



TEST REPORT

Test Report No. : UL-RPT-RP-12070862-916 FCC

Applicant : Busch-Jaeger
Model No. : SAP-S-3-US
System Access Point 2.0
FCC ID : 2AO6WSAP-S-3-US
Technology : IEEE 802.15.4 (Free@home)
Test Standard(s) : FCC Parts 15.209
For details of applied tests refer to test result summary

1. This test report shall not be reproduced in full or partial, without the written approval of UL International Germany GmbH.
2. The results in this report apply only to the sample tested.
3. The test results in this report are traceable to the national or international standards.
4. Test Report Version 1.3 - Supersedes Version 1.2
5. Result of the tested sample: **PASS**

Prepared by: Segun I. Adeniji
Title: Engineer
Date: 28.May.2018

Approved by: Jakob, Reschke
Title: Senior Test Engineer
Date: 13.June.2018



Deutsche
Akkreditierungsstelle
D-PL-19381-02-00

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The tests reported herein have been performed in
accordance with its' terms of accreditation.

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1. Customer Information

1.1.Applicant Information

Company Name:	Busch-Jaeger Elektro GmbH
Company Address:	Freisenberg straÙe 2, 58513 Luedenscheid, Germany
Company Phone No.:	--
Company E-Mail:	--
Contact Person:	Martin Klett
Contact E-Mail Address:	Martin.klett@de.abb.com
Contact Phone No.:	+49 2351 956 1842

1.2.Manufacturer Information

Company Name:	Busch-Jaeger Elektro GmbH
Company Address:	Freisenberg straÙe 2, 58513 Luedenscheid, Germany
Company Phone No.:	--
Company E-Mail:	--
Contact Person:	Martin Klett
Contact E-Mail Address:	Martin.klett@de.abb.com
Contact Phone No.:	+49 2351 956 1842

2. Summary of Testing

2.1. General Information

Applied Standards

Specification Reference:	47CFR15.247
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.247
Specification Reference:	47CFR15.209
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - 15.209
Test Firm Registration:	399704

Location

Location of Testing:	UL International Germany GmbH Hedelfinger Str. 61 70327 Stuttgart Germany
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Date information

Order Date:	30 November 2017
EUT arrived:	24 January, 07 March and 03 May 2018
Test Dates:	08 March 2018 to 22 May 2018
EUT returned:	N/A

2.2. Summary of Test Results

Clause	Measurement	Complied	Did not comply	Not performed	Not applicable
Part 15.207	Transmitter AC Conducted Emissions ⁽¹⁾	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Part 15.247(a)(2)	Transmitter Minimum 6 dB Bandwidth	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Part 15.247(e)	Transmitter Power Spectral Density	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Part 15.247(b)(3)	Transmitter Maximum Peak Output Power	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Part 15.247(d)/15.209(a)	Transmitter Radiated Emissions	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Part 15.247(d)/15.209(a)	Transmitter Band Edge Radiated Emissions	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Note: Only the intermodulation product of the combined operation of the *IEEE 802.15.4* and WIFI modules operating in 2.4 GHz and 5 GHz bands were required to be tested using Transmitter radiated spurious emission method and limit.

2.3. Methods and Procedures

Reference:	ANSI C63.10-2013
Title:	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Reference:	KDB 662911 D01 Multiple Output v02r01. October 31, 2013
Title:	Emissions Testing of Transmissions with Multiple Outputs in the same Band

2.4. Deviations from the Test Specification

The deviation is that the test focuses only on the intermodulation products produced due to the co-operation of the *IEEE 802.15.4* module and the WLAN module. The rest of the applicable measurements contained in the 47CFR15.247 and 47CFR15.209 has been tested and the result presented in the test report number: UL-RPT-RP-12070862-117_FCC.

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

EUT Description	Radio Test Sample (with Integrated Antennas / External Antenna Port)
Brand Name:	ABB
Model Name or Number:	SAP-S-3-US System Access Point 2.0
Test Sample Serial Number:	S13
Hardware Version Number:	Version 0.1 D1125
Software Version Number:	Version 1.793 (with HD wireless test software)
FCC ID:	2AO6WSAP-S-3-US

3.2. Description of EUT

The equipment under test was a System Access Point 2.0 integrating an IEEE 802.15.4. RF technology and a WLAN chip operating in the 2.4 GHz and in the 5 GHz band.

3.3. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.4. Additional Information Related to Testing

Technology Tested:	IEEE 802.15.4 (Digital Transmission System)		
Type of Unit:	Transceiver		
Transmit Frequency Range:	2405 MHz to 2480 MHz		
Power Levels	2405 MHz-2475 MHz : Level 8	2480 MHz : Level 14	
Channel Spacing:	5 MHz		
Modulation:	O-QPSK		
Data Rate:	250 kbit/s		
Power Supply Requirement(s):	Nominal	3.3 VDC	
Transmit Channels Tested:	Channel ID	RF Channel Number	Channel Frequency (MHz)
	Bottom	11	2405
	Middle	18	2440
	Top	26	2480
Supported Antenna Type:	Internal SMD Metal Antenna	Internal SMD Chip Antenna	External 1/2 Dipole Antenna
Antenna Part Designation:	PRO-OB-536 OnBoard™ SMD	Johansson-2450AT18D0100	Kinsun-6642 B03141-15M, Kinsun 6642-2.4G-SMA
Antenna Type:	Omnidirectional	Omnidirectional	Omnidirectional
Antenna Gain:	Max. 1.50 dBi	Typ. 1.50 dBi	Max. 1.51 dBi

3.5. Support Equipment

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

A. Support Equipment (In-house)

Item	Description	Brand Name	Model Name or Number	Serial Number
1				
2				
3				

B. Support Equipment (Manufacturer supplied)

Item	Description	Brand Name	Model Name or Number	Serial Number
1	Laptop	Lenovo	W530	Not marked/stated
2	USB-Serial Adapter	Not marked/stated	FTDI232	Not marked/stated
3	Power Supply	CINCON	TRE15R240-ASUE-12G681	Not marked/stated

4. Operation and Monitoring of the EUT during Testing

4.1. Operating Modes

The EUT was tested in the following operating mode(s):

- ☒ Transmitting at maximum power with modulation and maximum possible data length

4.2. Configuration and Peripherals

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

- The EUT was powered via 24 VDC power supply that later supplies an internal 3.3 VDC power to the chip module.
- Controlled using a software application on the laptop PC supplied by the customer. The application was used to enable continuous transmission and to select the test channels as required.
- *For the IEEE 802.15.4 module, power level 8 was used for the measurement while the EUT was tested on the 802.11 g where the worst case power was initially measured as given in the customer document named "SPB209 RF WLAN Test Report RevG"*
- The EUT radiated sample was used for the intermodulation measurement and the result was compared with the spurious emission limits.
- EMC32 v10.1 from Rohde and Schwarz was used for the measurement.

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 DAkkS 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. Transmitter Radiated Emissions

Test Summary:

Test Engineer:	Segun I. Adeniji	Test Date:	07 March, 08 May 2018
Test Sample Serial Number:	S13		
Test Site Identification	SR 1/2		

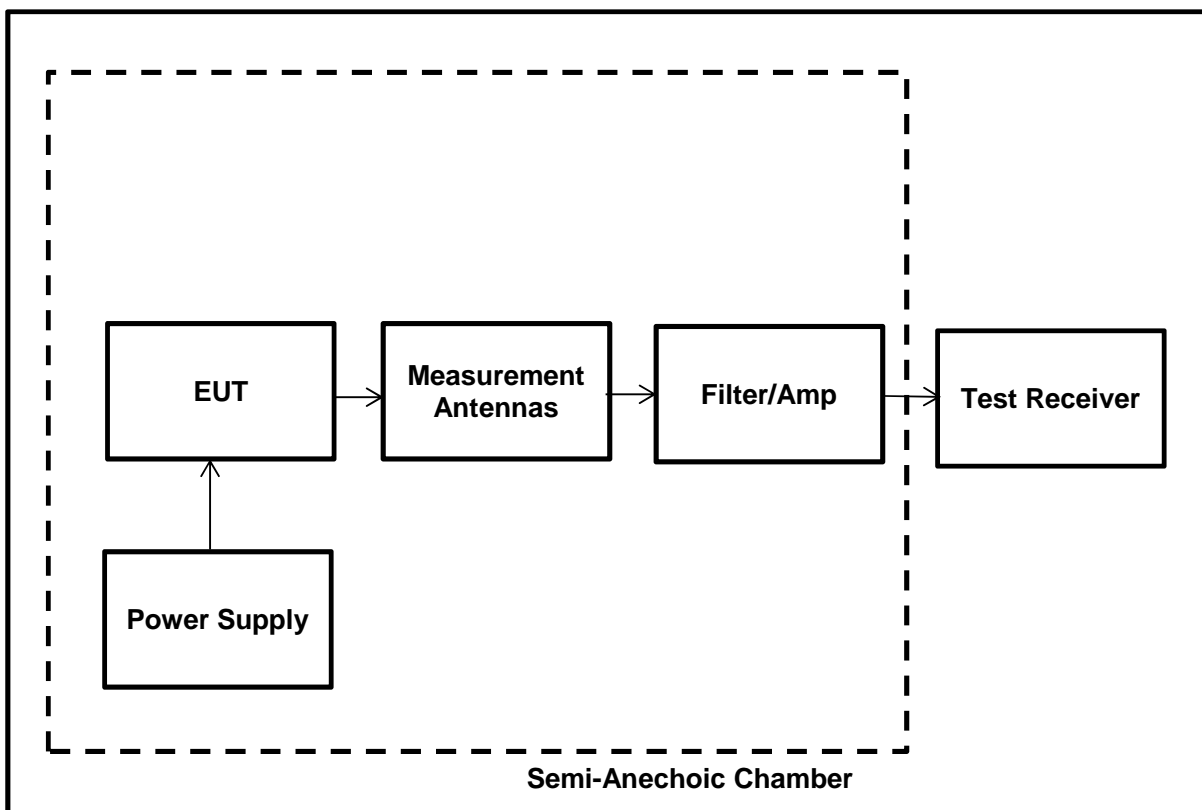
FCC Reference:	15.209
Test Method Used:	ANSI C63.10 Sections 6.3 and 6.5
Frequency Range	30 MHz to 1000 MHz

Environmental Conditions:

Temperature (°C):	23
Relative Humidity (%):	31

Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The preliminary scans showed similar emission levels below 1 GHz, for each combination of ZigBee and WLAN signal. For all the possible combinations of configurations, similar result was obtained and hence only the result for the combination of ZigBee 2.4 GHz (Bottom channel) and WLAN 2.4 GHz (Bottom channel) was presented in the table and plot below.
3. No intermodulation product resulting from the simultaneous operation of the two technologies (ZigBee and WLAN) was seen and only spurious emissions were found as the result is similar to what has been observed in the test report: RPT-RP-12070862-117_FCC.
4. Measurements below 1 GHz were performed in a semi-anechoic chamber at a distance of 3 metres. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
5. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.
6. Final measurements were performed on the marker frequencies and the results entered into the table below. The test receiver resolution bandwidth was set to 120 kHz, using a CISPR quasi-peak detector and span big enough to see the whole emission.

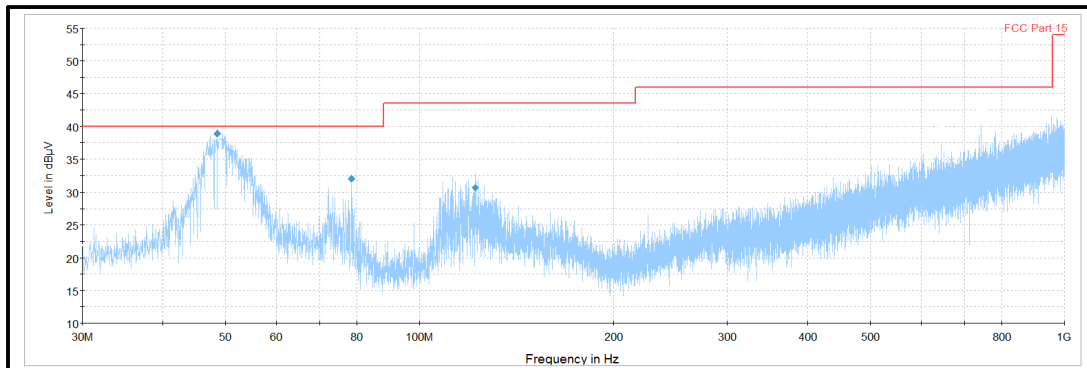
Test Setup:

Results: Bottom Channel/Peak/Internal SMD Metal Antenna

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
49.51	V	39.21	40.0	0.79	Complied
78.54	V	32.14	40.0	7.86	Complied
122.07	V	30.43	43.50	13.07	Complied

Results: Bottom Channel/Quasi-Peak/Internal SMD Metal Antenna

Frequency (MHz)	Antenna Polarization	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
49.51	V	32.04	40.0	7.96	Complied

Plot: 30 MHz – 1GHz

Note: This plot is a pre-scan to search for intermodulation products in the band from 30 MHz to 1 GHz (Peak detector).

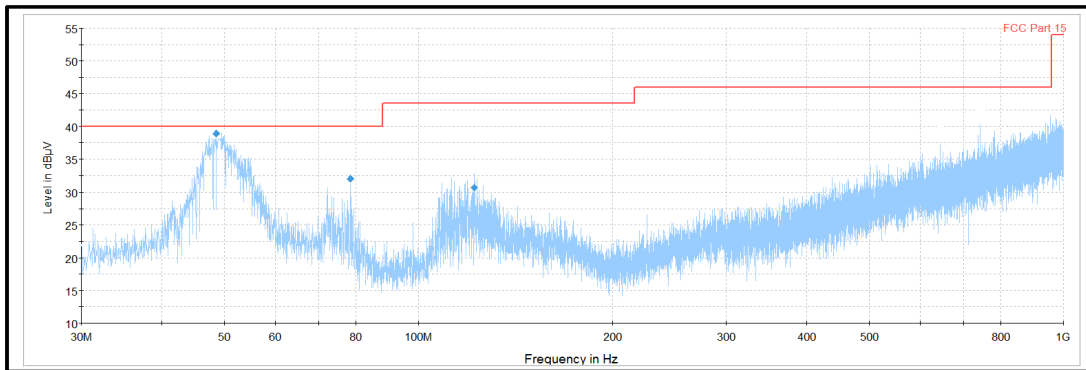
Result: Pass

Results: Bottom Channel/Peak/Internal SMD Chip Antenna

Frequency (MHz)	Antenna Polarization	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
41.78	Vertical	39.33	40.0	0.67	Complied
45.92	Vertical	30.73	40.0	9.27	Complied
65.51	Vertical	31.69	43.50	11.81	Complied
124.23	Vertical	38.01	46.0	7.99	Complied

Results: Bottom Channel/Quasi-Peak/Internal SMD Chip Antenna

Frequency (MHz)	Antenna Polarization	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
49.44	V	35.41	40.0	4.59	Complied

Plot: 30 MHz – 1GHz

Note: This plot is a pre-scan to search for intermodulation products in the band from 30 MHz to 1 GHz (Peak detector).

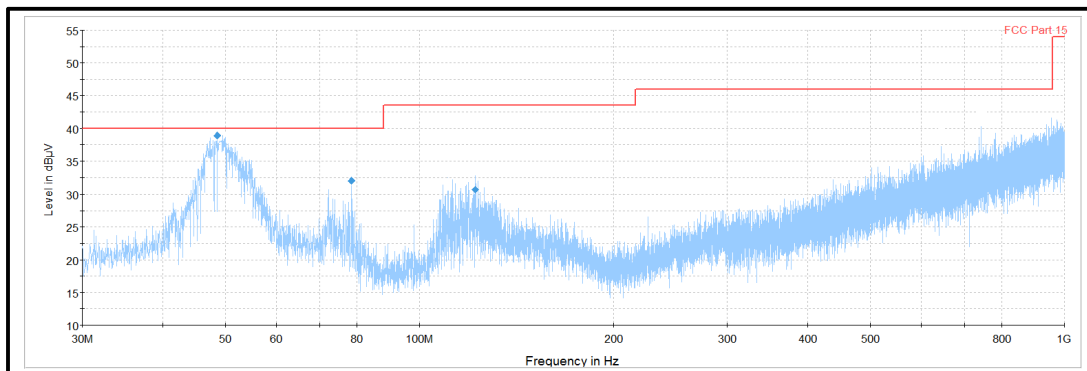
Result: Pass

Results: Bottom Channel/Peak/External $\lambda/2$ Dipole Antenna

Frequency (MHz)	Antenna Polarization	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
41.74	Vertical	39.36	40.0	0.64	Complied
45.90	Vertical	30.69	40.0	9.31	Complied
65.53	Vertical	31.71	43.50	11.79	Complied
124.24	Vertical	38.23	46.0	7.77	Complied

Results: Bottom Channel/Quasi-Peak/External $\lambda/2$ Dipole Antenna

Frequency (MHz)	Antenna Polarization	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
49.46	V	32.01	40.0	7.99	Complied

Plot: 30 MHz – 1GHz

Note: This plot is a pre-scan to search for intermodulation products in the band from 30 MHz to 1 GHz (Peak detector).

Result: **Pass**

Test Summary:

Test Engineer:	Segun I. Adeniji	Test Date:	08 March, 08 May 2018
Test Sample Serial Number:	S13		
Test Site Identification	SR 1/2		

FCC Reference:	15.209
Test Method Used:	FCC KDB 558074 Sections 11 & 12 referencing ANSI C63.10 Sections 6.3 and 6.6
Frequency Range	1 GHz to 25 GHz

Environmental Conditions:

Temperature (°C):	26
Relative Humidity (%):	35

Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. Several possible combinations of *IEEE 802.15.4* and *WLAN* was checked. Measurement was initially made on bottom channel of the *IEEE 802.15.4* module and bottom channel of the 2.4 GHz *WLAN* module. The next combination was for the top channel of the *IEEE 802.15.4* module and top channel of the 2.4 GHz *WLAN* and the last measurement was for the combination of the top channel operation of the *IEEE 802.15.4* module and the 5 GHz *WLAN* module.
3. Referring to the plots below, on the first and second plots, the emission shown around the 2.4 GHz is the combination of the two signals and no intermodulation product was found. On the third plot, except for the 2.4GHz carrier from the *IEEE 802.15.4* module and the 5 GHz *WLAN* carrier, all other emissions were found to be as a result of the over driving of the amplifier used in the measurement setup. This was discovered after proper investigation of each of the emission. The emissions have been labelled accordingly in the plot. Therefore only the noise floor levels have been recorded.
4. Measurement was made on a frequency range to cover up to at least 9th order intermodulation product.
5. Measurements above 1 GHz were performed in a semi-anechoic chamber at a distance of 3 metres. The EUT was placed at a height of 1.5 m above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
6. Pre-scans were performed and a marker placed on the highest measured level of the appropriate plot. The test receiver resolution bandwidth was set to 1 MHz and video bandwidth 3 MHz. The sweep time was set to auto.
7. *In accordance with ANSI C63.10 Section 6.6.4.3, Note 1, if the peak measured value complies with the average limit, it is unnecessary to perform an average measurement.
8. The reference level for the emission in the non-restricted band was established by following KDB 558074 Section 11.2 procedure.

Results: Internal SMD Metal Antenna**Results: Peak / Bottom Channel IEEE 802.15.4 + 2.4 GHz Bottom Channel WLAN**

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
13521.0	H	53.17	54.0	0.83	Complied

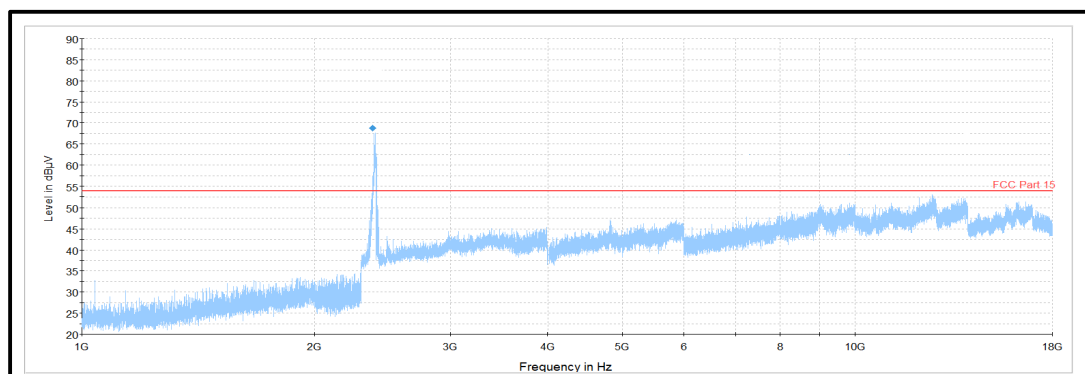
Results: Peak / TOP Channel IEEE 802.15.4 + 2.4 GHz TOP Channel WLAN

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
13521.0	H	53.53	54.0	0.47	Complied

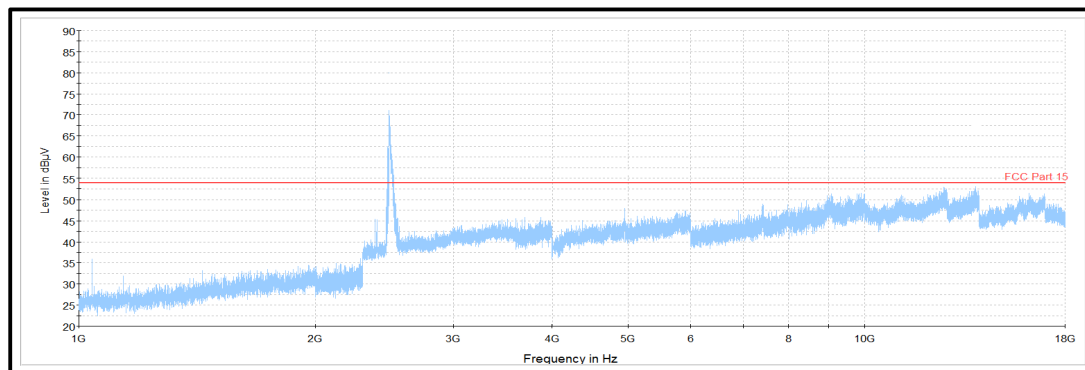
Results: Peak / TOP Channel IEEE 802.15.4 + 5 GHz Bottom Channel (36) WLAN

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
13521.0	H	53.21	54.0	0.79	Complied

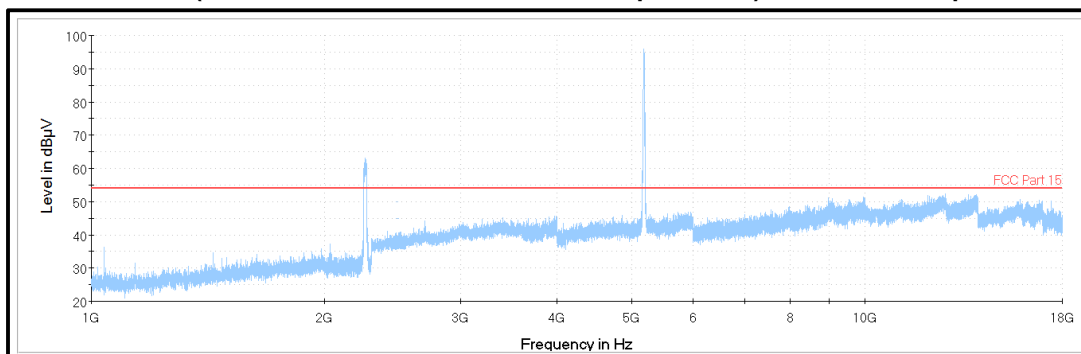
Result: Pass



Plot: 1 GHz – 18GHz (Both *IEEE 802.15.4* and *WLAN* on Bottom channel) measured with peak detector



Plot: 1 GHz – 18GHz (Both *IEEE 802.15.4* and *WLAN* on Top channel) measured with peak detector



Plot: 1 GHz – 18GHz (*IEEE 802.15.4* on the Top channel and the *WLAN 5 GHz* on Channel 36) measured with peak detector

Results: Internal SMD Chip Antenna**Results: Peak / Bottom Channel IEEE 802.15.4 + 2.4 GHz Bottom Channel WLAN**

Frequency (MHz)	Antenna Polarity	Level (dBμV/m)	Average Limit (dBμV/m)	Margin (dB)	Result
4824.28	H	53.21	54.0	0.79	Complied

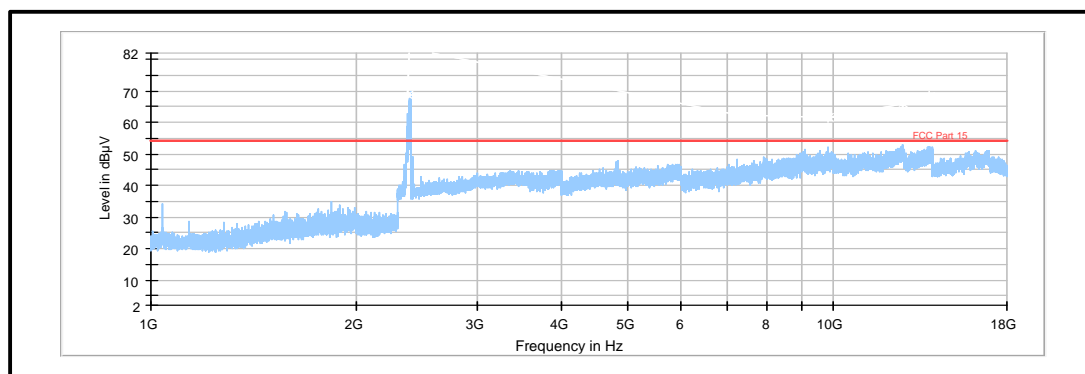
Results: Peak / TOP Channel IEEE 802.15.4 + 2.4 GHz TOP Channel WLAN

Frequency (MHz)	Antenna Polarity	Level (dBμV/m)	Average Limit (dBμV/m)	Margin (dB)	Result
4942.67	H	53.47	54.0	0.53	Complied

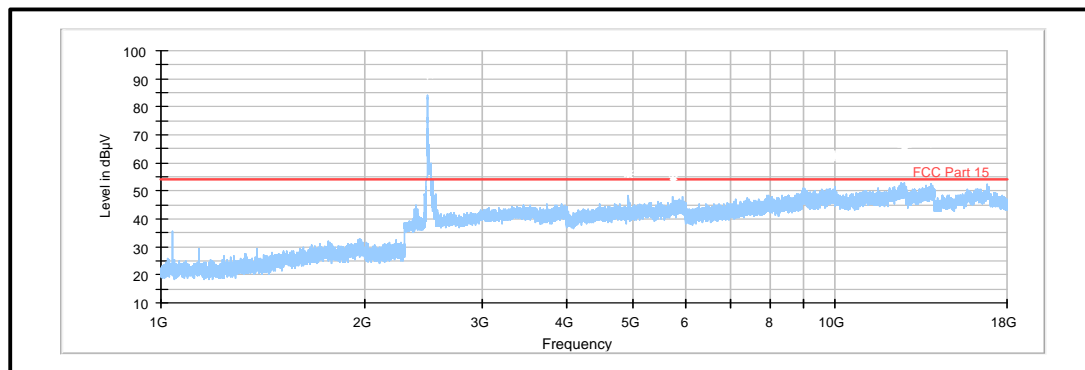
Results: Peak / TOP Channel IEEE 802.15.4 + 5 GHz Bottom Channel (36) WLAN

Frequency (MHz)	Antenna Polarity	Level (dBμV/m)	Average Limit (dBμV/m)	Margin (dB)	Result
4942.67	H	53.19	54.0	0.81	Complied

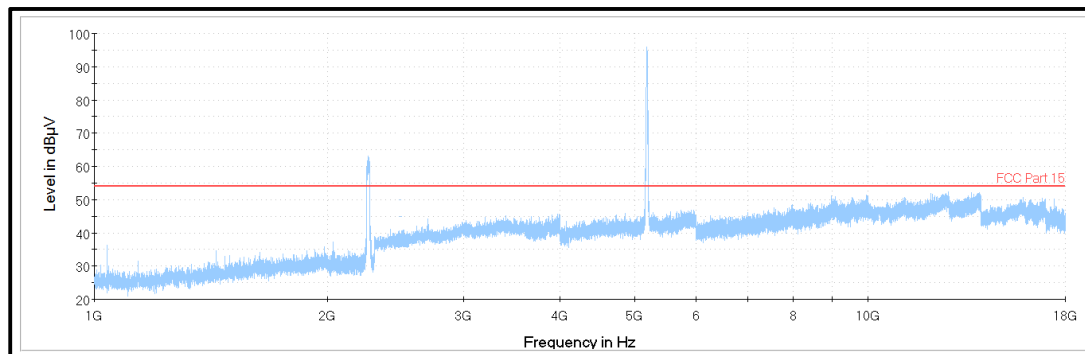
Result: Pass



Plot: 1 GHz – 18GHz (Both *IEEE 802.15.4* and *WLAN* on Bottom channel) measured with peak detector



Plot: 1 GHz – 18GHz (Both *IEEE 802.15.4* and *WLAN* on Top channel) measured with peak detector



Plot: 1 GHz – 18GHz (*IEEE 802.15.4* on the Top channel and the *WLAN 5 GHz* on Channel 36) measured with peak detector

Results: External $\lambda/2$ Dipole Antenna**Results: Peak / Bottom Channel IEEE 802.15.4 + 2.4 GHz Bottom Channel WLAN**

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
4824.31	H	53.16	54.0	0.84	Complied

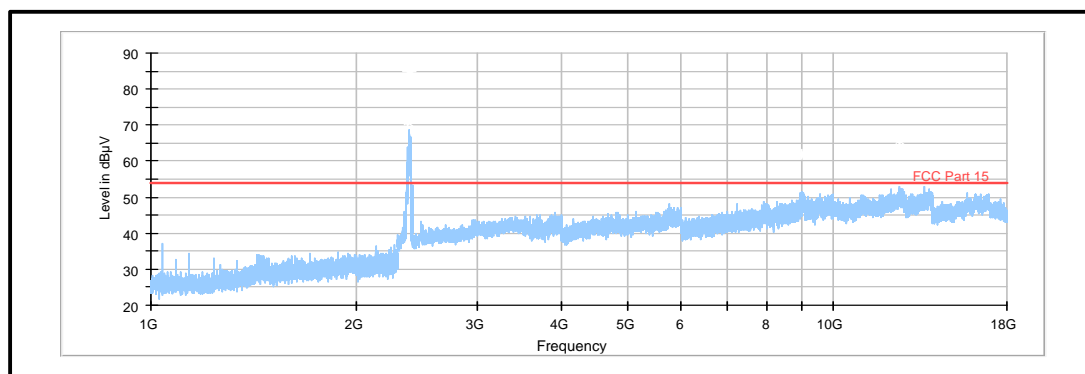
Results: Peak / TOP Channel IEEE 802.15.4 + 2.4 GHz TOP Channel WLAN

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
4942.13	H	53.35	54.0	0.65	Complied

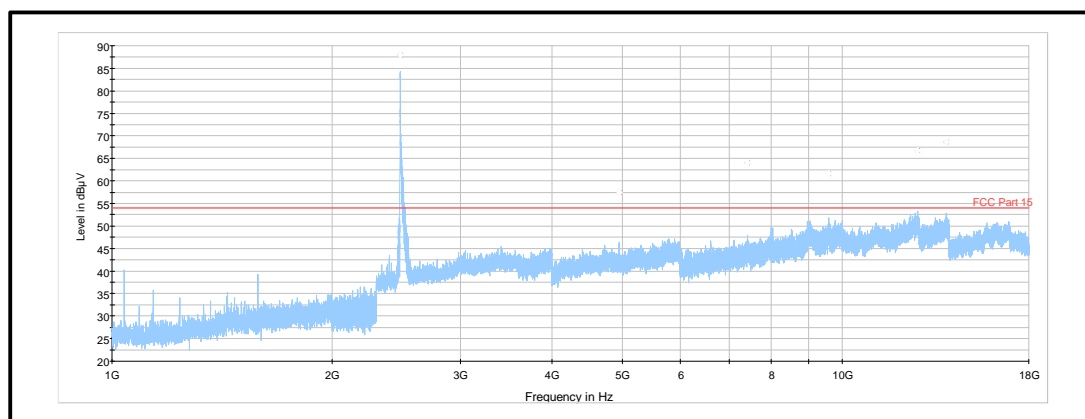
Results: Peak / TOP Channel IEEE 802.15.4 + 5 GHz Bottom Channel (36) WLAN

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
4942.34	H	53.23	54.0	0.77	Complied

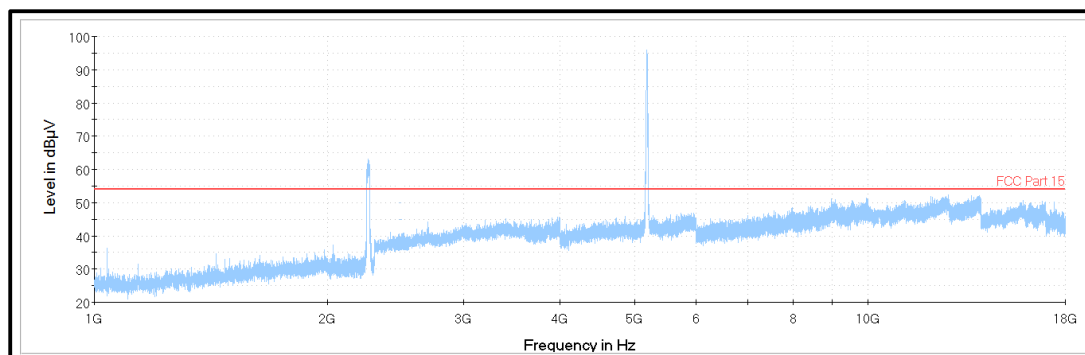
Result: Pass



Plot: 1 GHz – 18GHz (Both *IEEE 802.15.4* and *WLAN on Bottom channel*) measured with peak detector



Plot: 1 GHz – 18GHz (Both *IEEE 802.15.4* and *WLAN on Top channel*) measured with peak detector



Plot: 1 GHz – 18GHz (*IEEE 802.15.4 on the Top channel* and the *WLAN 5 GHz on Channel 36*) measured with peak detector

6. Measurement Uncertainty

The expression of uncertainty of a measurement result allows realistic comparison of results with reference values and limits given in specifications and standards.

The uncertainty of the result may need to be taken into account when interpreting the measurement results.

The reported expanded uncertainties below are based on a standard uncertainty multiplied by an appropriate coverage factor such that a confidence level of approximately 95% is maintained. For the purposes of this document "approximately" is interpreted as meaning "effectively" or "for most practical purposes".

Measurement Type	Confidence Level (%)	Calculated Uncertainty
Radiated Spurious Emissions	95%	± 3.10 dB

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty the published guidance of the appropriate accreditation body is followed.

7. Used equipment

Test site: SR 1/2

ID	Manufacturer	Type	Model	Serial No.	Calibration Date	Cal. Cycle
350	Rohde & Schwarz	Receiver, EMI Test	ESIB7	836697/014	7/13/2017	12
377	Bonn Elektronik	Amplifier, Low Noise Pre	BLMA 0118-1A	025294B	7/11/2017	12
423	Bonn Elektronik	Amplifier, Low Noise Pre	BLMA 1840-1A	055929	7/12/2017	12
460	Deisl	Turntable	DT 4250 S		n/a	n/a
465	Schwarzbeck	Antenna, Trilog Broadband	VULB 9168	9168-240	8/8/2016	36
496	Rohde & Schwarz	Antenna, log. - periodical	HL050	100297	7/20/2016	24
587	Maturo	antenna mast, tilting	TAM 4.0-E	011/7180311	n/a	n/a
588	Maturo	Controller	NCD	029/7180311	n/a	n/a
591	Rohde & Schwarz	Receiver	ESU 40	100244/040	7/12/2017	12
608	Rohde & Schwarz	Switch Matrix	OSP 120	101227	4/8/2014	60
614	Wainwright Instruments	Highpass Filter 3GHz	WHKX10-	1	Lab verification	n/a
615	Wainwright Instruments	Highpass Filter 1GHz	WHKX12-	3	Lab verification	n/a
620	Bonn Elektronik	pre-amplifier	BLNA 0110-01N	1510111	7/12/2017	24
628	Maturo	Antenna mast	CAM 4.0-P	224/19590716	n/a	n/a
629	Maturo	Kippeinrichtung	KE 2.5-R-M	MAT002	n/a	n/a

8. Report Revision History

Version Number	Revision Details		
	Page No(s)	Clause	Details
1.0	-	-	Initial Version
1.1	1, 7	3.0	FCC ID added,
1.2	14, 19	5.2.1	Measurement results of Internal SMD Chip Antenna & External $\lambda/2$ Dipole Antenna added
1.3	8	3.4	Changed antenna gain