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Test Report

- DFS tests only -

Report Number: F161612E3 2nd version

Equipment under Test (EUT):

PCI express Half mini card WLAN module
SX-PCEAN2

Applicant:

PHOENIX CONTACT Electronics GmbH

Manufacturer:

PHOENIX CONTACT Electronics GmbH

ilac-MRA

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-17186-01-01
D-PL-17186-01-02
D-PL-17186-01-03

REFERENCES

[1] **FCC CFR 47 Part 15** Radio Frequency Devices

[2] **KDB 905462 D02 UNII DFS Compliance Procedures New Rules v02 (April 2016)**
Compliance measurement procedures for Unlicensed - National Information Infrastructure (U-NII) Devices operating in the 5250-5350 MHz and 5470-5725 MHz bands incorporating Dynamic Frequency Selection.

[3] **KDB 905462 D03 Client without DFS New Rules v01r01 (August 2014)**
Client Devices without radar detection capability.

TEST RESULT

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test.
The complete test results are presented in the following.

	Name	Signature	Date
Test engineer:	Manuel BASTERT		31.08.2020
Authorized reviewer:	Paul NEUFELD		31.08.2020

RESERVATION

This test report is only valid in its original form.

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1 Identification

1.1 Applicant

Name:	PHOENIX CONTACT Electronics GmbH
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Applicant represented during the test by the following person:	none

1.2 Manufacturer

Name:	PHOENIX CONTACT Electronics GmbH
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Country:	Germany
Name for contact purposes:	Andreas Pape
Phone:	+49 5281 9 46-1545
Fax:	+49 5281 9 46-2398
eMail Address:	apape@phoenixcontact.com
Applicant represented during the test by the following person:	none

1.3 Test laboratory

The tests were carried out by: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-02, FCC Test Firm Accreditation with the registration number 469623, designation number DE0004 and Industry Canada Test site registration SITE# IC3469A-1.

1.4 EUT (Equipment Under Test)

Test object:	**PCI express Half mini card WLAN module**
FCC ID: *	YG3-SXPCEAN2
IC: *	4720B-SXPCEAN2
HVIN:*	SX-PCEAN2

* declared by the applicant

1.5 Dedicated Host device Description

Test object:	**WLAN Access Point and Client**
Model / PMN: *	**FL WLAN 2101**
Order number: *	2702540
Serial number: *	N/A (Engineering sample)
PCB identifier: *	PW101650BX
Hardware version: *	03
Software version: *	fl_wlan_1100PQC_tx99.bin
Software version (Final Version): *	1.00

* declared by the applicant

1.6 Technical data of equipment

Fulfills WLAN specification: *	IEEE, 802.11b, 802.11g, 802.11a, 802.11n HT20 + HT40,					
Antenna type: *	Directional antenna (EUT ant port 0) Omnidirectional antenna (EUT ant port 1)					
Antenna name: *	2JZ0102 (EUT ant port 0) 2JZ0102 (EUT ant port 1)					
Antenna gain: *	5 dBi peak (EUT ant port 0) 2 dBi peak (EUT ant port 1) 3.8 dBi (Directional gain with ant. Port 0&1 combined – calculated according to ANSI C63.10 clause 14.4.3.2.4 b)					
Antenna connector: *	U-FL					
Power supply:	DC					
Supply voltage Evaluation Board:	U_{nom} =	24.0 V DC	U_{min} =	18.0 V DC	U_{max} =	32.0 V DC
Power supply:	DC					
Supply voltage WLAN module:	U_{nom} =	3.3 V DC	U_{min} =	2.805 V DC	U_{max} =	3.795 V DC
Type of modulation: *	802.11b: DSSS 802.11g: OFDM 802.11a: OFDM 802.11n: OFDM					
Operating frequency range:*	2412 MHz to 2462 MHz, 5180 MHz to 5240 MHz, 5260 MHz to 5320 MHz, 5500 MHz to 5700 MHz, 5745 to 5825 MHz					
Number of channels: *	32 (802.11 b/g/n20), 16 (802.11 n40)					
Temperature range: *	-40 °C to 60 °C					
Lowest / highest internal clock frequency: *	32 kHz / 5825 MHz					
DFS operation mode: *	Client without radar detection					

* declared by the applicant

5.15 - 5.25 GHz band (Non-DFS-band)

Channel 36	RX:	5180 MHz	TX:	5180 MHz
Channel 40	RX:	5200 MHz	TX:	5200 MHz
Channel 44	RX:	5220 MHz	TX:	5220 MHz
Channel 48	RX:	5240 MHz	TX:	5240 MHz

5.25 - 5.35 GHz band

Channel 52	RX:	5260 MHz	TX:	5260 MHz
Channel 56	RX:	5280 MHz	TX:	5280 MHz
Channel 60	RX:	5300 MHz	TX:	5300 MHz
Channel 64	RX:	5320 MHz	TX:	5320 MHz

5.47 - 5.725 GHz band

Channel 100	RX:	5500 MHz	TX:	5500 MHz
Channel 104	RX:	5520 MHz	TX:	5520 MHz
Channel 108	RX:	5540 MHz	TX:	5540 MHz
Channel 112	RX:	5560 MHz	TX:	5560 MHz
Channel 116	RX:	5580 MHz	TX:	5580 MHz
Channel 120	RX:	5600 MHz	TX:	5600 MHz
Channel 124	RX:	5620 MHz	TX:	5620 MHz
Channel 128	RX:	5640 MHz	TX:	5640 MHz
Channel 132	RX:	5660 MHz	TX:	5660 MHz
Channel 136	RX:	5680 MHz	TX:	5680 MHz
Channel 140	RX:	5700 MHz	TX:	5700 MHz

The grey-marked channels are not supported by the EUT.

5.745 - 5.825 GHz band (Non-DFS-band)

Channel 149	RX:	5745 MHz	TX:	5745 MHz
Channel 153	RX:	5765 MHz	TX:	5765 MHz
Channel 157	RX:	5785 MHz	TX:	5785 MHz
Channel 161	RX:	5805 MHz	TX:	5805 MHz
Channel 165	RX:	5825 MHz	TX:	5825 MHz

1.7 Ancillary equipment

Provided by the applicant:

- Serial interface to USB connector

Provided by Phoenix Testlab

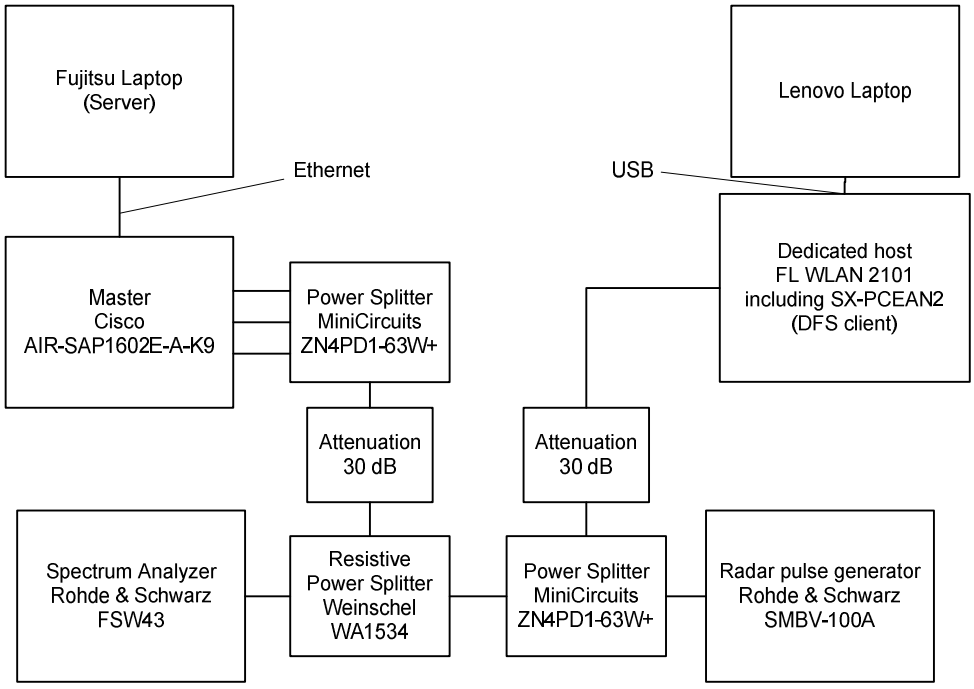
- MINI-PS-100-240AC/24DC/1.3
- Laptop Fujitsu E7800
- Laptop Lenovo X201T
- DFS Master Cisco AIR-SAP1602E-A-K9 (Serial-No.: FGL1739X1LS)
  FCC ID: LDK102084 / IC number: 2461B-102084

1.8 Dates

Date of receipt of test sample:	25.08.2016
Start of test:	22.11.2016
Finish of test:	22.11.2016

2 Operational states

The EUT is an industrial Wireless LAN slave device without own radar detection mechanism working in the 5 GHz U-NII band. The measurements were carried out according to setup shown in the drawing below. The traffic was generated streaming a test video from the master to the client device. A Cisco Access Point AIR-SAP1602E-A-9 was used as DFS master. The attenuation of the test system was adjusted to reach the DFS detection threshold of -62 dBm at the antenna ports of the master. The test setup is shown in the following picture.



3 Additional information

None.

4 Test overview and DFS parameters

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [1]	Status	Refer page
Dynamic Frequency Selection (DFS)	5250 – 5350 5470 – 5725	15.407 (h) (2)	Passed	14 et seq

4.1 Test frequencies

One frequency will be chosen from the operating channels of the EUT within the 5250 - 5350 MHz or 5470 - 5725 MHz bands.

4.2 Applicability of DFS requirements Prior to Use of a Channel

Requirement	**DFS Operational mode**		
	Master	**Client** (without DFS)	**Client** (with DFS)
Non-Occupancy Period	✓	Not required*	✓
DFS Detection Threshold	✓	Not required	✓
Channel Availability Check Time	✓	Not required	Not required
Uniform Spreading	✓	Not required	Not required
U-NII Detection Bandwidth	✓	Not required	✓

* An analyser plot containing a single 30-minute sweep on the original channel is stipulated by [3].

4.3 Applicability of DFS requirements during normal operation

Requirement	**DFS Operational mode**		
	Master	**Client** (without DFS)	**Client** (with DFS)
DFS Detection Threshold	✓	Not required	✓
Channel Closing Transmission Time	✓	✓	✓
Channel Move Time	✓	✓	✓
U-NII Detection Bandwidth	✓	Not required	✓

4.4 DFS detection thresholds for master devices and client devices with radar detection

Maximum transmit power	**Value (see Notes 1 and 2)**
≥ 200 mW (23 dBm)	-64 dBm
< 200 mW (23 dBm)	-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.	

4.5 DFS response requirement values

Parameter	Value
Non-Occupancy Period	Minimum 30 minutes
Channel Availability Check Time	60 s
Channel Move Time	10 s See Note 1
Channel Closing Transmission Time	200 ms + an aggregate of 60 ms over remaining 10 s period See Notes 1 and 2

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*.

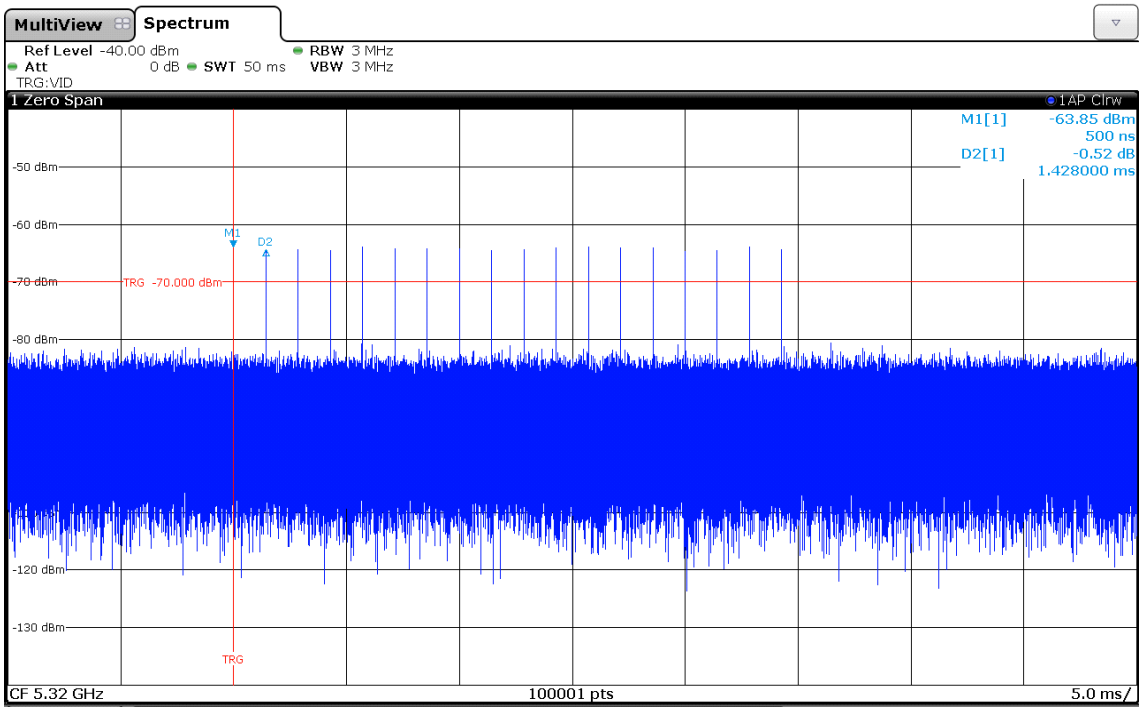
Note 2: The *Channel Closing Transmission Time* is comprised of 200 milliseconds starting at the beginning of the *Channel Move Time* plus any additional intermittent control signals required to facilitate a *Channel* move (an aggregate of 60 milliseconds) during the remainder of the 10 second period. The aggregate duration of control signals will not count quiet periods in between transmissions.

4.6 Radar test waveforms

Short pulse radar test waveform used for the tests:

Radar type	Pulse width [µs]	Pulse repetition interval [µs]	Number of pulses
0	1	1428	18

Radar test signal 0 at 5.3 GHz (detection threshold calibration plot)

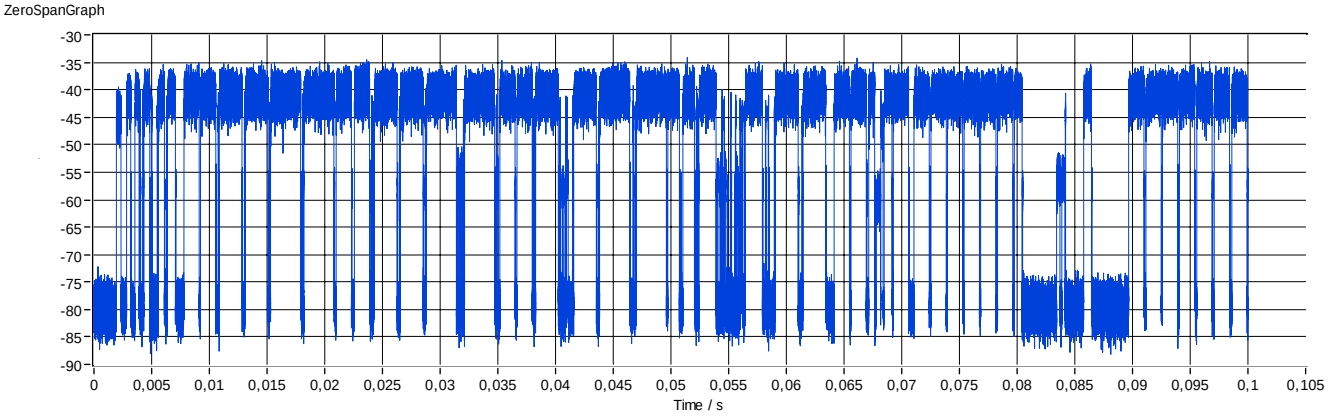


4.7 Channel loading

System testing will be performed with channel-loading using means appropriate to the data types that are used by the unlicensed device. The following requirements apply:

a) The data file must be of a type that is typical for the device (i.e., MPEG-2, MPEG-4, WAV, MP3, MP4, AVI, etc.) and must generally be transmitting in a streaming mode.
b) Software to ping the client is permitted to simulate data transfer but must have random ping intervals.
c) Timing plots are required with calculations demonstrating a minimum channel loading of approximately 17% or greater. For example, channel loading can be estimated by setting the spectrum analyzer for zero span and approximate the Time On / (Time On + Off Time). This can be done with any appropriate channel BW and modulation type.
d) Unicast or Multicast protocols are preferable but other protocols may be used. The appropriate protocol used must be described in the test procedures.

Channel load at 5.32 GHz:



$$Channel\ load = \frac{\text{Time on}}{(\text{Time on + Off Time})} = \frac{26.64\ \text{ms}}{100\ \text{ms}} = 0.2664 \xrightarrow{yields} 26.6\ \%$$

5 Test results

5.1 U-NII Detection Bandwidth

5.1.1 Measurement with nominal 20 MHz channel bandwidth

WLAN channel 60, Nominal Channel BW: 20 MHz, Radar type 0, Detection threshold: -64 dBm			
Radar frequency [MHz]	Successful Trials of 10	Detection rate [%]	Result
5285	0	0	
5286	0	0	
5287	1	10	
5288	7	70	
5289	10	100	f_L = 5289
5290	10	100	
5295	10	100	
5300	10	100	
5305	10	100	
5310	10	100	
5311	9	90	f_H = 5311
5312	7	70	
5313	4	40	
5314	0	0	
5315	0	0	
Detection Bandwith: f_H - f_L = 22 MHz			
Detection Bandwidth > 99 % Bandwidth: Passed			

WLAN channel 132, Nominal Channel BW: 20 MHz, Radar type 0, Detection threshold: -64 dBm			
Radar frequency [MHz]	Successful Trials of 10	Detection rate [%]	Result [MHz]
5575	0	0	
5574	1	10	
5573	3	30	
5572	6	60	
5571	10	100	f_L = 5571
5570	10	100	
5565	10	100	
5560	10	100	
5555	10	100	
5550	10	100	
5549	8	80	f_H = 5500
5548	7	70	
5547	1	10	
5546	0	0	
5545	0	0	
Detection Bandwith: f_H - f_L = 21 MHz			
Detection Bandwidth > 99 % Bandwidth: Passed			

5.1.2 Measurement with nominal 40 MHz channel bandwidth

WLAN channel 60, Nominal Channel BW: 20 MHz, Radar type 0, Detection threshold: -64 dBm			
Radar frequency [MHz]	Successful Trials of 10	Detection rate [%]	Result
5285	0	0	
5286	0	0	
5287	1	10	
5288	7	70	
5289	10	100	f_L = 5289
5290	10	100	
5295	10	100	
5300	10	100	
5305	10	100	
5310	10	100	
5311	9	90	f_H = 5311
5312	7	70	
5313	4	40	
5314	0	0	
5315	0	0	
Detection Bandwith: f_H - f_L = 22 MHz			
Detection Bandwidth > 99 % Bandwidth: Passed			

5.2 Channel Shutdown and Non-Occupancy period

The measurement procedure and limits are described in clause 7.8.3 [2].

Operation mode: EUT is in continuous transmission mode with specified test transmission load generated by specific load data (minimum 17 % channel load) from the master to the slave. After the radar event the master initiates the *Channel Shutdown* process given in the table below:

Channel Shutdown	Channel Closing Transmission Time	200 ms + 60 ms*
	Channel Move Time	10 s
Non-Occupancy period		30 min

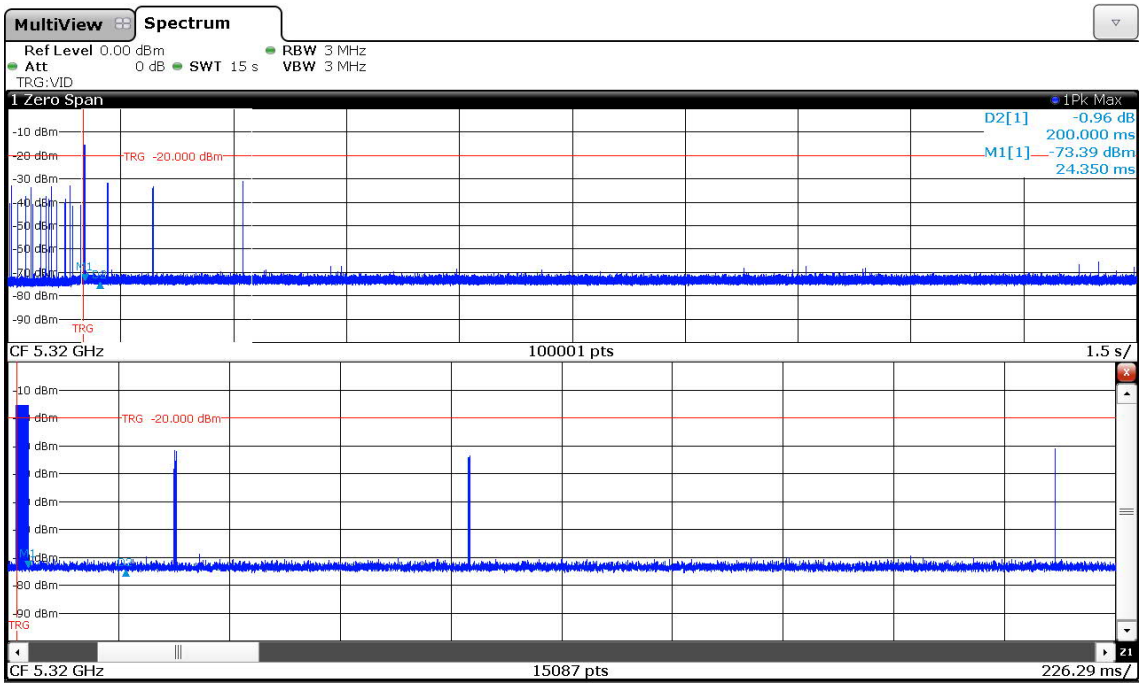
* see chapter 4.3, note 2

The following table and measurement plots show the results of the *Channel Shutdown*.

Measurement result Channel Shutdown	
Master and slave connected, data traffic active / Radar detection threshold level: -62 dBm	
Radar pulse	Radar type 0
Operating frequency	5 320 MHz
Channel bandwidth	20 MHz
Channel closing time	< 200 ms
Channel move time	< 10 s
Measurement uncertainty: < 10 %	

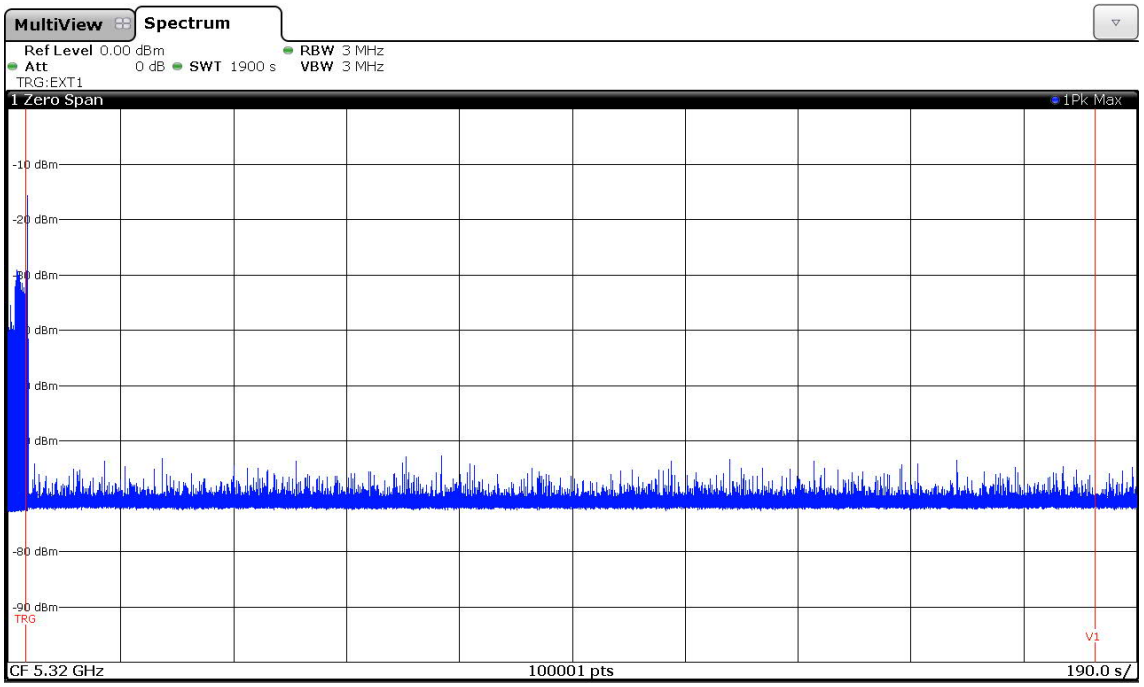
Measurement result Non-Occupancy period	
Master and slave connected, data traffic active / Radar detection threshold level: -62 dBm	
Radar pulse	Radar type 0
Operating frequency	5 320 MHz
Non occupancy period	> 30 min
Measurement uncertainty: < 10 %	

Channel closing transmission and move time at 5320 MHz after type 0 radar event



The beacons after the channel closing transmission time of 200 ms are additional intermittent control signals caused by the master (See Note 2 in 4.5).

Non occupancy period at 5320 MHz after type 0 radar event



6 Test equipment

No.	Test equipment	Type	Manufacturer	Serial No.	PM-No	Date of calibration	
01	Spectrum analyser	FSW43	Rohde & Schwarz	100586	481720	02/24/2016	02/2018
02	Vector signal generator	SMBV-100A	Rohde & Schwarz	255092	481326	02/17/2016	02/2017
03	Attenuator 11 dB	8494B	Hewlett-Packard	3308A38264	480264	Weekly verification	
04	Attenuator 110 dB	8496B	Agilent	00626	480265	Weekly verification	
05	4-way power divider	ZN4PD1-63W-S+	Mini Circuits	-	481787	Weekly verification	
06	4-way power divider	ZN4PD1-63W-S+	Mini Circuits	-	481788	Weekly verification	
07	2-way resistive divider	WA1534	Weinschel	A106	481453	Weekly verification	
08	Attenuator 10 dB	WA8/18-10-34	Weinschel	-	481448	Weekly verification	
09	Attenuator 20 dB	WA8/18-20-34	Weinschel	-	481451	Weekly verification	

7 Report history

Report Number	Date	Comment
F161612E3	07.04.2017	Document created
F161612E3 2nd version	31.08.2020	Correction of Equipment under Test on title page and in chapter 1.4. Addition of dedicated host in chapter 1.5. Correction of model / PMN on page 19 and in annexes B and C.

8 List of Annexes

Annex A	Test setup photos		6 pages
	161612_DFS1.jpg	Test setup	
	161612_DFS_C1.jpg	FL WLAN 2101, 3D view 1	
	161612_DFS_C2.jpg	FL WLAN 2101, 3D view 2	
	161612_DFS5.jpg	FL WLAN 2101, Main PCB, top view	
	161612_DFS6.jpg	FL WLAN 2101, Main PCB, top view, WLAN module removed	
	161612_DFS7.jpg	FL WLAN 2101, Main PCB, bottom view	
Annex B	External photos		2 pages
	161612_DFS3.jpg	SX-PCEAN2, WLAN module, top view	
	161612_DFS4.jpg	SX-PCEAN2, WLAN module, bottom view	