DFS TEST REPORT

Product	:	PCIE 802.11a/b/g/n/ac/ax 2.4GHz/5GHz+USB/UART BT 5.2 module
Model Name	:	ACB-QCA6391
Series Model	:	ACB-QCA6391-WX1, ACB-QCA6391-WX2, ACB-QCA6391-WX4, ACB-QCA6391-WX5, ACB-QCA6391-WI1, ACB-QCA6391-WI2, ACB-QCA6391-WI4, ACB-QCA6391-WI5
FCC ID	:	2AE3B-ACB-QCA6391
Test Regulation	:	FCC 47 CFR Part 15 Subpart E (Section 15.407)
Received Date	:	2021/5/18
Test Date	:	2023/6/1 ~ 2023/8/16
Issued Date	:	2023/9/12
Applicant	:	VOXMICRO LTD 20955 Pathfinder Rd., STE 100, Diamond Bar, California 91765, USA
Issued By	:	Underwriters Laboratories Taiwan Co., Ltd. Building A, B and E, No. 372-7, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County, Taiwan

Testing Laboratory
3398

REVISION HISTORY

Original Test Report No.: 4789913232-US-R2-V0

Revision	Test report No.	Date	Page revised	Contents
Original	4789913232-US-R2-V0	2023/9/12	-	Initial issue

Table of Contents

1. Attestation of Test Results

APPLICANT:	VOXMICRO LTD 20955 Pathfinder Rd., STE 100, Diamond Bar, California 91765, USA
MANUFACTURER:	VOXMICRO LTD 8F.-3, No.5, Aly. 22, Ln. 513, Rueiguang Rd., Neihu Dist., Taipei City 114, Taiwan
EUT DESCRIPTION:	PCIE 802.11a/b/g/n/ac/ax 2.4GHz/5GHz+USB/UART BT 5.2 module
BRAND:	AIRETOS
MODEL:	ACB-QCA6391
SERIES MODEL:	ACB-QCA6391-WX1, ACB-QCA6391-WX2, ACB-QCA6391-WX4, ACB-QCA6391-WX5, ACB-QCA6391-WI1, ACB-QCA6391-WI2, ACB-QCA6391-WI4, ACB-QCA6391-WI5
SAMPLE STAGE:	Design Verification Test sample
DATE of TESTED:	2023/6/1 ~ 2023/8/16

APPLICABLE STANDARDS	
STANDARD	**Test Results**
FCC 47 CFR PART 15 Subpart E (Section 15.407)	PASS

Underwriters Laboratories Taiwan Co., Ltd. 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 Underwriters Laboratories Taiwan Co., Ltd. based on interpretations and/or observations of test results. 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 Underwriters Laboratories Taiwan Co., Ltd. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by Underwriters Laboratories Taiwan Co., Ltd. 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.

Prepared By:

Sally Lu Date : 2023/9/12
Project Handler

Approved and Authorized By:

Eric Lee Date : 2023/9/12
Senior Laboratory Engineer

2. Test Methodology and Reference Procedures

The tests documented in this report were performed in accordance with KDB 905462 D02 UNII DFS Compliance Procedures New Rules v02, FCC KDB 905462 D06 802 11 Channel Plans v02, KDB 905462 D03 UNII Clients Without Radar Detection New Rules v01r02.

3. Facilities and Accreditation

Test Location	Underwriters Laboratories Taiwan Co., Ltd.
Address	Building A, B and E, No. 372-7, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County, Taiwan
Accreditation Certificate	Underwriters Laboratories Taiwan Co., Ltd. is accredited by TAF, Laboratory Code 3398.

4. Measurement Uncertainty

For statement of conformity, Simple acceptance (Section 4.3.4 of ISO Guide 115) was applied as decision rule for measurement in this test report.

The following uncertainties have been calculated to provide a confidence level of 95 % using a coverage factor k=2.

Determining compliance based on the results of the compliance measurement, not considering measurement instrumentation uncertainty.

Measurement	Frequency	Uncertainty
DFS Generated Signal Levels (Conducted)	5GHz - 6GHz	±2.3 dB
DFS Generated Signal Levels (Radiated)	5GHz - 6GHz	±3.7 dB

5. Equipment under Test

5.1. Description of EUT

Product	PCIE 802.11a/b/g/n/ac/ax 2.4GHz/5GHz+USB/UART BT 5.2 module
Brand Name	AIRETOS
Model Name	ACB-QCA6391
Series Model	ACB-QCA6391-WX1, ACB-QCA6391-WX2, ACB-QCA6391-WX4, ACB-QCA6391-WX5, ACB-QCA6391-WI1, ACB-QCA6391-WI2, ACB-QCA6391-WI4, ACB-QCA6391-WI5
Normal Voltage	3.7Vdc
S/N	E63B
Sample ID	3920615
Operating Frequency Range	5250~5350MHz 5470~5725MHz
Operational Mode	☐ Client with radar detection
	☒ Client without radar detection
TPC Function	☐ with TPC
	☒ without TPC
Weather Band	☒ with 5600 ~ 5650MHz
	☐ without 5600 ~ 5650MHz

Note:

1. The models difference table as below:

Brand	Model	Difference
AIRETOS	ACB-QCA6391	-
	ACB-QCA6391-WX1	Market assignment classification for application and grade finish
	ACB-QCA6391-WX2	
	ACB-QCA6391-WX4	
	ACB-QCA6391-WX5	
	ACB-QCA6391-WI1	
	ACB-QCA6391-WI2	
	ACB-QCA6391-WI4	
	ACB-QCA6391-WI5	

5.2. EUT Software and Firmware Version

Software/Firmware Version
1.0.0.1482

5.3. Support Equipment

No.	Equipment	Brand Name	Model Name	FCC ID	Remark
1	Laptop	Dell	Latatude 5490	AP2017AP6393	-
2	AP	ASUS	RT-AX88U	MSQ-RTAXHP00	-

5.4. Description of Available Antennas

Ant. No.	Transmitter Circuit	Brand Name	Model Name	Ant. Type	Maximum Gain (dBi)	Remark
1	Chain (0)+(1)	ethertronics	M830520	Chip	2.4GHz:1 5GHz: 2.6	UFL
2	Chain (0)+(1)	OXFORDTEC	WAFH-2DBI-15	FPC	2.4GHz: 2.7 5GHz: 2.6	UFL
3	Chain (0)+(1)	OXFORDTEC	WAND2DBI-SMA	Dipole	2.4GHz: 2 5GHz: 3	RP-SMA
4	Chain (0)+(1)	OXFORDTEC	WAND5DBI-SMA	Dipole	2.4GHz:3 5GHz: 5	RP-SMA
5	Chain (0)+(1)	OXFORDTEC	WAPH2DB4-15	PCB	2.4GHz:2.18 5GHz: 2.69	UFL

Note: The above antenna information was provided from customer and for more detailed features description, please refer the manufacturer's specification or user's manual, the laboratory shall not be held responsible.

5.5. EUT Maximum Conducted Power

Non-Beamforming mode

802.11a

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	17.88	61.38
5470~5725	20.49	111.94

802.11ax (HE20)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	17.91	61.80
5470~5725	21.77	150.31

802.11ax (HE40)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	17.50	56.23
5470~5725	20.88	122.46

802.11ax (HE80)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	14.60	28.84
5470~5725	16.47	44.36

Beamforming mode

802.11ax (HE20)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	14.52	28.31
5470~5725	21.66	146.56

802.11ax (HE40)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	14.83	30.41
5470~5725	20.83	121.06

802.11ax (HE80)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	14.52	28.31
5470~5725	16.38	43.45

5.6. EUT Maximum E.I.R.P. Power

Non-Beamforming mode

802.11a

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	22.88	194.09
5470~5725	25.49	354.00

802.11ax (HE20)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	22.91	195.43
5470~5725	26.77	475.34

802.11ax (HE40)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	22.50	177.83
5470~5725	25.88	387.26

802.11ax (HE80)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	19.60	91.20
5470~5725	21.47	140.28

Beamforming mode

802.11ax (HE20)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	22.53	179.06
5470~5725	29.67	926.83

802.11ax (HE40)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	22.84	192.31
5470~5725	28.84	765.60

802.11ax (HE80)

Frequency Band (MHz)	MAX. Power	
	Output Power(dBm)	Output Power(mW)
5250~5350	22.53	179.06
5470~5725	24.39	274.79

5.7. Test Condition

Test Item	Test Site No.	Environmental Condition	Input Power	Test Date	Tested by
DFS	SR4	20~26℃/ 62~68%RH	3.7Vdc	2023/06/01~ 2023/08/16	WaterNil Guan

6. Test Equipment

Test Equipment List					
Equipment	**Manufacturer**	**Model No.**	**Serial No.**	**Cal. Date**	**Expired date**
Antenna Port Conducted Measurement					
Spectrum Analyzer	Keysight	N9010A	MY56070834	2022/10/24	2023/10/23
Signal Generator	Keysight	N5182B	MY57300028	2022/11/15	2023/11/14

UL Software

Software	Test Item	Version
N7607B Signal Studio	DFS Radar Profiles	3.0.0.0
ISMointor10	DFS measurement	10.0.0.0

7. Test Result

7.1. Transmit Power Control (TPC)

Requirements

U-NII devices operating in the 5.25-5.35 GHz band and the 5.47-5.725 GHz band shall employ a TPC mechanism. The U-NII device is required to have the capability to operate at least 6 dB below the mean EIRP value of 30 dBm. A TPC mechanism is not required for systems with an e.i.r.p. of less than 500 mW.

Test Data

Applicable	EIRP	FCC 15.407 (h)(1)
	>500mW	The TPC mechanism is required for system with an EIRP of above 500mW
√	<500mW	The TPC mechanism is not required for system with an EIRP of less 500mW

7.2. Dynamic Frequency Selection (DFS)

7.2.1. Applicability of DFS Requirements

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	Yes note	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
Note: Per KDB 905462 D03 UNII Clients Without Radar Detection New Rules v01r02 section (b)(5/6), If the client moves with the master, the device is considered compliant if nothing appears in the client non-occupancy period test. For devices that shut down (rather than moving channels), no beacons should appear. An analyzer plot that contains a single 30-minute sweep on the original channel.			

Applicability of DFS Requirements during Normal Operation：

Requirement	Operational Mode	
	Master or Client with Radar Detection	Client Without Radar Detection
DFS Detection Threshold	Yes	Not required
Channel Closing Transmission Time	Yes	Yes
Channel Move Time	Yes	Yes
U-NII Detection Bandwidth	Yes	Not required

Additional requirements for devices with multiple bandwidth modes	Operational Mode	
	Master or Client with Radar Detection	Client Without Radar Detection
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 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 frequencies between the bonded 20 MHz channel blocks.		

7.2.2. DFS Detection Thresholds and Response Requirement

Below table provides the DFS Detection Thresholds for Master Devices as well as Client Devices incorporating In-Service Monitoring.

DFS Detection Thresholds for Master Devices and Client Devices With Radar Detection:

Maximum Transmit Power	Value (See Notes 1 , 2 and 3)
EIRP ≥ 200 milliwatt	-64 dBm
EIRP < 200 milliwatt and power spectral density < 10 dBm / MHz	-62 dBm
EIRP < 200 milliwatt and that do not meet the 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. Note3: EIRP is based on the highest antenna gain. For MIMO devices refer to KDB Publication 662911 D01.	

DFS Response Requirement Values：

Parameter	Value
Non-occupancy period	Minimum 30 minutes.
Channel Availability Check Time	60 seconds.
Channel Move Time	10 seconds. (See Note 1.)
Channel Closing Transmission Time	200 milliseconds + an aggregate of 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.	

7.2.3. Radar Test Waveforms

This section provides the parameters for required test waveforms, minimum percentage of successful detections, and the minimum number of trials that must be used for determining DFS conformance. Step intervals of 0.1 microsecond for Pulse Width, 1 microsecond for PRI, 1 MHz for chirp width and 1 for the number of pulses will be utilized for the random determination of specific test waveforms.

Short Pulse Radar Test Waveforms:

Radar Type	Pulse Width (µsec)	PRI (µsec)	Number of Pulses	Minimum Percentage of Successful Detection	Minimum Number of Trials
0	1	1428	18	See Note1	See Note1
1		Test A: 15 unique PRI values randomly selected from the list of 23 PRI values in Table 5a	Roundup $\left\{\left(\frac{1}{360}\right)\cdot\left(\frac{19\cdot 10^6}{\mathrm{PRI}_{\mu\mathrm{sec}}}\right)\right\}$	60%	30
		Test B: 15 unique PRI values randomly selected within the range of 518-3066 µsec, with a minimum increment of 1 µsec, 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.					

A minimum of 30 unique waveforms are required for each of the Short Pulse Radar Types 2 through 4. If more than 30 waveforms are used for Short Pulse Radar Types 2 through 4, then each additional waveform must also be unique and not repeated from the previous waveforms. If more than 30 waveforms are used for Short Pulse Radar Type 1, then each additional waveform is generated with Test B and must also be unique and not repeated from the previous waveforms in Tests A or B.

Long Pulse Radar Test Waveform:

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

The parameters for this waveform are randomly chosen. Thirty unique waveforms are required for the Long Pulse Radar Type waveforms. If more than 30 waveforms are used for the Long Pulse Radar Type waveforms, then each additional waveform must also be unique and not repeated from the previous waveforms.

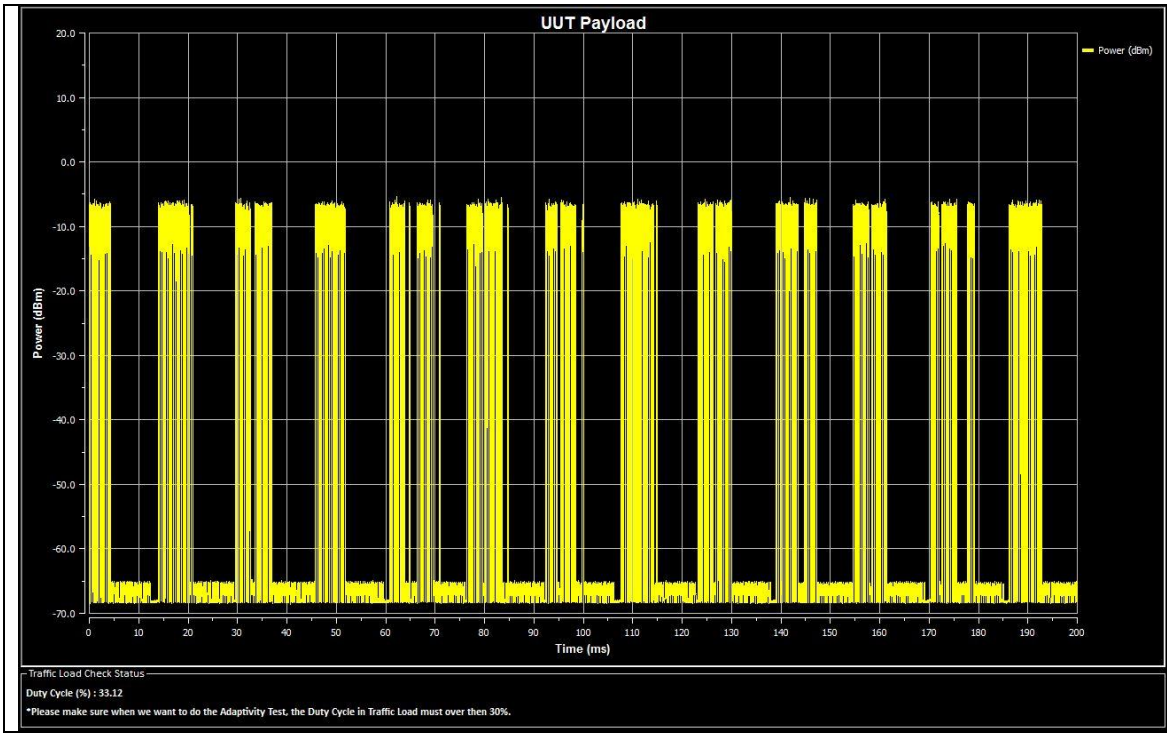
Frequency Hopping Radar Test Waveform:

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

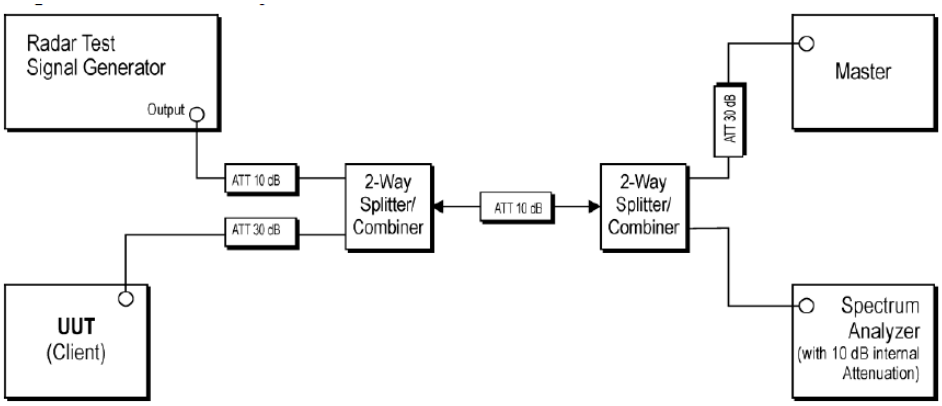
For the Frequency Hopping Radar Type, the same Burst parameters are used for each waveform. The hopping sequence is different for each waveform and a 100-length segment is selected from the hopping sequence defined by the following algorithm:The first frequency in a hopping sequence is selected randomly from the group of 475 integer frequencies from 5250 – 5724 MHz. Next, the frequency that was just chosen is removed from the group and a frequency is randomly selected from the remaining 474 frequencies in the group. This process continues until all 475 frequencies are chosen for the set. For selection of a random frequency, the frequencies remaining within the group are always treated as equally likely

7.2.4. Channel Loading / Data Streaming

	a) The data file must be of a type that is typical for the device (i.e., MPEG-2, MPEG-4, WAV, MP3, MP4, AVI, etc.) and must generally be transmitting in a streaming mode.
	b) Software to ping the client is permitted to simulate data transfer but must have random ping intervals.
V	c) Timing plots are required with calculations demonstrating a minimum channel loading of approximately 17% or greater.
	d) Unicast or Multicast protocols are preferable but other protocols may be used. The appropriate protocol used must be described in the test procedures.



7.2.5. Test Setup

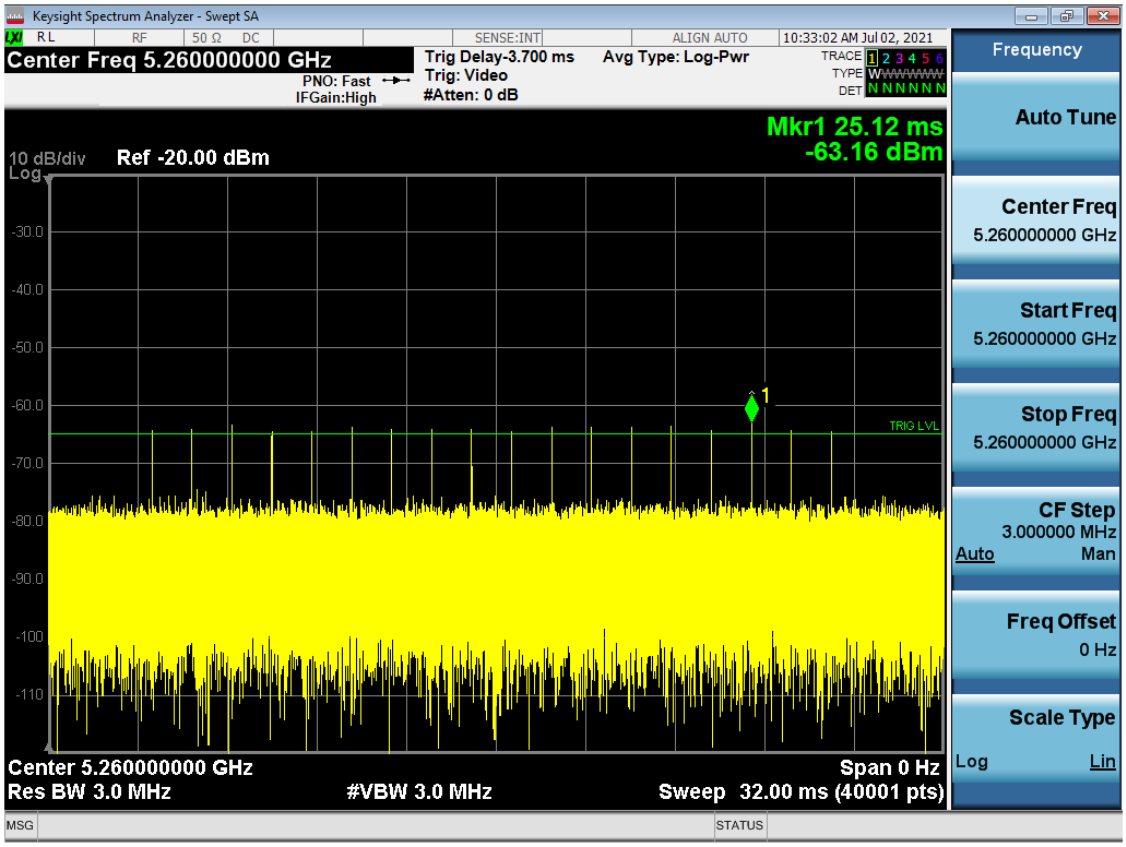


7.2.6. Test Result

DFS Detection Threshold

For detection threshold level of -64dBm, the required Radar Signal at antenna port was set to -64dBm + Ant Gain (0 dBi) + 1dB = -63 dBm. That had been taken into account the output power range and antenna gain.

Radar Signal 0

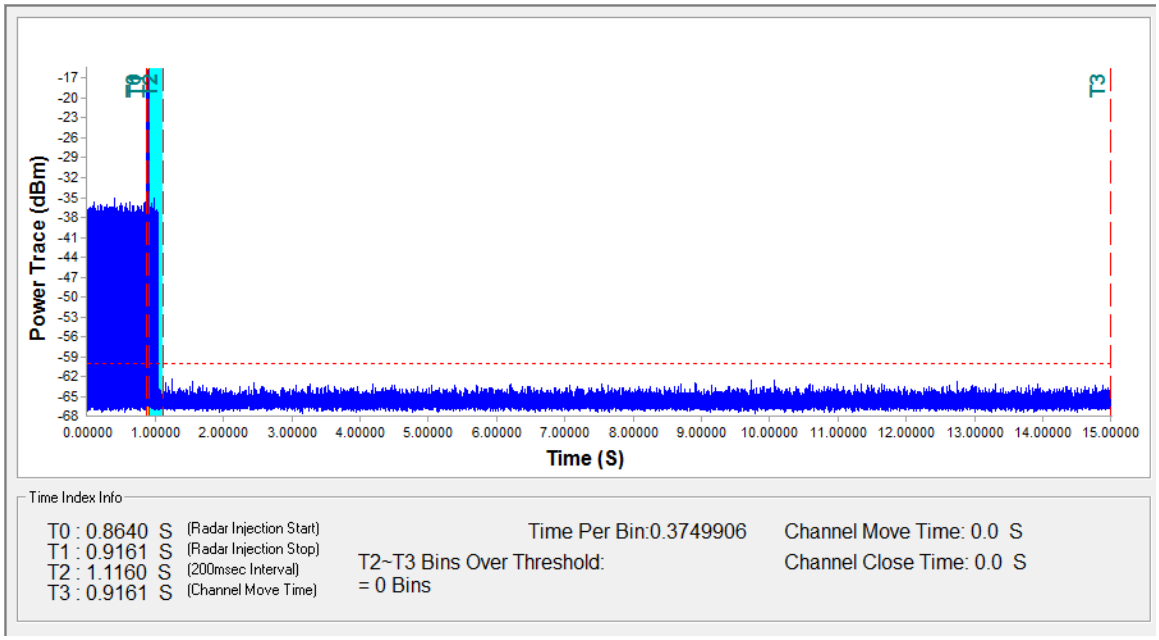


Channel Move Time & Channel Closing Transmission Time

802.11ax (HE20)

Ch52

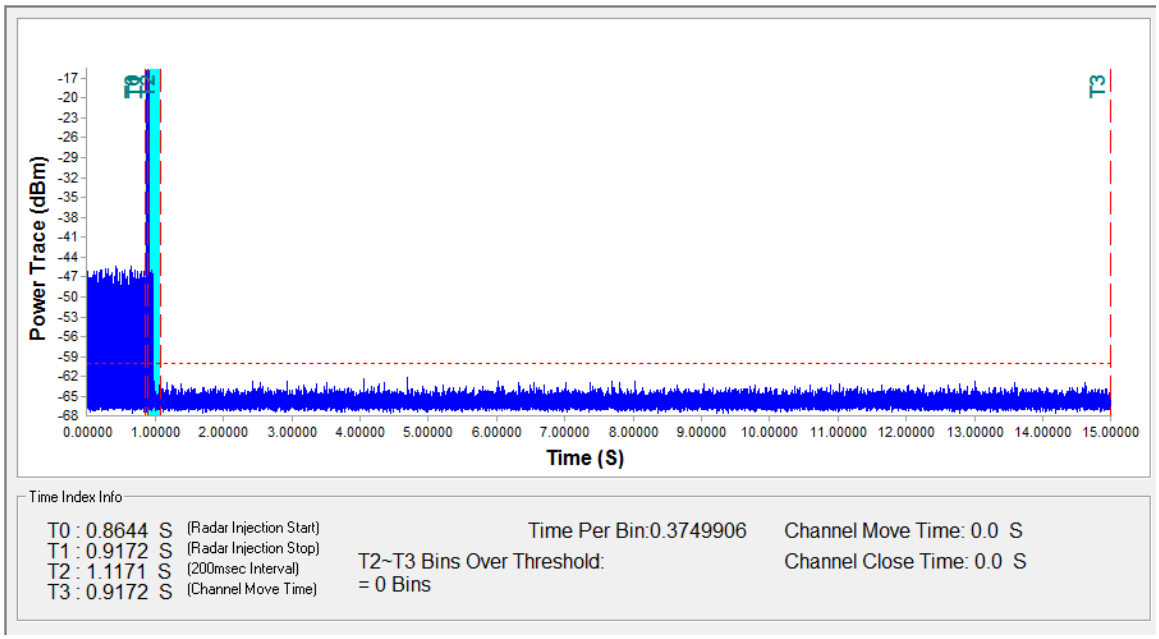
Channel Move Time(s)	Limit(s)	Result
0	10	PASS
Channel Closing Transmission Time(ms)	**Limit(ms)**	**Result**
0	60	PASS



802.11ax (HE80)

Ch58

Channel Move Time(s)	Limit(s)	Result
0	10	PASS
Channel Closing Transmission Time(ms)	**Limit(ms)**	**Result**
0	60	PASS

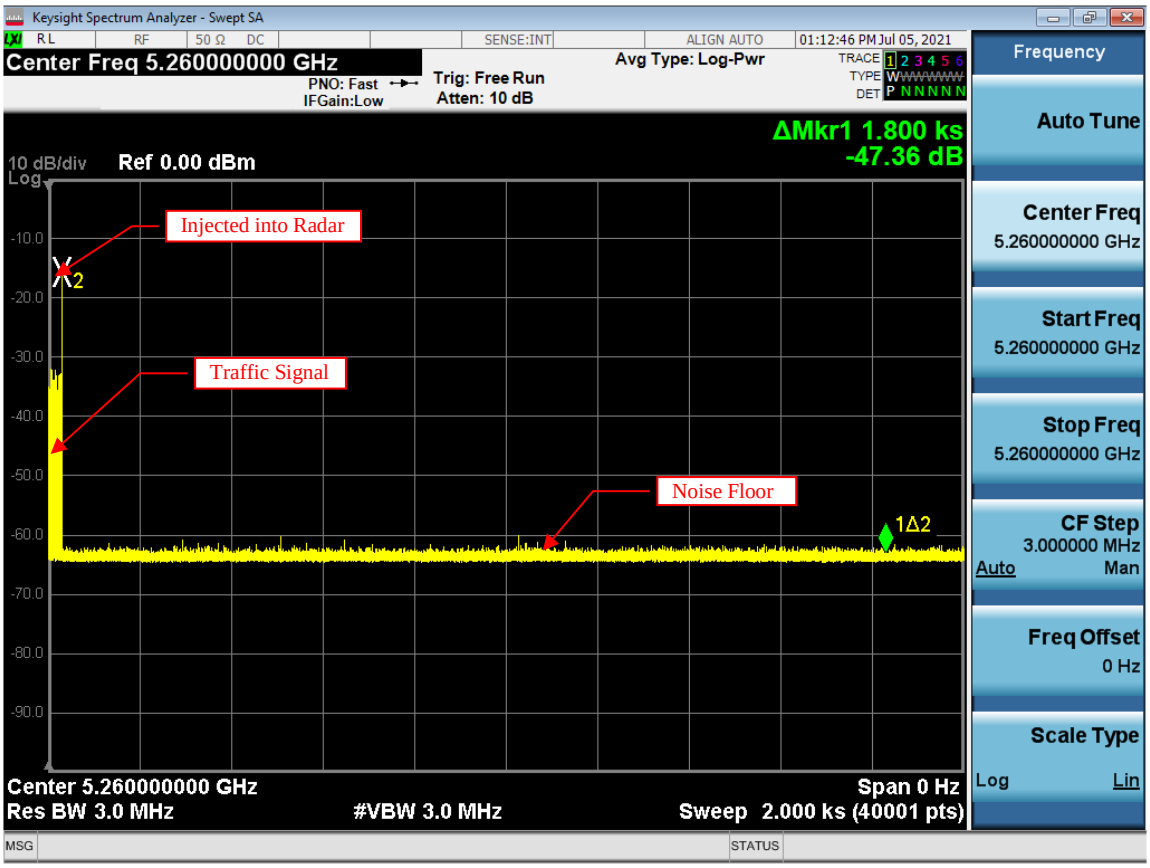


Non-Occupancy Period

During the 30 minutes observation time, UUT did not make any transmissions on a channel after a radar signal was detected on that channel by either the Channel Availability Check or the In-Service Monitoring

802.11ax (HE20)

Ch52



Note:
1. 5260MHz has been monitored in 30 minutes period. In this period, no any transmission occurs.

802.11ax (HE80)

Ch58

Note:

1. 5290MHz has been monitored in 30 minutes period. In this period, no any transmission occurs.

END OF REPORT