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Dynamic Frequency Selection (DFS) Test Results

15.407:
U-NII devices operating in the 5.25-5.35 GHz band and the 5.47-5.725 GHz band shall employ a TPC mechanism. The U-NII device is required to have the capability to operate at least 6 dB below the mean EIRP value of 30 dBm. A TPC mechanism is not required for systems with an e.i.r.p. of less than 500 mW.

U-NII devices operating in the 5.25-5.35 GHz and 5.47-5.725 GHz bands shall employ a DFS radar detection mechanism to detect the presence of radar systems and to avoid co-channel operation with radar systems.

UNII Device Description

The EUT operates in the following bands;

1. 2400-2483.5 MHz
2. 5150-5250 MHz
3. 5250-5350 MHz
4. 5470-5725 MHz
5. 5725-5850 MHz

The EUT is a Client Device that does not have radar detection capability. The 50-ohm Tx/Rx antenna port is connected to the test system to perform conducted tests. TPC is not required since the maximum EIRP is less than 500mW (27dBm).

The EUT utilizes 802.11a IP based architecture. One nominal channel bandwidth, 20 MHz, is implemented.

The master device is a Cisco Aironet 802.11a/b/g Access Point. FCC ID: LDK102056. The DFS software installed in the master device is Cisco IOS Releases 12.3(4)JA.

The rate output power of master device is > 23 dBm (EIRP). Therefore the required interference threshold level is -64 dBm. After correction for antenna gain (0 dBi was used) and procedural adjustments (1 dBm), the required conducted threshold at the antenna port is -64 + 1 = -63 dBm.

The calibrated conducted DFS Detection Threshold level is set to -63 dBm. The tested level is lower than the required hence it provides margin to the limit.

Limit

Applicability of DFS requirements prior to use of a channel

Requirement	Operational Mode		
	Master	Client (with radar detection)	Client (without radar detection)
Non-Occupancy Period	Yes	Yes	Yes
DFS Detection Threshold	Yes	Yes	Not Required
Channel Availability Check Time	Yes	Not Required	Not Required
Uniform Spreading	Yes	Not Required	Not Required

Applicability of DFS requirements during normal operation

Requirement	Operational Mode		
	Master	Client (with radar detection)	Client (without radar detection)
DFS Detection Threshold	Yes	Yes	Not Required
Channel Closing Transmission Time	Yes	Yes	Yes
Channel Move Time	Yes	Yes	Yes

Interference Threshold value, Master or Client incorporating In-Service Monitoring

Maximum Transmit Power	Value (see note)
≥200 milliwatt	-64 dBm
< 200 milliwatt	-62 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.	

DFS Response requirement values

Parameter	Value
Non-Occupancy Period	30 Minutes
Channel Availability Check Time	60 Seconds
Channel Move Time	10 Seconds
Channel Closing Transmission Time	200 milliseconds + approx. 60 milliseconds over remaining 10 seconds period (See Notes 1 and 2)
Note1: The instant that the Channel Move Time and the Channel Closing Transmission Time begins is as follows: ● For the short pulse radar test signals this instant is the end of the burst. ● For the frequency hopping radar test signal, this instant is the end of the last radar burst generated ● For the long pulse radar test signal this instant is the end of the 12 seconds period defining the radar transmission. 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 facilitating channel changes (an aggregate of approximately 60 milliseconds) during the remainder of the 10 seconds period. The aggregate duration of control signals will not count quiet periods in between transmissions.	

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Short Pulse Radar Test Waveforms

Radar Type	Pulse Width (μsec)	PRI (μsec)	Pulses	Minimum Percentage of Successful Detection	Minimum Trials
1	1	1428	18	60%	30
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

A minimum of 30 unique waveforms are required for each of the short pulse radar type 2 through 4. For short pulse radar type 1, then same waveform is used a minimum of 30 times. If more than 30 waveforms are used for short pulse radar type 2 through 4, then each additional waveform must also be unique and not repeated from the previous waveforms. The aggregate is the average of the percentage of successful detections of short pulse radar type 1-4.

Long Pulse Radar Test Signal

Radar Waveform	Bursts	Pulses Per Burst	Pulse Width (μsec)	Chirp Width (MHz)	PRI (μsec)	Minimum Percentage of Successful Detection	Minimum Trials
5	8-20	1-3	50-100	5-20	1000-2000	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.

Frequency Hopping Radar Test Signal

Radar Waveform	Pulse Width (μsec)	PRI (μsec)	Hopping Sequence Length (msec)	Pulses Per Hop	Hopping Rate (kHz)	Minimum Percentage of Successful Detection	Minimum Trials
6	1	333	300	9	.333	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.

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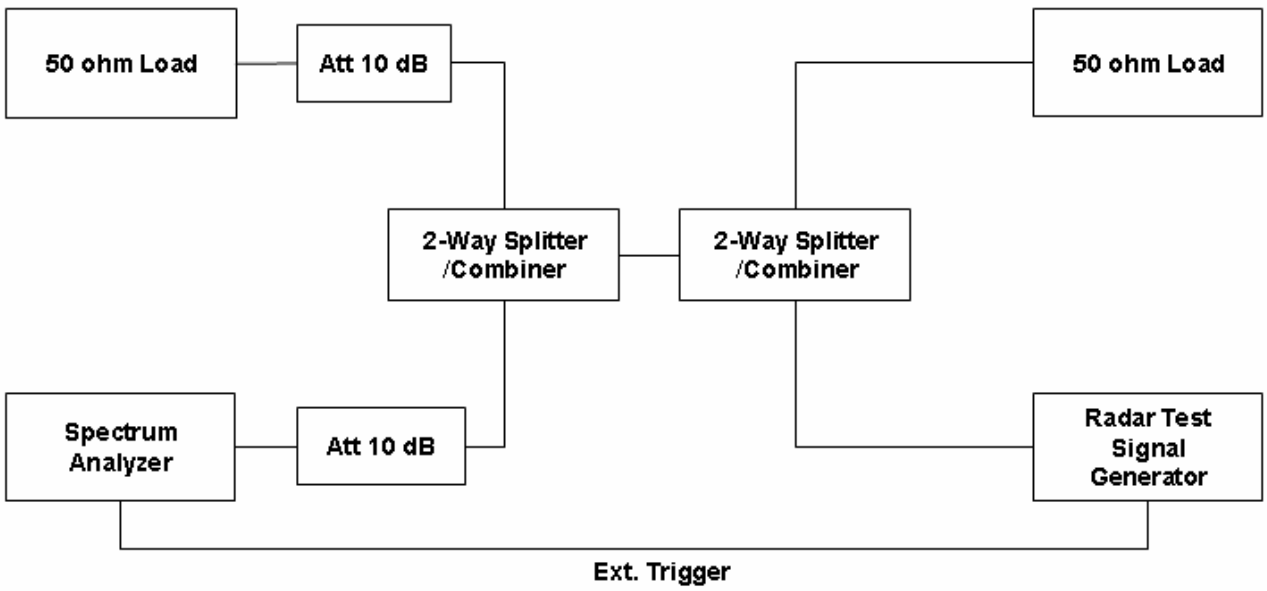
Radar Waveform Calibration

The following equipment setup was used to calibrate the conducted 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) 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 1 MHz and 3 MHz.

The signal generator amplitude was set so that the power level measured at the spectrum analyzer was -63 dBm.

Conducted Calibration Setup



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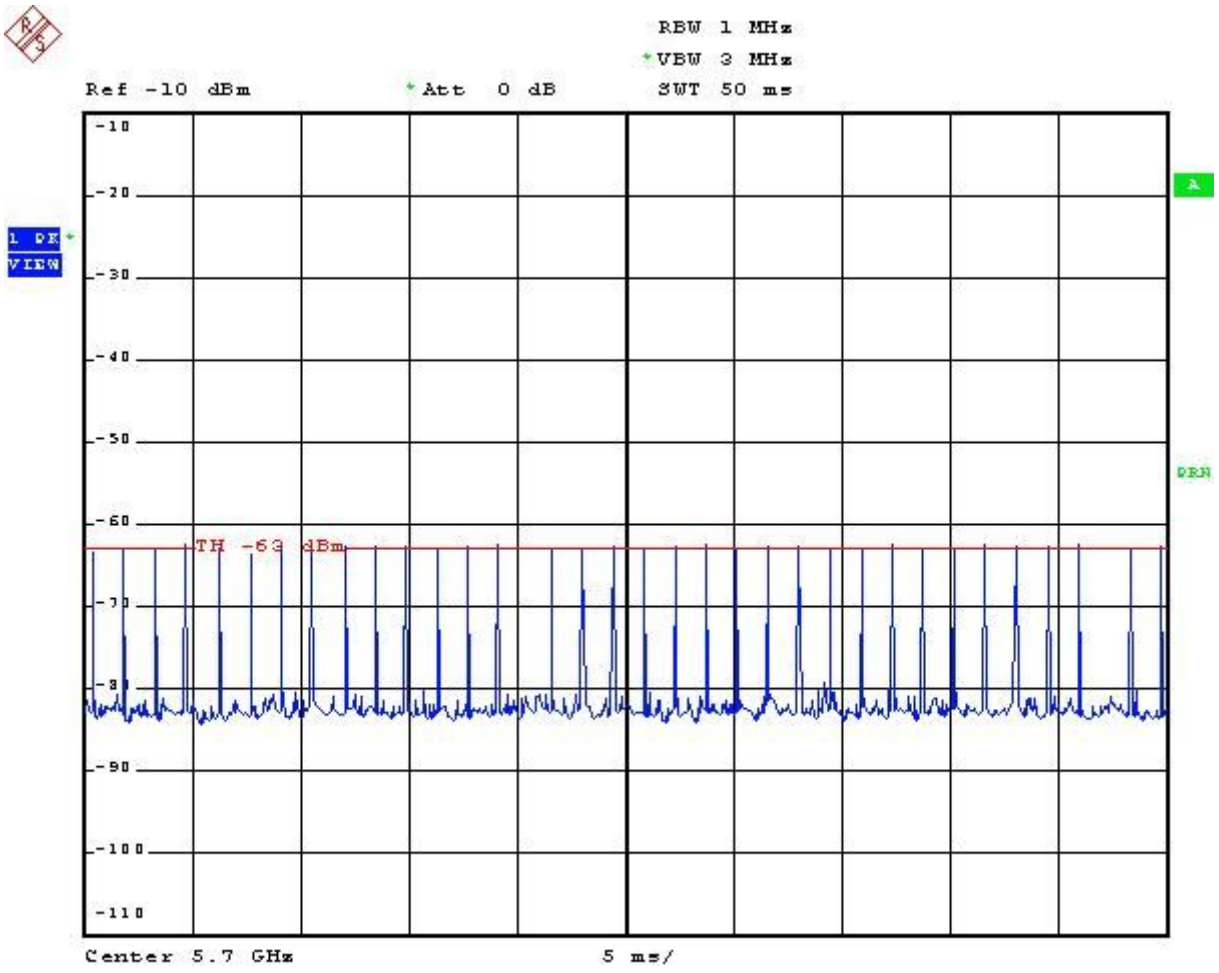
Radar Type 1 Calibration Plot



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Test Equipment

Instrument	Manufacturer	Type No.	Serial No.	Cal. Date
Spectrum Analyzer	Rohde & Schwarz	FSP	100561	2006/09/03
Vector Signal Generator	Rohde & Schwarz	SUM 200A	102168	2007/01/23

Instrument	Manufacturer	Type No.	Serial No.
Splitter/Combiner (Qty: 2)	Mini-Circuits	ZAPD-50W 4.2-6.0 GHz	NN256400424
ATT (Qty: 3)	Mini-Circuits	BW-S3W2 DC-18GHz	0025
Access Point	Cisco System	AIR-AP1242AG	FOC10352PCV
Laptop PC	Dell	M65	28G9N1S
Laptop PC	Dell	D400	GK43D1S
RF Cable (Qty: 5)	Schaffner		25494/6

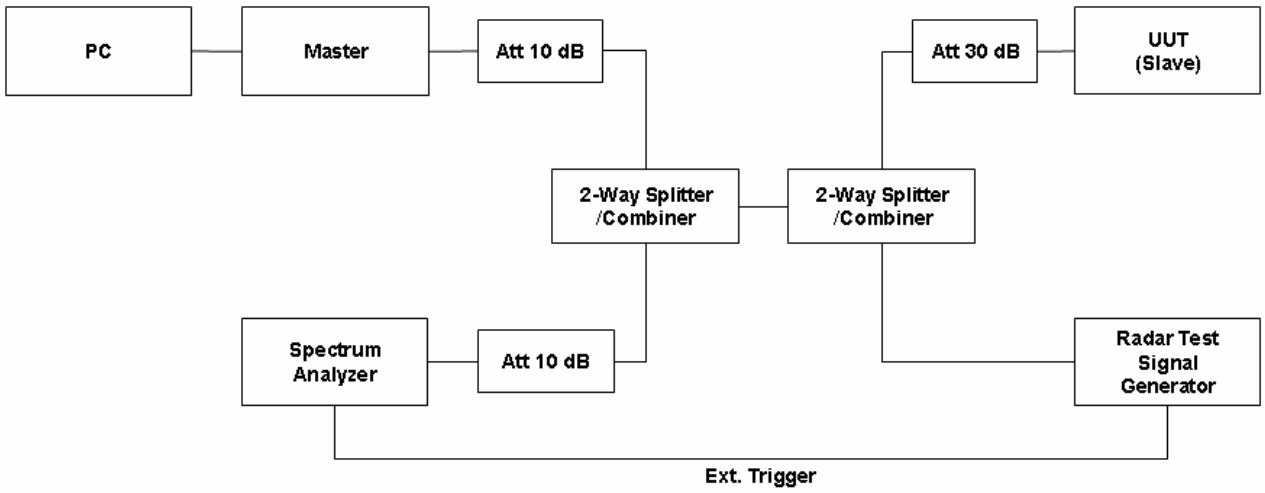
Software	Manufacturer	Function
Cisco IOS Releases 12.3(4)JA	Cisco	DFS software
R&S K6 Pulse Sequencer	Rohde & Schwarz	Radar Signal Generation Software
UTP Tool	UNICAST	Package data generator

Test Procedure

A spectrum analyzer is used as a monitor to verify that the EUT has vacated the channel within the channel closing transmission time and channel move time after the detection and channel move.

The EUT is a WLAN device operating as client without radar interference detection function. Radar test signals are injected into the master device. This set-up also contains a WLAN device operating in master device. The EUT (client device) is associated with the master device.

Following is the test setup used to generate the radar waveforms and for all DFS tests described herein.



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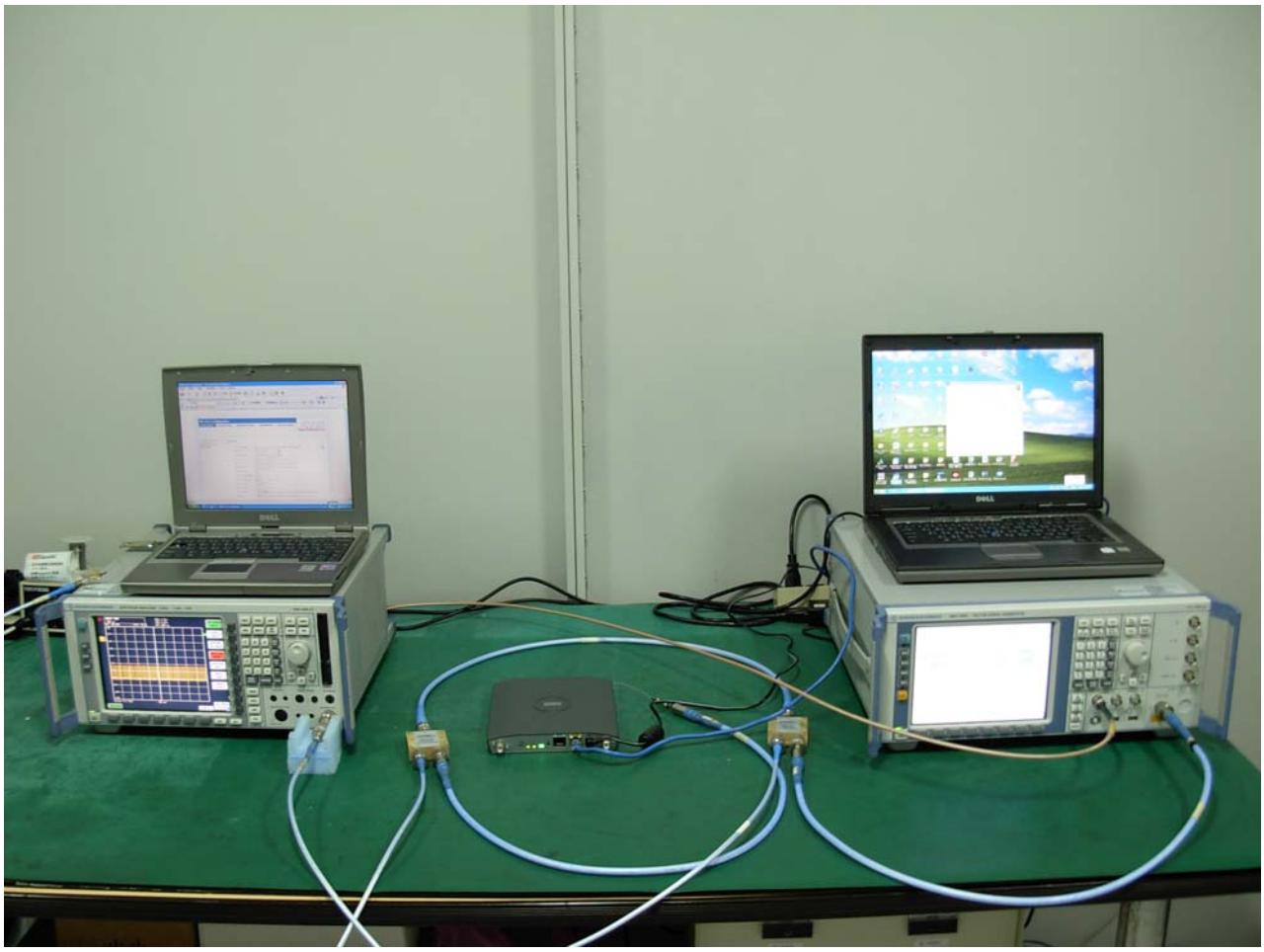
Full DFS Test Setup



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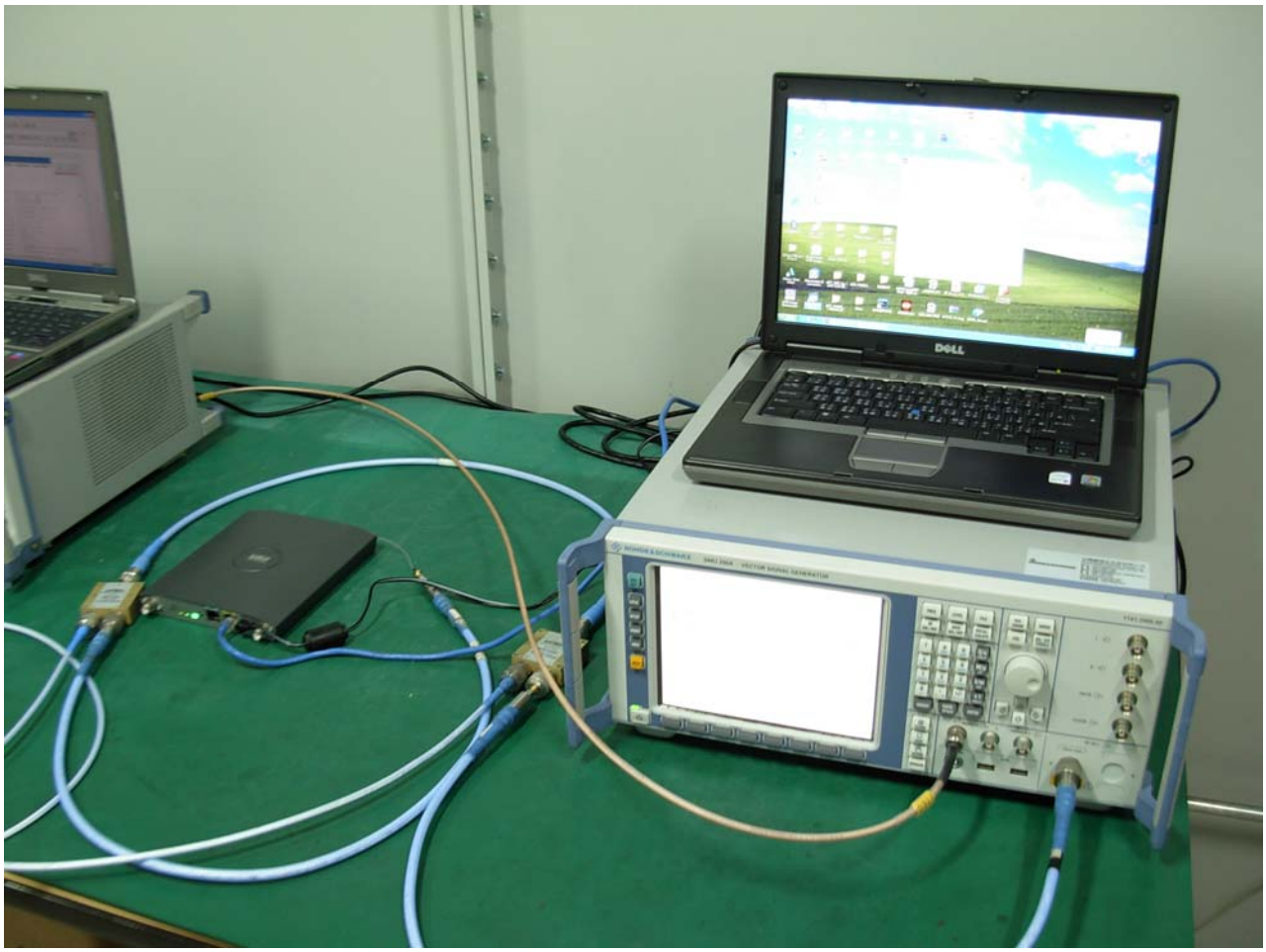
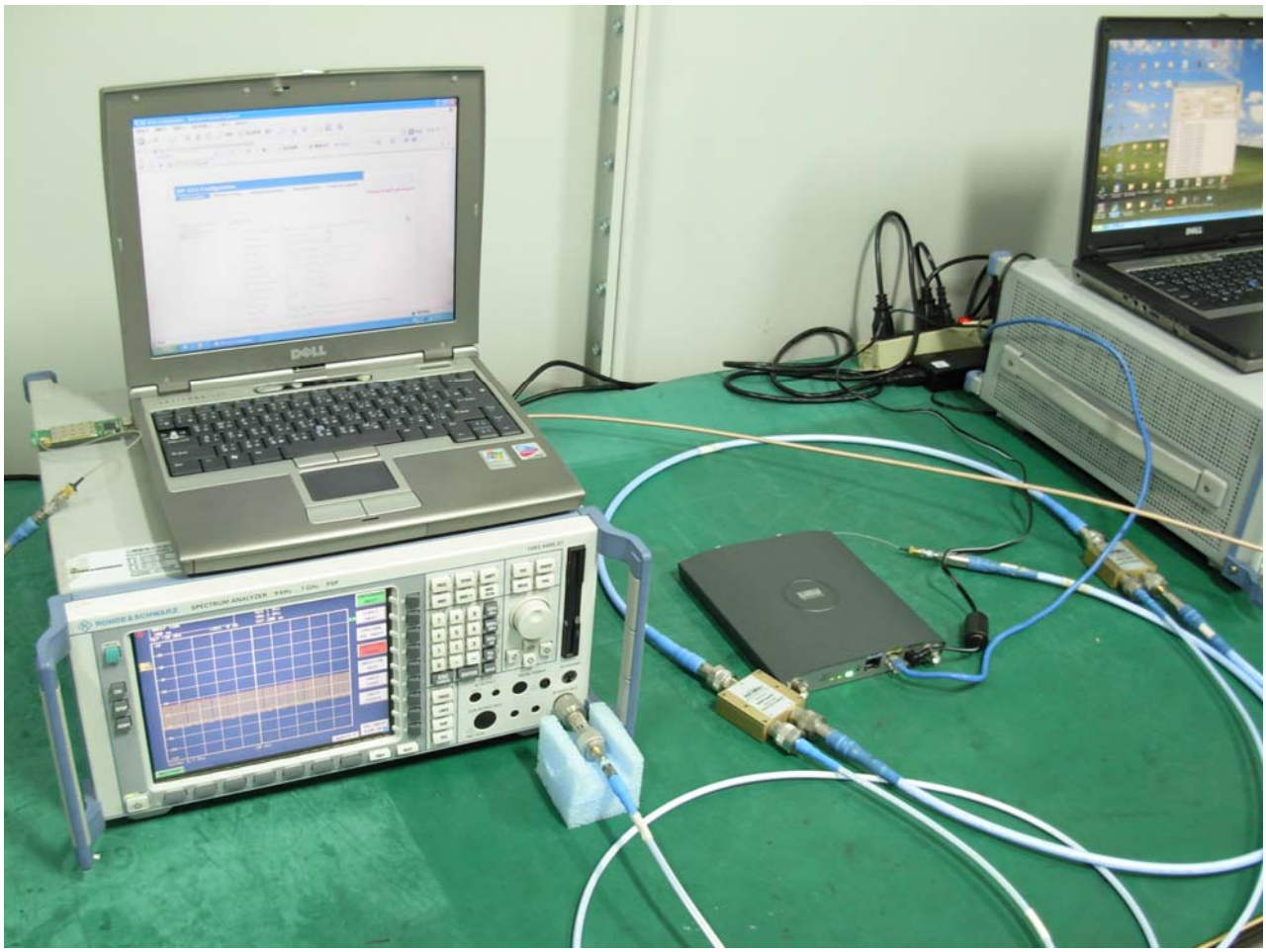
DFS Setup: Master Device and Radar Test Signal Generator



DFS Setup: EUT and Spectrum Analyzer



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Channel Move Time and Channel Closing Transmission Time

These tests define how the following DFS parameters are verified during In-Service Monitoring; Channel Closing Transmission Time and Channel Move Time.

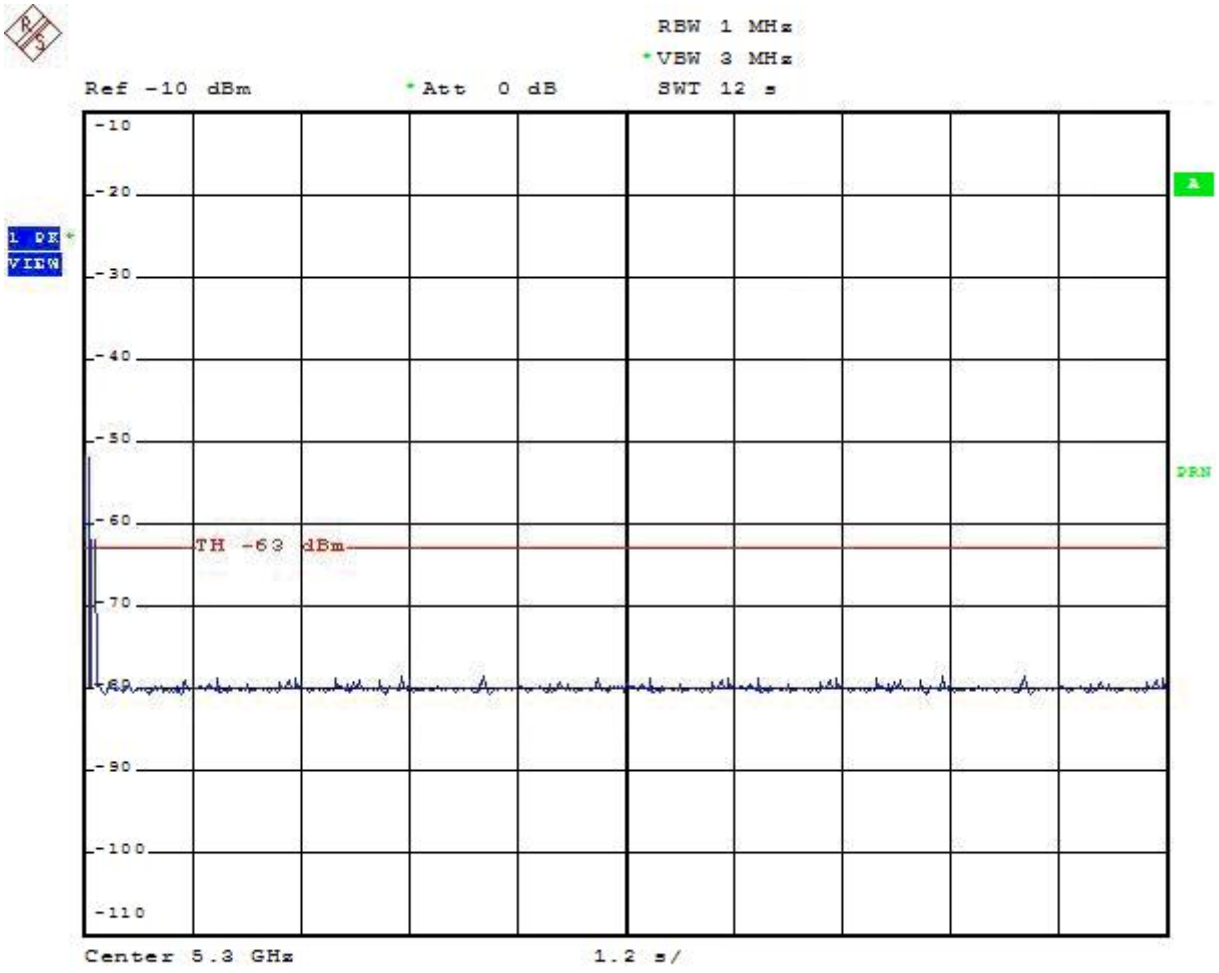
The steps below define the procedure to determine the above mentioned parameters when a radar burst with a level equal to the DFS detection threshold +1dB (-63 dBm) is generated on the operating channel of the U-NII device.

A U-NII device operating as a Client device will associate with the Master device at 5300 MHz. Traffic data from the master device to the client device on the selected channel for the entire period of the test.

The radar waveform generator sends a burst of pulses for each of the radar types at -63 dBm.

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 spectrum analyzer during the observation time (Channel Move Time). Compare the channel move time and channel closing transmission time results to the limits defined in the *DFS Response requirement values table***.**

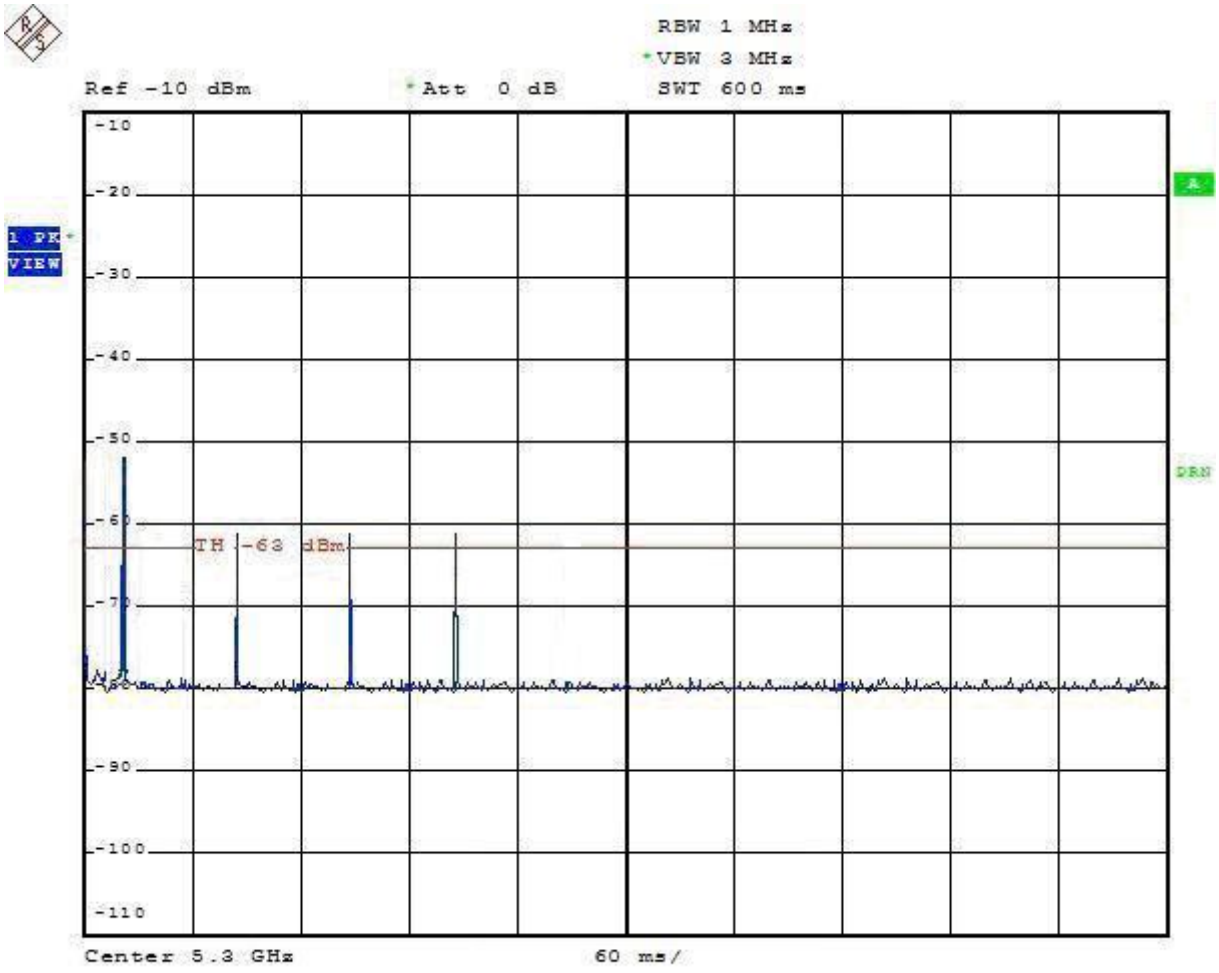
Channel Move Time for Radar Test Signal 1 at 5300 MHz



Test Item	Limit	Results
Channel Move Time	10 Seconds	Pass

The results showed that after radar signal injected the channel move time was less than 10 seconds.

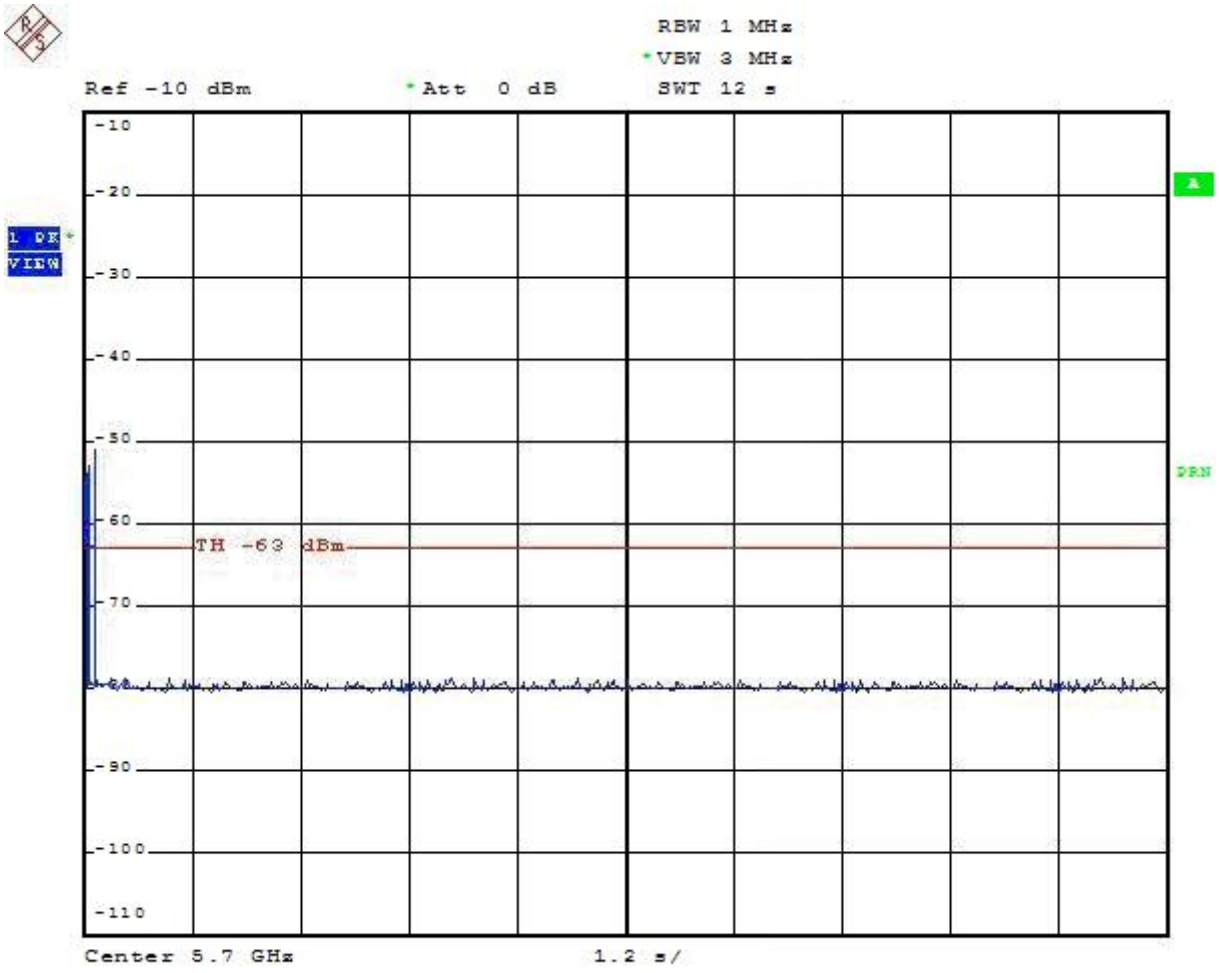
Channel Closing Transmission Time for Radar Test Signal 1 at 5300 MHz



Test Item	Limit	Results
Channel Closing Transmission	200 milliseconds + approx. 60 milliseconds over remaining 10 seconds period	Pass

The results showed that after radar signal injected the transmission closing was less than 260 milliseconds.

Channel Move Time for Radar Test Signal 1 at 5700 MHz.



Test Item	Limit	Results
Channel Move Time	10 Seconds	Pass

The results showed that after radar signal injected the channel move time was less than 10 seconds.

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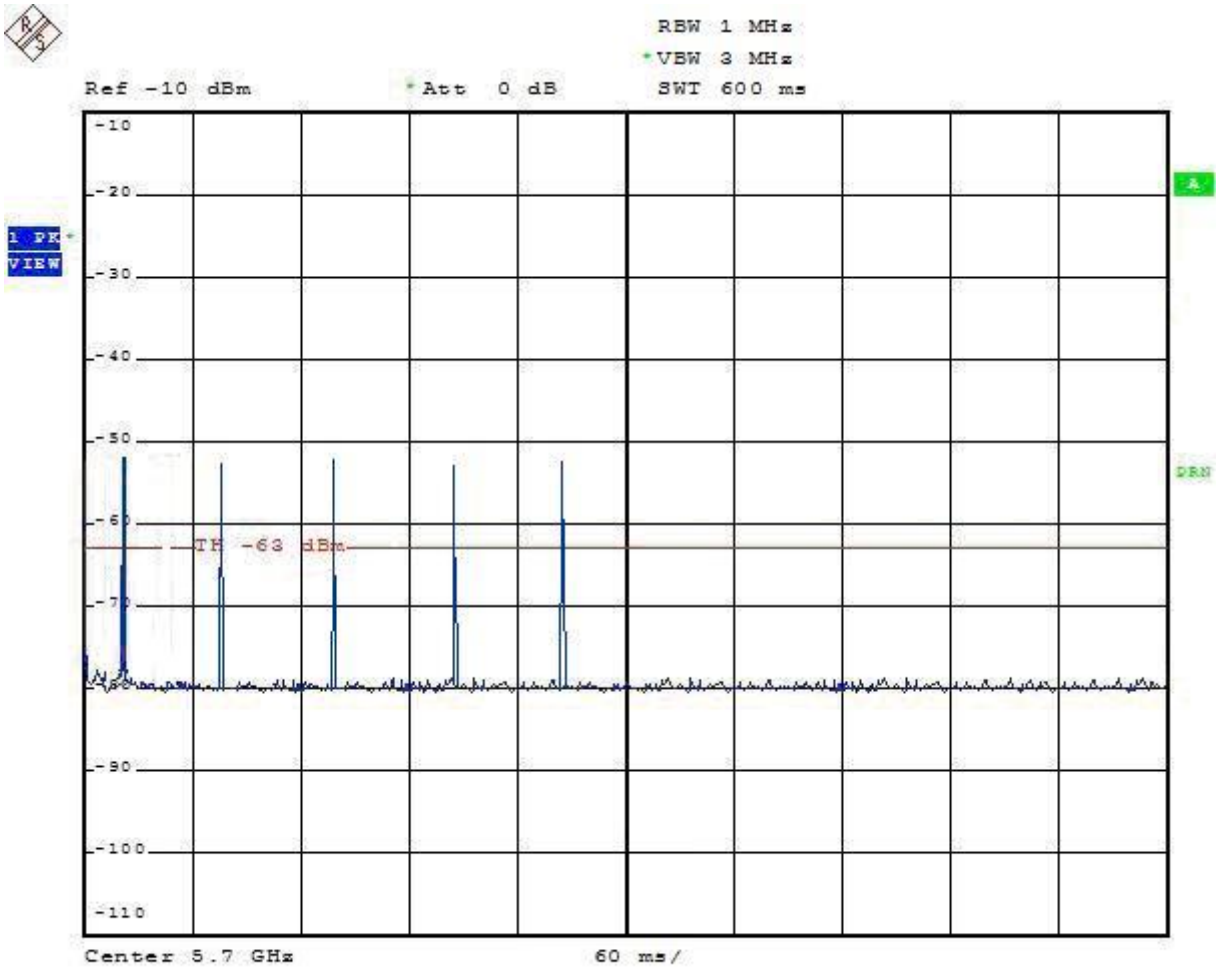
Channel Closing Transmission Time for Radar Test Signal 1 at 5700 MHz



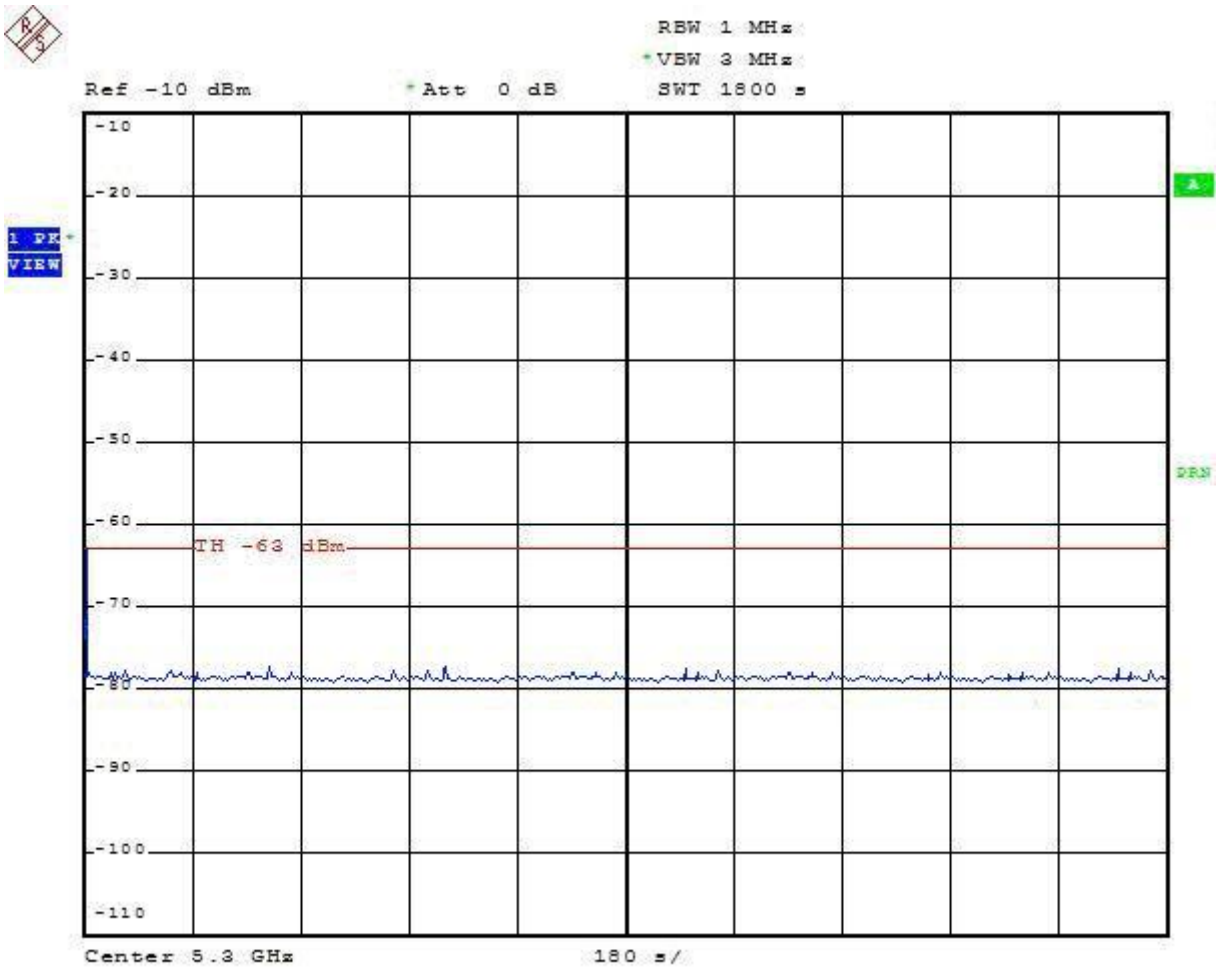
Test Item	Limit	Results
Channel Closing Transmission	200 milliseconds + approx. 60 milliseconds over remaining 10 seconds period	Pass

The results showed that after radar signal injected the transmission closing was less than 260 milliseconds.

Non-Occupancy Period

Measure the EUT for more than 30 minutes following the channel close/move time to verify that the UUT does not resume any transmissions on this channel.

30 Minute Non-Occupancy Period (using Type 1 Radar) at 5300 MHz



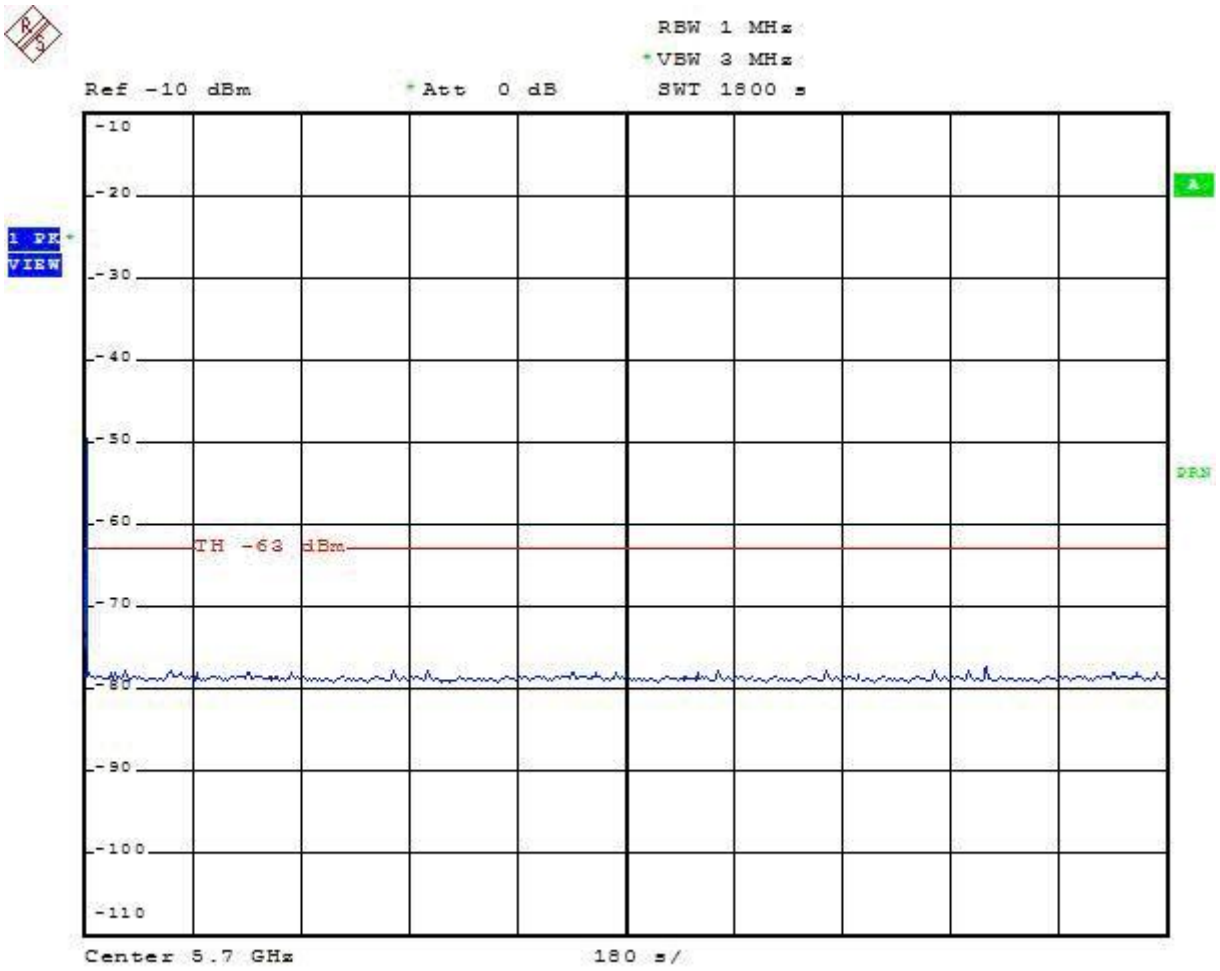
Test Item	Limit	Results
Non-Occupancy Period	30 Minutes	Pass

No EUT transmissions were observed on the test channel during 30 minutes observation time.

Non-Occupancy Period

Measure the EUT for more than 30 minutes following the channel close/move time to verify that the UUT does not resume any transmissions on this channel.

30 Minute Non-Occupancy Period (using Type 1 Radar) at 5700 MHz



Test Item	Limit	Results
Non-Occupancy Period	30 Minutes	Pass

No EUT transmissions were observed on the test channel during 30 minutes observation time.

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In-Service Monitoring Results at 5300 MHz

Radar Test Summary:				
Signal Type	Trial No.	Detection (%)	Limit (%)	Pass/Fail
Type 1	30	96.66	60	Pass
Type 2	30	93.33	60	Pass
Type 3	30	90.00	60	Pass
Type 4	30	90.00	60	Pass
Aggregate	4	92.49	80	Pass
Type 5	30	83.33	80	Pass
Type 6	30	73.33	70	Pass

In-Service Monitoring Results at 5700 MHz

Radar Test Summary:				
Signal Type	Trial No.	Detection (%)	Limit (%)	Pass/Fail
Type 1	30	96.66	60	Pass
Type 2	30	93.33	60	Pass
Type 3	30	93.33	60	Pass
Type 4	30	93.33	60	Pass
Aggregate	4	94.16	80	Pass
Type 5	30	86.67	80	Pass
Type 6	30	80.00	70	Pass