

RF TEST REPORT

Applicant Thunder Software Technology Co., Ltd.

FCC ID 2BA4NTX11010401

Product Hyliion Drive Processor

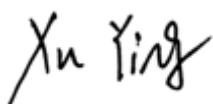
Brand HDP

Model HDP

Report No. R2306A0615-R3

Issue Date July 7, 2023

TA Technology (Shanghai) Co., Ltd. tested the above equipment in accordance with the requirements in **FCC CFR47 Part 15E (2022)**. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.



Prepared by: Xu Ying

Approved by: Xu Kai

TA Technology (Shanghai) Co., Ltd.

Building 3, No.145, Jintang Rd, Pudong Shanghai, P.R.China

TEL: +86-021-50791141/2/3

FAX: +86-021-50791141/2/3-8000

TABLE OF CONTENT

1. Test Laboratory	4
1.1. Notes of the Test Report	4
1.2. Test Facility	4
1.3. Testing Location	4
1. General Description of Equipment Under Test	5
2.1. Applicant and Manufacturer Information	5
2.2. General Information	5
3. Applied Standards	7
4. DFS Technical Requirements and Radar Test Waveforms	8
4.1. DFS Overview	8
4.2. DFS Detection Thresholds	9
4.3. Radar Test Waveforms	10
4.4. Test Set-ups	13
5. Test Case	15
5.1. DFS Detection Thresholds	15
5.2. Channel Move Time, Channel Closing Transmission Time and Non-Occupancy Period ...	16
6. Test Results	18
6.1. DFS Detection Thresholds	18
6.2. Channel Move Time, Channel Closing Transmission Time and Non-Occupancy Period ...	19
6. Main Test Instruments	23
ANNEX A: The EUT Appearance	24
ANNEX B: Test Setup Photos	25

Summary of Measurement Results

Number	Test Case	Clause in FCC rules	Verdict
1	DFS Detection Threshold	15.407/KDB 905462 5.2	Pass
2	U-NII Detection Bandwidth	15.407/KDB 905462 7.8.1	NA
3	Channel Availability Check Time	15.407/KDB 905462 7.8.2	NA
4	Channel Move Time	15.407/KDB 905462 7.8.3	Pass
5	Channel Closing Transmission Time	15.407/KDB 905462 7.8.3	Pass
6	Non-Occupancy Period(NOP)	15.407/KDB 905462 7.8.3	Pass
7	Statistical Performance Check	15.407/KDB 905462 7.8.4	NA

Date of Testing: June 16, 2023

Date of Sample Received: June 1, 2023

Note: PASS: The EUT complies with the essential requirements in the standard.

FAIL: The EUT does not comply with the essential requirements in the standard.

NA: Not applicable.

All indications of Pass/Fail in this report are opinions expressed by TA Technology (Shanghai) Co., Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only.

1. Test Laboratory

1.1. Notes of the Test Report

This report shall not be reproduced in full or partial, without the written approval of **TA technology (shanghai) co., Ltd.** The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein .Measurement Uncertainties were not taken into account and are published for informational purposes only. This report is written to support regulatory compliance of the applicable standards stated above.

1.2. Test Facility

FCC (Designation number: CN1179, Test Firm Registration Number: 446626)

TA Technology (Shanghai) Co., Ltd. has been listed on the US Federal Communications Commission list of test facilities recognized to perform electromagnetic emissions measurements.

A2LA (Certificate Number: 3857.01)

TA Technology (Shanghai) Co., Ltd. has been listed by American Association for Laboratory Accreditation to perform electromagnetic emission measurement.

1.3. Testing Location

Company: TA Technology (Shanghai) Co., Ltd.

Address: Building 3, No.145, Jintang Rd, Pudong Shanghai, P.R.China

City: Shanghai

Post code: 201201

Country: P. R. China

Contact: Xu Kai

Telephone: +86-021-50791141/2/3

Fax: +86-021-50791141/2/3-8000

Website: <http://www.ta-shanghai.com>

E-mail: xukai@ta-shanghai.com

1. General Description of Equipment Under Test

2.1. Applicant and Manufacturer Information

Applicant	Thunder Software Technology Co., Ltd.
Applicant address	ThunderSoft Building, Building 3, No.9 Qinghua Dong Road, Haidian District, Beijing, China
Manufacturer	Thunder Software Technology Co., Ltd.
Manufacturer address	ThunderSoft Building, Building 3, No.9 Qinghua Dong Road, Haidian District, Beijing, China

2.2. General Information

EUT Description	
Model	HDP
SN	B000210
Hardware Version	0.3
Software Version	HDP-1212-1218-R3
Power Supply	External power supply
Antenna Type	Internal Antenna
Operating Frequency Range(s)	U-NII-2C: 5470MHz-5725MHz
Modulation Type	802.11a: OFDM 802.11n(HT20/HT40) : OFDM 802.11ac (VHT20/VHT40/VHT80):OFDM
Operating Mode	<input type="checkbox"/> Master <input checked="" type="checkbox"/> Client with radar detection <input type="checkbox"/> Client without radar detection
Note: The EUT is sent from the applicant to TA and the information of the EUT is declared by the applicant.	

Wireless Technology and Frequency Range

Wireless Technology	Bandwidth	Channel	Frequency
Wi-Fi	U-NII-2C	20 MHz	100
			5500MHz
			104
			5520MHz
			108
			5540MHz
			112
			5560MHz
			116
			5580MHz
			120
			5600MHz
Wi-Fi	U-NII-2C	40 MHz	124
			5620MHz
			128
			5640MHz
			132
			5660MHz
		80 MHz	136
			5680MHz
			140
			5700MHz
			144
			5720MHz
Wi-Fi	U-NII-2C	40 MHz	102
			5510MHz
			110
			5550MHz
			118
			5590MHz
		80 MHz	126
			5630MHz
			134
			5670MHz
			142
			5710MHz
Does this device support TPC Function?		106	5530MHz
		122	5610MHz
		138	5690MHz
Does this device support TDWR Band? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			

3. Applied Standards

According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

Test standards:

FCC CFR47 Part 15E (2022) Unlicensed National Information Infrastructure Devices

Reference standard:

FCC KDB 905462 D02 UNII DFS Compliance Procedures New Rules v02

FCC KDB 905462 D03 Client Without DFS New Rules v01r02

4. DFS Technical Requirements and Radar Test Waveforms

4.1. DFS Overview

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 Device 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	Master Device or Client with Radar Detection	Client Without Radar Detection
U-NII Detection Bandwidth	All BW modes must be tested	Not required
Statistical Performance Check	All BW modes must be tested	Not required
Channel Closing Transmission Time	Test using widest BW mode available	Test using the widest BW mode available for the link
Channel Move 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.

4.2. DFS Detection Thresholds

Table 3 DFS Detection Thresholds for Master Devices and Client Devices with Radar Detection

Maximum Transmit Power	Value (See Notes 1, 2, and 3)
EIRP \geq 200 milliwatt	-64 dBm
EIRP $<$ 200 milliwatt and power spectral density $<$ 10 dBm/MHz	-62 dBm
EIRP $<$ 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.

Note 3: EIRP is based on the highest antenna gain. For MIMO devices refer to KDB Publication 662911 D01.

Table 4 DFS Response Requirement Values

Parameter	Value
Non-occupancy Period	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

4.3. Radar Test Waveforms

Table 5 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
1	1	Test A: 15 unique PRI values randomly selected from the list of 23 PRI values in Table 5a	Roundup	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
<p>Note 1: Short Pulse Radar Type 0 should be used for the detection bandwidth test, channel move time, and channel closing time tests.</p>					

Table 5a Pulse Repetition Intervals Values for Test A

Pulse Repetition Frequency Number	Pulse Repetition Frequency (Pulses Per Second)	Pulse Repetition Interval (Microseconds)
1	1930.5	518
2	1858.7	538
3	1792.1	558
4	1730.1	578
5	1672.2	598
6	1618.1	618
7	1567.4	638
8	1519.8	658
9	1474.9	678
10	1432.7	698
11	1392.8	718
12	1355	738
13	1319.3	758
14	1285.3	778
15	1253.1	798
16	1222.5	818
17	1193.3	838
18	1165.6	858
19	1139	878
20	1113.6	898
21	1089.3	918
22	1066.1	938
23	326.2	3066

The aggregate is the average of the percentage of successful detections of Short Pulse Radar Types 1-4. For example, the following table indicates how to compute the aggregate of percentage of successful detections.

Radar Type	Number of Trials	Number of Successful Detections	Minimum Percentage of Successful Detection
1	35	29	82.9%
2	30	18	60%
3	30	27	90%
4	50	44	88%
Aggregate $(82.9\% + 60\% + 90\% + 88\%)/4 = 80.2\%$			

Table 6 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.

Table 7 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.

4.4. Test Set-ups

We test the data stream using N7607C Signal Studio V2.2.0.0.

Channel loading is based on IP.

Setup for Master with Injection at the Master

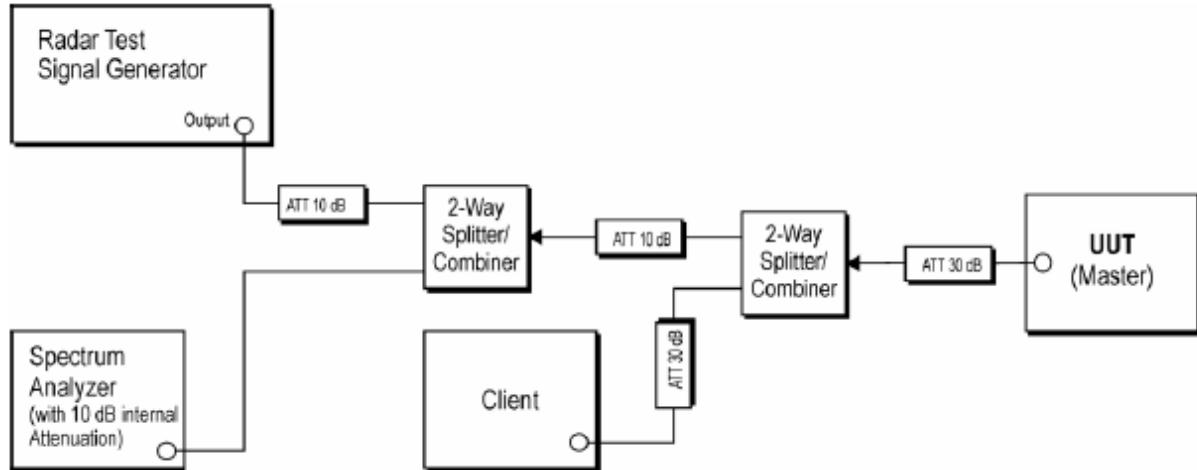


Figure 2: Example Conducted Setup where UUT is a Master and Radar Test Waveforms are injected into the Master

Setup for Client with Injection at the Master

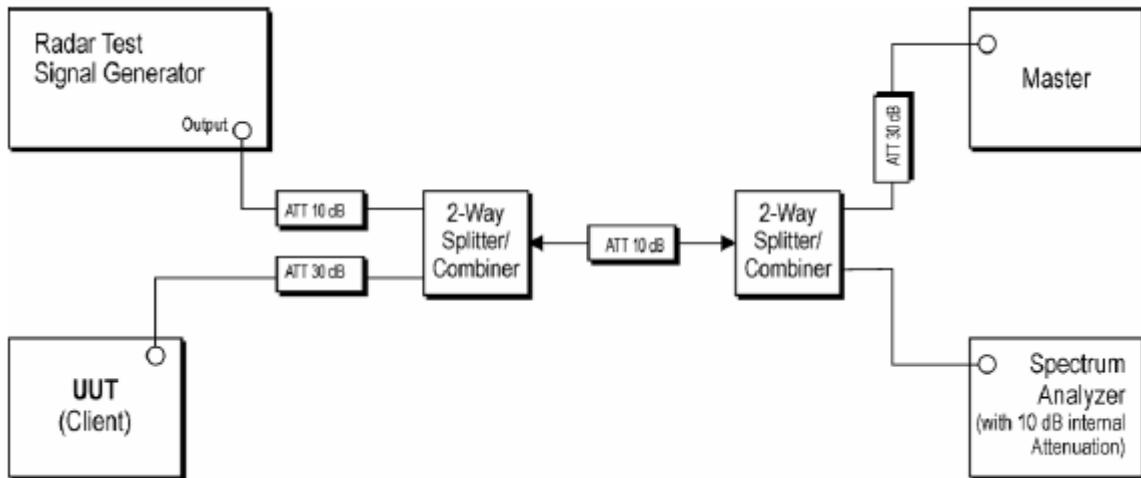


Figure 3: Example Conducted Setup where UUT is a Client and Radar Test Waveforms are injected into the Master

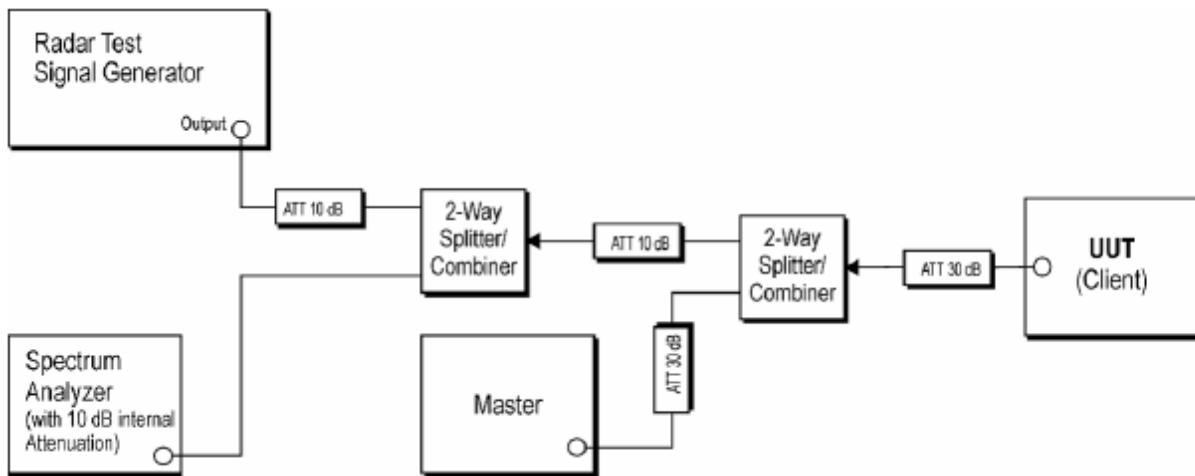
Setup for Client with Injection at the Client

Figure 4: Example Conducted Setup where UUT is a Client and Radar Test Waveforms are injected into the Client

5. Test Case

5.1. DFS Detection Thresholds

Ambient Condition

Temperature	Relative humidity
20°C ~25°C	45%~50%

Methods of Measurement

Client with injection at the Master.

For a detection threshold level of -64dBm, the required signal strength at EUT antenna location is -64dBm, the tested level is lower than required level hence it provides margin to the limit.

Frequency of Calibration	
Bandwidth	Central Frequency
802.11ac 20MHz	5500MHz
802.11ac 40MHz	5550MHz
802.11ac 80MHz	5610MHz

Calibration Result

Refer to the section 6.1 of this report for test data.

5.2. Channel Move Time, Channel Closing Transmission Time and Non-Occupancy Period

Ambient Condition

Temperature	Relative humidity
20°C ~25°C	45%~50%

Methods of Measurement

These tests define how the following DFS parameters are verified during In-Service Monitoring;

- Channel Closing Transmission Time
- Channel Move Time
- Non-Occupancy Period

The steps below define the procedure to determine the above mentioned parameters when a radar Burst with a level equal to the DFS Detection Threshold + 1dB is generated on the Operating Channel of the U-NII device (In- Service Monitoring).

1. One frequency will be chosen from the Operating Channels of the EUT within the 5250-5350 MHz or 5470-5725 MHz bands. For 802.11 devices, the test frequency must contain control signals. This can be verified by disabling channel loading and monitoring the spectrum analyzer. If no control signals are detected, another frequency must be selected within the emission bandwidth where control signals are detected.
2. In case the EUT is a U-NII device operating as a Client Device (with or without DFS), a U-NII device operating as a Master Device will be used to allow the EUT (Client device) to Associate with the Master Device. In case the EUT is a Master Device, a U-NII device operating as a Client Device will be used and it is assumed that the Client will Associate with the EUT (Master). In both cases for conducted tests, the Radar Waveform generator will be connected to the Master Device. For radiated tests, the emissions of the Radar Waveform generator will be directed towards the Master Device. If the Master Device has antenna gain, the main beam of the antenna will be directed toward the radar emitter. Vertical polarization is used for testing.
3. Stream the channel loading test file from the Master Device to the Client Device on the test Channel for the entire period of the test.
4. At time T_0 the Radar Waveform generator sends a Burst of pulses for one of the Radar Type 0 in Table 5 at levels defined in Table 3, on the Operating Channel. An additional 1 dB is added to the radar test signal to ensure it is at or above the DFS Detection Threshold, accounting for equipment variations/errors.
5. Observe the transmissions of the EUT at the end of the radar Burst on the Operating Channel for duration greater than 10 seconds. Measure and record the transmissions from the EUT during the observation time (Channel Move Time). Measure and record the Channel Move Time and Channel Closing Transmission Time if radar detection occurs. Figure 17 illustrates Channel Closing Transmission Time.

6. When operating as a Master Device, monitor the EUT for more than 30 minutes following instant T_2 to verify that the EUT does not resume any transmissions on this Channel. Perform this test once and record the measurement result.

7. In case the EUT is a U-NII device operating as a Client Device with In-Service Monitoring, perform steps 1 to 6.

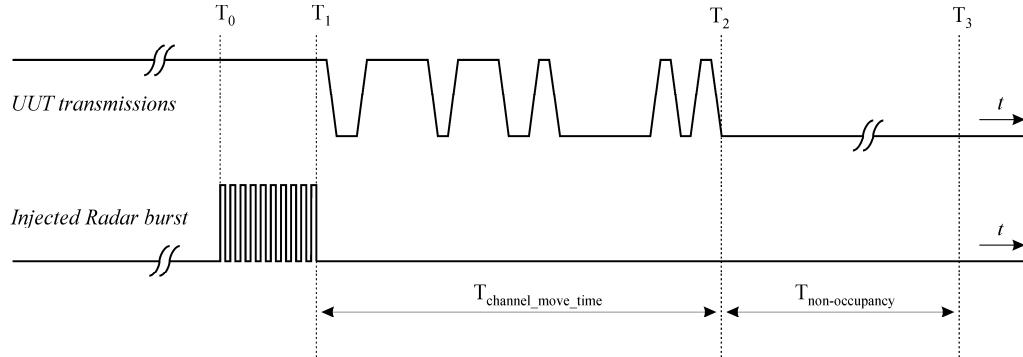


Figure 17: Example of Channel Closing Transmission Time & Channel Closing Time

Limits

Channel Move Time	$\leq 10s$
Channel Closing Transmission Time	$\leq 200ms + 60ms$ (over remaining 10s period)
Non-Occupancy Period	$\geq 30min$

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 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.

Measurement Uncertainty

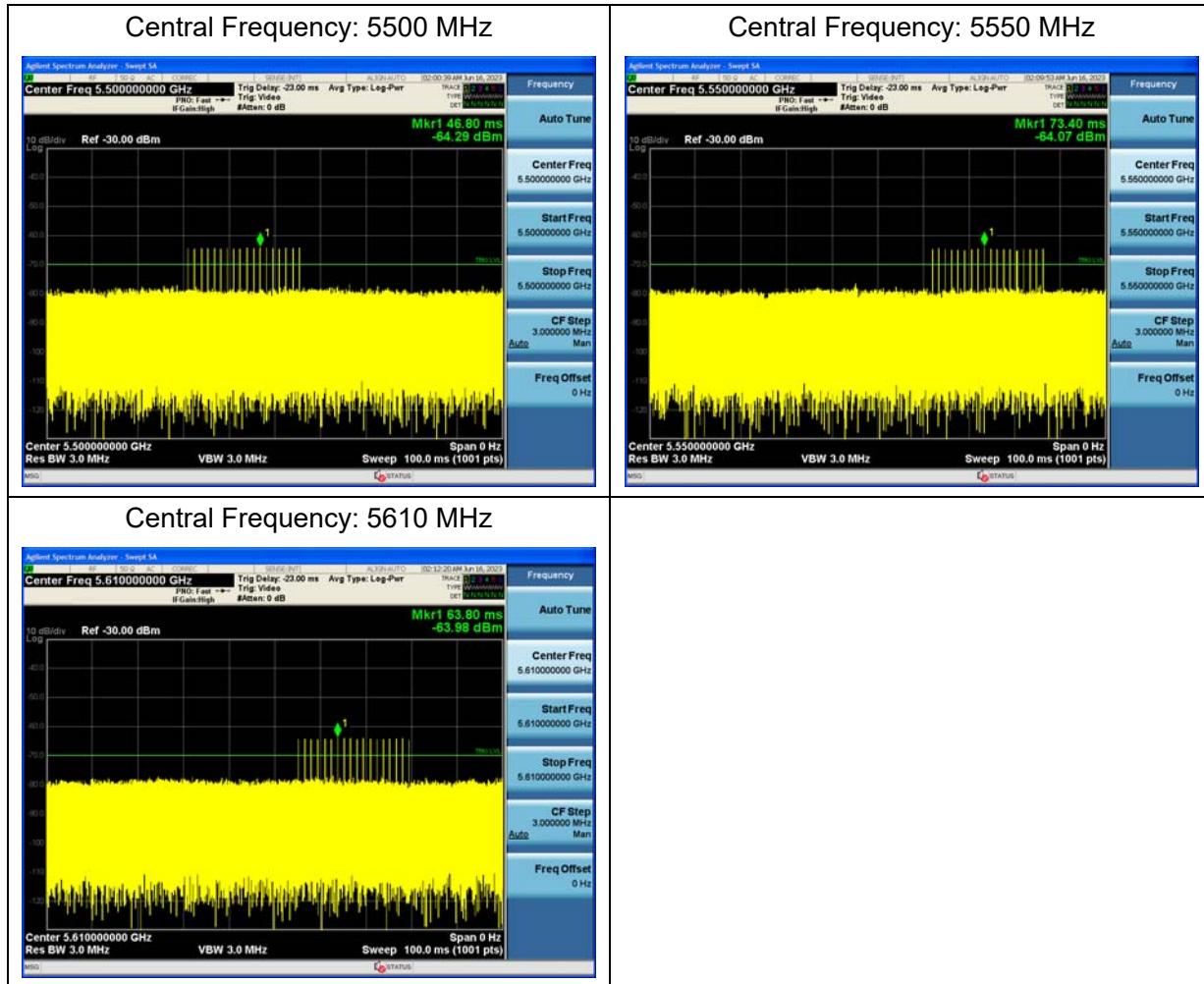
The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor $k = 1.96$, $U=2.69$ dB.

Test Results

Refer to the section 6.2 of this report for test data.

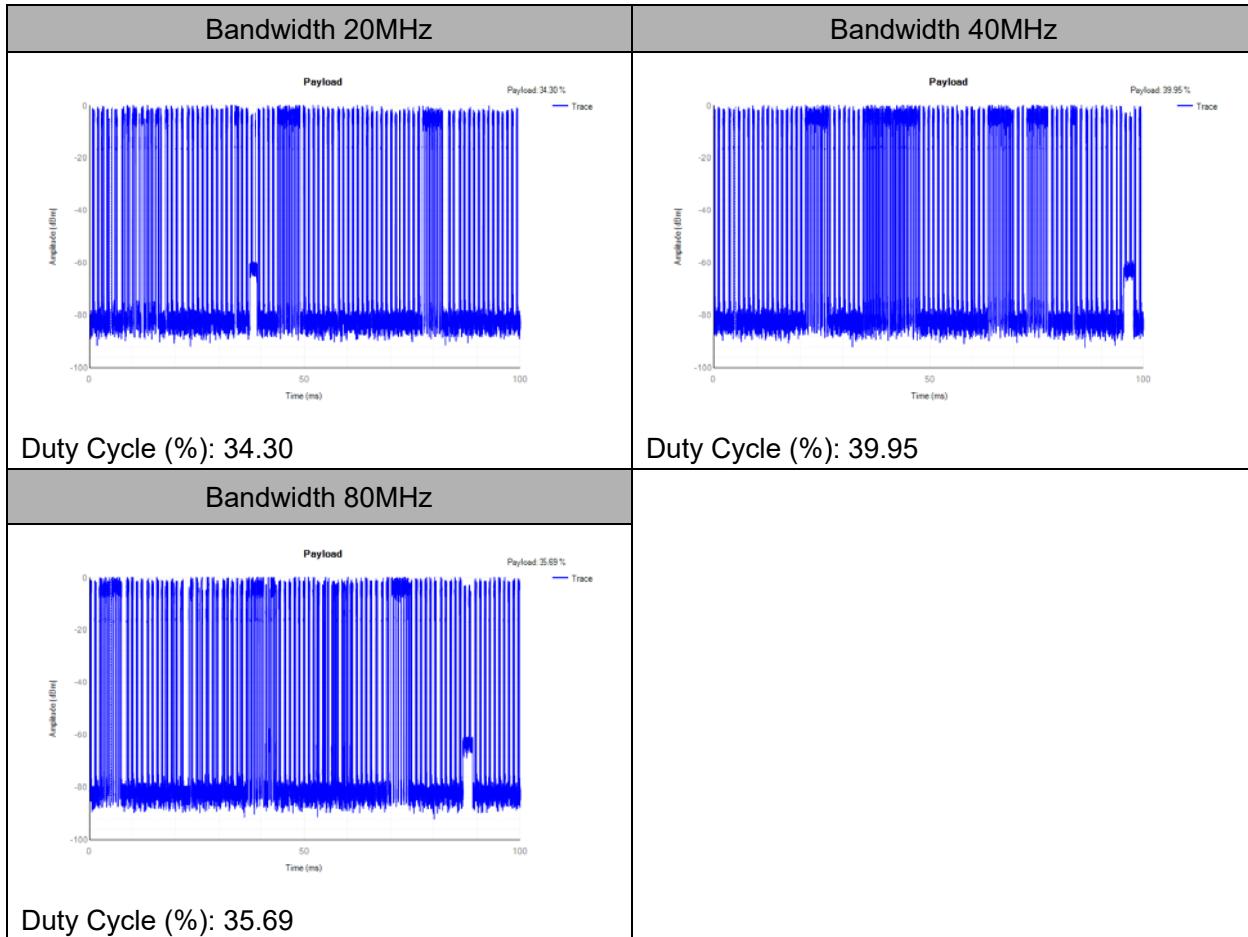
6. Test Results

6.1. DFS Detection Thresholds

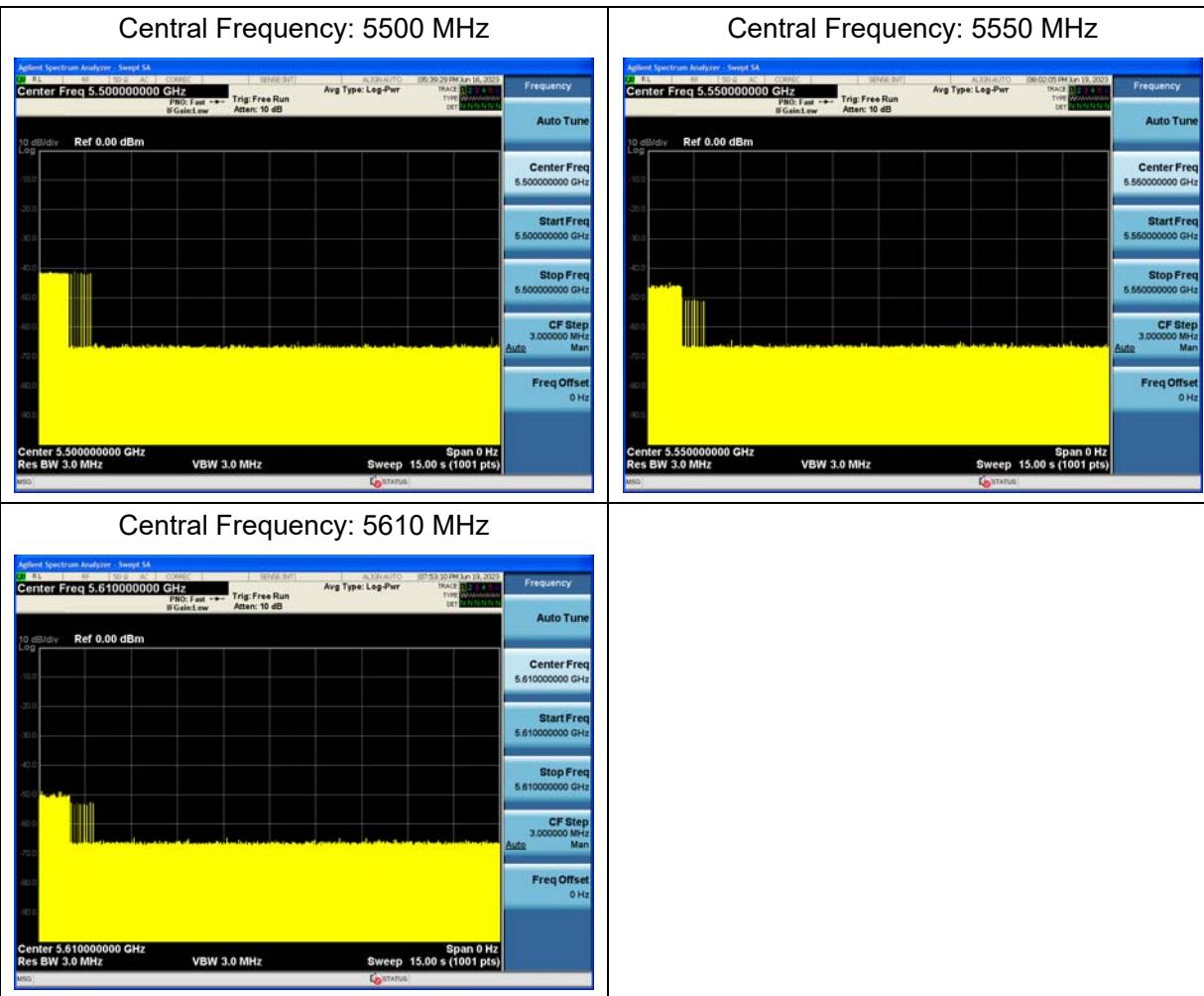


6.2. Channel Move Time, Channel Closing Transmission Time and Non-Occupancy Period

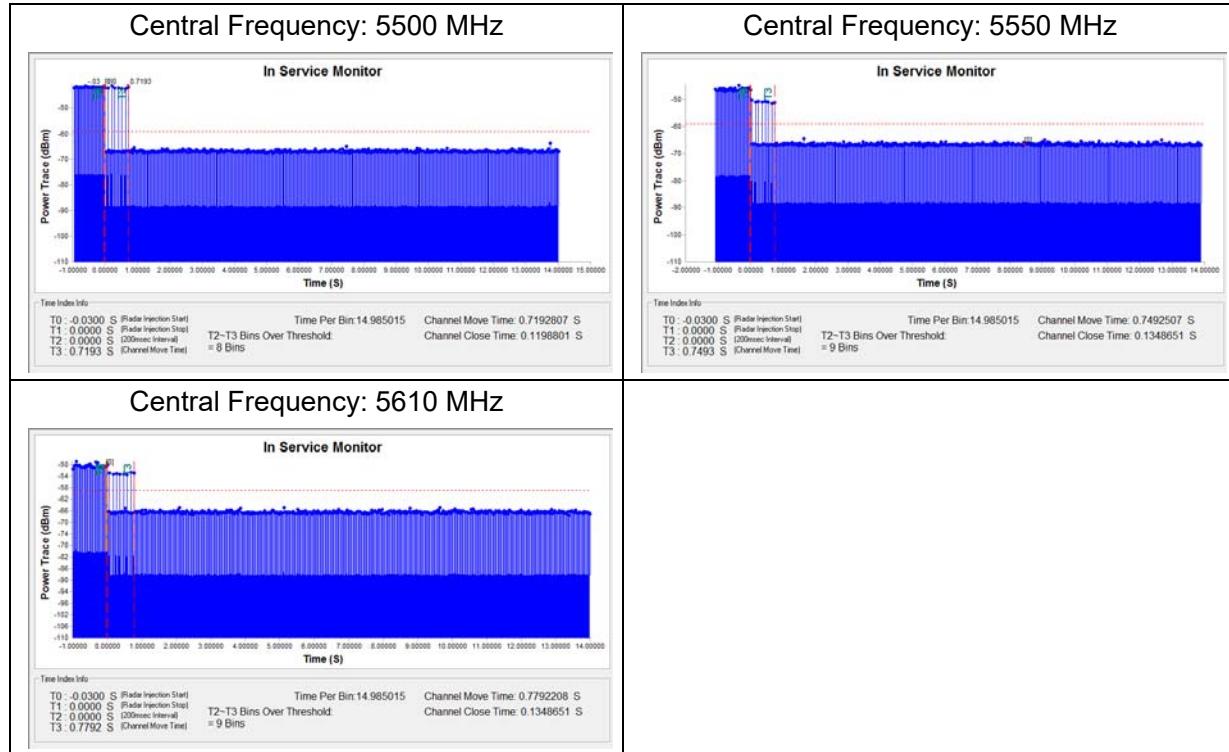
Timing plot



Channel Move Time

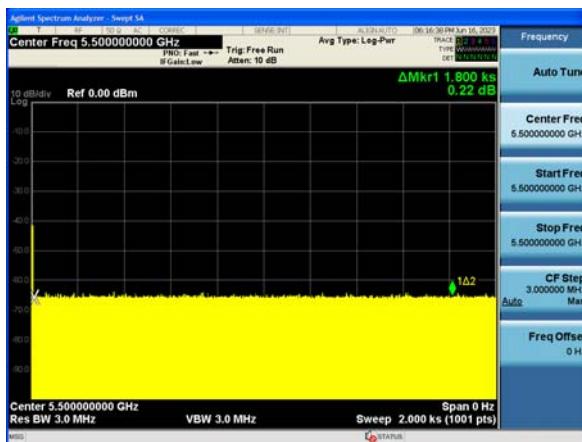


Channel Closing Transmission Time

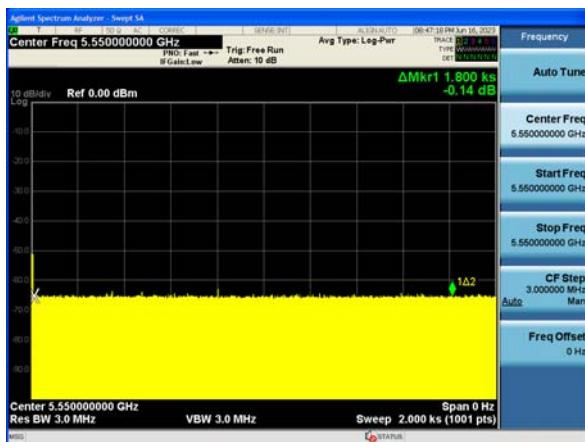


Non-Occupancy Period

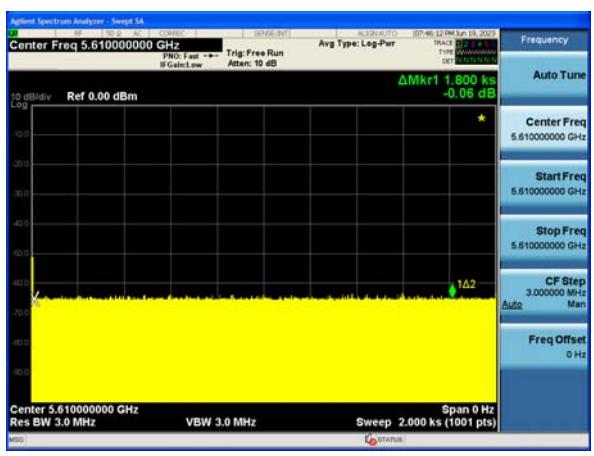
Central Frequency: 5500 MHz



Central Frequency: 5550 MHz



Central Frequency: 5610 MHz



6. Main Test Instruments

Name	Manufacturer	Type	Serial Number	Calibration Date	Expiration Date
Vector Signal Generator	KEYSIGHT	N5172B	MY53050900	2022-12-10	2023-12-09
Spectrum Analyzer	Agilent	N9010A	MY50210259	2022-12-10	2023-12-09
Splitter	UCL Microwave	2 way	UCL-PD0512-2S	/	/
Splitter	UCL Microwave	2 way	UCL-PD0512-2S	/	/
RF Cable	Agilent	SMA 15cm	0001	/	/
RF Cable	Agilent	SMA 15cm	0002	/	/
RF Cable	Agilent	SMA 15cm	0003	/	/
RF Cable	Agilent	SMA 15cm	0004	/	/
Software	KEYSIGHT	N7607C	/	/	/
Wireless Router	ASUS	AXE11000	GT-AXE11000 (FCC ID: MSQ-RTAXJF00)	/	/

ANNEX A: The EUT Appearance

The EUT Appearance is submitted separately.

ANNEX B: Test Setup Photos

The Test Setup Photos is submitted separately.

***** END OF REPORT *****