5.9 DFS(Dynamic Frequency Selection)

5.9.1 Regulation

According to §15.407(h)(2) Radar Detection Function of Dynamic Frequency Selection (DFS). 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. The minimum DFS detection threshold for devices with a maximum e.i.r.p. of 200 mW to 1 W is -64 dBm. For devices that operate with less than 200 mW e.i.r.p. the minimum detection threshold is -62 dBm. The detection threshold is the received power averaged over 1 microsecond referenced to a 0 dBi antenna. The DFS process shall be required to provide a uniform spreading of the loading over all the available channels.

(i) Operational Modes. The DFS requirement applies to the following operational modes:
(A) The requirement for channel availability check time applies in the master operational mode.
(B) The requirement for channel move time applies in both the master and slave operational modes.
(ii) Channel Availability Check Time. A U-NII device shall check if there is a radar system already operating on the channel before it can initiate a transmission on a channel and when it has to move to a new channel. The U-NII device may start using the channel if no radar signal with a power level greater than the interference threshold values listed in paragraph (h)(2) of this part, is detected within 60 seconds.
(iii) Channel Move Time. After a radar's presence is detected, all transmissions shall cease on the operating channel within 10 seconds. Transmissions during this period shall consist of normal traffic for a maximum of 200 ms after detection of the radar signal. In addition, intermittent management and control signals can be sent during the remaining time to facilitate vacating the operating channel.
(iv) Non-occupancy Period. A channel that has been flagged as containing a radar system, either by a channel availability check or in-service monitoring, is subject to a non-occupancy period of at least 30 minutes. The non-occupancy period starts at the time when the radar system is detected.

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5.9.2 EUT Information

5.9.2.1 Operating Frequency bands.

Operational mode	Operating Frequency Range	
	5 250~ 5 350 MHz	5 470~ 5 725MHz
Client without radar detection	O	O

5.9.2.2 Software and Firmware Version.

EUT	Model No.	Software and Firmware Version
SATELLITE RECEIVER	HR44-500	Wi-Fi Driver Ver: 5.90.188.59

5.9.2.3 Description of Available Antennas.

Antenna Type	Frequency Range(MHz)	Max Gain(dBi)
PCB Ant0	4 900 ~ 5 900	3.20
PCB Ant1	4 900 ~ 5 900	3.20
PCB Ant0 + Ant1	4 900 ~ 5 900	6.21

5.9.2.4 Highest and Lowest Conducted Output Power.

- Highest power level

Test Mode	Frequency Range	Highest Output Power	
		Output Power(dBm)	Output Power(mW)
802.11a	5 250 ~ 5 350	20.30	107.15
	5 470 ~ 5 725	19.93	98.40
802.11n 20 MHz	5 250 ~ 5 350	21.47	140.29
	5 470 ~ 5 725	20.74	118.53
802.11n 40 MHz	5 250 ~ 5 350	21.26	133.53
	5 470 ~ 5 725	21.68	147.19

- Lowest power level

Test Mode	Frequency Range	Lowest Output Power	
		Output Power(dBm)	Output Power(mW)
802.11a	5 250 ~ 5 350	18.90	77.62
	5 470 ~ 5 725	17.52	56.49
802.11n 20 MHz	5 250 ~ 5 350	19.22	83.56
	5 470 ~ 5 725	16.61	45.81
802.11n 40 MHz	5 250 ~ 5 350	18.64	73.12
	5 470 ~ 5 725	15.78	37.88

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82 31 336 9919 (Main) 82 31 336 4767 (Fax)

5.9.2.5 Highest and Lowest E.I.R.P. Output Power.

- Highest power level

Test Mode	Frequency Range	Highest E.I.R.P. Power	
		Output Power(dBm)	Output Power(mW)
802.11a	5 250 ~ 5 350	23.50	109.24
	5 470 ~ 5 725	23.13	100.49
802.11n 20MHz	5 250 ~ 5 350	27.68	144.46
	5 470 ~ 5 725	21.17	130.84
802.11n 40MHz	5 250 ~ 5 350	27.38	135.02
	5 470 ~ 5 725	24.85	77.30

- Lowest power level

Test Mode	Frequency Range	Lowest E.I.R.P. Power	
		Output Power(dBm)	Output Power(mW)
802.11a	5 250 ~ 5 350	22.10	79.71
	5 470 ~ 5 725	20.72	58.58
802.11n 20MHz	5 250 ~ 5 350	22.42	85.65
	5 470 ~ 5 725	19.81	47.90
802.11n 40MHz	5 250 ~ 5 350	24.85	77.30
	5 470 ~ 5 725	21.99	42.06

5.9.2.6 Statement of Maunfacturer.

Manufacturer statement confirming that information regarding the parameters of the detected Radar Waveforms is not available to the end user. And the device doesn’t have Ad Hoc mode and on DFS frequency band.

5.9.2.7 Support Equipment

Product	Manufacture	Model No.	Serial No.	FCCID.
Cisco Aironet IOS Access Point	Cisco	AIR-AP1252AG-K-K9	FGL1439ZOHS	LDK102056

Note. This device was functioned as a Master device during the DFS test.

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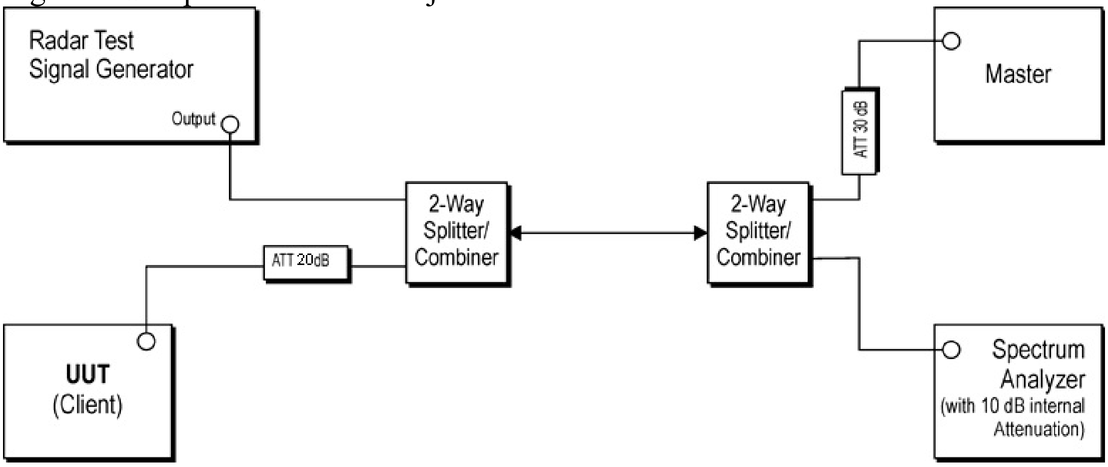
5.9.3 Test Setup

The FCC 06-96 describes a conducted test setup. A conducted test setup was used for this testing. Figure 1 shows the typical test setup. Each one channel selected between 5250 and 5350 MHz, 5470 and 5725 is chosen for the testing.

Figure 1. Setup for Client with injection at the Master



1. The vector signal generator is setup to provide a pulse at the frequency that the Master and Client are operating. A Type 1 radar pulse is used for the testing.

2. The vector signal generator is adjusted to provide the radar burst at a level of approximately -62 dBm at the antenna of the Master device.

3. The Client Device (EUT) is set up per the diagram in Figure 1 and communications between the Master device and the Client is established.

4. The MPEG file specified by the FCC(NTIA approved MPEG2 file) is streamed from the "file computer" through the Master to the Slave Device and played in full motion in order to properly load the network.

5. The spectrum analyzer is set to record about 20 sec window to any transmissions occurring up to and after 10 sec.

6. The system is again setup and the monitoring time is shortened in order to capture the Channel Closing Transmission Time. This time is measured to insure that the Client ceases transmission within 200 ms and the aggregate of emissions occurring after 200 ms up to 10 sec do not exceed 60 ms.

7. After the initial radar burst the channel is monitored for 30 minutes to insure no transmissions or beacons occur. A second monitoring setup is used to verify that the Master and Client have both moved to different channels.

480-5 Shin-dong, Yeongtong-gu, Suwon-city, Gyunggi-do, 443-390, Korea
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5.9.4 Measurement Procedure

The following table from FCC 06-96 lists the applicable requirements for the DFS testing.
The device evaluated in this report is considered a client device without radar detection capability.

5.9.4.1 Applicability

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
Uniform Spreading	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	Client Without Radar Detection	Client With Radar Detection
DFS Detection Threshold	Yes	Not required	Yes
Channel Closing Transmission Time	Yes	Yes	Yes
Channel Move Time	Yes	Yes	Yes
U-NII Detection Bandwidth	Yes	Not required	Yes

5.9.4.2 Requirements

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.

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5.9.4.3 DFS Detection Thresholds

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

Maximum Transmit Power	Value (See Notes 1 and 2)
≥ 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.

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 80% of the U-NII 99% transmission power bandwidth. See Note 3.

Note 1: 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 second period defining the Radar Waveform.

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 1 is used and for each frequency step the minimum percentage of detection is 90 percent. Measurements are performed with no data traffic.

480-5 Shin-dong, Yeongtong-gu, Suwon-city, Gyunggi-do, 443-390, Korea
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5.9.4.4 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
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 Types 2 through 4. For Short Pulse Radar Type 1, the same waveform is used a minimum of 30 times. 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.
The aggregate is the average of the percentage of successful detections of Short Pulse Radar Types 1-4.

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

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 Burst will have the same chirp width. Pulses in different Bursts may have different chirp widths. 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 random time interval between the first and second pulses is chosen independently of the random time interval 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 / 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 / Burst_Count) – (Total Burst Length) + (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 randomly.

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A representative example of a Long Pulse Radar Type waveform:

1) The total test waveform length is 12 seconds.
2) Eight (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).

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.

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5.9.5 Test Result

The UUT is a U-NII Device operating in Client mode without radar detection.
The radar test signals are injected into the Master Device.

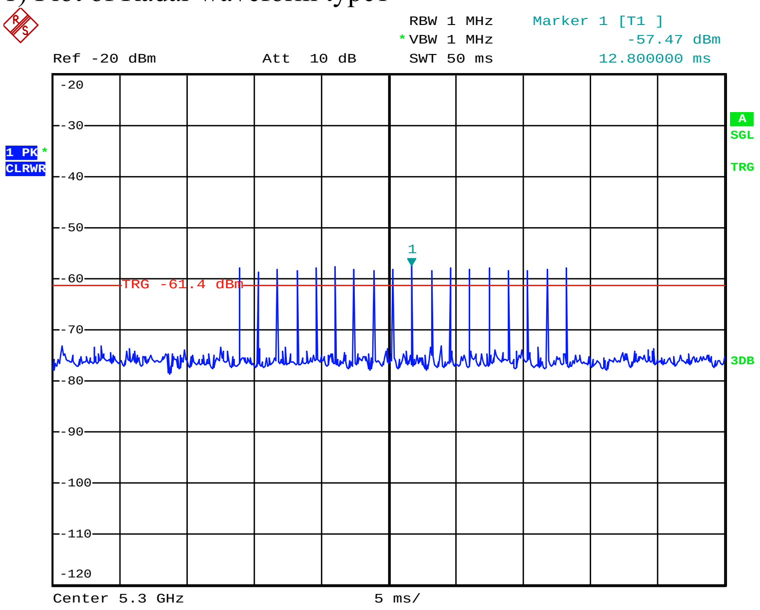
The highest power level within these bands in 21.47 dBm(140.29 mW) EIRP in the 5250 ~ 5350 MHz band and 21.68 dBm(147.19 mW) EIRP in the 5470 ~ 5725 MHz band.

The gain antenna assembly utilized with the master has a gain of 3.5 dBi.

The calibrated conducted DFS detection threshold level is set to - 57.5 dBm. (- 62 + 1 + 3.5 = - 57.5)

5 250 ~ 5 350 MHz band

1) Plot of Radar waveform type1



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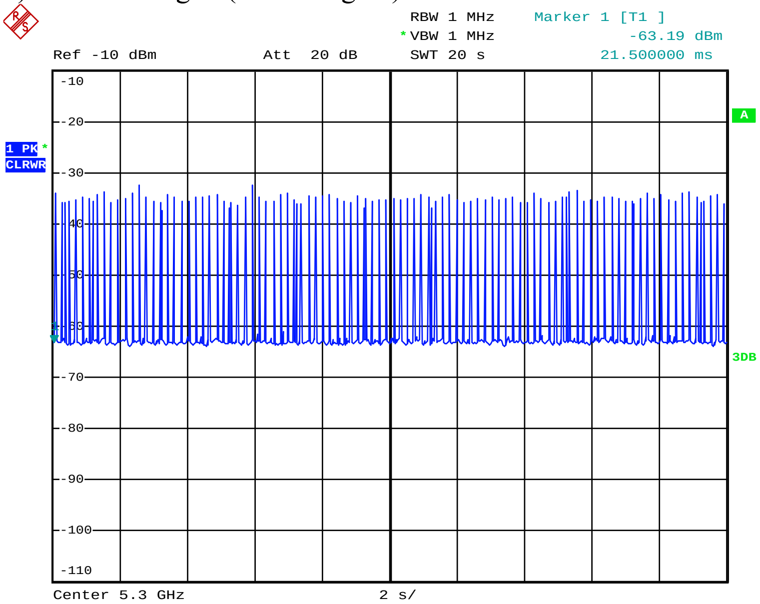
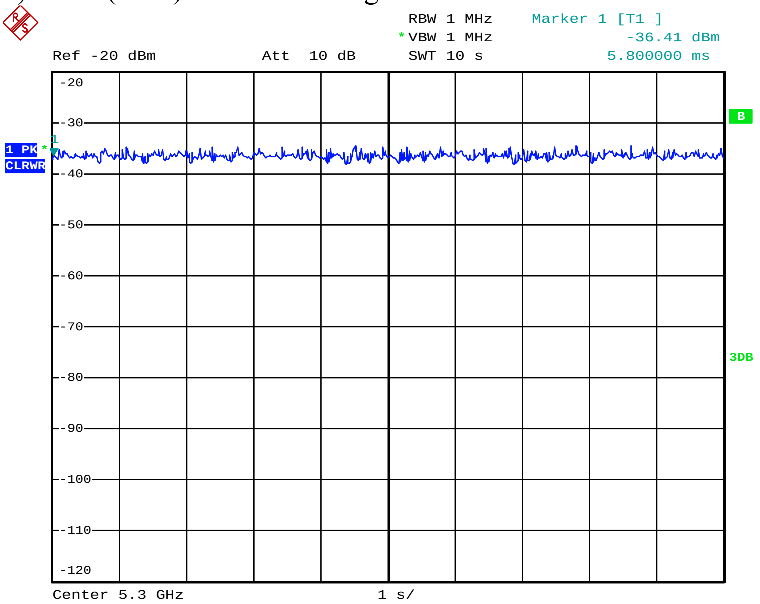
2) No traffic signal(master signal)



3) Client(EUT) Data Traffic Signal



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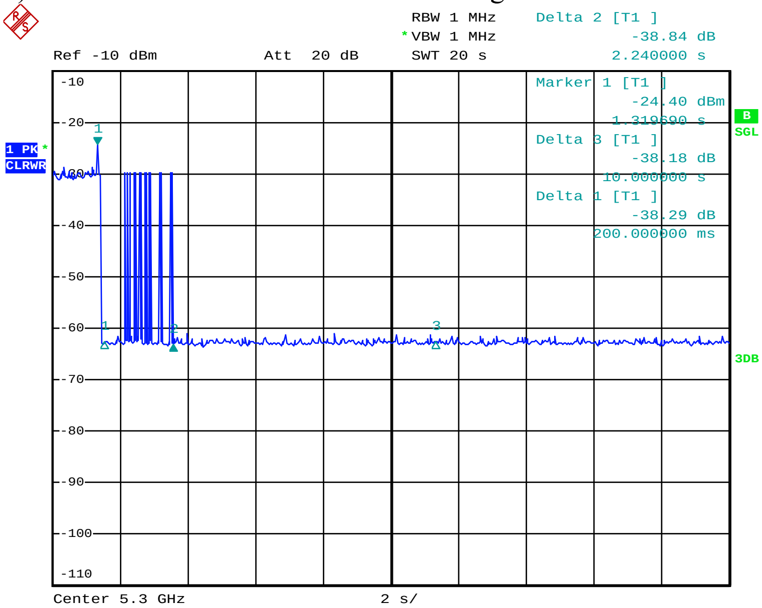
4) Channel move time and channel closing transmission time



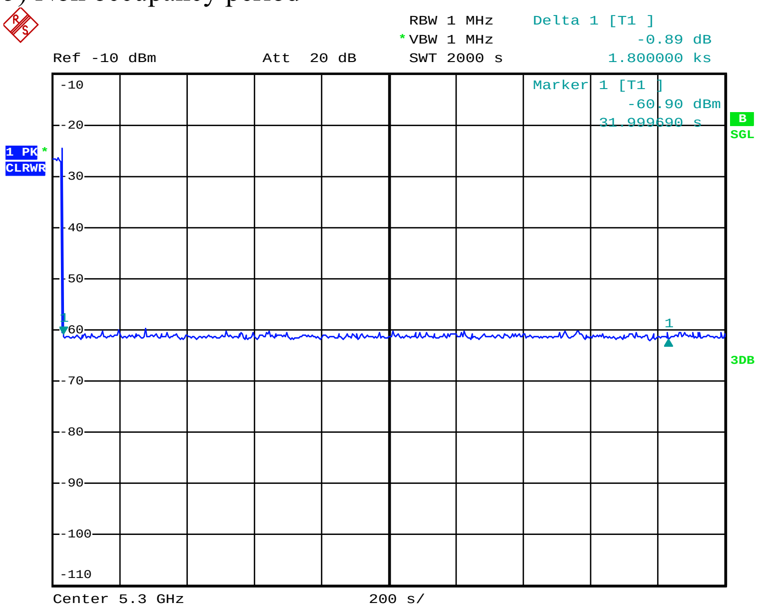
Note. Marker1: Radar signal.

Delta1: The data transmission time of 200ms from Marker1.

Delta2: The end of Channel Move Time.

Delta3: The 10 second from T1 to observe the aggregate duration of transmissions.

5) Non occupancy period



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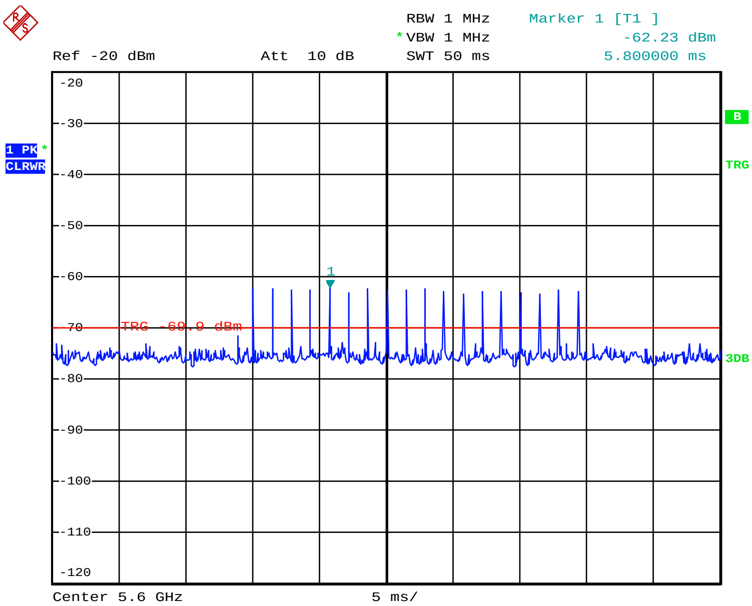
5 470 ~ 5 725 MHz band

Frequency (MHz)	Channel move time(s)		channel closing transmission time(ms)	
	Measured	Limit	Measured	Limit
5 600	2.48	10	6.44	60

Note. Channel closing transmission time: 77 * 83.6 us = 6.44 ms

1) Plot of Radar waveform type1



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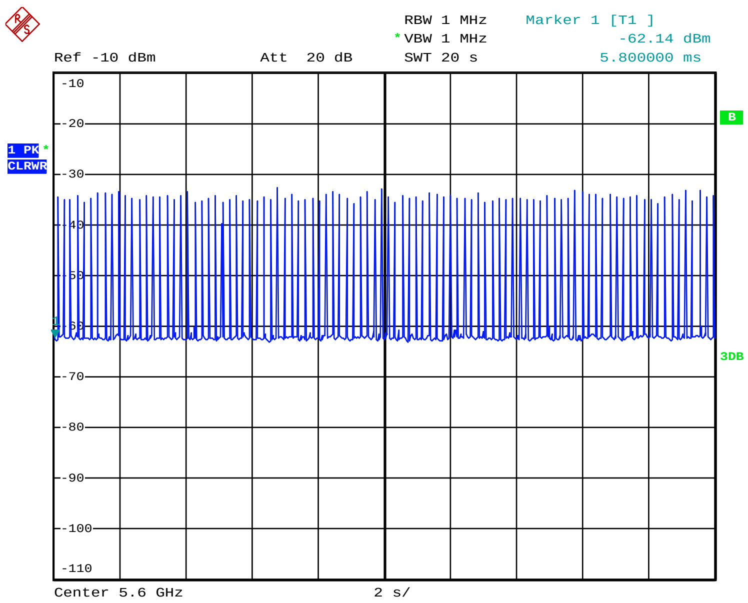
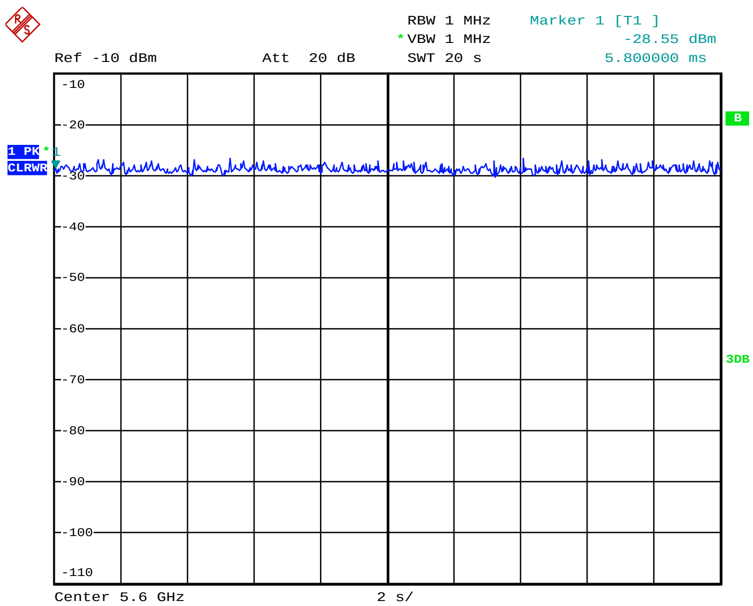
2) No traffic signal(master signal)



3) Client(EUT) Data Traffic Signal



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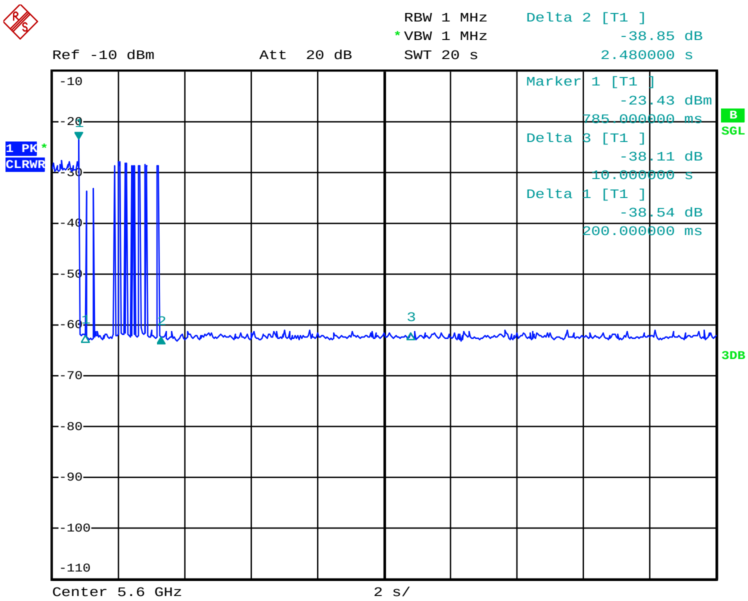
4) Channel move time and channel closing transmission time



Note. Marker1: Radar signal.
Delta1: The data transmission time of 200ms from Marker1.
Delta2: The end of Channel Move Time.
Delta3: The 10 second from T1 to observe the aggregate duration of transmissions.

5) Non occupancy period