Cambium Networks™

Test Report

Listen Before Talk (LBT)

Test of Canopy PMP450b - 0a-00-3e-44-00-66, 3.6GHz MIMO OFDM

11/27/2019

The unrestricted contention based protocol for devices operating in the 3650 – 3700 MHz under Part 90Z of the FCC rules permit operation on a co-channel with like systems (similar systems) and unlike systems.

This report was prepared by:			
First and Last Names	**Title**	**Date**	**Signature**
Pavel Polyakov	Senior Staff Engineer, SIT	27 Nov 2019	Pavel Polyakov

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1. Customer Information

Company name:	Cambium Networks Ltd.
Address:	3800 Golf Road, Suite 360, Rolling Meadows, IL 60008 United States of America

2. Summary of Testing

2.1 General Information

Specification Reference:	Section 90.7 of Part 90Z of the US FCC rules
Specification Description of Contention Based Protocol (CBP):	A protocol that allows multiple users to share the same spectrum by defining the events that must occur when two or more transmitters attempt to simultaneously access the same channel and establishing rules by which a transmitter provides reasonable opportunities for other transmitters to operate. Such a protocol may consist of procedures for initiating new transmissions, procedures for determining the state of the channel (available or unavailable), and procedures for managing retransmissions in the event of a busy channel. The 'Listen Before Talk' (LBT) operational procedure is the most well-known Contention-based Protocol (CBP)
Test Dates:	27 November 2019

2.2 Summary of Test Results

Reference	Part	Measurement	Result
Section 90.7 of US FCC rules	Part 90Z	Verification of Unrestricted Contention Based Protocol operation	PASSED

Notes:

1) The Device Under Test (DUT) is operating in OFDM mode in the 3.65 – 3.70 GHz frequency band.

2) The DUT was operating in the following channel bandwidths: 5/7/10/15/20/30/40 MHz.

2.3 Methods and procedures

Reference:	Section 90.7 of Part 90 of the US FCC rules
Title:	Private land mobile radio services

3. Equipment Under Test (EUT)

3.1 Identification of Equipment Under Test (EUT)

Brand Name:	Cambium Networks
Model Name:	PMP 450b
MAC Address:	0a-00-3e-44-00-66
Software Version Number:	CANOPY 16.1.1 (Build SIT-7)

3.2 Description of EUT

The device can be configured in several different ways: Access Point or Subscriber Module in Point to Multipoint topology; or Backhaul - Timing Master or Timing Slave in Point to Point topology. This test is covering only Backhaul - Timing Master configuration.

3.3 Modifications Incorporated in the EUT

No modifications were made to the EUT during testing.

3.4 Additional Information Related to Testing

Technology Tested:	Unrestricted Contention Based Protocol operation: Listen Before Talk	
Type of Unit:	Backhaul - Timing Master	
Modulation:	OFDM	
External Antenna Gain:	2 dBi	
Power Supply Requirement:	Nominal	802.3af PoE Supply
Transmit & Receive Frequency Range:	3675 MHz	
Channel Bandwidth:	5/7/10/15/20/30/40 MHz	
Transmit & Receive Channel Tested:	Channel Frequency (MHz):	three per band

3.5 Support Equipment

The following support equipment was used to exercise the EUT during testing:

Description:	PTP450 Backhaul - Timing Slave
Brand Name:	Cambium Networks
Software Version Number:	CANOPY 16.1.1 (Build SIT-7)
MAC Address:	0a-00-3e-44-00-23

Description:	450i Access Point
Brand Name:	Cambium Networks
Software Version Number:	CANOPY 16.1.1 (Build SIT-7)
MAC Address:	0a-00-3e-45-11-9e

Description:	AC/DC Power Supply Unit
Brand Name:	Phihong
Model Name or Number:	PSA 15R-295(MOT)
Serial Number:	P81000498A1

Description:	AC/DC Power Supply Unit
Brand Name:	Phihong
Model Name or Number:	PSA 15R-240(MOT)
Serial Number:	P74215491A1

Description:	I.T.E Power Supply
Model Name or Number:	NU60-R550111-I3
Serial Number:	11000571371411000476

Description:	Desktop Computer
Operation System:	Windows 7 Professional, Service Pack 1
MAC Address:	68:05:CA:2A:DD:1C

Description:	Desktop Computer
Operation System:	Windows 7 Professional, Service Pack 1
MAC Address:	68:05:CA:2A:DD:1A

Description:	Apple laptop
Model Name or Number:	MacBook Air
Serial Number:	C02PJJV3GFWM

4. Operation and Monitoring of the EUT during Testing

4.1 Operating Modes

The EUT was tested in the following operating modes, unless otherwise stated

- The EUT was tested as a Master unit connected to a Slave transmitting using OFDM modulation as the manufacturer declared that as a representative modulation mode for LBT testing and further declared that the modulation mode used would not impact the results.
- The EUT has two receive channels which normally connect to vertically and horizontally polarized antennas.
- The device is operating at 3675 MHz carrier frequency.
- LBT Detection Threshold (dBm) = -73 dBm/MHz + 10*log (BW) + 23 – P_T + A, where

BW is the channel bandwidth value;

P_T is the sum of the conducted transmit power Pc and the transmit antenna gain A;

A is the antenna gain.

- The device was tested with antenna gain of 2 dBi. Therefore, the target LBT Detection Threshold is following:

for BW = 40 MHz: Detection Threshold = -73 + 16 + 23 – 30 + 2 = -62 dBm.
for BW = 30 MHz: Detection Threshold = -73 + 15 + 23 – 29 + 2 = -62 dBm.
for BW = 20 MHz: Detection Threshold = -73 + 13 + 23 – 27 + 2 = -62 dBm.
for BW = 15 MHz: Detection Threshold = -73 + 12 + 23 – 26 + 2 = -62 dBm.
for BW = 10 MHz: Detection Threshold = -73 + 10 + 23 – 24 + 2 = -62 dBm.
for BW = 7 MHz: Detection Threshold = -73 + 8 + 23 – 23 + 2 = -63 dBm.
for BW = 5 MHz: Detection Threshold = -73 + 7 + 23 – 21 + 2 = -62 dBm.

4.2 Configuration and Peripherals

The EUT was tested in the following configurations(s):

- All measurements were made using a conducted link. The antenna ports gave independent access to horizontal and vertical antenna connections;
- A laptop PC was used to configure the EUT parameters during the testing using a standard web browser and via SSH. The laptop was connected to the EUT via Ethernet to set EUT parameters;
- When the system required channel loading a UDP data stream with predefined parameters was generated with iperf network testing tool. This stream was transferred from the laptop, connected to the master device (AP) to the laptop, connected to the slave device (SM).

5. Measurements, Examinations and Delivered Results

5.1 Test Results

Test Summary: CW signal was used as an interferer for unlike systems

Test Engineer:	Pavel Polyakov	**Test Dates:**	27 November 2019
Test Sample MAC Address:	0a-00-3e-44-00-66		

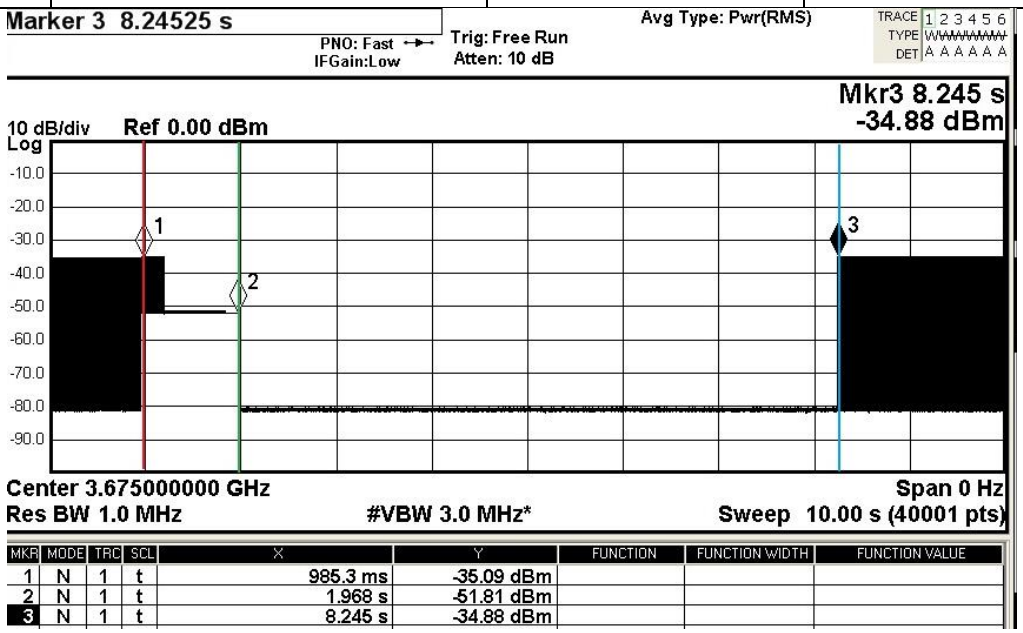
Environmental Conditions:

Temperature (°C):	27.6
Relative Humidity (%):	32

Results: CW was used as an interferer

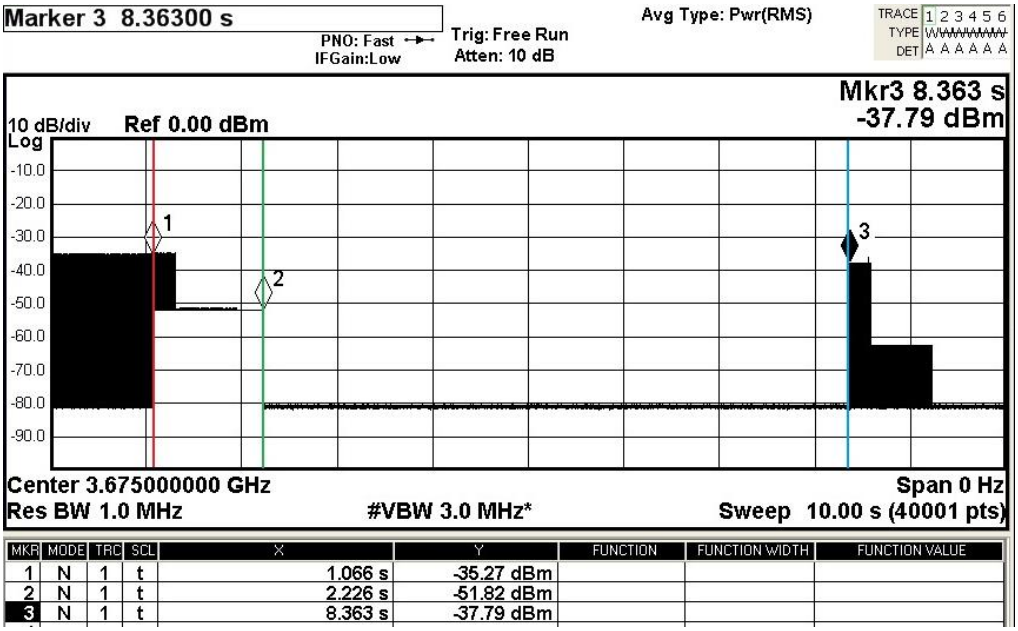
Bandwidth	TX Off at 3660 MHz	TX Off at 3675 MHz	TX Off at 3690 MHz
5 MHz	-71 dBm	-71 dBm	-71 dBm
7 MHz	-71 dBm	-71 dBm	-72 dBm
10 MHz	-71 dBm	-70 dBm	-71 dBm
15 MHz	-71 dBm	-71 dBm	-72 dBm
20 MHz	-70 dBm	-70 dBm	-71 dBm

Bandwidth	Tx Off at 3670 MHz	Tx Off at 3675 MHz	Tx Off at 3680 MHz
30 MHz	-71 dBm	-71 dBm	-72 dBm
40 MHz	-69 dBm	-70 dBm	-70 dBm



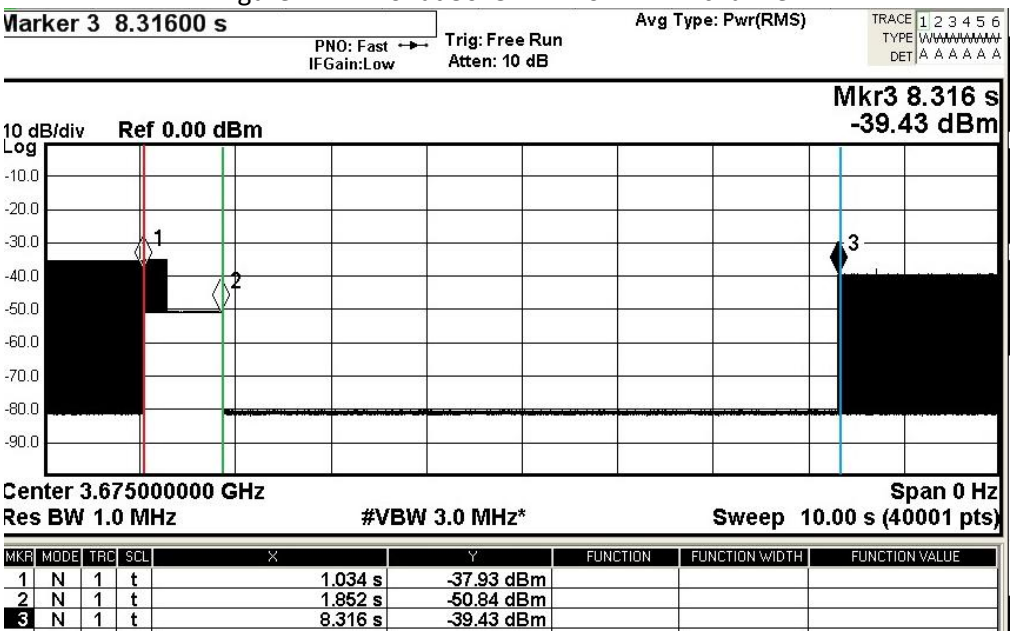
Red line – Interferer is on; Green line – Interferer is off; Blue line – TX is back on

Figure 1-1: TX of at 3675 MHz for 5 MHz channel



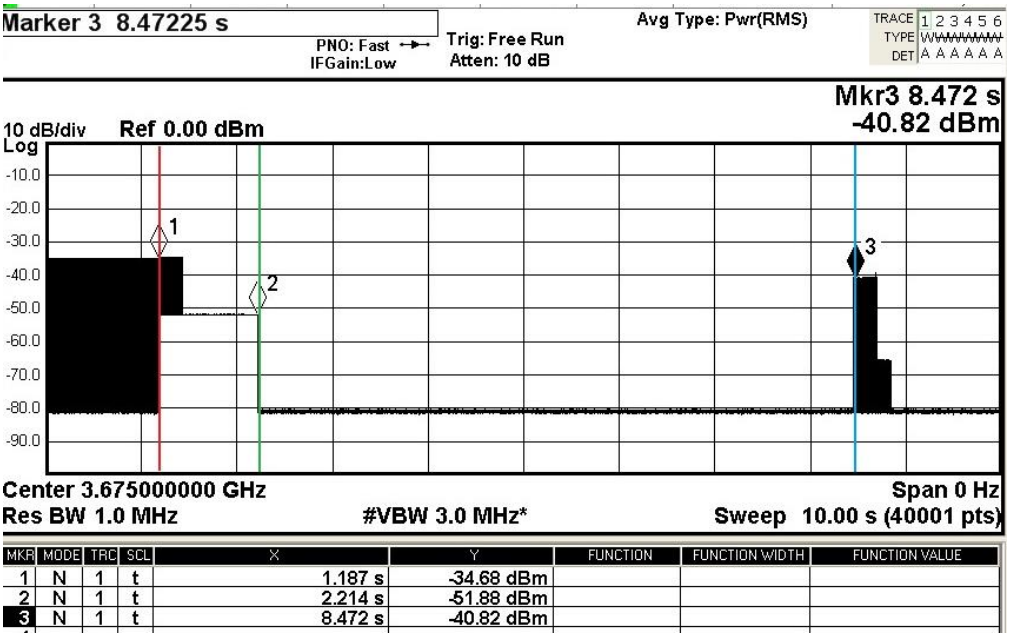
Red line – Interferer is on; Green line – Interferer is off; Blue line – TX is back on

Figure 1-2: TX of at 3675 MHz for 7 MHz channel



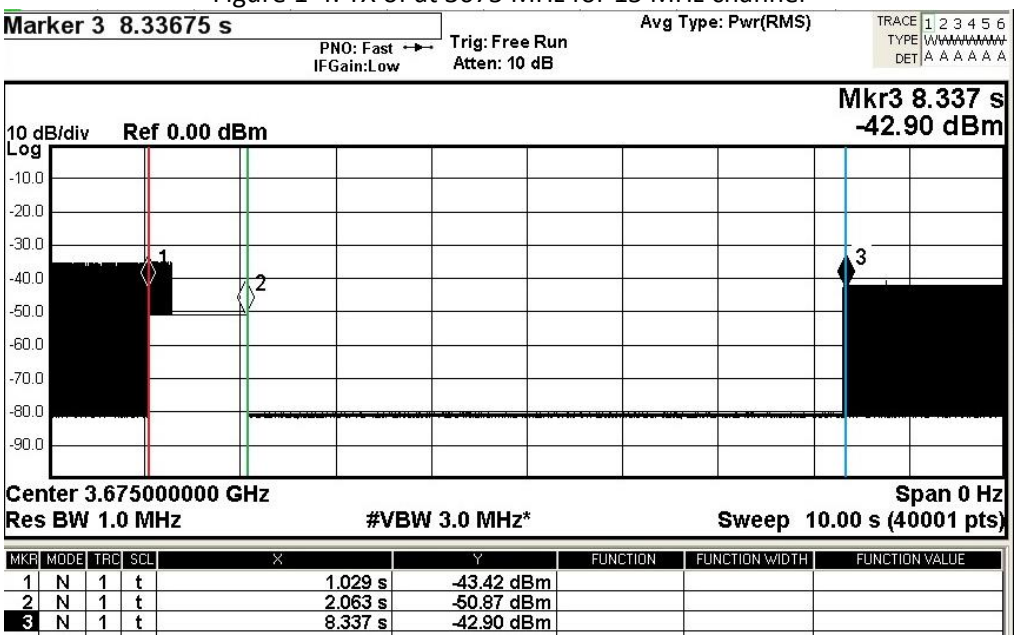
Red line – Interferer is on; Green line – Interferer is off; Blue line – TX is back on

Figure 1-3: TX of at 3675 MHz for 10 MHz channel



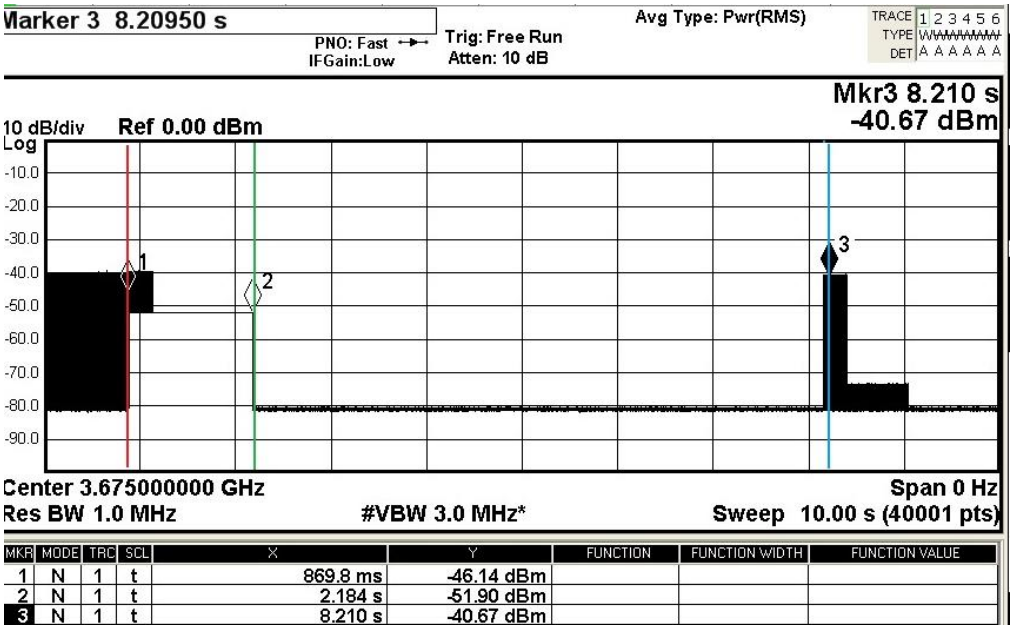
Red line – Interferer is on; Green line – Interferer is off; Blue line – TX is back on

Figure 1-4: TX of at 3675 MHz for 15 MHz channel



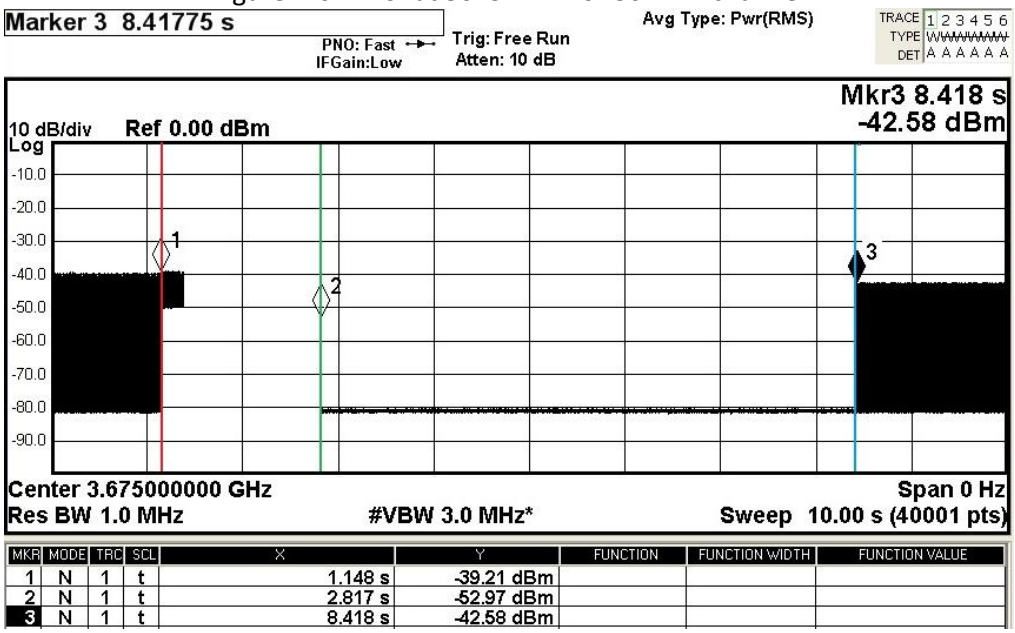
Red line – Interferer is on; Green line – Interferer is off; Blue line – TX is back on

Figure 1-5: TX of at 3675 MHz for 20 MHz channel



Red line – Interferer is on; Green line – Interferer is off; Blue line – TX is back on

Figure 1-6: TX of at 3675 MHz for 30 MHz channel



Red line – Interferer is on; Green line – Interferer is off; Blue line – TX is back on

Figure 1-7: TX of at 3675 MHz for 40 MHz channel

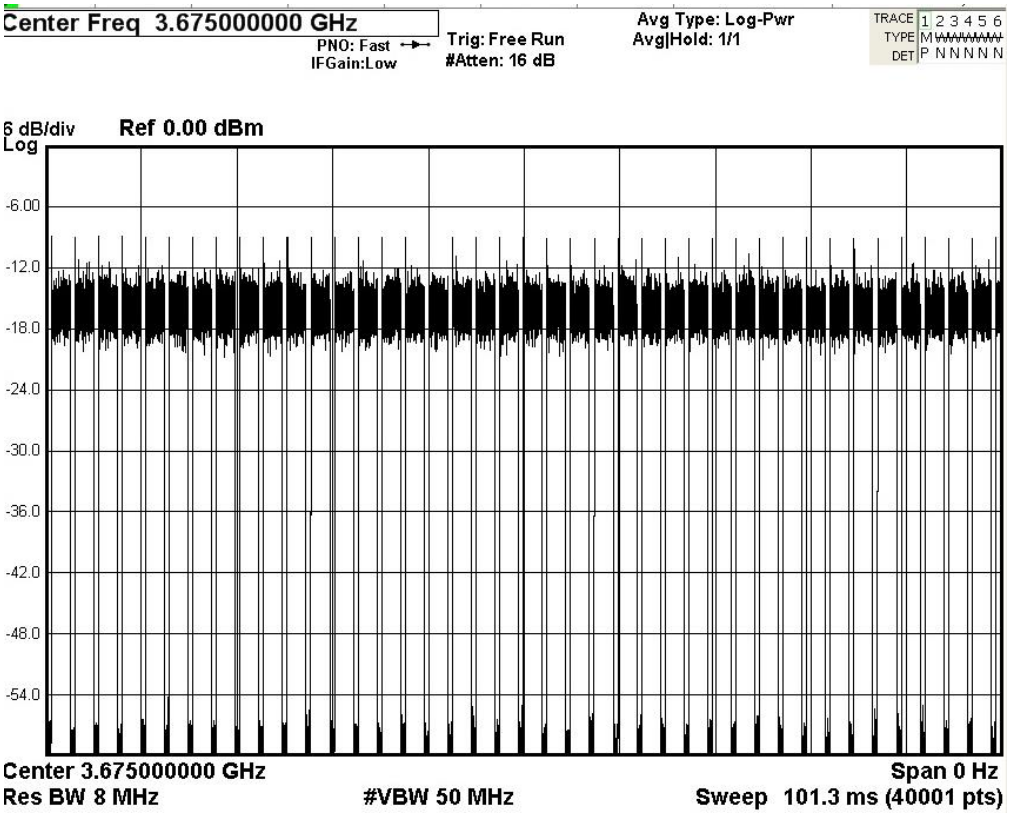
Test Summary: OFDM signal from the similar AP was used as an interferer

Test Engineer:	Pavel Polyakov	**Test Dates:**	27 November 2019
Test Sample MAC Address:	0a-00-3e-44-00-66		

Environmental Conditions:

Temperature (°C):	27.6
Relative Humidity (%):	32

450i Access Point that was used as a source of interference was configured to have 40 MHz channel bandwidth for each test case. With 2.5 ms frame the interfering signal is supposed to be turned on 100 % of the time, i.e. 2.5 ms. However, measurements showed that the actual 'on time' is less than that. Based on the calculations the time that the TX is open is 79.57 %. Please see the screenshot below:



Taking in consideration the fact that the Access Point is not transmitting 100 % of the time the time domain correction factor should be taking into the account whilst calculating the detection threshold. This correction factor is calculated based on the following equation: Factor=10*log10(Duty Cycle), for this particular case the correction factor is 10*log10(0.79) = -1.024 dB. Therefore, all the thresholds calculated earlier goes up by 1.1 dB.

Results: at 3675 MHz carrier frequency

Bandwidth	TX Off without correction factor	TX Off with correction factor
5 MHz	-61 dBm	-62.1 dBm
7 MHz	-62 dBm	-63.1 dBm
10 MHz	-61 dBm	-62.1 dBm
15 MHz	-63 dBm	-64.1 dBm
20 MHz	-62 dBm	-63.1 dBm
30 MHz	-61 dBm	-62.1 dBm
40 MHz	-61 dBm	-62.1 dBm

Appendix 1: Test Equipment Used

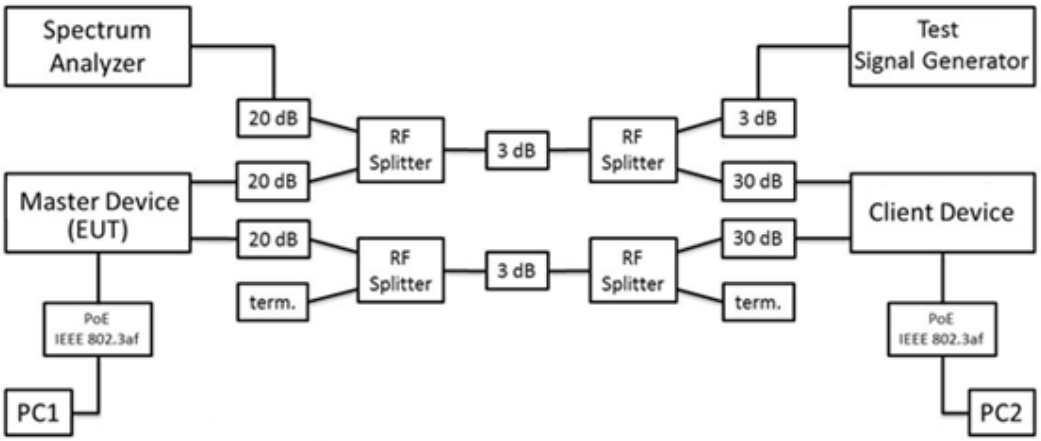
Manufacturer	Description	Model	Date Calibration Due
Agilent Technologies	MXA Signal Analyzer 20 Hz-8.4 GHz	N9020A	24 Jul 2020
Rohde & Schwarz	Vector Signal Generator	SMU200A	31 May 2020

Note: all cables, splitter and attenuators that were used for test setup were preliminary calibrated.

Appendix 2: Monitoring Methods Diagrams

All tests were performed as conducted measurements using the setups as shown below.

Setup Diagram – EUT – Master, CW signal Injection at Master. Client Device acts as a Slave Device for this scenario.



Note: for the test when a similar Canopy AP was used as an interferer, the CW Signal Generator was substituted for this AP for unlike system.