

TEST REPORT ADDENDUM - DFS

FROM



Test of: Radwin Ltd. Outdoor Subscriber Radio Unit

to

To: FCC CFR 47 Part 15.407, IC RSS-247

Test Report Serial No.: RDWN41-U9_DFS Rev A

Issue Date: 1st December 2016

| Master Document Number | Addendum Reports |
|------------------------|-------------------------------------|
| RDWN41-U9_Master | RDWN41-U9_Conducted |
| | RDWN41-U9_Radiated |
| | RDWN41-U9_DFS |
| | RDWN41-U5_(FCC Part 15B & ICES-003) |



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1. MEASUREMENT AND PRESENTATION OF TEST DATA

The measurement and graphical data presented in this test report was generated automatically using state-of-the-art technology creating an easy to read report structure. Numerical measurement data is separated from supporting graphical data (plots) through hyperlinks. Numerical measurement data can be reviewed without scrolling through numerous graphical pages to arrive at the next data matrix.

Plots have been relegated into the Appendix 'Graphical Data'.

Testing and report automation was performed by [MiTest](#). [MiTest](#) is an automated test system developed by MiCOM Labs. [MiTest](#) is the first cloud based modular test system enabling end-to-end automation of regulatory compliance testing for regulatory compliance.



The MiCOM Labs "[MiTest](#)" Automated Test System" (Patent Pending)

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2. TEST SUMMARY

List of Measurements

| Test Header | Result | Data Link |
|-----------------------------------|---------------|---------------------------|
| Dynamic Frequency Selection (DFS) | Complies | -- |
| Channel Availability Check | *Not Required | -- |
| Initial CAC | *Not Required | -- |
| Beginning CAC | *Not Required | -- |
| End CAC | *Not Required | -- |
| Channel Close Transmission Time | Complies | View Data |
| Non-Occupancy Period | Complies | View Data |
| Probability of Detection | *Not Required | -- |
| Detection Bandwidth | *Not Required | -- |

*Test item is a client device without radar detection capability



3. TEST METHODOLOGY

3.1. Dynamic Frequency Selection (DFS) Overview

A U-NII network will employ a DFS function to detect signals from radar systems and to avoid co-channel operation with these systems. This applies to the 5250-5350 MHz and/or 5470-5725 MHz bands. Within the context of the operation of the DFS function, a U-NII device will operate in either Master Mode or Client Mode. U-NII devices operating in Client Mode can only operate in a network controlled by a U-NII device operating in Master Mode. The following tables summarize the requirements.

| Requirement | Master Device or Client with Radar Detection | Client without Radar Detection |
|-----------------------------------|--|--------------------------------|
| | Operational Mode | |
| 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 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.



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The operational behavior and individual DFS requirements associated with these modes are as follows:

3.1.1. Master Devices

- a) The Master Device will use DFS in order to detect Radar Waveforms with received signal strength above the DFS Detection Threshold in the 5250 – 5350 MHz and 5470 – 5725 MHz bands. DFS is not required in the 5150 – 5250 MHz or 5725 – 5850 MHz bands.
- b) Before initiating a network on a Channel, the Master Device will perform a Channel Availability Check for a specified time duration (Channel Availability Check Time) to ensure that there is no radar system operating on the Channel, using DFS described under subsection a) above.
- c) The Master Device initiates a U-NII network by transmitting control signals that will enable other U-NII devices to Associate with the Master Device.
- d) During normal operation, the Master Device will monitor the Channel (In-Service Monitoring) to ensure that there is no radar system operating on the Channel, using DFS described under a).
- e) If the Master Device has detected a Radar Waveform during In-Service Monitoring as described under d), the Operating Channel of the U-NII network is no longer an Available Channel. The Master Device will instruct all associated Client Device(s) to stop transmitting on this Channel within the Channel Move Time. The transmissions during the Channel Move Time will be limited to the Channel Closing Transmission Time.
- f) Once the Master Device has detected a Radar Waveform it will not utilize the Channel for the duration of the Non-Occupancy Period.
- g) If the Master Device delegates the In-Service Monitoring to a Client Device, then the combination will be tested to the requirements described under d) through f) above.

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3.1.2. Client Devices

- a) A Client Device will not transmit before having received appropriate control signals from a Master Device.
- b) A Client Device will stop all its transmissions whenever instructed by a Master Device to which it is associated and will meet the Channel Move Time and Channel Closing Transmission Time requirements. The Client Device will not resume any transmissions until it has again received control signals from a Master Device.
- c) If a Client Device is performing In-Service Monitoring and detects a Radar Waveform above the DFS Detection Threshold, it will inform the Master Device. This is equivalent to the Master Device detecting the Radar Waveform and d) through f) of section 5.1.1 apply.
- d) Irrespective of Client Device or Master Device detection the Channel Move Time and Channel Closing Transmission Time requirements remain the same.
- e) The client test frequency must be monitored to ensure no transmission of any type has occurred for 30 minutes. Note: 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 shutdown (rather than moving channels), no beacons should appear.

3.2. DFS Detection Thresholds

The table below 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 \geq 200 milliwatt | -64 dBm |
| EIRP \leq 200 milliwatt and power density \leq 10 dBm/MHz | -62 dBm |
| EIRP \leq 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.



3.3. Response Requirements

The following table provides the response requirements for Master and Client Devices incorporating DFS.

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.



3.4. 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.

3.4.1. Short Radar Pulses

Short Pulse Radar Test Waveforms

| Radar Type | Pulse Width (μS) | PRI (μS) | 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 $\left\{ \begin{array}{l} \left(\frac{1}{360} \right) \cdot \\ \left(\frac{19 \cdot 10^6}{\text{PRI}_{\mu\text{sec}}} \right) \end{array} \right\}$ | 60% | 30 |
| | | Test B: 15 unique PRI values randomly selected in the range 518-3066 μS, with a minimum increment of 1 μS, 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 Radar Pulse 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.



3.4.2. Long Radar Pulse Test

Long Pulse Radar Test Waveforms

| Radars Type | Pulse Width (µsec) | Chirp Width (MHz) | PRI (µsec) | Number of Pulses per Burst | Number of Bursts | Minimum Percentage of Successful Detection | Minimum 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 test signal. If more than 30 waveforms are used for the Long Pulse radar test signal, then each additional waveform must also be unique and not repeated from the previous waveforms.

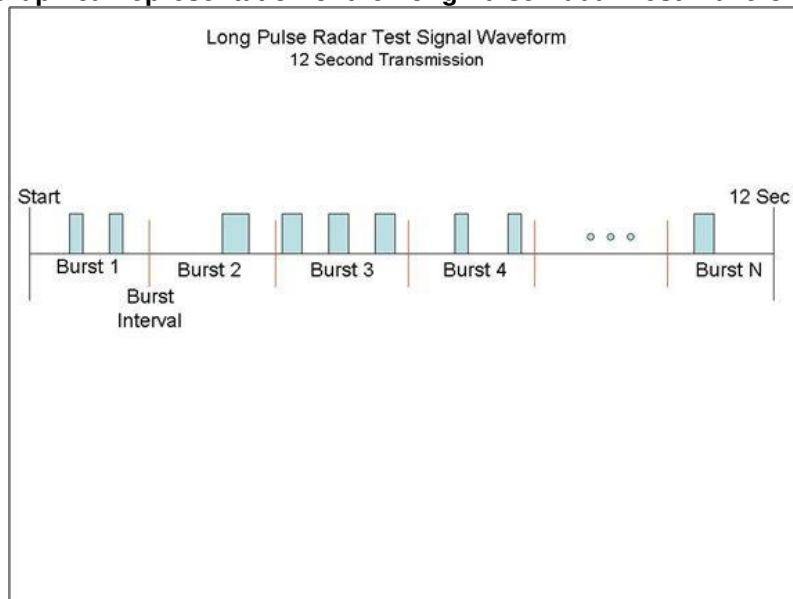
Each waveform is defined as follows:

1. The transmission period for the Long Pulse Radar test signal is 12 seconds.
2. There are a total of 8 to 20 Bursts in the 12 second period, with the number of Bursts being randomly chosen. This number is Burst Count.
3. Each Burst consists of 1 to 3 pulses, with the number of pulses being randomly chosen. Each Burst within the 12 second sequence may have a different number of pulses.
4. The pulse width is between 50 and 100 microseconds, with the pulse width being randomly chosen. Each pulse within a Burst will have the same pulse width. Pulses in different Bursts may have different pulse widths.
5. Each pulse has a linear frequency modulated chirp between 5 and 20 MHz, with the chirp width being randomly chosen. Each pulse within a transmission period will have the same chirp width. The chirp is centered on the pulse. For example, with a radar frequency of 5300 MHz and a 20 MHz chirped signal, the chirp starts at 5290 MHz and ends at 5310 MHz
6. If more than one pulse is present in a Burst, the time between the pulses will be between 1000 and 2000 microseconds, with the time being randomly chosen. If three pulses are present in a Burst, the time between the first and second pulses is chosen independently of the time between the second and third pulses.
7. The 12 second transmission period is divided into even intervals. The number of intervals is equal to Burst_Count. Each interval is of length $(12,000,000 / \text{Burst_Count})$ microseconds. Each interval contains one Burst. The start time for the Burst, relative to the beginning of the interval, is between 1 and $[(12,000,000 / \text{Burst_Count}) - (\text{Total Burst Length}) + (\text{One Random PRI Interval})]$ microseconds, with the start time being randomly chosen. The step interval for the start time is 1 microsecond. The start time for each Burst is chosen independently.

A representative example of a Long Pulse radar test waveform:

1. The total test signal length is 12 seconds.
2. 8 Bursts are randomly generated for the Burst_Count
3. Burst 1 has 2 randomly generated pulses.
4. The pulse width (for both pulses) is randomly selected to be 75 microseconds.
5. The PRI is randomly selected to be at 1213 microseconds.
6. Bursts 2 through 8 are generated using steps 3 – 5.
7. Each Burst is contained in even intervals of 1,500,000 microseconds. The starting location for Pulse 1, Burst 1 is randomly generated (1 to 1,500,000 minus the total Burst 1 length + 1 random PRI interval) at the 325,001 microsecond step. Bursts 2 through 8 randomly fall in successive 1,500,000 microsecond intervals (i.e. Burst 2 falls in the 1,500,001 – 3,000,000 microsecond range).

Graphical representation of the Long Pulse Radar Test Waveform.



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3.4.3. 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 Trials |
|-------------------|---------------------------|-------------------|-----------------------|---------------------------|---------------------------------------|---|-----------------------|
| 6 | 1 | 333 | 9 | .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.

3.5. Radar Waveform Calibration

The following equipment setup was used to calibrate the Radar Waveform. A spectrum analyzer was used to establish the test signal level for each radar type. During this process, there were no transmissions by either the Master or Client Device. The spectrum analyzer was switched to the zero span (Time Domain) mode at the frequency of the Radar Waveform generator. Peak detection was utilized. The spectrum analyzer resolution bandwidth (RBW) and video bandwidth (VBW) were set to 3 MHz.

The signal generator amplitude was set so that the power level measured at the spectrum analyzer was equal to the DFS detection threshold +1dB (Ref Section 9.2).



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3.6. Test Program Details

EUT Type: Client device without radar detection

Frequency band(s): 5,250 - 5,350 MHz and 5,470 – 5,725 MHz

Uniform Loading: For the above frequency band(s) the manufacturer declared that the device provides an aggregate uniform loading of the spectrum across all devices by selecting an operating channel among the available channels using a random algorithm.

Test Environment: Radiated

Antenna Gain used for Testing: 17 dBi

Channel 80 MHz: Transmit Power: 9 dBm Data Rate: 23 Mbit/s Duty Cycle: 17%

Number of Antenna Chains: 2

Test Communication Throughput Methodology

The requisite MPEG video file ("TestFile.mpg" available on the NTIA website at the following link <http://ntiacsd.ntia.doc.gov/dfs/>) is used during this video stream.

EUT Software Version: Prototype

Test Environmental Conditions - Ambient:

Temperature: 17 to 23 °C

Relative humidity: 31 to 57%

Pressure: 999 to 1012 mbar

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4. TEST RESULTS

4.1. Dynamic Frequency Selection (DFS)

4.1.1. Channel Close / Transmission Time

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 is generated on the Operating Channel of the U-NII device.

The EUT will be associated with a support U-NII device in order to setup an appropriate transmission media in accordance with the FCC requirements.

Channel Closing Transmission Time and Channel Mode Time - Measurement

The test system was setup to capture all data after being triggered by the radar injection, which was routed directly into the spectrum analyzer for visibility. Two scans were made using this methodology, the first shows the 200 ms channel close period which begins at the end of the radar pulse and is indicated by marker 1 and the first red line on the plot. The second red line indicates the end of the 200 ms window. Marker 2 indicates the end of the data transmission and therefore the difference between marker 2 and marker 1 is the channel close time.

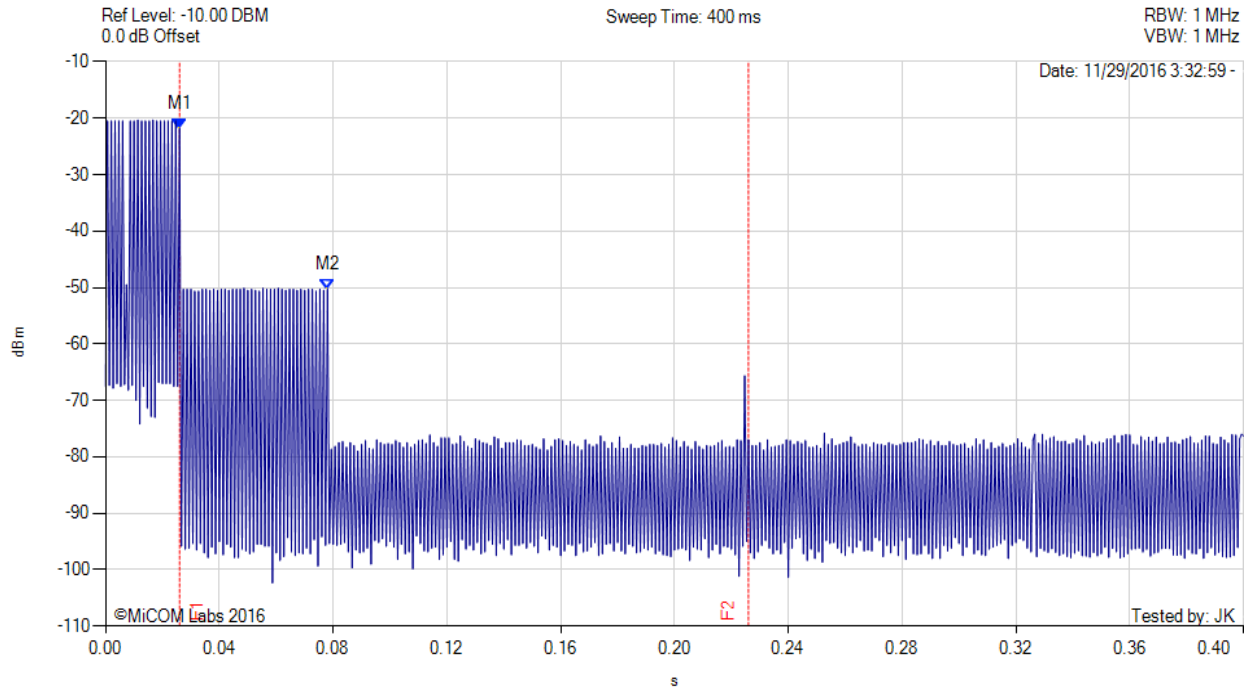
The second plot shows the 12 second channel move window. Again, triggered by the radar pulse the 10 second window is marked by the two red lines and the final control transmission is marked by marker 2. The channel move time is the difference between marker 2 and marker 1.

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CHANNEL CLOSING TIME



Variant: 802.11ac 80, Channel: 5530.00 MHz, Data Rate: 23 Mbit/s, Duty Cycle: 17.00%, Antenna Gain: 17.00 dBi



| Analyzer Setup | Marker:Time:Amplitude | Test Results |
|---|--|---|
| Detector = NRM Sweep Count = View RF Atten (dB) = 0 Trace Mode = 0 | M1 : 0.026 s : -21.830 dBm M2 : 0.078 s : -50.330 dBm | Channel Frequency: 5530.00 MHz M2 - M1 = 0.078 s - 0.026 s = 0.052 s = 52 ms |

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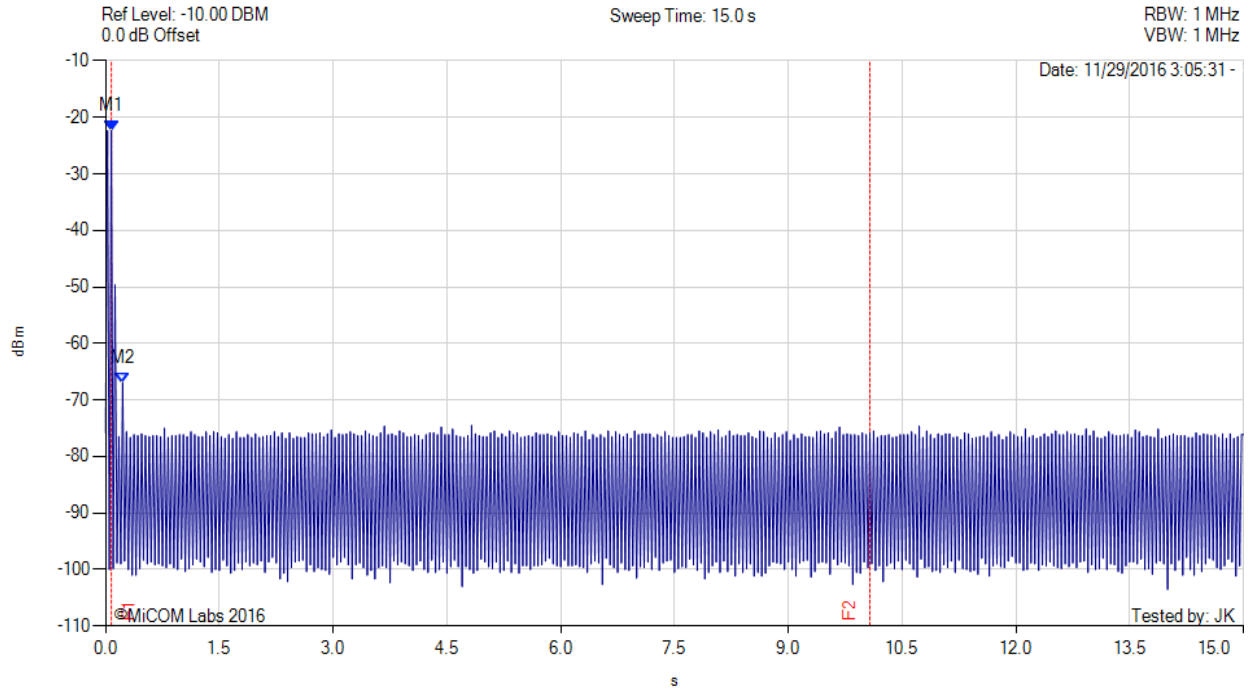


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CHANNEL MOVE TIME



Variant: 802.11ac 80, Channel: 5530.00 MHz, Data Rate: 23 Mbit/s, Duty Cycle: 17.00%, Antenna Gain: 17.00 dBi



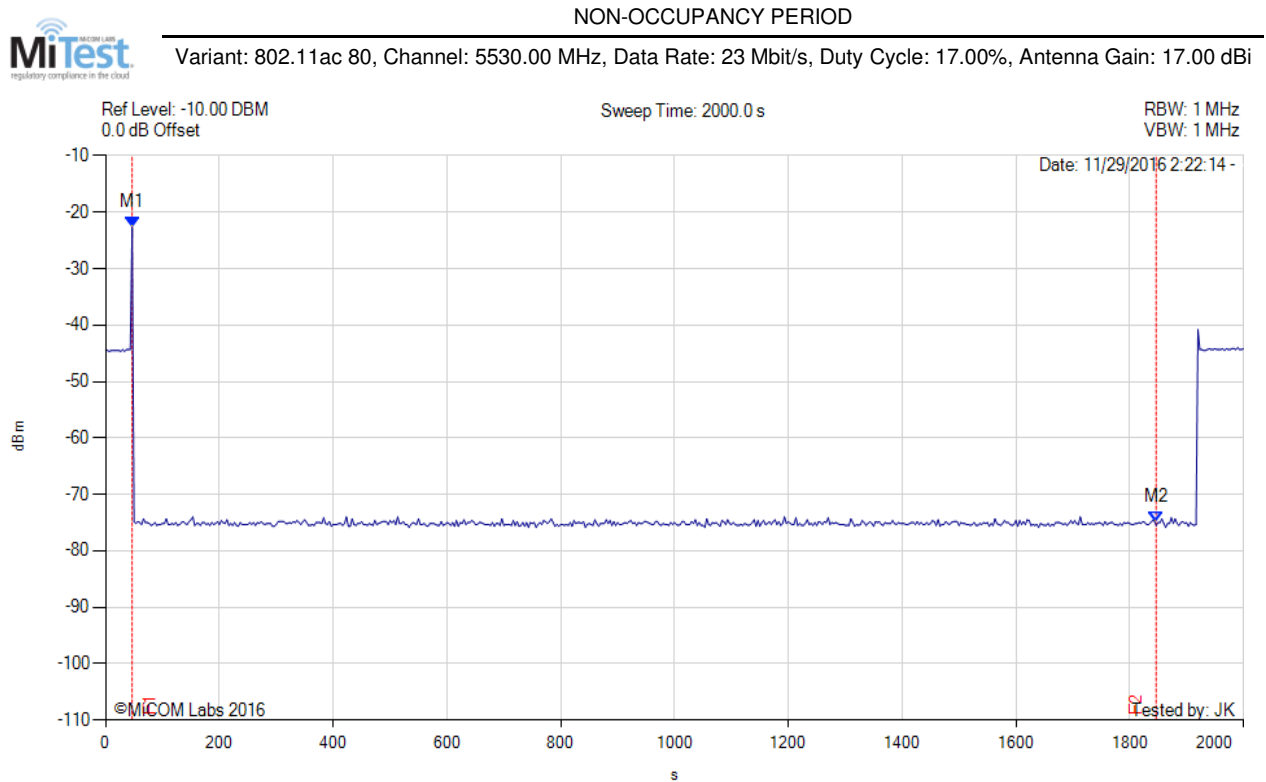
| Analyzer Setup | Marker:Time:Amplitude | Test Results |
|---|--|--|
| Detector = NRM Sweep Count = View RF Atten (dB) = 0 Trace Mode = 0 | M1 : 0.075 s : -22.330 dBm M2 : 0.225 s : -67.000 dBm | Channel Frequency: 5530.00 MHz M2 - M1 = 0.225 - 0.075 = 0.150 s = 150 ms |

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4.1.2. Non-Occupancy Period

The EUT is monitored for more than 30 minutes following the channel close/move time to verify no transmissions resume on this Channel. There should be no transmissions on the frequency of interest during the non-occupancy period.



| Analyzer Setup | Marker:Time:Amplitude | Test Results |
|---|--|--------------------------------|
| Detector = POS Sweep Count = View RF Atten (dB) = 0 Trace Mode = 0 | M1 : 46.670 s : -22.660 dBm M2 : 1846.670 s : -75.000 dBm | Channel Frequency: 5530.00 MHz |

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