FCC Radio Test Report

FCC ID: 2BCGWH500

Report No.	:	BTL-FCCP-3-2404G123
Equipment	:	Smart HomeBase
Model Name	:	Tapo H500
Brand Name	:	tp-link, tapo
Applicant	:	TP-LINK CORPORATION PTE. LTD.
Address	:	7 Temasek Boulevard #29-03 Suntec Tower One, Singapore 038987
Radio Function	:	RLAN 5 GHz (U-NII 2C)
FCC Rule Part(s)	:	FCC CFR Title 47, Part 15, Subpart E (15.407) (Only DFS)
Date of Receipt	:	2024/5/31
Date of Test	:	2024/6/4 ~ 2024/6/26
Issued Date	:	2024/9/26

The above equipment has been tested and found in compliance with the requirement of the above standards by BTL Inc.

Prepared by : Poken Huang, Engineer

Approved by : Peter Chen, Manager

BTL Inc.
No.18, Ln. 171, Sec. 2, Jiuzong Rd., Neihu Dist., Taipei City 114, Taiwan
Tel: +886-2-2657-3299 Fax: +886-2-2657-3331 Web: **www.newbtl.com** Service mail: btl_qa@newbtl.com

Declaration

BTL represents to the client that testing is done in accordance with standard procedures as applicable and that test instruments used has been calibrated with standards traceable to international standard(s) and/or national standard(s).

BTL's reports apply only to the specific samples tested under conditions. It is manufacture's responsibility to ensure that additional production units of this model are manufactured with the identical electrical and mechanical components. **BTL** assumes no responsibility for the data provided by the Customer, any statements, inferences or generalizations drawn by the customer or others from the reports issued by **BTL**.

This report is the confidential property of the client. As a mutual protection to the clients, the public and ourselves, the test report shall not be reproduced, except in full, without our written approval.

BTL's laboratory quality assurance procedures are in compliance with the **ISO/IEC 17025** requirements, and accredited by the conformity assessment authorities listed in this test report.

BTL is not responsible for the sampling stage, so the results only apply to the sample as received.

The information, data and test plan are provided by manufacturer which may affect the validity of results, so it is manufacturer's responsibility to ensure that the apparatus meets the essential requirements of applied standards and in all the possible configurations as representative of its intended use.

Limitation

For the use of the authority's logo is limited unless the Test Standard(s)/Scope(s)/Item(s) mentioned in this test report is (are) included in the conformity assessment authorities acceptance respective.

Please note that the measurement uncertainty is provided for informational purpose only and are not use in determining the Pass/Fail results.

Table of Contents Page

REPORT ISSUED HISTORY

Report No.	Version	Description	Issued Date	Note
BTL-FCCP-3-2404G123	R00	Original Report.	2024/9/14	Invalid
BTL-FCCP-3-2404G123	R01	Revised report to address comments.	2024/9/26	Valid

1. SUMMARY OF TEST RESULTS

Test procedures according to the technical standard(s):

FCC CFR Title 47, Part 15, Subpart E				
Standard(s) Section	**Test Item**	**Test Result**	**Judgment**	**Remark**
FCC 15.407(h)	Dynamic Frequency Selection (DFS)	------	PASS	------

NOTE:
(1) The report format version is TP.1.1.1.

1.1 REFERENCE TEST GUIDANCE

FCC KDB 789033 D02 General UNII Test Procedures New Rules v02r01
FCC KDB 905462 D02 UNII DFS Compliance Procedures New Rules v02

1.2 TEST FACILITY

The test locations stated below are under the TAF Accreditation Number 0659.
The test location(s) used to collect the test data in this report are:
No. 72, Ln. 169, Sec. 2, Datong Rd., Xizhi Dist., New Taipei City 221, Taiwan
(FCC DN: TW0659)

1.3 TEST ENVIRONMENT CONDITIONS

Test Item	Temperature	Humidity	Test Voltage	Tested By
Dynamic Frequency Selection (DFS)	24°C	60%	AC 120 V	Cheng Tsai

2. GENERAL INFORMATION

2.1 GENERAL DESCRIPTION OF EUT

Equipment	Smart HomeBase
Brand Name	tp-link, tapo
Model Name	Tapo H500
Model Difference	N/A
Software Version	1.X
Hardware Version	1.0
Power Source	DC Voltage supplied from AC adapter. Model: T120200-2B4
Power Rating	I/P: 100-240V~ 50/60Hz 0.8A O/P:12.0V⎓2.0A
Operation Frequency Band(s)	UNII-2A: 5250 MHz ~ 5350 MHz UNII-2C: 5470 MHz ~ 5725 MHz
Modulation Type	IEEE 802.11a/n/ac: OFDM
Transfer Rate	802.11a: 54/48/36/24/18/12/9/6 Mbps 802.11n: up p to 300Mbps 802.11ac: up to 866.7 Mbps
Operational Mode	☐ Master ☐ Slave with radar detection ☒ Slave without radar detection
Maximum Output Power _UNII-2A Non Beamforming	IEEE 802.11ac(VHT40): 23.71 dBm (0.2350 W)
Output Power Max. _UNII-2C Non Beamforming	IEEE 802.11ac(VHT80): 23.97 dBm (0.2495 W)
Output Power Max. _UNII-2A Beamforming	IEEE 802.11ac(VHT80): 23.10 dBm (0.2042 W)
Output Power Max. _UNII-2C Beamforming	IEEE 802.11ac(VHT80): 23.47 dBm (0.2218 W)
Test Model	Tapo H500
Sample Status	Engineering Sample
EUT Modification(s)	N/A

Note:

1. The above EUT information is declared by manufacturer and for more detailed features description, please refers to the manufacturer's specifications or user's manual.

2. Channel List:

IEEE 802.11a IEEE 802.11n(HT20) IEEE 802.11ac(VHT20)		IEEE 802.11n(HT40) IEEE 802.11ac(VHT40)		IEEE 802.11ac(VHT80)	
UNII-2A		UNII-2A		UNII-2A	
Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
52	5260	54	5270	58	5290
56	5280	62	5310		
60	5300				
64	5320				

IEEE 802.11a IEEE 802.11n(HT20) IEEE 802.11ac(VHT20)		IEEE 802.11n(HT40) IEEE 802.11ac(VHT40)		IEEE 802.11ac(VHT80)	
UNII-2C		UNII-2C		UNII-2C	
Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
100	5500	102	5510	106	5530
104	5520	110	5550	122	5610
108	5540	118	5590	138	5690
112	5560	126	5630		
116	5580	134	5670		
120	5600	142	5710		
124	5620				
128	5640				
132	5660				
136	5680				
140	5700				
144	5720				

3. Table for Filed Antenna:

Ant.	Brand Name	P/N	Type	Connector	Gain (dBi)
1	TP-LINK CORPORATION PTE. LTD.	3101506738	Dipole	N/A	3.00
2	TP-LINK CORPORATION PTE. LTD.	3101506739	Dipole	N/A	3.00

Note:

1) This EUT supports CDD, and all antennas have the same gain, Directional gain = G_{ANT}+Array Gain. For power measurements, Array Gain=3.00dB (N_{ANT}≤4), so the Directional gain=3.00. For power spectral density measurements, N_{ANT}=4, N_{SS} = 1. So the Directional gain=G_{ANT}+Array Gain=G_{ANT}+10log(N_{ANT}/ N_{SS})dBi=3.00+10log(2/1)dBi=6.01. Then, the UNII-1 power spectral density limit is 17-(6.01-6)=16.99. the UNII-2A, UNII-2C power spectral density limit is 11-(6.01-6)=10.99, the UNII-3 power spectral density limit is 30-(6.01-6)=29.99.
2) Beamforming Gain: 3.00dB, so the Directional gain=3.00+3.00=6.00dB.
3) The above Antenna information are derived from the antenna data sheet provided by manufacturer and for more detailed features description, please refer to the manufacturer's specifications, the laboratory shall not be held responsible.

4. Table for Antenna Configuration:

For Non Beamforming:

Operating Mode / TX Mode	2TX
IEEE 802.11a	V (Ant. 1+Ant. 2)
IEEE 802.11ac (VHT20)	V (Ant. 1+Ant. 2)
IEEE 802.11ac (VHT40)	V (Ant. 1+Ant. 2)
IEEE 802.11ac (VHT80)	V (Ant. 1+Ant. 2)

For Beamforming:

Operating Mode / TX Mode	2TX
IEEE 802.11ac (VHT20)	V (Ant. 1+Ant. 2)
IEEE 802.11ac (VHT40)	V (Ant. 1+Ant. 2)
IEEE 802.11ac (VHT80)	V (Ant. 1+Ant. 2)

2.2 MAXIMUM OUTPUT POWER AND E.I.R.P.

Non Beamforming				
Frequency Band (MHz)	**Max Output Power (dBm)**	**Directional gain (dBi)**	**Max. e.i.r.p. (dBm)**	**Max. e.i.r.p. (mW)**
5250~5350	23.71	3.00	26.71	468.81
5470~5725	23.97	3.00	26.97	497.74

Beamforming				
Frequency Band (MHz)	**Max Output Power (dBm)**	**Directional gain (dBi)**	**Max. e.i.r.p. (dBm)**	**Max. e.i.r.p. (mW)**
5250~5350	23.10	6.00	29.10	812.83
5470~5725	23.47	6.00	29.47	885.12

Note:
1) 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. A TPC mechanism is not required for systems with an e.i.r.p. of less than 500 mW.

2.3 TRANSMIT POWER CONTROL (TPC)

The U-NII device is required to have the capability to operate at least 6 dB below the mean EIRP value of 30 dBm.

Beamforming

Test Mode: UNII-2A / IEEE 802.11ac(VHT20) Mode			
Channel	Frequency (MHz)	Output Power (TPC High) (dBm)	Output Power (TPC Low) (dBm)
52	5260	20.72	14.72
60	5300	22.57	16.57
64	5320	22.67	16.67

Test Mode: UNII-2A / IEEE 802.11ac(VHT40) Mode			
Channel	Frequency (MHz)	Output Power (TPC High) (dBm)	Output Power (TPC Low) (dBm)
54	5270	23.05	17.05
62	5310	22.99	16.99

Test Mode: UNII-2A / IEEE 802.11ac(VHT80) Mode			
Channel	Frequency (MHz)	Output Power (TPC High) (dBm)	Output Power (TPC Low) (dBm)
58	5290	23.10	17.10

Test Mode: UNII-2C / IEEE 802.11ac(VHT20) Mode			
Channel	Frequency (MHz)	Output Power (TPC High) (dBm)	Output Power (TPC Low) (dBm)
100	5500	23.07	17.07
116	5580	21.27	15.27
140	5700	21.83	15.83
144	5720	19.58	13.58

Test Mode: UNII-2C / IEEE 802.11ac(VHT40) Mode			
Channel	Frequency (MHz)	Output Power (TPC High) (dBm)	Output Power (TPC Low) (dBm)
102	5510	23.22	17.22
110	5550	16.36	10.36
134	5670	19.01	13.01
142	5710	18.78	12.78

Test Mode: UNII-2C / IEEE 802.11ac(VHT80) Mode			
Channel	Frequency (MHz)	Output Power (TPC High) (dBm)	Output Power (TPC Low) (dBm)
106	5530	23.20	17.20
122	5610	23.46	17.46
138	5690	23.47	17.47

2.4 DESCRIPTION OF TEST MODES

Test Mode	Description
Mode 1	IEEE 802.11a: 5500MHz
Mode 2	IEEE 802.11n(HT40): 5550MHz
Mode 3	IEEE 802.11ac(VHT80): 5290MHz

3. U-NII DFS RULE REQUIREMENTS

3.1 WORKING MODES AND REQUIRED TEST ITEMS

The manufacturer shall state whether the UUT is capable of operating as a Master and/or a Client. If the UUT is capable of operating in more than one operating mode then each operating mode shall be tested separately. See tables below for the applicability of DFS requirements for each of the operational modes.

Applicability of DFS requirements prior to use a channel

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

Applicability of DFS requirements during normal operation

Requirement	Operational Mode		
	Master	Client without radar detection	Client with radar detection
DFS Detection Threshold	√	Not required	√
Channel Closing Transmission Time	√	√	√
Channel Move Time	√	√	√
U-NII Detection Bandwidth	√	Not required	√

Additional requirements for devices with multiple bandwidth modes	Master Device 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 each of the bonded 20 MHz channels and the channel center frequency.

3.2 TEST LIMITS AND RADAR SIGNAL PARAMETERS

DETECTION THRESHOLD VALUES

DFS Detection Thresholds for Master Devices and Client Devices with Radar Detection

Maximum Transmit Power	Value (See Notes 1, 2 and 3)
e.i.r.p. ≥ 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 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: e.i.r.p. is based on the highest antenna gain. For MIMO devices refer to KDB Publication 662911 D01.

TEST LIMIT

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 UNII 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.

PARAMETERS OF DFS TEST SIGNALS

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 Note 1	See Note 1

Note 1: Short Pulse Radar Type 0 should be used for the detection bandwidth test, channel move time, and channel closing time tests.

4. MEASUREMENT INSTRUMENTS LIST

Item	Kind of Equipment	Manufacturer	Type No.	Serial No.	Calibrated Date	Calibrated Until
1	EXA Spectrum Analyzer	keysight	N9010A	MY56480554	2023/9/12	2024/9/11
2	MXG Vector Signal Generator	Keysight	N5182B	MY62220448	2023/9/14	2024/9/13
3	Keysight Singnal Studio for DFS Radar Profiles	N/A	2.0.0.0	N/A	N/A	N/A
4	InServiceMonitor Utility	N/A	11	N/A	N/A	N/A

Remark: “N/A” denotes no model name, serial no. or calibration specified.
All calibration period of equipment list is one year.

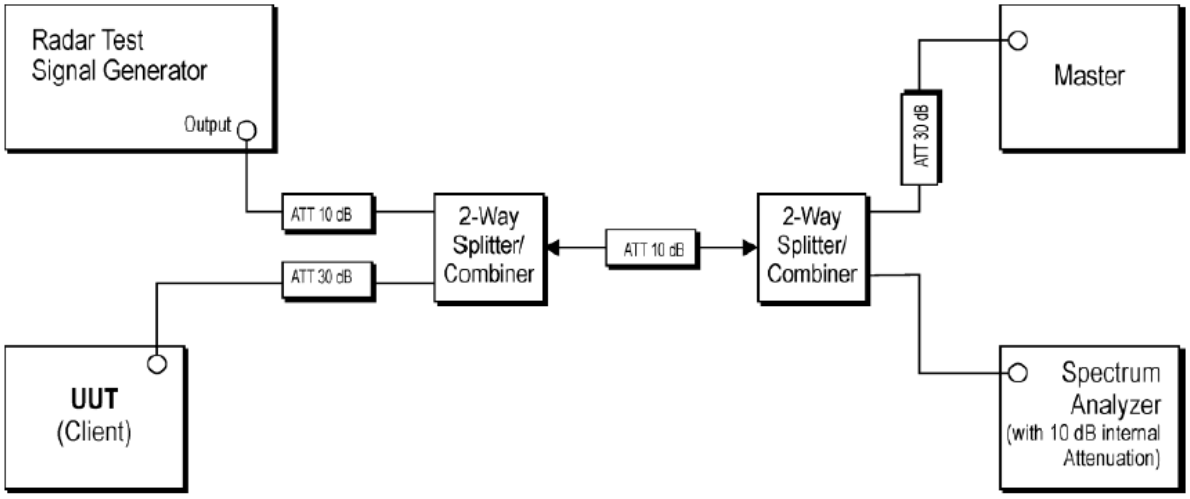
5. DYNAMIC FREQUENCY SELECTION (DFS)

5.1 DFS MEASUREMENT SYSTEM

Test Precedure

1. Master device and client device are set up by conduction method as the following configuration.
2. The client device is connected to notebook and to access a IP address on wireless connection with the master device.
3. Then the master device is connected to another notebook to access a IP address.
4. Finally, let the two IP addresses run traffic with each other through the Run flow software “Lan test” to reach 17% channel loading as below.

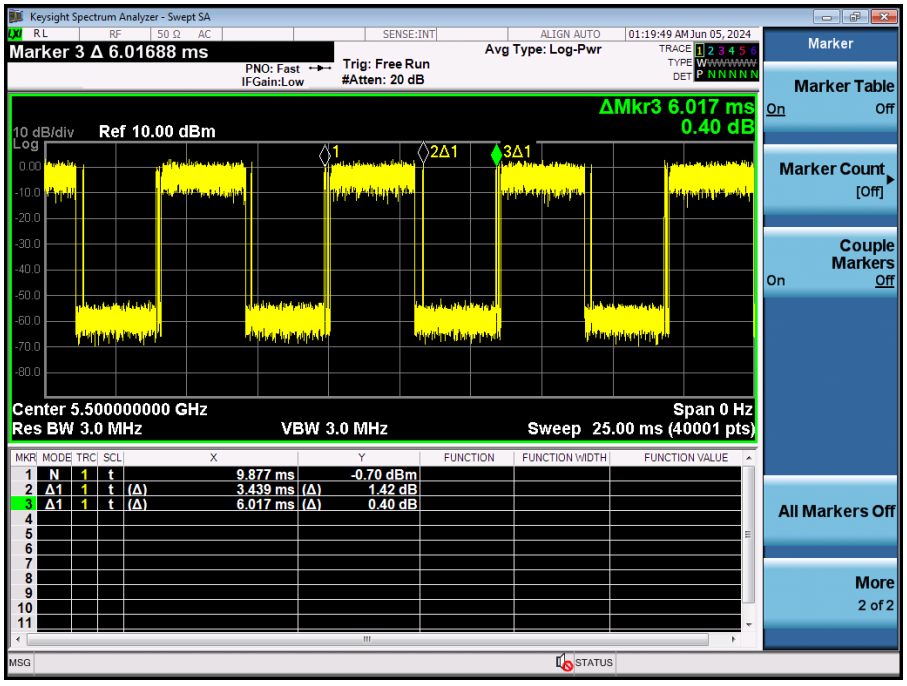
Setup for Client with injection at the Master



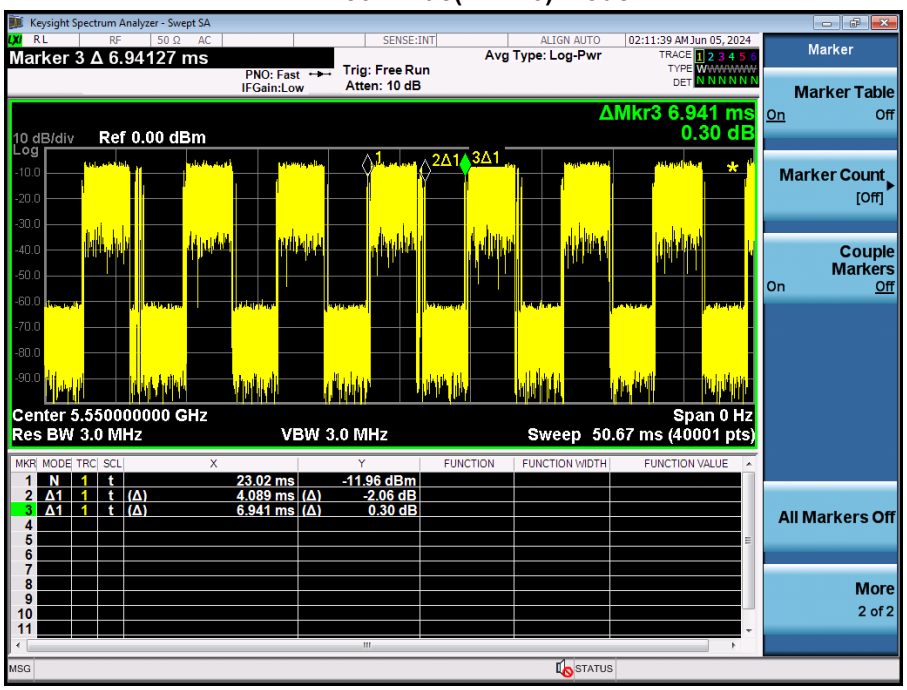
Radar Test Waveforms are injected into the Master.

Channel Loading

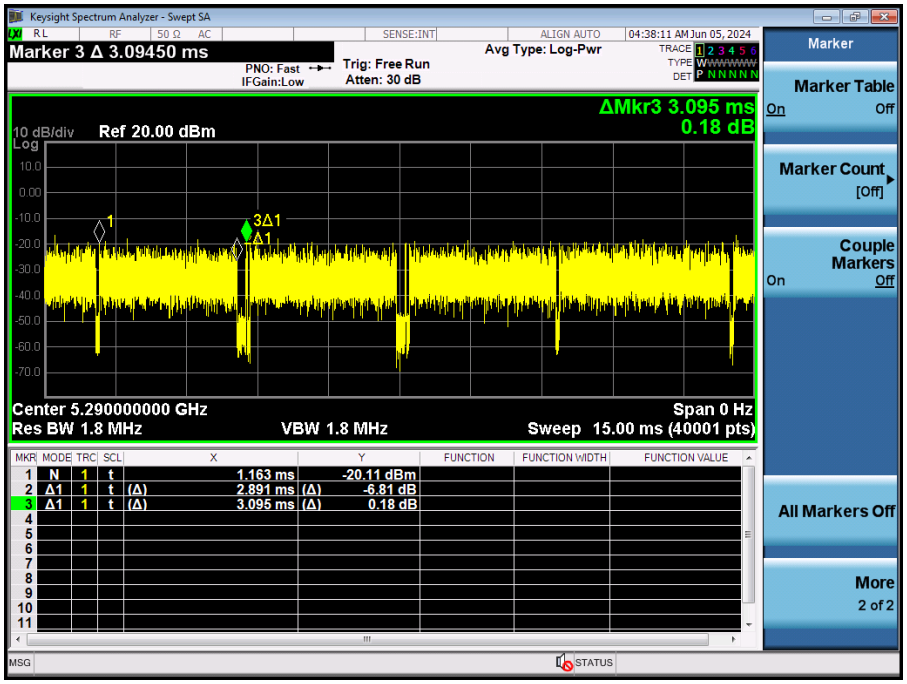
IEEE 802.11a Mode



IEEE 802.11ac(VHT40) Mode



IEEE 802.11ac(VHT80) Mode



Frequency (MHz)	Marker Delta (ms)	Number	On Time (ms)	Total Time (ms)	Duty cycle (%)	Limit (%)
5500	3.439	4	13.756	25	55.02	17
5550	4.089	7	28.623	50.67	56.49	17
5290	2.891	4	11.564	15	77.09	17

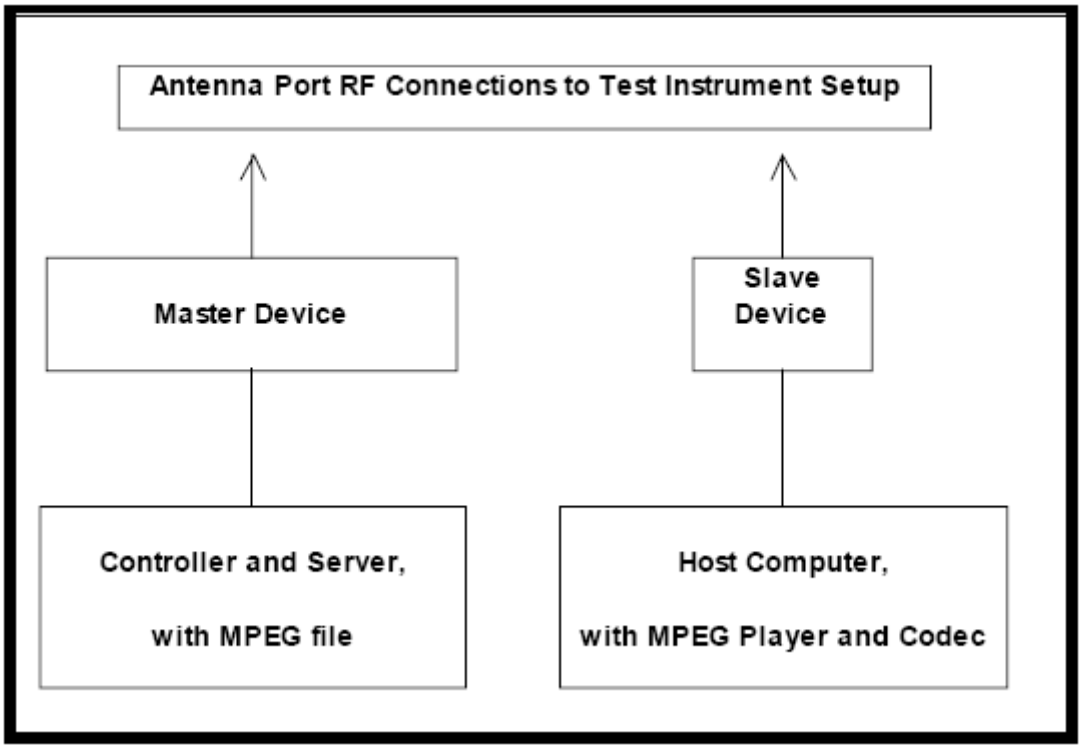
The signal monitoring equipment consists of a spectrum analyzer set to display 8001 bins on the horizontal axis. The time-domain resolution is 2 msec / bin with a 16 second sweep time, meeting the 10 second short pulse reporting criteria. The aggregate ON time is calculated by multiplying the number 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 are utilized such that there is one pad at each RF port on each EUT.

5.2 CALIBRATION OF DFS DETECTION THRESHOLD LEVEL

A 50 ohm load is connected in place of the spectrum analyzer, and the spectrum analyzer is connected in place of the master device and the signal generator is set to CW mode. The amplitude of the signal generator is adjusted to yield a level of -64dBm as measured on the spectrum analyzer.

Without changing any of the instrument settings, the spectrum analyer is reconnected to the Common port of the Spectrum Analyzer Combiner/Divider. Measure the amplitude and calculate the difference from -64 dBm. Adjust the Reference Level Offset of the spectrum analyzer to this difference.
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.
Set the signal generator to produce a radar waveform, trigger a burst manually and measure the level on the spectrum analyzer. Readjust the amplitude of the signal generator as required so that the peak level of the waveform is at a displayed level equal to the required or desired interference detection threshold. Separate signal generator amplitude settings are determined as required for each radar type.



5.3 DEVIATION FROM TEST STANDARD

No deviation.

6. TEST RESULTS

6.1 SUMMARY OF DFS TEST RESULT

Clause	Test Parameter	Remarks	Result
FCC 15.407	Channel Move Time	Applicable	Pass
	Channel Closing Transmission Time	Applicable	Pass
	Non-Occupancy Period	Applicable	Pass

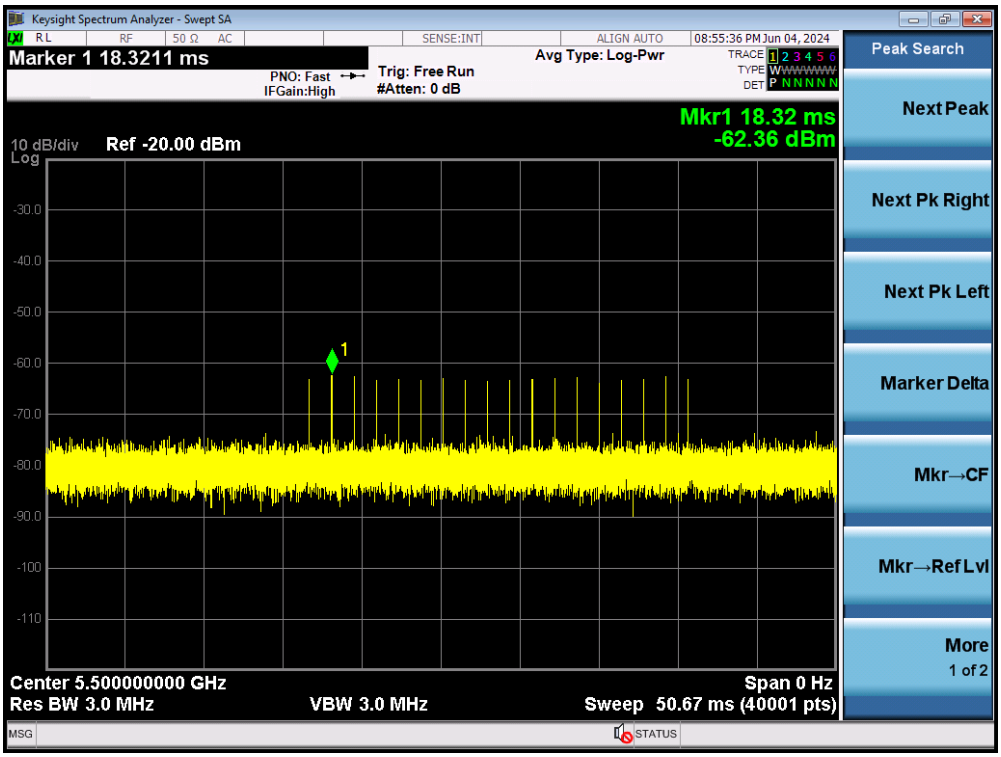
6.2 DFS DETECTION THRESHOLD

Calibration:

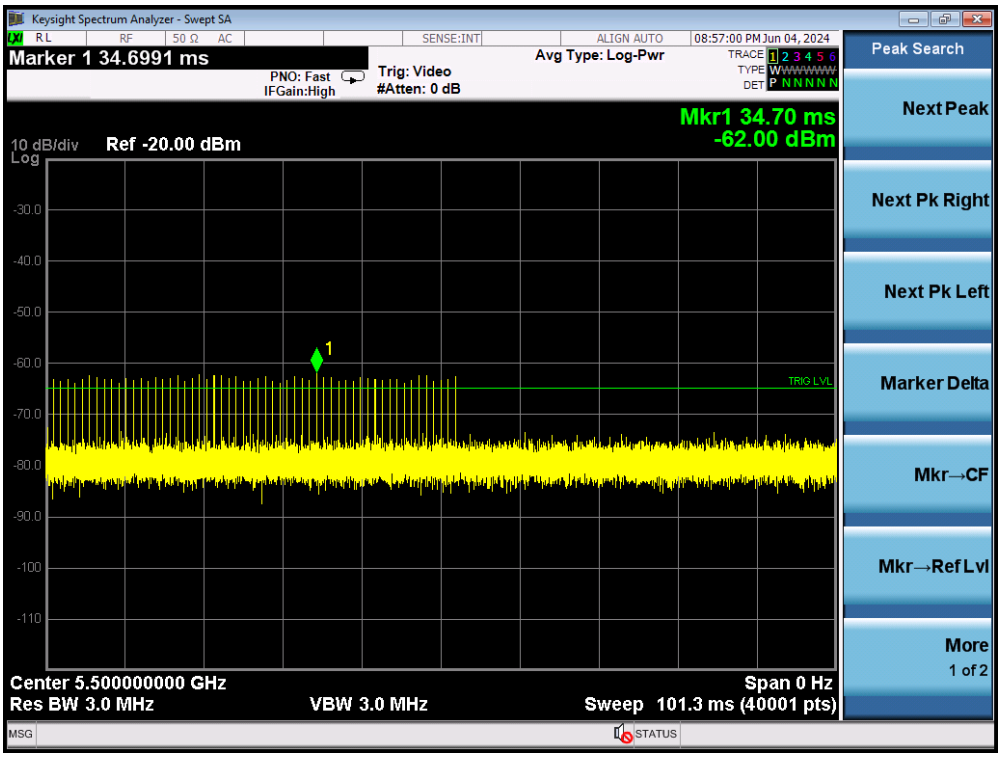
The EUT is slave equipment and it with a lowest gain is 3.00 dBi.
For a detection threshold level of -62dBm and the master antenna gain is 2.90 dBi, required detection threshold is -59.10 dBm (= -62+2.90).

Note: Maximum Transmit Power is less than 200 milliwatt in this report, so detection threshold level is -62dBm.

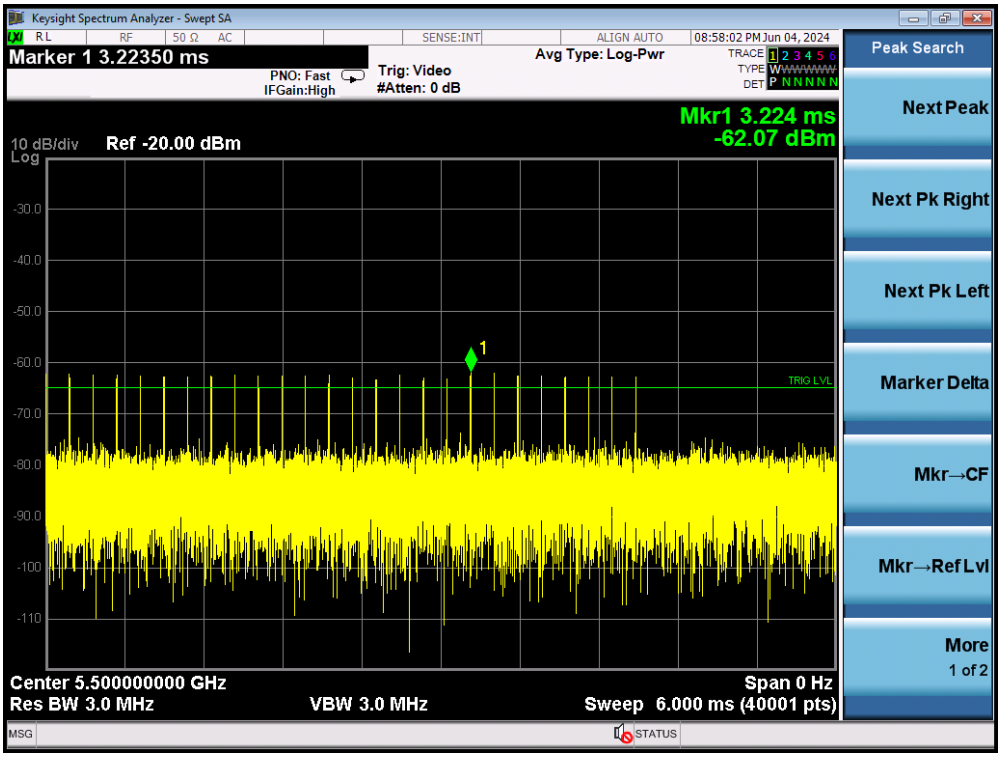
Radar Signal 0



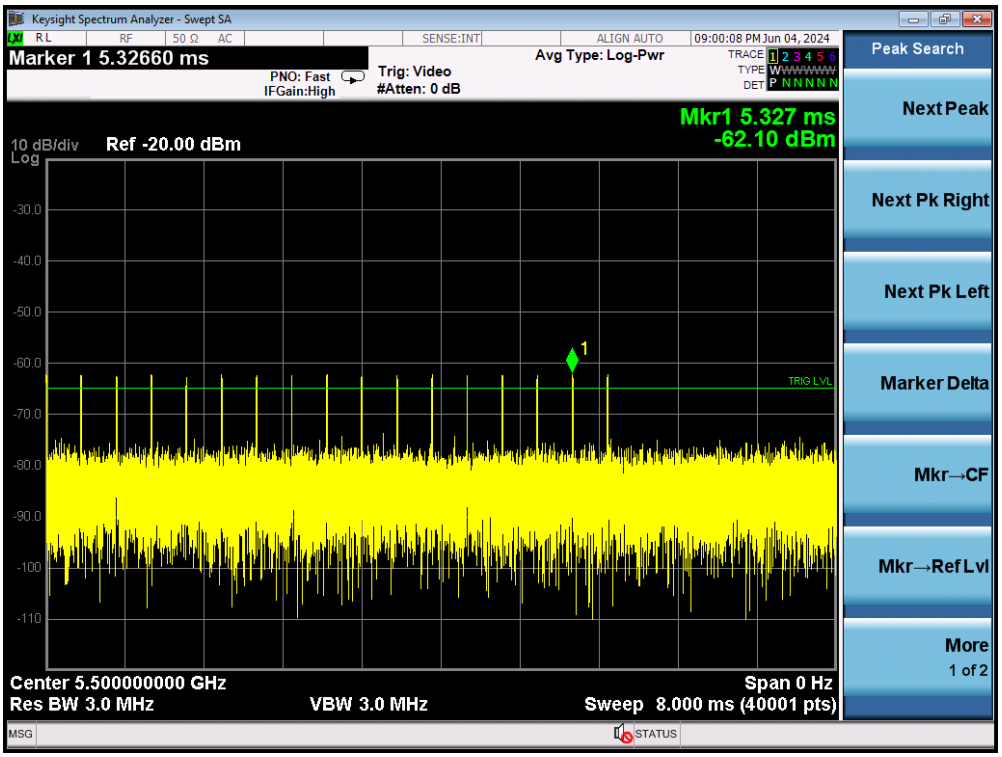
Radar Signal 1



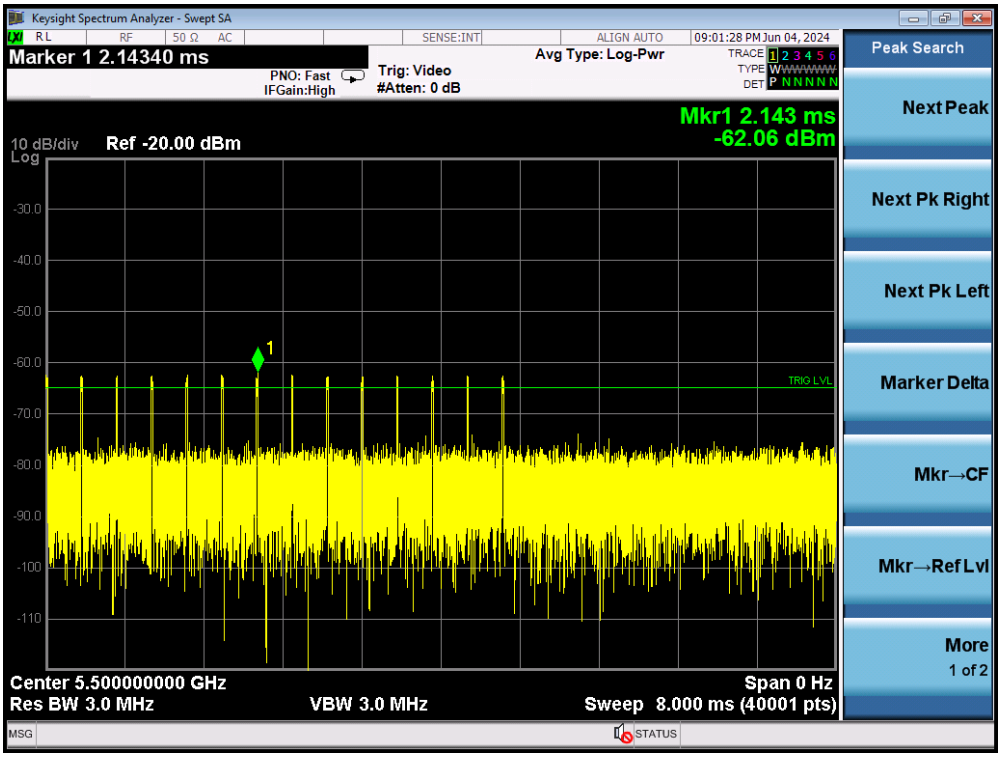
Radar Signal 2



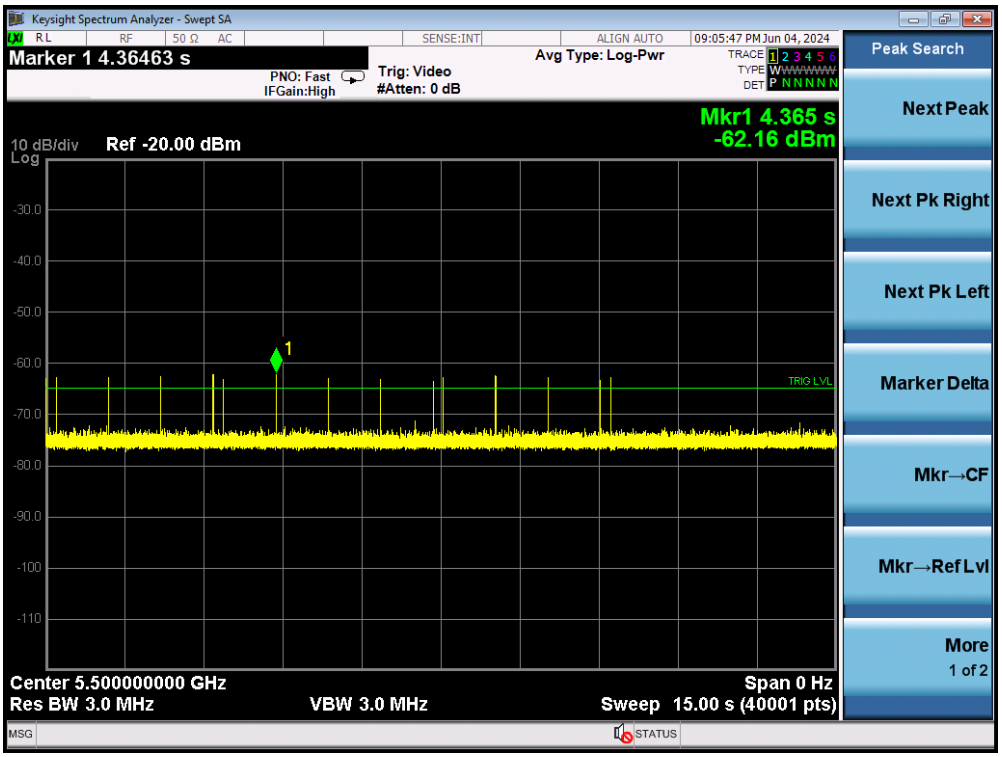
Radar Signal 3



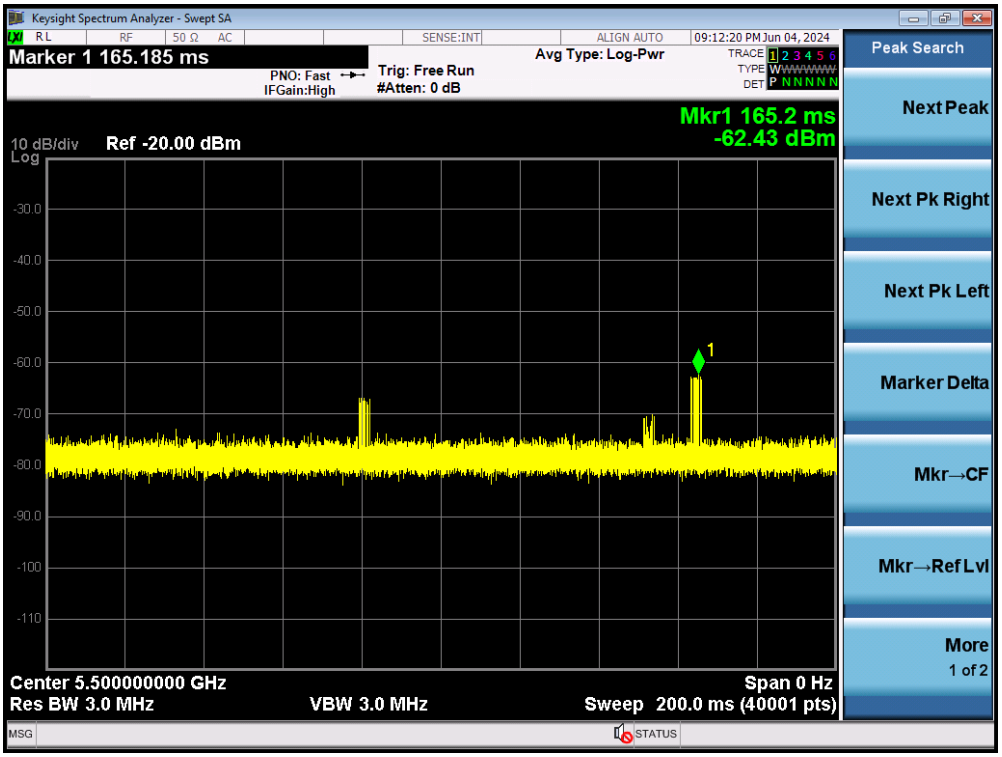
Radar Signal 4



Radar Signal 5



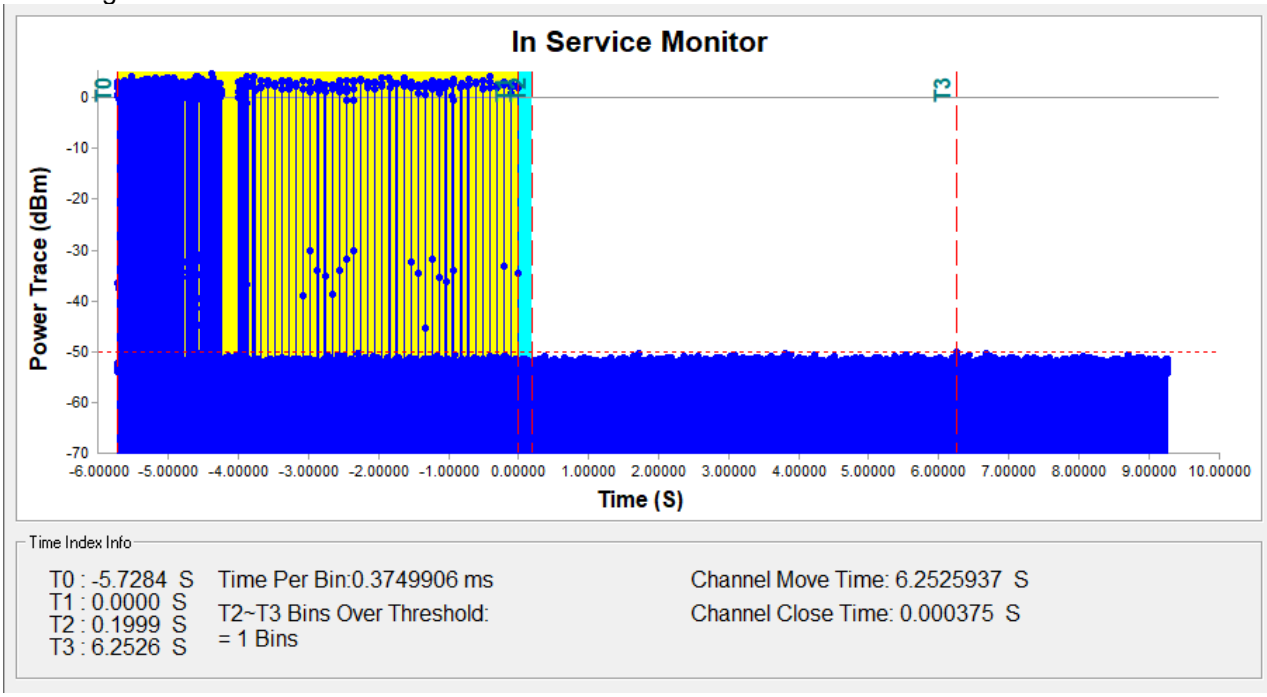
Radar Signal 5



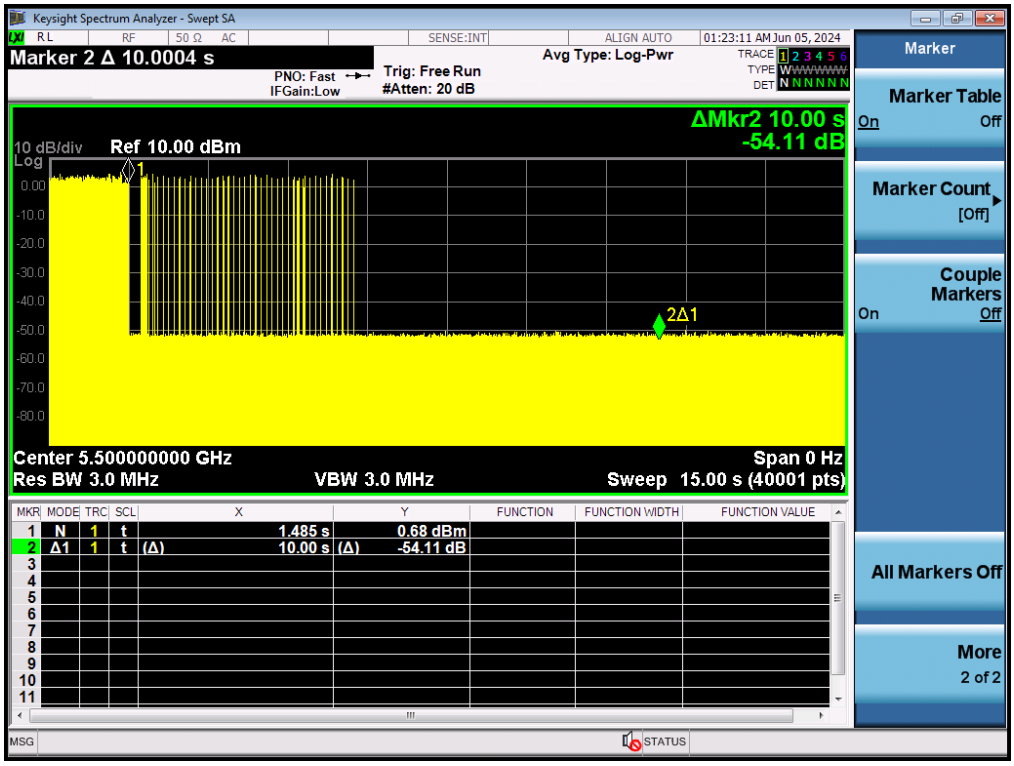
6.3 CHANNEL MOVE TIME AND CHANNEL CLOSING TRANSMISSION TIME

IEEE 802.11a Mode / 5500MHz

Radar signal 0



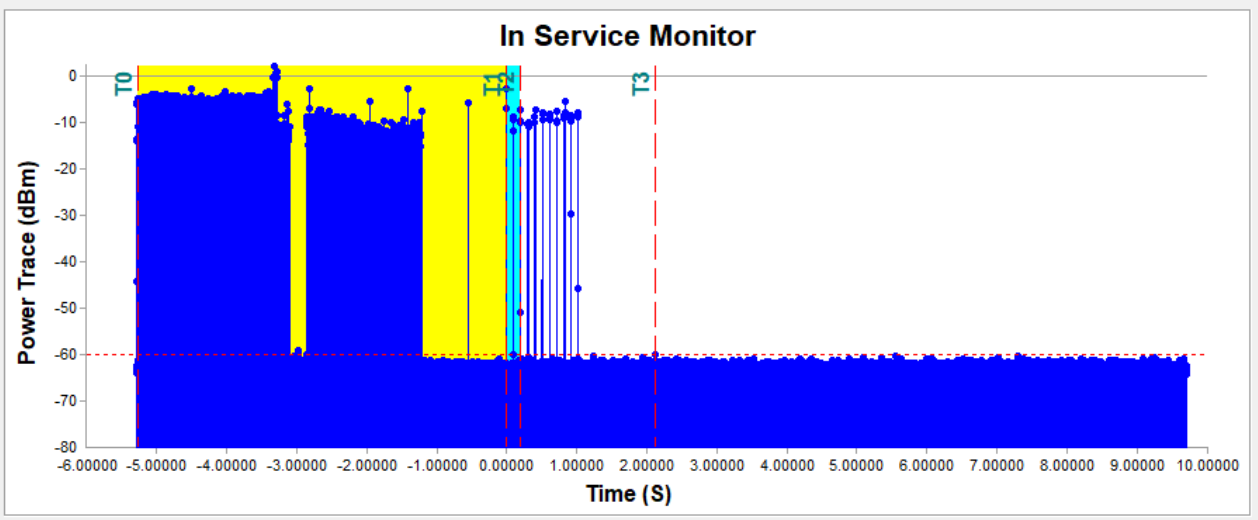
Note: T0 denotes the Radar Injection Start.
T1 denotes the start of Channel Move Time upon the end of the last Radar burst.
T2 denotes the data transmission time of 200ms from T1.
T3 denotes the end of Channel Move Time.



Note: An expanded plot for the device vacates the channel in the required 500ms.

IEEE 802.11ac (VHT40) Mode / 5550MHz

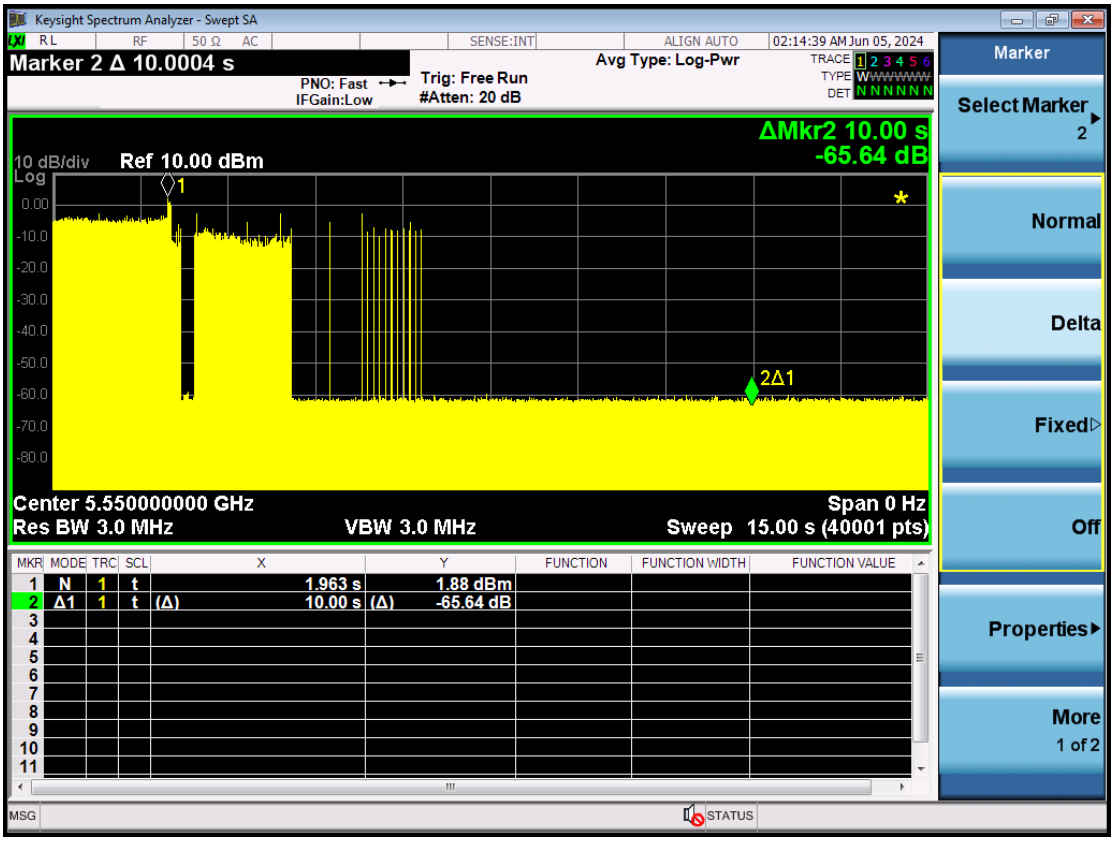
Radar signal 0



Time Index Info

T0 : -5.2596 S T1 : 0.0000 S T2 : 0.1999 S T3 : 2.1254 S	Time Per Bin:0.3749906 ms T2~T3 Bins Over Threshold: = 32 Bins	Channel Move Time: 2.1254469 S Channel Close Time: 0.0119997 S

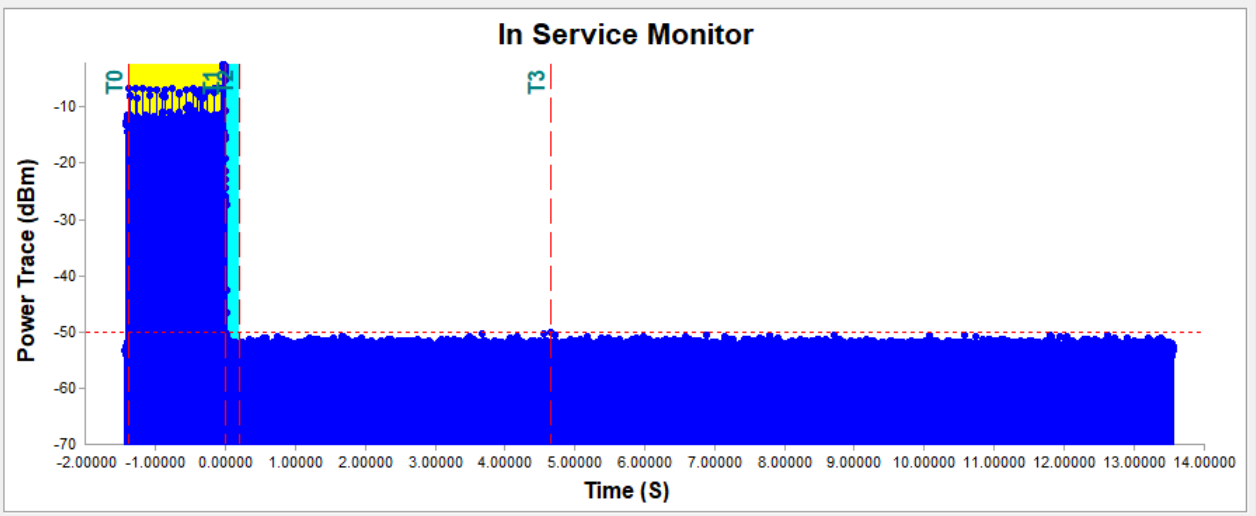
Note: T0 denotes the Radar Injection Start.
T1 denotes the start of Channel Move Time upon the end of the last Radar burst.
T2 denotes the data transmission time of 200ms from T1.
T3 denotes the end of Channel Move Time.



Note: An expanded plot for the device vacates the channel in the required 500ms.

IEEE 802.11ac(VHT80) Mode / 5290MHz

Radar signal 0



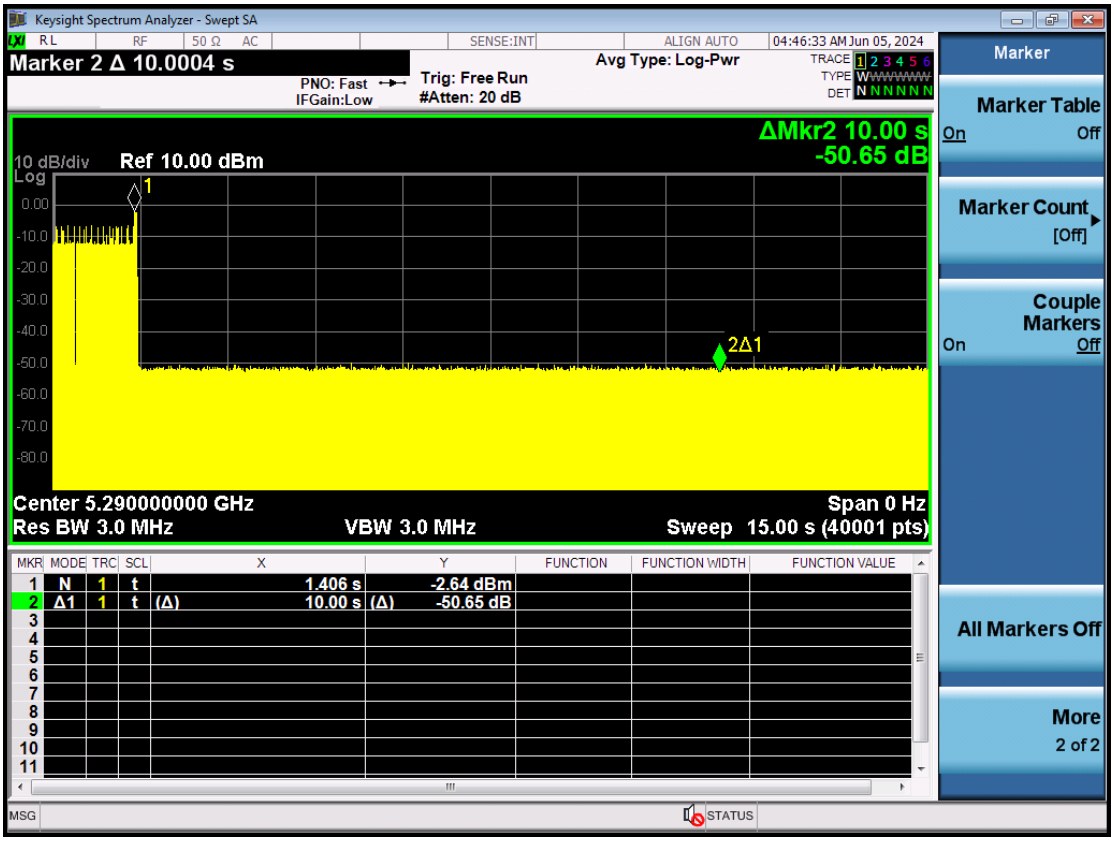
Time Index Info

T0 : -1.3867 S
T1 : 0.0000 S
T2 : 0.1999 S
T3 : 4.6461 S

Time Per Bin:0.3749906 ms
T2~T3 Bins Over Threshold:
= 1 Bins

Channel Move Time: 4.6461338 S
Channel Close Time: 0.000375 S

Note: T0 denotes the Radar Injection Start.
T1 denotes the start of Channel Move Time upon the end of the last Radar burst.
T2 denotes the data transmission time of 200ms from T1.
T3 denotes the end of Channel Move Time.



Note: An expanded plot for the device vacates the channel in the required 500ms.

IEEE 802.11a Mode		
Item	Measured Value(s)	Limit(s)
Channel Move Time	6.2525937	10
Channel Close Time	0.000375	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period.

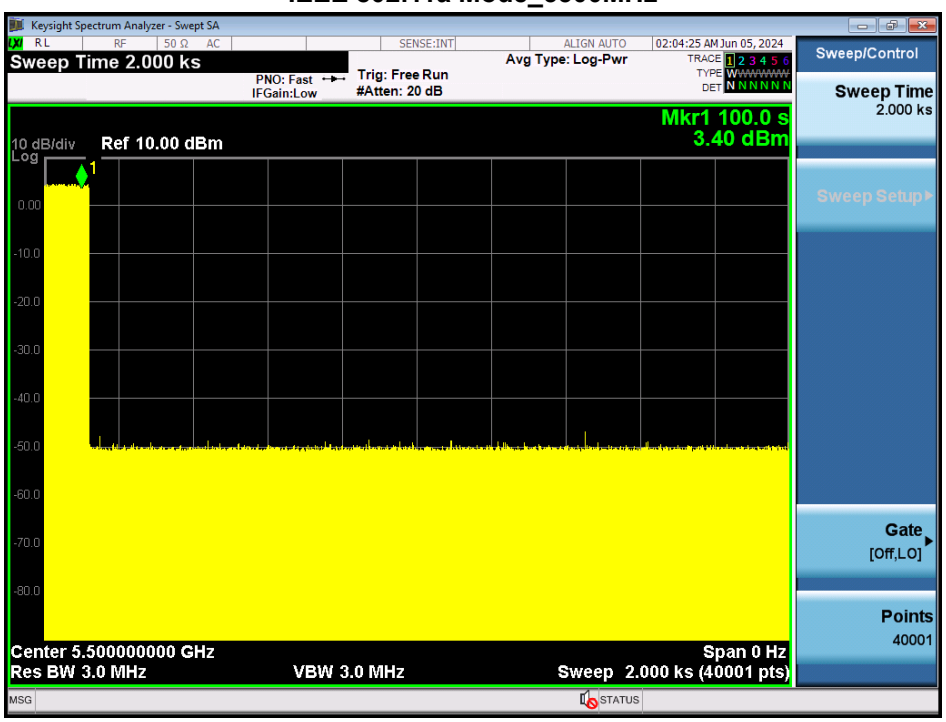
IEEE 802.11ac(VHT40) Mode		
Item	Measured Value(s)	Limit(s)
Channel Move Time	2.1254469	10
Channel Close Time	0.0119997	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period.

IEEE 802.11ac(VHT80) Mode		
Item	Measured Value(s)	Limit(s)
Channel Move Time	4.6461338	10
Channel Close Time	0.000375	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period.

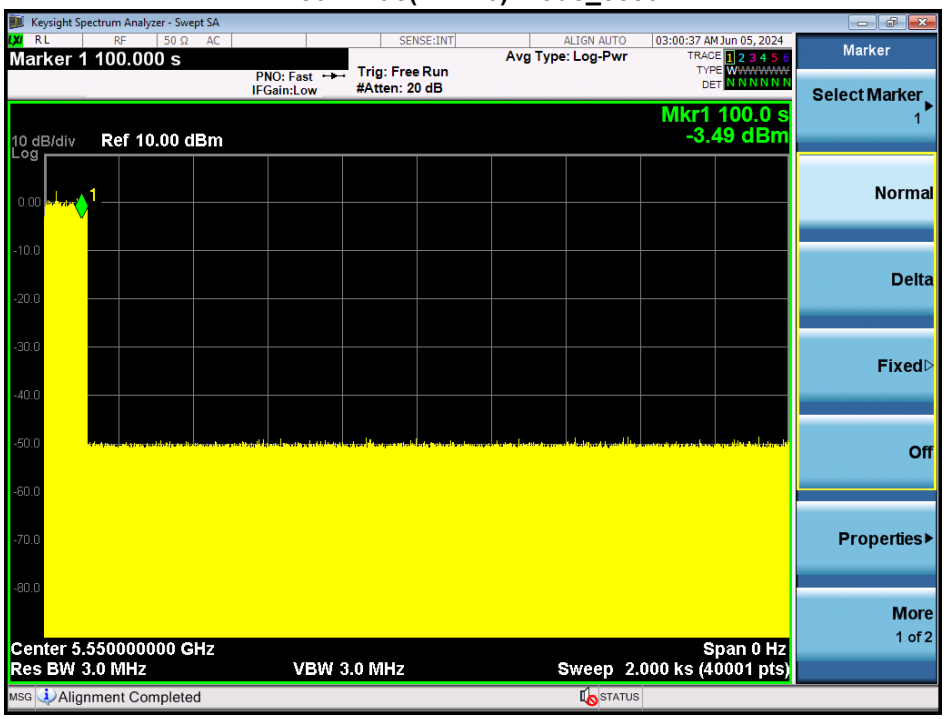
6.4 NON-OCCUPANCY PERIOD

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.

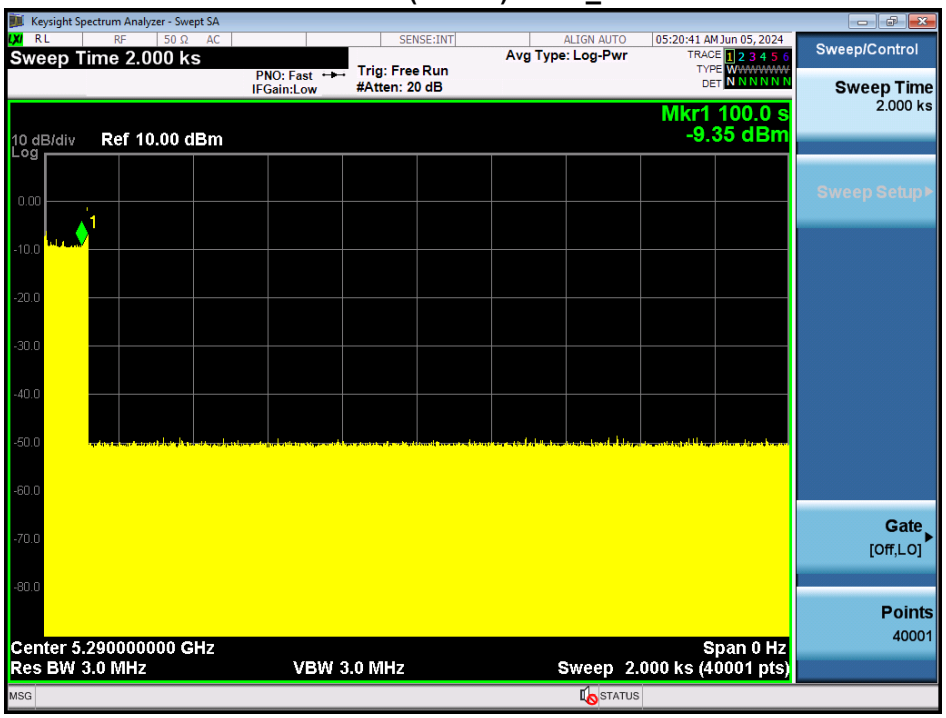
IEEE 802.11a Mode_5500MHz



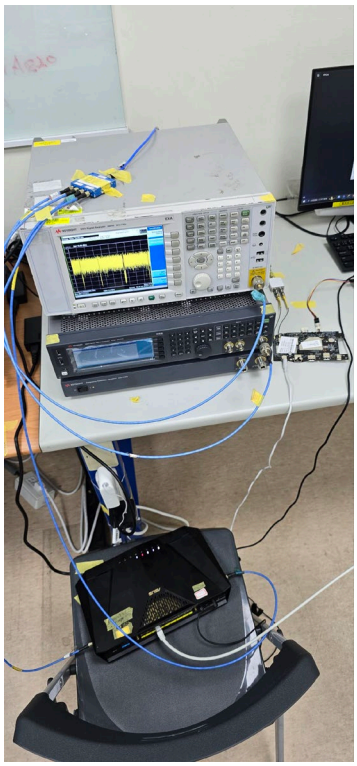
IEEE 802.11ac(VHT40) Mode_5550MHz



IEEE 802.11ac(VHT80) Mode_5290MHz



7. EUT TEST PHOTO



End of Test Report