Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

Test report no.: 1-5394/17-01-02

DAkkS Deutsche Akkreditierungsstelle D-PL-12076-01-03

Testing laboratory

CTC advanced GmbH
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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-12076-01-03

Applicant

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Manufacturer

Sennheiser electronic GmbH & Co. KG
Am Labor 1
30900 Wedemark / GERMANY

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 2	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

Kind of test item:	**Wireless Microphone Bodypack**
Model name:	**SK D1**
FCC ID:	**DMOSK2G4WE**
IC:	**2099A-SK2G4WE**
Frequency:	DTS band 2400 MHz to 2483.5 MHz Lowest channel: 2403MHz, Middle channel: 2443MHz, Highest channel: 2481MHz
Technology tested:	Proprietary digital audio transmission
Antenna:	2 Integrated PCB antennas
Power supply:	1.8 V to 4.7 V DC by Li-Ion or 2x AA batteries
Temperature range:	-10°C to +55°C

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

Test report authorized:

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Marco Bertolino
Lab Manager
Radio Communications & EMC

Test performed:

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David Lang
Lab Manager
Radio Communications & EMC

1 Table of contents

2 General information

2.1 Notes and disclaimer

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2.2 Application details

Date of receipt of order:	2017-11-23
Date of receipt of test item:	2017-11-27
Start of test:	2017-11-29
End of test:	2018-01-25
Person(s) present during the test:	-/-

2.3 Test laboratories sub-contracted

None

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 2	February 2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence - Exempt Local Area Network (LE-LAN) Devices
RSS - Gen Issue 4	November 2014	Spectrum Management and Telecommunications Radio Standards Specifications - General Requirements and Information for the Certification of Radio Apparatus

Guidance	Version	Description
DTS: KDB 558074 D01	V04	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
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_{nom} T_{max} T_{min}	+22 °C during room temperature tests +55 °C during high temperature tests -10 °C during low temperature tests
Relative humidity content	:		35 %
Barometric pressure	:		1002 hpa
Power supply	:	V_{nom} V_{max} V_{min}	3.0 V DC by Li-Ion or 2x AA batteries 4.7 V 1.8 V

5 Test item

5.1 General description

Kind of test item	:	Wireless Microphone Bodypack
Type identification	:	SK D1
HMN	:	-/-
PMN	:	Evolution wireless D1
HVIN	:	SK D1
FVIN	:	2.5.0
S/N serial number	:	Rad. 1367115486 Cond. 1487116785
HW hardware status	:	V2.0
SW software status	:	2.5.0
Frequency band	:	DTS band 2400 MHz to 2483.5 MHz Lowest channel: 2403MHz, Middle channel: 2443MHz, Highest channel: 2481MHz
Type of radio transmission Use of frequency spectrum	: :	DTS
Type of modulation	:	GFSK
Number of channels	:	40
Antenna	:	2 Integrated PCB antennas
Power supply	:	1.8 V to 4.7 V DC by Li-Ion or 2x AA batteries
Temperature range	:	-10°C to +55°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: 1-5394/17-01-01_AnnexA
1-5394/17-01-01_AnnexB
1-5394/17-01-01_AnnexD

6 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).

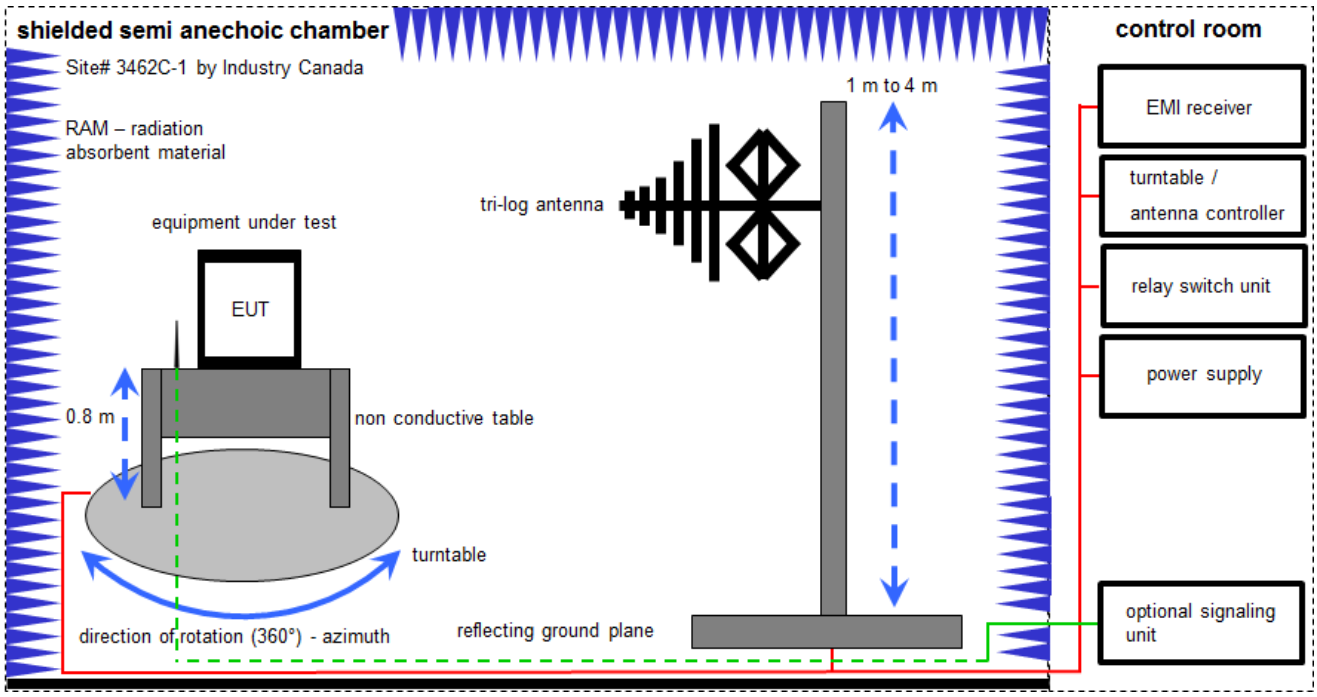
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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
vlkl!	Attention: extended calibration interval		
NK!	Attention: not calibrated	*)	next calibration ordered / currently in progress

6.1 Shielded semi anechoic chamber

The radiated measurements are performed in vertical and horizontal plane in the frequency range from 30 MHz 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 conform to 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

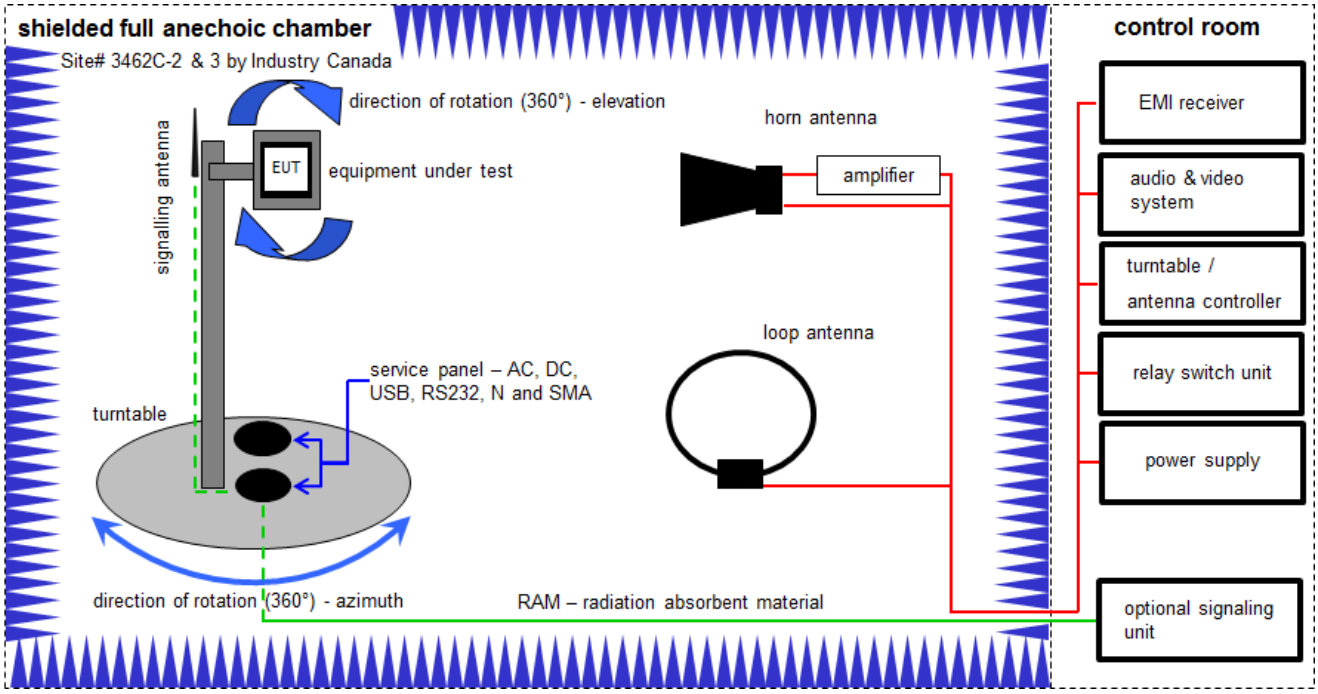
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-
2	A	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04466	300000580	ne	-/-	-/-
3	A	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	01.02.2017	31.01.2018
4	A	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
5	A	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
6	A	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
7	A	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck	295	300003787	k	25.04.2016	25.04.2018

6.2 Shielded fully anechoic chamber



Measurement distance: horn antenna 3 meter; loop antenna 3 meter / 1 meter

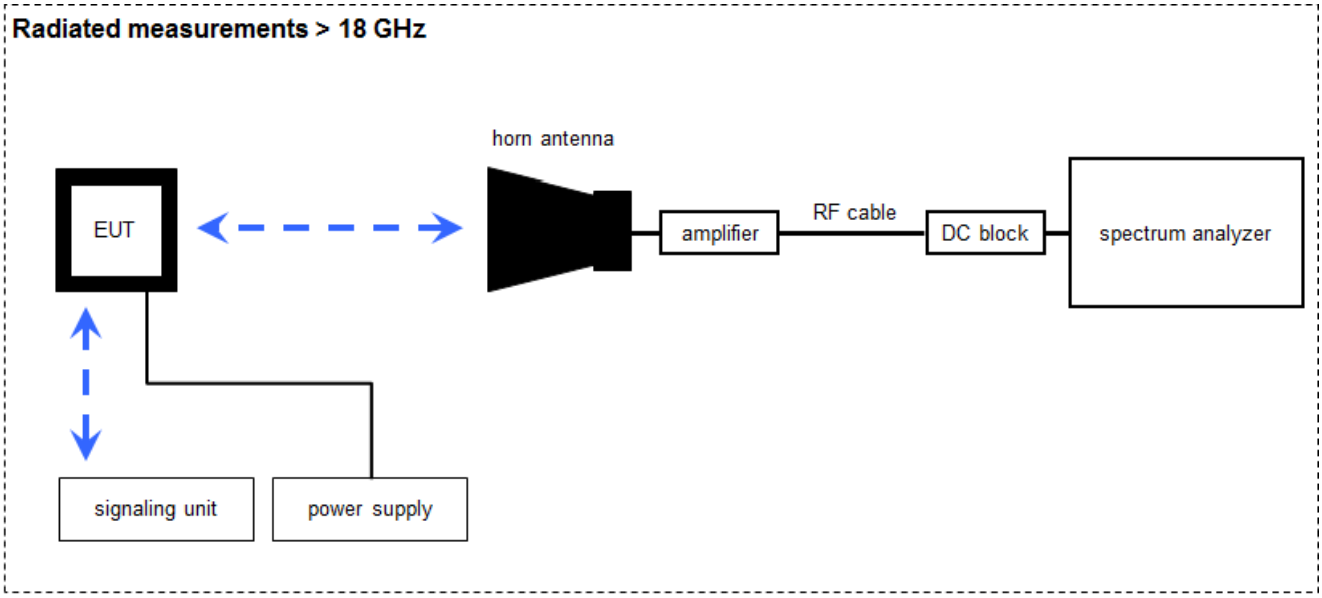
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dBµV/m] (71.61 µV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	k	07.07.2017	06.07.2019
2	A+B	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
3	B	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3697	300001605	vIKI!	14.02.2017	13.02.2019
4	A+B	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
5	B	Band Reject filter	WRCG2400/2483-2375/2505-50/10SS	Wainwright	11	300003351	ev	-/-	-/-
6	A+B	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	31.01.2017	30.01.2018
7	B	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
8	B	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
9	A+B	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
10	A+B	NEXIO EMV-Software	BAT EMC V3.16.0.49	EMCO	-/-	300004682	ne	-/-	-/-
11	A+B	PC	ExOne	F+W	-/-	300004703	ne	-/-	-/-
12	B	Highpass Filter (Chebyshev)	WHKX10-4432.5-4925-18000-40SS	Wainwright	1	300005028	ev	-/-	-/-
13	B	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-

6.3 Radiated measurements > 18 GHz



Measurement distance: horn antenna 50 cm

FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss signal path & distance correction; AF-antenna factor)

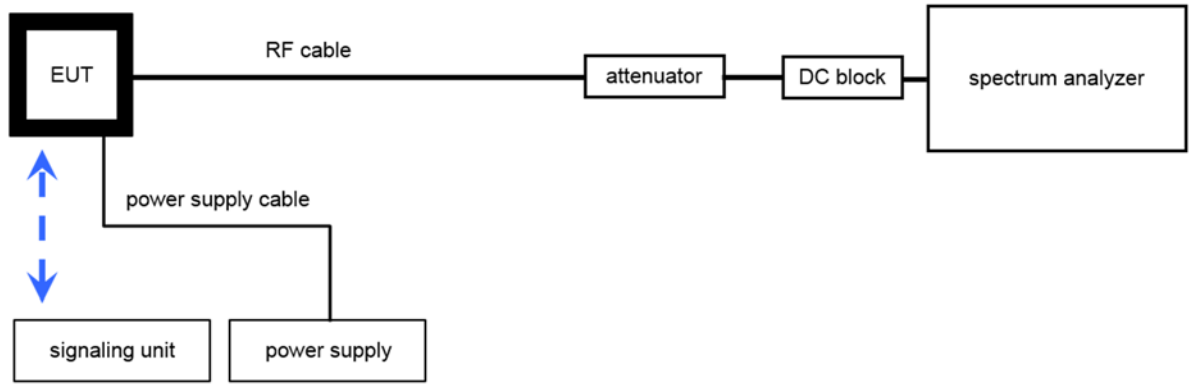
Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-60.1) [dB] + 36.74 [dB/m] = 16.64 [dBµV/m] (6.79 µV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Horn Antenna 18,0-40,0 GHz	LHAF180	Microw.Devel	39180-103-022	300001748	k	22.05.2015	22.05.2018
2	A	Amplifier 2-40 GHz	JS32-02004000-57-5P	MITEQ	1777200	300004541	ev	-/-	-/-
3	A	RF-Cable	ST18/SMAm/SMAm/48	Huber & Suhner	Batch no. 600918	400001182	ev	-/-	-/-
4	A	RF-Cable	ST18/SMAm/SMAm/48	Huber & Suhner	Batch no. 127377	400001183	ev	-/-	-/-
5	A	Signal Analyzer 40 GHz	FSV40	R&S	101353	300004819	k	19.09.2016	18.09.2018

6.4 Conducted measurements

Conducted measurements normal conditions



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

Example calculation:
OP [dBm] = 6.0 [dBm] + 11.7 [dB] = 17.7 [dBm] (58.88 mW)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Signal Analyzer 40 GHz	FSV40	R&S	101353	300004819	k	19.09.2016	18.09.2018
2	A	Open Switch and Control Unit and Power Sensors	OSP120 incl. B157	R&S	101274, 100877	300004825	ne	-/-	-/-
3	A	RF-Cable WLAN-Tester Analyzer	ST18/SMAm/SMAm/36	Huber & Suhner	Batch no. 54876	400001220	ev	-/-	-/-
4	A	Power Supply	HMP2020	Rohde & Schwarz	102219	300005264	ne	-/-	-/-

7 Sequence of testing

7.1 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, it is placed on a table with 0.8 m height.
- 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 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 pre-measurement are maximized by the software by rotating the turntable from 0° to 360°.
- Loop antenna is rotated about its vertical axis for maximum response at each azimuth about the EUT. (For certain applications, the loop antenna plane may also need to be positioned horizontally at the specified distance from the EUT)
- 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.

*)Note: The sequence will be repeated three times with different EUT orientations.

7.2 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 ± 45° 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.

7.3 Sequence of testing radiated spurious 1 GHz to 18 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.

7.4 Sequence of testing radiated spurious above 18 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- 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.
- The measurement distance is as appropriate (e.g. 0.5 m).
- The EUT is set into operation.

Premeasurement

- The test antenna is handheld and moved carefully over the EUT to cover the EUT's whole sphere and different polarizations of the antenna.

Final measurement

- The final measurement is performed at the position and antenna orientation causing the highest emissions with Peak and RMS detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement and the limit is stored.

8 Measurement uncertainty

Measurement uncertainty	
Test case	**Uncertainty**
Antenna gain	± 3 dB
Power spectral density	± 1.5 dB
DTS bandwidth	± 100 kHz (depends on the used RBW)
Occupied bandwidth	± 100 kHz (depends on the used RBW)
Maximum output power	± 1.5 dB
Detailed spurious emissions @ the band edge - conducted	± 1.5 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
Spurious emissions conducted below 30 MHz (AC conducted)	± 2.6 dB

9 Summary of measurement results

☐	No deviations from the technical specifications were ascertained
☐	There were deviations from the technical specifications ascertained
☒	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 2	See table!	2018-03-05	Reduced test plan according customers specification!

Test specification clause	Test case	Guideline	Temperature conditions	Power source voltages	Mode	C	NC	NA	NP	Remark
§15.247(b)(4) RSS - 247 / 5.4 (f)(ii)	Antenna gain	-/-	Nominal	Nominal	GFSK	☒	☐	☐	☐	-/-
§15.35	Duty cycle	-/-	Nominal	Nominal	GFSK	-/-				-/-
§15.247(e) RSS - 247 / 5.2 (b)	Power spectral density	KDB 558074 DTS clause: 10.2	Nominal	Nominal	GFSK	☐	☐	☐	☒	-/-
§15.247(a)(2) RSS - 247 / 5.2 (a)	DTS bandwidth	KDB 558074 DTS clause: 8.1	Nominal	Nominal	GFSK	☐	☐	☐	☒	-/-
RSS Gen clause 4.6.1	Occupied bandwidth	-/-	Nominal	Nominal	GFSK	☐	☐	☐	☒	-/-
§15.247(b)(3) RSS - 247 / 5.4 (d)	Maximum output power	KDB 558074 DTS clause: 9.1.1	Nominal	Nominal	GFSK	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5	Detailed spurious emissions @ the band edge – cond.	-/-	Nominal	Nominal	GFSK	☐	☐	☐	☒	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance cond..	KDB 558074 DTS clause: 13.3.2 and clause 12.2.2	Nominal	Nominal	GFSK	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5	TX spurious emissions cond.	KDB 558074 DTS clause: 11.1 & 11.2 11.3	Nominal	Nominal	GFSK	☐	☐	☐	☒	-/-
§15.209(a) RSS-Gen	TX spurious emissions rad. below 30 MHz	-/-	Nominal	Nominal	GFSK	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5 RSS-Gen	TX spurious emissions rad. 30 MHz to 1 GHz	-/-	Nominal	Nominal	GFSK	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5 RSS-Gen	TX spurious emissions rad. above 1 GHz	-/-	Nominal	Nominal	GFSK	☒	☐	☐	☐	-/-
§15.109 RSS-Gen	RX spurious emissions rad. 30 MHz to 1 GHz	-/-	Nominal	Nominal	GFSK	☒	☐	☐	☐	-/-
§15.109 RSS-Gen	RX spurious emissions rad. above 1 GHz	-/-	Nominal	Nominal	GFSK	☒	☐	☐	☐	-/-
§15.107(a) §15.207	Conducted emissions < 30 MHz	-/-	Nominal	Nominal	GFSK	☐	☐	☐	☒	-/-

Notes:

C	Compliant	**NC**	Not compliant	**NA**	Not applicable	**NP**	Not performed

10 Additional comments

Reference documents:	Test mode instructions: Anleitung-Testmode.pdf
Special test descriptions:	None
Configuration descriptions:	The DUT is configured via a GUI based software provide by the manufacturer. Power settings were fix programmed and could not be changed.
Provided channels:	0 to 39 (2403 MHz to 2481 MHz)

11 Additional EUT parameter

Test mode:

☐ No test mode available
Iperf was used to ping another device with the largest support packet size

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

Modulation types:

☒ GFSK

☐ Frequency Hopping Spread Spectrum (FHSS)

Antennas and transmit operating modes:

☐ Operating mode 1 (single antenna)

- *Equipment with 1 antenna,*
- *Equipment with 2 diversity antennas operating in switched diversity mode by which at any moment in time only 1 antenna is used,*
- *Smart antenna system with 2 or more transmit/receive chains, but operating in a mode where only 1 transmit/receive chain is used)*

☒ Operating mode 2 (multiple antennas, no beamforming)

- *Equipment operating in this mode contains a smart antenna system using two or more transmit/receive chains simultaneously but without beamforming.*

☐ Operating mode 3 (multiple antennas, with beamforming)

- *Equipment operating in this mode contains a smart antenna system using two or more transmit/receive chains simultaneously with beamforming.*
  In addition to the antenna assembly gain (G), the beamforming gain (Y) may have to be taken into account when performing the measurements.

12 Measurement results

12.1 Testability check

Description:

Comparison of the first assessment with the current product based on the performance and decision of the test ability.

Measurement:

Measurement parameters	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	3 MHz
Video bandwidth	3 MHz
Span	5 MHz
Trace mode	Max hold
Test setup	See chapter 6.4 A
Measurement uncertainty	See chapter 8

Limits:

Main report value -2 dB / +1.5 dB

Results:

T_{nom}	V_{nom}	lowest channel	middle channel	highest channel
GFSK mode				
Conducted power / dBm Main report 1-5735/12-01-16-A Sum (Ant1 & Ant2)		16.0	16.2	15.8
Conducted power / dBm Test ability check – delta sample Sum (Ant1 & Ant2)		17.1	17.2	16.9

12.2 Antenna gain

Description:

The antenna gain of the complete system is calculated by the difference of radiated power (@ 3 MHz) in EIRP and the conducted power (@ 3 MHz) of the module.

Measurement:

Measurement parameter	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	3 MHz
Video bandwidth	10 MHz
Trace mode	Max hold
Test setup	See chapter 6.4 A (conducted) See chapter 6.2 B (radiated)
Measurement uncertainty	See chapter 8

Limits:

FCC	IC
6 dBi / > 6 dBi output power and power density reduction required	

Results:

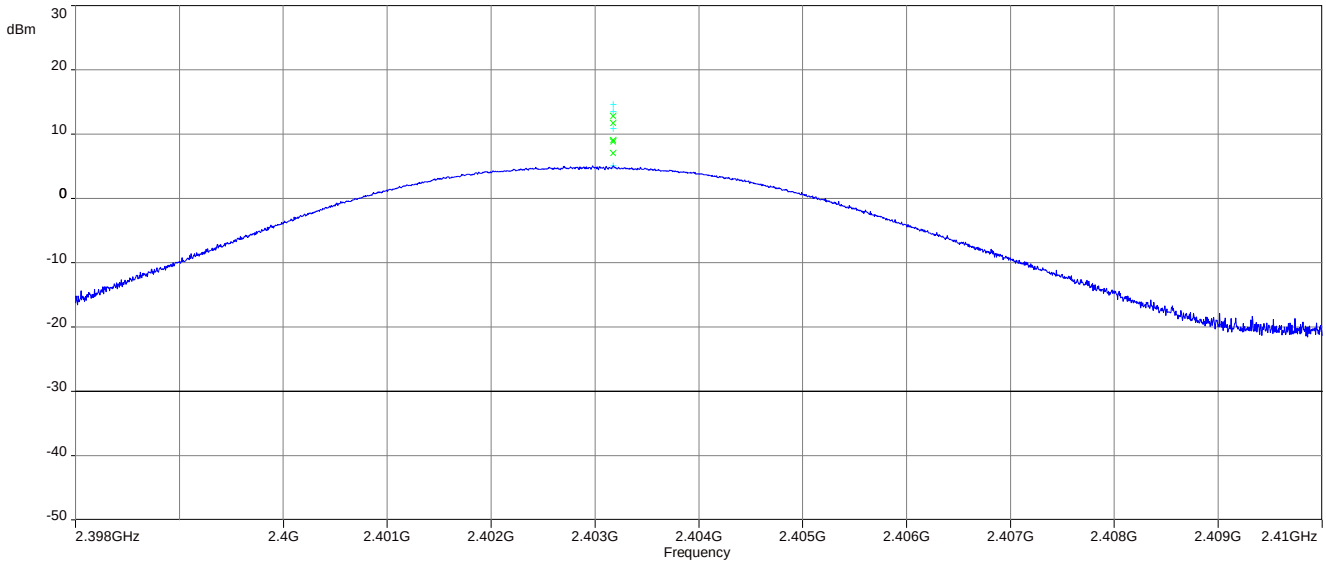
antenna port 1	lowest channel	middle channel	highest channel
Conducted power / dBm Measured with GFSK modulation	17.4	17.4	17.0
Radiated power / dBm Measured with GFSK modulation	15.2	15.8	16.1
Gain / dBi Calculated	-2.2	-1.6	-0.9

Results:

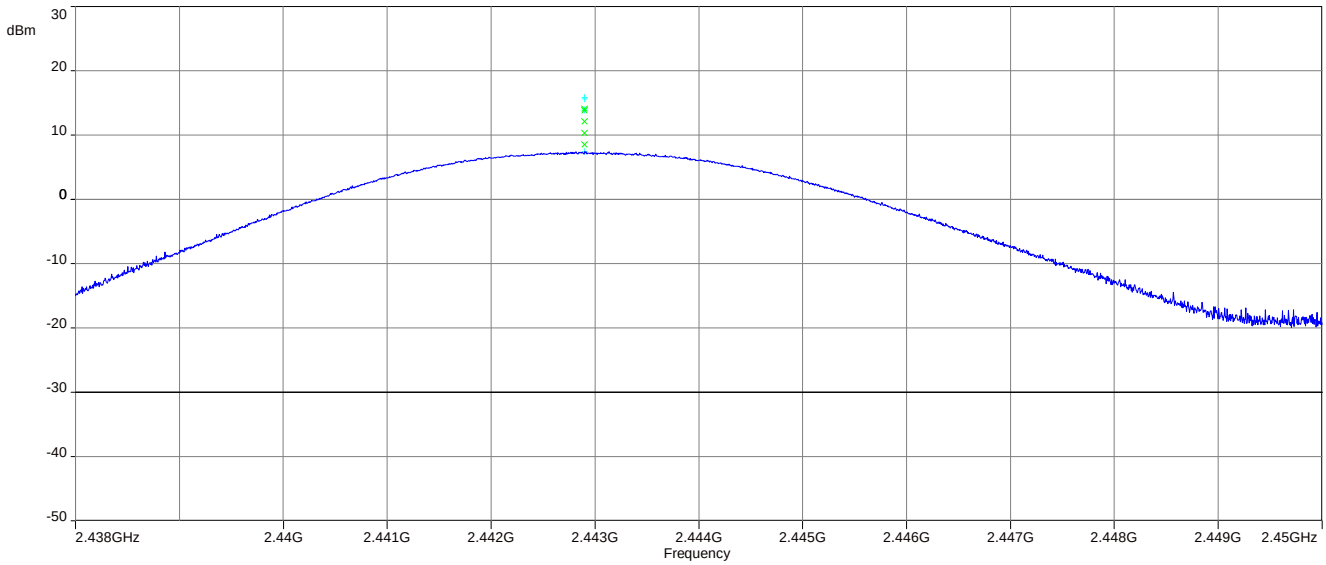
antenna port 2	lowest channel	middle channel	highest channel
Conducted power / dBm Measured with GFSK modulation	16.6	16.7	16.6
Radiated power / dBm Measured with GFSK modulation	14.6	15.9	15.6
Gain / dBi Calculated	-2.0	-0.8	-1.0

Plots: GFSK – mode; antenna port 1 (radiated)

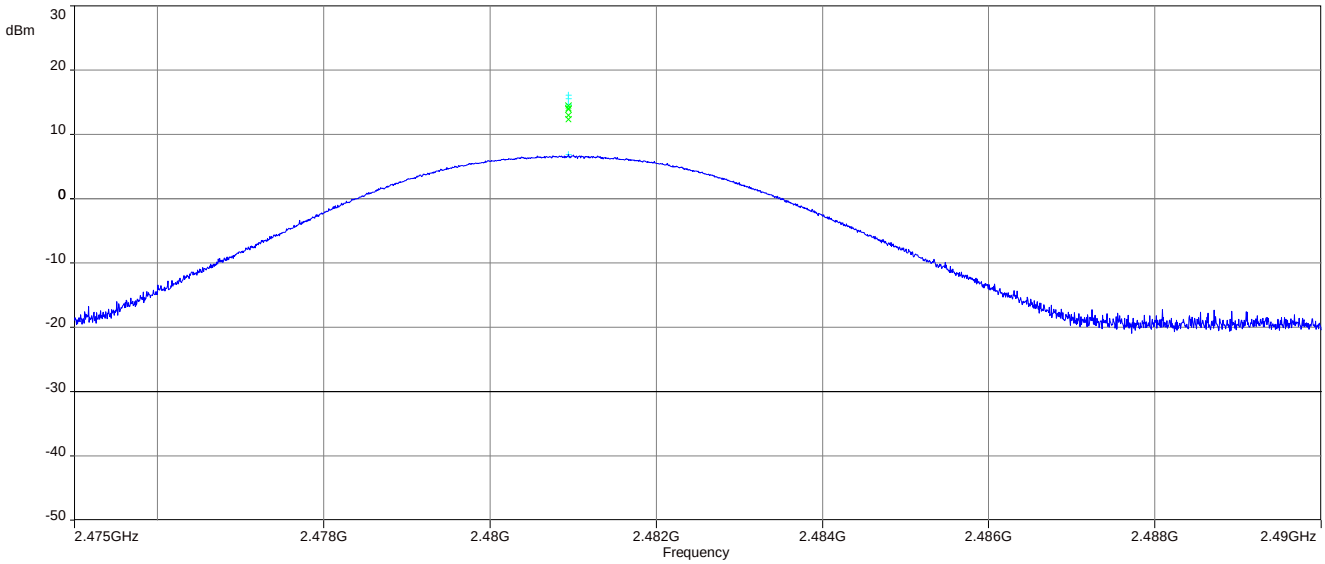
Plot 1: Lowest channel



Plot 2: Middle channel

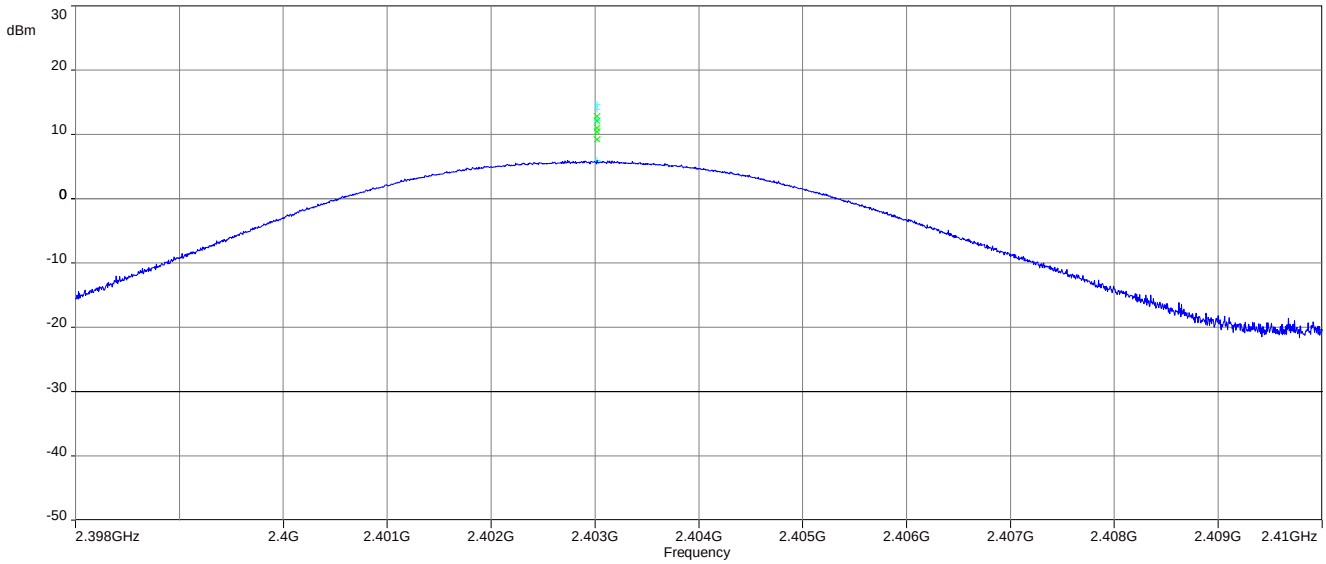


Plot 3: Highest channel

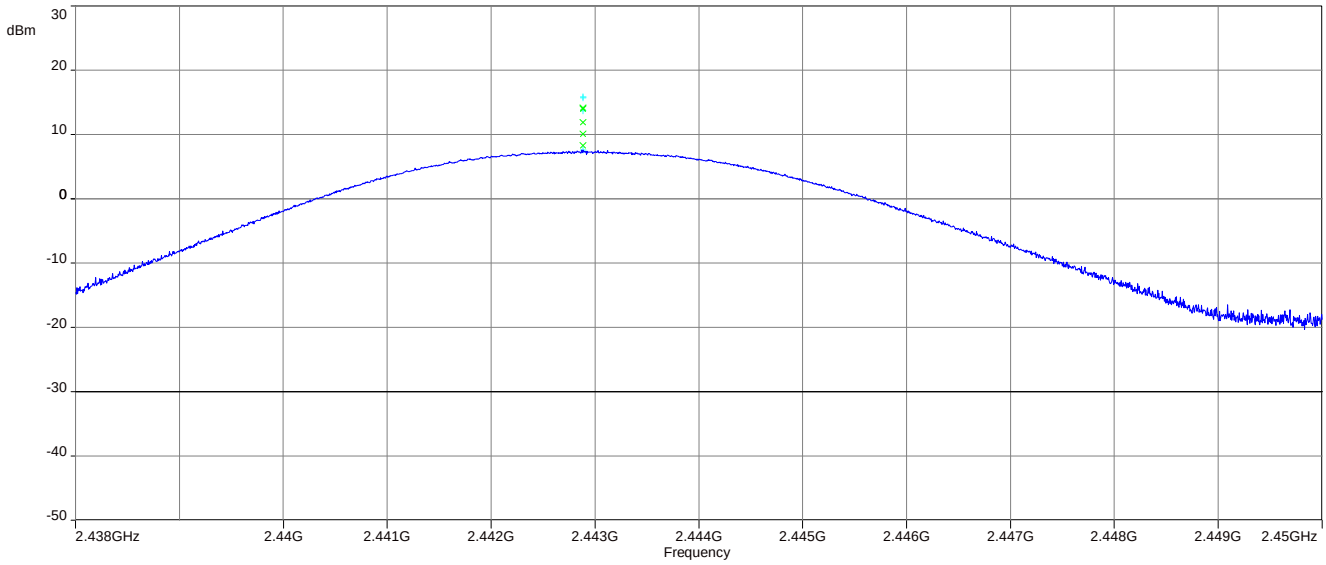


Plots: GFSK – mode; antenna port 2 (radiated)

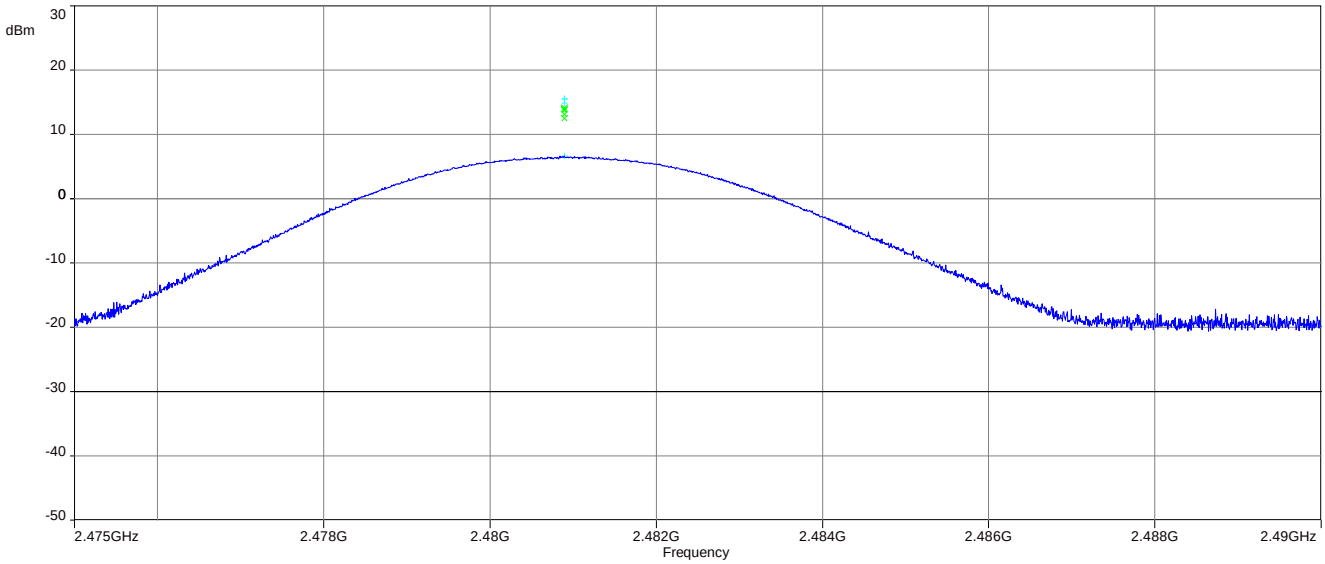
Plot 1: Lowest channel



Plot 2: Middle channel



Plot 3: Highest channel



12.3 Maximum output power

Description:

Measurement of the maximum conducted peak output power. The measurements are performed using the data rate identified in the previous chapter.

Measurement:

Measurement parameter	
According to DTS clause: 9.1.1	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	3 MHz
Video bandwidth	10 MHz
Trace mode	Max hold
Test setup	See chapter 6.4 A
Measurement uncertainty	See chapter 8

Limits:

FCC	IC
Conducted 1.0 W / 30 dBm with an antenna gain of max. 6 dBi	

Results:

antenna port 1	maximum output power / dBm		
	lowest channel	middle channel	highest channel
Output power conducted	17.4	17.4	17.0

antenna port 2	maximum output power / dBm		
	lowest channel	middle channel	highest channel
Output power conducted	16.6	16.7	16.6

12.4 Duty cycle

Description:

Measurement of the timing behavior.

Measurement:

Measurement parameter	
Detector	Peak
Sweep time	Depends on the signal see plot
Resolution bandwidth	10 MHz
Video bandwidth	10 MHz
Trace mode	Max hold
Test setup	See chapter 6.4 A
Measurement uncertainty	See chapter 8

Limits:

FCC	IC
No limitation!	

Results:

T_{nom}	V_{nom}	lowest channel	middle channel	highest channel
GFSK Modulation		54.6 %	54.7%	54.6%

Duty Cycle correction factor as per DTS clause 13.3.2:

10 log (1/x) = 10 log (1/0.546) = **2.6 dB**

where x is the duty cycle

12.5 Band edge compliance conducted

Description:

Measurement of the radiated band edge compliance. The EUT is turned in the position that results in the maximum level at the band edge. Then a sweep over the corresponding restricted band is performed. The EUT is set to the lowest channel for the lower restricted band and to the highest channel for the upper restricted band. The measurement is repeated for all modulations. Measurement distance is 3 meter.

Measurement:

	Measurement parameter for peak measurements	Measurement parameter for average measurements
		According to DTS clause: 13.3.2
Detector	Peak	RMS
Sweep time	Auto	Auto
Resolution bandwidth	1 MHz	100 kHz
Video bandwidth	1 MHz	300 kHz
Span	See plot	2 MHz
Trace mode	Max. hold	RMS Average over 101 sweeps
Analyzer function	-/-	Band power function (Compute the power by integrating the spectrum over 1 MHz)
Test setup	See chapter 6.4 A	
Measurement uncertainty	See chapter 8	

Limits:

FCC	IC
74 dBµV/m @ 3 m (Peak) 54 dBµV/m @ 3 m (AVG) -41.2 dBm (if measured according DTS clause 13.3.2)	

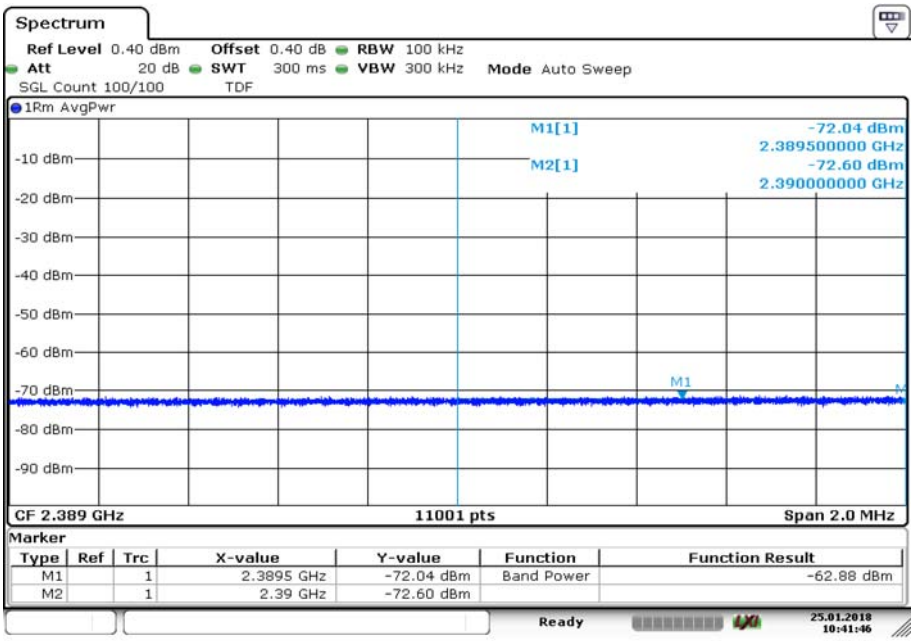
Results:

band edge compliance conducted / dBm			
	Antenna 1	Antenna 2	-/-
Lower band edge	-62.9	-49.4	-/-
Upper band edge	-60.4	-49.1	-/-

Note: Antenna gain as well as duty cycle correction factor is considered with the Reference Level Offset

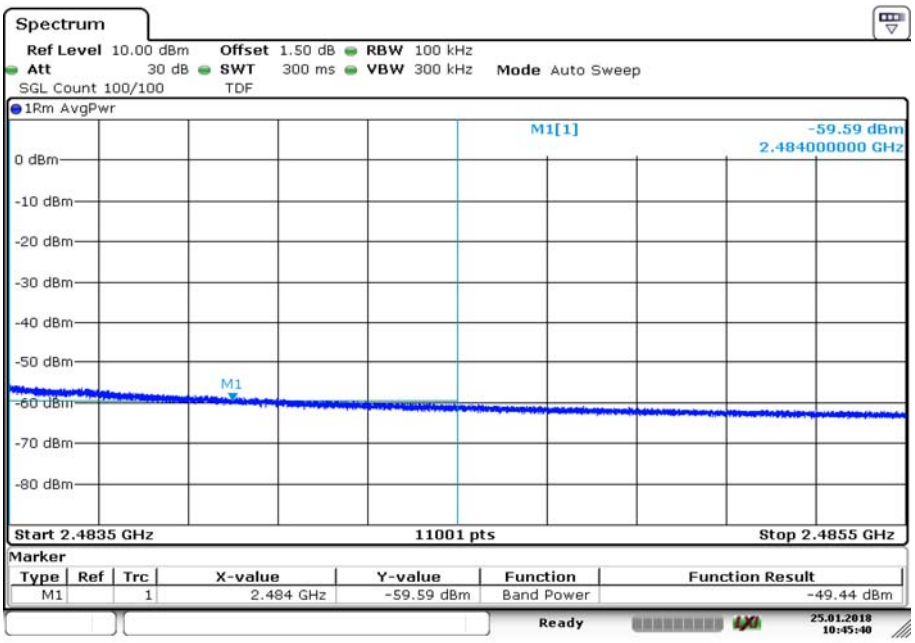
Plots: GFSK - Antenna 1

Plot 1: lower band edge



Date: 25.JAN.2018 10:41:46

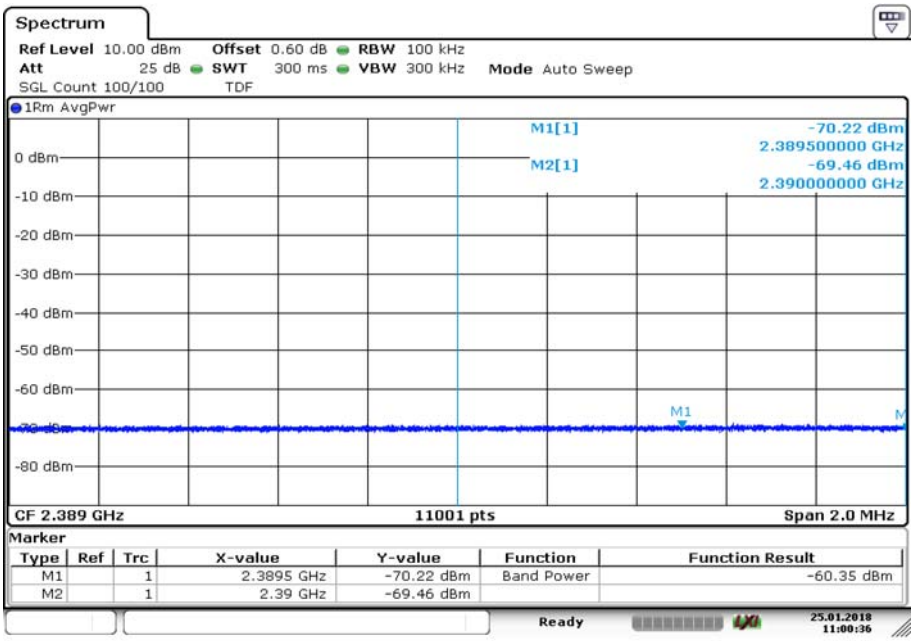
Plot 2: upper band edge



Date: 25.JAN.2018 10:45:40

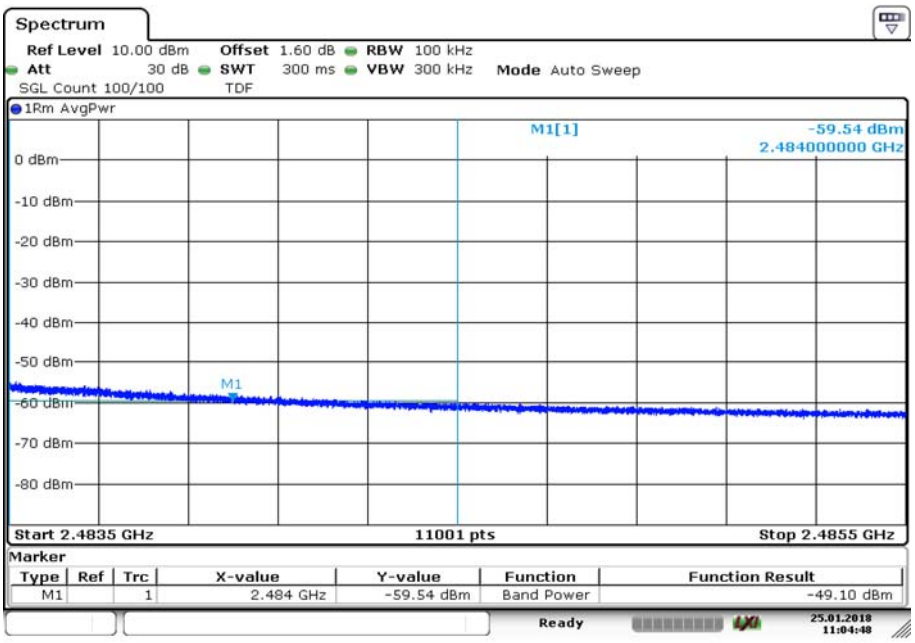
Plots: GFSK - Antenna 2

Plot 1: lower band edge



Date: 25.JAN.2018 11:00:36

Plot 2: upper band edge



Date: 25.JAN.2018 11:04:48

12.6 Spurious emissions radiated below 30 MHz

Description:

Measurement of the radiated spurious emissions in transmit mode below 30 MHz. The limits are recalculated to a measurement distance of 3 m with 40 dB/decade according CFR Part 2.

Measurement:

Measurement parameter	
Detector	Peak / Quasi Peak
Sweep time	Auto
Resolution bandwidth	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Video bandwidth	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Span	9 kHz to 30 MHz
Trace mode	Max Hold
Test setup	See chapter 6.2 A
Measurement uncertainty	See chapter 8

Limits:

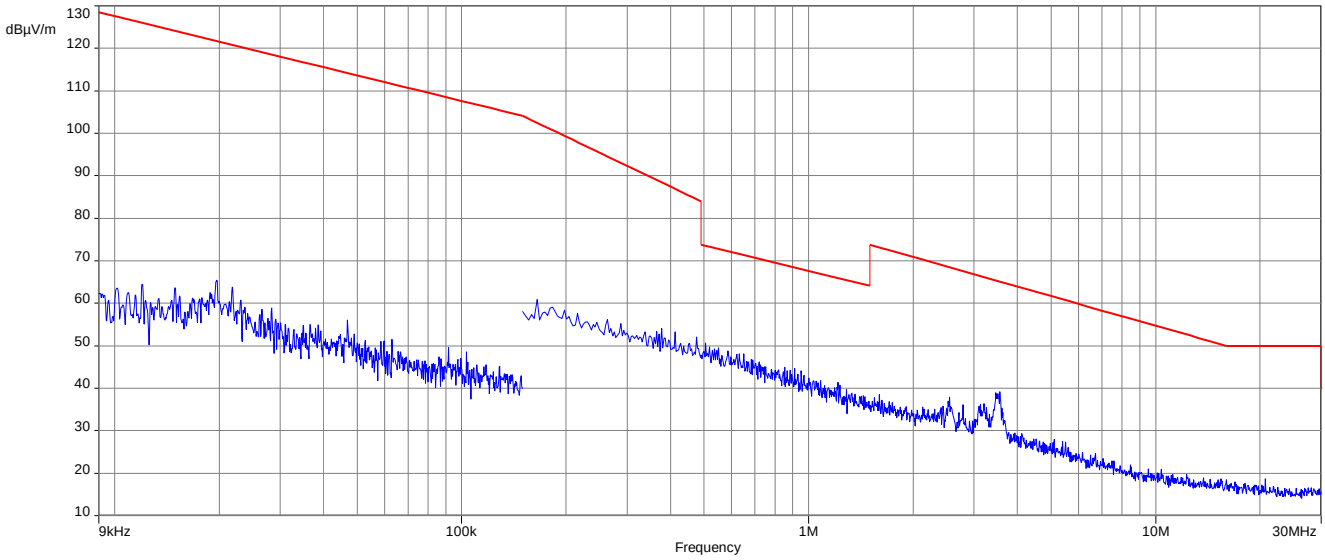
FCC		IC
Frequency / MHz	Field Strength / (dBµV / m)	Measurement distance / m
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30

Results:

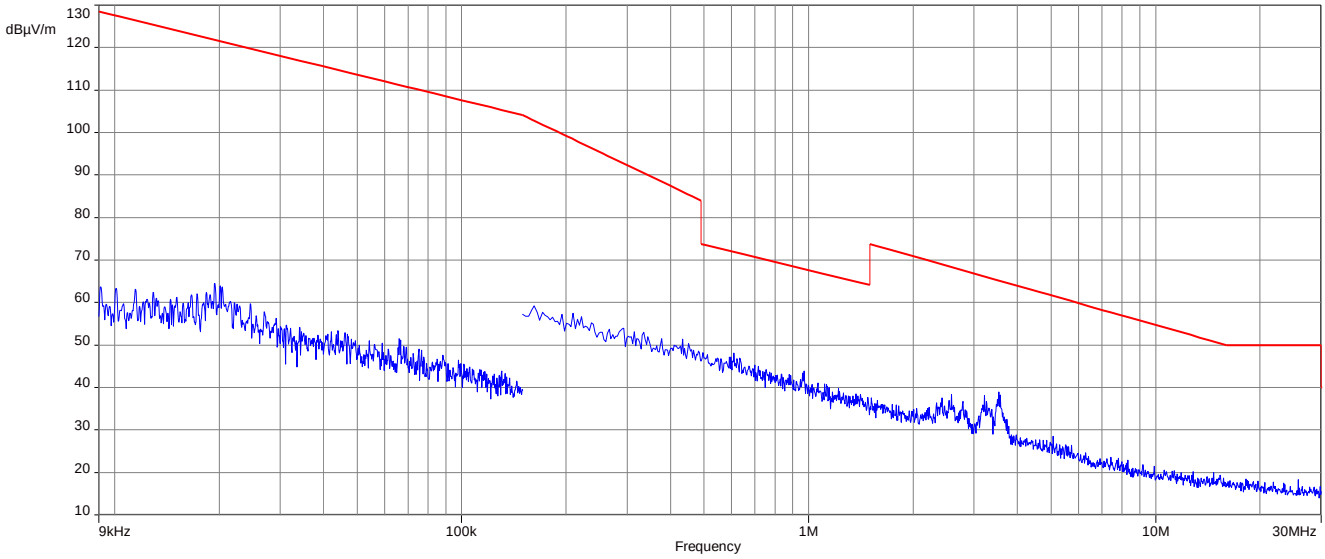
TX spurious emissions radiated < 30 MHz / (dBµV / m) @ 3 m		
Frequency / MHz	Detector	Level / (dBµV / m)
All detected peaks are more than 20 dB below the limit.		

Plots: GFSK (Antenna 1)

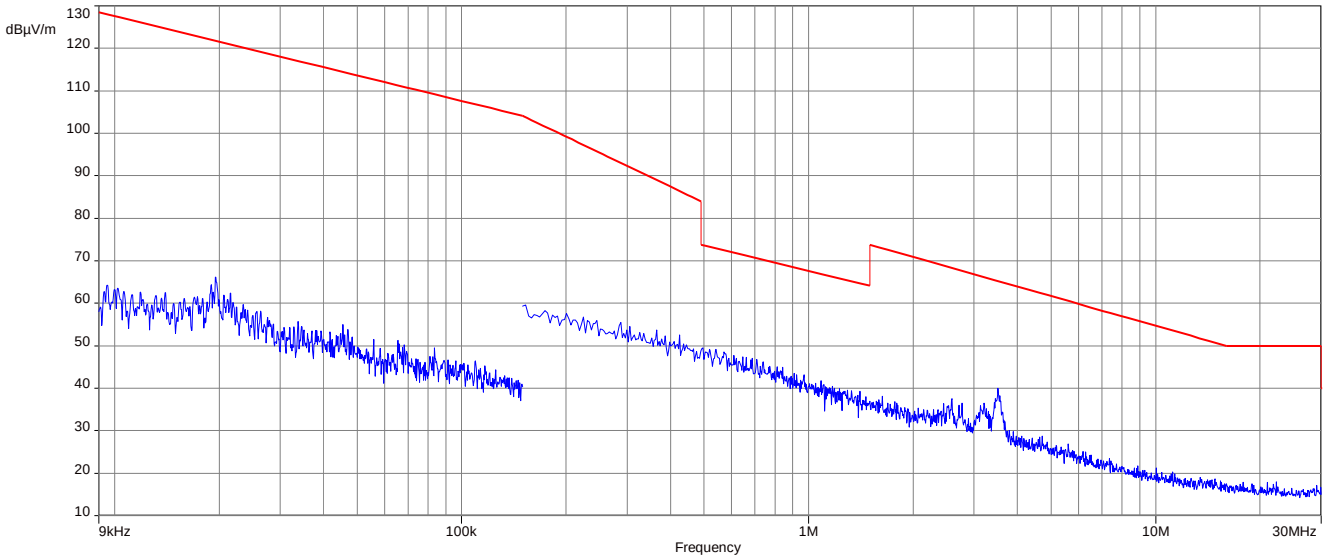
Plot 1: 9 kHz to 30 MHz, lowest channel



Plot 2: 9 kHz to 30 MHz, middle channel

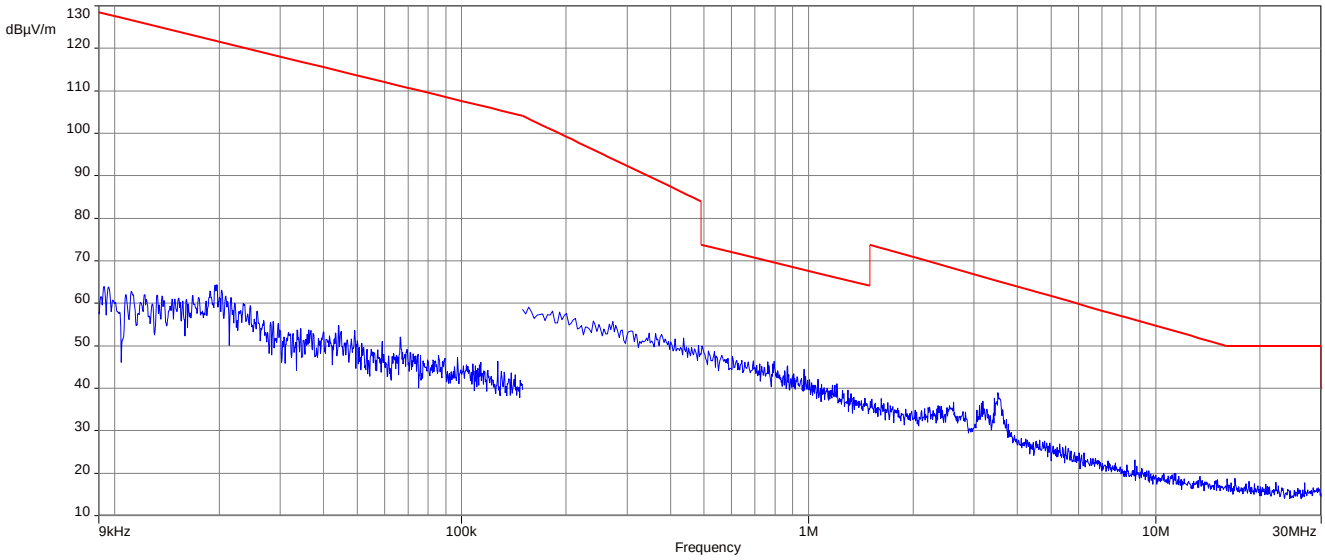


Plot 3: 9 kHz to 30 MHz, highest channel

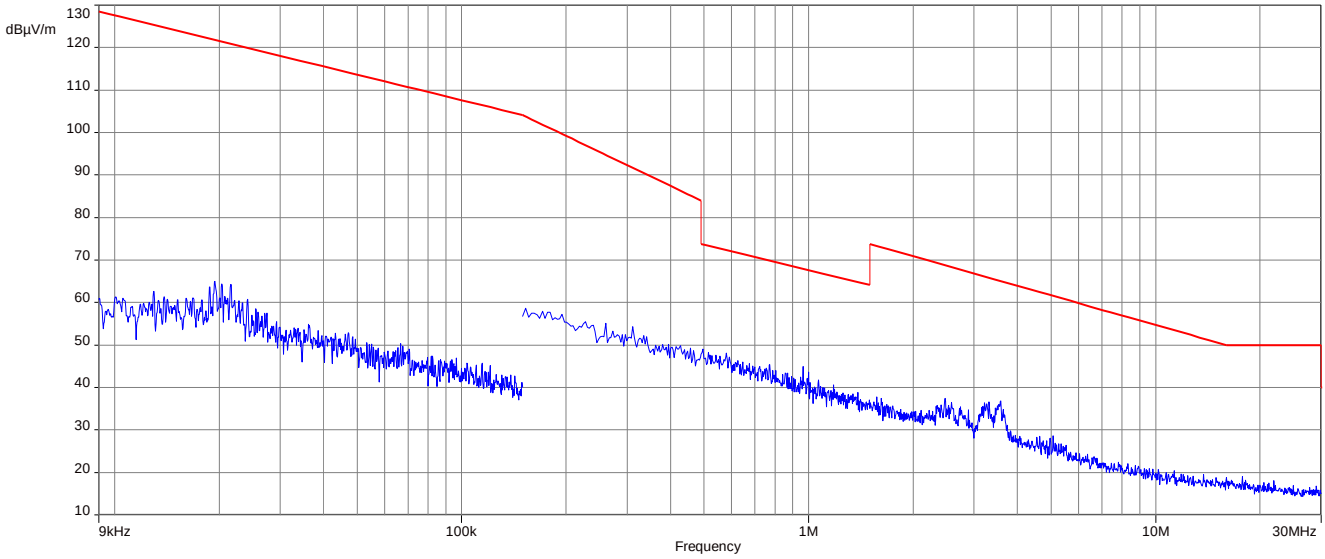


Plots: GFSK (Antenna 2)

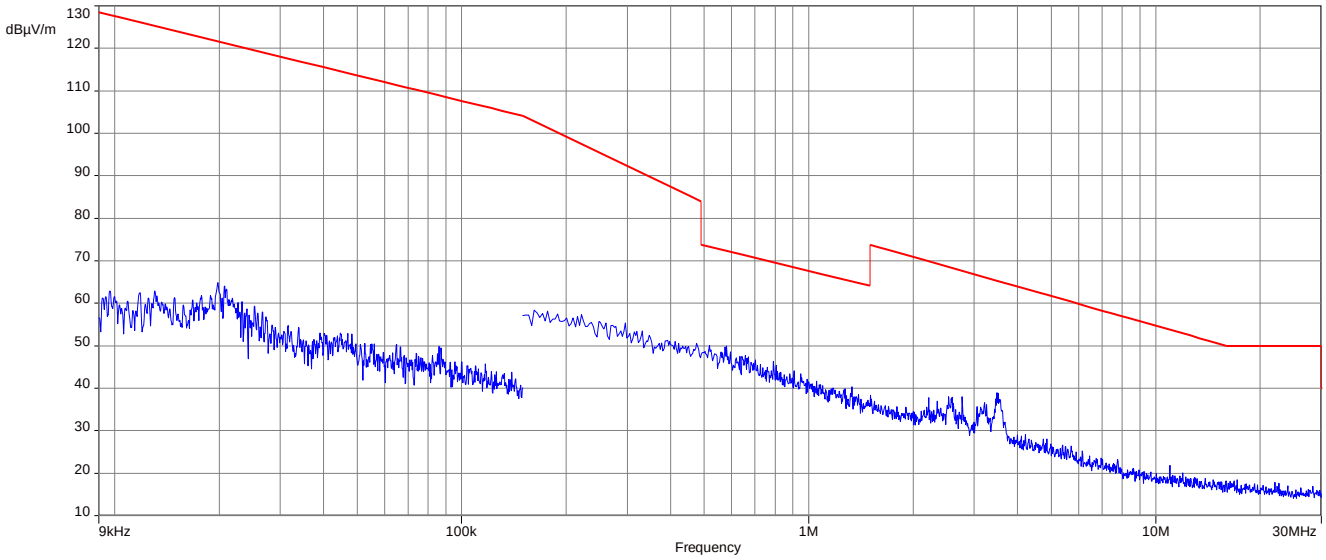
Plot 1: 9 kHz to 30 MHz, lowest channel



Plot 2: 9 kHz to 30 MHz, middle channel



Plot 3: 9 kHz to 30 MHz, highest channel



12.7 Spurious emissions radiated 30 MHz to 1 GHz

Description:

Measurement of the radiated spurious emissions and cabinet radiations below 1 GHz.

Measurement:

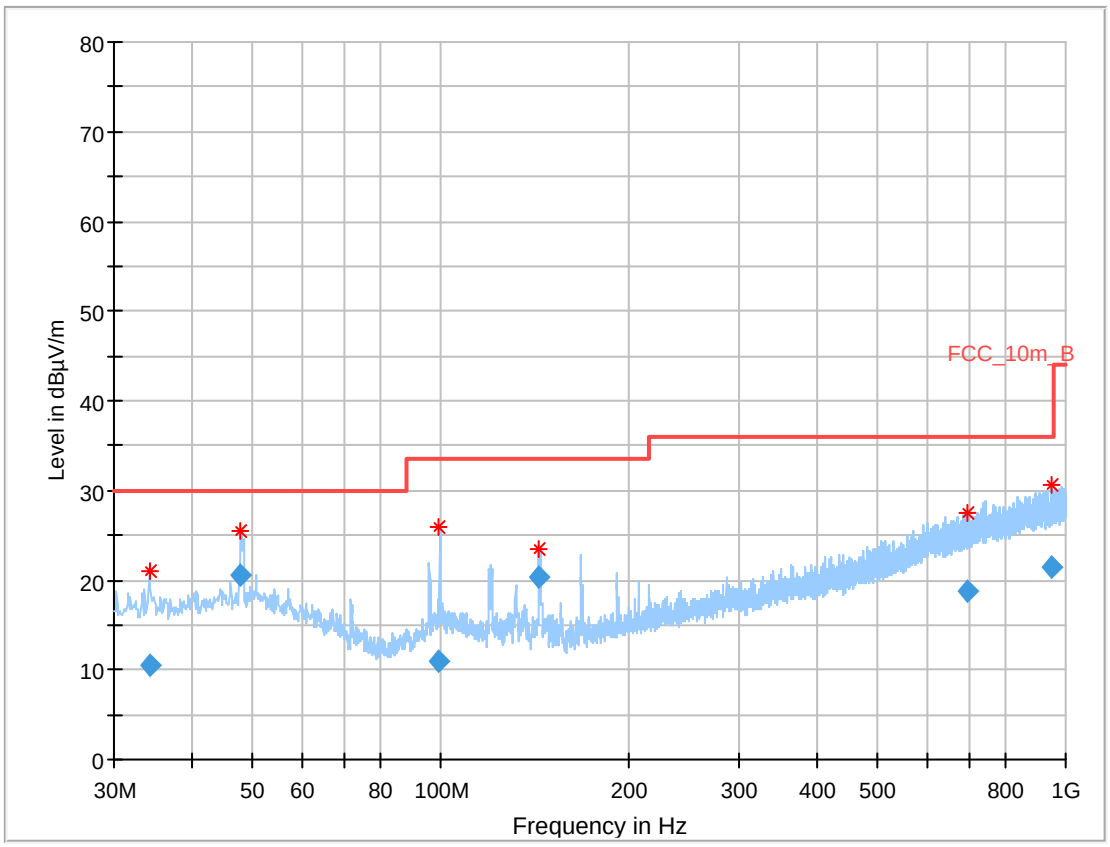
Measurement parameter	
Detector	Peak / Quasi Peak
Sweep time	Auto
Resolution bandwidth	120 kHz
Video bandwidth	3 x RBW
Span	30 MHz to 1 GHz
Trace mode	Max Hold
Test setup	See chapter 6.1 A
Measurement uncertainty	See chapter 8

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. 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 / m
30 – 88	30.0	10
88 – 216	33.5	10
216 – 960	36.0	10

Plot: GFSK (Antenna 1)

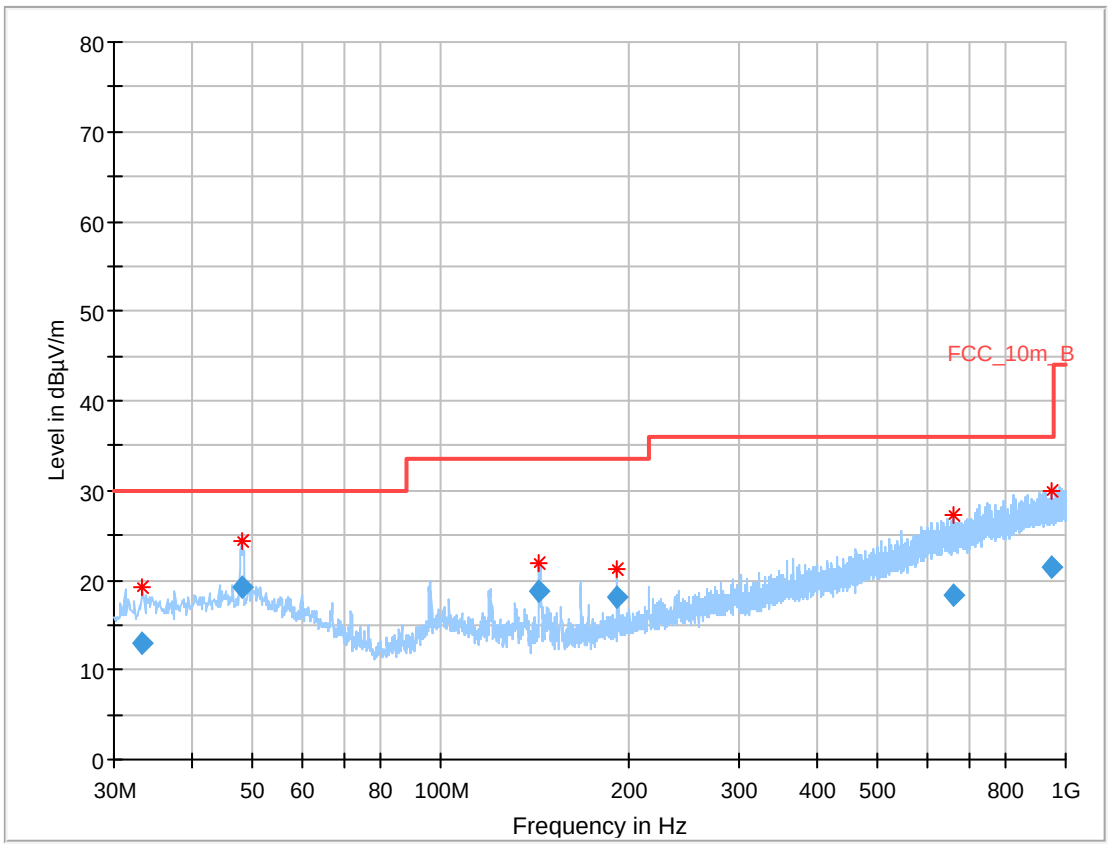
Plot 1: 30 MHz to 1 GHz, vertical & horizontal polarization, lowest channel



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
34.354	10.43	30.0	19.57	1000	120	101.0	V	172.0	12.6
47.856	20.65	30.0	9.35	1000	120	98.0	V	342.0	13.7
99.502	10.91	33.5	22.59	1000	120	101.0	V	117.0	12.0
143.806	20.32	33.5	13.18	1000	120	98.0	V	-4.0	9.0
694.549	18.84	36.0	17.16	1000	120	170.0	V	105.0	21.5
950.272	21.52	36.0	14.48	1000	120	101.0	H	347.0	24.3

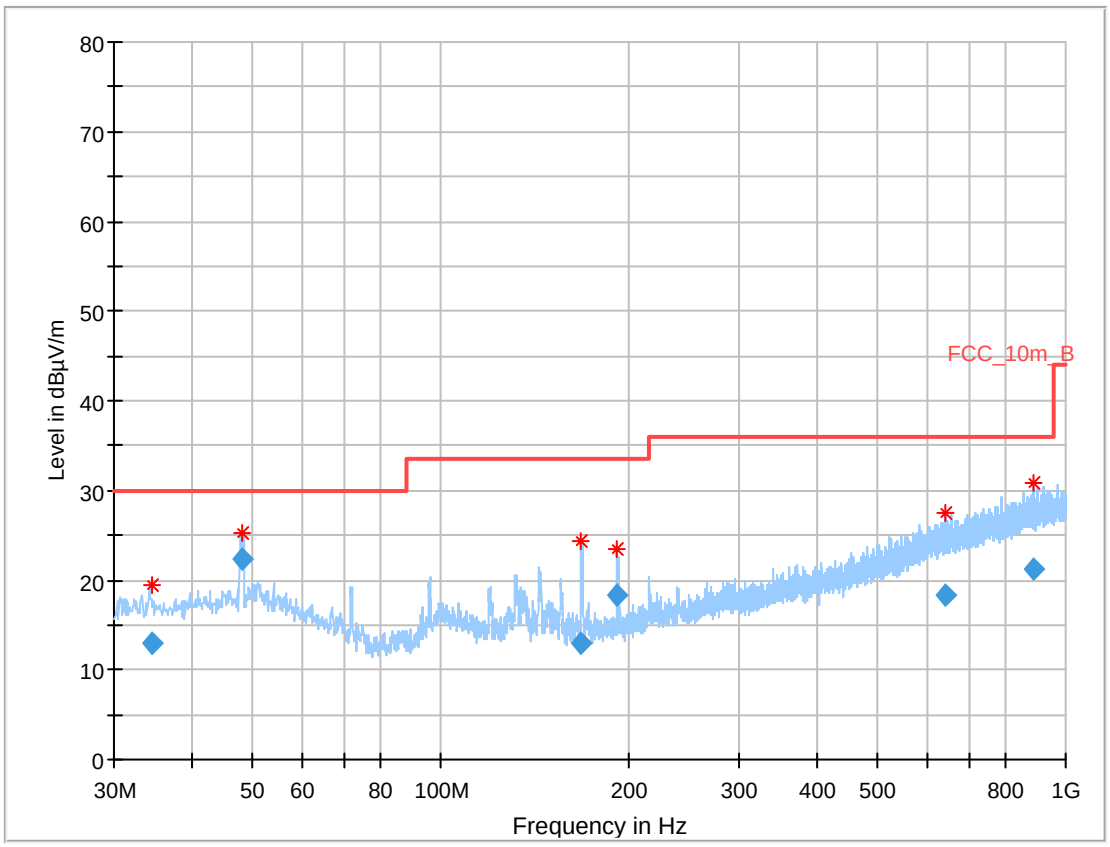
Plot 2: 30 MHz to 1 GHz, vertical & horizontal polarization, middle channel



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
33.172	12.96	30.0	17.04	1000	120	101.0	V	353.0	12.4
48.055	19.24	30.0	10.76	1000	120	98.0	V	65.0	13.7
143.658	18.81	33.5	14.69	1000	120	98.0	V	-6.0	9.0
191.327	18.02	33.5	15.48	1000	120	98.0	V	200.0	11.5
662.969	18.42	36.0	17.58	1000	120	98.0	H	53.0	21.2
950.034	21.51	36.0	14.49	1000	120	101.0	H	-9.0	24.3

Plot 3: 30 MHz to 1 GHz, vertical & horizontal polarization, highest channel

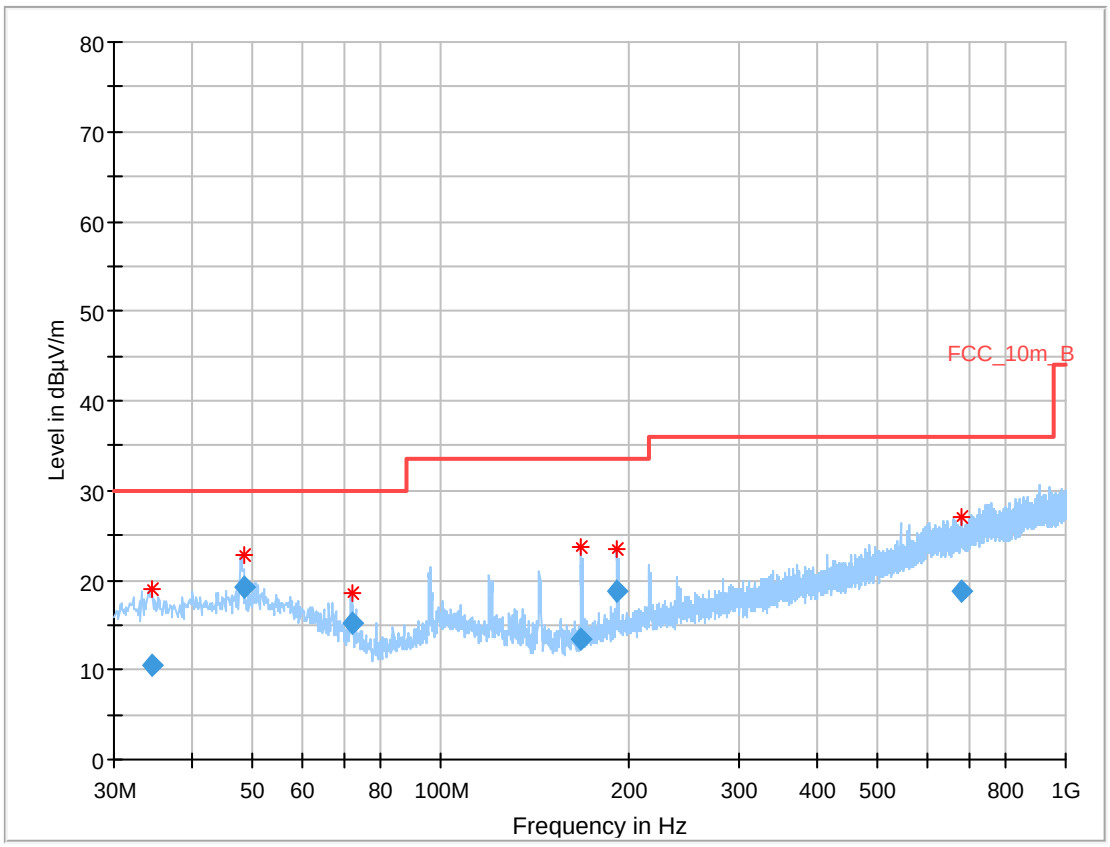


Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
34.623	12.97	30.0	17.03	1000	120	100.0	V	350.0	12.6
47.980	22.45	30.0	7.55	1000	120	98.0	V	198.0	13.7
167.946	12.91	33.5	20.59	1000	120	98.0	V	33.0	10.2
191.712	18.36	33.5	15.14	1000	120	170.0	V	65.0	11.5
641.822	18.32	36.0	17.68	1000	120	170.0	V	244.0	21.1
887.765	21.34	36.0	14.66	1000	120	101.0	V	285.0	24.0

Plot: GFSK (Antenna 2)

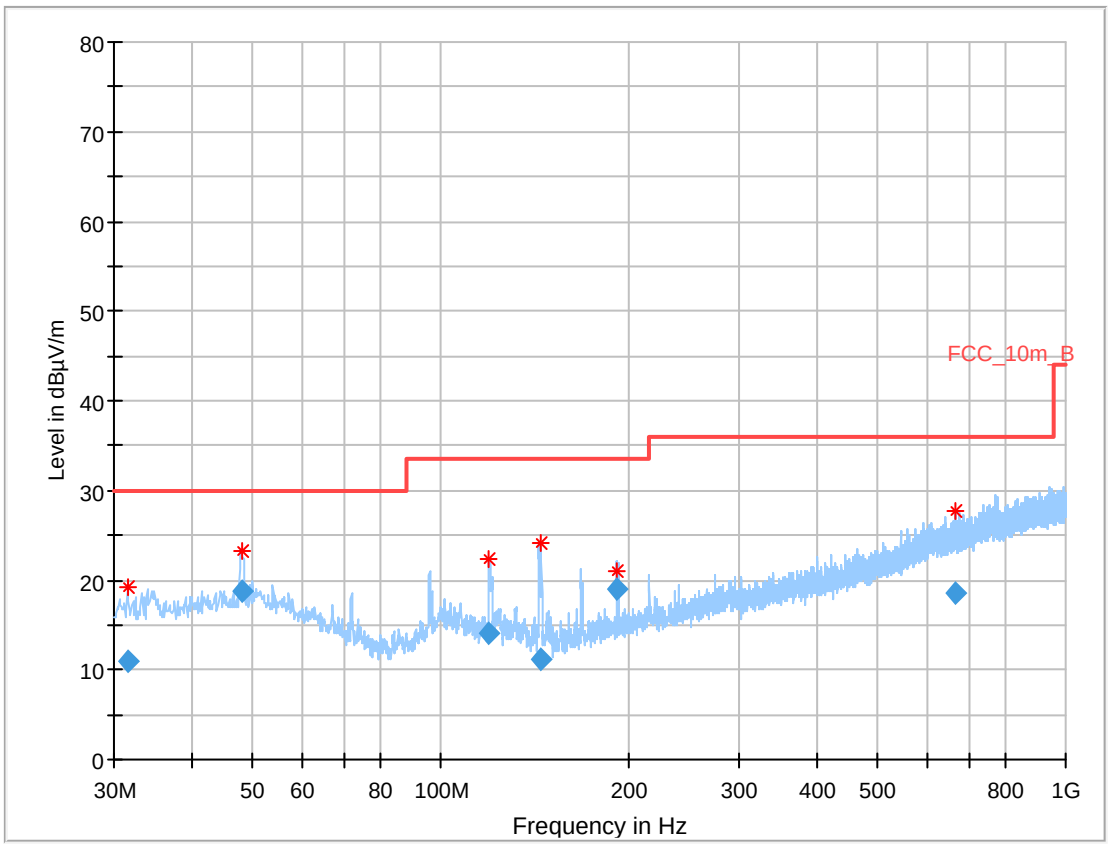
Plot 1: 30 MHz to 1 GHz, vertical & horizontal polarization, lowest channel



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
34.413	10.46	30.0	19.54	1000	120	101.0	V	341.0	12.6
48.316	19.16	30.0	10.84	1000	120	101.0	V	341.0	13.7
71.993	15.10	30.0	14.90	1000	120	170.0	V	331.0	9.4
167.972	13.51	33.5	19.99	1000	120	98.0	V	192.0	10.2
191.489	18.68	33.5	14.82	1000	120	101.0	V	264.0	11.5
681.177	18.76	36.0	17.24	1000	120	170.0	H	126.0	21.4

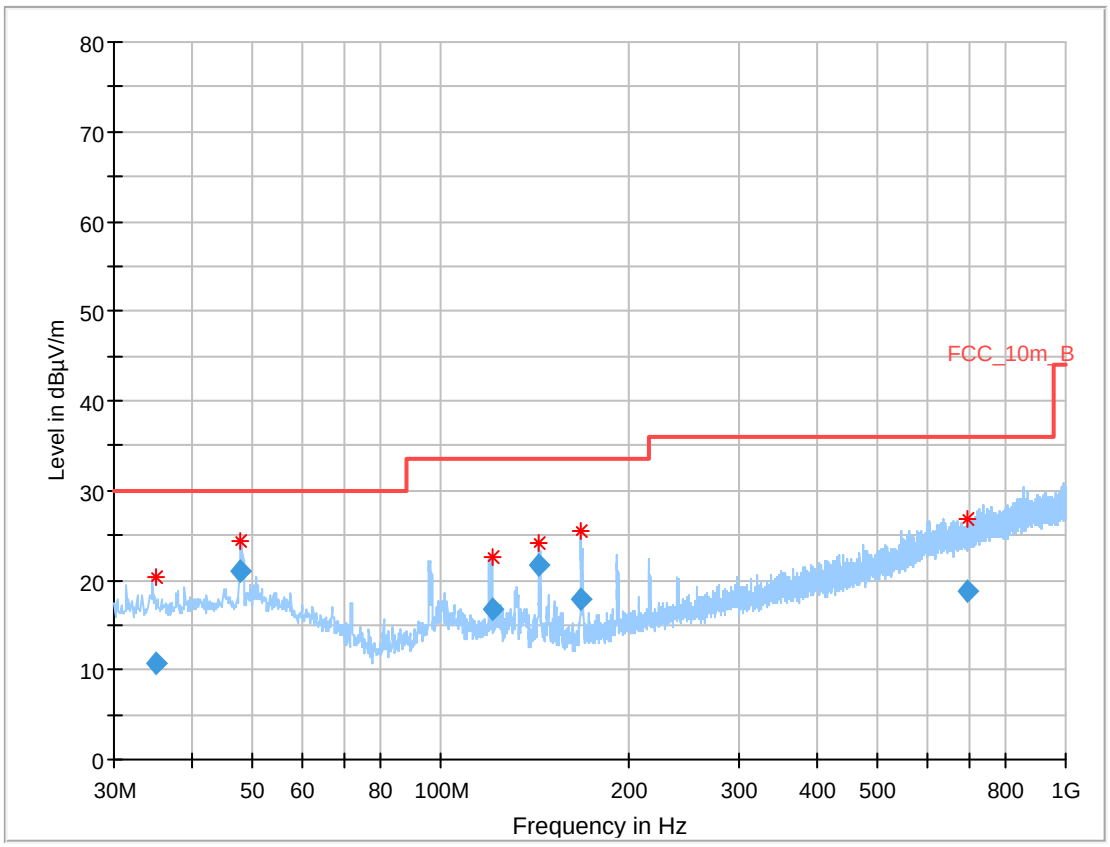
Plot 2: 30 MHz to 1 GHz, vertical & horizontal polarization, middle channel



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
31.618	11.06	30.0	18.94	1000	120	98.0	V	232.0	12.1
47.967	18.84	30.0	11.16	1000	120	98.0	V	0.0	13.7
119.710	14.06	33.5	19.44	1000	120	170.0	V	172.0	10.3
144.145	11.22	33.5	22.28	1000	120	98.0	V	153.0	9.0
191.391	18.98	33.5	14.52	1000	120	170.0	V	266.0	11.5
667.271	18.57	36.0	17.43	1000	120	98.0	V	182.0	21.3

Plot 3: 30 MHz to 1 GHz, vertical & horizontal polarization, highest channel

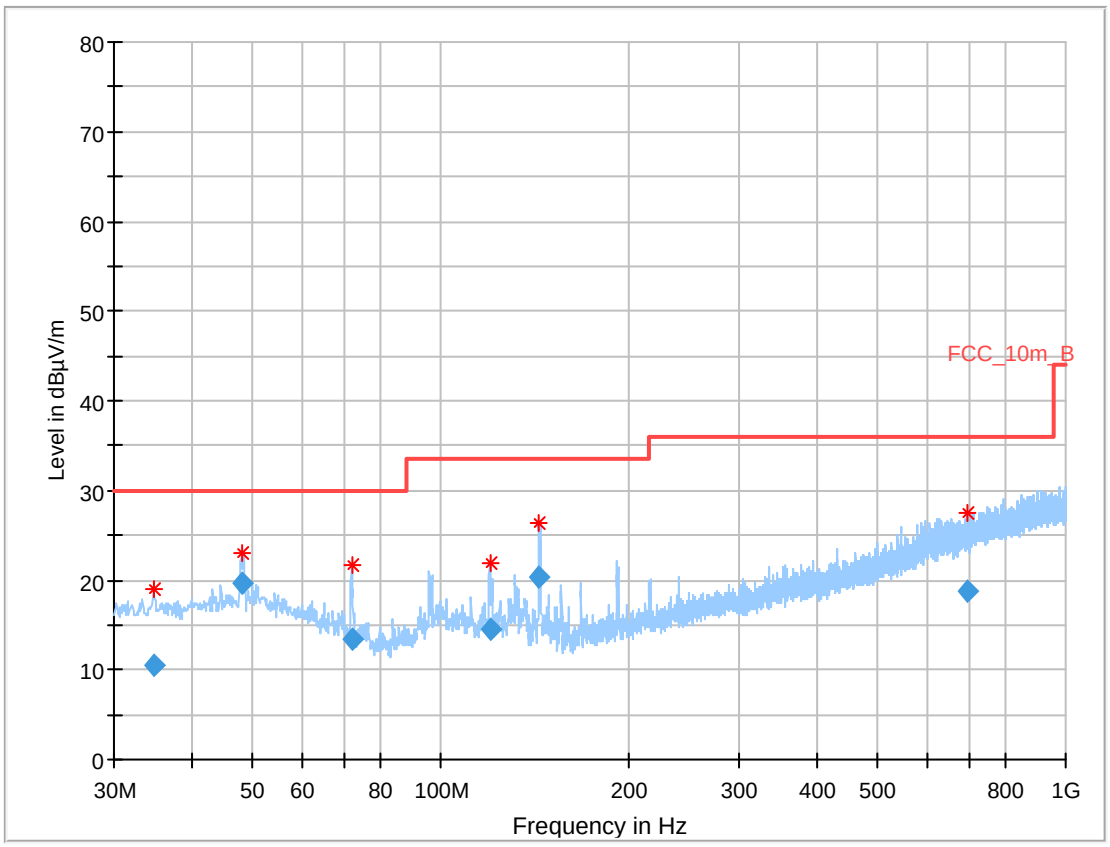


Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
35.045	10.69	30.0	19.31	1000	120	170.0	V	345.0	12.7
47.901	20.92	30.0	9.08	1000	120	98.0	V	169.0	13.7
120.698	16.85	33.5	16.65	1000	120	170.0	V	344.0	10.2
143.528	21.70	33.5	11.80	1000	120	98.0	V	16.0	9.0
167.966	17.79	33.5	15.71	1000	120	98.0	V	204.0	10.2
695.128	18.83	36.0	17.17	1000	120	170.0	H	298.0	21.5

Plot: RX / Idle mode (Antenna 1)

Plot 1: 30 MHz to 1 GHz, vertical & horizontal polarization

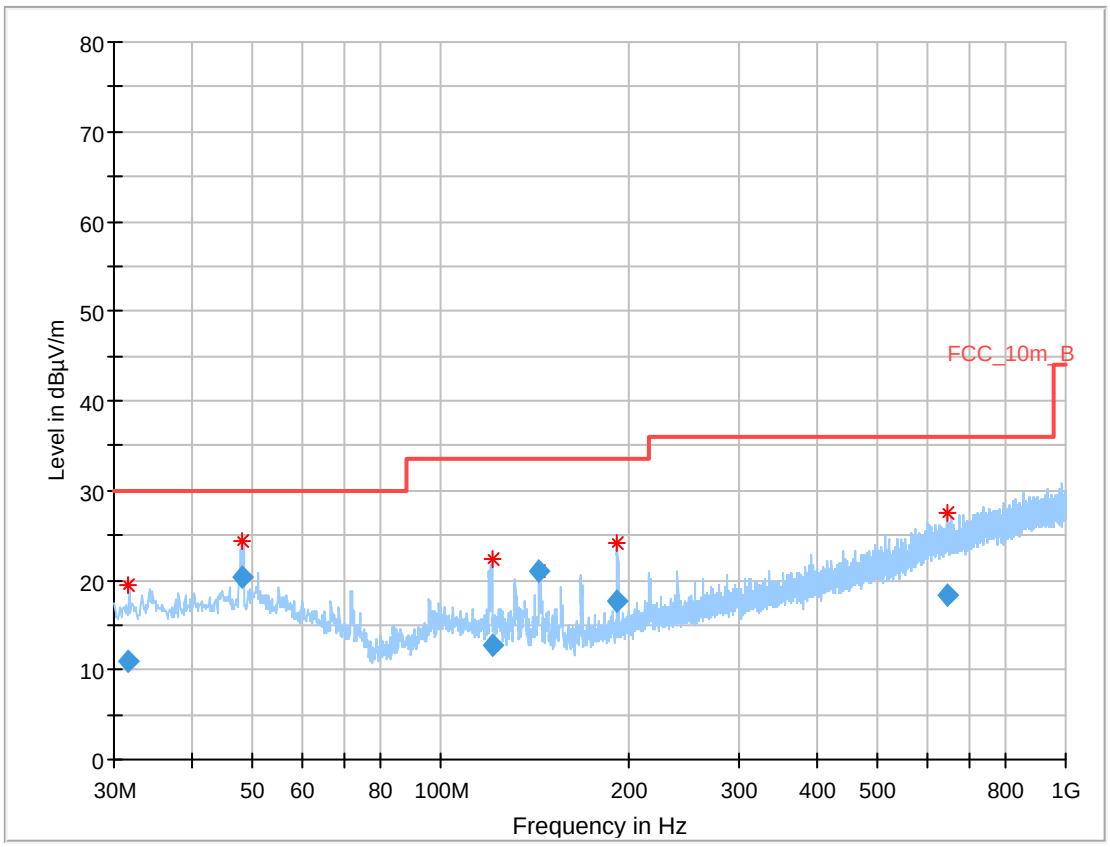


Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
34.898	10.41	30.0	19.59	1000	120	101.0	V	179.0	12.6
47.992	19.75	30.0	10.25	1000	120	170.0	V	10.0	13.7
72.088	13.31	30.0	16.69	1000	120	101.0	V	110.0	9.4
120.022	14.49	33.5	19.01	1000	120	101.0	V	116.0	10.3
144.011	20.44	33.5	13.06	1000	120	101.0	V	331.0	9.0
694.861	18.85	36.0	17.15	1000	120	170.0	H	243.0	21.5

Plot: RX / Idle mode (Antenna 2)

Plot 1: 30 MHz to 1 GHz, vertical & horizontal polarization



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
31.624	10.97	30.0	19.03	1000	120	102.0	V	347.0	12.1
47.968	20.41	30.0	9.59	1000	120	98.0	V	189.0	13.7
120.712	12.76	33.5	20.74	1000	120	170.0	V	0.0	10.2
143.978	20.95	33.5	12.55	1000	120	100.0	V	85.0	9.0
191.501	17.71	33.5	15.79	1000	120	98.0	V	111.0	11.5
644.769	18.33	36.0	17.67	1000	120	170.0	H	182.0	21.1

12.8 Spurious emissions radiated above 1 GHz

Description:

Measurement of the radiated spurious emissions above 1 GHz in transmit mode and receiver / idle mode.

Measurement:

Measurement parameter	
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
Test setup	See chapter 6.2 B & 6.3 A
Measurement uncertainty	See chapter 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 30 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)).		
Frequency / MHz	Field Strength / (dBµV / m)	Measurement distance / m
Above 960	54.0 (AVG)	3
	74.0 (peak)	

Results: GFSK (Antenna 1)

TX spurious emissions radiated / dBµV/m @ 3 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
1593	Peak	50.3	7329	Peak	52.1	4961	Peak	55.3
	AVG	34.4		AVG	43.8		AVG	47.4
7209	Peak	55.1	-/-	Peak	-/-	7441	Peak	52.5
	AVG	47.5		AVG	-/-		AVG	43.6
For peak emissions results > 18 GHz see plots below								

Results: GFSK (Antenna 2)

TX spurious emissions radiated / dBµV/m @ 3 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
4805	Peak	51.7	7330	Peak	53.9	4961	Peak	54.5
	AVG	41.2		AVG	45.1		AVG	48.1
7209	Peak	58.8		Peak		7441	Peak	60.1
	AVG	51.6		AVG			AVG	53.9
For peak emissions results > 18 GHz see plots below								

Results: RX / idle – mode (Antenna 1)

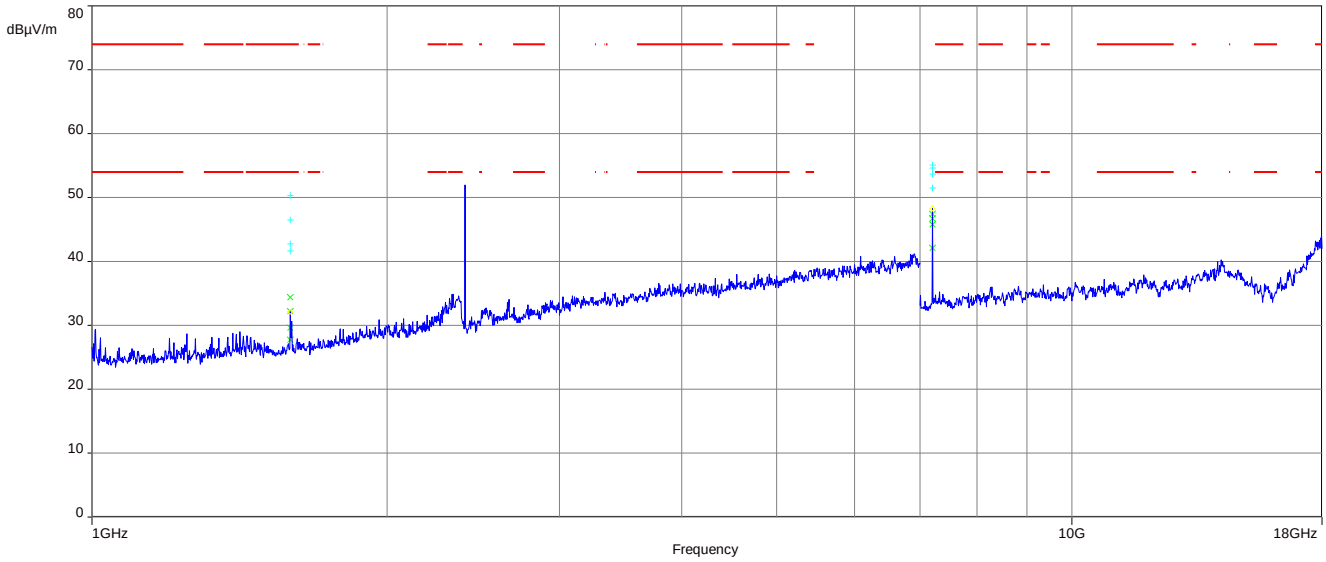
TX spurious emissions radiated / dBµV/m @ 3 m		
f / MHz	Detector	Level / dBµV/m
All detected emissions are more than 10 dB below the limit.		
For peak emissions results > 18 GHz see plots below		

Results: RX / idle – mode (Antenna 2)

TX spurious emissions radiated / dBµV/m @ 3 m		
f / MHz	Detector	Level / dBµV/m
All detected emissions are more than 10 dB below the limit.		
For peak emissions results > 18 GHz see plots below		

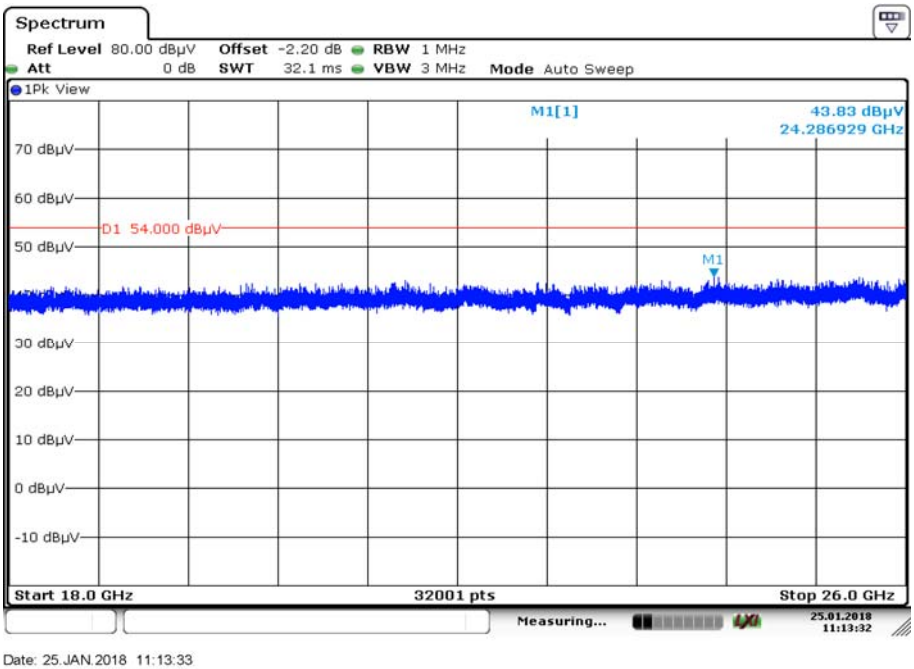
Plots: Antenna 1

Plot 1: Lowest channel, 1 GHz to 18 GHz, vertical & horizontal polarization



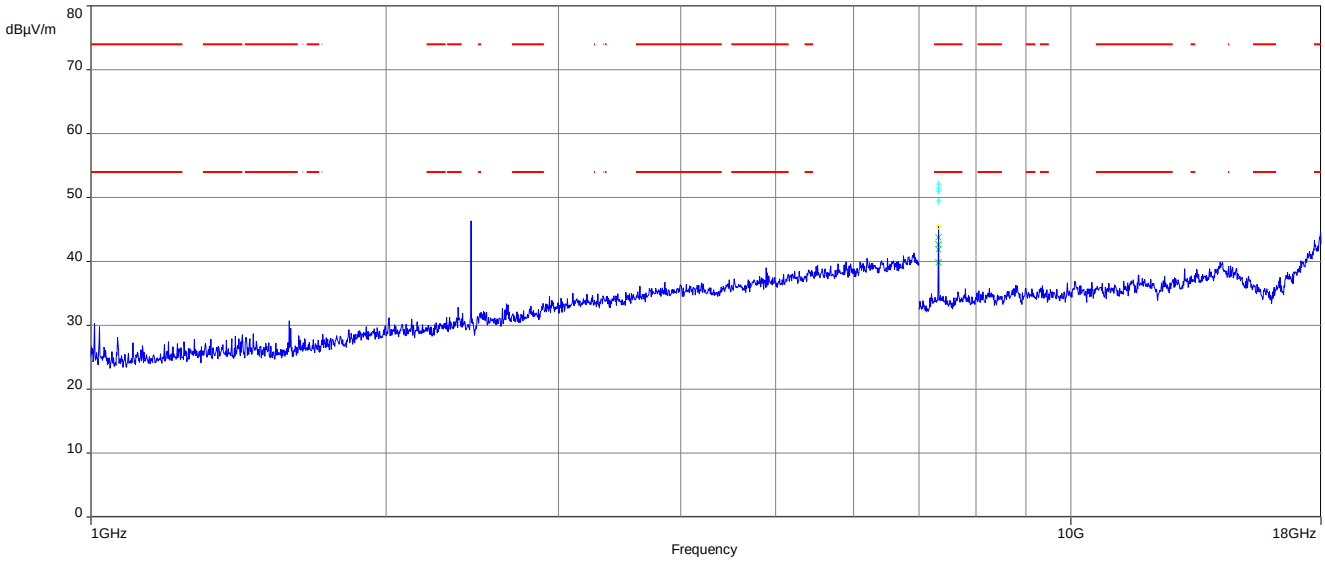
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 3: Lowest channel, 18 GHz to 26 GHz, vertical & horizontal polarization



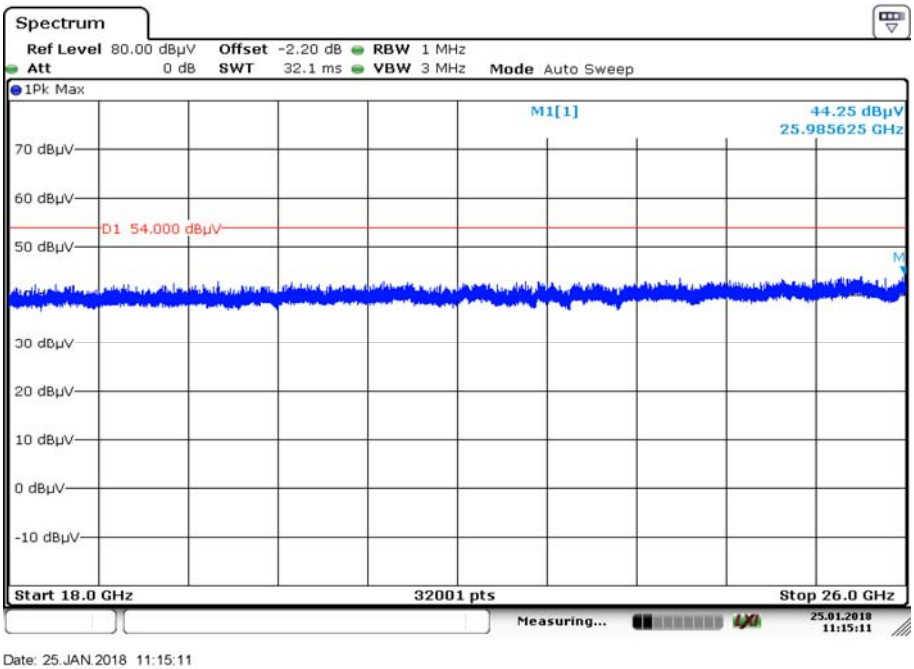
Date: 25.JAN.2018 11:13:33

Plot 4: Middle channel, 1 GHz to 18 GHz, vertical & horizontal polarization



The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 6: Middle channel, 18 GHz to 26 GHz, vertical & horizontal polarization



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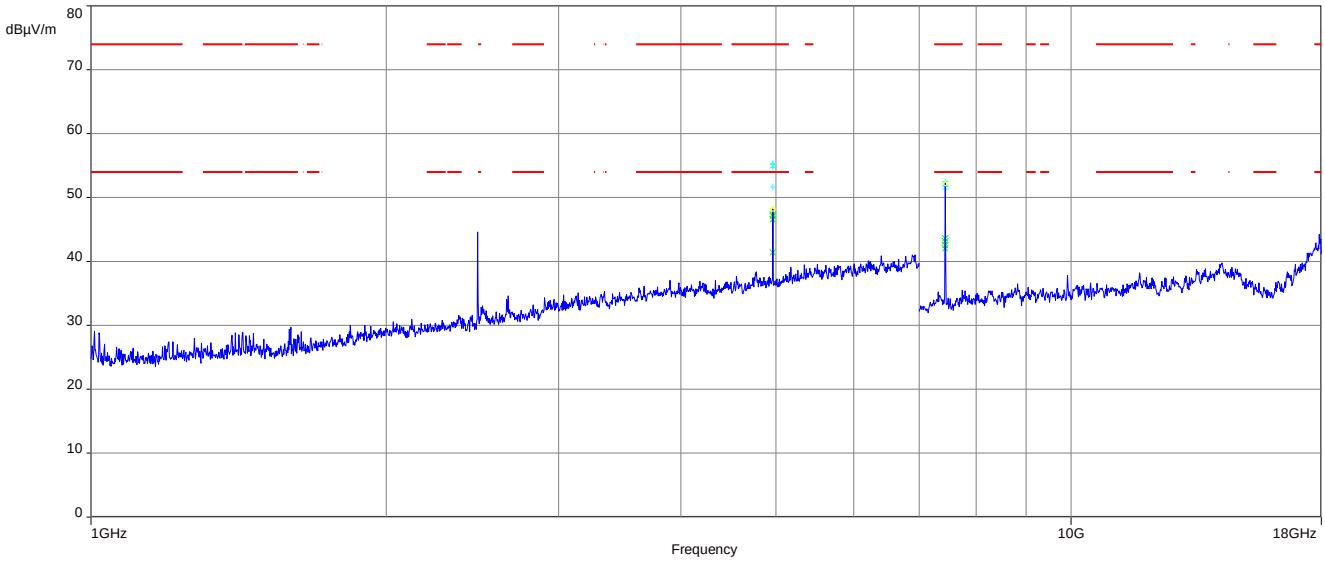
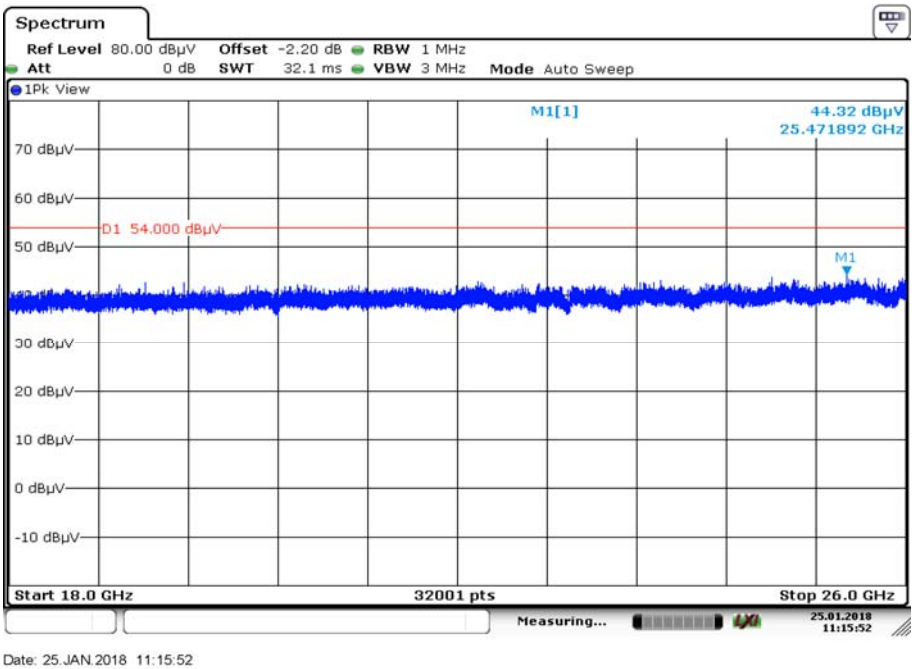
Plot 7: Highest channel, 1 GHz to 18 GHz, vertical & horizontal polarization



The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 9: Highest channel, 18 GHz to 26 GHz, vertical & horizontal polarization



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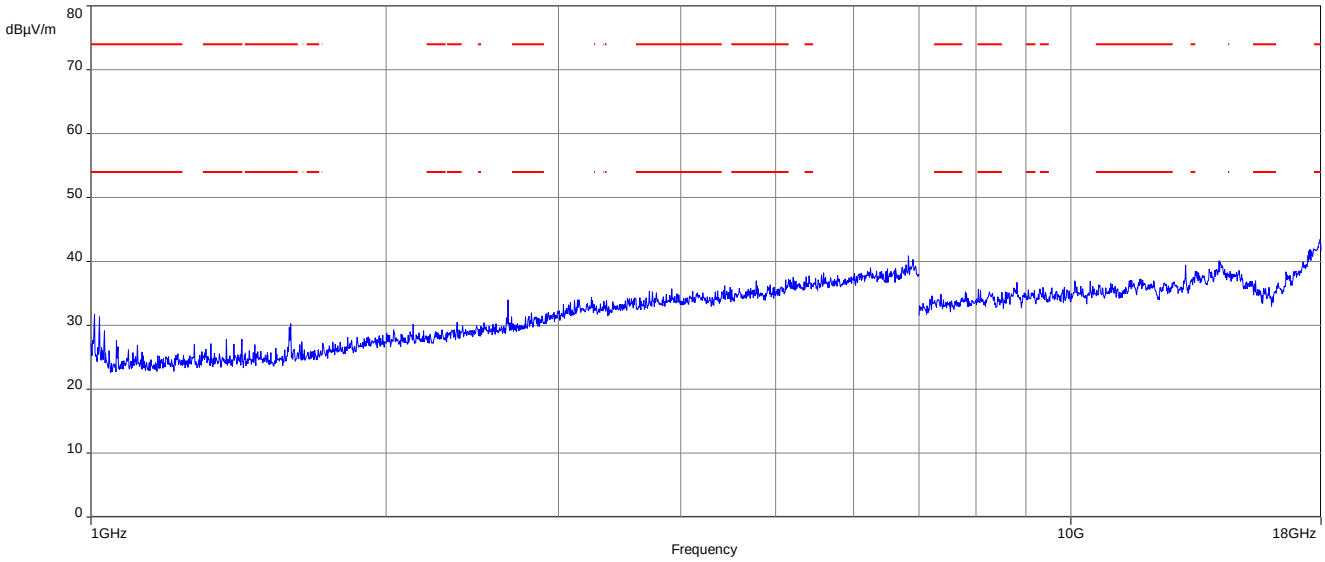
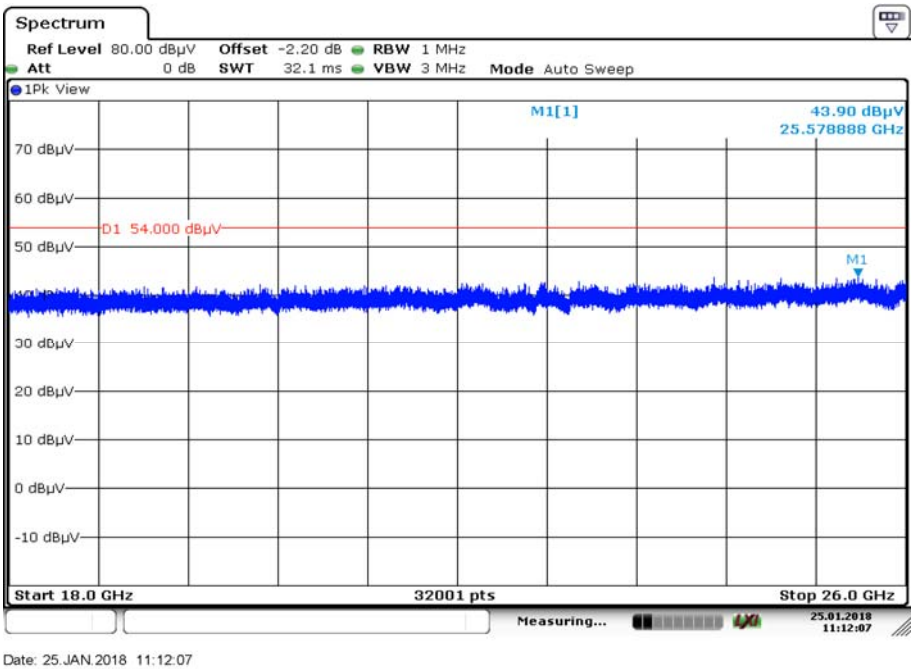
Plot 10: Rx-Mode, 1 GHz to 18 GHz, vertical & horizontal polarization



The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 3: Rx-Mode, 18 GHz to 26 GHz, vertical & horizontal polarization



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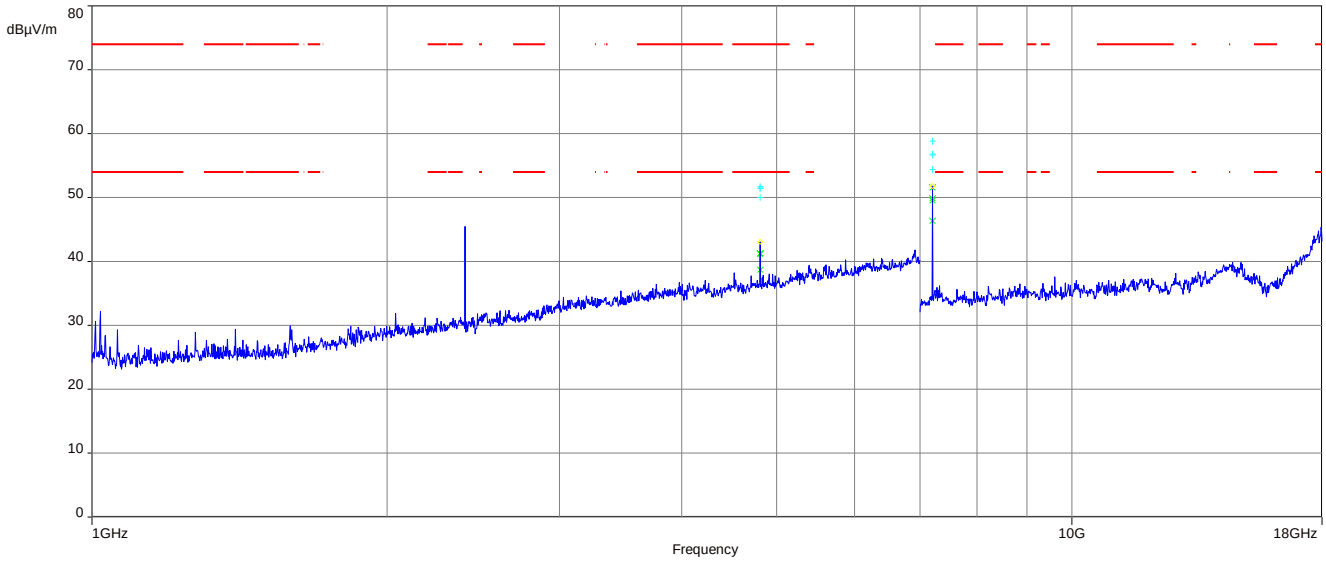
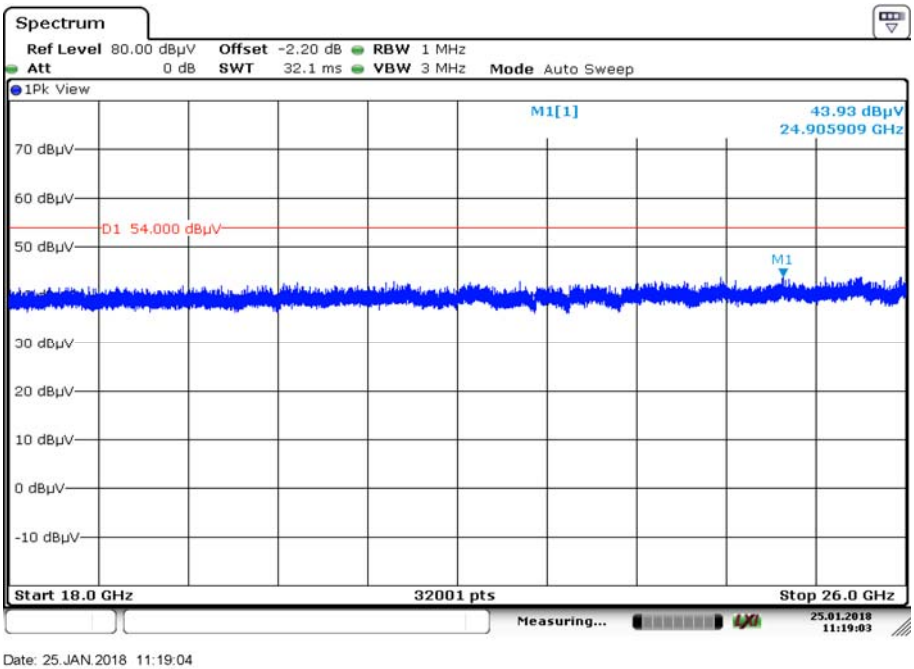
Plots: Antenna 2

Plot 1: Lowest channel, 1 GHz to 18 GHz, vertical & horizontal polarization



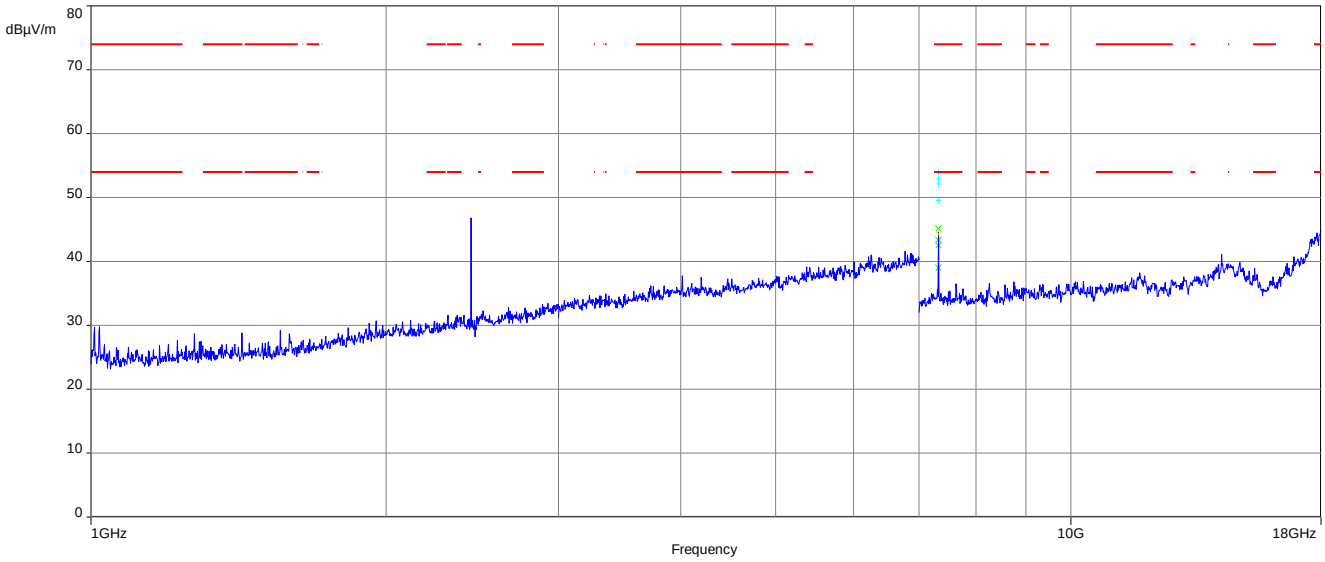
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 3: Lowest channel, 18 GHz to 26 GHz, vertical & horizontal polarization



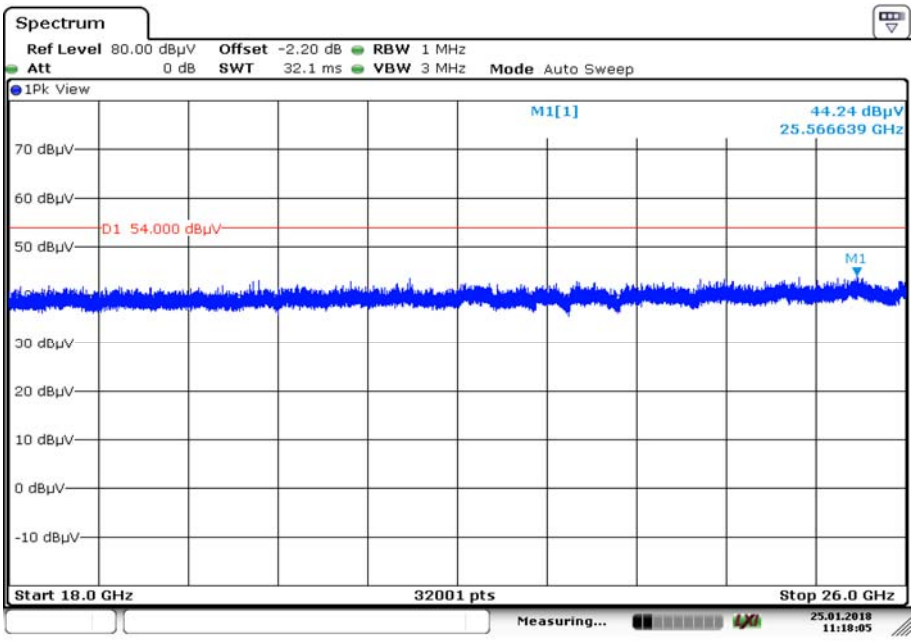
Date: 25.JAN.2018 11:19:04

Plot 4: Middle channel, 1 GHz to 18 GHz, vertical & horizontal polarization



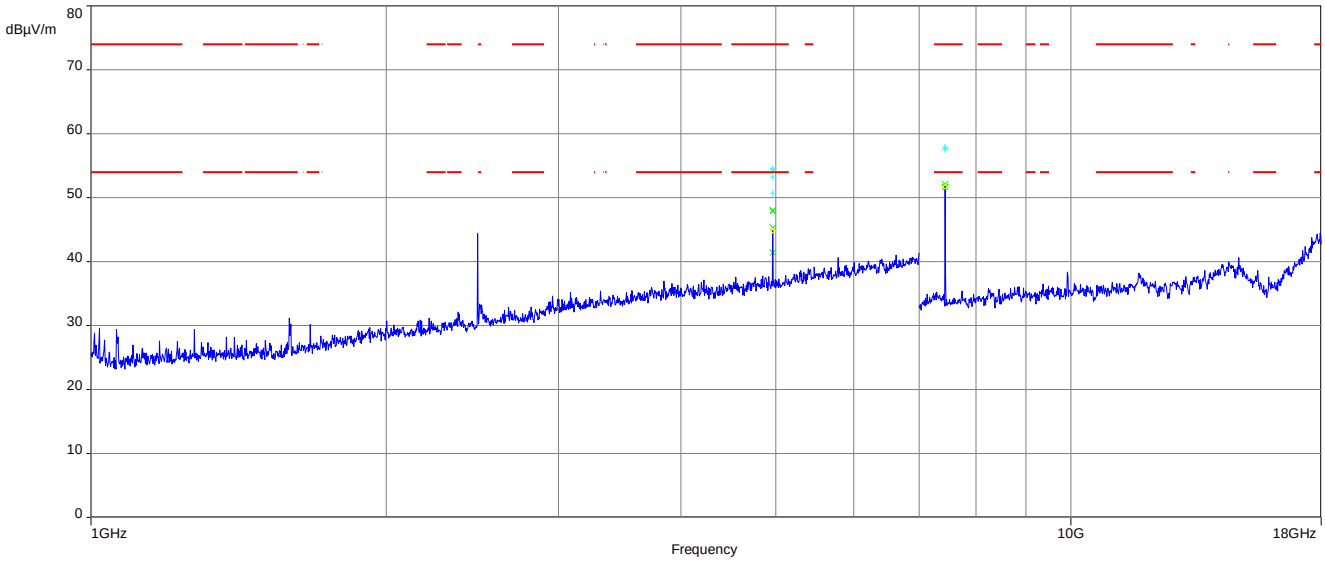
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 6: Middle channel, 18 GHz to 26 GHz, vertical & horizontal polarization



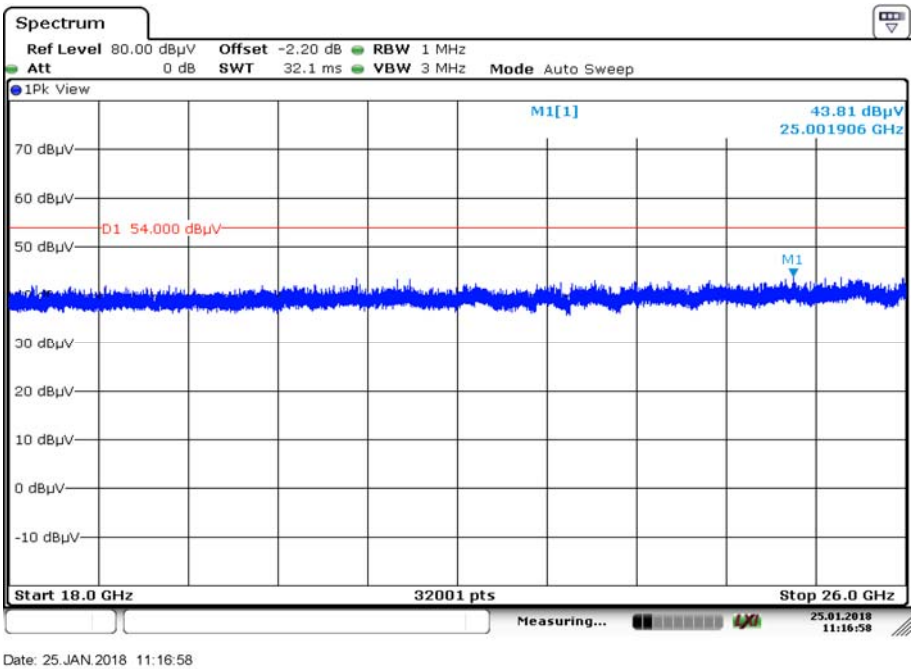
Date: 25.JAN.2018 11:18:05

Plot 7: Highest channel, 1 GHz to 18 GHz, vertical & horizontal polarization



The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 9: Highest channel, 18 GHz to 26 GHz, vertical & horizontal polarization



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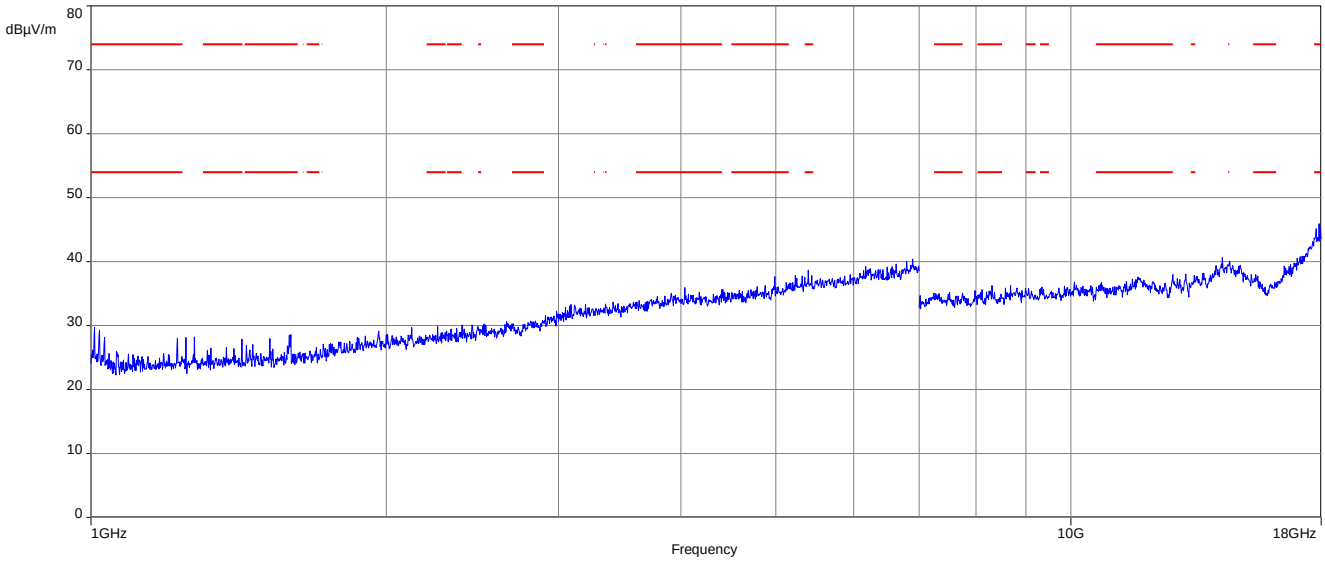
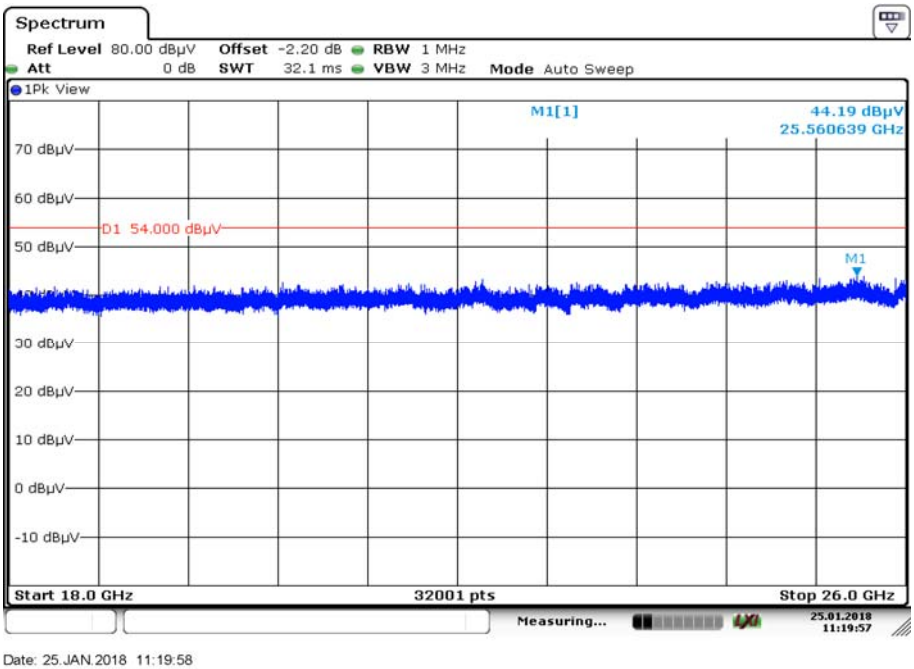
Plot 10: Rx-Mode, 1 GHz to 18 GHz, vertical & horizontal polarization



Plot 3: Rx-Mode, 18 GHz to 26 GHz, vertical & horizontal polarization



Date: 25.JAN.2018 11:19:58

13 Observations

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

Annex A Glossary

EUT	Equipment under test
DUT	Device under test
UUT	Unit under test
FCC	Federal Communications Commission
FCC ID	Company Identifier at FCC
IC	Industry Canada
PMN	Product marketing name
HMN	Host marketing name
HVIN	Hardware version identification number
FVIN	Firmware version identification number
EMC	Electromagnetic Compatibility
HW	Hardware
SW	Software
Inv. No.	Inventory number
S/N or SN	Serial number
C	Compliant
NC	Not compliant
NA	Not applicable
NP	Not performed
PP	Positive peak
QP	Quasi peak
AVG	Average
OC	Operating channel
OCW	Operating channel bandwidth
OBW	Occupied bandwidth
OOB	Out of band
DFS	Dynamic frequency selection
CAC	Channel availability check
OP	Occupancy period
NOP	Non occupancy period
DC	Duty cycle
PER	Packet error rate
CW	Clean wave
MC	Modulated carrier

Annex B Document history

Version	Applied changes	Date of release
-/-	Initial release	2018-03-05

Annex C Accreditation Certificate

first page	last page
	

Note: The current certificate annex is published on the website (link see below) of the Accreditation Body DAkkS or may be received by CTC advanced GmbH on request

http://www.dakks.de/as/ast/d/D-PL-12076-01-03.pdf