

# FCC & ISSED DFS TEST REPORT

**Project Number** : EA2002C-029  
**Test Report Number** : TR-W2006-025  
**Type of Equipment** : WiFi/BT Combo Module  
**Model Name** : SBW-M3  
**Equipment Class** : NII - Unlicensed National Information Infrastructure TX  
**FCC ID** : WF5SBWM3  
**ISSED Canada ID** : 9080A-SBWM3  
**Multiple Model Name** : N/A  
**Applicant** : Aroot Co., Ltd.  
**Address** : 28-6, Gajangsaneopdong-ro, Osan-si, Gyeonggi-do, Republic of Korea  
**Manufacturer** : Aroot Co., Ltd.  
**Address** : 28-6, Gajangsaneopdong-ro, Osan-si, Gyeonggi-do, Republic of Korea  
**Regulation** : FCC Part 15 Subpart E Section 15.407, ISSED RSS-247 Issue2  
**Total page of Report** : 18 Pages  
**Date of Receipt** : 2020-02-10  
**Date of Issue** : 2020-06-30  
**Test Result** : PASS

This test report only contains the result of a single test of the sample supplied for the examination.  
It is not a generally valid assessment of the features of the respective products of the mass-production.

Prepared by Song, In-young / Senior Engineer  2020-06-30  
Signature Date

Reviewed by Choi, Yeong-min / Technical Manager  2020-06-30  
Signature Date

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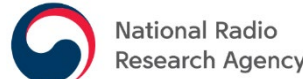
### Release Control Record

| Issue Report No. | Issued Date | Details/Revisions |
|------------------|-------------|-------------------|
| TR-W2006-025     | 2020-06-30  | Initial Release   |
| -                | -           | -                 |



## 1.5 Test Facility

The measurement facilities are located at 135-60 Gyeongchung-daero, Gonjam-eup, Gwangju-si, Gyeonggi-do 12813, Korea. Our test facilities are accredited as a Conformity Assessment Body (CAB) by the FCC and ISED Canada, designated by the RRA (National Radio Research Agency), and accredited by KOLAS (Korea Laboratory Accreditation Scheme) in Korea and approved by TUV Rheinland, TUV SÜD and Korean Register of Shipping according to the requirement of ISO/IEC 17025.

| Laboratory Qualification                   | Registration No.            | Mark                                                                                  |
|--------------------------------------------|-----------------------------|---------------------------------------------------------------------------------------|
| FCC                                        | KR0160                      |    |
| ISED Canada                                | 12721A                      |    |
| RRA                                        | KR0160                      |    |
| TUV Rheinland                              | UA 50314109-0002            |   |
| TUV SÜD                                    | CARAT 094465 0004<br>Rev.00 |  |
| Korean Agency for Technology and Standards | KT733                       |  |
| KOREAN REGISTER OF SHIPPING                | PCT40841-TL001              |  |

Remark. This report is not related to KOLAS accreditation and relevant regulation.

## 2. EUT (Equipment Under Test) INFORMATION

### 2.1 General Description

The Aroot Co., Ltd., Model SBW-M3 (referred to as the EUT in this report) is a WiFi/BT Combo Module. which has 3 Equipment Class, DSS, DTS, and NII. This test report covers NII portion only and other functions are covered by other test report. The product specification described herein was obtained from product data sheet or user's manual.

| Equipment Class                |                                           | NII – Unlicensed National Information Instructure TX                                        |  |
|--------------------------------|-------------------------------------------|---------------------------------------------------------------------------------------------|--|
| Operating Frequency            | Bluetooth LE                              | 2 402 MHz – 2 480 MHz                                                                       |  |
|                                | Bluetooth                                 | 2 402 MHz – 2 480 MHz                                                                       |  |
|                                | WLAN 2.4 GHz                              | 2 412 MHz – 2 462 MHz (802.11b/g/n HT20)                                                    |  |
|                                |                                           | 2 422 MHz – 2 452 MHz (802.11n HT40)                                                        |  |
|                                | UNII 1 band<br>5 150 MHz –<br>5 250 MHz   | 5 180 MHz – 5 240 MHz (802.11a/n HT20/ac VHT20)                                             |  |
|                                |                                           | 5 190 MHz – 5 230 MHz (802.11n HT40/ac VHT40)                                               |  |
|                                |                                           | 5 210 MHz (802.11ac VHT80)                                                                  |  |
|                                | UNII 2-A band<br>5 250 MHz –<br>5 350 MHz | 5 260 MHz – 5 320 MHz (802.11a/n HT20/ac VHT20)                                             |  |
|                                |                                           | 5 270 MHz – 5 310 MHz (802.11n HT40/ac VHT40)                                               |  |
|                                |                                           | 5 290 MHz (802.11ac VHT80)                                                                  |  |
|                                | UNII 2-C band<br>5 470 MHz –<br>5 725 MHz | 5 500 MHz – 5 700 MHz (802.11a/n HT20/ac VHT20)                                             |  |
|                                |                                           | 5 510 MHz – 5 670 MHz (802.11n HT40/ac VHT40)                                               |  |
|                                |                                           | 5 530 MHz – 5 610 MHz (802.11ac VHT80)                                                      |  |
|                                | UNII 3 band<br>5 725 MHz –<br>5 850 MHz   | 5 745 MHz – 5 825 MHz (802.11a/n HT20/ac VHT20)                                             |  |
|                                |                                           | 5 755 MHz – 5 795 MHz (802.11n HT40/ac VHT40)                                               |  |
|                                |                                           | 5 775 MHz (802.11ac VHT80)                                                                  |  |
|                                | Straddle channel<br>UNII 2-C to 3 band    | 5 720 MHz (802.11a/n HT20/ac VHT20)                                                         |  |
|                                |                                           | 5 710 MHz (802.11n HT40/ac VHT40)                                                           |  |
|                                |                                           | 5 690 MHz (802.11ac VHT80)                                                                  |  |
| Generated or used Freq. in EUT |                                           | 32.768 kHz, 37.4 MHz                                                                        |  |
| Type of Antenna                |                                           | <input type="checkbox"/> Integrated Type <input checked="" type="checkbox"/> Dedicated Type |  |
| Antenna Gain                   |                                           | 4.61 dBi                                                                                    |  |
| Operating Temperature          |                                           | - 20 °C ~ + 55 °C                                                                           |  |
| Normal Test Voltage            |                                           | DC 3.3 V                                                                                    |  |
| Electrical Rating              |                                           | DC 3.3 V                                                                                    |  |
| Test SW Version                |                                           | DBGMon version: unknown                                                                     |  |
| Software Version               |                                           | Ver 1.0                                                                                     |  |
| Hardware Version               |                                           | Ver 1.0                                                                                     |  |

## 2.2 Additional Model

None

### 3. TEST CONDITION

#### 3.1 Equipment Used During Test

The following peripheral devices and/or interface cables were connected during the measurement:

| Description                | Model No.    | Serial No.                                                     | Manufacturer.                                  |
|----------------------------|--------------|----------------------------------------------------------------|------------------------------------------------|
| WiFi/BT Combo Module (EUT) | SBW-M3       | N/A                                                            | Aroot Co., Ltd.                                |
| Notebook PC                | 15s-du0069TU | CND9503W22                                                     | HP                                             |
| Adapter for Notebook PC    | TPN-CA14     | N/A                                                            | Chicony Power Technology (Chongqing) Co., Ltd. |
| Wireless Access Point      | WA730        | 4D7689EP000FB<br>(FCC ID: PY315300320)<br>(IC: 4054A-15300320) | NETGEAR                                        |

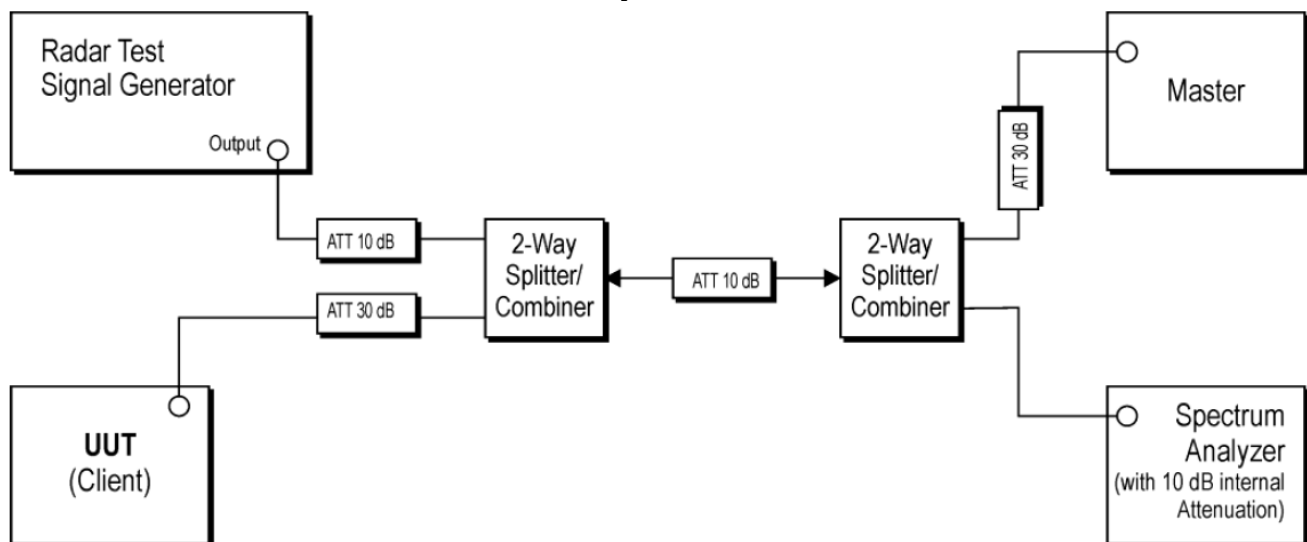
#### 3.2 Mode of operation during the test

Software used to control the EUT for staying in continuous transmitting mode is programmed.

The used modulation type for the testing is OFDM

#### 3.3 Test Setup Drawing

UUT is a Client and Radar Test Waveforms are injected into the Master



#### 3.4 EUT Modifications

- No EMC Relevant Modifications were performed by this test laboratory.

## 4. TEST RESULT

### 4.1 Dynamic Frequency Selection (DFS)

#### 4.1.1 Limit

Acc. to KDB 905462 D02 UNII DFS compliance Procedures New Rules v02, following tables shall be applied.

**Table 1: Applicability of DFS Requirement Prior to Use of a Channel**

| Requirement                            | Operational Mode |                                |                             |
|----------------------------------------|------------------|--------------------------------|-----------------------------|
|                                        | Master           | Client Without Radar Detection | Client With Radar Detection |
| <i>Non-Occupancy Period</i>            | Yes              | Not Required                   | Yes                         |
| <i>DFS Detection Threshold</i>         | Yes              | Not Required                   | Yes                         |
| <i>Channel Availability Check Time</i> | Yes              | Not Required                   | Not Required                |
| <i>U-NII Detection Bandwidth</i>       | Yes              | Not Required                   | Yes                         |

**Table 2: Applicability of DFS Requirement Prior to Use of a Channel**

| Requirement                              | Operational Mode                             |                             |
|------------------------------------------|----------------------------------------------|-----------------------------|
|                                          | Master Device or Client with Radar Detection | Client With Radar Detection |
| <i>DFS Detection Threshold</i>           | Yes                                          | Not Required                |
| <i>Channel Closing Transmission Time</i> | Yes                                          | Yes                         |
| <i>Channel Move Time</i>                 | Yes                                          | Yes                         |
| <i>U-NII Detection Bandwidth</i>         | Yes                                          | Not Required                |

| Additional requirements for devices with multiple bandwidth modes  | Master Device or Client with Radar Detection | Client With Radar Detection                          |
|--------------------------------------------------------------------|----------------------------------------------|------------------------------------------------------|
| <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 each of the bonded 20 MHz channels and the channel center frequency.

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

| Maximum Transmit Power                                                          | Value<br>(See Notes 1, 2, and 3) |
|---------------------------------------------------------------------------------|----------------------------------|
| EIRP $\geq$ 200 milliwatt                                                       | -64 dBm                          |
| EIRP < 200 milliwatt and<br>power spectral density < 10 dBm/MHz                 | -62 dBm                          |
| EIRP < 200 milliwatt that do not meet the power spectral density<br>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.

**Table 4: DFS Response Requirement Values**

| Parameter                                | Value                                                                                                     |
|------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| <i>Non-occupancy period</i>              | Minimum 30 minutes                                                                                        |
| <i>Channel Available Check Time</i>      | 60 seconds                                                                                                |
| <i>Channel Move Time</i>                 | 10 seconds See Note1.                                                                                     |
| <i>Channel Closing Transmission Time</i> | 200 milliseconds + an aggregate of 60 milliseconds over remaining<br>10 second period. See Notes 1 and 2. |
| <i>U-NII Detection Bandwidth</i>         | Minimum 100 % of the U-NII 99 % transmissions power bandwidth.<br>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.

#### 4.1.2 DFS Test Signals

**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 Note1                                  | See Note1                |
| 1                                                                                                                                           | 1                  | Test A: 15 unique PRI values randomly selected from the list of 23 PRI values in Table 5a                                                                     | $\text{Roundup}\left\{\left(\frac{1}{360}\right) \cdot \left(\frac{19 \cdot 10^6}{PRI_{\mu\text{sec}}}\right)\right\}$ | 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                      |
| <b>Note 1:</b> Short Pulse Radar Type 0 should be used for the detection bandwidth test, channel move time, and channel closing time tests. |                    |                                                                                                                                                               |                                                                                                                        |                                            |                          |

**Table 6: Long Pulse Radar Test Waveform**

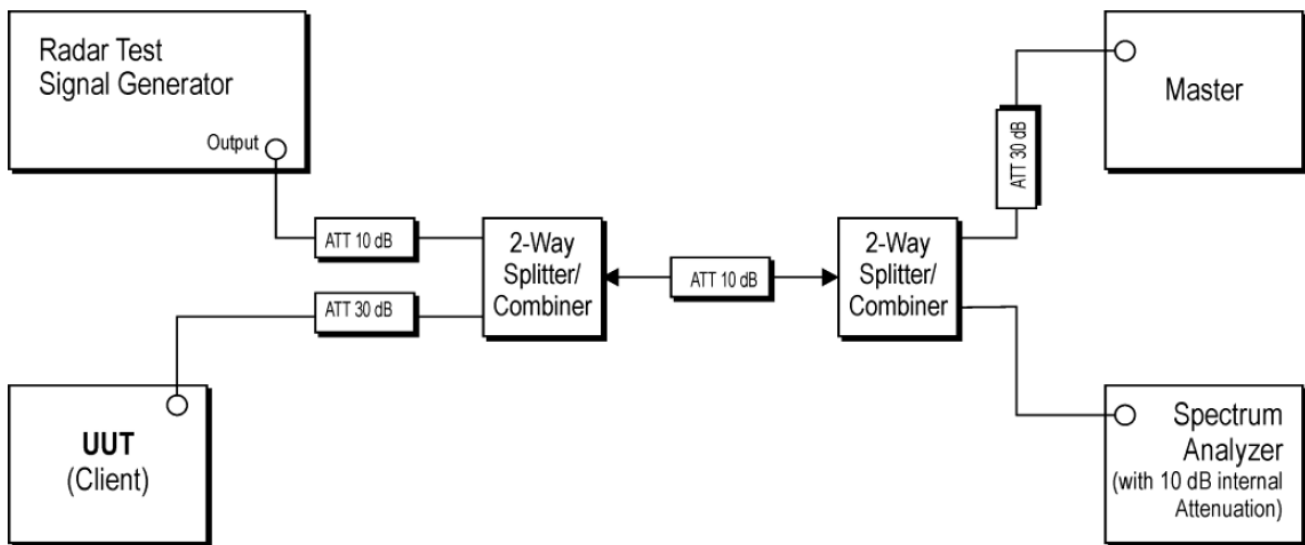
| Radar Type | Pulse Width (μsec) | Chirp Width (MHz) | PRI (μsec) | Number of Pulses per Burst | Number of Bursts | Minimum Percentage of Successful Detection | Minimum Number of Trials |
|------------|--------------------|-------------------|------------|----------------------------|------------------|--------------------------------------------|--------------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

**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                       |

#### 4.1.3 Method of Measurement

Acc. to KDB 905462 D02 UNII DFS compliance Procedures New Rules v02, figure 3 describes a conducted test setup.



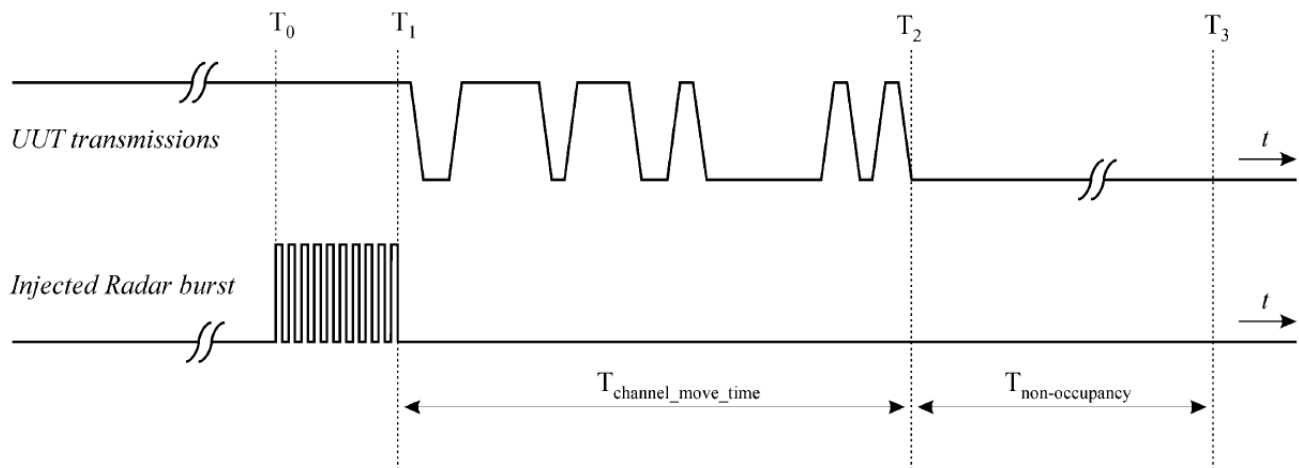
**Figure 3: Example Conducted Setup where UUT is a Client and Radar Test Waveforms are injected into the Master**

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*).

- One frequency will be chosen from the *Operating Channels* of the UUT within the 5250-5350 MHz or 5470-5725 MHz bands.
- In case the UUT 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 UUT (Client device) to *Associate* with the *Master Device*.
- 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.
- 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.
- Observe the transmissions of the UUT at the end of the radar *Burst* on the *Operating Channel* for duration

greater than 10 seconds. Measure and record the transmissions from the UUT 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*.

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



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

#### 4.1.4 Test Data

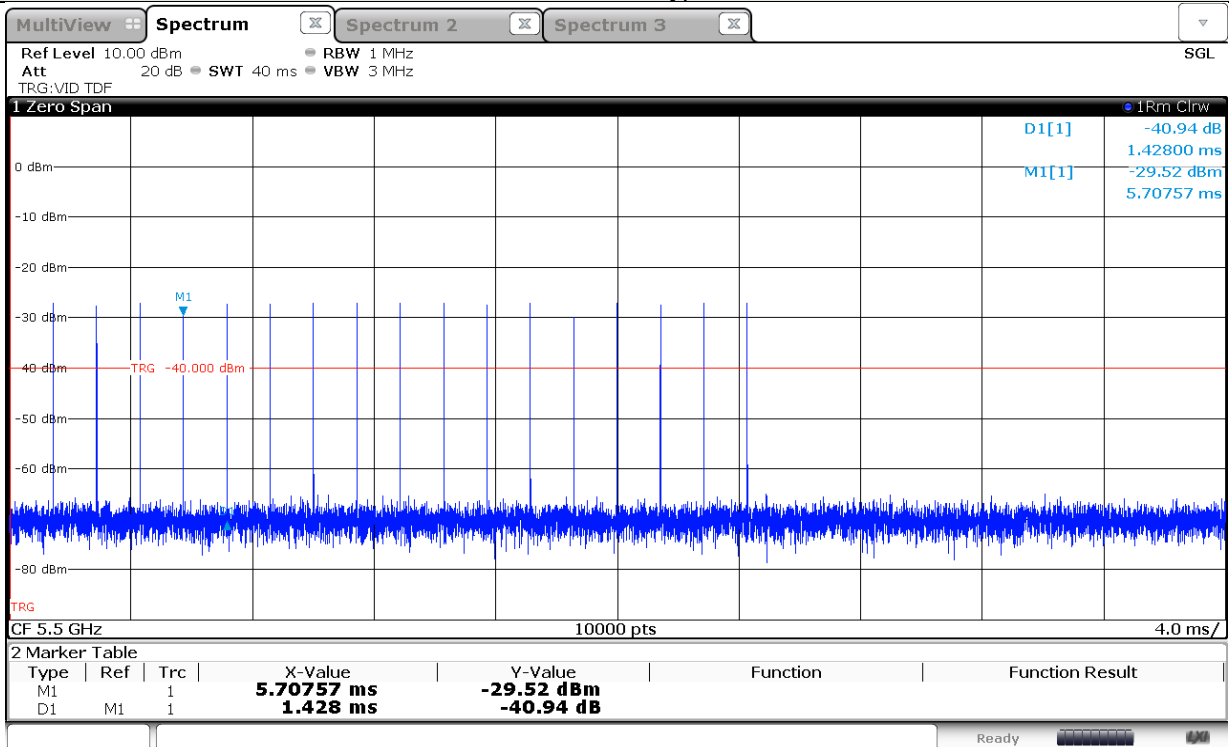
|                       |            |                                                 |                     |
|-----------------------|------------|-------------------------------------------------|---------------------|
|                       |            |                                                 |                     |
| Date of Test          | 2020-06-01 | Temperature                                     | (26.8 ± 1.4) °C     |
|                       |            | Relative humidity                               | (47.3 ± 7.4) % R.H. |
| Measurement Frequency |            | 5 500 MHz at 20 MHz BW / 5 530 MHz at 80 MHz BW |                     |
| Test Result           | PASS       | Tested By                                       | Do-heon Kim         |

| Parameter                              | Test Data | Limit     | Test Result |
|----------------------------------------|-----------|-----------|-------------|
|                                        | Type 0    |           |             |
| Test Frequency (MHz)                   | 5 500     | -         | -           |
| Channel Move Time (Sec)                | 0.012     | < 10 Sec. | PASS        |
| Channel Closing Transmission Time (ms) | 0.012     | < 60 ms   | PASS        |
| Non-Occupancy Period (Min.)            | ≥ 30      | ≥ 30      | PASS        |

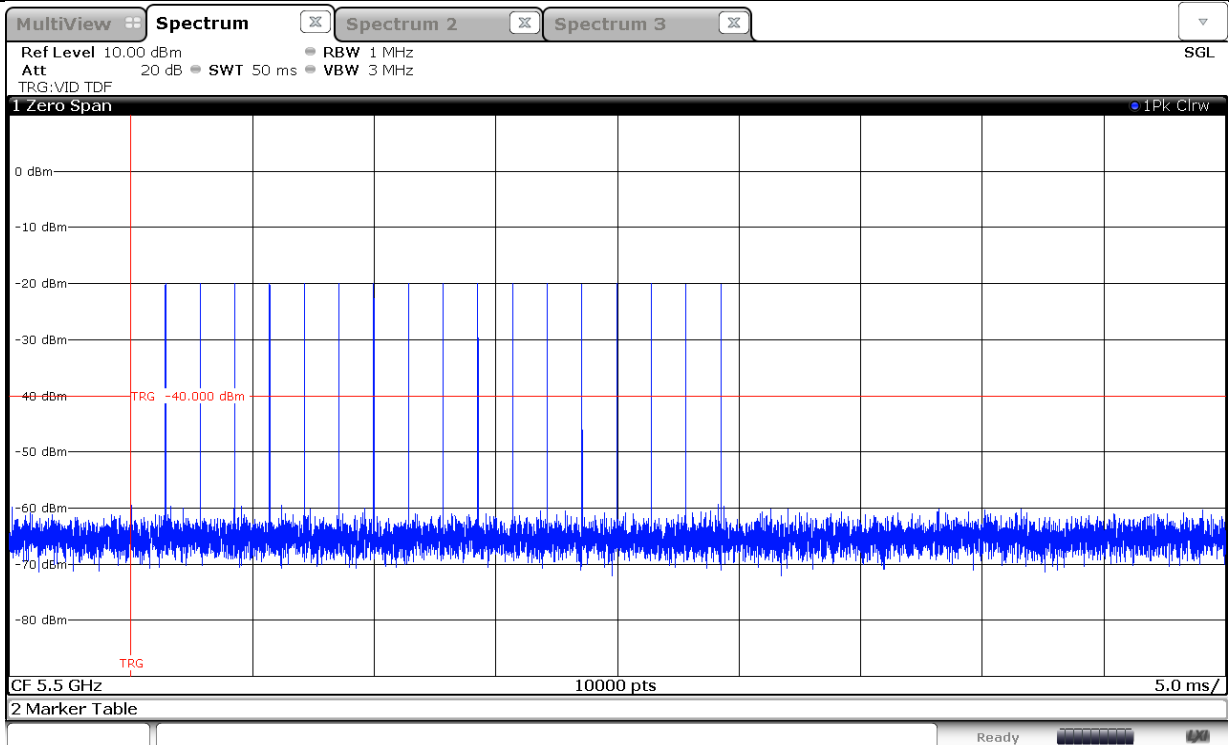
| Parameter                              | Test Data | Limit     | Test Result |
|----------------------------------------|-----------|-----------|-------------|
|                                        | Type 0    |           |             |
| Test Frequency (MHz)                   | 5 530     | -         | -           |
| Channel Move Time (Sec)                | 0.034     | < 10 Sec. | PASS        |
| Channel Closing Transmission Time (ms) | 0.034     | < 60 ms   | PASS        |
| Non-Occupancy Period (Min.)            | ≥ 30      | ≥ 30      | PASS        |

**Remark.** The EUT is a client device without radar detecting

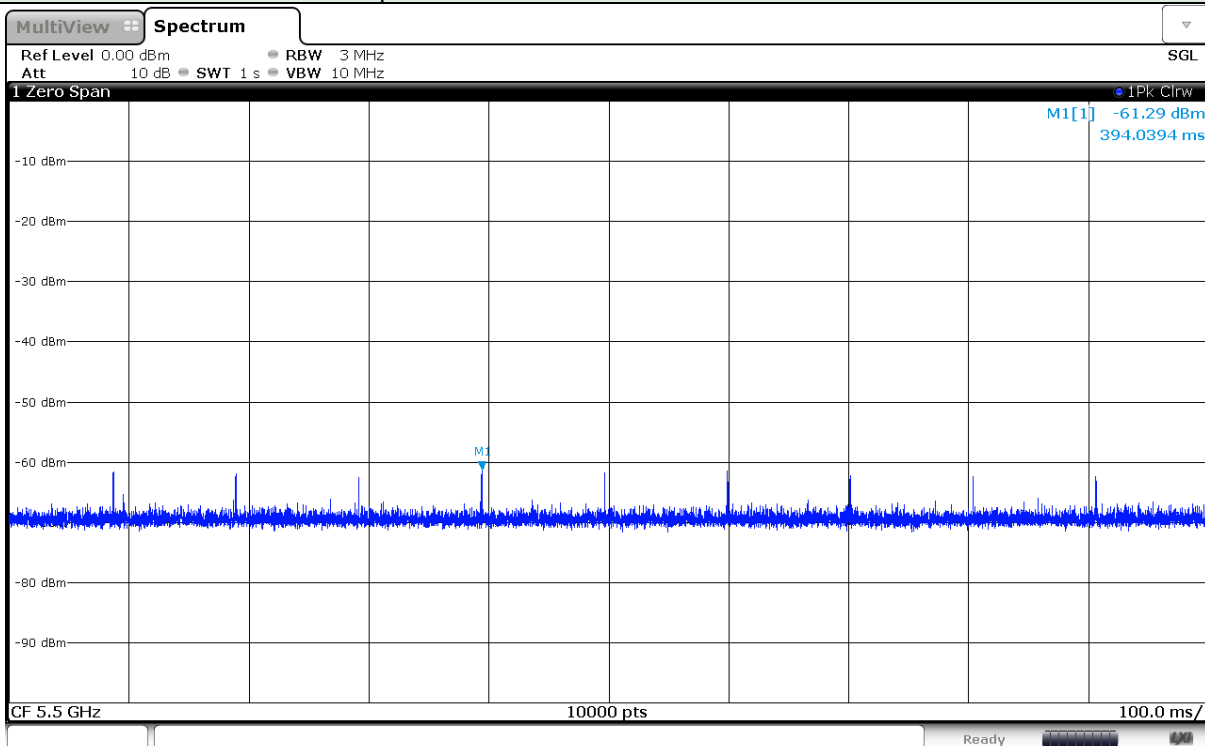
### Radar Waveform Type 0: PRI



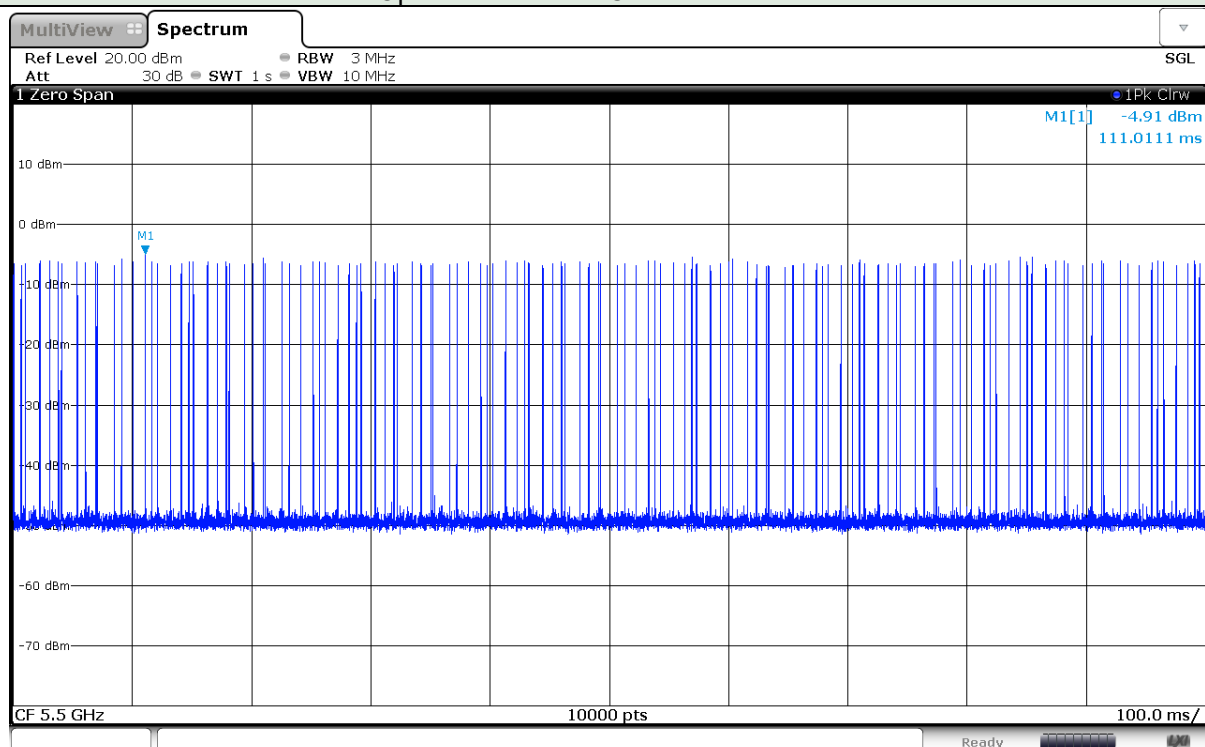
### Radar Waveform Type 0: Number of Pulses



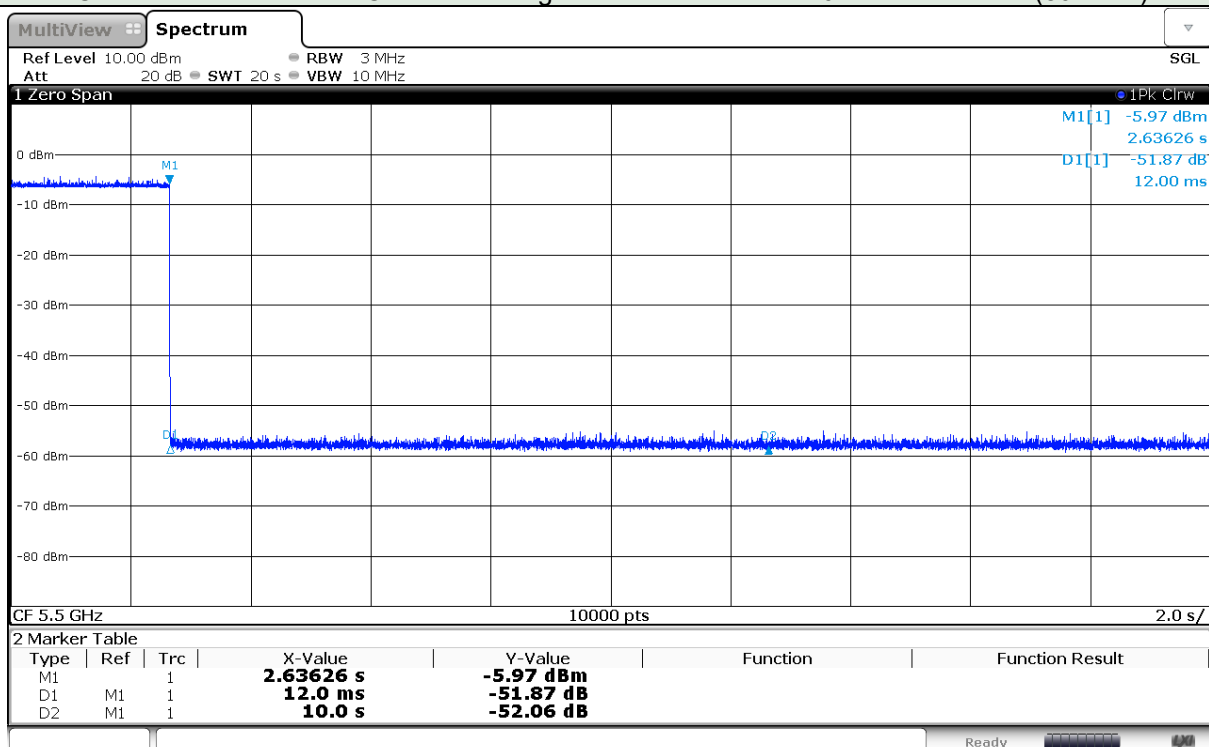
### Operational WLAN Channel without Traffic



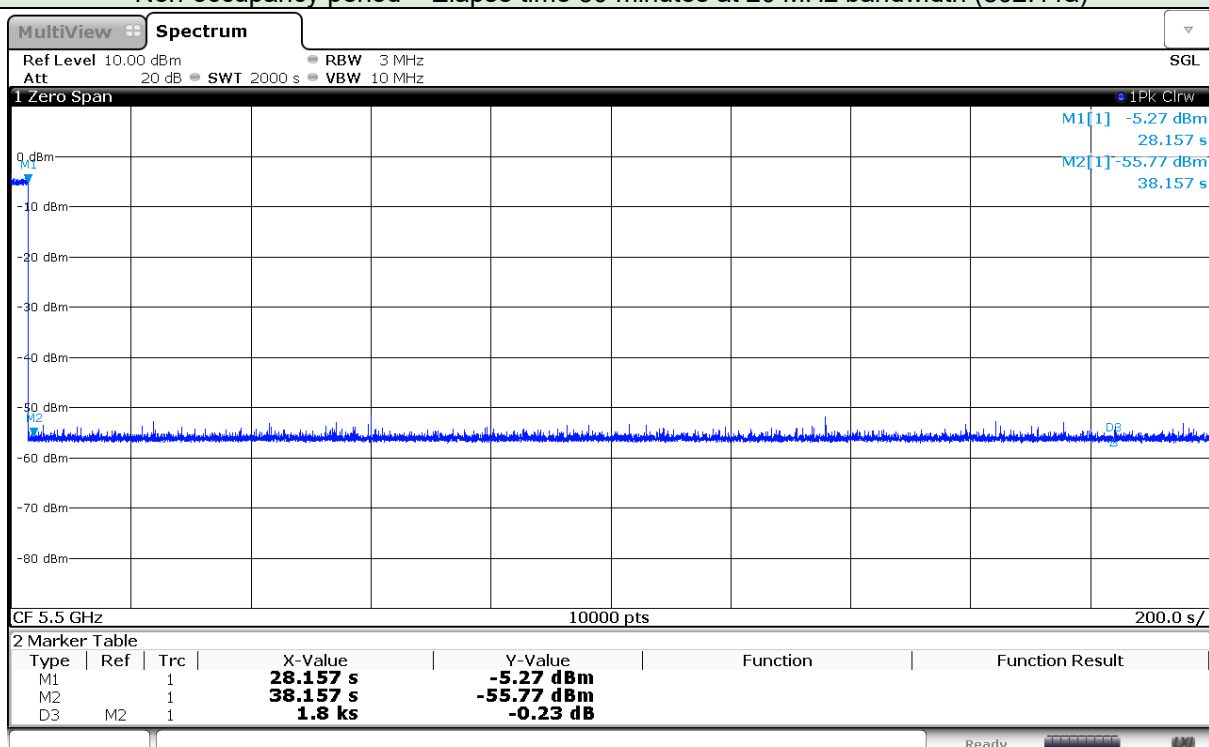
### Operational WLAN Channel with Traffic



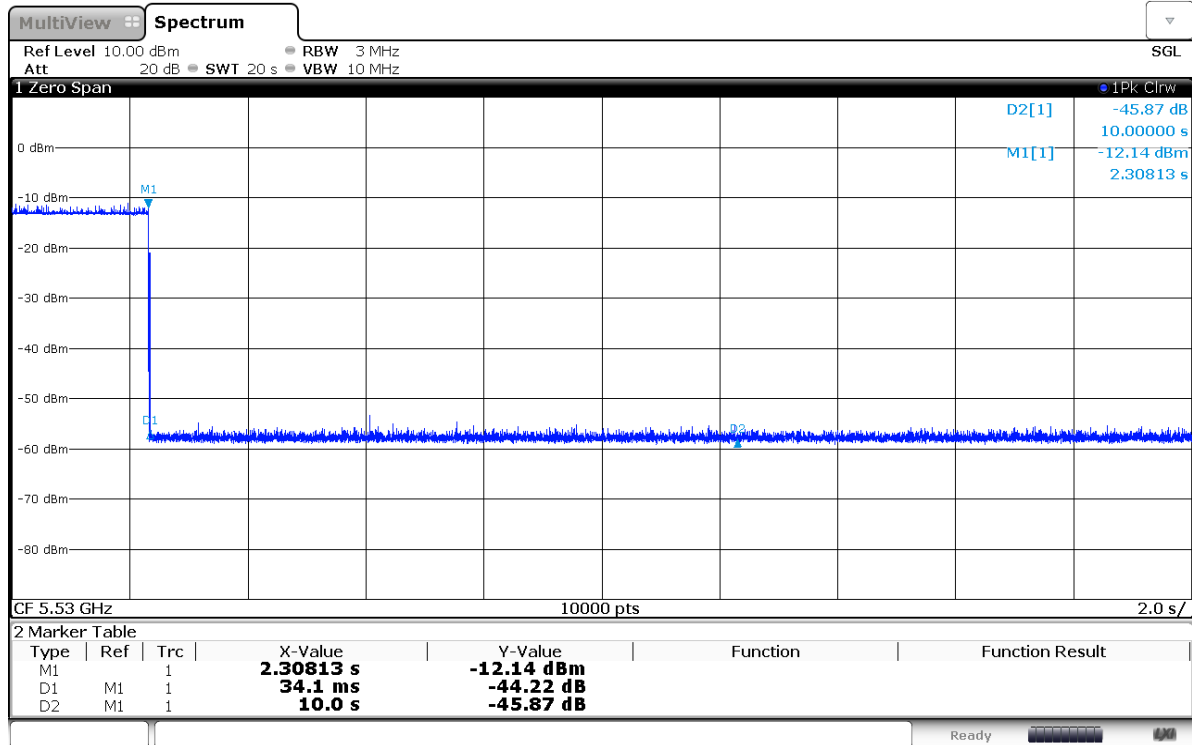
### Channel move time and Channel closing transmission time at 20 MHz bandwidth (802.11a)



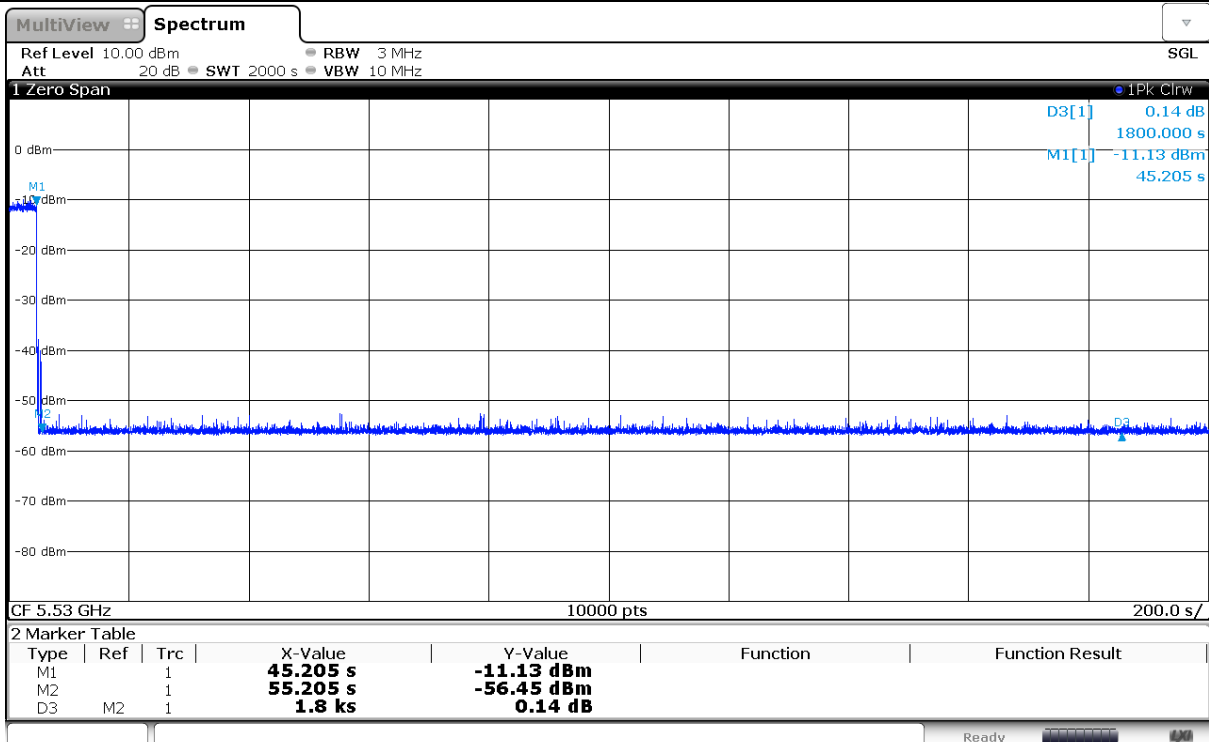
### Non-occupancy period – Elapse time 30 minutes at 20 MHz bandwidth (802.11a)



### Channel move time and Channel closing transmission time at 80 MHz bandwidth (802.11ac VHT80)



### Non-occupancy period – Elapse time 30 minutes at 80 MHz bandwidth (802.11ac VHT80)



## Appendix I – Test Instrumentation

| Description                | Model No.             | Serial No.    | Manufacturer.   | Due for Cal. Date | Cal. Interval |
|----------------------------|-----------------------|---------------|-----------------|-------------------|---------------|
| Signal & Spectrum Analyzer | FSW 43                | 100578        | Rohde & Schwarz | 2021-04-20        | 1 Y           |
| Vector Signal Generator    | SMBV100A              | 101441        | Rohde & Schwarz | 2021-01-26        | 1 Y           |
| Attenuator                 | 56-10                 | 58769         | WEINSCHTEL      | 2021-01-20        | 1 Y           |
| Attenuator                 | 10 dB                 | ENG-1         | Rohde & Schwarz | 2021-01-16        | 1 Y           |
| DC Power Supply            | 6032A                 | SG41000637    | Agilent         | 2021-03-25        | 1 Y           |
| Directional Coupler        | AAMCS-UDC-0.5G-18G-SF | 000757        | AAMCS           | 2021-01-17        | 1 Y           |
| Splitter                   | 1580                  | SC321         | WEINSCHTEL      | 2021-01-20        | 1 Y           |
| Attenuator                 | 8496A                 | 3308A3798S    | HP              | 2021-01-16        | 1 Y           |
| Attenuator                 | 8494B                 | 3308a38821    | HP              | 2021-01-16        | 1 Y           |
| Wireless Access Point      | WAC720                | 4D7689EP000FB | NETGEAR         | -                 | N/A           |

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