Dynamic Frequency Selection (DFS)

Test Report

Product Name	:	Android Based UI
Trade Name	:	PCI
Model No.	:	CSD-ELINK2
FCC ID.	:	LY5-PCIABUI

Applicant	:	PCI Private Limited
Address	:	35 Pioneer Road North, Singapore 628475 Singapore

Date of Receipt	:	Feb. 03, 2020
Issued Date	:	Mar. 17, 2020
Report No.	:	2020009R-RFUSP63V00-A
Report Version	:	V1.0

Testing Laboratory
3024

DFS Test Report

Issued Date: Mar. 17, 2020
Report No.: 2020009R-RFUSP63V00-A

Product Name	:	Android Based UI
Applicant	:	PCI Private Limited
Address	:	35 Pioneer Road North, Singapore 628475 Singapore
Manufacturer	:	PCI Private Limited
Address	:	35 Pioneer Road North, Singapore 628475 Singapore
Trade Name	:	PCI
Model No.	:	CSD-ELINK2
FCC ID.	:	LY5-PCIABUI
EUT Voltage	:	DC 5V
Testing Voltage	:	DC 5V
Applicable Standard	:	FCC CFR Title 47 Part 15 Subpart E Section 15.407: 2018 ANSI C63.10: 2013 KDB 789033 D02 v02r01 KDB 662911 D01 v02r01
Laboratory Name	:	Hsin Chu Laboratory
Address	:	No.372-2, Sec. 4, Zhongxing Rd., Zhudong Township, Hsinchu County 31061, Taiwan, R.O.C. TEL: +886-3-582-8001 / FAX: +886-3-582-8958
Test Result	:	Complied

Documented By :

(Carol Tsai / Senior Engineering Adm. Specialist)

Tested By :

(Rueyyan Lin / Senior Engineer)

Approved By :

(Louis Hsu / Deputy Manager)

Revision History

Report No.	Version	Description	Issued Date
2020009R-RFUSP63V00-A	V1.0	Initial issue of report	Mar. 17, 2020

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1. General Information

1.1. EUT Description

Product Name	Android Based UI	
Trade Name	PCI	
Model No.	CSD-ELINK2	
DFS Frequency Range / Number of DFS Channels	IEEE 802.11a/ IEEE 802.11n (20MHz) /	5260~5320MHz / 4 Channels 5500~5700MHz / 11 Channels
	IEEE 802.11n (40MHz) / IEEE 802.11ac (40MHz)	5270~5310MHz / 2 Channels 5510~5670MHz / 5 Channels
	IEEE 802.11ac (80MHz)	5290~5290MHz / 1 Channel 5530~5610MHz / 2 Channel
Data Rate	802.11a	6, 9, 18, 24, 36, 48, 54Mbps
	802.11n	up to 450Mbps
	802.11ac 80MHz	up to 1733.3MHz
Channel Control	Auto	
Type of Modulation	802.11a/n/ac	OFDM, BPSK, QPSK, 16QAM, 64QAM, 256QAM
Channel Bandwidth	20/40/80 MHz	
DFS Function	□ Master ■ Slave	
TPC Function	■ <500mW not required □ ≧ 500mW employ a TPC*	
Communication Mode	■ IP Based Systems □ Frame Based System □ Other System	
Antenna Gain	Refer to the table “Antenna List”	

*Note: The TPC test by U-NII report.

Antenna Information	
Antenna Type	Dipole PCB Antenna
Effective Antenna Gain	3.44 dBi

IEEE 802.11a/n (20MHz)

Working Frequency of Each Channel							
Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
52	5260 MHz	56	5280 MHz	60	5300 MHz	64	5320 MHz
100	5500 MHz	104	5520 MHz	108	5540 MHz	112	5560 MHz
116	5580 MHz	120	5600 MHz	124	5620 MHz	128	5640 MHz
132	5660 MHz	136	5680 MHz	140	5700 MHz		

IEEE 802.11n (40MHz)

Working Frequency of Each Channel:							
Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
54	5270 MHz	62	5310 MHz	102	5510 MHz	110	5550 MHz
118	5590 MHz	126	5630 MHz	134	5670 MHz		

IEEE 802.11ac (80MHz)

Working Frequency of Each Channel:							
Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
58	5290 MHz	106	5530 MHz	122	5610 MHz		

Test Mode	Mode 1: Transmit (802.11ac 80BW)

Note:

1. This device is an Android Based UI including 2.4GHz b/g/n, 5GHz a/n/ac, BT2.0/BT 4.0 transmitting and receiving functions.
2. Regards to the frequency band operation; the lowest、middle and highest frequency of channel were selected to perform the test, and then shown on this report.
3. The EUT description is from the customer declaration.

1.2. Standard Requirement

FCC Part 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 30dBm. A TPC mechanism is not required for systems with an E.I.R.P. of less than 500mW.

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.

1.3. UNII Device Description

1. The EUT operates in the following DFS band:
   (1) 5250-5350 MHz
   (2) 5470-5725 MHz

2. The U-NII device maximum power is 20.46dBm (E.I.R.P).
   Below are the available 50 ohm antenna assemblies and their corresponding gains. 0dBi gain was used to set the -63 dBm threshold level (-64dBm +1 dB) during calibration of the test setup.

3. WLAN traffic is generated by the test software “Iperf.exe” from the Master device to the Slave device in the transfer data rate >17%.

4. For the 5250-5350 MHz and 5470-5725 MHz bands, the Master device provides, on aggregate, uniform loading of the spectrum across all devices by selecting an operating channel among the available channels using a random algorithm.

1.4. Test Equipment

DFS / SR11-H

Instrument	Manufacturer	Model No.	Serial No.	Cal. Date	Next Cal. Date
Spectrum Analyzer	Agilent	N9010A	US47140172	2019/06/28	2020/06/27
ESG Vector Signal Generator	Agilent	E4438C	MY45095759	2019/05/21	2020/05/20
MXG Vector Signal Generator	Keysight	N5182B	MY53052548	2020/02/24	2021/02/23
Signal & Spectrum Analyzer	R&S	FSV40	101049	2019/09/11	2020/09/10
EXA Signal Analyzer	Keysight	N9010A	MY51440132	2020/02/21	2021/02/20
Horn Antenna	Schwarzbeck	BBHA 9120D	639	2019/05/28	2020/05/27
Horn Antenna	Schwarzbeck	BBHA 9120D	01656	2019/10/25	2020/10/24
Spectrum Analyzer	Keysight	N9030B	MY57140404	2019/06/18	2020/06/17

Note: All equipment upon which need to calibrated are with calibration period of 1 year.

Instrument	Manufacturer	Type No.	Serial No	FCC ID.
Laptop PC	DELL	Vostro A860	CD8BMH1	--
Laptop PC	ASUS	K45VD	0343G3110M	--
Wireless Router	ASUS	ASUS RT-AX88U	JCITHP000040	MSQ-RTAXHP00
ATT (Qty: 3)	Mini-Circuits	BW-S3W2 DC-18GHz	0025	--
RF Cable (Qty: 6)	Schaffner	-	25494/6	--

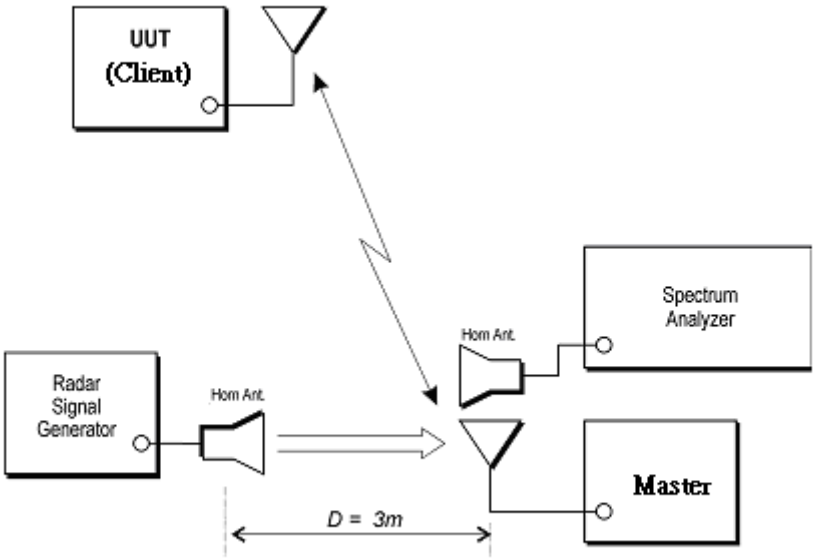
Software	Manufacturer	Function
Agilent Signal Studio for DFS_V1.0.0	Agilent	Radar Signal Generation Software
OA7 1.7	Omnitracs	Omnitracs OS

1.5. Uncertainty

Test item	Uncertainty
DFS	± 1ms

Note: Determining compliance shall be based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty.

1.6. Test Setup



1.7. DFS Detection Thresholds

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

Maximum Transmit Power	Value (see note)
≥200 milliwatt	-64dBm
EIRP < 200 milliwatt and power spectral density < 10 dBm/MHz	-62dBm
EIRP < 200 milliwatt that do not meet the power spectral density requirement	-64dBm
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.	

(2) 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 + approx. 60 milliseconds over remaining 10 seconds period (See Notes 1 and 2)
U-NII Detection Bandwidth	Minimum 100% of the 99% 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.

1.8. 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.

(1) 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 $\left\{\left(\frac{1}{360}\right)\cdot\left(\frac{19\cdot 10^6}{PRI_{\mu sec}}\right)\right\}$	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
Note 1: Short Pulse Radar 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.

(2) Long Pulse Radar Test Signal

Radar Waveform	Bursts	Number of Pulses Per Burst	Pulse Width (usec)	Chirp Width (MHz)	PRI (usec)	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.

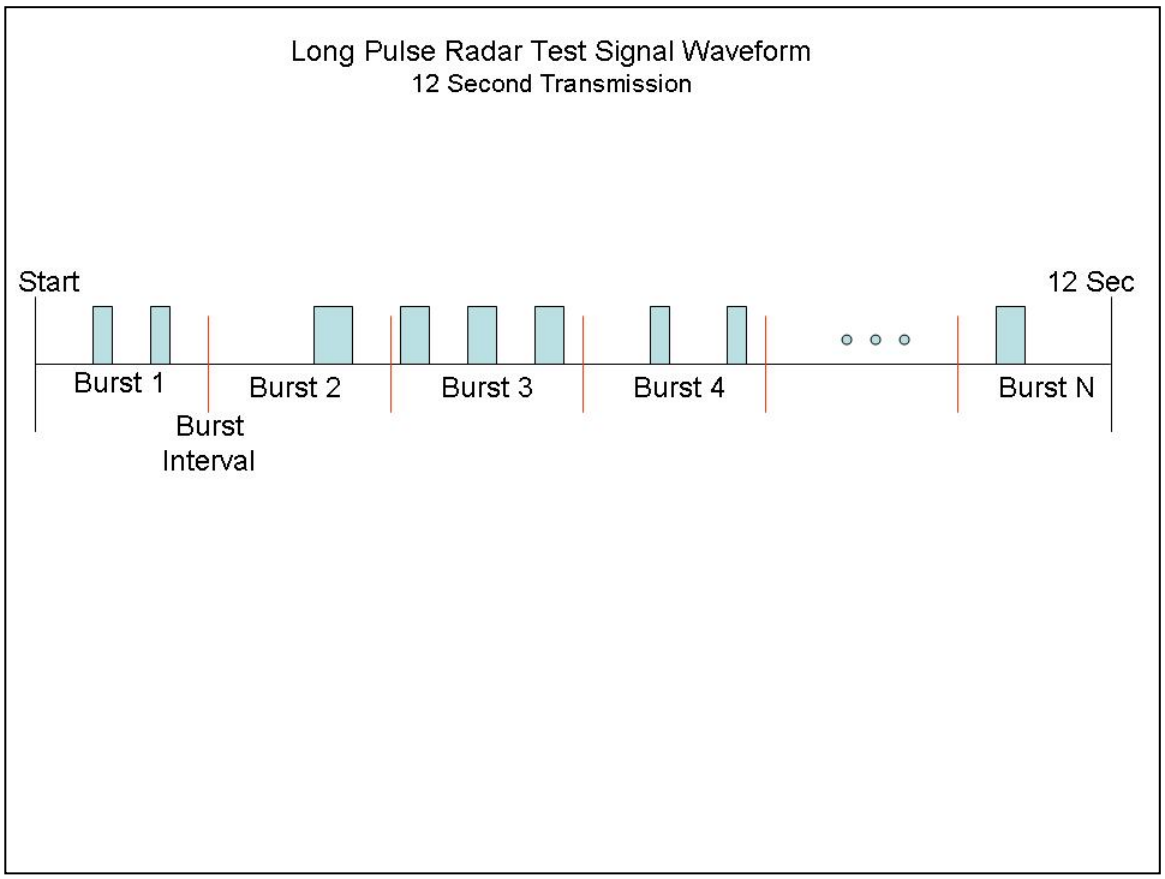
Each waveform is defined as follows:

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 / 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 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 a Long Pulse radar Test Waveform



(3) 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	0.333	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[1] from the hopping sequence defined by the following algorithm:

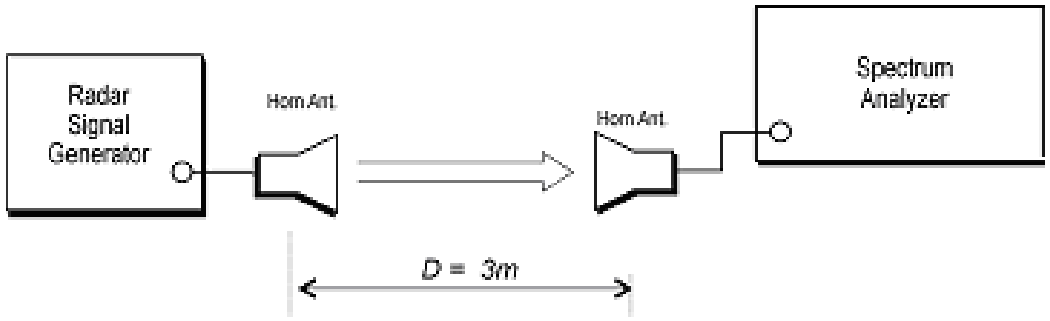
The first frequency in a hopping sequence is selected randomly from the group of 475 integer frequencies from 5250 – 5724 MHz. Next, the frequency that was just chosen is removed from the group and a frequency is randomly selected from the remaining 474 frequencies in the group. This process continues 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.

1.9. 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 replace 50ohm terminal from master and client device and 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 1MHz and 1MHz.

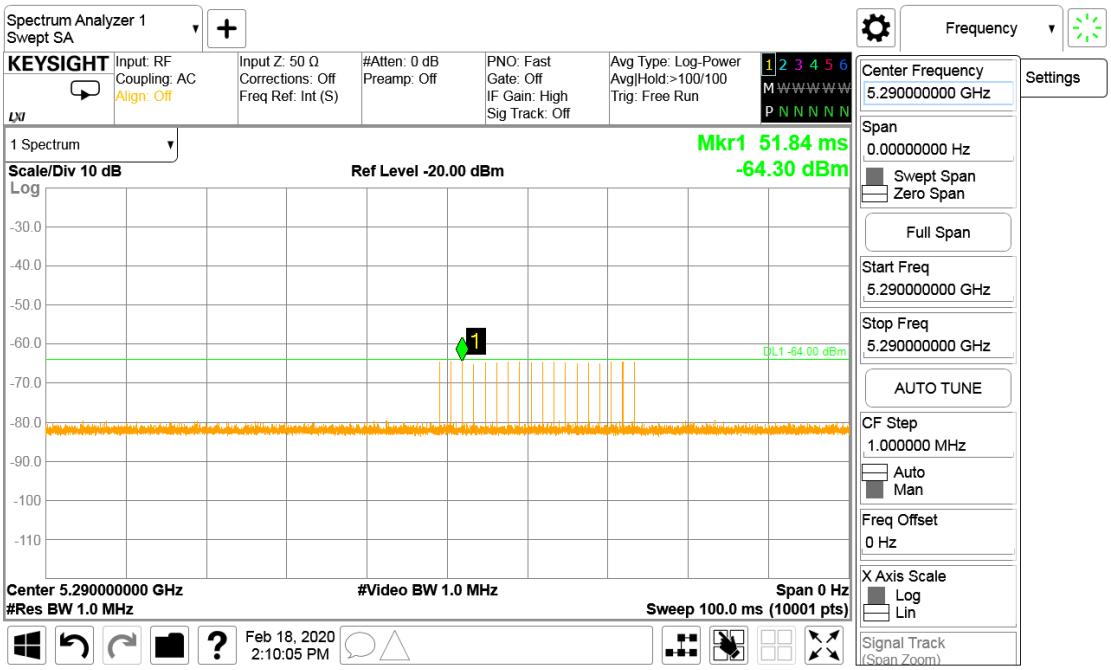
The signal generator amplitude was set so that the power level measured at the spectrum analyzer was -63dBm due to the interference threshold level is not required.

Radiated Calibration Setup

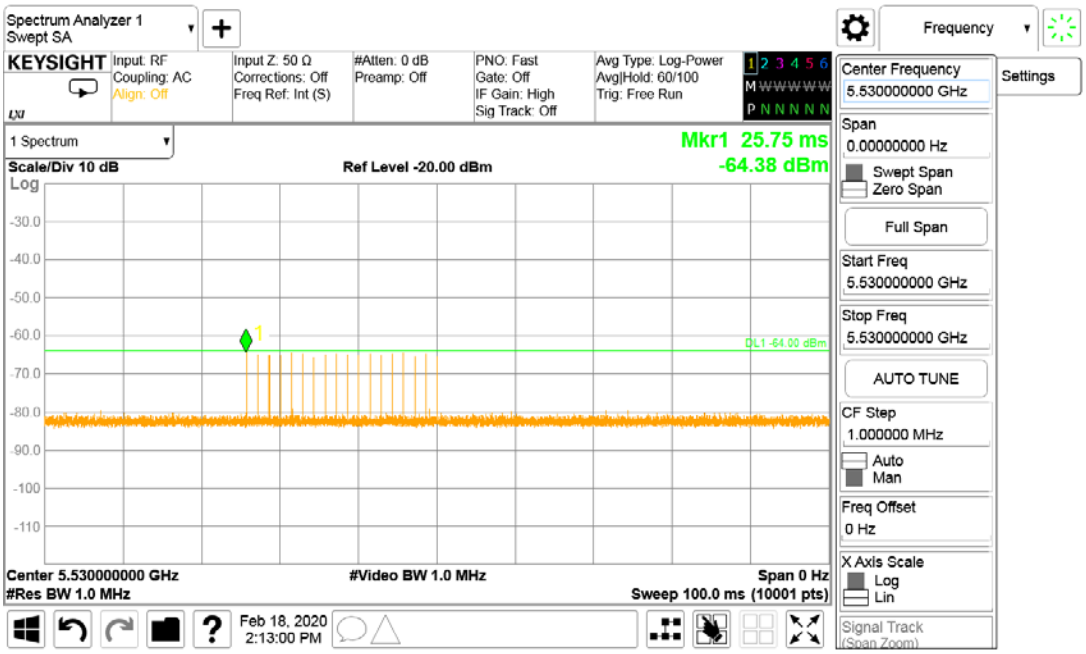


1.10. Radar Waveform Calibration Result

Calibration Plot (5290MHz)



Calibration Plot (5290MHz)



2. In-Service Monitoring for Channel Move Time and Channel Closing Transmission Time and Non-Occupancy Period

2.1. Test Procedure

The EUT was tested according to U-NII test procedure of KDB905462 D02 for compliance to FCC 47CFR 15.407 requirements.

These tests define how the following DFS parameters are verified during In-Service Monitoring; Channel Closing Transmission Time, Channel Move Time, and 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 (-63dBm) is generated on the Operating Channel of the U-NII device.

A U-NII device operating as a Client Device will associate with the UUT (Master) at 5300MHz/ 5510MHz and 5630MHz.

Stream the MPEG test file from the Master Device to the Client Device on the selected Channel for the entire period of the test.

At time T0 the Radar Waveform generator sends a Burst of pulses for each of the radar types at -63dBm.

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). Compare the Channel Move Time and Channel Closing Transmission Time results to the limits defined in the DFS Response requirement values table.

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

2.2. Test Requirement

Parameter	Value
Channel Move Time	10 Seconds
Channel Closing Transmission Time	200 milliseconds + approx. 60 milliseconds over remaining 10 seconds period
Non-Occupancy Period	Minimum 30 minutes

2.3. Test Result of Channel Move Time and Channel Closing Transmission Time and Non-Occupancy Period

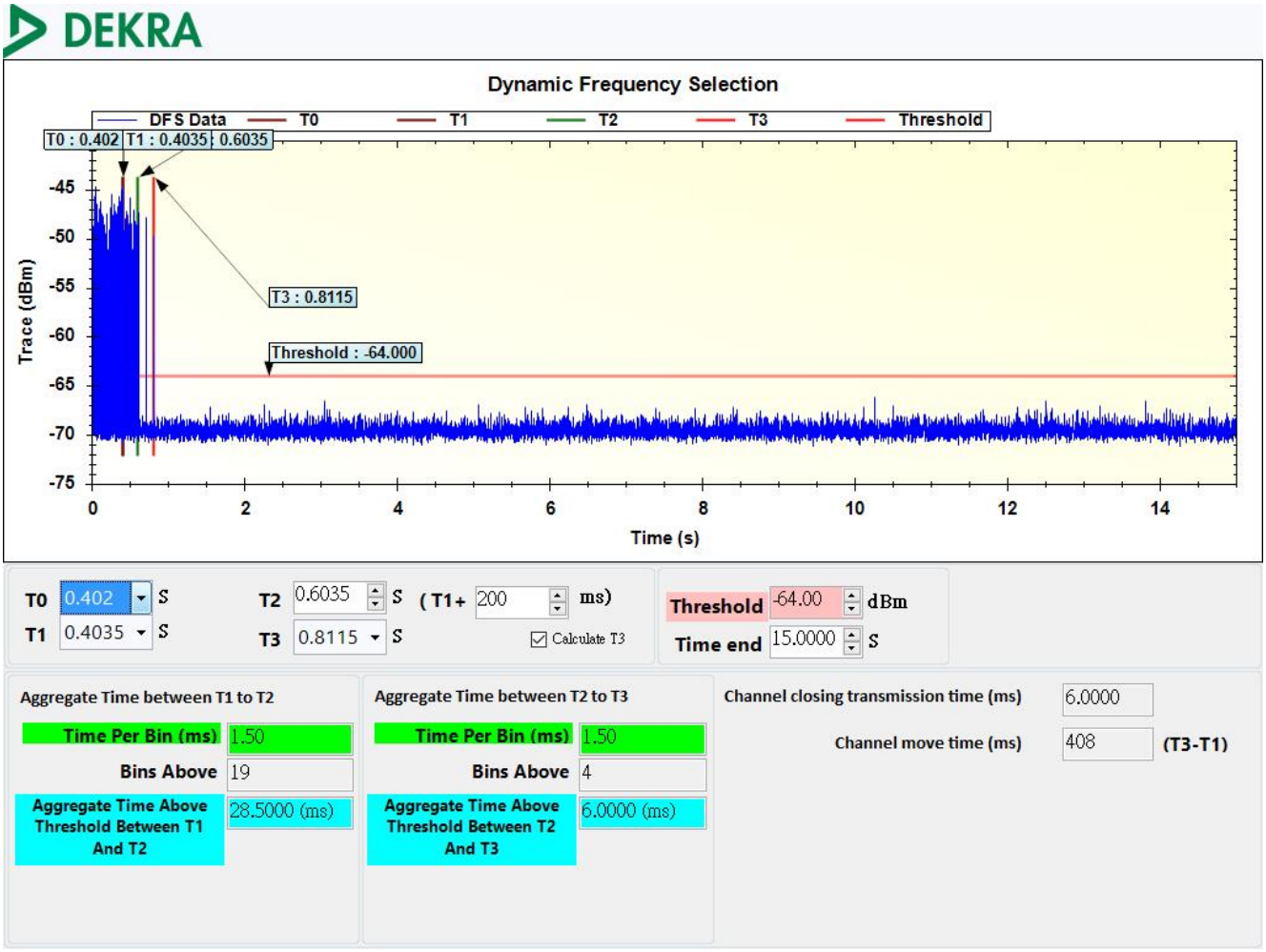
Product : Android Based UI

Test Item : Channel Move Time and Channel Closing Transmission Time Test

Radar Type : Type 0

Test Mode : Mode 1: Transmit (802.11ac 80BW)

Radar Test Type 0 at 5290MHz

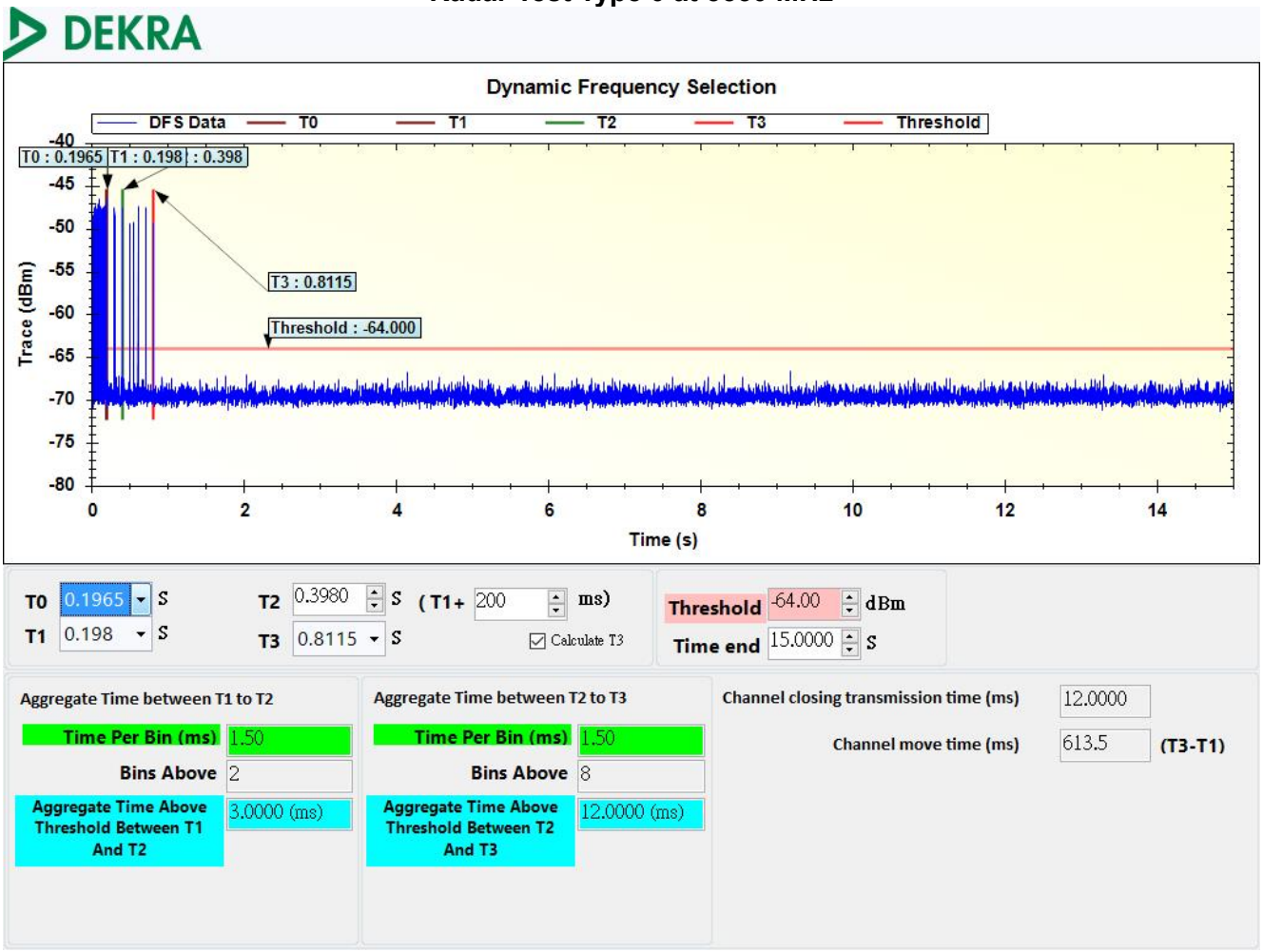


Test Item	Test Result (Sec)	Limit (Sec)
Channel Move Time	0.408	10
Channel Closing Transmission	0.006	200 milliseconds + approx. 60 milliseconds over remaining 10 seconds period

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

Product : Android Based UI
Test Item : Channel Move Time and Channel Closing Transmission Time Test
Radar Type : Type 0
Test Mode : Mode 1: Transmit (802.11ac 80BW)

Radar Test Type 0 at 5530 MHz

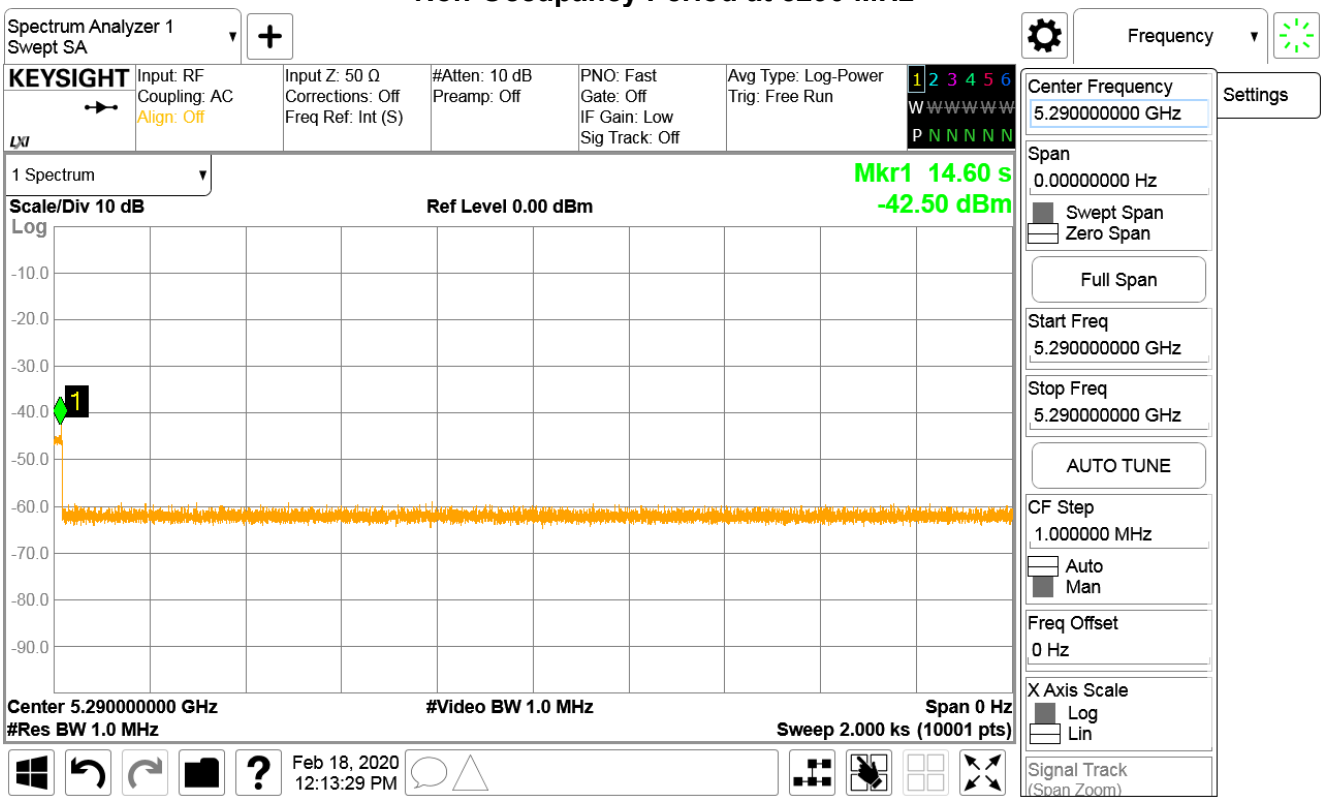


Test Item	Test Result (Sec)	Limit (Sec)
Channel Move Time	0.614	10
Channel Closing Transmission	0.012	200 milliseconds + approx. 60 milliseconds over remaining 10 seconds period

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

Product : Android Based UI
Test Item : Non-Occupancy Period
Radar Type : Type 0
Test Mode : Mode 1: Transmit (802.11ac 80BW)

Non-Occupancy Period at 5290 MHz

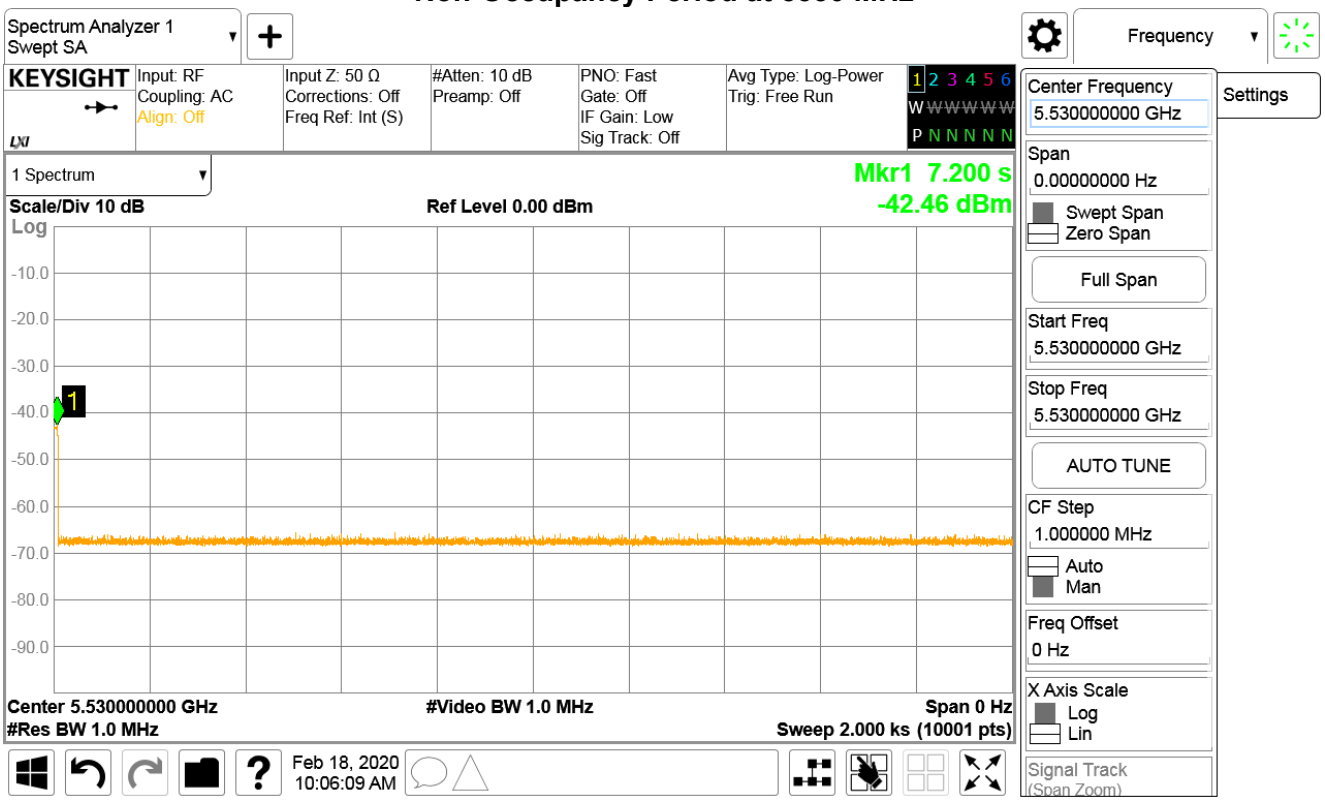


Test Item	Test Result (Minutes)	Limit (Minutes)
Non-Occupancy Period	>30	>30

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

Product : Android Based UI
Test Item : Non-Occupancy Period
Radar Type : Type 0
Test Mode : Mode 1: Transmit (802.11ac 80BW)

Non-Occupancy Period at 5530 MHz



Test Item	Test Result (Minutes)	Limit (Minutes)
Non-Occupancy Period	>30	>30

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