TEST REPORT

Test Report No. : UL-RPT-RP11047187JD01A V3.0

Manufacturer	:	Siemens AG
Model No.	:	ELN-W1-RJ-E1
FCC ID	:	LYHELN1V1
Technology	:	WLAN (802.11 a/n)
Test Standard(s)	:	FCC Part 15.407(h)(2)

1. This test report shall not be reproduced in full or partial, without the written approval of UL VS LTD.
2. The results in this report apply only to the sample(s) tested.
3. The sample tested is in compliance with the above standard(s).
4. The test results in this report are traceable to the national or international standards.
5. Version 3.0 supersedes all previous versions.

Date of Issue: 20 April 2016

Checked by:

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Engineer, Radio Laboratory

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This laboratory is accredited by UKAS. The tests reported herein have been performed in accordance with its terms of accreditation.

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1. Customer Information

Company Name:	Siemens AG
Address:	Process Industries and Drives Division Gleiwitzer Strasse 555 90475 Nuernberg Germany

2. Summary of Testing

2.1. General Information

Specification Reference:	47CFR15.407
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart E (Unlicensed National Information Infrastructure Devices) – Section 15.407
Site Registration:	FCC: 209735
Location of Testing:	UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom
Test Dates:	24 November 2015 to 09 December 2015

2.2. Summary of Test Results

FCC Reference (47CFR)	Measurement	Result
Part 15.407(h)(2)	U-NII Detection Bandwidth	✓
Part 15.407(h)(2)(ii)	Initial Channel Availability Check Time	✓
Part 15.407(h)(2)(ii)	Radar Burst at the Beginning of the Channel Availability Check Time	✓
Part 15.407(h)(2)(ii)	Radar Burst at the End of the Channel Availability Check Time	✓
Part 15.407(h)(2)(iii)	Channel Closing Transmission Time and Channel Move Time	✓
Part 15.407(h)(2)(iv)	Non-occupancy Period	✓
Part 15.407(h)(2)	Statistical Performance Check – Short Pulse Radar Types 1-4	✓
Part 15.407(h)(2)	Statistical Performance Check – Long Pulse Radar Type 5	✓
Part 15.407(h)(2)	Statistical Performance Check – Frequency Hopping Radar Type 6	✓
Key to Results ✓ = Complied ✗ = Did not comply		

Note(s):

1. The EUT operates in the 5250-5350 MHz, 5470-5600 MHz and 5650- 5725 MHz bands. It was tested operating on representative channels in the 5470-5600 MHz band.
2. The manufacturer confirms that information regarding the parameters of the radar waveforms is not available to, or configurable by the end user.
3. The customer requested testing to be performed using a 0 dBi antenna gain, which is less than the minimum of the antenna gains supported (5 dBi). Using a 0 dBi antenna gain, the EUT has to detect radars at 5 dB lower power levels than using a 5 dBi antenna gain. Therefore, the use of a 0 dBi antenna gain was deemed worst case.

2.3. Methods and Procedures

Reference:	FCC KDB 905462 D02 UNII DFS Compliance Procedures New Rules v01r02, May 15 2015
Title:	Compliance Measurement Procedures for Unlicensed-National Information Infrastructure Devices Operating in the 5250-5350 MHz and 5470-5725 MHz Bands Incorporating Dynamic Frequency Selection

2.4. Deviations from the Test Specification

For the measurements contained within this test report, there were no deviations or exclusions from the test specification identified above.

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	Siemens
Model Name or Number:	ELN-W1-RJ-E1
Test Sample Serial Number:	VPE7129190
Hardware Version:	2
Software Version:	V5.2
FCC ID:	LYHELN1V1

3.2. Untested Variants

The customer has declared that the above model ELN-W1-RJ-E1, marketing name SCALANCE W761-1 RJ45, used for testing is also a representative model for the following variants in terms of both hardware and firmware.

These variants have identical hardware and firmware. They only differ in terms of the software functionality which is enabled.

The SCALANCE W761-1 RJ45 has selectable AP or Client functionality, while the SCALANCE W721 and W722 both support Client functionality only.

Marketing Name	Model
SCALANCE W761-1 RJ45	ELN-W1-RJ-E1
SCALANCE W721-1 RJ45	ELN-W1-RJ-E1
SCALANCE W722-1 RJ45	ELN-W1-RJ-E1

3.3. Description of EUT

The equipment under test was an 802.11a/b/g/n Wi-Fi Access Point.

The EUT can be operated in either Master or Client mode depending on the firmware configuration. Client mode does not feature radar detection.

- The 802.11n mode supports both 20 MHz and 40 MHz bandwidths. It has a single antenna port and therefore only supports SISO data rates (MCS0-7).

3.4. Modifications Incorporated in the EUT

No modifications were made to the EUT during testing.

3.5. Additional Information Related to Testing

Technology Tested:	Unlicensed National Information Infrastructure Devices (U-NII)		
Type of Unit:	Access Point		
Modulation:	BPSK, QPSK, 16QAM & 64QAM		
Data Rates:	IEEE 802.11a	6, 9, 12, 18, 24, 36, 48 & 54 Mbps	
	IEEE 802.11n HT20	MCS0 to MCS7	
	IEEE 802.11n HT40	MCS0 to MCS7	
Power Supply Requirement:	Nominal	24 VDC	
Transmit & Receive Frequency Range:	5250-5350 MHz, 5470-5600 and 5650-5725 MHz		
Transmit / Receive Channels Tested at each bandwidth setting:	**Bandwidth (MHz)**	**Channel Frequency (MHz)**	
	20	5500	
	40	5510	

3.6. Support Equipment

The following support equipment was used to exercise the EUT during testing:

Description:	Wi-Fi Access Point in Client mode (for Master Testing)
Brand Name:	Siemens
Model Name or Number:	MSN-W1-RJ-E2
Serial Number:	VPE2195446
FCC ID:	LYHMSN1V1

Description:	Wi-Fi Access Point in Master mode (for Client Testing)
Brand Name:	Siemens
Model Name or Number:	MSN-W1-RJ-E2
Serial Number:	VPF7165808
FCC ID:	LYHMSN1V1

Description:	Laptop Computer (on Master Device)
Brand Name:	Lenovo
Model Name or Number:	L440
Serial Number:	R9-019EA0 14/04

Description:	Laptop Computer (on Client Device)
Brand Name:	Lenovo
Model Name or Number:	L440
Serial Number:	R9-019EA2 14/04

3.7. Antenna

The table below lists the antennas that the manufacturer intends to use with this product when operating in the 5250-5350 & 5470-5725 MHz bands. The antenna gains were stated by Siemens AG.

Antenna Type / Name	Stated Gain (dBi)	Manufacturer
ANT795-6DC	9.0	Siemens
ANT795-6MN	8.0	Siemens
ANT795-4MD	5.0	Siemens
ANT795-4MA	5.0	Siemens
ANT795-4MC	5.0	Siemens
ANT793-8DK	23.0	Siemens
ANT793-8DJ	18.0	Siemens
ANT793-8DP	13.5	Siemens
ANT793-6DG	9.0	Siemens
ANT793-4MN	6.0	Siemens
ANT793-6MN	5.0	Siemens
ANT795-4MX	2.0	Siemens

4. Operation and Monitoring of the EUT during Testing

4.1. Operating Modes

The EUT was tested in the following operating modes, unless otherwise stated:

- As a Master or Client device, transmitting on full power. (The highest setting of 20 dBm was selected in the http interface).
- The EUT was tested with 802.11n MCS7 modulation (65 Mbps data rate).
- The EUT has radar detection in Master mode only.
- The EUT has a single antenna port which normally connects to an external antenna. The radar signal was applied to this port, at the levels defined in KDB 905462 D02, compensated for the minimum antenna gain.
- The EUT transmit duty cycle was set depending on the test being performed. See each applicable test for details of the UDP pseudo-random data stream used to give >17% channel loading as required by KDB 905462 D02 Section 7.7.2.

4.2. Configuration and Peripherals

The EUT was tested in the following configuration(s):

- All measurements were made using a conducted link.
- A laptop PC was used to configure the EUT parameters during the testing using a standard web browser and via a terminal application. The laptop was connected to the EUT via Ethernet and serial connections to set EUT parameters.
- The EUT's serial interface was used to report radar detection events.
- Further details of the conducted test network and set-up can be found in Appendix 2 of this test report.
- The DFS detection threshold of -62 dBm was used throughout, as the maximum transmit power was <200 mW and the power spectral density was < 10 dBm/MHz.
- The customer requested testing to be performed using a 0 dBi antenna gain. Since the test is performed conducted, this additional gain which would normally be present in the signal is added to the radar test level.
    - The radar level to be presented at the antenna ports was calculated as:
    - -62 dBm +0 dBi antenna gain +1 dB to account for variations = -61.0 dBm radar level at antenna ports.

KDB 905462 D02 Table 3: DFS Detection Thresholds for Master Devices and Client Devices With Radar Detection

Maximum Transmit Power	**Value (See Notes 1, 2, and 3)**
EIRP ≥ 200 milliwatt	-64 dBm
EIRP < 200 milliwatt and power spectral density < 10 dBm/MHz	-62 dBm
EIRP < 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.	

5. Measurements, Examinations and Derived Results

5.1. General Comments

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to *Section* 6 *Measurement Uncertainty* for details.

In accordance with UKAS requirements all the measurement equipment is on a calibration schedule. All equipment was within the calibration period on the date of testing.

5.2. Test Results

5.2.1. U-NII Detection Bandwidth

Test Summary:

Test Engineer:	Georgios Vrezas	**Test Date:**	24 November 2015
Test Sample Serial Number:	VPE7129190		

FCC Reference:	Part 15.407(h)(2)
Test Method Used:	KDB 905462 D02 Section 7.8.1 and Notes below

Environmental Conditions:

Temperature (°C):	24
Relative Humidity (%):	31

Notes:

1. In accordance with KDB 905462 D02 Table 2, the U-NII Detection Bandwidth test was performed on all supported channel bandwidths.
2. The 99% bandwidth was measured in accordance with FCC KDB 789033 D02 General UNII Test Procedures New Rules v01, Section II D.
3. Tests were performed using a type 0 radar (as stated in KDB 905462 D02 Table 4, Note 3) and the radar detection threshold used was as calculated in Section 4.2 of this test report.
4. KDB 905462 D02 Section 7.8.1 requests testing detection bandwidth at 1 MHz steps near the channel edges until the entire 99% bandwidth is covered. However, due to small channel bandwidths or 99% bandwidths of the EUT, smaller steps were used at the channel edge extremities on all supported channel bandwidths.

U-NII Detection Bandwidth (continued)

Results: 20 MHz Master

Channel Bandwidth (MHz)	99% Bandwidth (MHz)	U-NII Detection Bandwidth $F_H - F_L$ (MHz)	Result
20	17.910	≥18	Complied

Measurement Offsets from centre frequency (MHz)	Detection attempts successful from 10 attempts at each frequency	Detection Rate (%)
-9 (F_L)	10	100
-8	10	100
-7	10	100
-6	10	100
-5	10	100
0 (5500 MHz)	10	100
+5	10	100
+6	10	100
+7	10	100
+8	10	100
+9 (F_H)	10	100

The EUT exceeded the requirement of ≥90% detection probability over 100% of the measured 99% bandwidth.

U-NII Detection Bandwidth (continued)

Results: 40 MHz Master

Channel Bandwidth (MHz)	99% Bandwidth (MHz)	U-NII Detection Bandwidth $F_H - F_L$ (MHz)	Result
40	37.380	≥38	Complied

Measurement Offsets from centre frequency (MHz)	Detection attempts successful from 10 attempts at each frequency	Detection Rate (%)
-19 (F_L)	10	100
-18	10	100
-17	10	100
-16	10	100
-15	10	100
-10	10	100
-5	10	100
0 (5510 MHz)	10	100
+5	10	100
+10	10	100
+15	10	100
+16	10	100
+17	10	100
+18	10	100
+19 (F_H)	10	100

The EUT exceeded the requirement of ≥90% detection probability over 100% of the measured 99% bandwidth.

Limits:

Part 15.407(h)(2)

The device must sense for radar signals at 100 percent of its emission bandwidth.

KDB 905462 D02 Table 4: DFS Response Requirement Values

Parameter	Value
U-NII Detection Bandwidth	Minimum 100% of the U-NII 99% transmission power bandwidth. See Note 3.
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.	

5.2.2. Initial Channel Availability Check Time

Test Summary:

Test Engineer:	Georgios Vrezas	**Test Date:**	25 November 2015
Test Sample Serial Number:	VPE7129190		

FCC Reference:	Part 15.407(h)(2)(ii)
Test Method Used:	KDB 905462 D02 Section 7.8.2.1 and Notes below

Environmental Conditions:

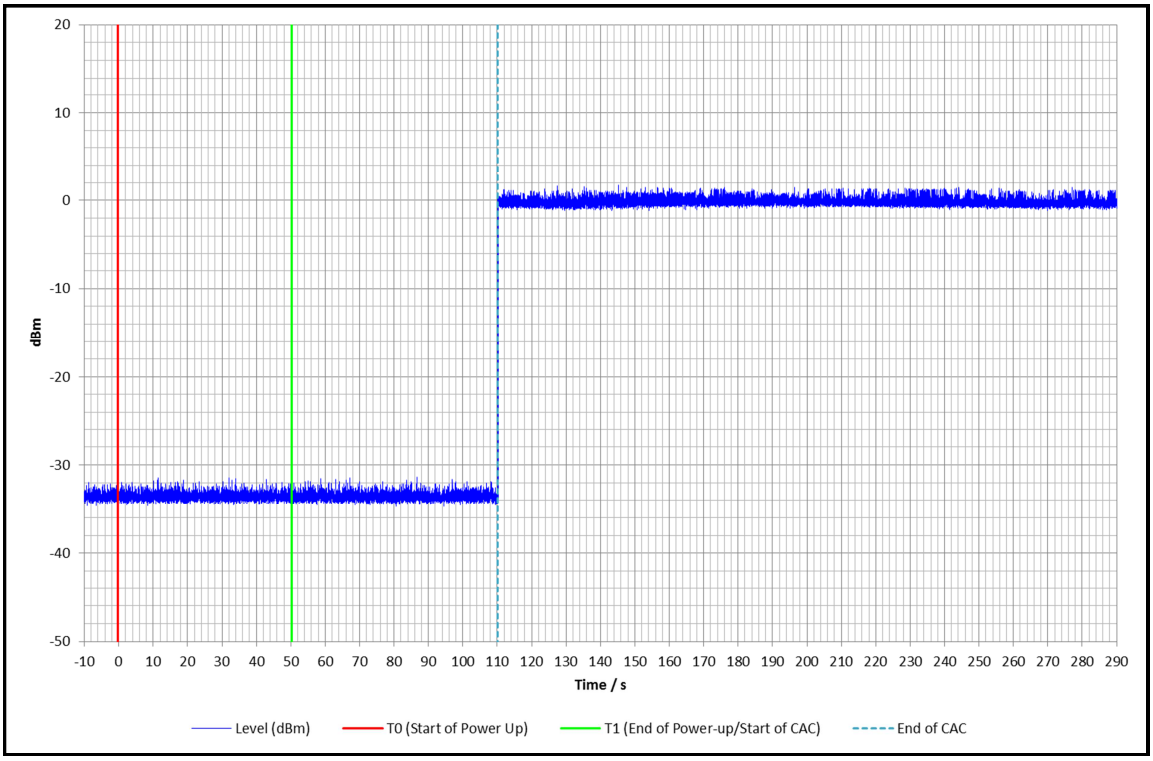
Temperature (°C):	24
Relative Humidity (%):	34

Notes:

1. In accordance with KDB 905462 D02 Table 2, the Initial Channel Availability Check test can be performed on any single bandwidth. It was therefore tested only on a 40 MHz channel bandwidth.
2. The EUT Master device was powered on at T0 (red vertical line) on the plot below. This gave improved accuracy over starting the sweep at the same time as power up as requested by KDB 905462 D02. 30,001 sweep points were used on the spectrum analyser. The measurement was performed with the spectrum analyser in zero span and the 30,001 data points exported as an ASCII file. The ASCII file was then imported and analysed in Microsoft Excel.
3. No beacon or data transmission was seen from the Master during channel availability check time. The Master did not transmit for 60 seconds. The EUT therefore complies, as shown by the results plot on the following page.
4. All emissions remained below the -27 dBm/MHz spurious limit. This was measured worst-case with a peak detector and 3 MHz RBW in accordance with KDB 905462 D02 Section 7.8.2.1(a).

Initial Channel Availability Check Time (continued)

Results: 40 MHz Master



Limits:

Part 15.407(h)(2)(ii)

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.

KDB 905462 D02 Table 4: DFS Response Requirement Values

Parameter	Value
Channel Availability Check Time	60 seconds

5.2.3. Radar Burst at the Beginning of the Channel Availability Check Time

Test Summary:

Test Engineer:	Georgios Vrezas	**Test Date:**	25 November 2015
Test Sample Serial Number:	VPE7129190		

FCC Reference:	Part 15.407(h)(2)(ii)
Test Method Used:	KDB 905462 D02 Section 7.8.2.2

Environmental Conditions:

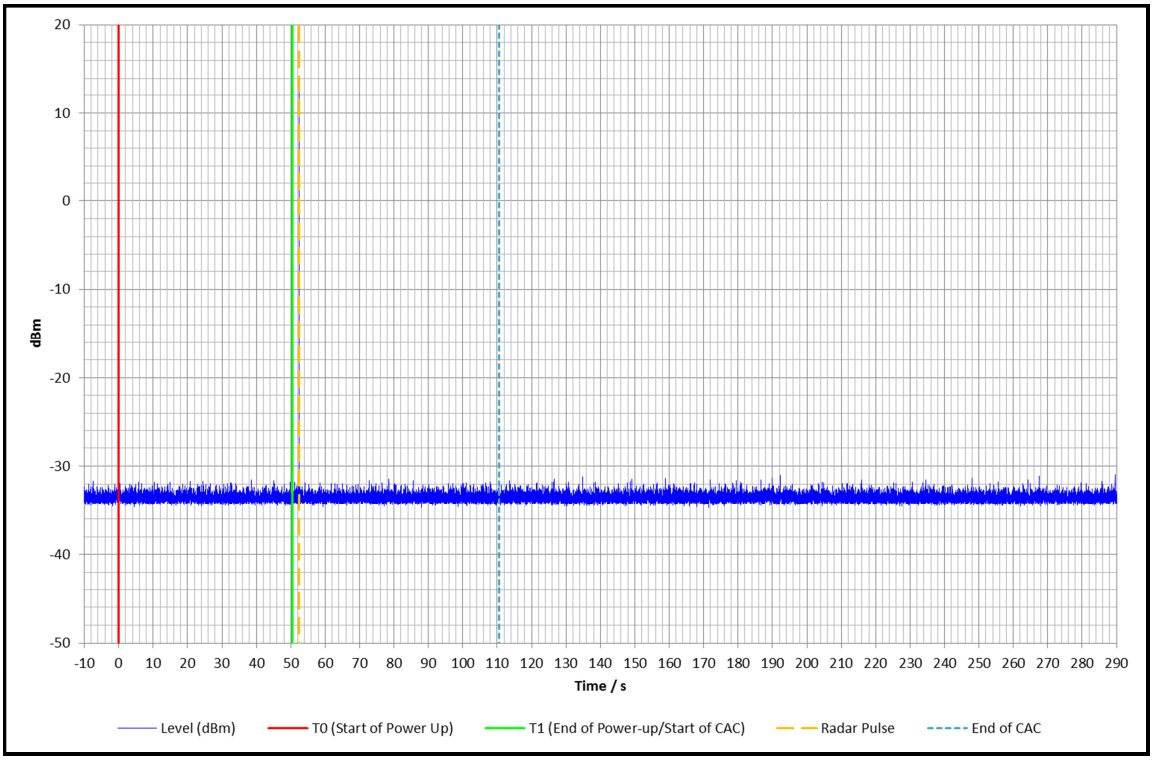
Temperature (°C):	24
Relative Humidity (%):	34

Notes:

1. In accordance with KDB 905462 D02 Table 2, the Initial Channel Availability Check test was performed on any single bandwidth. It was therefore tested only on a 40 MHz channel bandwidth.
2. The radar was fired 52.4 seconds after power on, and therefore 1.9 seconds into the allowed 6 second radar window at the beginning of CAC (power up time shown to be 50.5 seconds during Initial Channel Availability Check test).
3. Observation of Ch_r continued for >2.5 minutes after the radar burst was generated.
4. Tests were performed using a type 0 radar and the radar detection threshold used was as calculated in Section 4.2 of this test report.
5. The radar burst type 0, shown occurring just after the T1 line on the plot on the following page, was detected and no beacon or data transmission seen from the EUT after the end of CAC. Therefore the CAC starts at the time declared and, in conjunction with the *Radar Burst at the End of the Channel* Availability Check Time test, shows the CAC duration is greater or equal to the 60 second minimum.
6. No transmissions occurred.
7. All emissions remained below the -27 dBm spurious limit. This was measured worst-case with a peak detector and 3 MHz RBW to give equivalent results to the Initial Channel Availability Check test method defined in KDB 905462 D02 Section 7.8.2.1(a). Measured results were recorded and the EUT complies.

Radar Burst at the Beginning of the Channel Availability Check Time (continued)

Results: 40 MHz Master



Plot showing the radar at the beginning of CAC

Limits:

Part 15.407(h)(2)(ii)

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.

KDB 905462 D02 Table 4: DFS Response Requirement Values

Parameter	Value
Channel Availability Check Time	60 seconds

5.2.4. Radar Burst at the End of the Channel Availability Check Time

Test Summary:

Test Engineer:	Georgios Vrezas	**Test Date:**	25 November 2015
Test Sample Serial Number:	VPE7129190		

FCC Reference:	Part 15.407(h)(2)(ii)
Test Method Used:	KDB 905462 D02 Section 7.8.2.3

Environmental Conditions:

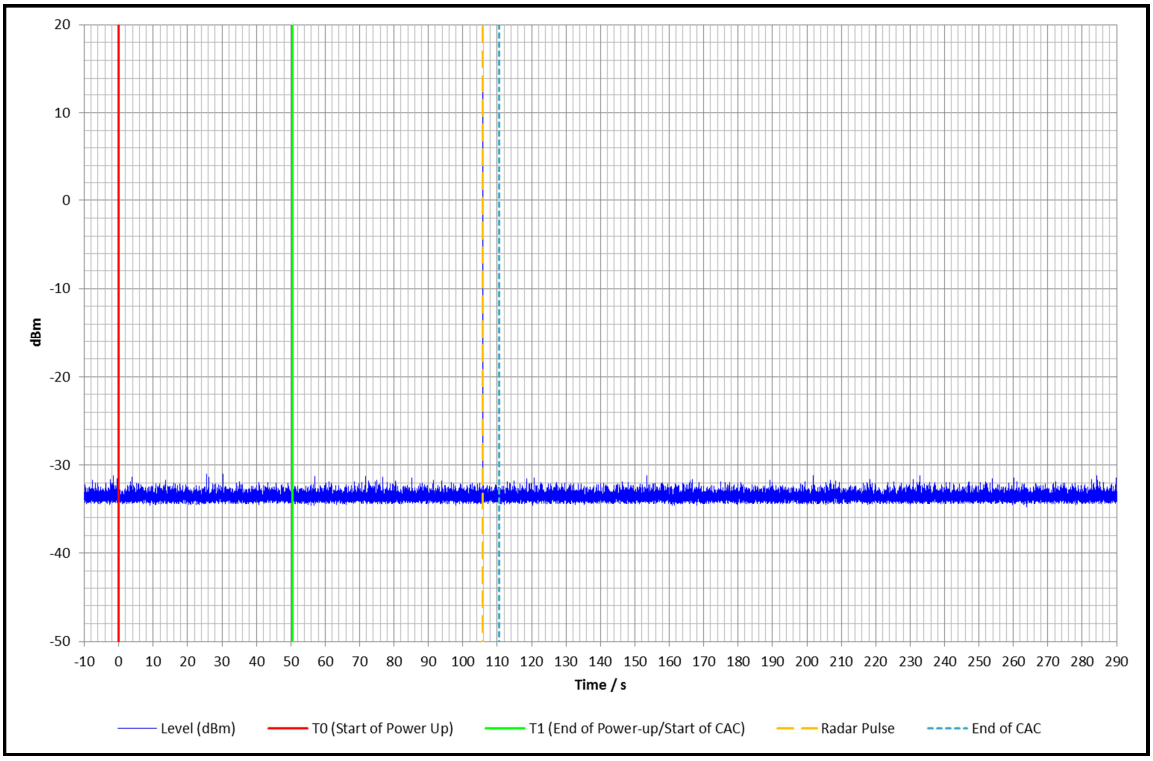
Temperature (°C):	24
Relative Humidity (%):	34

Notes:

1. In accordance with KDB 905462 D02 Table 2, the Initial Channel Availability Check test was performed on any single bandwidth. It was therefore tested only on a 40 MHz channel bandwidth.
2. The radar was fired 105.8 seconds after power on, and therefore 4.7 seconds before the end of the allowed 6 second radar window at the end of CAC (power up time shown to be 50.5 seconds during Initial Channel Availability Check test).
3. Observation of Ch_r continued for >2.5 minutes after the radar burst was generated.
4. Tests were performed using a type 0 radar and the radar detection threshold was as calculated in Section 4.2 of this test report.
5. The radar burst type 0, shown occurring just before the End of CAC line on the plot on the following page, was detected and no beacon or data transmission seen from the EUT after the end of CAC. Therefore the CAC ends at the point declared and, in conjunction with the *Radar Burst at the Beginning of the Channel Availability Check Time* test, shows the CAC duration is greater than the 60 second minimum.
6. All emissions remained below the -27 dBm/MHz spurious limit. This was measured worst-case with a peak detector and 3 MHz RBW to give equivalent results to the *Initial Channel Availability Check* test method defined in KDB 905462 D02 Section 7.8.2.1(a). Measured results were recorded and the EUT complies.

Radar Burst at the End of the Channel Availability Check Time (continued)

Results: 40 MHz Master



Plot showing the radar fired at the end of CAC

Limits:

Part 15.407(h)(2)(ii)

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.

KDB 905462 D02 Table 4: DFS Response Requirement Values

Parameter	Value
Channel Availability Check Time	60 seconds

5.2.5. Channel Closing Transmission Time and Channel Move Time

Test Summary:

Test Engineer:	Georgios Vrezas	**Test Dates:**	08 December 2015 & 09 December 2015
Test Sample Serial Number:	VPE7129190		

FCC Reference:	Part 15.407(h)(2)(iii)
Test Method Used:	KDB 905462 D02 Section 7.8.3

Environmental Conditions:

Temperature (°C):	22 to 23
Relative Humidity (%):	40 to 48

Notes:

1. In accordance with KDB 905462 D02 Table 2, the Initial Channel Availability Check test was performed on the widest channel bandwidth. It was therefore tested only on a 40 MHz channel bandwidth.
2. UDP test data was streamed from the Master to the Client device using iPerf3 bandwidth testing tool. The channel loading was 24.2% with a 30 Mbit/s data rate. This therefore met the channel loading requirement of >17% in KDB 905462 D02 Section 7.7(c).
3. Tests were performed using a type 0 radar and the radar detection threshold calculated in Section 4.2 of this test report.
4. The total channel closing time limit was 200 ms + 60 ms = 260 ms (from KDB 905462 D02 Table 4).
5. Radar burst type 0 was detected and channel move occurred within the channel move and channel closing time limits, for both Master and Client modes. Therefore the EUT complied.

Results: 40 MHz Master – Channel Move Time

Channel (MHz)	Move Time (ms)	Limit (ms)	Margin (ms)	Detected
5510	452	10000	9548	Yes

Results: 40 MHz Master – Channel Closing Transmission Time

Channel (MHz)	Total Aggregate Tx Time (ms)	Limit (ms)	Margin (ms)	Tx Time >200 ms after end of radar (ms)	Limit (ms)	Margin (ms)
5510	5.3	260	254.7	3.3	60	56.7