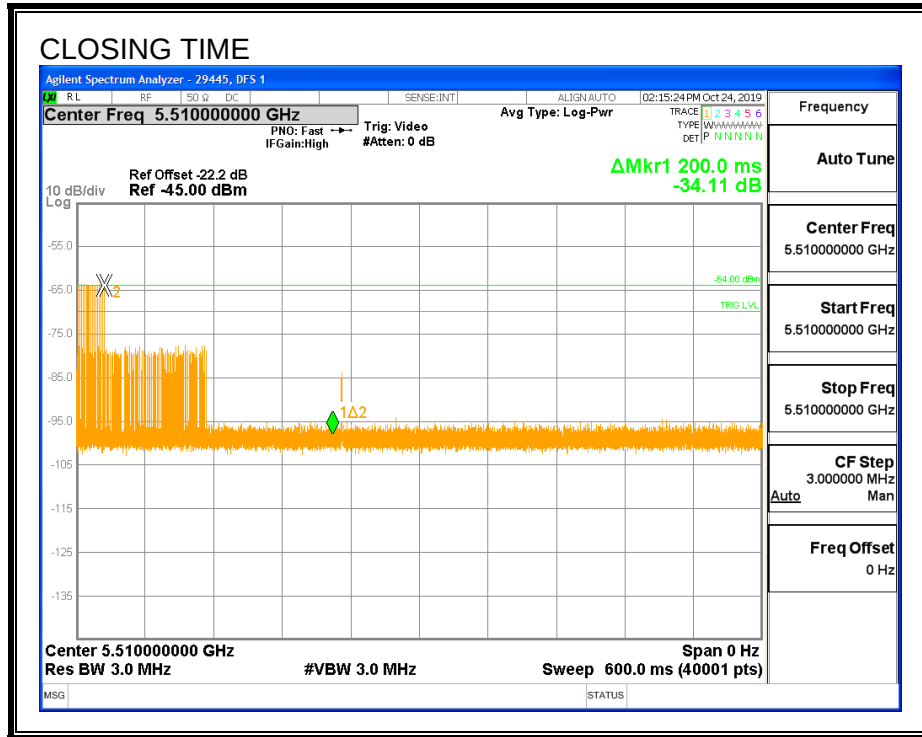
Channel Move Time (sec)	Limit (sec)
4.124	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
40.4	60

MOVE TIME

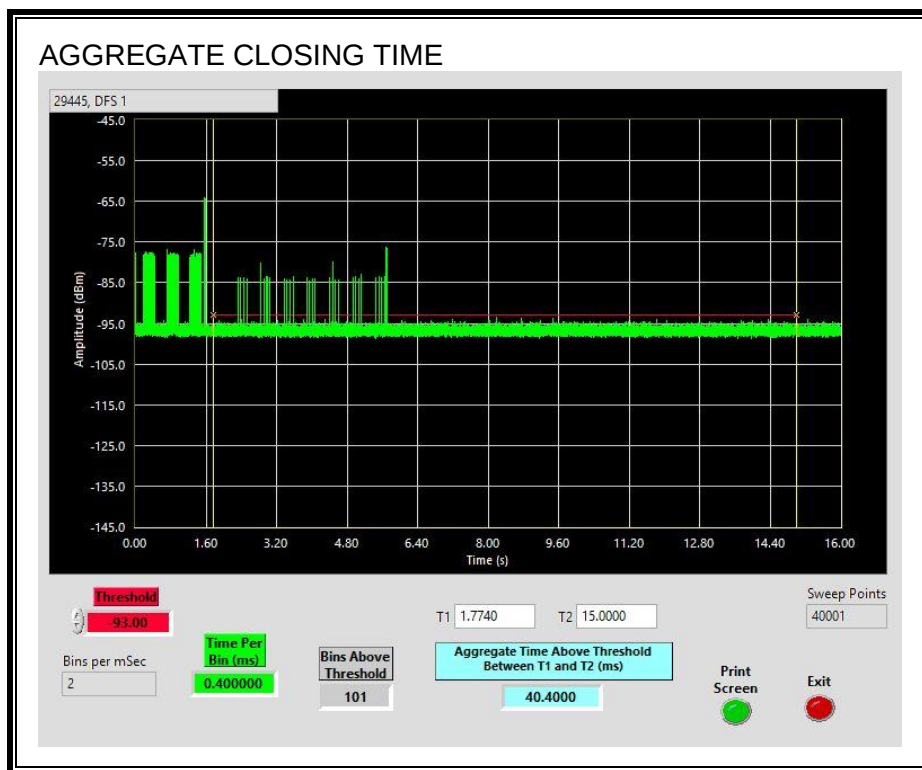


CHANNEL CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

Only intermittent transmissions are observed during the aggregate monitoring period.



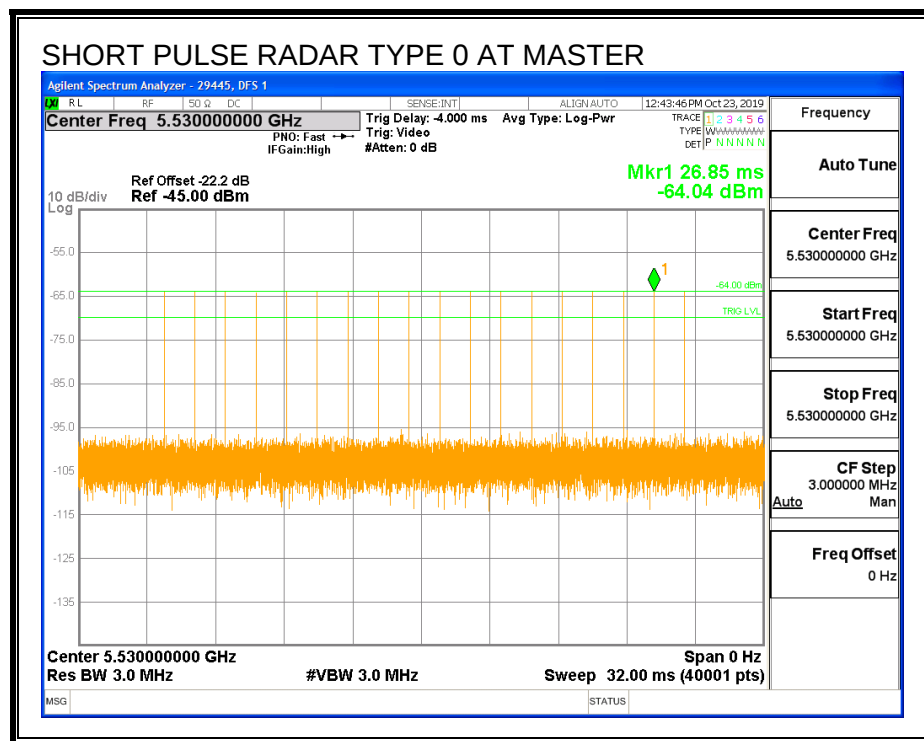
6.13. PEER TO PEER MODE PEER SLAVE DEVICE RESULTS FOR 80 MHz BANDWIDTH

6.13.1. TEST CHANNEL

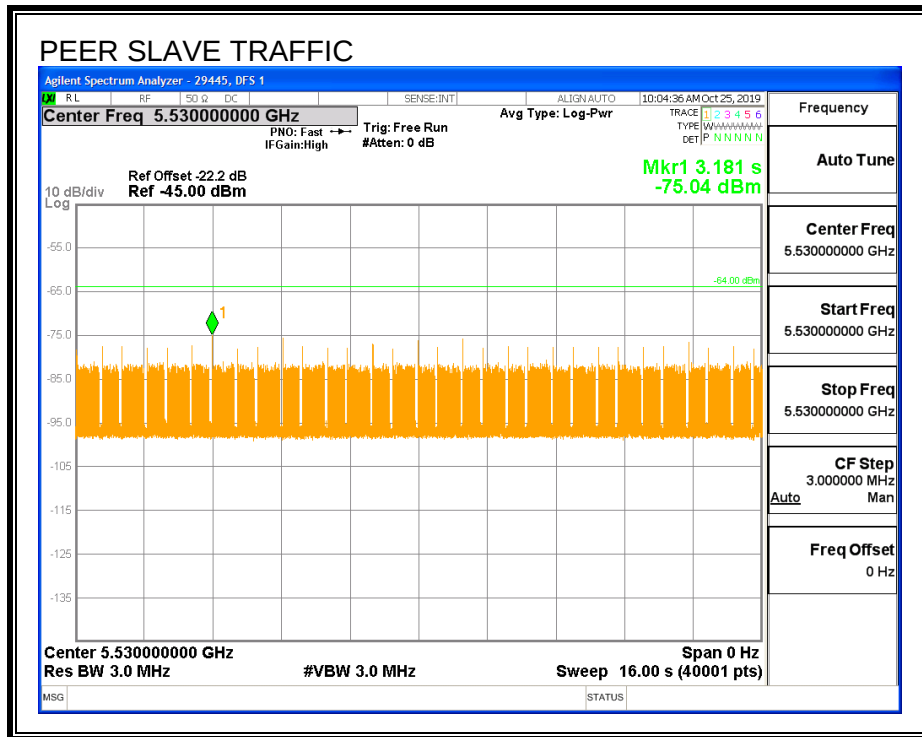
All tests were performed at a channel center frequency of 5530 MHz.

6.13.2. RADAR WAVEFORM AND TRAFFIC

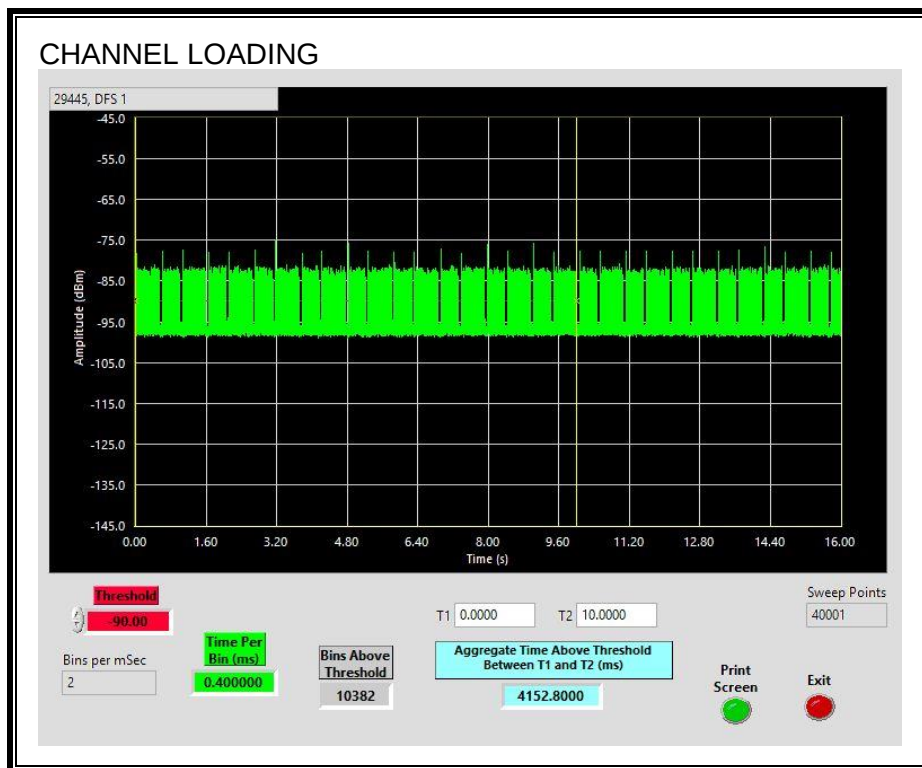
RADAR WAVEFORM



TRAFFIC



CHANNEL LOADING



The level of traffic loading on the channel by the Peer Slave is 41.52%

6.13.3. OVERLAPPING CHANNEL TESTS

RESULTS

These tests are not applicable.

6.13.4. 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)

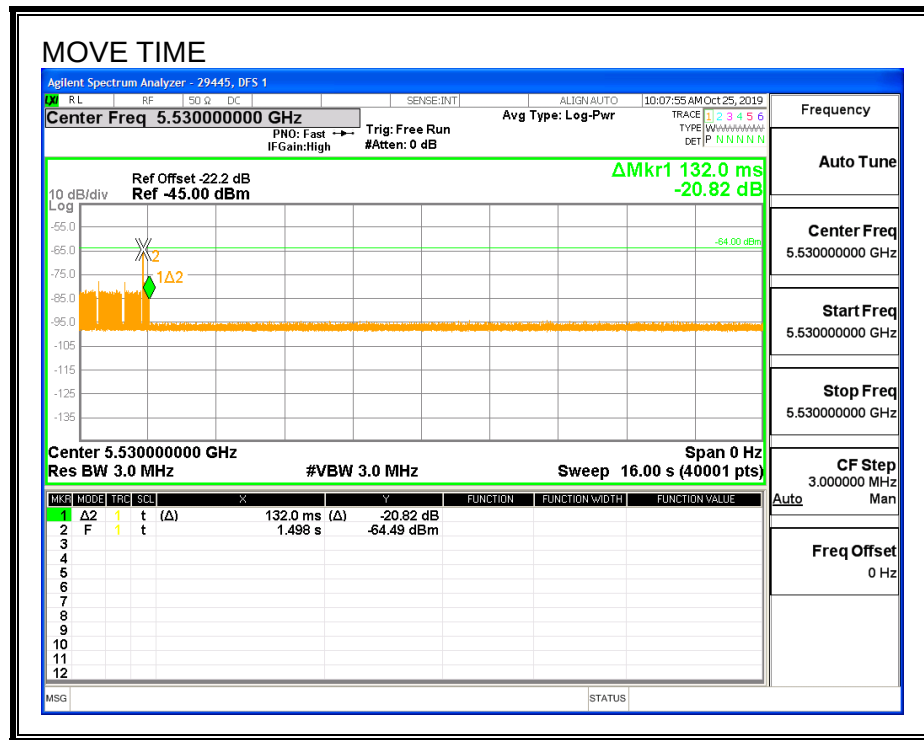
The observation period over which the aggregate time is calculated begins at (Reference Marker + 200 msec) and ends no earlier than (Reference Marker + 10 sec).

RESULTS

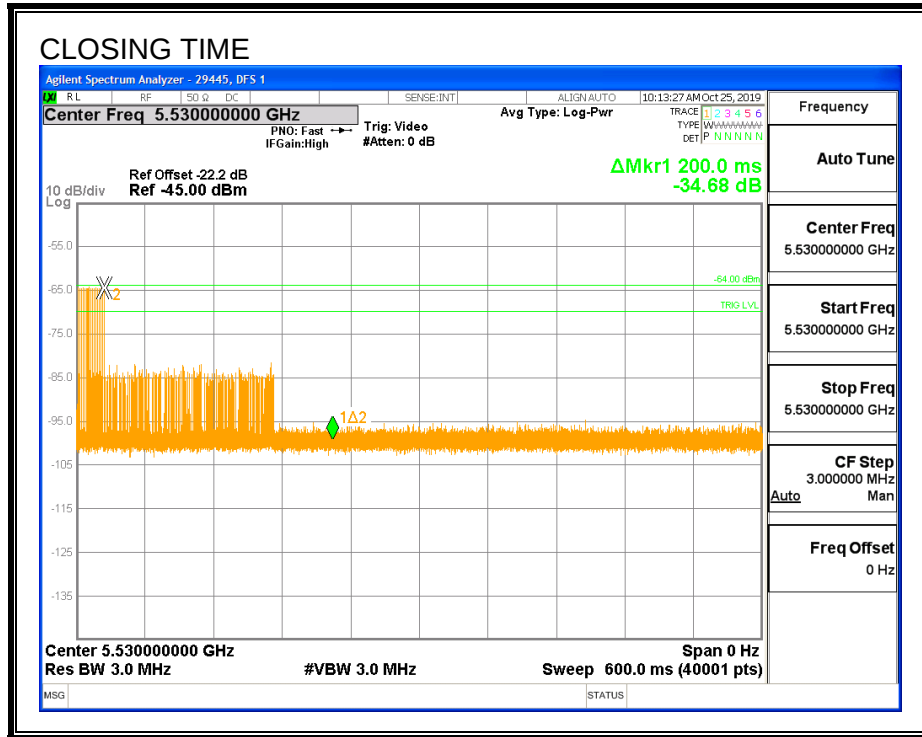
Channel Move Time (sec)	Limit (sec)
0.132	10

Aggregate Channel Closing Transmission Time (msec)	Limit (msec)
0	60

MOVE TIME



CHANNEL CLOSING TIME



AGGREGATE CHANNEL CLOSING TRANSMISSION TIME

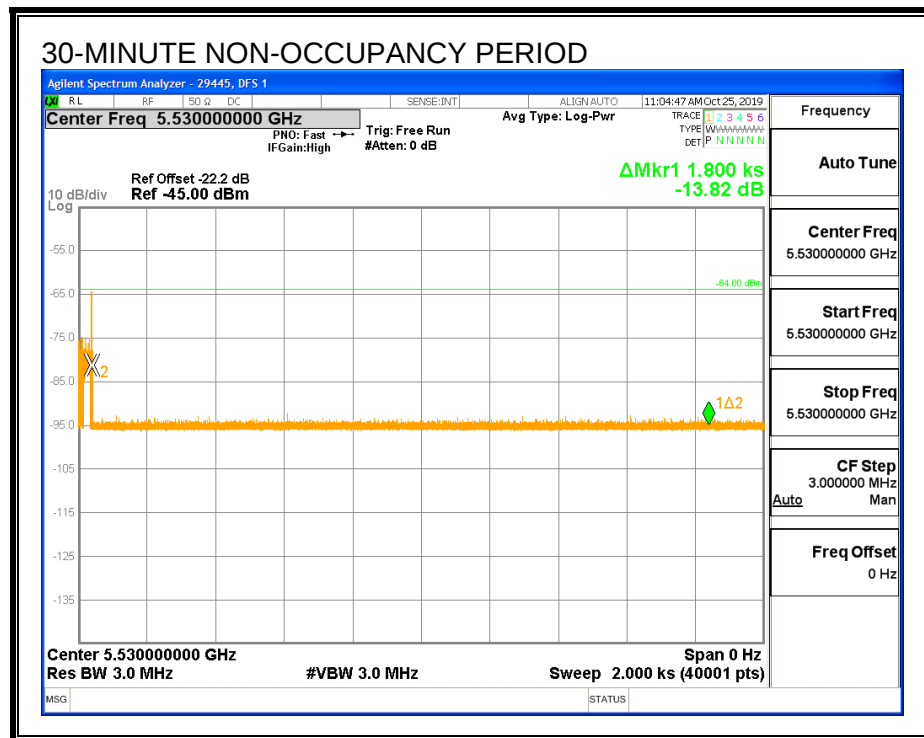
No transmissions are observed during the aggregate monitoring period.



6.13.5. 30-MINUTE NON-OCCUPANCY PERIOD

RESULTS

No EUT transmissions were observed on the test channel during the 30-minute observation time.



7. SETUP PHOTOS

Please refer to 13018918-EP1V1 for setup photos.

END OF REPORT