

## TEST REPORT

Test report no.: 1-2105/16-01-06-A



Deutsche  
Akkreditierungsstelle  
D-PL-12076-01-01

### Testing laboratory

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**Accredited Testing Laboratory:**

The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2005) by the Deutsche Akkreditierungsstelle GmbH (DAkkS). The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate with the registration number: D-PL-12076-01-01

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### Manufacturer

**SIGFOX**

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### Test standard/s

47 CFR Part 15	Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 247 Issue 1	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence - Exempt Local Area Network (LE-LAN) Devices

For further applied test standards please refer to section 3 of this test report.

### Test Item

<b>Kind of test item:</b>	<b>sigfox demonstrator</b>
<b>Model name:</b>	<b>sensit</b>
<b>FCC ID:</b>	<b>2ACK7SENSIT4</b>
<b>IC:</b>	<b>-/-</b>
<b>Frequency:</b>	DTS band 902 MHz – 928 MHz
<b>Technology tested:</b>	Proprietary FHSS
<b>Antenna:</b>	Integrated antenna
<b>Power supply:</b>	3.7 V DC by Li Po battery
<b>Temperature range:</b>	22 °C



This test report is electronically signed and valid without handwriting signature. For verification of the electronic signatures, the public keys can be requested at the testing laboratory.

### Test report authorized:

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Christoph Schneider  
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Radio Communications & EMC

### Test performed:

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## 2 General information

### 2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CTC advanced GmbH does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.

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**This test report replaces the test report with the number 1-2105/16-01 and dated 2016-10-05**

### 2.2 Application details

Date of receipt of order:	2016-06-29
Date of receipt of test item:	2016-07-05
Start of test:	2016-07-06
End of test:	2016-07-07
Person(s) present during the test:	-/-

## 3 Test standard/s and references

Test standard	Date	Description
47 CFR Part 15	-/-	Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 247 Issue 1	May 2015	Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence - Exempt Local Area Network (LE-LAN) Devices

Guidance	Version	Description
ANSI C63.4-2014	-/-	American national standard for methods of measurement of radio-noise emissions from low-voltage electrical and electronic equipment in the range of 9 kHz to 40 GHz
ANSI C63.10-2013	-/-	American national standard of procedures for compliance testing of unlicensed wireless devices

## 4 Test environment

Temperature	:	T <sub>nom</sub> T <sub>max</sub> T <sub>min</sub>	+22 °C during room temperature tests No tests under extreme conditions required No tests under extreme conditions required
Relative humidity content	:		55 %
Barometric pressure	:		not relevant for this kind of testing
Power supply	:	V <sub>nom</sub> V <sub>max</sub> V <sub>min</sub>	3.70 V DC by Li Po battery No tests under extreme conditions required No tests under extreme conditions required

## 5 Test item

### 5.1 General description

Kind of test item	:	sigfox demonstrator
Type identification	:	sensit
HMN	:	-/-
PMN	:	Sens'it
HVIN	:	Sens'it 2.4
FVIN	:	-/-
S/N serial number	:	No information available
HW hardware status	:	V3.4
SW software status	:	V2.0
Frequency band	:	DTS band 902 MHz – 928 MHz
Type of radio transmission	:	FHSS
Use of frequency spectrum	:	
Type of modulation	:	DBPSK
Number of channels	:	54 (9 Macro channels x 6 Micro channels)
Antenna	:	Integrated antenna
Power supply	:	3.7 V DC by Li Po battery
Temperature range	:	22 °C

### 5.2 Additional information

The content of the following annexes is defined in the QA. It may be that not all of the listed annexes are necessary for this report, thus some values in between may be missing.

Test setup- and EUT-photos are included in test report: 1-2105\_16-01-01\_AnnexA  
 1-2105\_16-01-01\_AnnexB  
 1-2105\_16-01-01\_AnnexD

## 6 Test laboratories sub-contracted

None

## 7 Description of the test setup

Typically, the calibrations of the test apparatus are commissioned to and performed by an accredited calibration laboratory. The calibration intervals are determined in accordance with the DIN EN ISO/IEC 17025. In addition to the external calibrations, the laboratory executes comparison measurements with other calibrated test systems or effective verifications. Weekly chamber inspections and range calibrations are performed. Where possible, RF generating and signaling equipment as well as measuring receivers and analyzers are connected to an external high-precision 10 MHz reference (GPS-based or rubidium frequency standard).

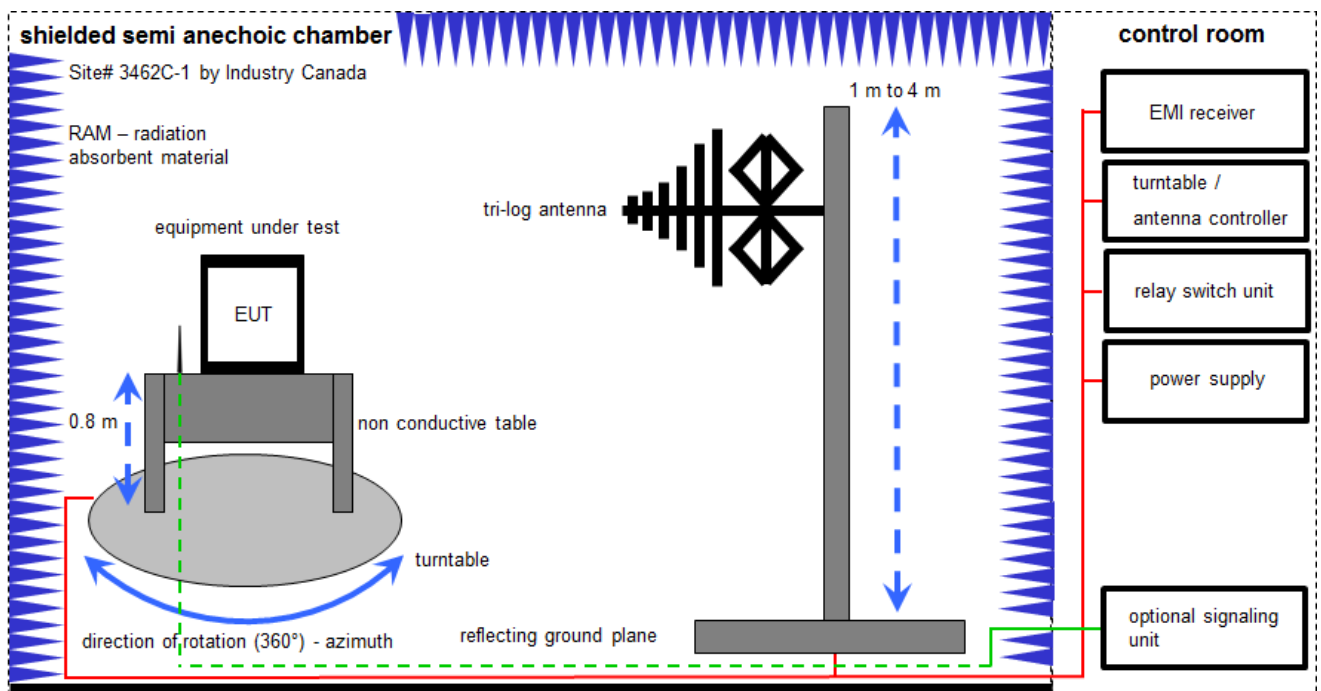
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

**Agenda:** Kind of Calibration

k	calibration / calibrated	EK	limited calibration
ne	not required (k, ev, izw, zw not required)	zw	cyclical maintenance (external cyclical maintenance)
ev	periodic self verification	izw	internal cyclical maintenance
Ve	long-term stability recognized	g	blocked for accredited testing
vlk!	Attention: extended calibration interval		
NK!	Attention: not calibrated	*)	next calibration ordered / currently in progress

## 7.1 Shielded semi anechoic chamber

The radiated measurements are performed in vertical and horizontal plane in the frequency range from 9 kHz to 1 GHz in semi-anechoic chambers. The EUT is positioned on a non-conductive support with a height of 0.80 m above a conductive ground plane that covers the whole chamber. The receiving antennas are confirmed with specifications ANSI C63. These antennas can be moved over the height range between 1.0 m and 4.0 m in order to search for maximum field strength emitted from EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by spectrum analyzers where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: tri-log antenna 10 meter

$$FS = UR + CL + AF$$

(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

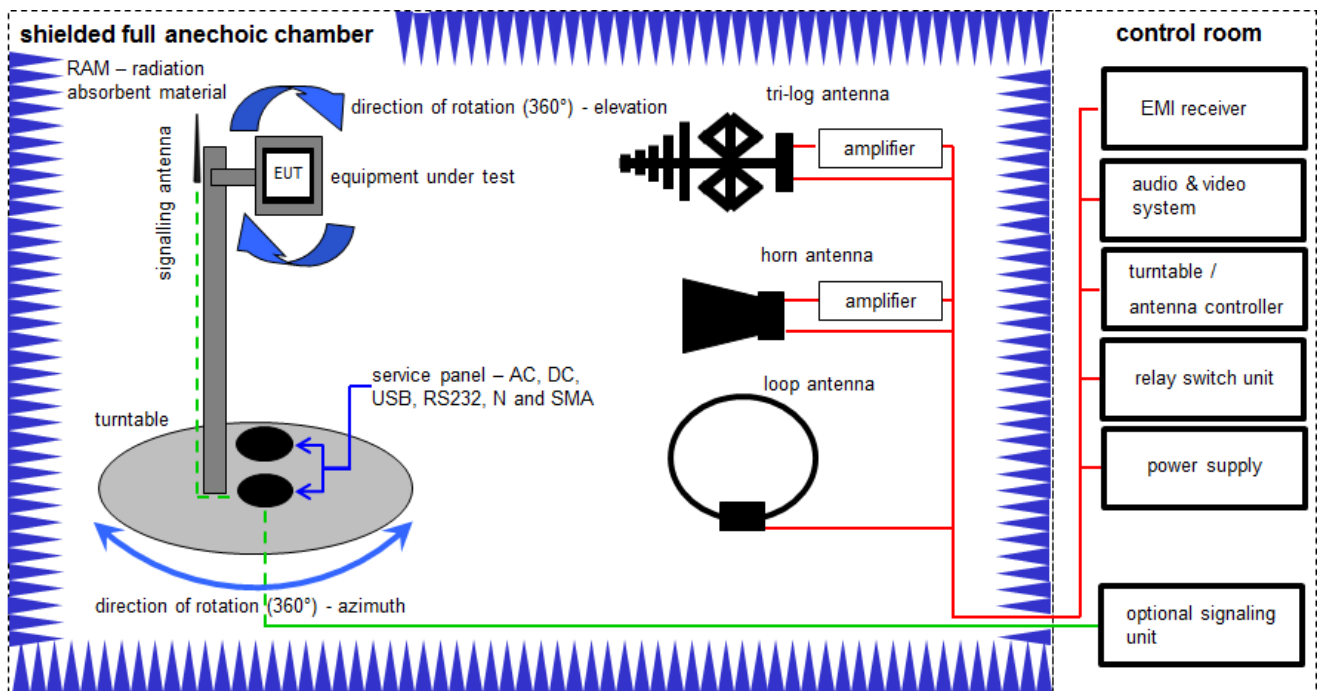
Example calculation:

$$FS [dB\mu V/m] = 12.35 [dB\mu V/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dB\mu V/m] (35.69 \mu V/m)$$

### Equipment table:

No.	Lab / Item	Equipment	Type	Manufact.	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-
2	A	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	08.03.2016	08.03.2017
3	A	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
4	A	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
5	A	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
6	A	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck	295	300003787	k	25.04.2016	25.04.2018
7	A	Spectrum-Analyzer	FSU26	R&S	200809	300003874	k	29.01.2016	29.01.2017

## 7.2 Shielded fully anechoic chamber



Measurement distance: horn antenna 3 meter; loop antenna 3 meter

$$FS = UR + CA + AF$$

(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

Example calculation:

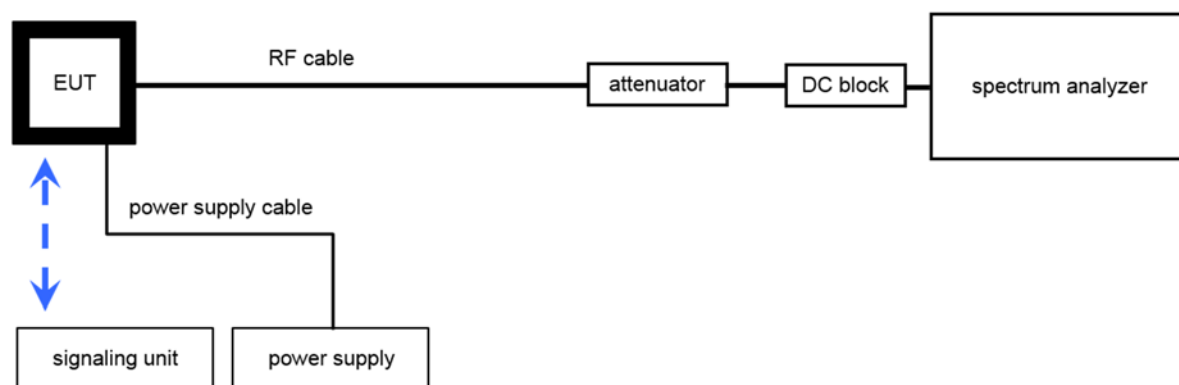
$$FS [dB\mu V/m] = 40.0 [dB\mu V/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dB\mu V/m] (71.61 \mu V/m)$$

### Equipment table:

No.	Lab / Item	Equipment	Type	Manufact.	Serial No.	INV. No	Kind of Calibration	Last Calibration	Next Calibration
1	C	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	8812-3088	300001032	vKI!	20.05.2015	20.05.2017
2	A,B,C	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
3	A,B,C	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
4	A	Active Loop Antenna 10 kHz to 30 MHz	6502	EMCO/2	8905-2342	300000256	k	24.06.2015	24.06.2017
5	C	Amplifier	js42-00502650-28-5a	Parzich GMBH	928979	300003143	ne	-/-	-/-
6	C	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	18	300003789	ne	-/-	-/-
7	B	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck	371	300003854	vKI!	29.10.2014	29.10.2017
8	A,B,C	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
9	A,B,C	EMI Test Receiver 9kHz-26,5GHz	ESR26	R&S	101376	300005063	k	04.09.2015	04.09.2016

### 7.3 Conducted measurements

#### Conducted measurements normal conditions



$$OP = AV + CA$$

(OP-output power; AV-analyzer value; CA-loss signal path)

#### Example calculation:

$$OP \text{ [dBm]} = 6.0 \text{ [dBm]} + 11.7 \text{ [dB]} = 17.7 \text{ [dBm]} \text{ (58.88 mW)}$$

#### Equipment table:

No.	Lab / Item	Equipment	Type	Manufact.	Serial No.	INV. No	Kind of Calibration	Last Calibration	Next Calibration
1	A	Spectrum Analyzer 9kHz to 30GHz - 140..+30dBm	FSP30	R&S	100886	300003575	k	27.01.2016	27.01.2018
2	A	RF-Cable	ST18/SMAm/SMAm/60	Huber & Suhner	Batch no. 606844	400001181	ev	-/-	-/-
3	A	DC-Blocker 0.1-40 GHz	8141A	Inmet	Batch no. 606844	400001185	ev	-/-	-/-
4	A	Coax Attenuator 10 dB 2W 0-40 GHz	MCL BW-K10-2W44+	Mini Circuits	Batch no. 606844	400001186	ev	-/-	-/-



**8 Measurement uncertainty**

Measurement uncertainty	
Test case	Uncertainty
Antenna gain	± 3 dB
Carrier frequency separation	± 21.5 kHz
Number of hopping channels	-/-
Spectrum bandwidth	± 21.5 kHz absolute; ± 15.0 kHz relative
Maximum output power	± 1 dB
Detailed conducted spurious emissions @ the band edge	± 1 dB
Band edge compliance radiated	± 3 dB
Spurious emissions conducted	± 3 dB
Spurious emissions radiated below 30 MHz	± 3 dB
Spurious emissions radiated 30 MHz to 1 GHz	± 3 dB
Spurious emissions radiated 1 GHz to 12.75 GHz	± 3.7 dB
Spurious emissions radiated above 12.75 GHz	± 4.5 dB

## 9 Sequence of testing

### 9.1 Sequence of testing radiated spurious 9 kHz to 30 MHz

#### Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a 2-axis positioner with 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turn table.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

#### Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna height is 1.5 m.
- At each turntable position the analyzer sweeps with positive-peak detector to find the maximum of all emissions.

#### Final measurement

- Identified emissions during the premeasurement are maximized by the software by rotating the turntable from 0° to 360°. In case of the 2-axis positioner is used the elevation axis is also rotated from 0° to 360°.
- The final measurement is done in the position (turntable and elevation) causing the highest emissions with quasi-peak (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. A plot with the graph of the premeasurement and the limit is stored.

## 9.2 Sequence of testing radiated spurious 30 MHz to 1 GHz

### Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 10 m or 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

### Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1 m to 3 m.
- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

### Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable position  $\pm 45^\circ$  and antenna height between 1 and 4 m.
- The final measurement is done with quasi-peak detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

### 9.3 Sequence of testing radiated spurious 1 GHz to 12.75 GHz

#### Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a 2-axis positioner with 1.5 m height is used.
- If the EUT is a floor standing device, it is placed directly on the turn table.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

#### Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height is 1.5 m.
- At each turntable position and antenna polarization the analyzer sweeps with positive peak detector to find the maximum of all emissions.

#### Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximizes the peaks by rotating the turntable from 0° to 360°. This measurement is repeated for different EUT-table positions (0° to 150° in 30°-steps) and for both antenna polarizations.
- The final measurement is done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

## 10 Summary of measurement results

<input checked="" type="checkbox"/>	No deviations from the technical specifications were ascertained
<input type="checkbox"/>	There were deviations from the technical specifications ascertained
<input type="checkbox"/>	This test report is only a partial test report. The content and verdict of the performed test cases are listed below.

TC Identifier	Description	Verdict	Date	Remark
RF-Testing	CFR Part 15 RSS - 247, Issue 1	See table!	2016-12-16	-/-

Test specification clause	Test case	Temperature conditions	Power source voltages	Mode	C	NC	NA	NP	Remark
§15.247(b)(4) RSS - 247 / 5.4 (2)	Antenna gain	Nominal	Nominal	CW	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) RSS - 247 / 5.1 (2)	Carrier frequency separation	Nominal	Nominal	DBPSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) RSS - 247 / 5.1 (4)	Number of hopping channels	Nominal	Nominal	DBPSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) (iii) RSS - 247 / 5.1 (4)	Time of occupancy (dwell time)	Nominal	Nominal	DBPSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(a)(1) RSS - 247 / 5.1 (1)	Spectrum bandwidth of a FHSS system bandwidth	Nominal	Nominal	DBPSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(b)(1) RSS - 247 / 5.4 (2)	Maximum output power	Nominal	Nominal	DBPSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS - 247 / 5.5	Detailed spurious emissions @ the band edge - conducted	Nominal	Nominal	DBPSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance radiated	Nominal	Nominal	DBPSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS - 247 / 5.5	Spurious emissions conducted	Nominal	Nominal	DBPSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.209(a) RSS - Gen	Spurious emissions radiated below 30 MHz	Nominal	Nominal	DBPSK	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen	Spurious emissions radiated 30 MHz to 1 GHz	Nominal	Nominal	DBPSK / RX mode	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen	Spurious emissions radiated above 1 GHz	Nominal	Nominal	DBPSK / RX mode	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
§15.107(a) §15.207	Conducted emissions below 30 MHz (AC conducted)	Nominal	Nominal	-/-	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	EUT ceases transmitting after connecting the charger

**Note:** C = Compliant; NC = Not compliant; NA = Not applicable; NP = Not performed

## 11 RF measurements

### 11.1 Additional comments

Reference documents: None

Special test descriptions: None

Configuration descriptions: The EUT uses 9 macro channels. Every macro channel is divided into 6 micro channels. In summary, the EUT uses 54 single channels.

Test mode: ☒ Special software is used.  
EUT is transmitting pseudo random data by itself

## 12 Measurement results

### 12.1 Antenna gain

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module.

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Span	5 MHz
Trace mode	Max hold
Test setup	See sub clause 7.2 B (radiated) See sub clause 7.3 A (conducted)
Measurement uncertainty	See sub clause 8

#### Limits:

FCC	IC
Antenna gain	
The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.	

#### Results:

	Low channel 920.1 MHz	Middle channel 921.4 MHz	High channel 922.7 MHz
Conducted power [dBm]	24.0	23.9	24.0
Radiated power [dBm]	26.7	26.1	25.7
Gain [dBi] Calculated	2.7	2.2	1.7

## 12.2 Carrier Frequency Separation

### Description:

Measurement of the carrier frequency separation of a hopping system. The carrier frequency separation is constant for all modulation-modes. We use DBPSK-modulation to show compliance. EUT in hopping mode.

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	10 kHz
Video bandwidth	30 kHz
Span	See plots
Trace mode	Max hold
Test setup	See sub clause 7.3 A
Measurement uncertainty	See sub clause 8

### Limits:

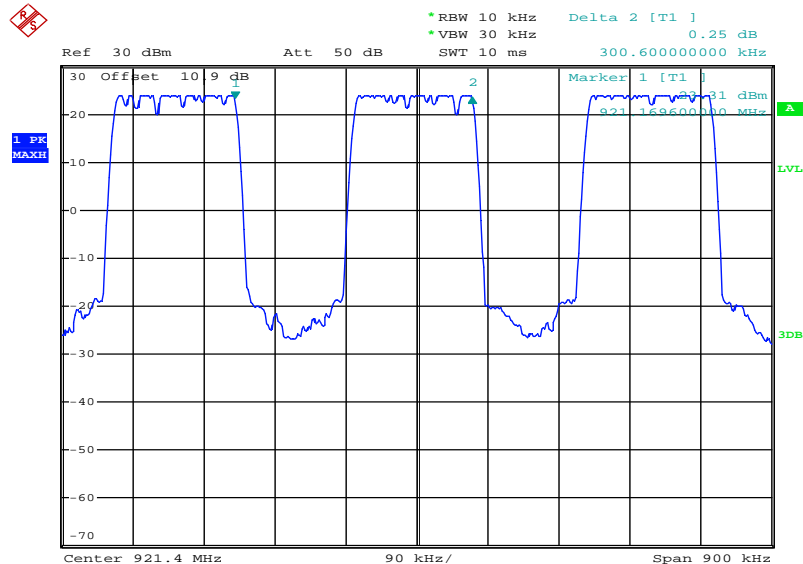
FCC	IC
Carrier frequency separation	
Minimum 25 kHz or two-thirds of the 20 dB bandwidth of the hopping system whichever is greater.	

**Result:** The channel separation is 300.6 kHz for the macro channels and 26.0 kHz for the micro channels.



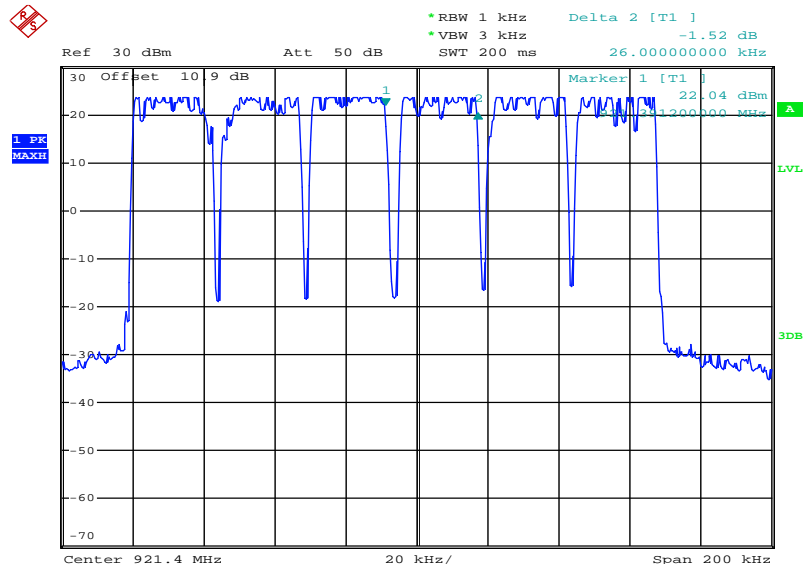
**Plots:**

Plot 1: Frequency separation macro channels



Date: 28.SEP.2016 11:52:18

Plot 2: Frequency separation micro channels



Date: 28.SEP.2016 12:16:43

## 12.3 Number of Hopping Channels

### Description:

Measurement of the total number of used hopping channels. The number of hopping channels is constant for all modulation-modes. We use DBPSK -modulation to show compliance. EUT in hopping mode.

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	See plots
Video bandwidth	See plots
Span	See plots
Trace mode	Max hold
Test setup	See sub clause 7.3 A
Measurement uncertainty	See sub clause 8

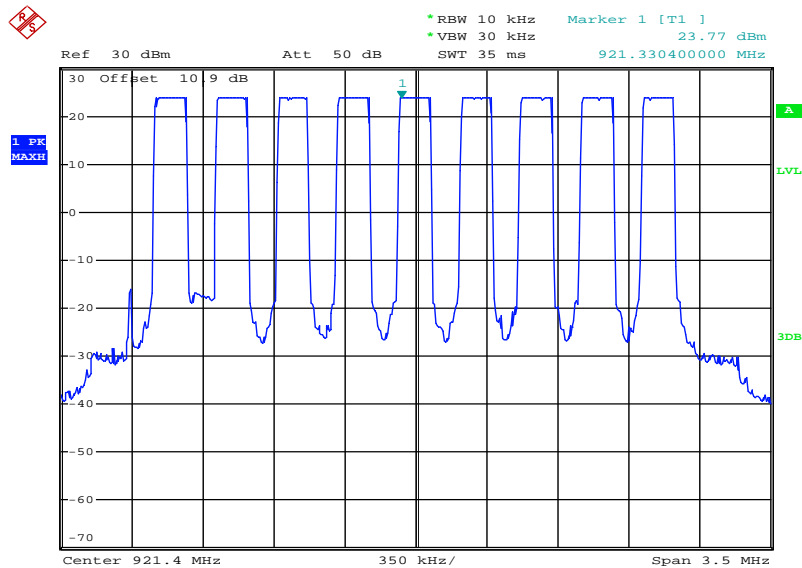
### Limits:

FCC	IC
Number of hopping channels	
At least 15 non overlapping hopping channels	

**Result:** The number of macro hopping channels is 9. Each macro channel is divided into 6 micro channels. So in summary the EUT uses  $9 \times 6 = 54$  channels.

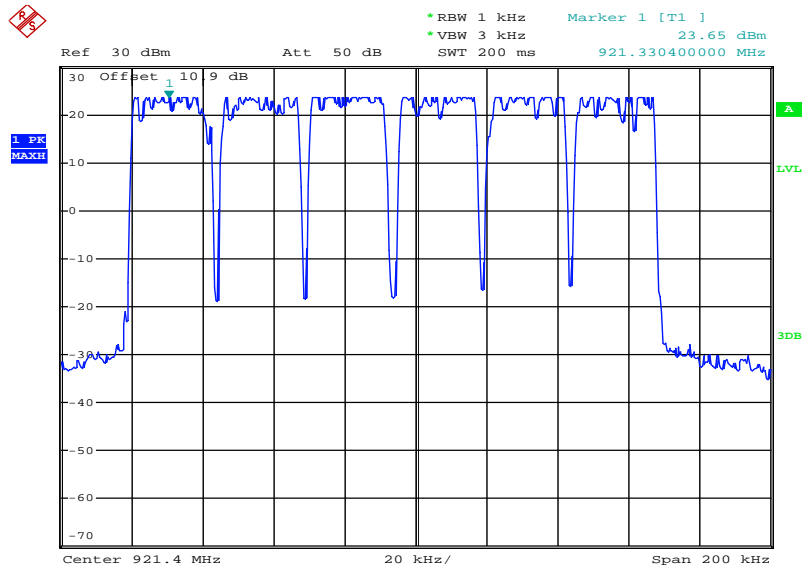
**Plots:**

Plot 1: Number of macro channels



Date: 28.SEP.2016 12:23:50

Plot 2: Number of micro channels in one single macro channel zoomed



Date: 28.SEP.2016 12:17:55

## 12.4 Time of occupancy (dwell time)

### Measurement:

The measurement is performed in zero span mode to show that none of the 54 used channels is allocated more than 0.4 seconds within a 10 seconds interval (54 channels times 0.4s).

### Limits:

FCC	IC
<b>Average time of occupancy</b>	
<b>For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within 10 second period.</b>	

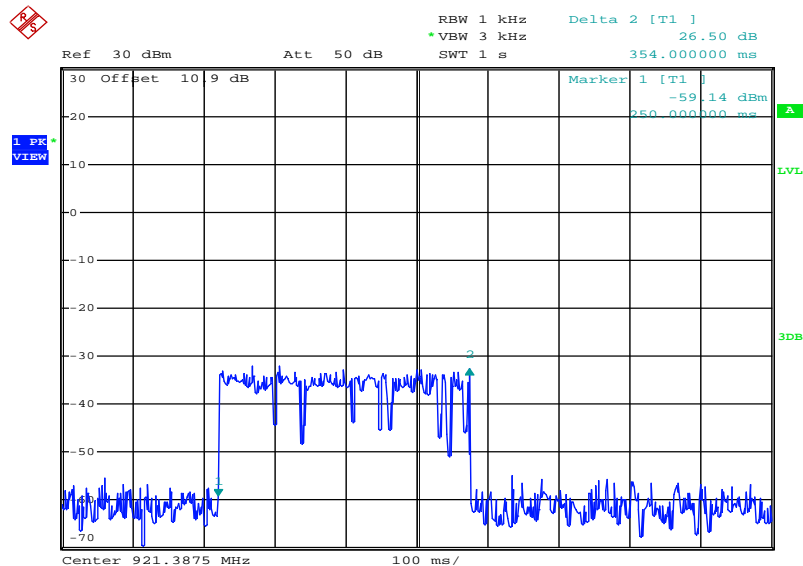
**Result:**      The time slot length is = 356 ms  
                     Number of hops / channel @ 20s = 1

Within 30 s period, the average time of occupancy in 30 s:  $1 \cdot 354 \text{ ms}$

→ The average time of occupancy = 354 ms

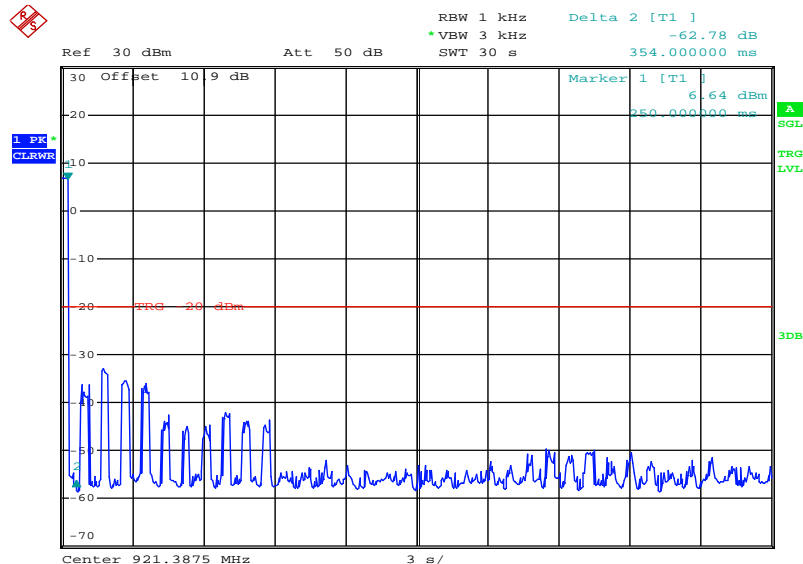
**Plots:**

Plot 1: Time slot length = 356 ms



Date: 28.SEP.2016 15:27:46

Plot 2: hops / channel @ 20s = 1



Date: 28.SEP.2016 15:32:58

## 12.5 Spectrum bandwidth of a FHSS system

### Description:

Measurement of the 20dB bandwidth and 99% bandwidth of the modulated signal. The measurement is performed according to the "Measurement Guidelines" (DA 00-705, March 30, 2000). EUT in single channel mode.

### Measurement:

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	300 Hz
Video bandwidth	1 kHz
Span	See plots
Trace mode	Max hold
Test setup	See sub clause 7.3 A
Measurement uncertainty	See sub clause 8

### Limits:

FCC	IC
Spectrum bandwidth of a FHSS system	
DBPSK < 1500 kHz	

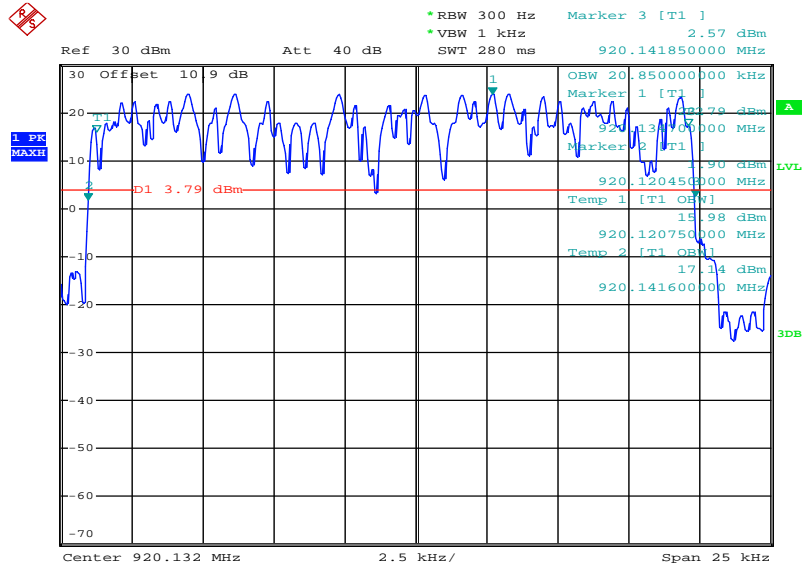
### Result:

Test Conditions		20dB BANDWIDTH [kHz]		
		Low channel	Middle channel	High channel
T <sub>nom</sub>	V <sub>nom</sub>	21.4	21.8	21.5

Test Conditions		99% BANDWIDTH [kHz]		
		Low channel	Middle channel	High channel
T <sub>nom</sub>	V <sub>nom</sub>	20.9	21.1	20.9

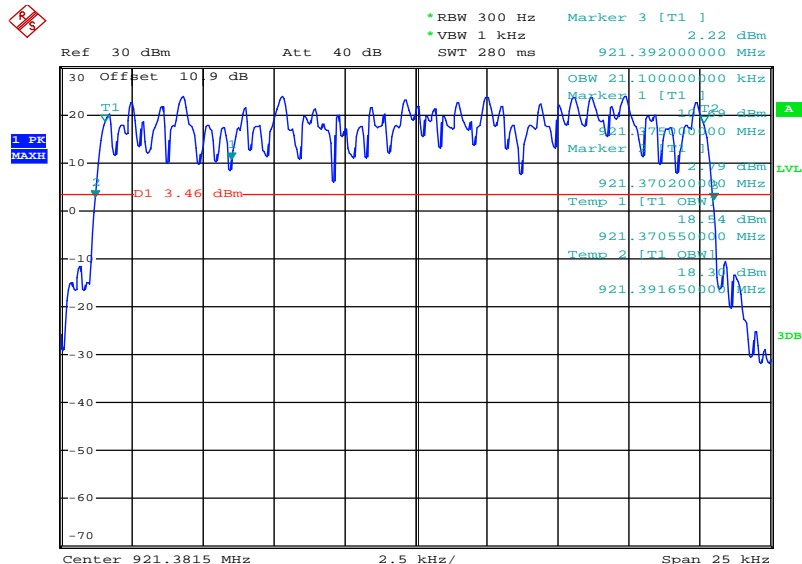
**Plots:**

Plot 1: Low Channel



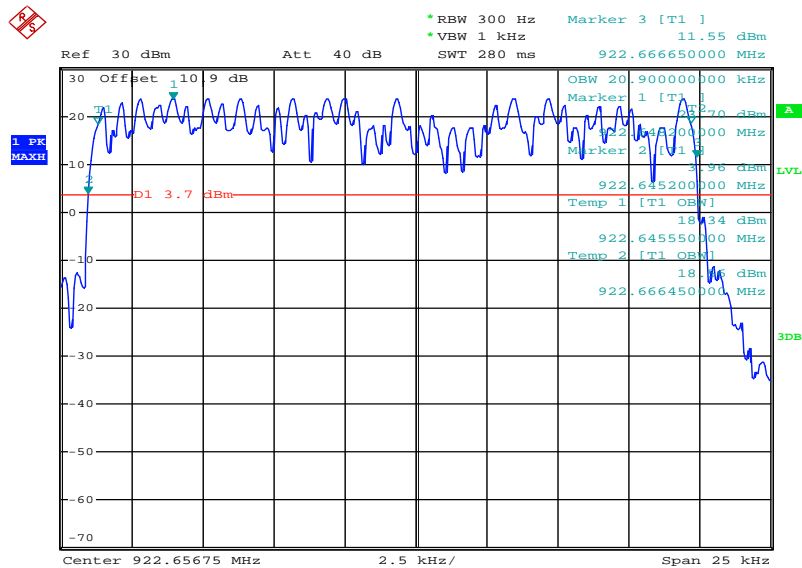
Date: 28.SEP.2016 13:16:27

Plot 2: Middle Channel



Date: 28.SEP.2016 14:23:24

Plot 3: High Channel



Date: 28.SEP.2016 15:18:47



## 12.6 Maximum Output Power

### Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Span:	5 MHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 7.3 A
Measurement uncertainty:	See chapter 8

### Limits:

FCC	IC
Maximum Output Power Conducted	
For frequency hopping systems operating in the 902–928 MHz band: 1 watt (30 dBm) for systems employing at least 50 hopping channels; and, 0.25 watts (24 dBm) for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.	

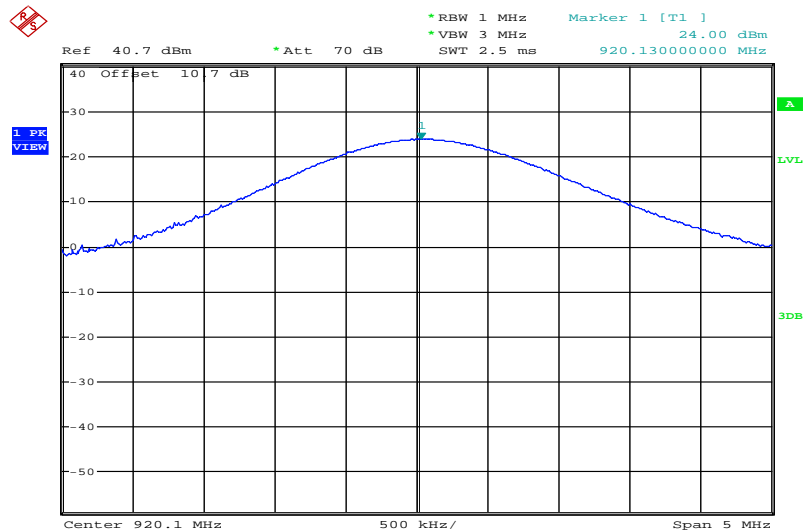
### Result:

Test Conditions		Maximum Output Power Conducted [dBm]		
		Low channel	Middle channel	High channel
$T_{nom}$	$V_{nom}$	24.0	23.9	24.0

Test Conditions		ERP [dBm]		
		Low channel	Middle channel	High channel
$T_{nom}$	$V_{nom}$	26.7	26.1	25.7

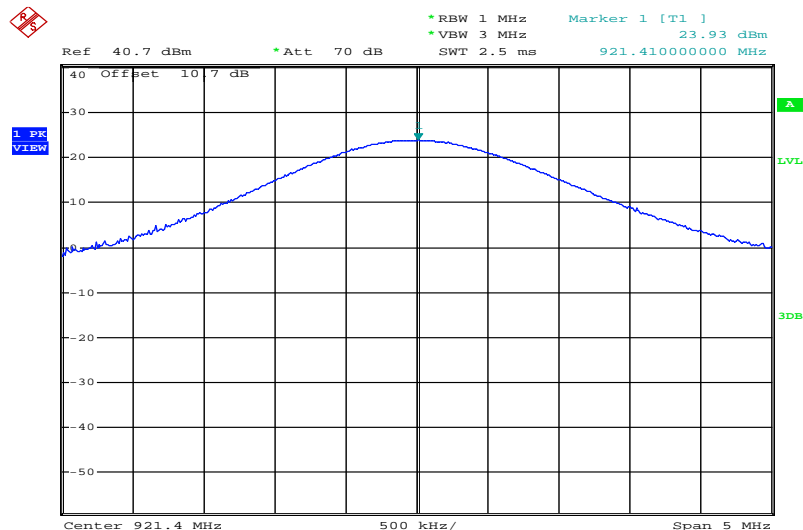
**Plots:**

Plot 1: Low Channel



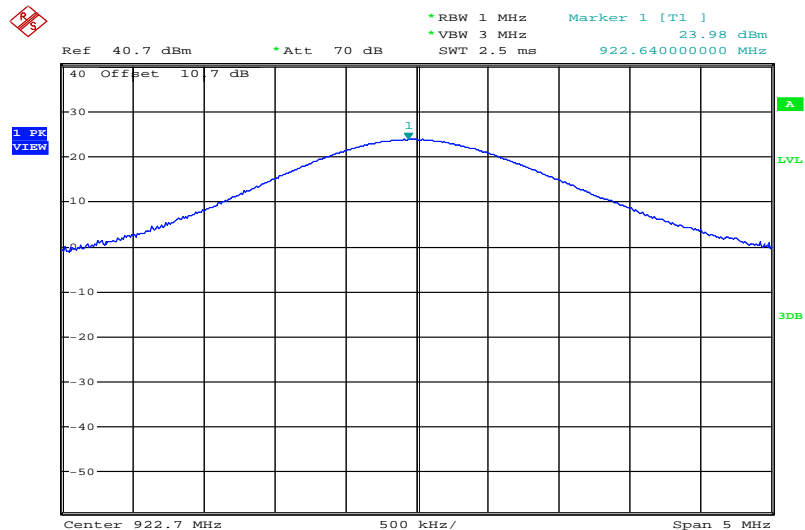
NOP  
Date: 18.AUG.2016 13:41:55

Plot 2: Middle Channel



NOP  
Date: 18.AUG.2016 13:44:29

Plot 3: High Channel



NOP  
Date: 18.AUG.2016 13:43:15

## 12.7 Detailed spurious emissions @ the band edge – conducted and radiated

### Description:

Measurement of the conducted band edge compliance. EUT is measured at the lower and upper band edge in single channel and hopping mode. The measurement is repeated for all modulations.

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Span	Lower Block Edge: 918.9 MHz Upper Block Edge: 923.9 MHz
Trace mode	Max hold
Test setup	See sub clause 7.3 A
Measurement uncertainty	See sub clause 8

### Limits:

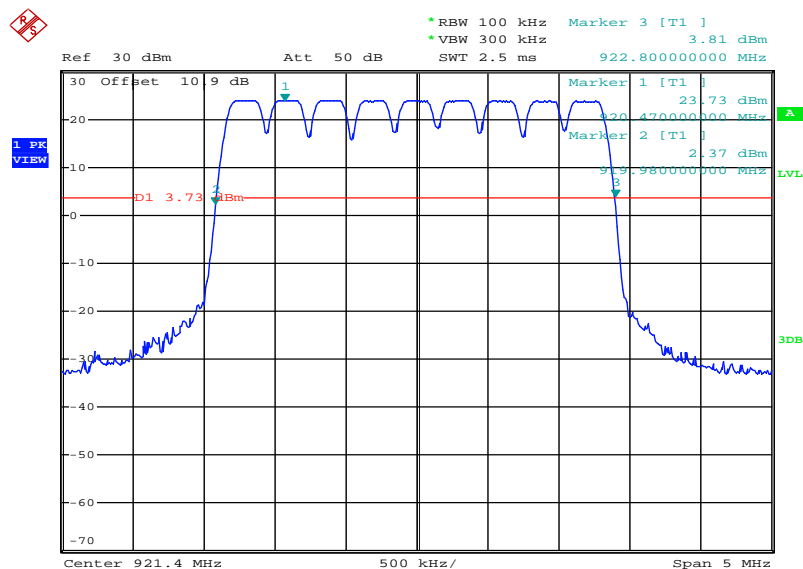
FCC	IC
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required.	

### Results conducted:

Scenario Modulation	Spurious band edge conducted [dB]		
	lowest channel	middle channel	highest channel
Lower band edge – hopping on	> 20 dB	> 20 dB	> 20 dB
Upper band edge – hopping on	> 20 dB	> 20 dB	> 20 dB

**Plots:**

**Plot 1: 20 dB – hopping on**



Date: 28.SEP.2016 12:29:47

**Results radiated:**

No restricted band in the range  $\pm 2$  channel bandwidths of the Band-edges of the specified emission band! (608 MHz – 614 MHz and 960 MHz – 1240 MHz).

Section 15.205 Restricted bands of operation.

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
<sup>1</sup> 0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	( <sup>2</sup> )
13.36 - 13.41			

## 12.8 Spurious Emissions Conducted

### Description:

Measurement of the conducted spurious emissions in transmit mode. The EUT is set to single channel mode. The measurement is repeated for low, mid and high channel.

### Measurement:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Video bandwidth:	F < 1 GHz: 1 MHz F > 1 GHz: 1 MHz
Resolution bandwidth:	F < 1 GHz: 100 kHz F > 1 GHz: 100 kHz
Span:	9 kHz to 12.75 GHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 7.3A
Measurement uncertainty:	See chapter 8

### Limits:

FCC	IC
TX spurious emissions conducted	
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required	

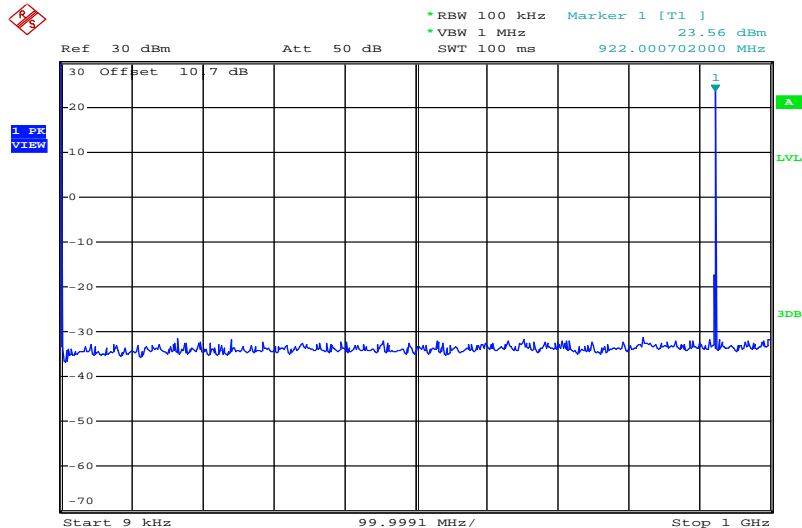
**Result:**

Emission Limitation					
Frequency [MHz]		Amplitude of emission [dBm]	Limit max. allowed emission power	actual attenuation below frequency of operation [dB]	Results
		23.56	24 dBm		Operating frequency
No emissions detected!			-20 dBc		
		23.58	24 dBm		Operating frequency
No emissions detected!			-20 dBc		
		23.50	24 dBm		Operating frequency
No emissions detected!			-20 dBc		



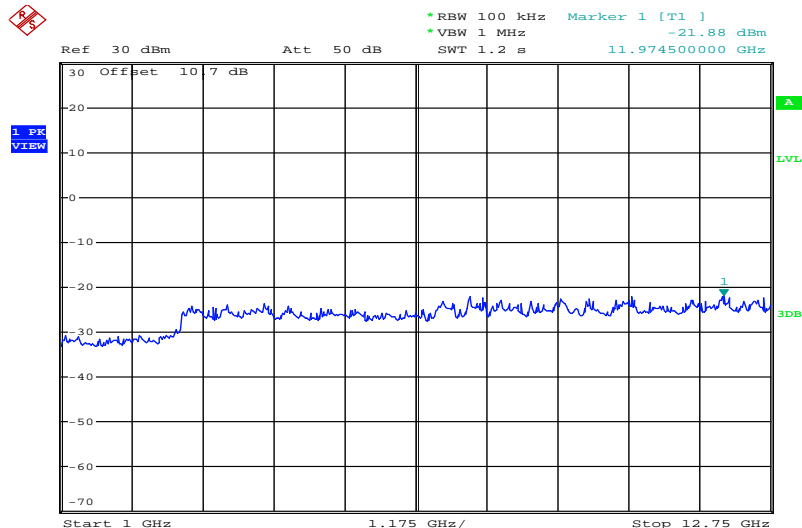
**Plots:**

Plot 1: Low channel, 9 kHz – 1 GHz



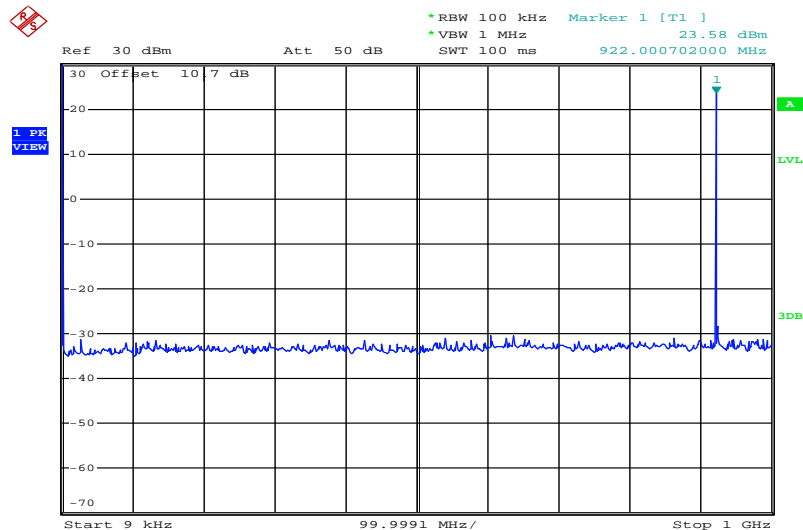
NOP  
Date: 18.AUG.2016 13:51:04

Plot 2: Low channel, 1 GHz – 12.75 GHz



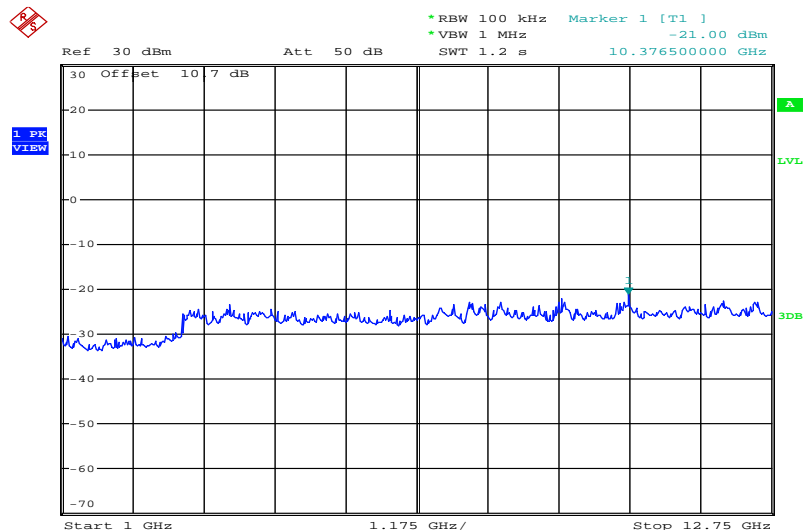
NOP  
Date: 18.AUG.2016 13:55:53

Plot 3: Middle channel, 9 kHz – 1 GHz



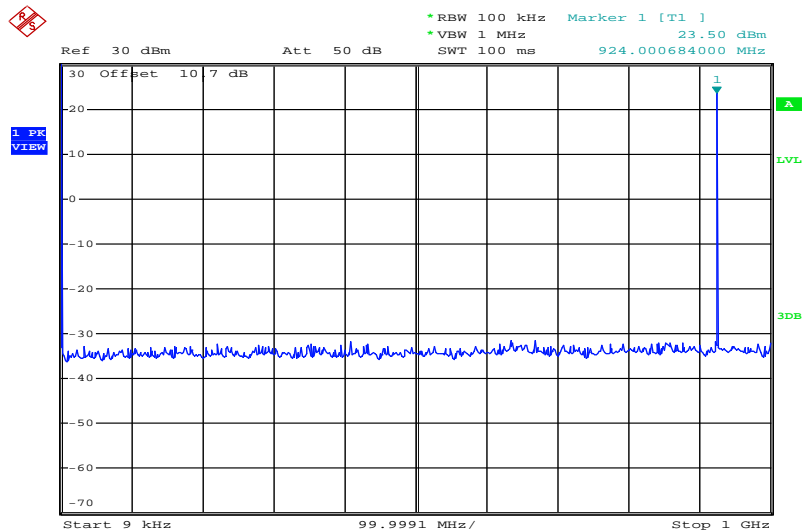
NOP  
Date: 18.AUG.2016 13:47:03

Plot 4: Middle channel, 1 GHz – 12.75 GHz



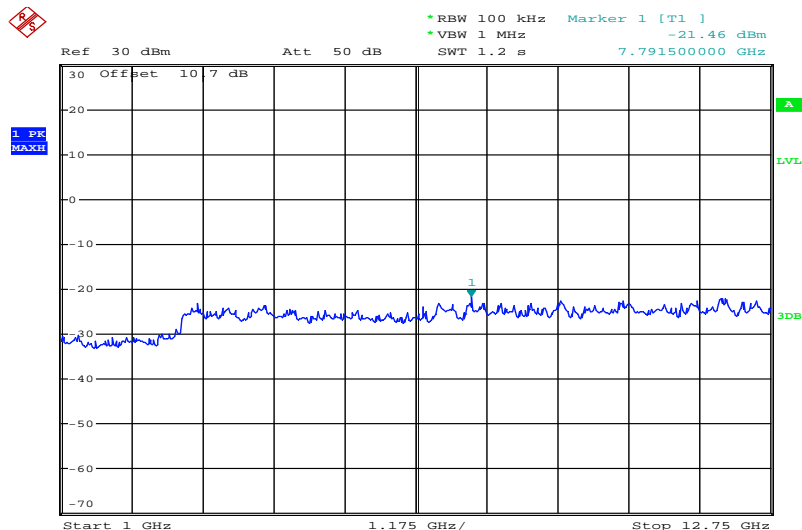
NOP  
Date: 18.AUG.2016 13:54:37

Plot 5: High channel, 9 kHz – 1 GHz



NOP  
Date: 18.AUG.2016 13:51:53

Plot 6: High channel, 1 GHz – 12.75 GHz



NOP  
Date: 18.AUG.2016 13:53:48

## 12.9 Spurious Emissions Radiated < 30 MHz

### Description:

Measurement of the radiated spurious emissions in transmit mode below 30 MHz. The EUT is set to single channel mode and the transmit channels are 00; 39 and 78. The measurement is performed in the mode with the highest output power. The limits are recalculated to a measurement distance of 3 m according the ANSI C63.10.

### Measurement:

Measurement parameter	
Detector:	Peak / Quasi Peak
Sweep time:	Auto
Video bandwidth:	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Resolution bandwidth:	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Span:	9 kHz to 30 MHz
Trace-Mode:	Max Hold
Used equipment:	See chapter 7.2 B
Measurement uncertainty:	See chapter 8

### Limits:

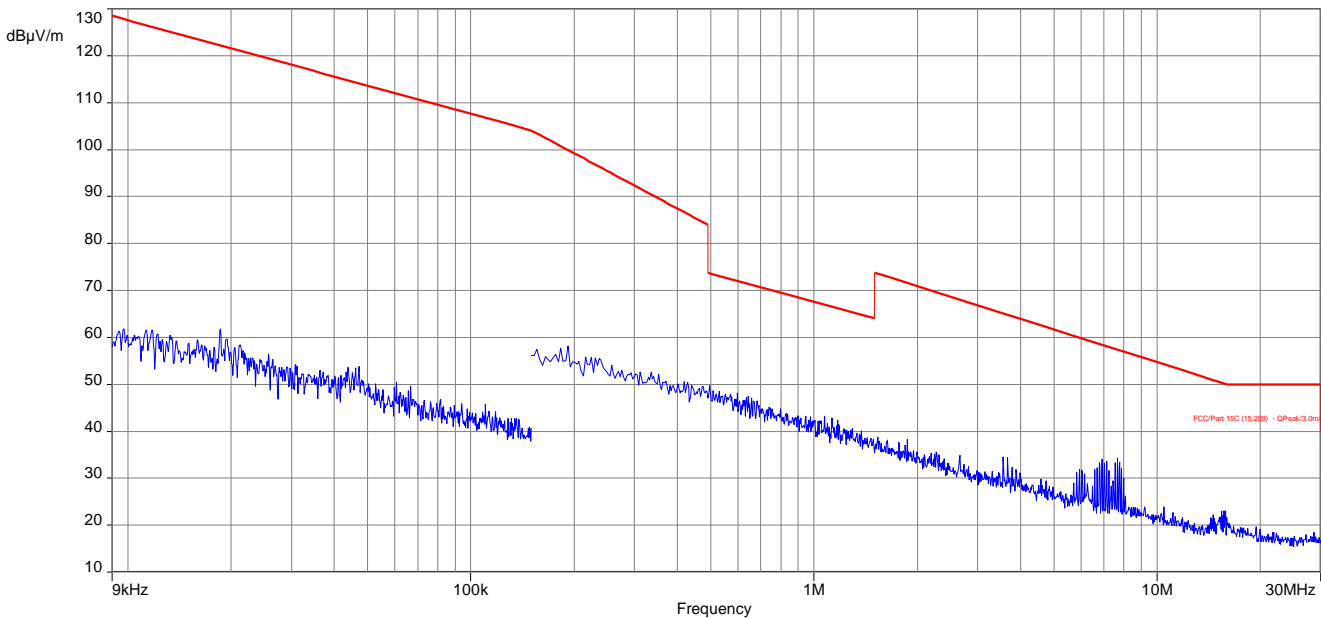
FCC		IC
TX spurious emissions radiated < 30 MHz		
Frequency (MHz)	Field strength (dB $\mu$ V/m)	Measurement distance
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30

### Result:

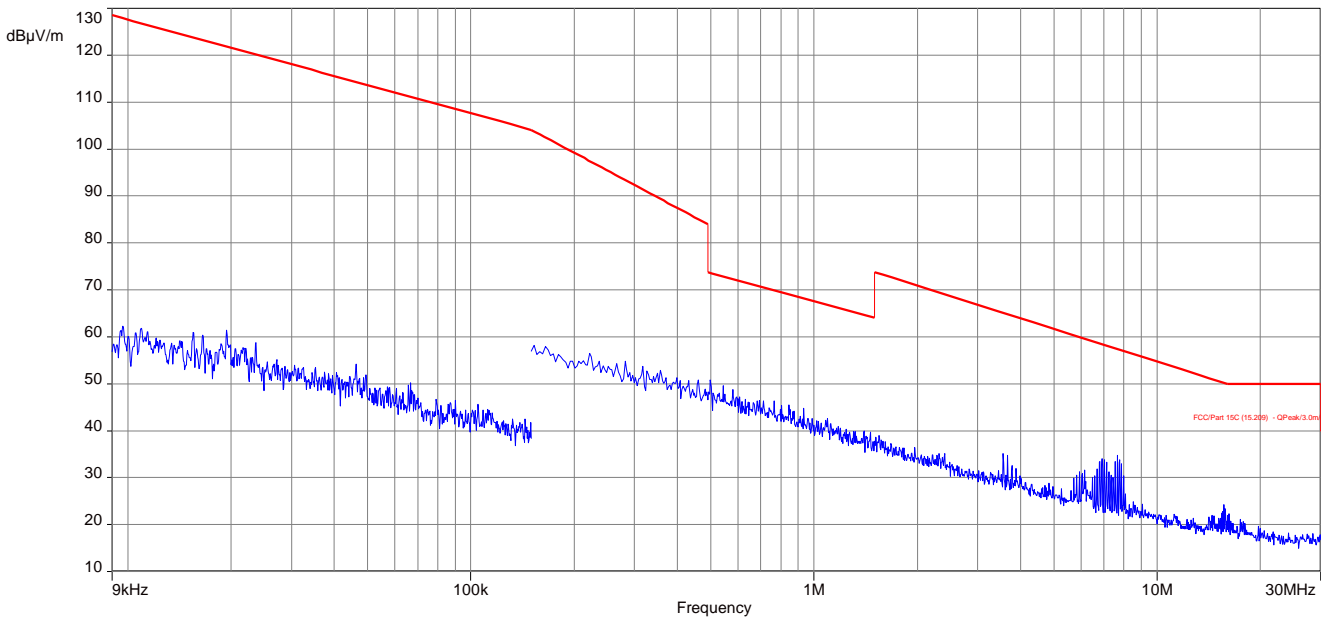
SPURIOUS EMISSIONS LEVEL [dB $\mu$ V/m]								
Lowest channel			Middle channel			Highest channel		
Frequency [MHz]	Detector	Level [dB $\mu$ V/m]	Frequency [MHz]	Detector	Level [dB $\mu$ V/m]	Frequency [MHz]	Detector	Level [dB $\mu$ V/m]
All emissions were more than 10 dB below the limit.								

**Plots:**

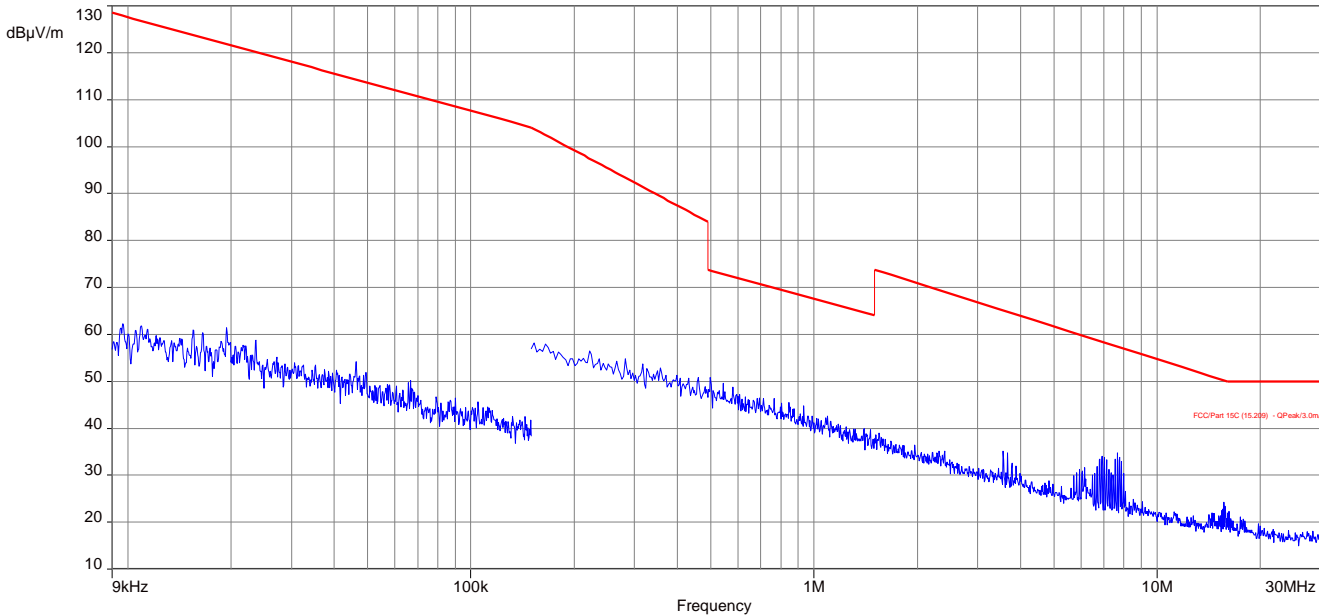
Plot 1: TX-Mode low channel



Plot 2: TX-Mode mid channel



Plot 3: TX-Mode high channel



## 12.10 Spurious Emissions Radiated (Transmitter) > 30 MHz

### 12.10.1 Spurious emissions radiated 30 MHz to 1 GHz

#### Description:

Measurement of the radiated spurious emissions in transmit mode. The measurement is performed at channel low, mid and high.

#### Measurement:

Measurement parameters	
Detector	Peak / Quasi Peak
Sweep time	Auto
Resolution bandwidth	3 x VBW
Video bandwidth	120 kHz
Span	30 MHz to 1 GHz
Trace mode	Max hold
Measured modulation	DBPSK
Test setup	See sub clause 7.1 A
Measurement uncertainty	See sub clause 8

#### Limits:

FCC		IC
Band-edge Compliance of conducted and radiated emissions		
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).		
Frequency (MHz)	Field Strength (dBµV/m)	Measurement distance
30 - 88	30.0	10
88 – 216	33.5	10
216 – 960	36.0	10
Above 960	54.0	3

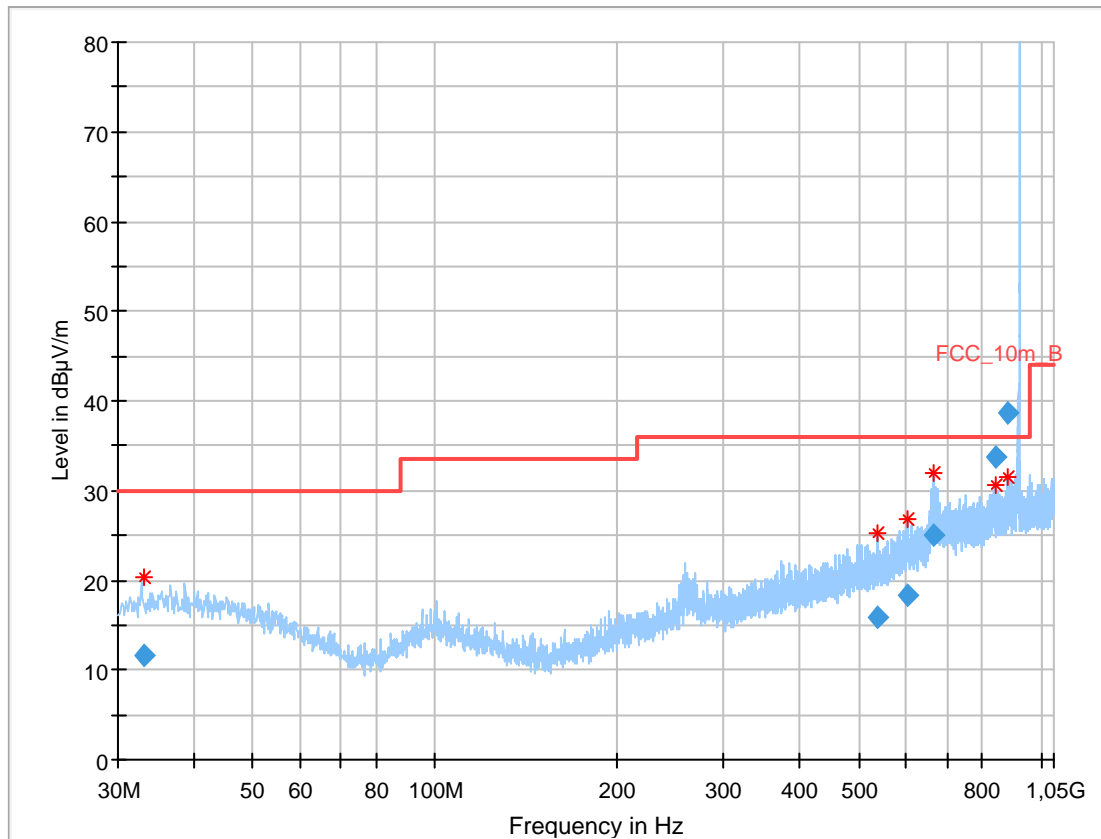
**Note:** The limit was recalculated with 20 dB / decade (Part 15.31) for all radiated spurious emissions 30 MHz to 1 GHz from 3 meter limit to a 10 meter distance. (40dB/decade for emissions < 30MHz)

#### Result:

See result table below the plots.

**Plots:**

Plot 1: 30 MHz – 1 GHz, horizontal & vertical polarisation (lowest channel)

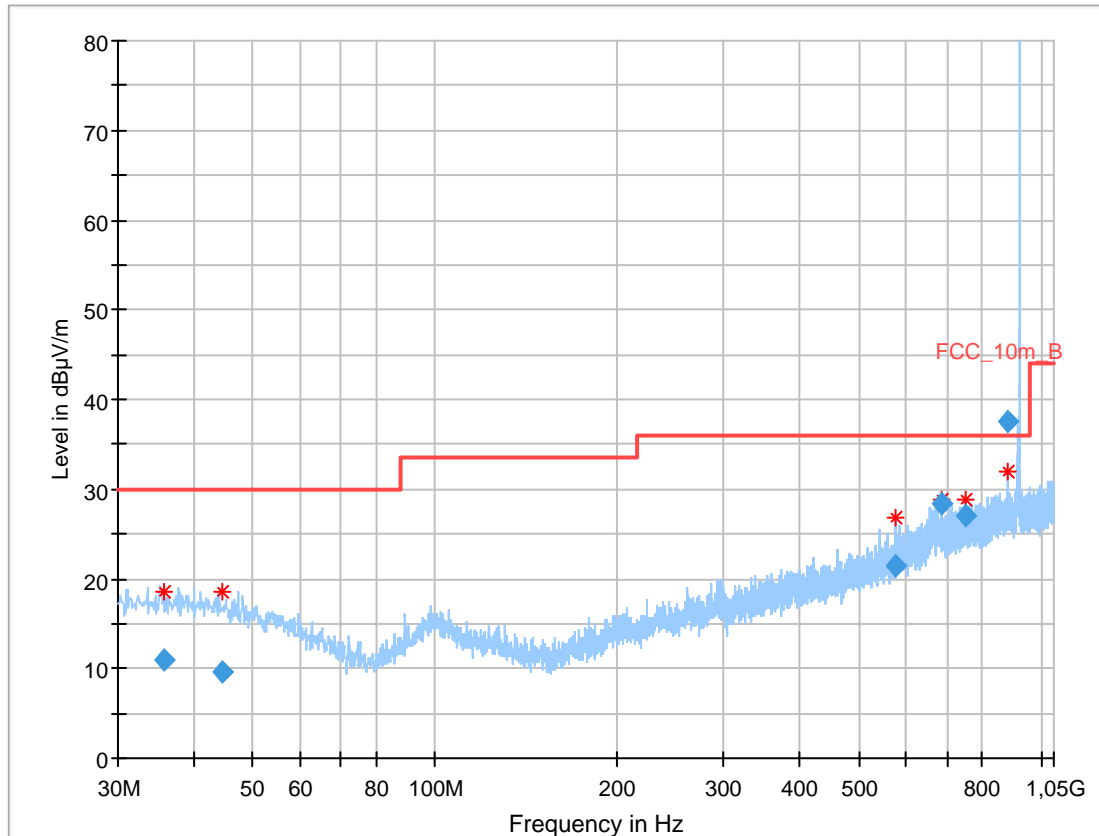
**Final\_Result**

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
33.086100	11.58	30.00	18.42	1000.0	120.000	101.0	V	80.0	13.6
538.390650	15.79	36.00	20.21	1000.0	120.000	170.0	V	170.0	19.2
601.546200	18.35	36.00	17.65	1000.0	120.000	170.0	V	190.0	20.7
664.584900	25.06	36.00	10.94	1000.0	120.000	98.0	H	100.0	21.2
*840.251700	33.65	36.00	2.35	1000.0	120.000	170.0	V	10.0	23.3
880.128600	38.76	36.00	-2.76	1000.0	120.000	170.0	V	280.0	23.9

\*Frequency outside any restricted band (20 dBc-criteria is valid)



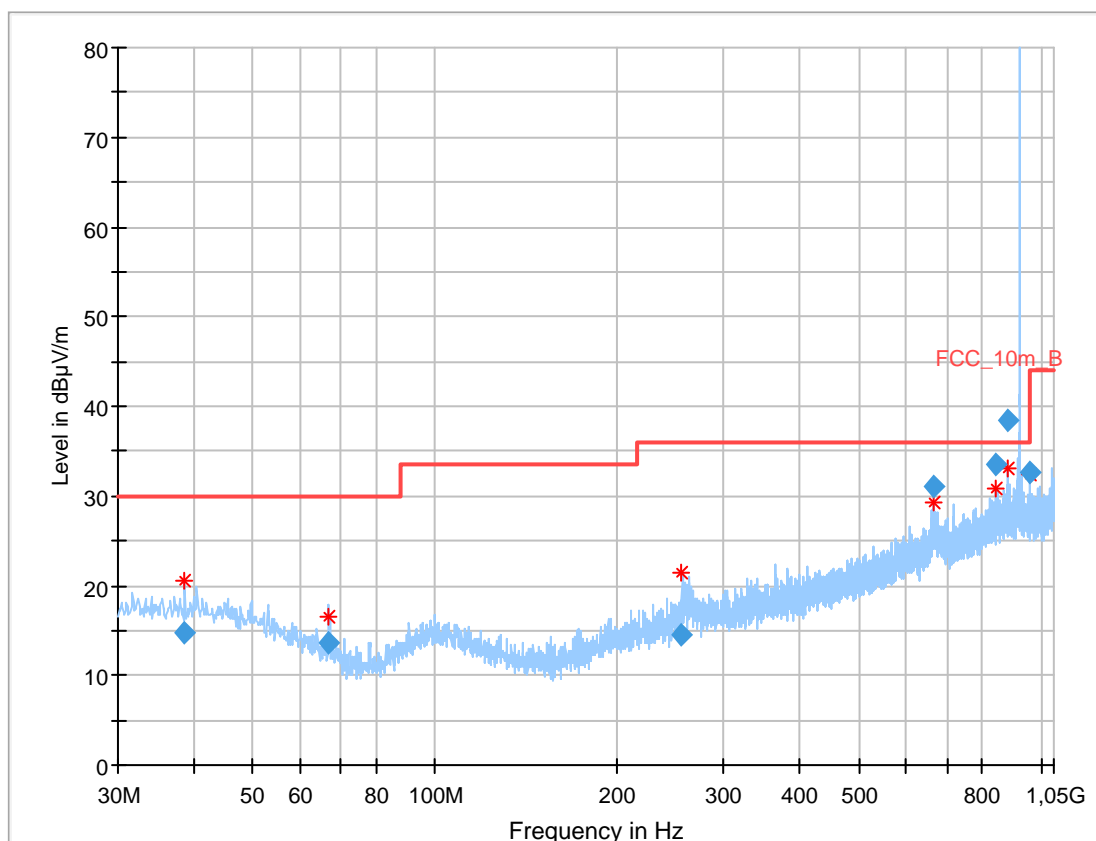
Plot 2: 30 MHz – 1 GHz, horizontal &amp; vertical polarisation (middle channel)

**Final\_Result**

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
35.782500	11.01	30.00	18.99	1000.0	120.000	170.0	H	-9.0	13.8
44.549700	9.59	30.00	20.41	1000.0	120.000	101.0	H	190.0	13.9
576.013800	21.50	36.00	14.50	1000.0	120.000	170.0	H	80.0	20.0
685.401300	28.46	36.00	7.54	1000.0	120.000	170.0	V	171.0	21.4
752.078250	27.13	36.00	8.87	1000.0	120.000	170.0	V	-10.0	22.7
*880.129350	37.59	36.00	-1.59	1000.0	120.000	170.0	V	171.0	23.9

\*Frequency outside any restricted band (20 dBc-criteria is valid)

Plot 3: 30 MHz – 1 GHz, horizontal &amp; vertical polarisation (highest channel)

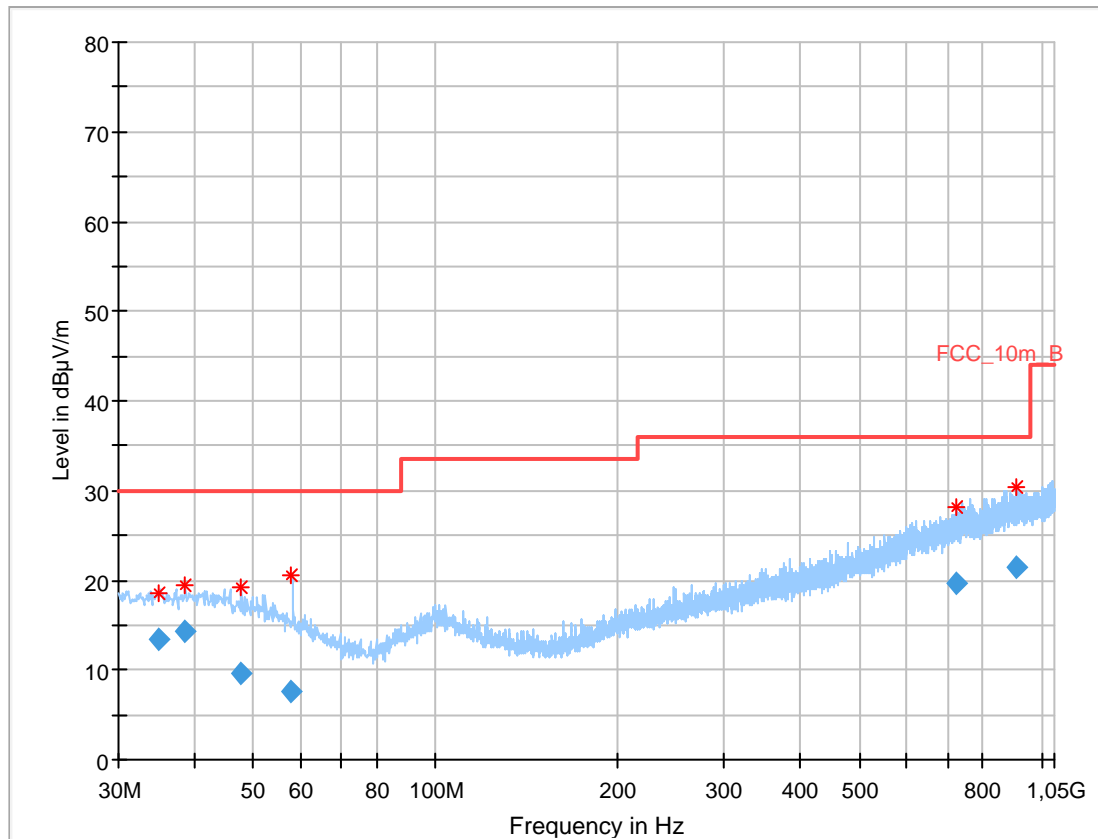


## Final\_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
38.708100	14.77	30.00	15.23	1000.0	120.000	101.0	V	171.0	14.0
66.972300	13.55	30.00	16.45	1000.0	120.000	101.0	V	-10.0	9.0
255.650850	14.46	36.00	21.54	1000.0	120.000	98.0	V	280.0	13.5
663.060900	31.00	36.00	5.00	1000.0	120.000	98.0	V	170.0	21.2
842.617500	33.54	36.00	2.46	1000.0	120.000	170.0	V	10.0	23.3
*882.663000	38.40	36.00	-2.40	1000.0	120.000	170.0	V	-10.0	23.9
960.004350	32.52	44.00	11.48	1000.0	120.000	170.0	V	170.0	24.4

\*Frequency outside any restricted band (20 dBc-criteria is valid)

Plot 4: 30 MHz – 1 GHz, horizontal &amp; vertical polarisation (RX-Mode)

**Final\_Result**

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
35.016000	13.32	30.00	16.68	1000.0	120.000	101.0	V	1.0	13.8
38.682150	14.23	30.00	15.77	1000.0	120.000	177.0	V	198.0	14.0
47.573250	9.62	30.00	20.38	1000.0	120.000	101.0	V	353.0	13.2
57.603750	7.62	30.00	22.38	1000.0	120.000	101.0	H	291.0	11.2
725.719500	19.65	36.00	16.35	1000.0	120.000	98.0	H	330.0	22.1
910.055100	21.49	36.00	14.51	1000.0	120.000	185.0	V	156.0	24.1

## 12.10.2 Spurious emissions radiated above 1 GHz

### Description:

Measurement of the radiated spurious emissions in transmit mode. The measurement is performed in the mode with the highest output power.

Measurement parameters	
Detector	Peak / RMS
Sweep time	Auto
Resolution bandwidth	1 MHz
Video bandwidth	3 x RBW
Span	1 GHz to 26 GHz
Trace mode	Max hold
Measured modulation	DBPSK
Test setup	See sub clause 7.2 C (1 GHz – 12.75 GHz)
Measurement uncertainty	See sub clause 8

The modulation with the highest output power was used to perform the transmitter spurious emissions. If spurious were detected a re-measurement was performed on the detected frequency with each modulation.

### Limits:

ANSI C63.3
The average emission shall be determined by using RMS detector. If the dwell time of the hopping signal is less than 100 ms (per channel), the RMS reading may be adjusted by a factor: $F = 20\log(\text{dwell time}/100 \text{ ms})$

FCC	IC	
TX spurious emissions radiated		
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).		
§15.209		
Frequency (MHz)	Field strength (dBµV/m)	Measurement distance
Above 960	54.0	3

**Result:**

For radiated spurious emission the limits of 15.209 applies for all frequencies mentioned in 15.205. According to ANSI C63.3 the average emission shall be determined by using RMS detector. If the dwell time of the hopping signal is less than 100 ms (per channel), the RMS reading may be adjusted by a factor:

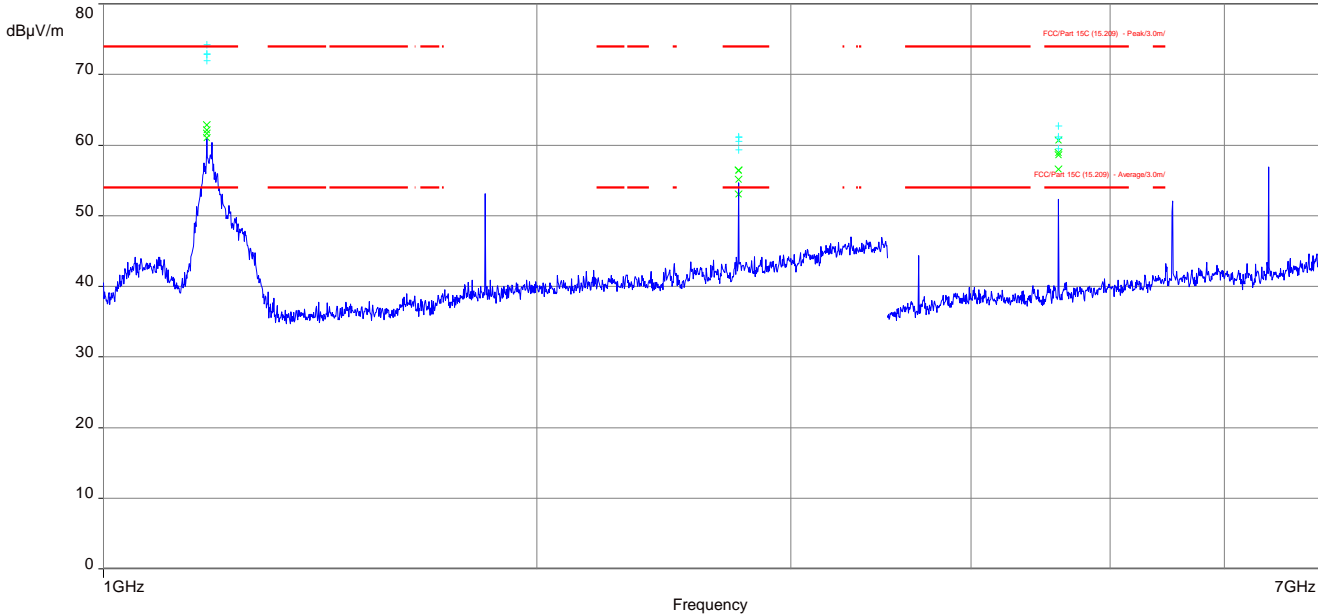
$$F = 20 \cdot \log (\text{dwell time}/100 \text{ ms})$$

One pulse train is higher than 100 ms so the correction factor is 0 (see plots in chapter 12.4)

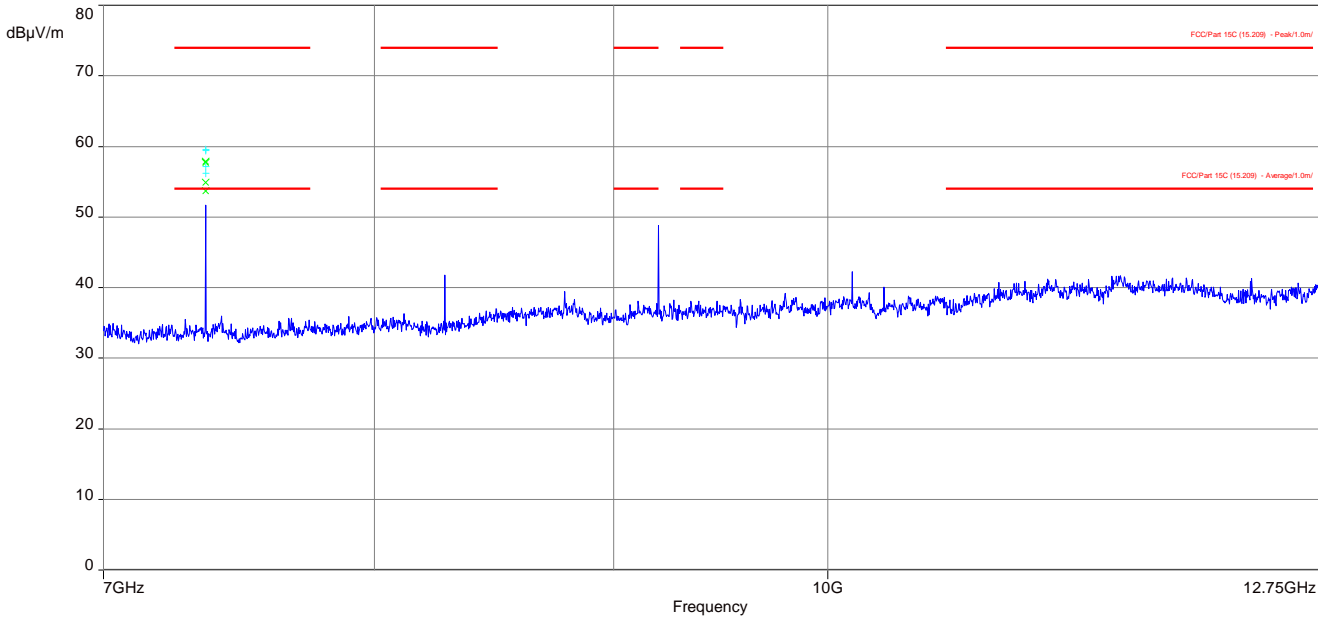
TX spurious emissions radiated [dBμV/m]								
Lowest channel			Middle channel			Highest channel		
F [MHz]	Detector	Level [dBμV/m]	F [MHz]	Detector	Level [dBμV/m]	F [MHz]	Detector	Level [dBμV/m]
1180	Peak	73.9	Same as lowest channel					
	AVG	42.0						
2760	Peak	61.1	2764	Peak	60.5	2768	Peak	59.9
	AVG	46.5		AVG	51.8		AVG	45.3
4600	Peak	62.7	3685	Peak	58.9	3690	Peak	58.7
	AVG	49.8		AVG	49.9		AVG	44.7
7360	Peak	59.6	4607	Peak	63.2	4613	Peak	57.5
	AVG	51.3		AVG	51.3		AVG	49.8

**Plots:**

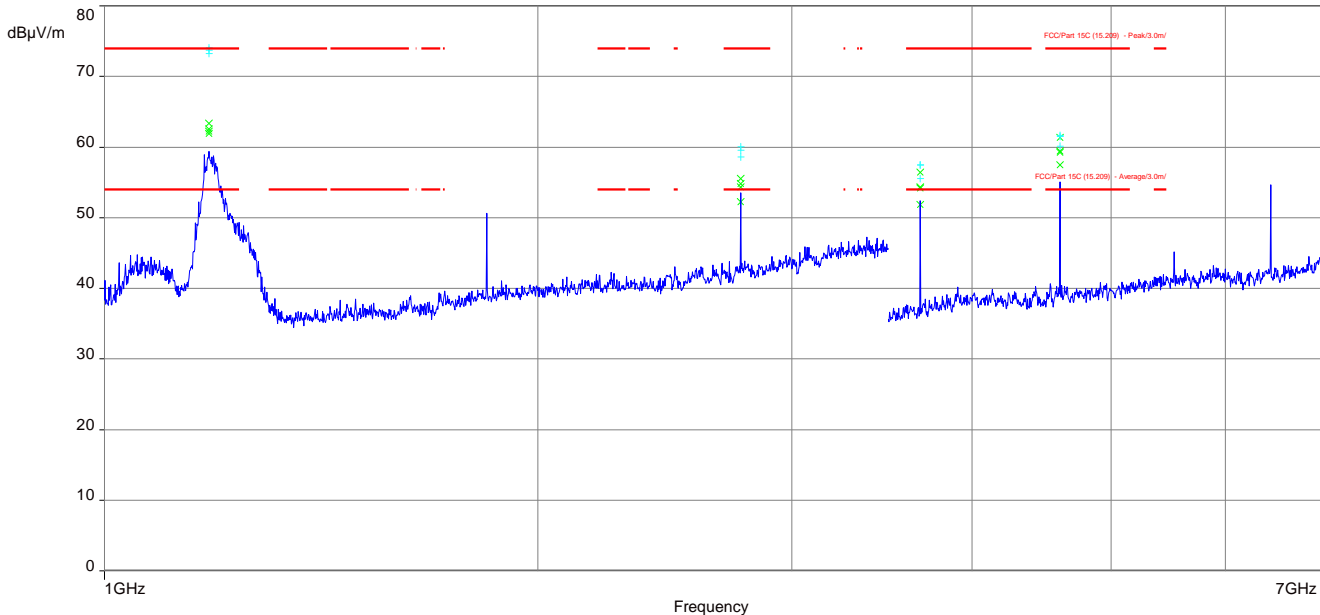
Plot 1: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (lowest channel)



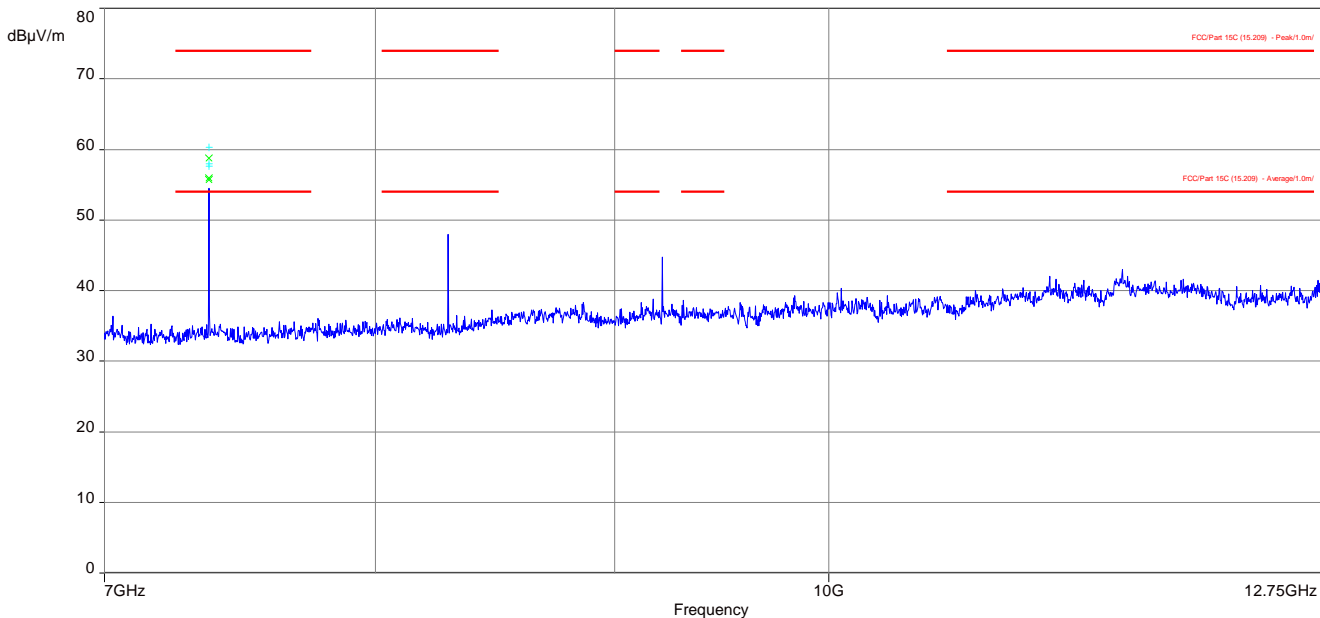
Plot 2: 7 GHz – 12.75 GHz, horizontal & vertical polarisation (lowest channel)



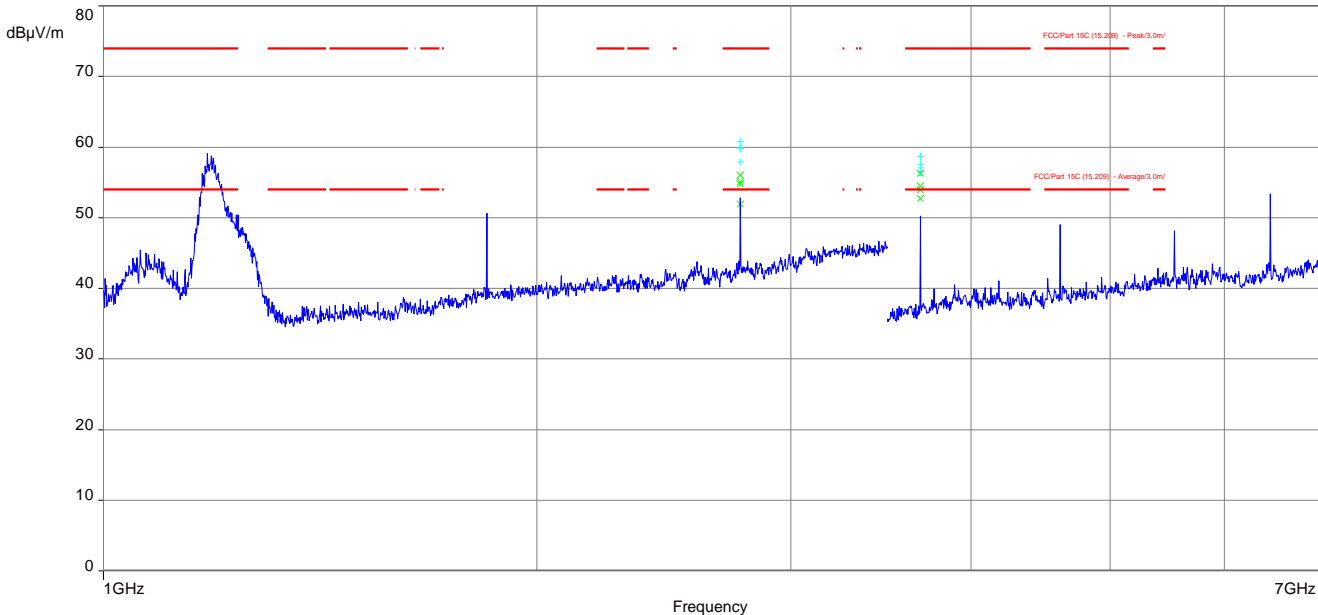
Plot 3: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (middle channel)



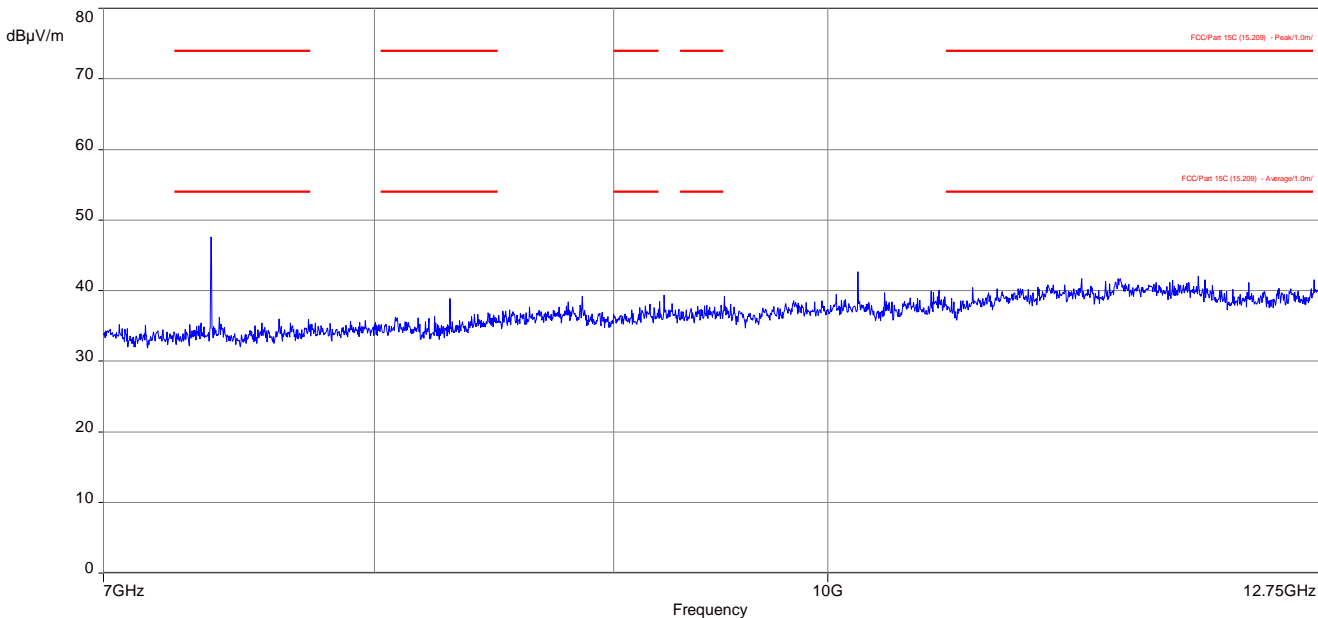
Plot 4: 7 GHz – 12.75 GHz, horizontal & vertical polarisation (middle channel)



Plot 5: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (highest channel)

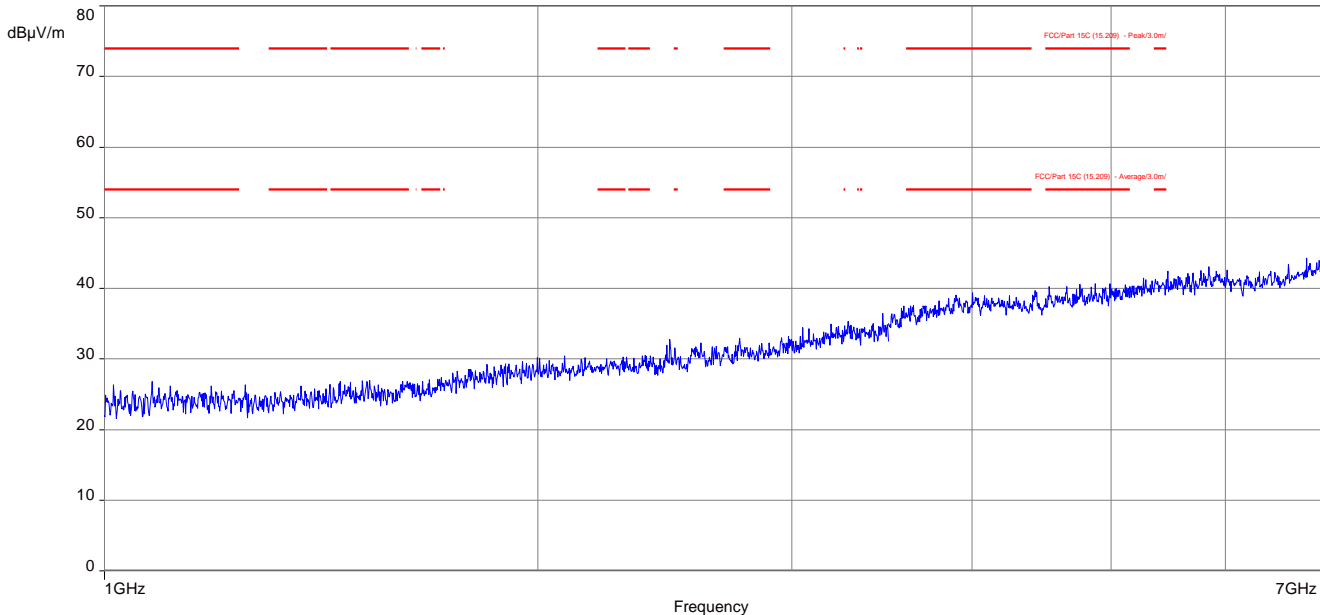


Plot 6: 7 GHz – 12.75 GHz, horizontal & vertical polarisation (highest channel)

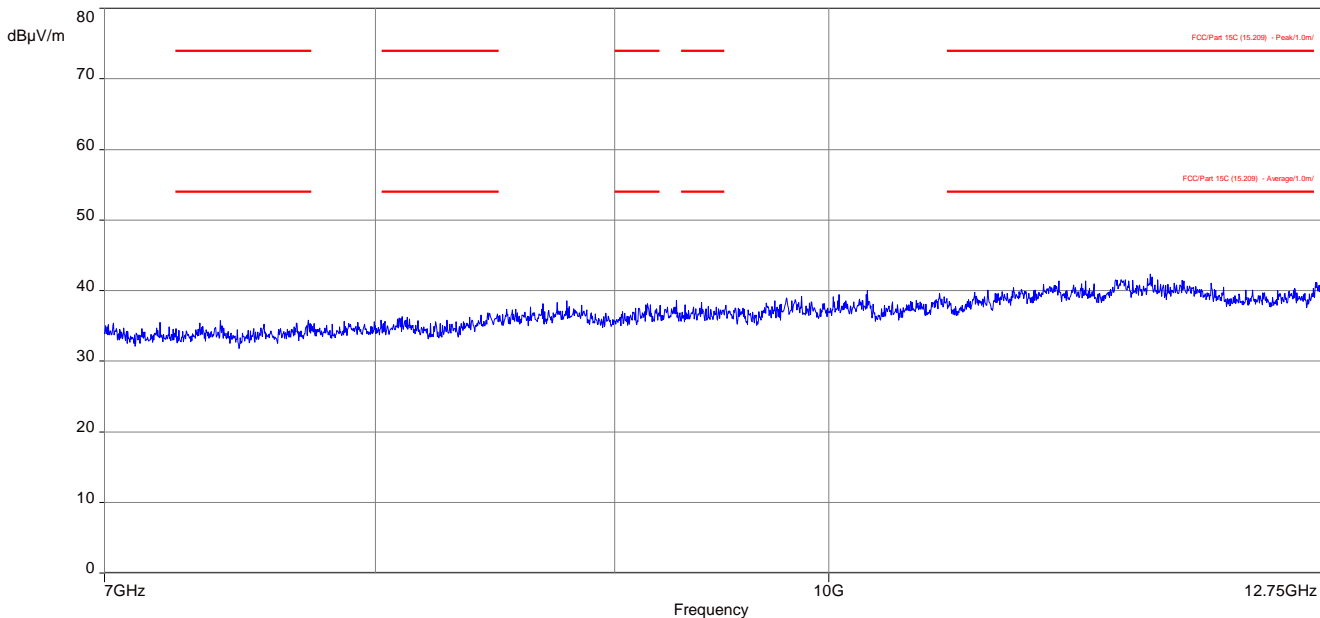




Plot 7: 1 GHz – 12.75 GHz, horizontal & vertical polarisation (RX)



Plot 8: 7 GHz – 12.75 GHz, horizontal & vertical polarisation (RX)



### 13 Observations

No observations except those reported with the single test cases have been made.

### Annex A Document history

Version	Applied changes	Date of release
	Initial release	2016-10-05
A	Editorial corrections	2016-12-16

### Annex B Further information

#### Glossary

AVG	-	Average
DUT	-	Device under test
EMC	-	Electromagnetic Compatibility
EN	-	European Standard
EUT	-	Equipment under test
ETSI	-	European Telecommunications Standard Institute
FCC	-	Federal Communication Commission
FCC ID	-	Company Identifier at FCC
HW	-	Hardware
IC	-	Industry Canada
Inv. No.	-	Inventory number
N/A	-	Not applicable
PP	-	Positive peak
QP	-	Quasi peak
S/N	-	Serial number
SW	-	Software
PMN	-	Product marketing name
HMN	-	Host marketing name
HVIN	-	Hardware version identification number
FVIN	-	Firmware version identification number

## Annex C Accreditation Certificate

first page

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Deutsche Akkreditierungsstelle GmbH

Befähigung gemäß § 8 Absatz 1 AkkStelleG i.V.m. § 1 Absatz 1 AkkStelleGBV  
Unterzeichnerin der Multilateralen Abkommen  
von EA, ILAC und IAF zur gegenseitigen Anerkennung

**Akkreditierung**



Die Deutsche Akkreditierungsstelle GmbH bestätigt hiermit, dass das Prüflaboratorium

**CTC advanced GmbH**  
Untertürkheimer Straße 6-10, 66117 Saarbrücken

die Kompetenz nach DIN EN ISO/IEC 17025:2005 besitzt, Prüfungen in folgenden Bereichen durchzuführen:

**Funk**  
Mobilfunk (GSM / DCS) + OTA  
Elektromagnetische Verträglichkeit (EMV)  
Produktsicherheit  
SAR / EMF  
Umwelt  
Smart Card Technology  
Bluetooth®  
Automotive  
Wi-Fi-Services  
Kanadische Anforderungen  
US-Anforderungen  
Akustik  
Near Field Communication (NFC)

Die Akkreditierungsurkunde gilt nur in Verbindung mit dem Bescheid vom 25.11.2016 mit der Akkreditierungsnummer D-PL-12076-01 und ist gültig bis 17.01.2018. Sie besteht aus diesem Deckblatt, der Rückseite des Deckblatts und der folgenden Anlage mit insgesamt 63 Seiten.

Registrierungsnummer der Urkunde: D-PL-12076-01-01

Frankfurt, 25.11.2016

Stelle Weisner auf der Rückseite

Im Auftrag Dipl.-Ing. Ralf Eigner  
Abteilungsleiter

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Die auszugsweise Veröffentlichung der Akkreditierungsurkunde bedarf der vorherigen schriftlichen Zustimmung der Deutsche Akkreditierungsstelle GmbH (DAKKS). Ausgenommen davon ist die separate Weiterverbreitung des Deckblattes durch die umseitig genannte Konformitätsbewertungsstelle in unveränderter Form.

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Die Akkreditierung erfolgte gemäß des Gesetzes über die Akkreditierungsstelle (AkkStelleG) vom 31. Juli 2009 (BGBl. I S. 2625) sowie der Verordnung (EG) Nr. 765/2008 des Europäischen Parlaments und des Rates vom 9. Juli 2008 über die Vorschriften für die Akkreditierung und Marktüberwachung im Zusammenhang mit der Vermarktung von Produkten (Abl. L 218 vom 9. Juli 2008, S. 30). Die DAKKS ist Unterzeichnerin der Multilateralen Abkommen zur gegenseitigen Anerkennung der European co-operation for Accreditation (EA), des International Accreditation Forum (IAF) und der International Laboratory Accreditation Cooperation (ILAC). Die Unterzeichner dieser Abkommen erkennen ihre Akkreditierungen gegenseitig an.

Der aktuelle Stand der Mitgliedschaft kann folgenden Webseiten entnommen werden:  
EA: [www.european-accreditation.org](http://www.european-accreditation.org)  
ILAC: [www.ilac.org](http://www.ilac.org)  
IAF: [www.iaf.nu](http://www.iaf.nu)

### Note:

The current certificate including annex can be received on request.