
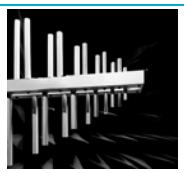
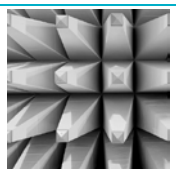

CTC advanced
member of RWTÜV group

Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

Test report no.: 1-3977/22-03-03

Testing laboratory

CTC advanced GmbH
Untertuerkheimer Strasse 6 – 10
66117 Saarbruecken / Germany
Phone: + 49 681 5 98 - 0
Fax: + 49 681 5 98 - 9075
Internet: https://www.ctcadvanced.com
e-mail: mail@ctcadvanced.com

Accredited Testing Laboratory:
The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2018-03) by the Deutsche Akkreditierungsstelle GmbH (DAkkS)
The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate starting with the registration number: D-PL-12076-01.

Applicant

SAGEMCOM BROADBAND SAS
250, route de l´ Empereur
92848 Rueil-Malmaison Cedex / FRANCE
Phone: -/-
Contact: Ludovic Bomba
e-mail: ludovic.bomba@sagemcom.com

Manufacturer

SAGEMCOM BROADBAND SAS
250, route de l´ Empereur
92848 Rueil-Malmaison Cedex / FRANCE

Test standard/s

FCC - Title 47 CFR Part 15	FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices

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

Test Item

Kind of test item:	**Gateway**
Model name:	**F5688W**
FCC ID:	**VW3F5688W**
Frequency:	2400 MHz to 2483.5 MHz
Technology tested:	WLAN
Antenna:	4 integrated antennas
Power supply:	120 V AC by power mains
Temperature range:	0°C to +50°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:

cn=Andreas Luckenbill, o=CTC advanced GmbH, ou=LUC-180217, email=andreas.luckenbill@ctcadvanced.com, c=DE
2022.12.19 13:05:03 +01'00'

Andreas Luckenbill
Head of Department
Radio Communications

Test performed:

cn=Michael Dorongovski, o=CTC advanced GmbH, ou=DOR-210422, email=Michael.Dorongovski@ctcadvanced.com, c=DE
2022.12.19 13:05:25 +01'00'

Michael Dorongovski
Lab Manager
Radio Communications

1 Table of contents

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

2.2 Application details

Date of receipt of order:	2022-10-04
Date of receipt of test item:	2022-10-04
Start of test:*	2022-11-16
End of test:*	2022-12-07
Person(s) present during the test:	-/-

*Date of each measurement, if not shown in the plot, can be requested. Dates are stored in the measurement software.

2.3 Test laboratories sub-contracted

None

3 Test standard/s, references and accreditations

Test standard	Date	Description
FCC - Title 47 CFR Part 15		FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices

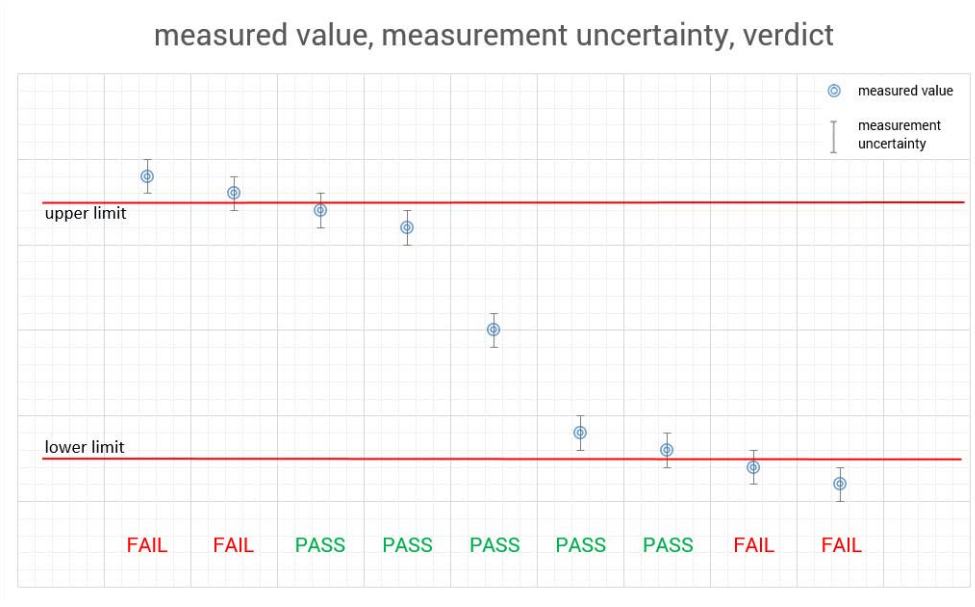
Guidance	Version	Description
KDB 558074 D01	v05r02	GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES
ANSI C63.4-2014	-/-	American National Standard for Methods of Measurement 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
KDB 662911 D01	v02r01	Emissions Testing of Transmitters with Multiple Outputs in the Same Band

Accreditation	Description
D-PL-12076-01-05	Telecommunication FCC requirements https://www.dakks.de/as/ast/d/D-PL-12076-01-05e.pdf

FCC designation number: DE0002

4 Reporting statements of conformity – decision rule

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3.
The measurement uncertainty is mentioned in this test report, see chapter 9, but is not taken into account - neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong."



5 Test environment

Temperature	:	T_{nom} T_{max} T_{min}	+22 °C during room temperature tests No tests under extreme environmental conditions required. No tests under extreme environmental conditions required.
Relative humidity content	:		42 %
Barometric pressure	:		1021 hpa
Power supply	:	V_{nom} V_{max} V_{min}	120 V AC by power mains No tests under extreme environmental conditions required. No tests under extreme environmental conditions required.

6 Test item

6.1 General description

Kind of test item	:	Gateway
Model name	:	F5688W
S/N serial number	:	Rad. QS2212959002917 (WALSIN) QS2212959002844 (HL) QS2212959002927 (COLFLY) Cond. QS2212959002927
Hardware status	:	V1.2
Software status	:	SGJi10105-0.1.52
Firmware status	:	SGJi10105-0.1.52
Frequency band	:	2400 MHz to 2483.5 MHz
Type of radio transmission Use of frequency spectrum	: :	DSSS, OFDM
Type of modulation	:	CCK, (D)BPSK, (D)QPSK, 16 – QAM, 64 – QAM
Number of channels	:	11 (20 MHz) 9 (40 MHz)
Antenna	:	4 integrated antennas
Power supply	:	120 V AC by power mains
Temperature range	:	0°C to +50°C

6.2 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: 1-3977/22-03-01_AnnexA
1-3977/22-03-01_AnnexB
1-3977/22-03-01_AnnexD

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).

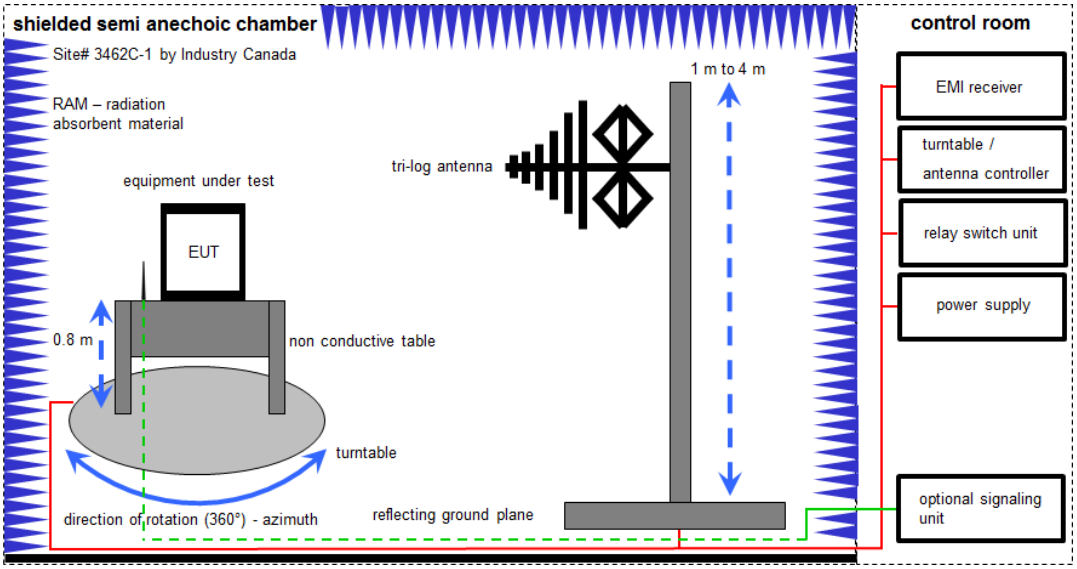
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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
vlkl!	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 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
EMC32 software version: 10.59.00

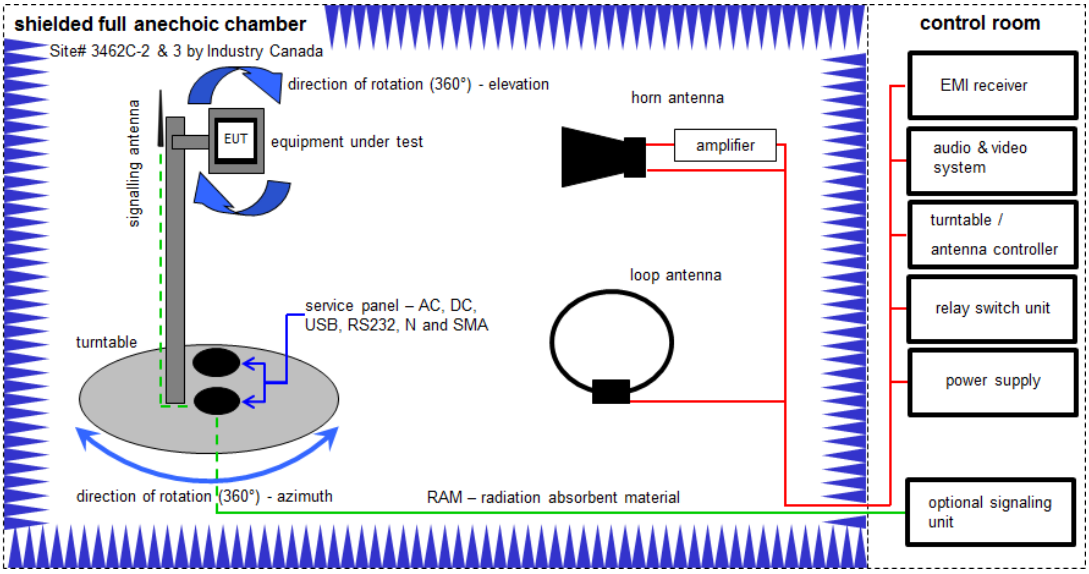
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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	Meßkabine 1	HF-Absorberhalle	MWB AG 300023	Batch no. 699714	300000551	ne	-/-	-/-
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 Mess - Elektronik	295	300003787	vIKI!	21.04.2021	20.04.2023
7	A	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	20.05.2022	31.05.2023

7.2 Shielded fully anechoic chamber



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

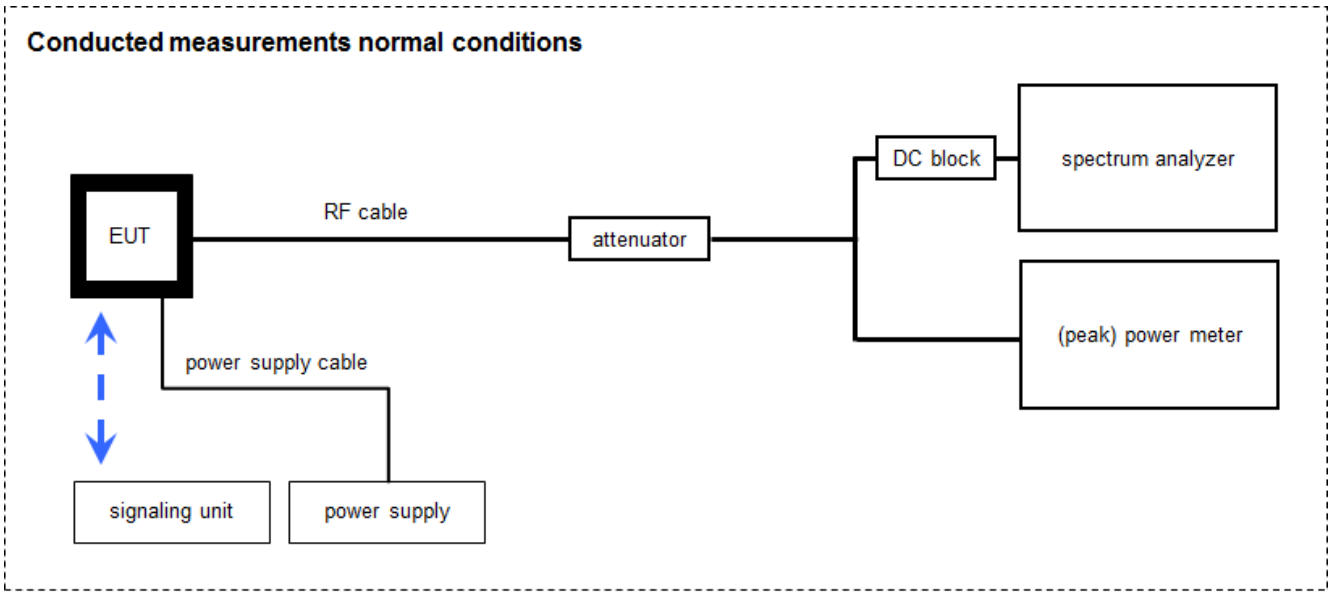
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

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

Equipment table:

No.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	C	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	vIKI!	01.07.2021	30.06.2023
2	A, B, C	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
3	A, B	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3697	300001605	vIKI!	12.03.2021	11.03.2023
4	A, B, C	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, C	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	09.12.2021	08.12.2022
7	A, B	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
8	A, B, C	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
9	A, B, C	NEXIO EMV-Software	BAT EMC V3.21.0.27	EMCO	-/-	300004682	ne	-/-	-/-
10	A, B	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-

7.3 Conducted measurements



WLAN tester version: 1.1.13; LabView2015

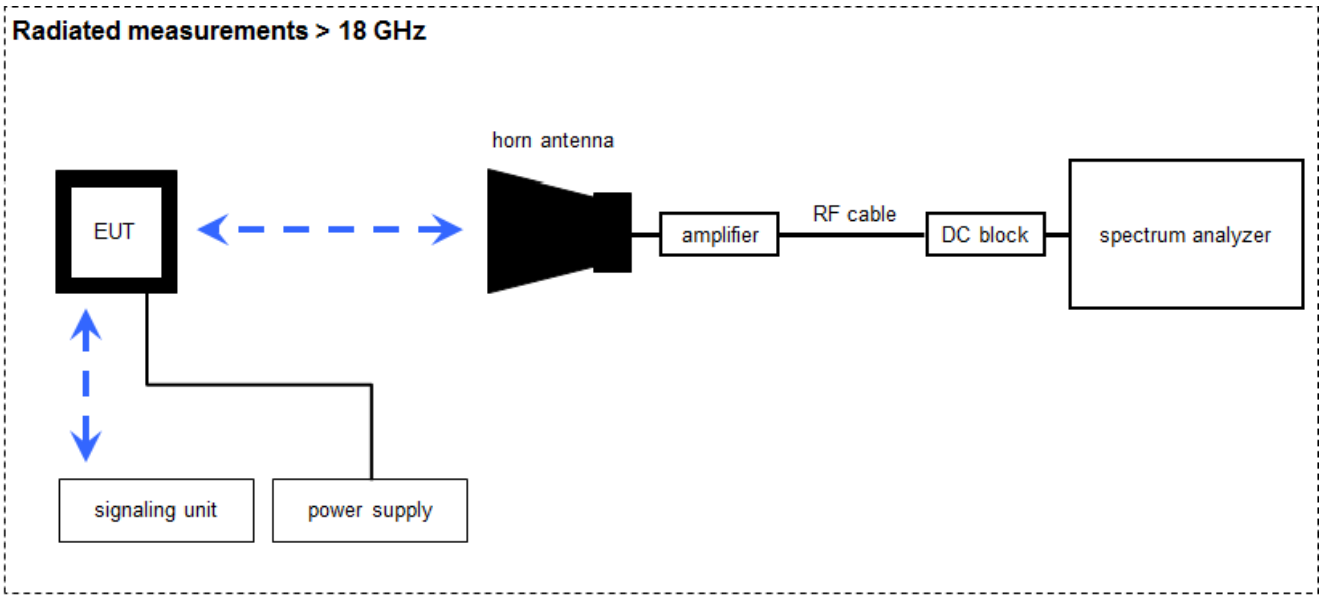
OP = AV + CA
(OP-output power; AV-analyzer value; CA-loss signal path)

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

Equipment table:

No.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	USB/GPIB interface	82357B	Agilent Technologies	MY52103346	300004390	ne	-/-	-/-
2	A	PC Laboratory	Exone	Fröhlich + Walter	S2642279-03 / 10	300004179	ne	-/-	-/-
3	A	Signal analyzer	FSV40	Rohde&Schwarz	1307.9002K40 / 101042	300004517	k	25.01.2022	31.01.2023
4	A	Tester Software RadioStar (C.BER2 for BT Conformance)	Version 1.0.0.X	CTC advanced GmbH	0001	400001380	ne	-/-	-/-

7.4 Radiated measurements > 18 GHz



Measurement distance: horn antenna 50 cm

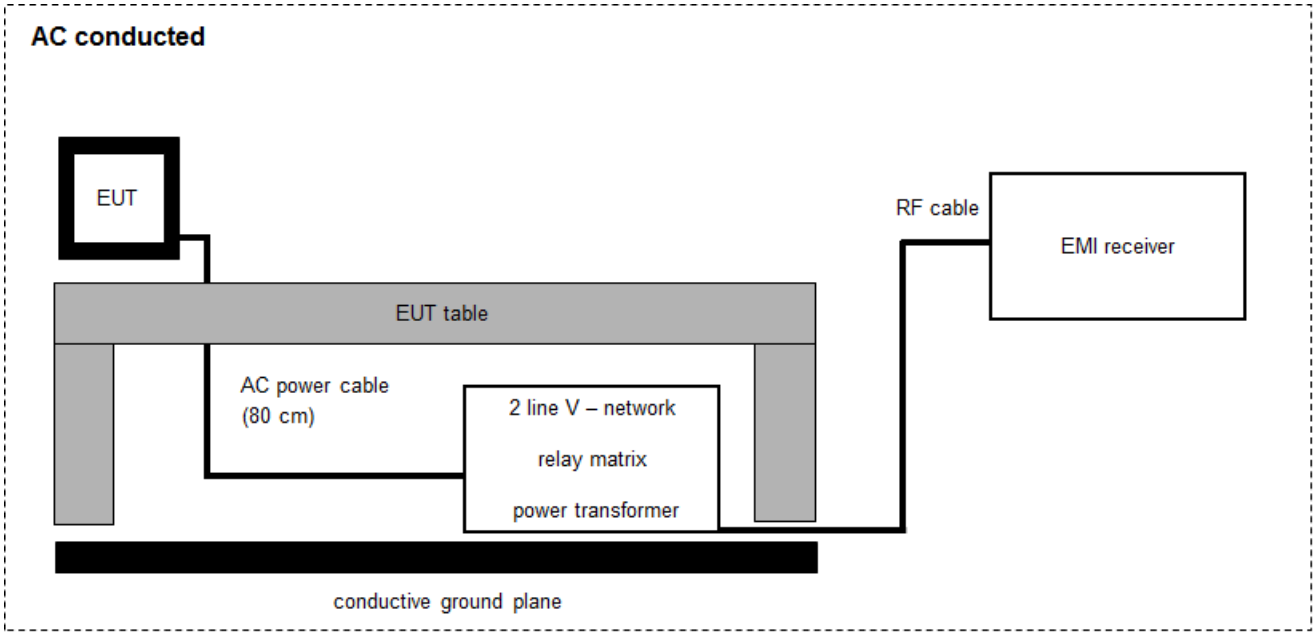
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss signal path & distance correction; AF-antenna factor)

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.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Microwave System Amplifier, 0.5-26.5 GHz	83017A	HP	00419	300002268	ev	-/-	-/-
2	A	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda	01096	300000486	vlKl!	-/-	-/-
3	A	RF-Cable	ST18/SMAm/SMAm /48	Huber & Suhner	Batch no. 600918	400001182	ev	-/-	-/-
4	A	Signal analyzer	FSV40	Rohde&Schwarz	1307.9002K40 / 101042	300004517	k	25.01.2022	31.01.2023

7.5 AC conducted



FS = UR + CF + VC
(FS-field strength; UR-voltage at the receiver; CR-loss of the cable and filter; VC-correction factor of the ISN)

Example calculation:
FS [dBµV/m] = 37.62 [dBµV/m] + 9.90 [dB] + 0.23 [dB] = 47.75 [dBµV/m] (244.06 µV/m)

Equipment table:

No.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Two-line V-Network (LISN) 9 kHz to 30 MHz	ESH3-Z5	Rohde & Schwarz	892475/017	300002209	vIKI!	14.12.2021	13.12.2023
2	A	RF-Filter-section	85420E	HP	3427A00162	300002214	NK!	-/-	-/-
3	A	EMI Test Receiver	ESR	R&S	102981	300006318	k	24.05.2022	23.05.2023
4	A	Analyzer-Reference-System (Harmonics and Flicker)	ARS 16/1	SPS	A3509 07/0 0205	300003314	vIKI!	29.12.2021	28.12.2023
5	A	Hochpass 150 kHz	EZ-25	R&S	100010	300003798	ev	-/-	-/-
6	A	PC	TecLine	F+W		300003532	ne	-/-	-/-
7	A	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-

8 Sequence of testing

8.1 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.

8.2 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.

8.3 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.

8.4 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.

9 Measurement uncertainty

Measurement uncertainty		
Test case	**Uncertainty**	
Antenna gain	± 3 dB	
Power spectral density	± 1.56 dB	
DTS bandwidth	± 100 kHz (depends on the used RBW)	
Occupied bandwidth	± 100 kHz (depends on the used RBW)	
Maximum output power conducted	± 1.56 dB	
Detailed spurious emissions @ the band edge - conducted	± 1.56 dB	
Band edge compliance radiated	± 3 dB	
Spurious emissions conducted	> 3.6 GHz	± 1.56 dB
	> 7 GHz	± 1.56 dB
	> 18 GHz	± 2.31 dB
	≥ 40 GHz	± 2.97 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	

10 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!	2022-12-19	-/-

Test specification clause	Test case	Guideline	Temperature & voltage conditions	C	NC	NA	NP	Remark
§15.247(b)(4) RSS - 247 / 5.4 (f)(ii)	Antenna gain	-/-	Nominal	Declared by customer				-/-
§15.35	Duty cycle	-/-	Nominal	-/-				-/-
§15.247(e) RSS - 247 / 5.2 (b)	Power spectral density	KDB 558074 DTS clause: 8.4	Nominal	☒	☐	☐	☐	-/-
§15.247(a)(2) RSS - 247 / 5.2 (a)	DTS bandwidth	KDB 558074 DTS clause: 8.2	Nominal	☒	☐	☐	☐	-/-
RSS Gen clause 4.6.1	Occupied bandwidth	-/-	Nominal	☒	☐	☐	☐	-/-
§15.247(b)(3) RSS - 247 / 5.4 (d)	Maximum output power	KDB 558074 DTS clause: 8.3.1.3	Nominal	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5	Detailed spurious emissions @ the band edge – cond.	-/-	Nominal	☒	☐	☐	☐	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance cond. or rad.	KDB 558074 DTS clause: 8.7.3	Nominal	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5	TX spurious emissions cond.	KDB 558074 DTS clause: 8.5	Nominal	☒	☐	☐	☐	-/-
§15.209(a) RSS-Gen	TX spurious emissions rad. below 30 MHz	-/-	Nominal	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5 RSS-Gen	TX spurious emissions rad. 30 MHz to 1 GHz	-/-	Nominal	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5 RSS-Gen	TX spurious emissions rad. above 1 GHz	-/-	Nominal	☒	☐	☐	☐	-/-
§15.107(a) §15.207	Conducted emissions < 30 MHz	-/-	Nominal	☒	☐	☐	☐	-/-

Notes:

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

11 Additional information and comments

Reference documents: None

Co-applicable documents:
1-3977_22-03-03_Annex_MR_A1.pdf (802.11b)
1-3977_22-03-03_Annex_MR_A2.pdf (802.11g)
1-3977_22-03-03_Annex_MR_A3.pdf (802.11n HT20)
1-3977_22-03-03_Annex_MR_A4.pdf (802.11n HT40)
1-3977_22-03-03_Annex_MR_A5.pdf (802.11ax HE20)
1-3977_22-03-03_Annex_MR_A6.pdf (802.11ax HE40)

Special test descriptions: All tests were performed with the EUT transmitting on all ports/antennas simultaneously with >98% duty cycle.
There are three different versions of the device. The only differences in the versions are the antennas. All antennas have the same type, size and characteristics but they are provided by different manufacturers (COLFLY, HL and WALSIN). Therefore antenna gains slightly differ (See chapter 13.1 for detailed information). Full radiated tests were performed with the COLFLY antennas. On HL and WALSIN antennas only partial testing in the worst case scenarios was performed.
Used power settings for all tests:

Power settings													
channel	1	2	3	4	5	6	7	8	9	10	11	12	13
f_c / MHz	2412	2417	2422	2427	2432	2437	2442	2447	2452	2457	2462	2467	2472
b-mode	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**		
g-mode	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**		
nHT20-mode	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**21**		
nHT40-mode			**23**	**23**	**23**	**23**	**23**	**23**	**21**				
axHE20-mode	**21**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**20**		
axHE40-mode			**22**	**23**	**23**	**23**	**23**	**23**	**21**				

Configuration descriptions: All tests were performed with the QRCT software.

EUT selection:
☐ Only one device available
☐ Devices selected by the customer
☒ Devices selected by the laboratory (Randomly)

Provided channels:

Channels with 20 MHz channel bandwidth:

channel number & center frequency													
channel	**1**	2	3	4	5	**6**	7	8	9	10	**11**	12	13
f_c / MHz	**2412**	2417	2422	2427	2432	**2437**	2442	2447	2452	2457	**2462**	2467	2472

Channels with 40 MHz channel bandwidth:

channel number & center frequency													
channel	-/-	-/-	**3**	4	5	**6**	7	8	**9**	10	11	-/-	-/-
f_c / MHz	-/-	-/-	**2422**	2427	2432	**2437**	2442	2447	**2452**	2457	2462	-/-	-/-

Note: The channels used for the tests are marked in bold in the list, plus some additional channel conducted if the power increases compared to the band edge channel.

12 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:	☒	Wide Band Modulation (None Hopping – e.g. DSSS, OFDM)
	☐	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.*

13 Measurement results

13.1 Antenna gain

Limits:

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

See antenna documentation provided by the customer for details on the antenna gain.

Results: COLFLY antennas

Combined gain for 4x4 MIMO	lowest channel	middle channel	highest channel
Gain [dBi] / Declared	6.64		

Results: WALSIN antennas

Combined gain for 4x4 MIMO	lowest channel	middle channel	highest channel
Gain [dBi] / Declared	6.36		

Results: HL antennas

Combined gain for 4x4 MIMO	lowest channel	middle channel	highest channel
Gain [dBi] / Declared	5.57		

13.2 Identify worst case data rate

Results:

Modulation scheme / bandwidth	
802.11b	1 Mbit/s
802.11g	6 Mbit/s
802.11n HT20	MCS24
802.11n HT40	MCS24
802.11ax HE20	MCS0
802.11ax HE40	MCS0

The worst case data rates are declared by manufacturer.

13.3 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	
Average measurement method according to ANSI C63.10-2013 Chapter 11.9.2.2.2	
Test setup	See chapter 7.3 setup A
Measurement uncertainty	See chapter 9

Limits:

FCC
29.36 dBm (As the highest gain is 6.64 dBi, the limit has to be reduced to 36 dBm – 6.64 dBi = 29.36 dBm)

Results:

antenna port 1	maximum output power / [dBm]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	20.9		20.7		20.4
802.11g	22.5		22.7		23.0
802.11n HT20	23.3		23.4	22.9	20.6
802.11ax HE20	21.6	22.7	23.3	22.6	19.8
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	22.4		23.1	23.1	21.2
802.11ax HE40	21.5	22.8	23.2	23.2	21.0

antenna port 2	maximum output power / [dBm]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	20.4		20.3		20.9
802.11g	22.2		22.7		22.9
802.11n HT20	22.9		22.9	21.9	20.1
802.11ax HE20	21.5	22.8	23.2	23.0	19.8
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	22.6		22.7	22.7	21.0
802.11ax HE40	21.7	22.6	22.8	22.9	21.0

antenna port 3	maximum output power / [dBm]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	21.1		21.3		20.9
802.11g	22.6		23.0		23.1
802.11n HT20	23.2		23.3	22.5	20.5
21802.11ax HE20	21.3	23.0	23.4	23.0	19.9
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	22.5		23.0	22.8	21.0
802.11ax HE40	21.7	22.8	23.3	23.1	21.1

antenna port 4	maximum output power / [dBm]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	20.6		20.9		20.9
802.11g	22.5		22.9		23.0
802.11n HT20	23.1		23.3	22.7	20.6
802.11ax HE20	23.0	22.9	23.4	23.0	19.9
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	22.3		23.1	22.8	21.0
802.11ax HE40	21.7	22.8	23.3	23.1	21.1

Sum of antenna ports 1, 2, 3 and 4	maximum output power / [dBm]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	26.78		26.84		26.80
802.11g	28.47		28.85		29.02
802.11n HT20	29.15		29.25	28.54	26.48
802.11ax HE20	27.93	28.87	29.35	28.92	25.87
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	28.47		29.00	28.87	27.07
802.11ax HE40	27.67	28.77	29.18	29.10	27.07

13.4 Duty cycle

Limits:

FCC
No limitation!

Results:

Duty cycle / correction factor	All channels		
802.11b	100 % / 0.0 dB	100 % / 0.0 dB	100 % / 0.0 dB
802.11g	100 % / 0.0 dB	100 % / 0.0 dB	100 % / 0.0 dB
802.11n HT20	100 % / 0.0 dB	100 % / 0.0 dB	100 % / 0.0 dB
802.11n HT40	100 % / 0.0 dB	100 % / 0.0 dB	100 % / 0.0 dB
802.11ax HE20	100 % / 0.0 dB	100 % / 0.0 dB	100 % / 0.0 dB
802.11ax HE40	100 % / 0.0 dB	100 % / 0.0 dB	100 % / 0.0 dB

13.5 Average power spectral density

Description:

Measurement of the peak power spectral density of a digital modulated system. The PSD shows the strength of the variations as a function of the frequency.

Measurement:

Measurement parameter	
Average measurement method according to ANSI C63.10-2013 Chapter 11.10.5	
External result file(s)	1-3977_22-03-03_Annex_MR_A1.pdf (802.11b) 1-3977_22-03-03_Annex_MR_A2.pdf (802.11g) 1-3977_22-03-03_Annex_MR_A3.pdf (802.11n HT20) 1-3977_22-03-03_Annex_MR_A4.pdf (802.11n HT40) 1-3977_22-03-03_Annex_MR_A5.pdf (802.11ax HE20) 1-3977_22-03-03_Annex_MR_A6.pdf (802.11ax HE40)
Test setup	See chapter 7.3 setup A
Measurement uncertainty	See chapter 9

Limits:

FCC
8 dBm / 3 kHz (conducted)

Results:

antenna port 1	Average power spectral density / [dBm] @ 3 kHz				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	-7.8		-8.2		-8.6
802.11g	-9.8		-9.9		-10.5
802.11n HT20	-8.9		-9.8	-10.2	-12.5
802.11ax HE20	-12.1	-10.8	-11.0	-11.5	-14.8
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	-13.2		-12.9	-12.8	-14.8
802.11ax HE40	-15.5	-14.5	-14.2	-14.2	-16.2

antenna port 2	Average power spectral density / [dBm] @ 3 kHz				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	-8.6		-8.6		-8.9
802.11g	-10.0		-10.1		-10.2
802.11n HT20	-9.9		-10.2	-11.2	-13.1
802.11ax HE20	-12.7	-11.6	-11.3	-12.0	-14.9
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	-13.4		-13.5	-13.5	-15.0
802.11ax HE40	-15.5	-14.6	-14.6	-14.5	-16.5

antenna port 3	Average power spectral density / [dBm] @ 3 kHz				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	-7.6		-7.9		-8.0
802.11g	-10.2		-9.9		-10.3
802.11n HT20	-9.8		-9.4	-10.9	-12.8
802.11ax HE20	-12.8	-11.5	-11.0	-12.0	-14.7
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	-13.4		-13.1	-13.1	-15.3
802.11ax HE40	-15.6	-14.5	-14.4	-14.8	-16.6

antenna port 4	Average power spectral density / [dBm] @ 3 kHz				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	-8.2		-8.5		-7.5
802.11g	-9.9		-9.8		-9.6
802.11n HT20	-9.8		-9.8	-10.8	-12.7
802.11ax HE20	-12.8	-11.3	-11.3	-11.9	-14.4
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	-13.5		-13.2	-13.6	-15.5
802.11ax HE40	-15.7	-14.5	-14.4	-14.7	-16.8

Sum of antenna ports 1, 2, 3 and 4	**Average power spectral density / [dBm] @ 3 kHz**				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	-2.1		-2.3		-2.2
802.11g	-4.0		-3.9		-4.1
802.11n HT20	-3.6		-3.8	-4.7	-6.8
802.11ax HE20	-6.6	-5.3	-5.1	-5.8	-8.7
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	-7.4		-7.2	-7.2	-9.1
802.11ax HE40	-9.6	-8.5	-8.4	-8.5	-10.5

13.6 6 dB DTS bandwidth

Description:

Measurement of the 6 dB bandwidth of the modulated signal.

Measurement:

Measurement parameter	
According to DTS clause: 8.2	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	100 kHz
Video bandwidth	500 kHz
Span	30 MHz / 50 MHz
Trace mode	Single count with 200 counts
External result file(s)	1-3977_22-03-03_Annex_MR_A1.pdf (802.11b) 1-3977_22-03-03_Annex_MR_A2.pdf (802.11g) 1-3977_22-03-03_Annex_MR_A3.pdf (802.11n HT20) 1-3977_22-03-03_Annex_MR_A4.pdf (802.11n HT40) 1-3977_22-03-03_Annex_MR_A5.pdf (802.11ax HE20) 1-3977_22-03-03_Annex_MR_A6.pdf (802.11ax HE40)
Test setup	See chapter 7.3 setup A
Measurement uncertainty	See chapter 9

Limits:

FCC
Systems using digital modulation techniques may operate in the 2400–2483.5 MHz band. The minimum 6 dB bandwidth shall be at least 500 kHz.

Results:

antenna port 1	6 dB DTS bandwidth / [kHz]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	7992		8044		7544
802.11g	15676		16280		15928
802.11n HT20	15944		16916	17128	16516
802.11ax HE20	17512	18204	18246	17872	17760
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	35496		35704	35680	35688
802.11ax HE40	36992	37488	37448	37328	36416

antenna port 2	6 dB DTS bandwidth / [kHz]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	7048		8032		8000
802.11g	15748		15900		15696
802.11n HT20	16332		17288	16872	17148
802.11ax HE20	18452	18716	18628	18752	18728
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	35880		35704	35304	35688
802.11ax HE40	37704	37888	37544	37584	37440

antenna port 3	6 dB DTS bandwidth / [kHz]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	7560		8004		8048
802.11g	16284		16308		16280
802.11n HT20	17140		17504	17280	17284
802.11ax HE20	18628	18500	18716	18740	18712
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	35264		35280	35440	35696
802.11ax HE40	37480	37360	37232	37272	36992

antenna port 4	6 dB DTS bandwidth / [kHz]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	7548		7528		8024
802.11g	15932		16284		16004
802.11n HT20	16924		17288	17548	17136
802.11ax HE20	18828	18756	18888	18896	18764
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	35048		35680	35896	35712
802.11ax HE40	36560	37480	37712	37744	36784

13.7 Occupied bandwidth – 20 dB bandwidth

Description:

Measurement of the 20 dB bandwidth of the modulated carrier.

Measurement:

Measurement parameter	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	100 kHz
Video bandwidth	500 kHz
Span	30 MHz / 50 MHz
Trace mode	Single count with min. 200 counts
External result file(s)	1-3977_22-03-03_Annex_MR_A1.pdf (802.11b) 1-3977_22-03-03_Annex_MR_A2.pdf (802.11g) 1-3977_22-03-03_Annex_MR_A3.pdf (802.11n HT20) 1-3977_22-03-03_Annex_MR_A4.pdf (802.11n HT40) 1-3977_22-03-03_Annex_MR_A5.pdf (802.11ax HE20) 1-3977_22-03-03_Annex_MR_A6.pdf (802.11ax HE40)
Test setup	See chapter 7.3 setup A
Measurement uncertainty	See chapter 9

Usage:

FCC
The complete bandwidth has to be within the frequency range of the band.

Results:

antenna port 1	20 dB bandwidth / [MHz]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	14.7		15.1		14.8
802.11g	18.5		18.9		18.8
802.11n HT20	19.8		20.0	19.9	19.7
802.11ax HE20	20.5	20.6	20.9	20.7	20.6
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	39.5		39.9	40.2	39.4
802.11ax HE40	40.6	40.9	41.1	40.9	40.3

antenna port 2	20 dB bandwidth / [MHz]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	14.5		15.0		15.2
802.11g	18.5		18.4		18.8
802.11n HT20	19.7		19.6	19.8	19.7
802.11ax HE20	20.7	20.6	20.8	20.9	20.6
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	39.6		39.6	39.4	39.4
802.11ax HE40	40.6	40.7	40.6	40.8	40.6

antenna port 3	20 dB bandwidth / [MHz]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	14.8		14.8		14.7
802.11g	18.5		18.6		19.0
802.11n HT20	19.8		19.8	20.1	19.8
802.11ax HE20	20.5	20.8	20.8	20.9	20.7
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	39.4		39.5	39.6	39.6
802.11ax HE40	40.7	40.4	40.6	40.7	40.5

antenna port 4	20 dB bandwidth / [MHz]				
	Channel 1	Channel 2	Channel 6	Channel 10	Channel 11
802.11b	14.8		14.8		14.7
802.11g	18.5		18.5		18.5
802.11n HT20	19.6		19.5	19.7	19.4
802.11ax HE20	20.6	20.8	20.7	20.9	20.5
	Channel 3	Channel 4	Channel 6	Channel 8	Channel 9
802.11n HT40	39.2		39.6	39.5	39.2
802.11ax HE40	40.5	40.8	40.8	40.8	40.6

13.8 Band edge compliance radiated

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. Measurement distance is 3 meter.

Measurement:

	Measurement parameter for peak measurements	Measurement parameter for average measurements According to DTS clause: 8.7.3
Detector	Peak / AVG	RMS
Sweep time	Auto	Auto
Resolution bandwidth	1 MHz	100 kHz
Video bandwidth	3 MHz	300 kHz
Span	See plots	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 7.2 setup A	
Measurement uncertainty	See chapter 9	

Limits:

FCC
74 dBµV/m @ 3 m (Peak) 54 dBµV/m @ 3 m (AVG)

NOTE: The markers in the plots represent the results of an optimization procedure which results in an overestimation of the average values. Therefore sometimes average markers above the average limit line can be seen. After automatic optimization, all critical values were manually checked and re-measured with correct settings and suitable sweep times. The correct measured values are all included in the results tables below.

Results: COLFLY antennas

Scenario	Band edge compliance radiated [dBµV/m]
Mode	802.11b
Lower restricted band	46.5 dBµV/m AVG 58.4 dBµV/m Peak
Upper restricted band	47.2 dBµV/m AVG 58.8 dBµV/m Peak
Mode	802.11g
Lower restricted band	53.0 dBµV/m AVG 67.7 dBµV/m Peak
Upper restricted band	53.9 dBµV/m AVG 71.4 dBµV/m Peak
Mode	802.11n HT20
Lower restricted band	53.97 dBµV/m AVG 68.1 dBµV/m Peak
Upper restricted band	52.9 dBµV/m AVG 68.1 dBµV/m Peak
Mode	802.11n HT40
Lower restricted band	53.6 dBµV/m AVG 66.2 dBµV/m Peak
Upper restricted band	53.6 dBµV/m AVG 70.3 dBµV/m Peak
Mode	802.11ax HE20
Lower restricted band	53.1 dBµV/m AVG 68.6 dBµV/m Peak
Upper restricted band	52.9 dBµV/m AVG 70.2 dBµV/m Peak
Mode	802.11ax HE40
Lower restricted band	53.0 dBµV/m AVG 65.5 dBµV/m Peak
Upper restricted band	53.4 dBµV/m AVG 66.2 dBµV/m Peak

Results: WALSIN antennas

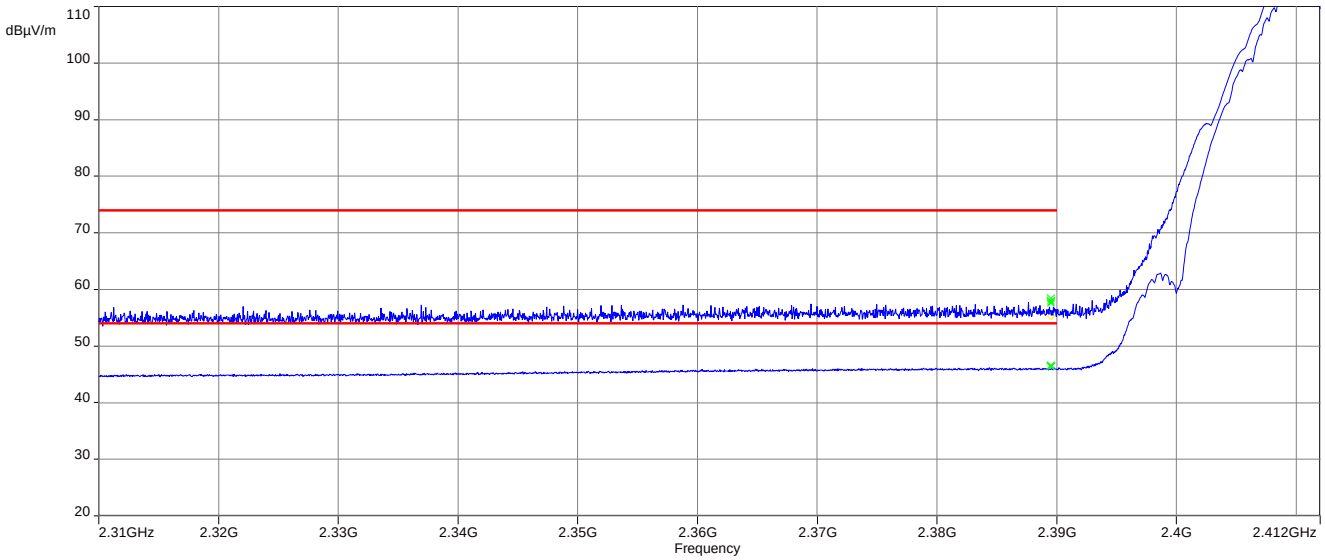
Scenario	Band edge compliance radiated [dBµV/m]
Mode	802.11g
Upper restricted band	53.9 dBµV/m AVG 72.0 dBµV/m Peak
Mode	802.11n HT20
Upper restricted band	53.8 dBµV/m AVG 70.1 dBµV/m Peak
Mode	802.11n HT40
Upper restricted band	51.5 dBµV/m AVG 67.5 dBµV/m Peak
Mode	802.11ax HE20
Upper restricted band	53.3 dBµV/m AVG 70.6 dBµV/m Peak
Mode	802.11ax HE40
Lower restricted band	53.3 dBµV/m AVG 66.2 dBµV/m Peak

Results: HL antennas

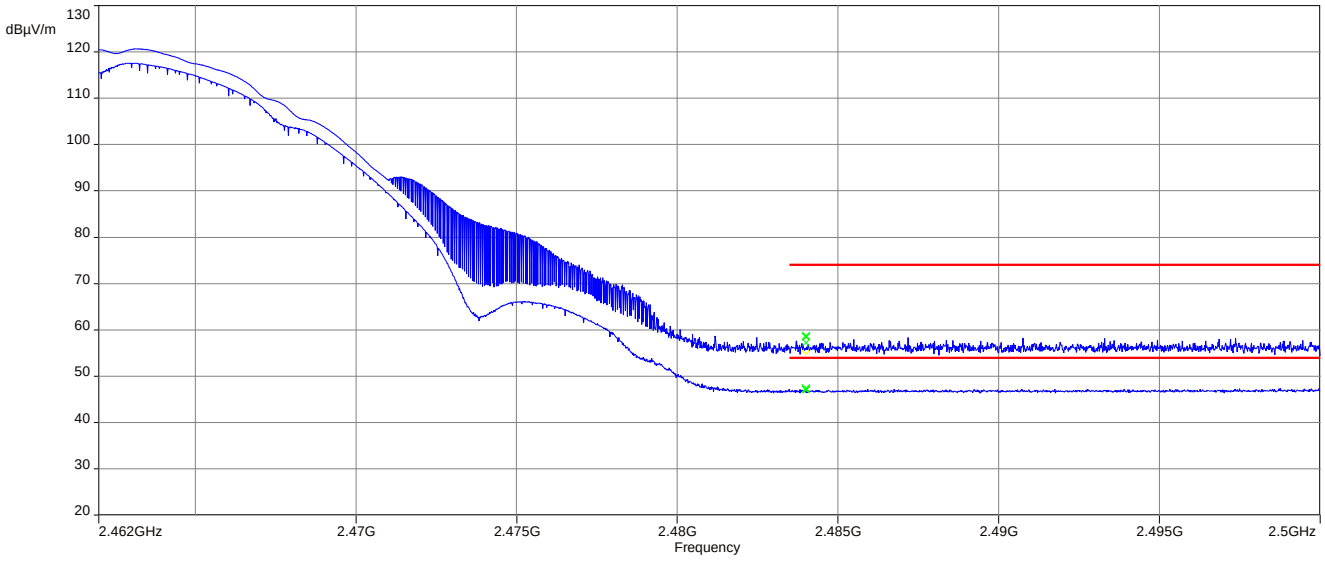
Scenario	Band edge compliance radiated [dBµV/m]
Mode	802.11g
Upper restricted band	50.6 dBµV/m AVG 67.3 dBµV/m Peak
Mode	802.11n HT20
Upper restricted band	53.7 dBµV/m AVG 70.1 dBµV/m Peak
Mode	802.11n HT40
Upper restricted band	48.8 dBµV/m AVG 64.6 dBµV/m Peak
Mode	802.11ax HE20
Upper restricted band	50.4 dBµV/m AVG 66.1 dBµV/m Peak
Mode	802.11ax HE40
Lower restricted band	53.8 dBµV/m AVG 68.8 dBµV/m Peak

Plots: COLFLY antennas

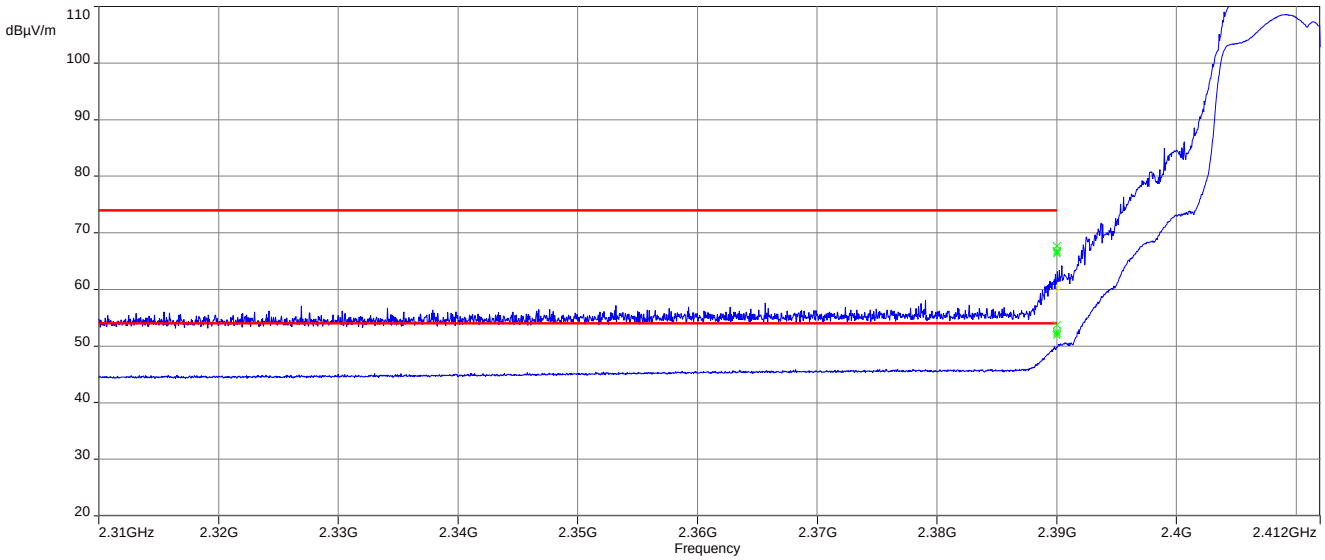
Plot 1: Lowest channel, b-mode



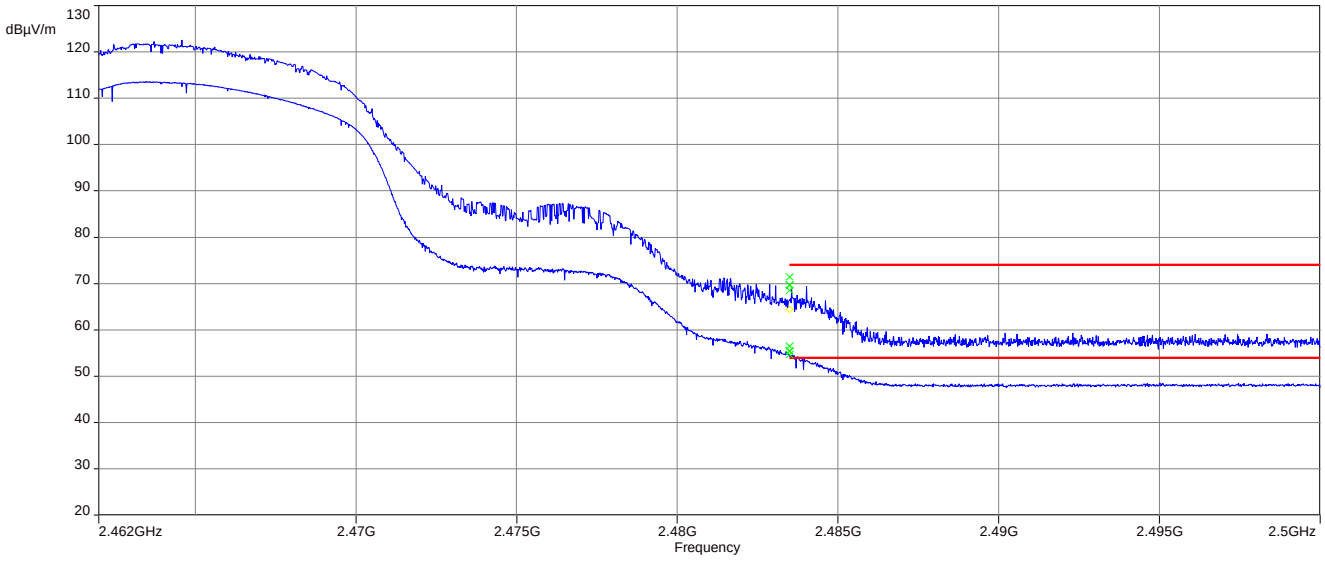
Plot 2: Highest channel, b-mode



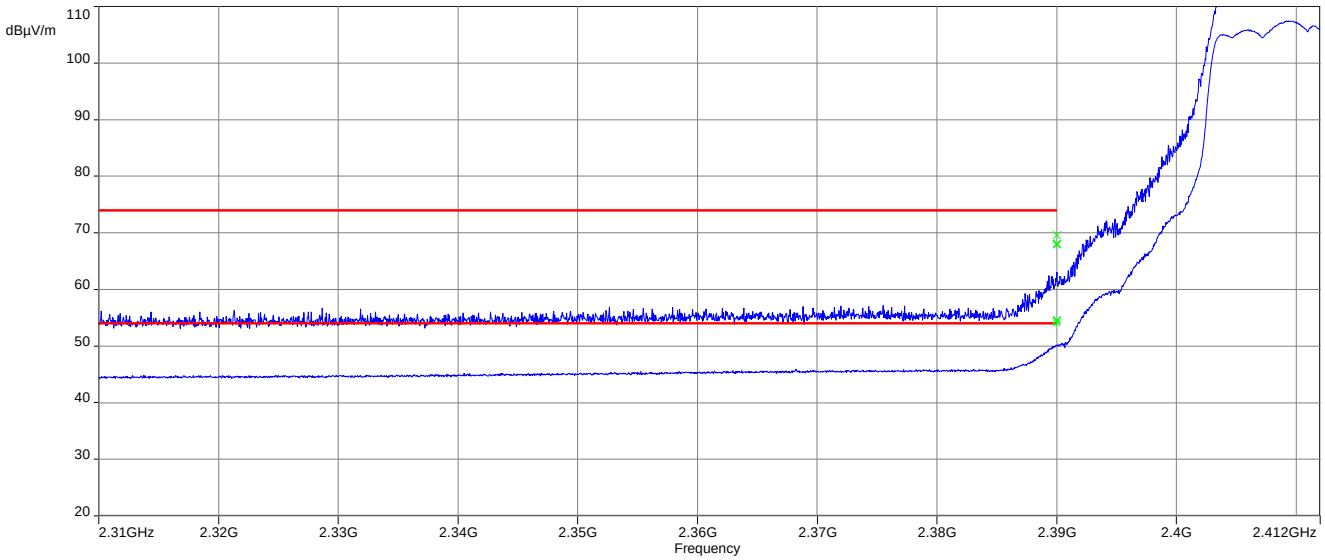
Plot 3: Lowest channel, g-mode



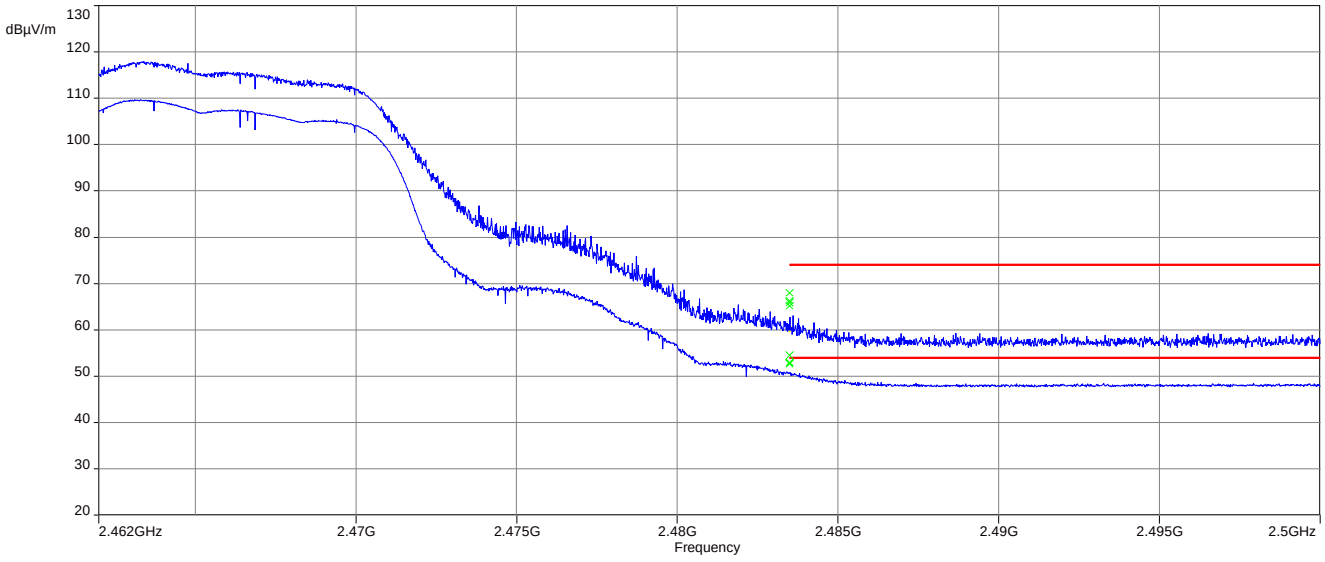
Plot 4: Highest channel, g-mode



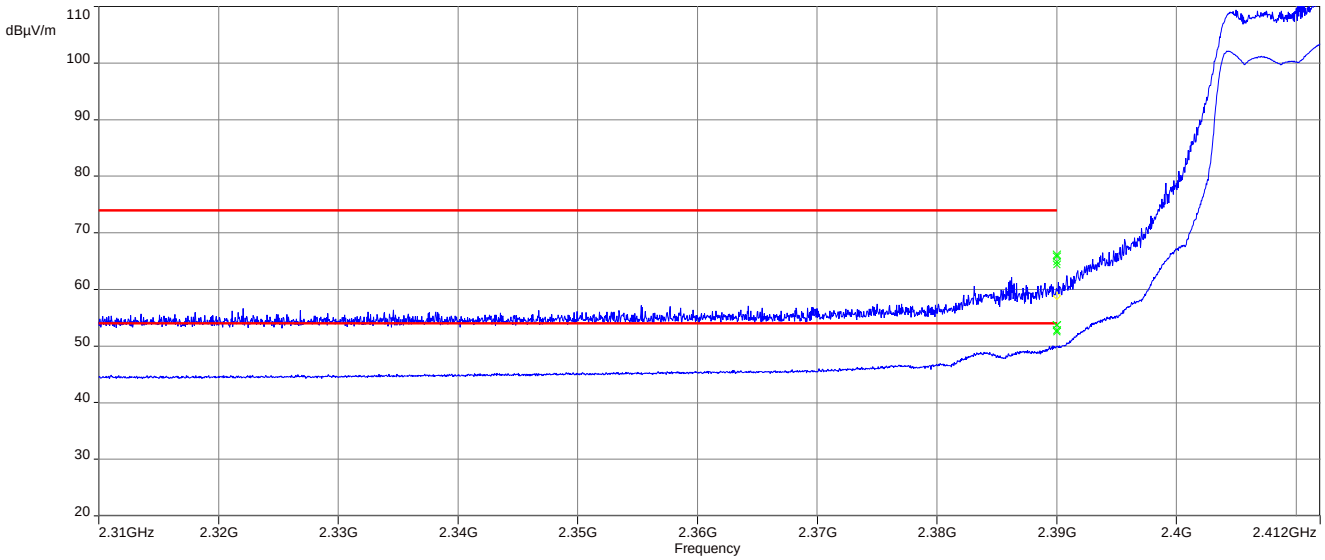
Plot 5: Lowest channel, nHT20-mode



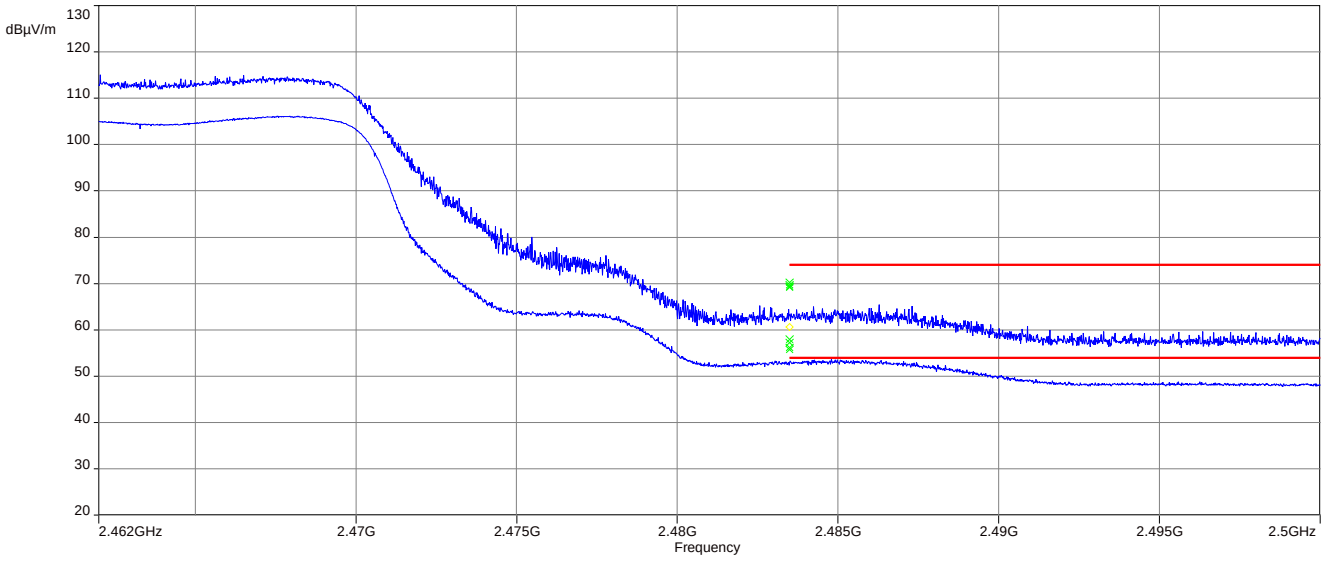
Plot 6: Highest channel, nHT20-mode



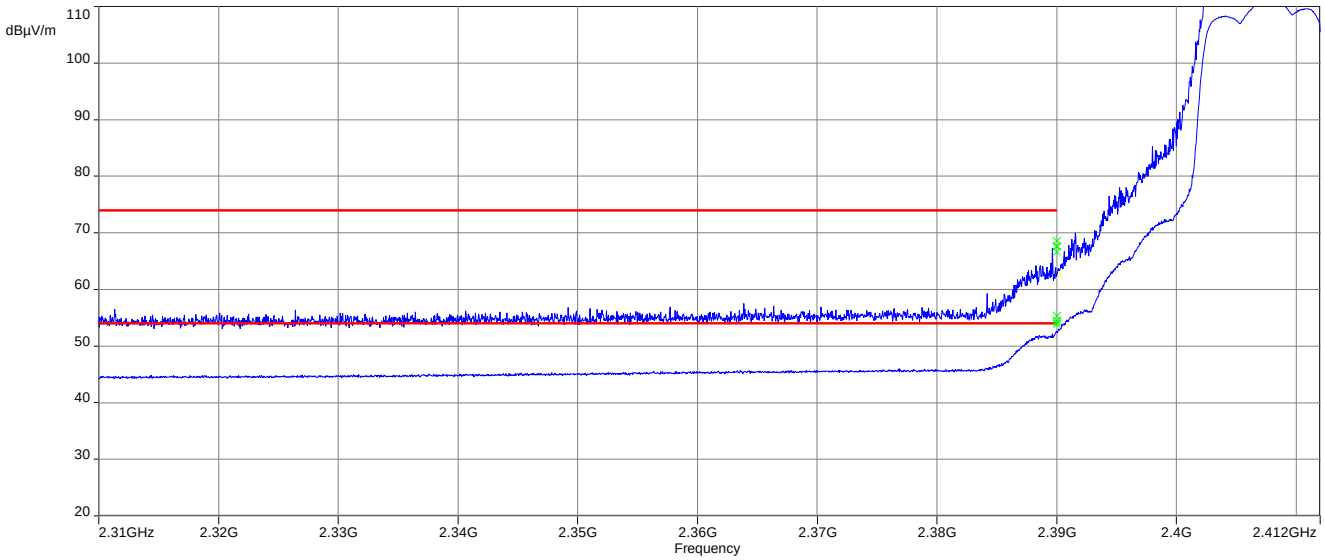
Plot 7: Lowest channel, nHT40-mode



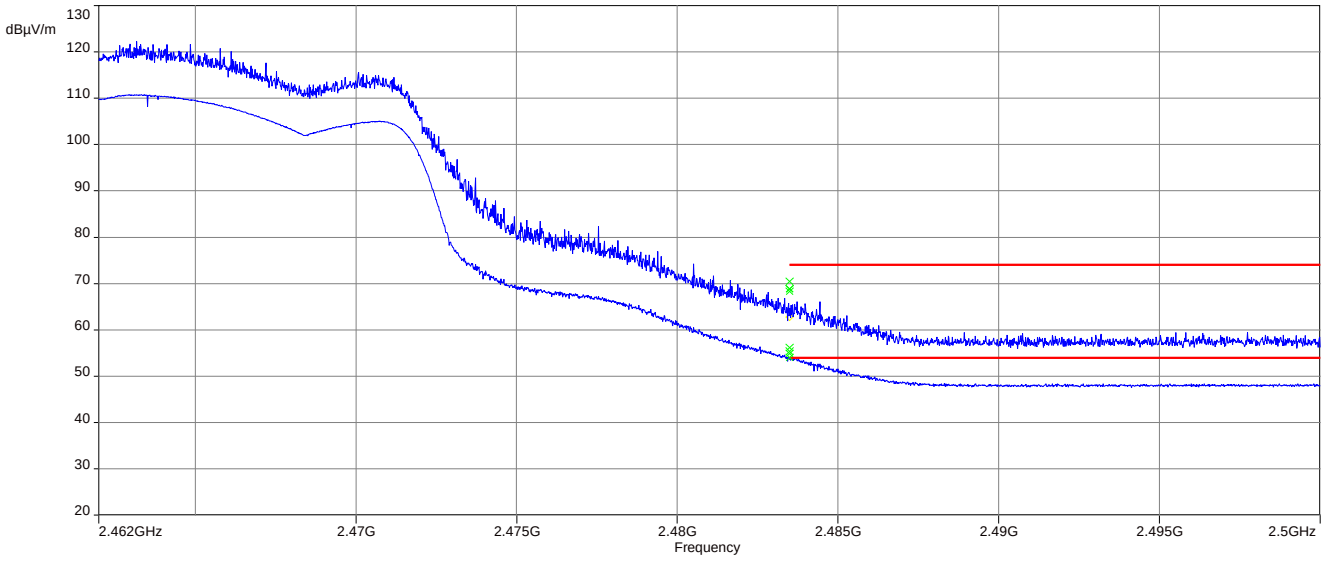
Plot 8: Highest channel, nHT40-mode



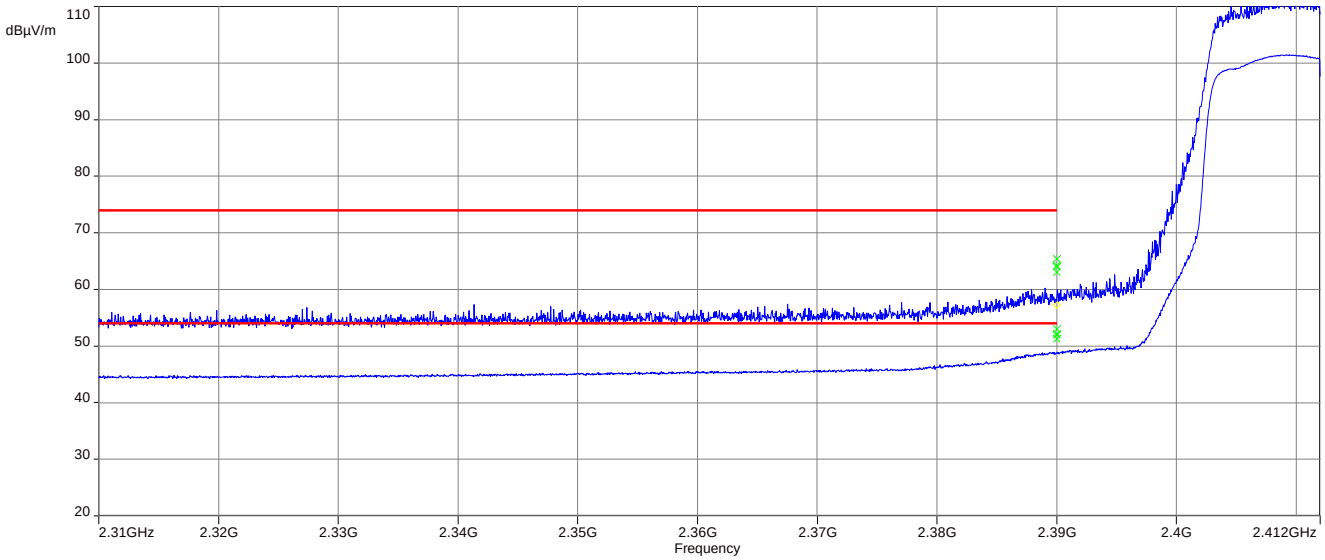
Plot 9: Lowest channel, axHE20-mode



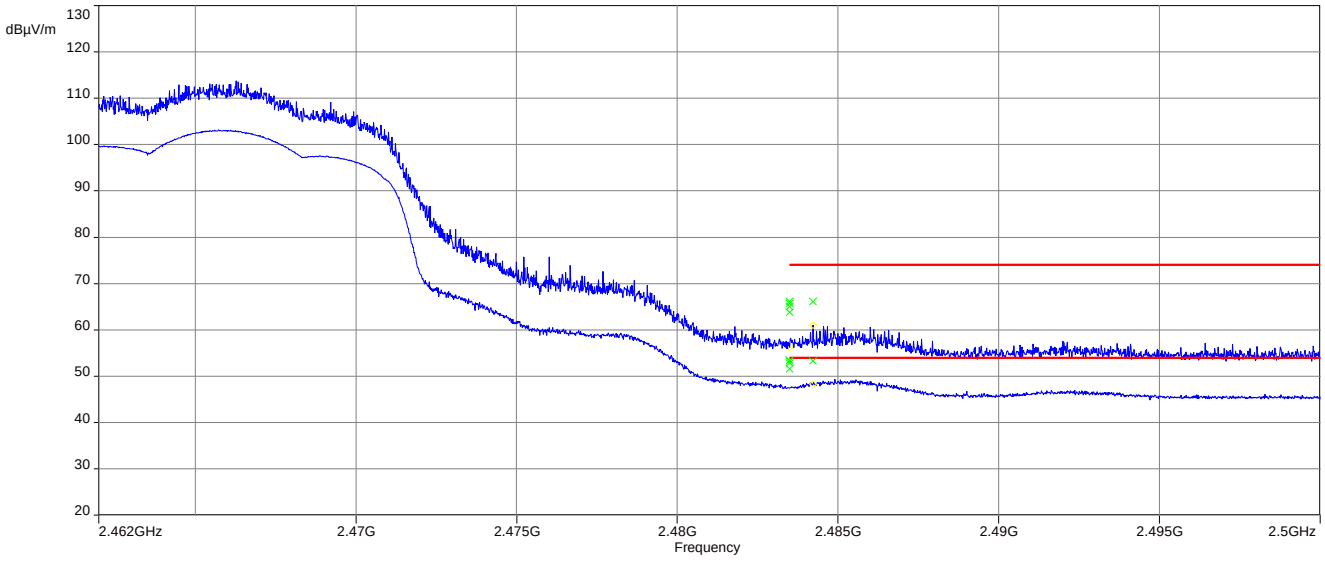
Plot 10: Highest channel, axHE20-mode



Plot 11: Lowest channel, axHE40-mode

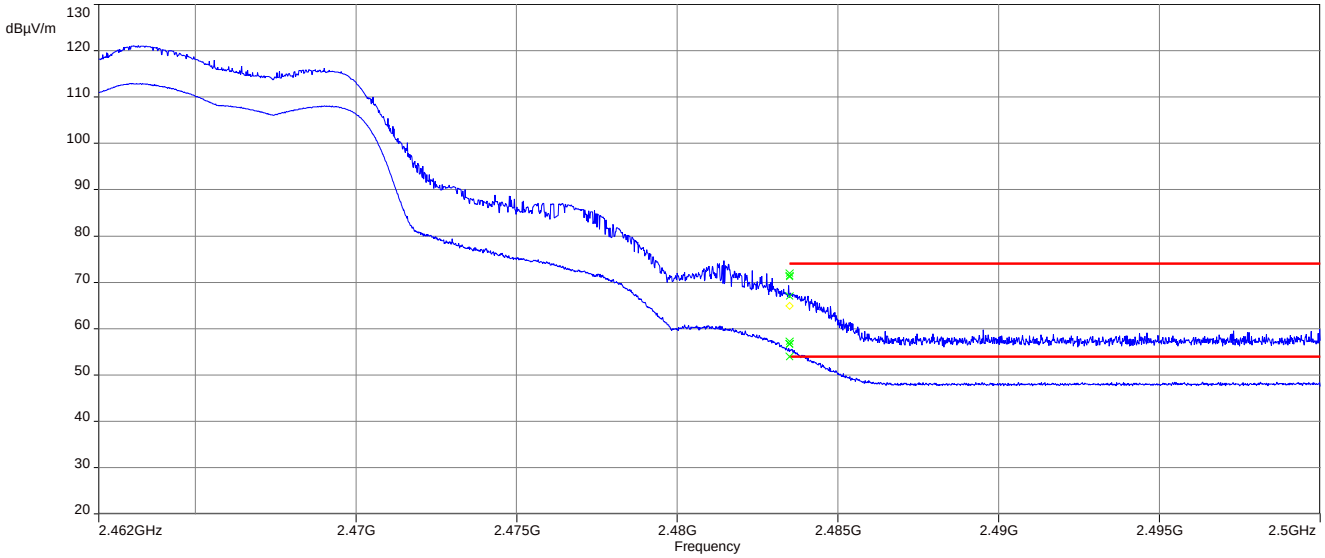


Plot 12: Highest channel, axHE40-mode

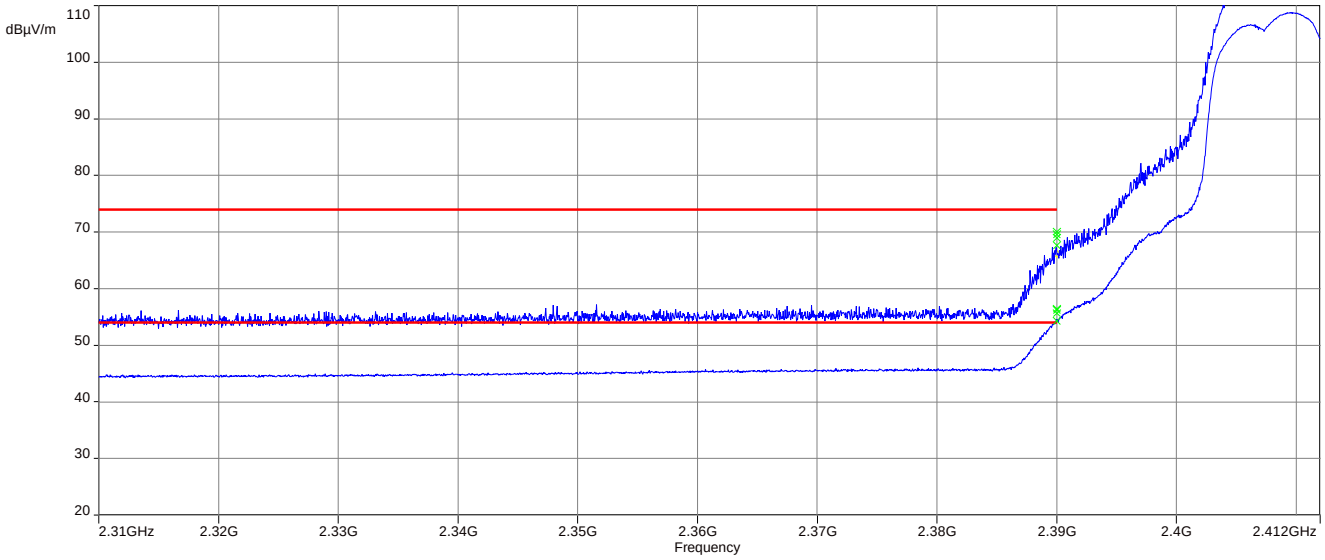


Plots: WALSIN antennas

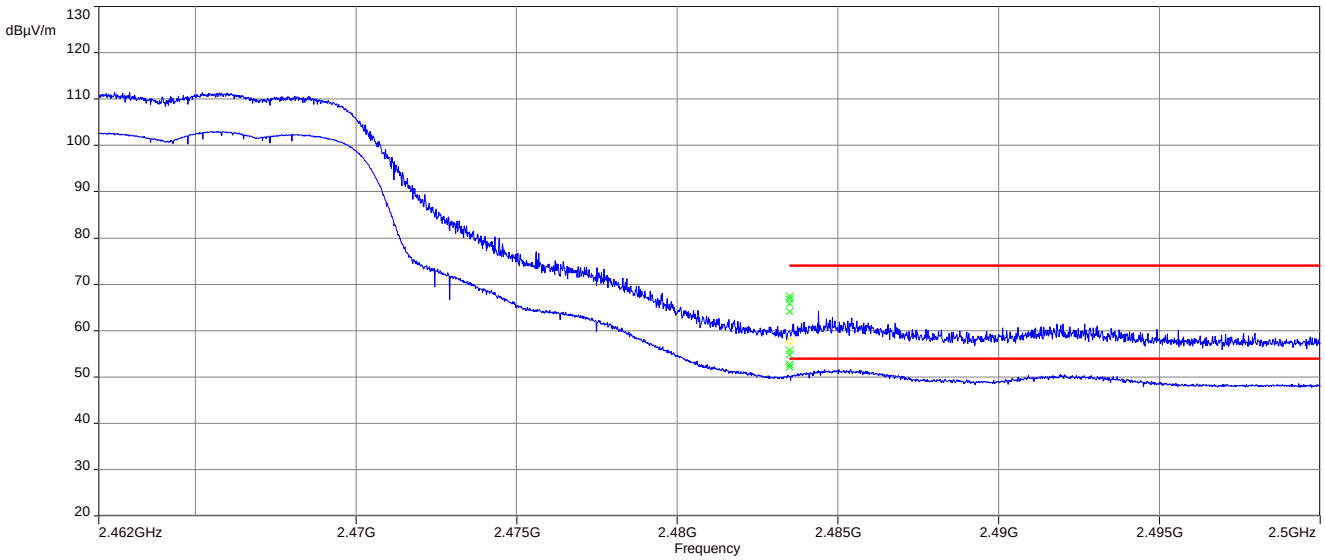
Plot 1: Highest channel, g-mode



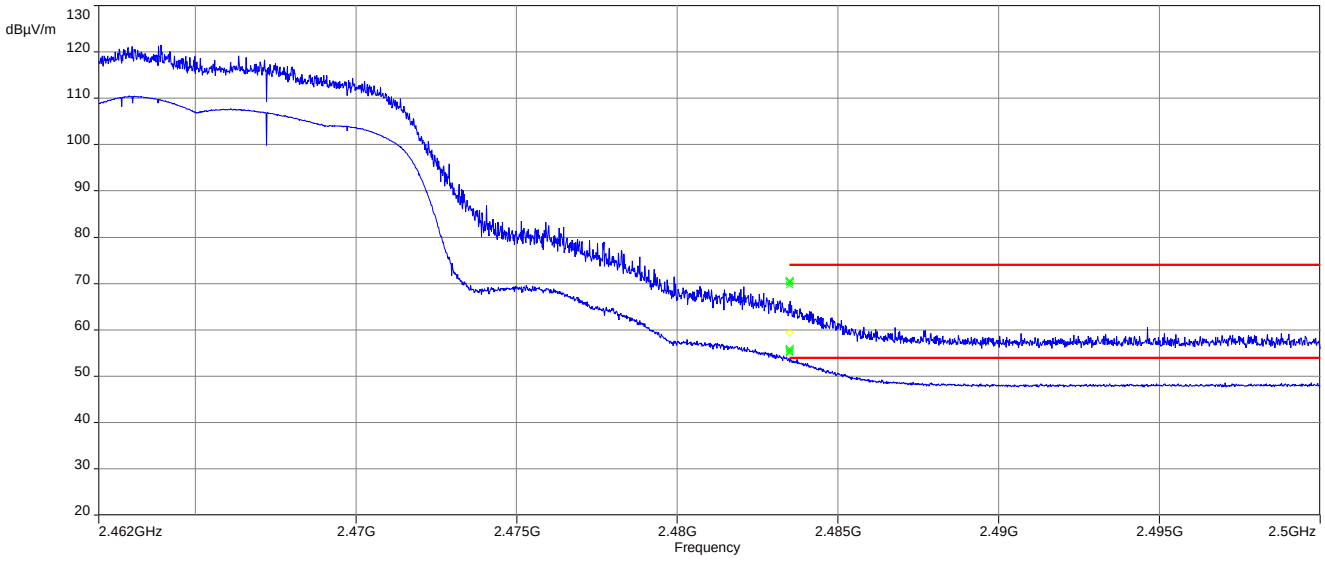
Plot 2: Highest channel, nHT20-mode



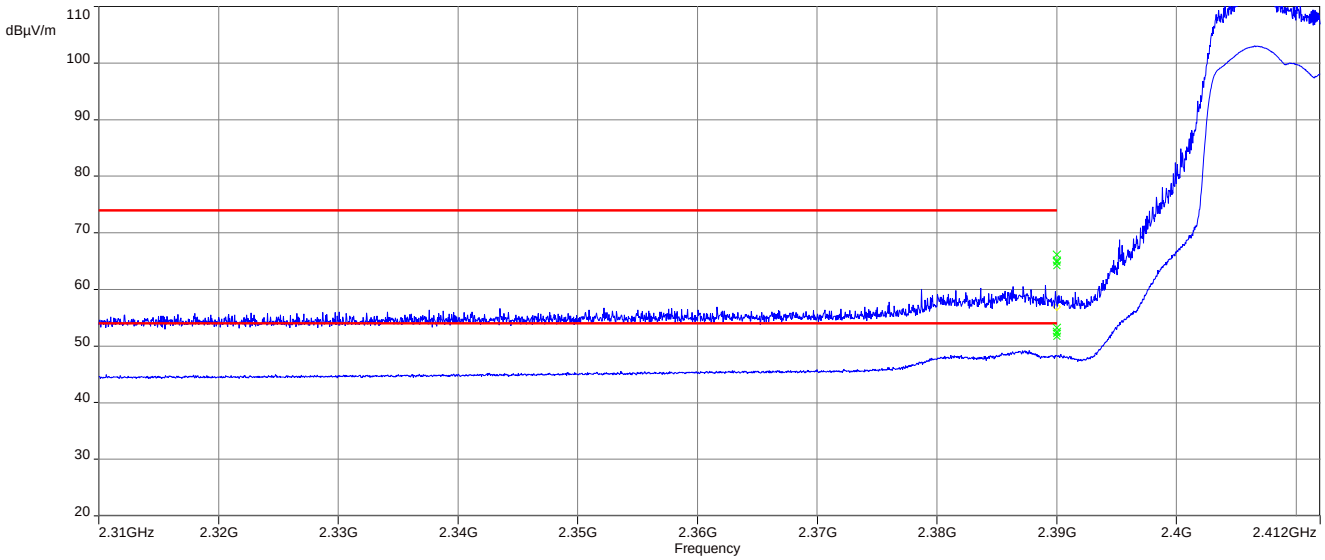
Plot 3: Highest channel, nHT40-mode



Plot 4: Highest channel, axHE20-mode

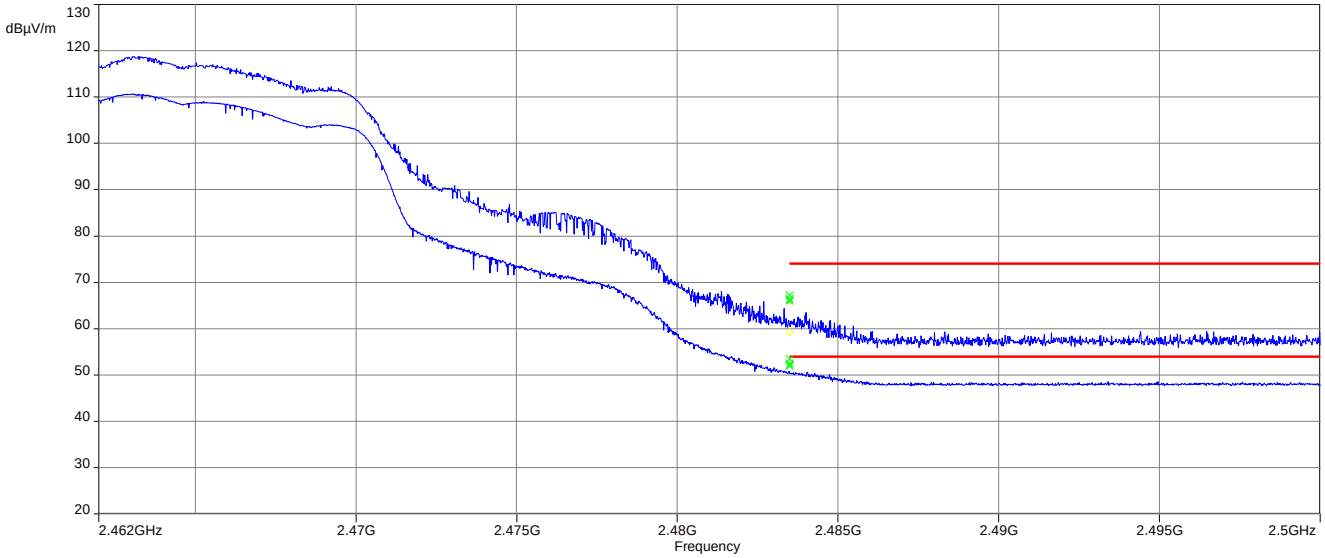


Plot 5: Lowest channel, axHE40-mode

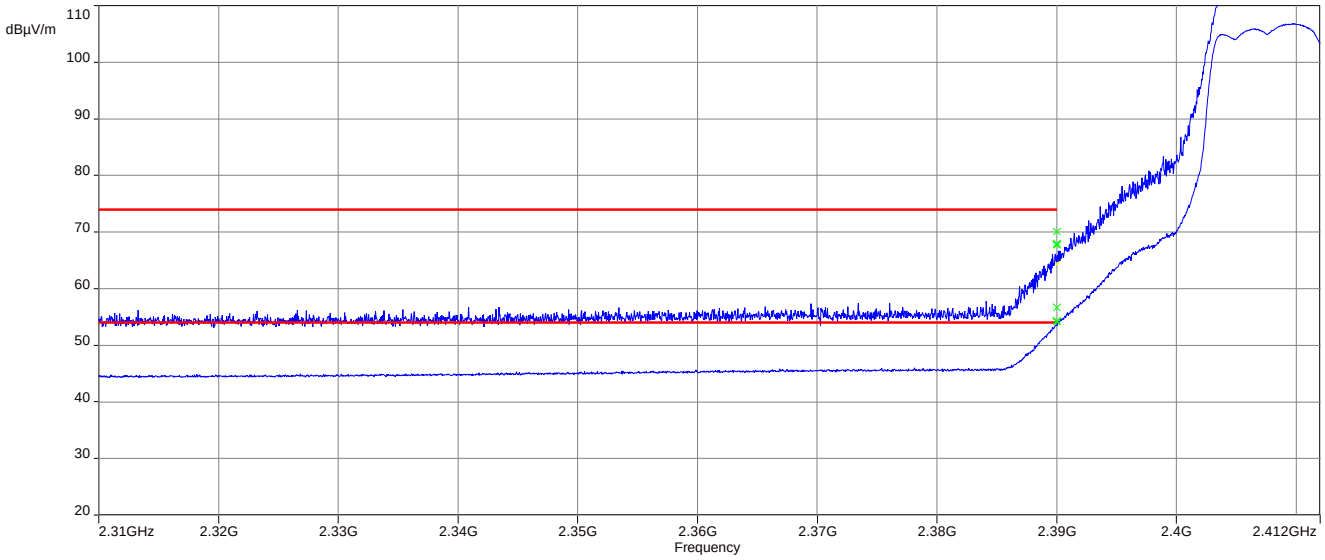


Plots: HL antennas

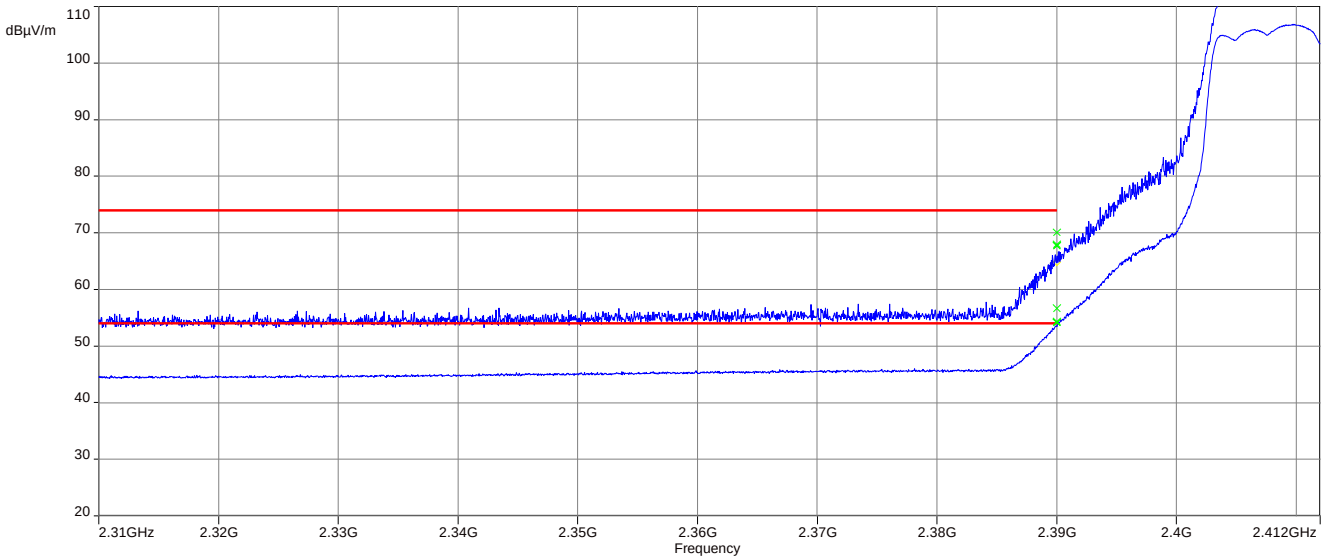
Plot 1: Highest channel, g-mode



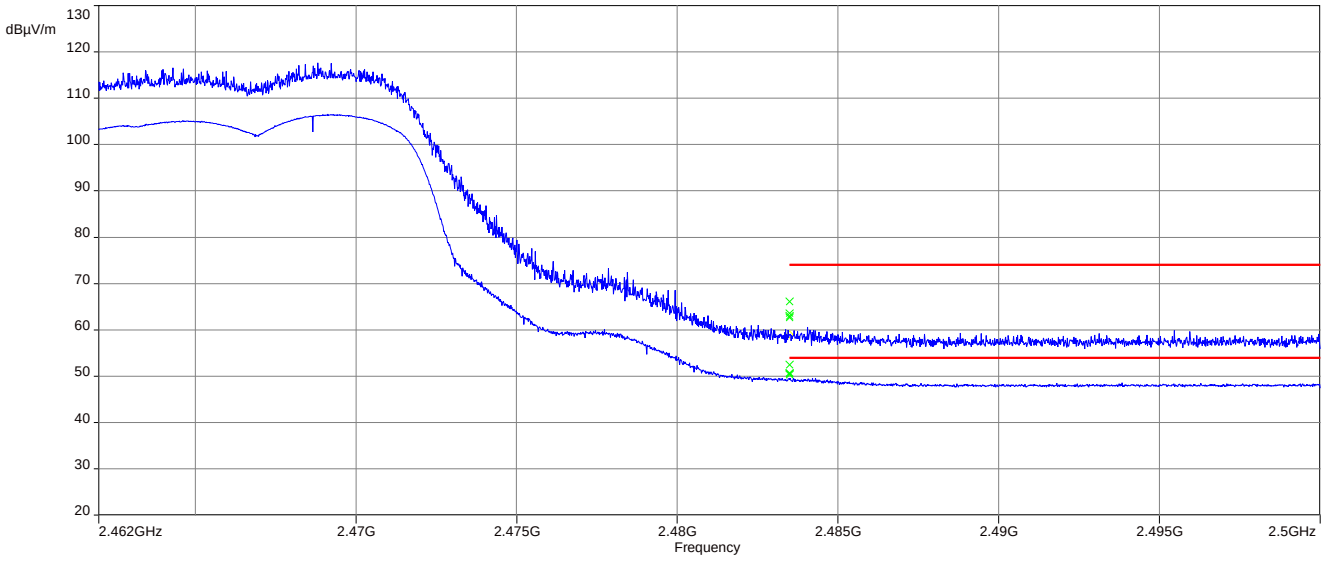
Plot 2: Highest channel, nHT20-mode



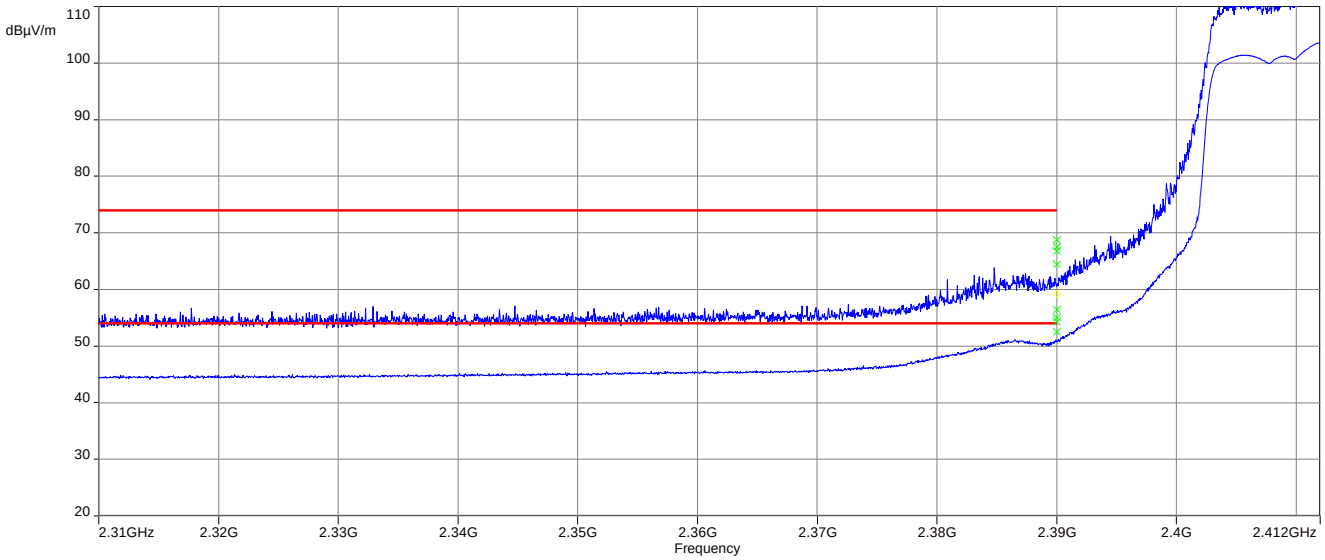
Plot 3: Highest channel, nHT40-mode



Plot 4: Highest channel, axHE20-mode



Plot 5: Lowest channel, axHE40-mode



13.9 Spurious emissions conducted

Description:

Measurement of the conducted spurious emissions in transmit mode. The measurement is performed at the lowest; the middle and the highest channel.

Measurement:

Measurement parameter	
Detector	Peak
Sweep time	Auto
Resolution bandwidth	100 kHz
Video bandwidth	500 kHz
Span	9 kHz to 25 GHz
Trace mode	Max Hold
External result file(s)	1-3977_22-03-03_Annex_MR_A1.pdf (802.11b) 1-3977_22-03-03_Annex_MR_A2.pdf (802.11g) 1-3977_22-03-03_Annex_MR_A3.pdf (802.11n HT20) 1-3977_22-03-03_Annex_MR_A4.pdf (802.11n HT40) 1-3977_22-03-03_Annex_MR_A5.pdf (802.11ax HE20) 1-3977_22-03-03_Annex_MR_A6.pdf (802.11ax HE40)
Test setup	See chapter 7.3 setup A
Measurement uncertainty	See chapter 9

Limits:

FCC
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

Result: Compliant (See log files for detailed plots)

13.10 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
Measured modulation	☒ 802.11b ☒ 802.11g ☐ 802.11n HT20 ☐ 802.11n HT40 ☐ 802.11ax HE20 ☒ 802.11ax HE40
Test setup	See chapter 7.2 setup C
Measurement uncertainty	See chapter 9

Limits:

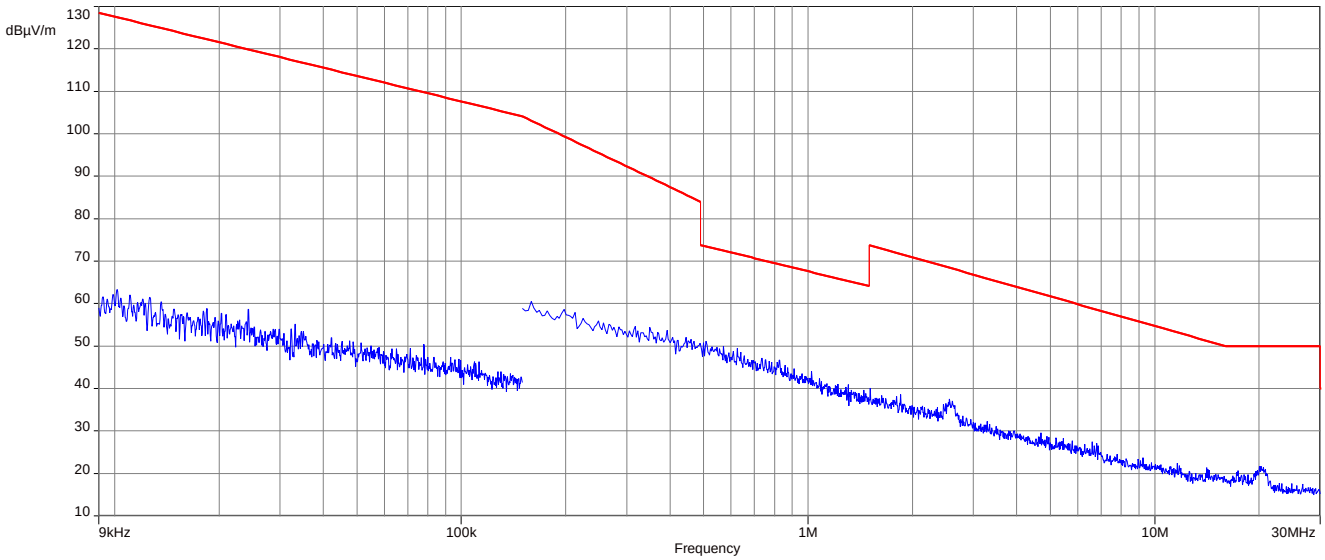
FCC		
Frequency / MHz	Field Strength / (dBµV / m)	Measurement distance / m
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30

Results:

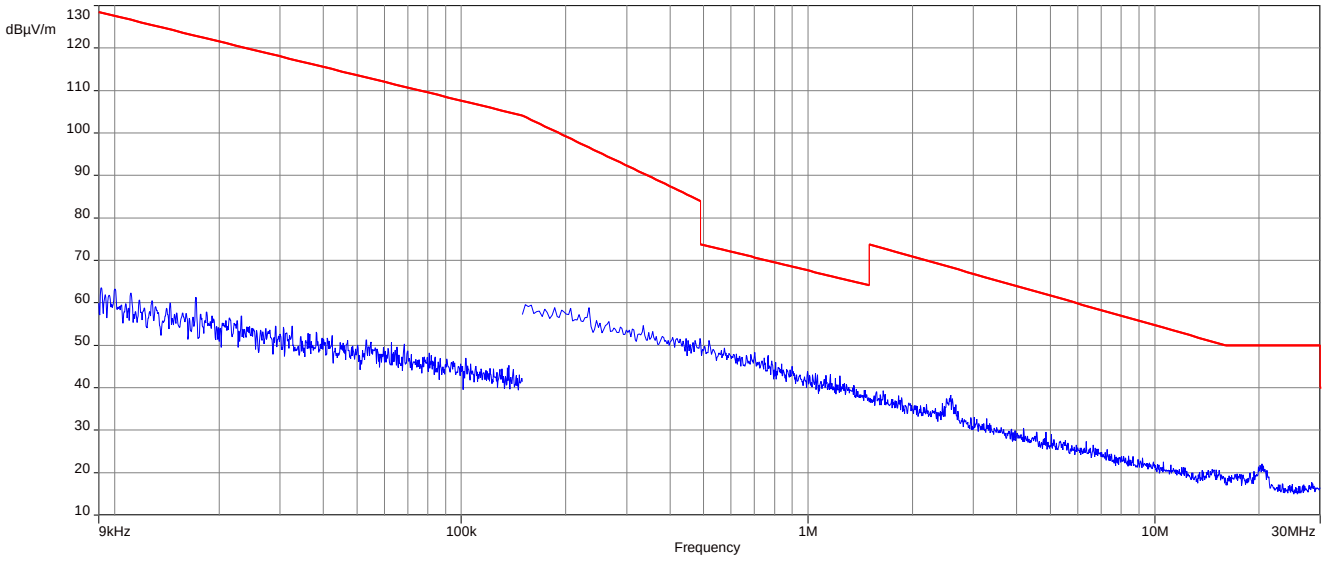
TX spurious emissions radiated < 30 MHz / (dBµV / m) @ 3 m		
Frequency / MHz	Detector	Level / (dBµV / m)
All detected peaks are more than 20 dB below the limit.		

Plots: 802.11b, COLFLY antennas

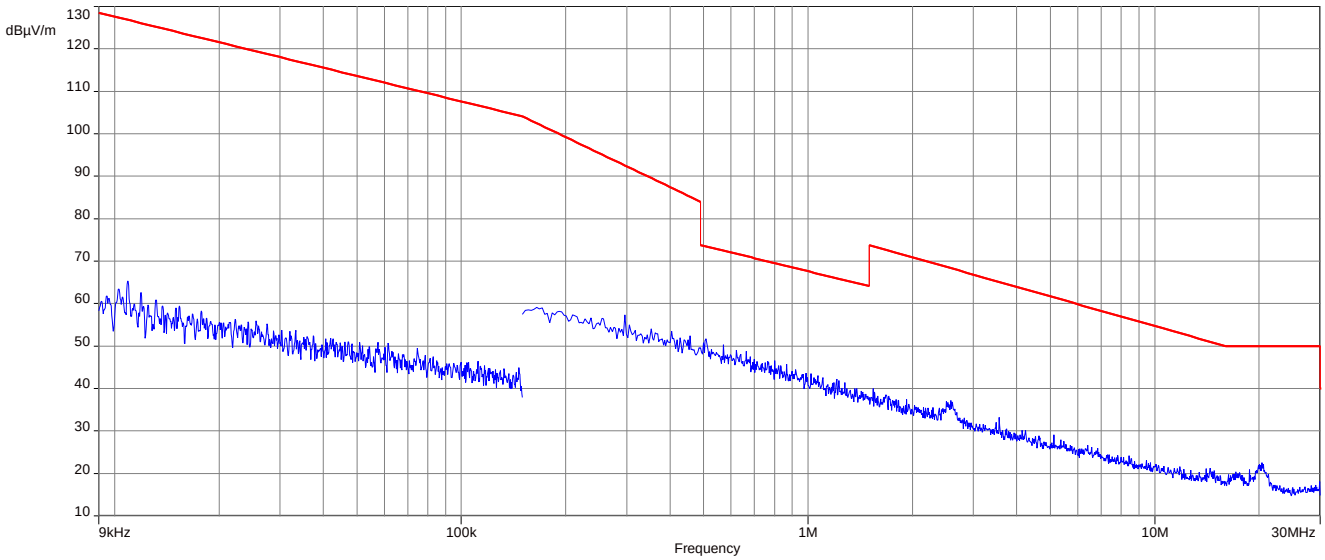
Plot 1: 9 kHz to 30 MHz, lowest channel



Plot 2: 9 kHz to 30 MHz, middle channel

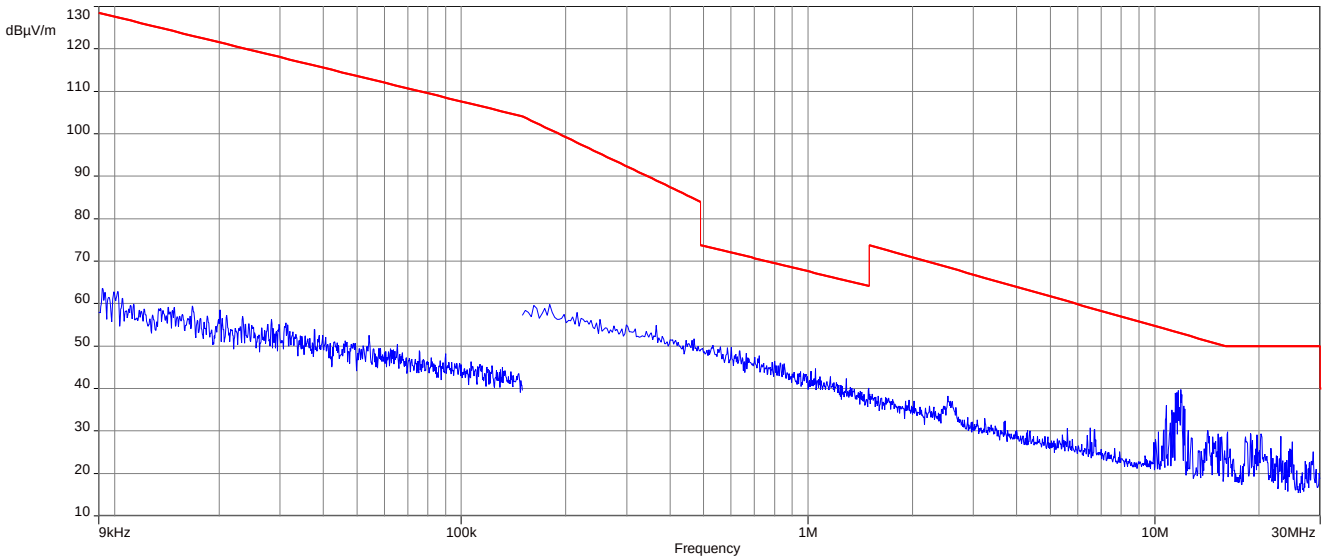


Plot 3: 9 kHz to 30 MHz, highest channel

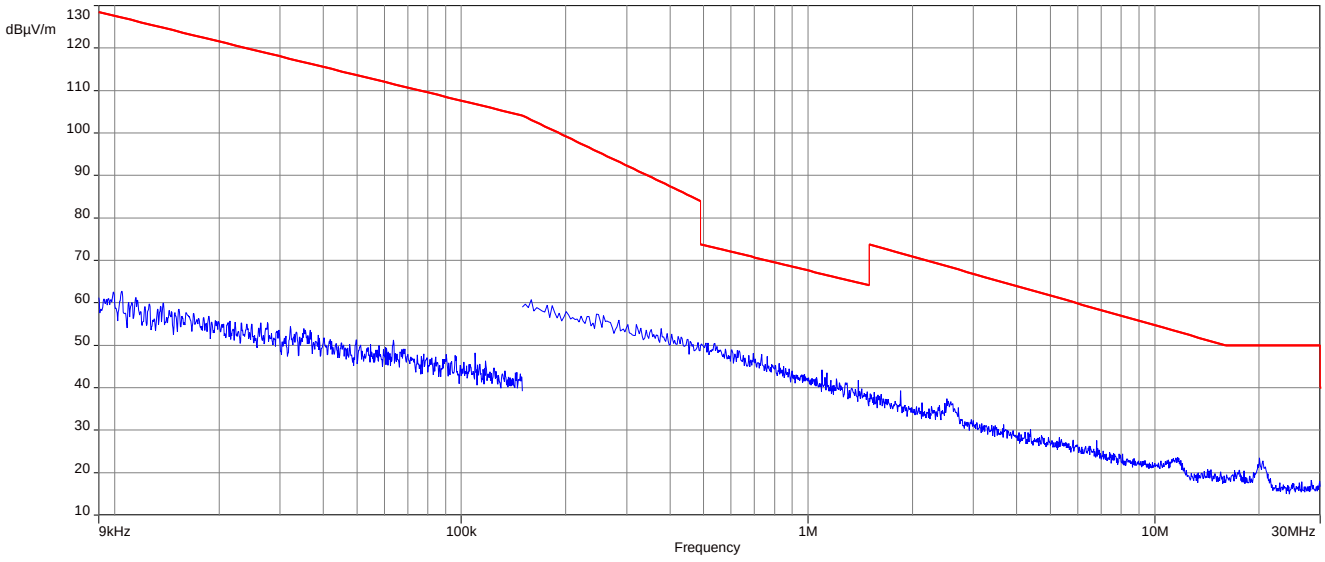


Plots: 802.11g, COLFLY antennas

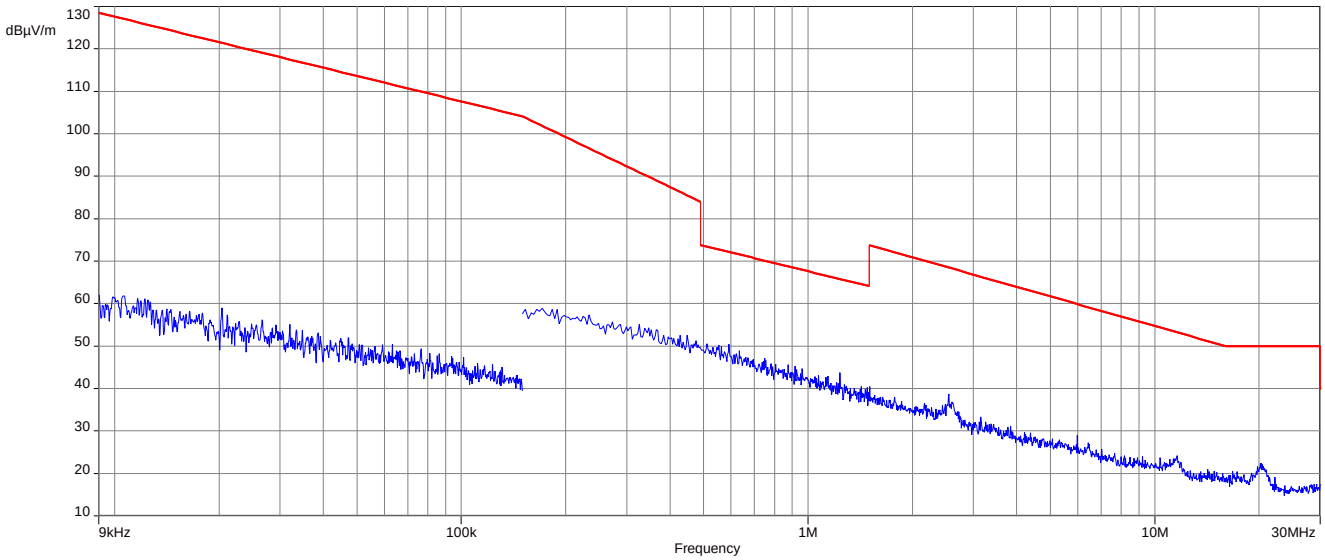
Plot 1: 9 kHz to 30 MHz, lowest channel



Plot 2: 9 kHz to 30 MHz, middle channel

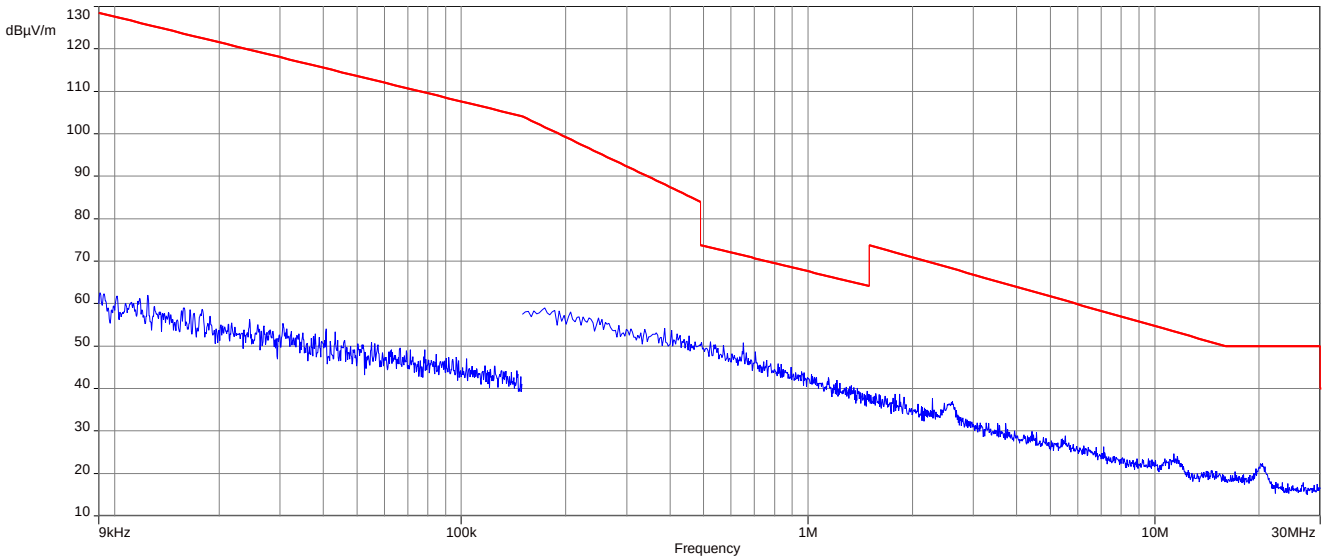


Plot 3: 9 kHz to 30 MHz, highest channel

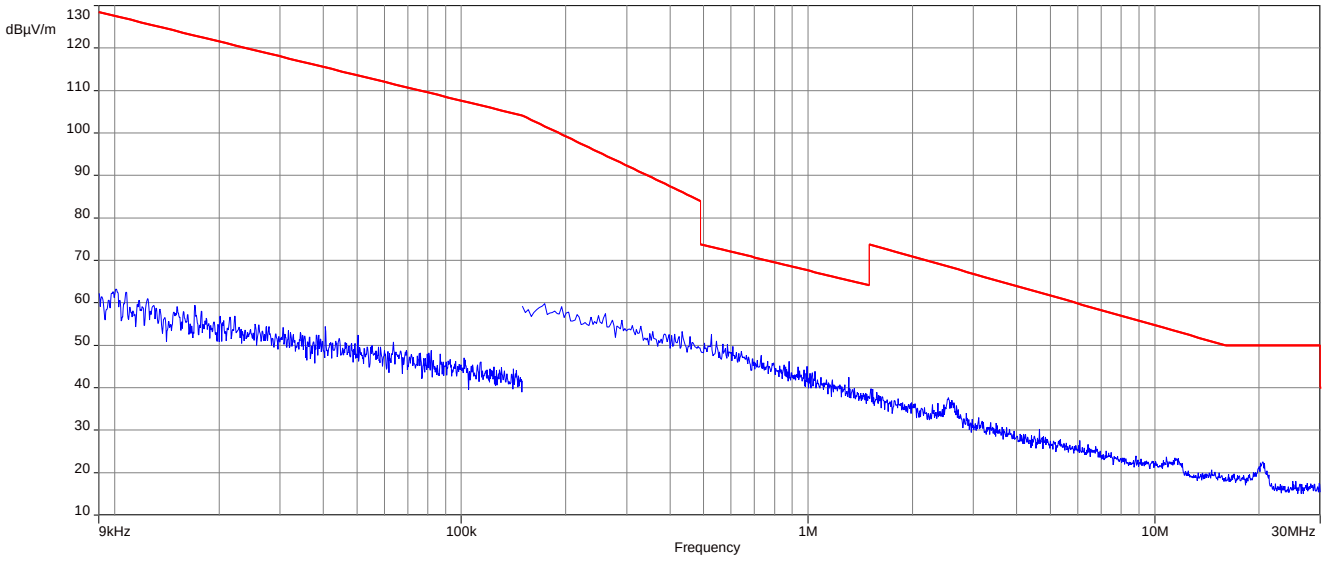


Plots: 802.11ax HE40, COLFLY antennas

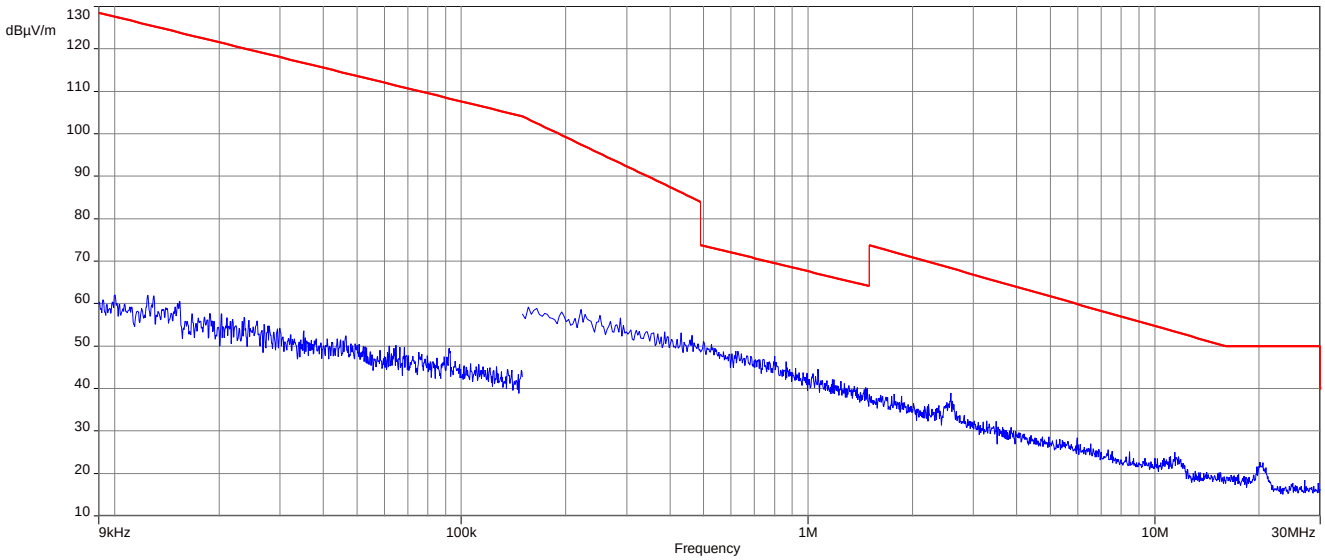
Plot 1: 9 kHz to 30 MHz, lowest channel



Plot 2: 9 kHz to 30 MHz, middle channel

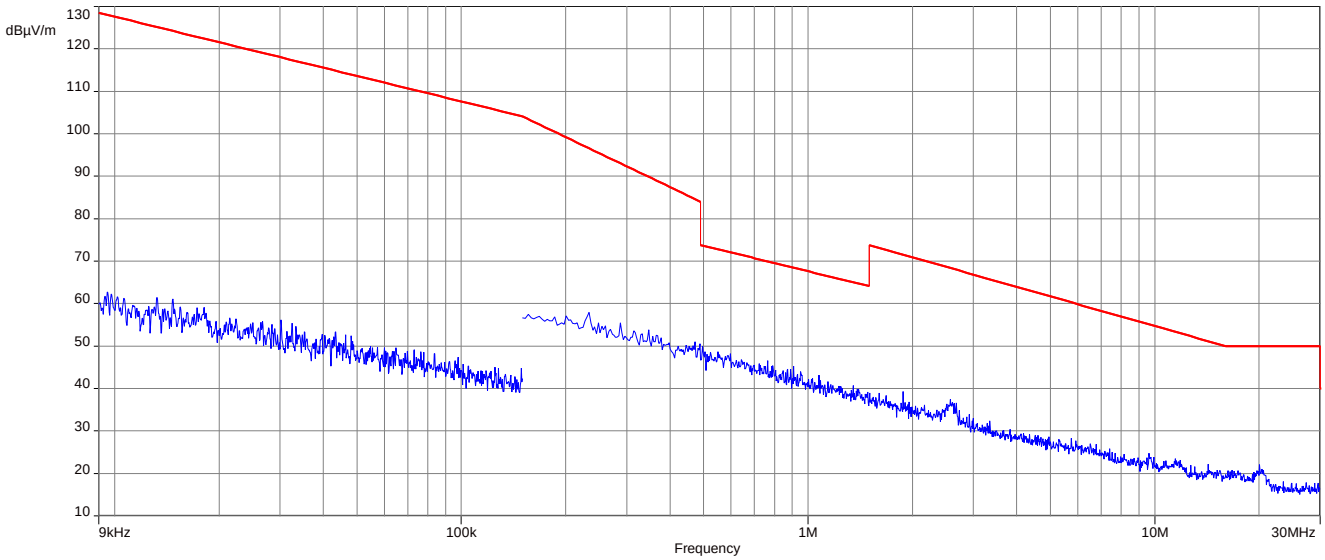


Plot 3: 9 kHz to 30 MHz, highest channel

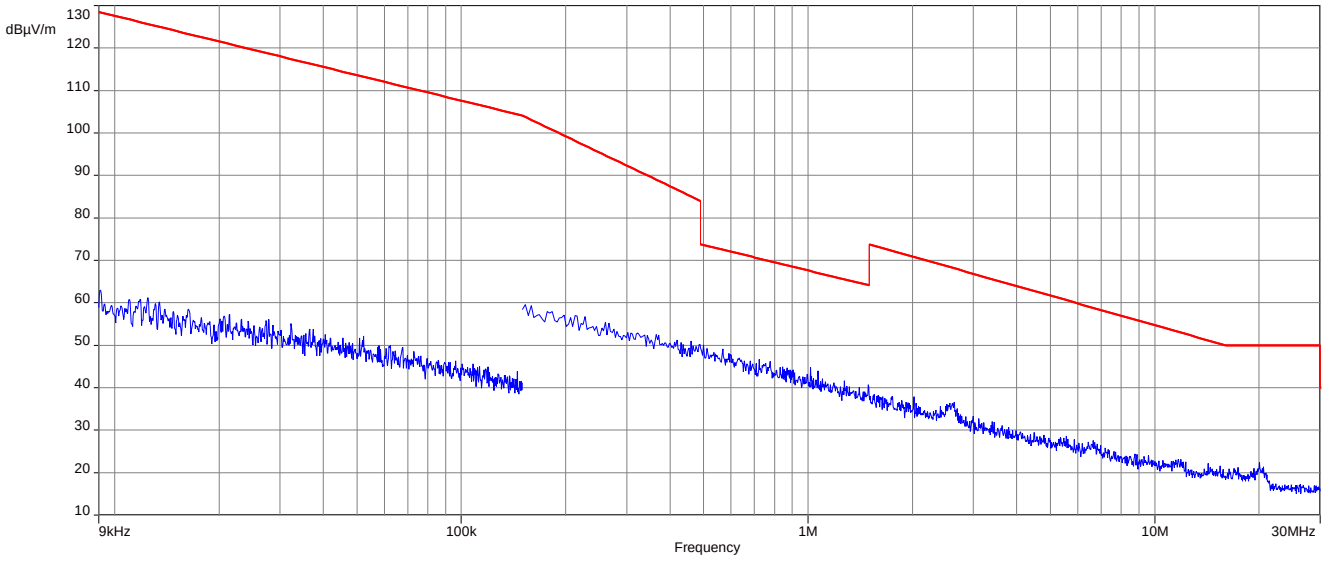


Plots: 802.11b, WALSIN antennas

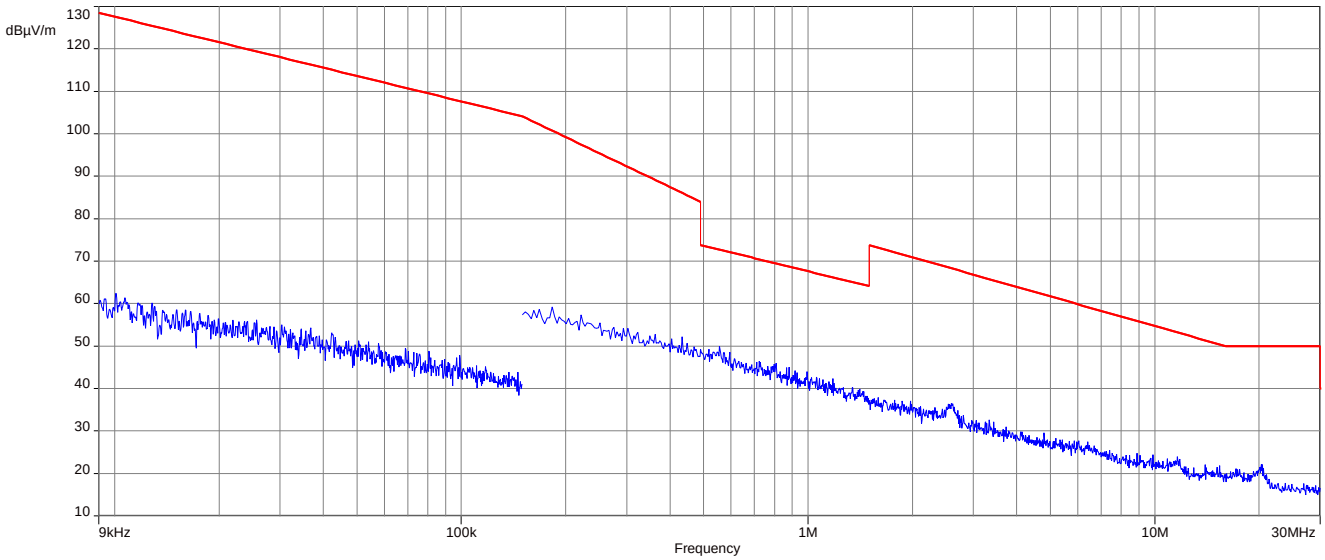
Plot 1: 9 kHz to 30 MHz, lowest channel



Plot 2: 9 kHz to 30 MHz, middle channel

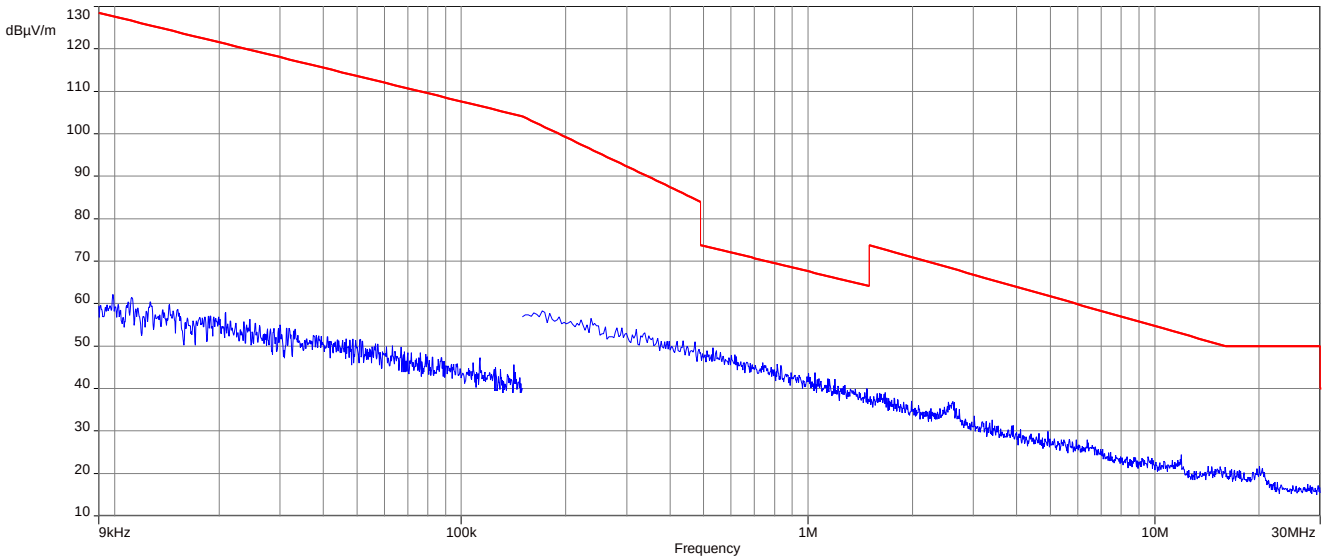


Plot 3: 9 kHz to 30 MHz, highest channel

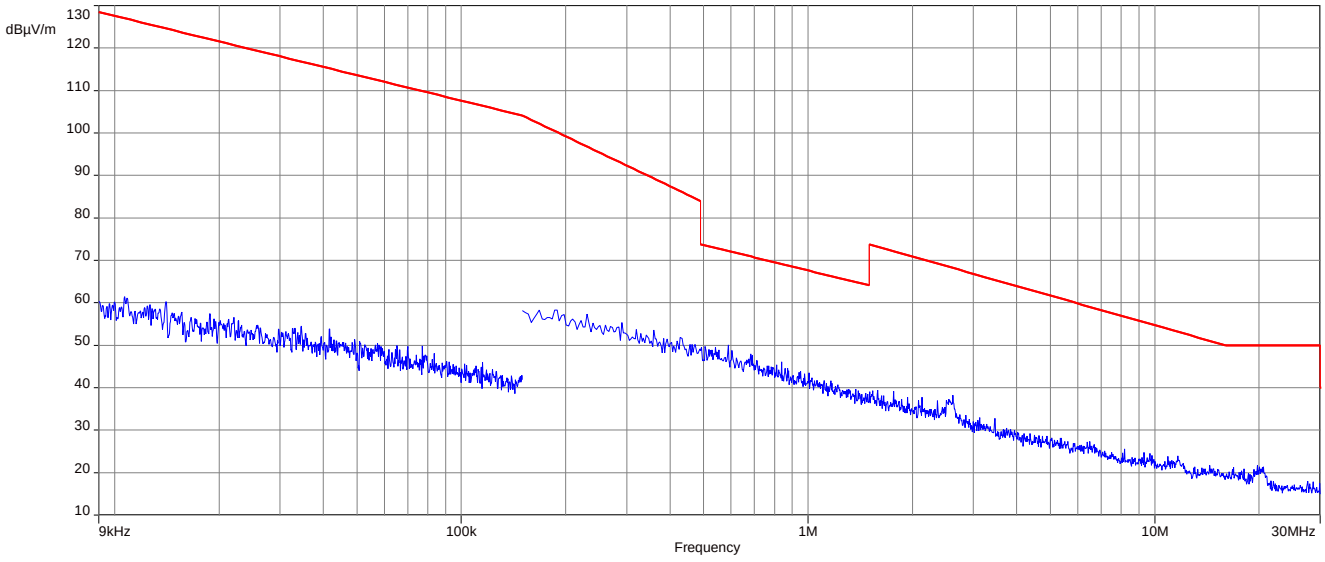


Plots: 802.11b, HL antennas

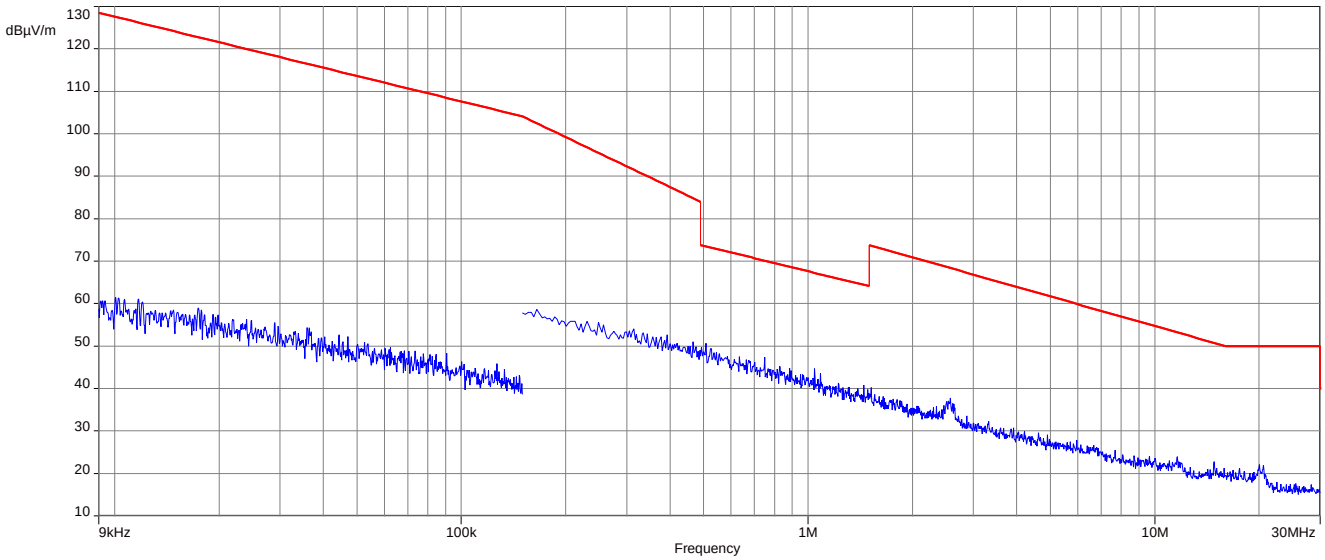
Plot 1: 9 kHz to 30 MHz, lowest channel



Plot 2: 9 kHz to 30 MHz, middle channel



Plot 3: 9 kHz to 30 MHz, highest channel



13.11 Spurious emissions radiated 30 MHz to 1 GHz

Description:

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

Measurement:

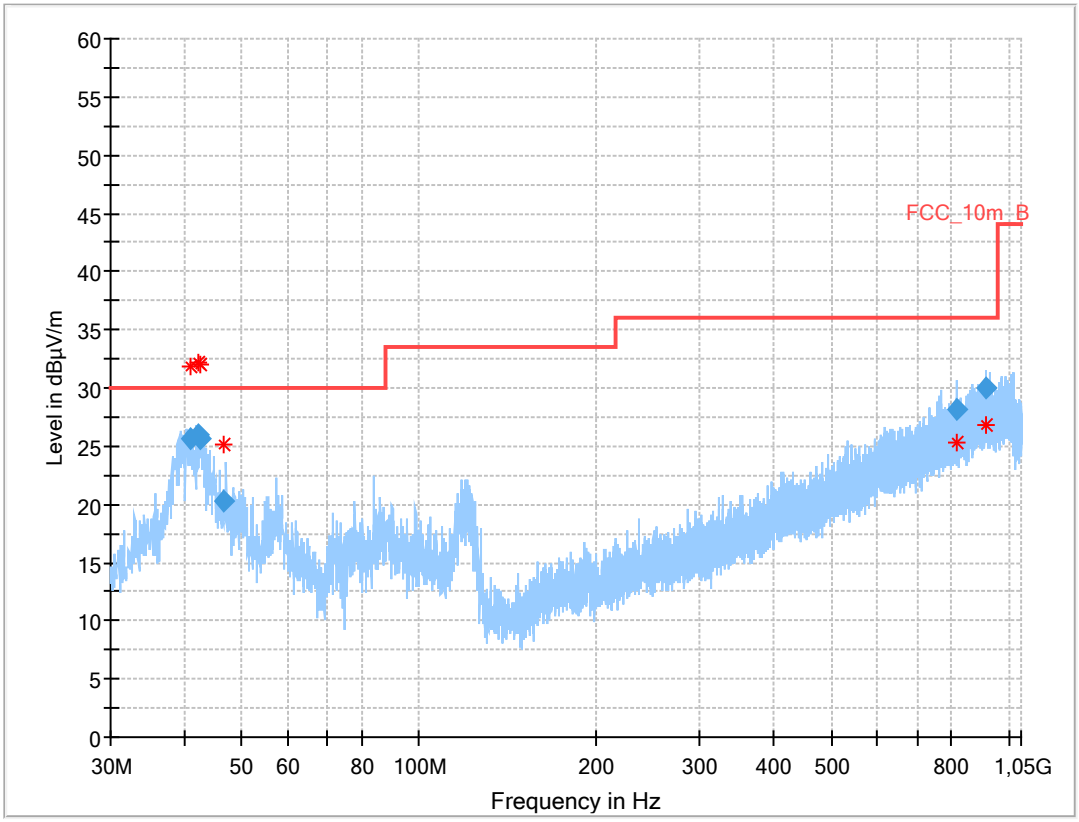
Measurement parameter	
Detector	Peak / Quasi Peak
Sweep time	Auto
Resolution bandwidth	120 kHz
Video bandwidth	3 x RBW
Span	30 MHz to 1 GHz
Trace mode	Max Hold
Test setup	See chapter 7.1 setup A
Measurement uncertainty	See chapter 9

Limits:

FCC		
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:

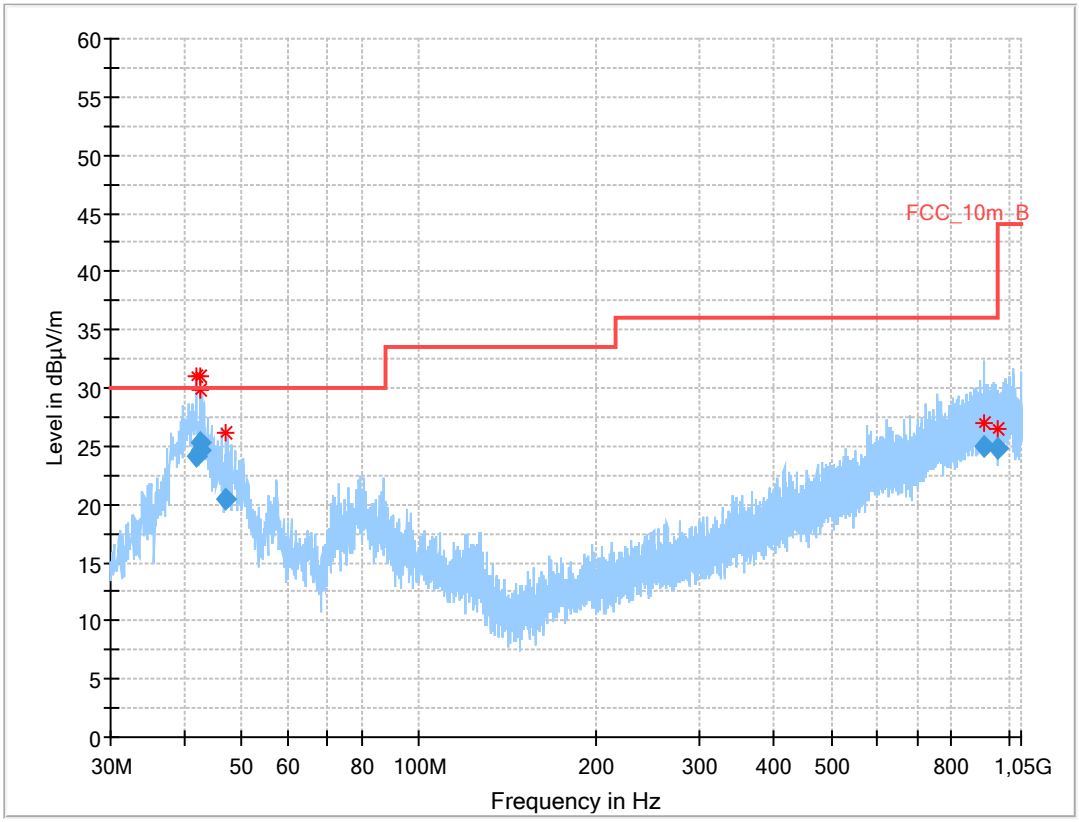
Plot 1: 30 MHz to 1 GHz, vertical & horizontal polarization, 802.11b, channel 6, valid for all channels of 802.11b, valid for COLFLY, WALSIN and HL antennas



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
40.998	25.57	30.0	4.4	1000	120.0	106.0	V	307	15
42.328	25.94	30.0	4.1	1000	120.0	110.0	V	294	16
42.484	25.60	30.0	4.4	1000	120.0	104.0	V	217	16
46.598	20.36	30.0	9.6	1000	120.0	195.0	V	217	16
816.343	28.16	36.0	7.8	1000	120.0	183.0	V	232	24
915.474	30.04	36.0	6.0	1000	120.0	195.0	H	-34	26

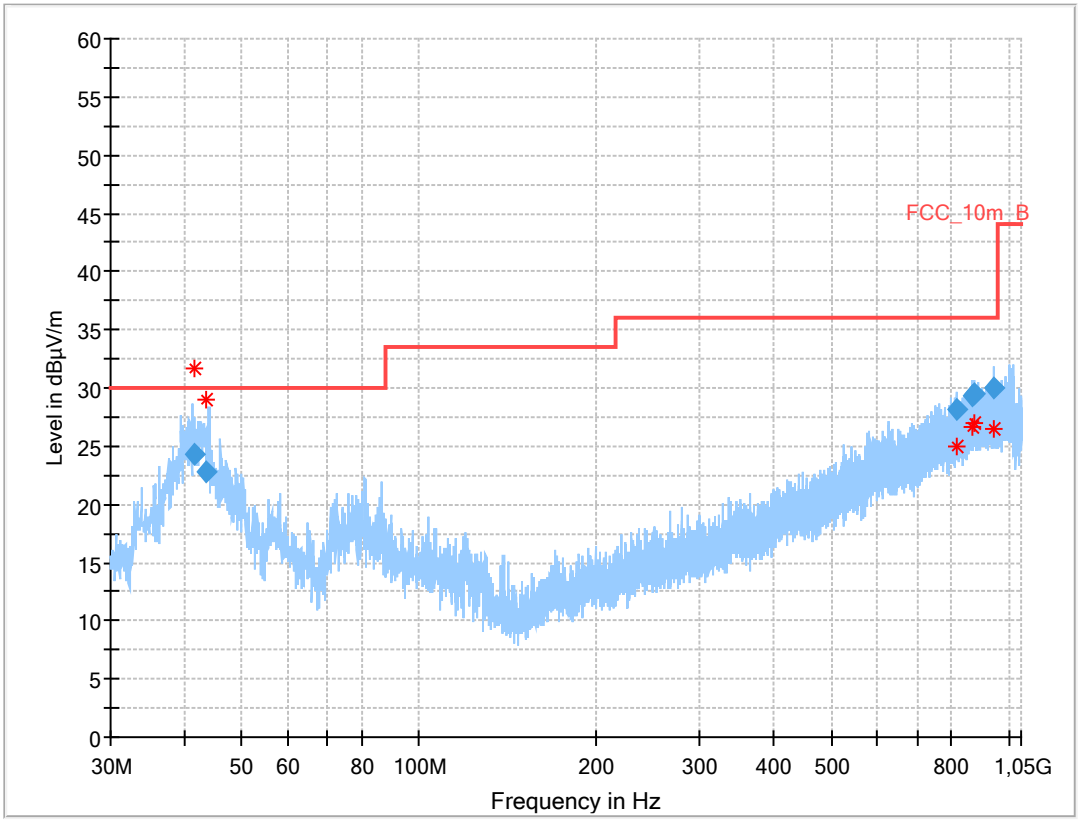
Plot 2: 30 MHz to 1 GHz, vertical & horizontal polarization, 802.11n HT20, channel 6, valid for all channels of all 20 MHz modes, valid for COLFLY, WALSIN and HL antennas



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
41.900	24.21	30.0	5.8	1000	120.0	195.0	V	-36	16
42.474	24.59	30.0	5.4	1000	120.0	102.0	V	-34	16
42.539	25.35	30.0	4.7	1000	120.0	107.0	V	-29	16
46.934	20.37	30.0	9.6	1000	120.0	189.0	V	28	16
906.451	24.95	36.0	11.1	1000	120.0	195.0	H	142	26
959.083	24.87	36.0	11.1	1000	120.0	129.0	V	94	25

Plot 3: 30 MHz to 1 GHz, vertical & horizontal polarization, 802.11ax HE40, channel 6, valid for all channels of all 40 MHz modes, valid for COLFLY, WALSIN and HL antennas



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
41.672	24.25	30.0	5.8	1000	120.0	144.0	V	217	16
43.553	22.87	30.0	7.1	1000	120.0	112.0	V	217	16
813.793	28.12	36.0	7.9	1000	120.0	195.0	H	142	24
869.551	29.35	36.0	6.7	1000	120.0	177.0	V	52	25
873.698	29.52	36.0	6.5	1000	120.0	134.0	V	244	25
943.834	30.03	36.0	6.0	1000	120.0	195.0	H	8	25

13.12 Spurious emissions radiated above 1 GHz

Description:

Measurement of the radiated spurious emissions above 1 GHz in transmit 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
Measured modulation	☒ 802.11b ☒ 802.11g ☐ 802.11n HT20 ☐ 802.11n HT40 ☐ 802.11ax HE20 ☒ 802.11ax HE40
Test setup	See chapter 7.2 setup B & 7.4 setup A
Measurement uncertainty	See chapter 9

Limits:

FCC		
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: 802.11b, COLFLY antennas

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
4824	Peak	50.8	4874	Peak	57.5	4924	Peak	60.5
	AVG	46.9		AVG	51.6		AVG	53.8
11000	Peak	47.3	-/-	Peak	-/-	-/-	Peak	-/-
	AVG	41.7		AVG	-/-		AVG	-/-

Results: 802.11g, COLFLY antennas

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
11000	Peak	47.8	4866	Peak	56.8	4916	Peak	61.9
	AVG	43.2		AVG	40.8		AVG	45.9
-/-	Peak	-/-	-/-	Peak	-/-	-/-	Peak	-/-
	AVG	-/-		AVG	-/-		AVG	-/-

Results: 802.11ax HE40, COLFLY antennas

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
-/-	Peak	-/-	4905	Peak	57.9	4912	Peak	56.9
	AVG	-/-		AVG	40.4		AVG	40.4
-/-	Peak	-/-	-/-	Peak	-/-	-/-	Peak	-/-
	AVG	-/-		AVG	-/-		AVG	-/-

Results: 802.11b, WALSIN antennas

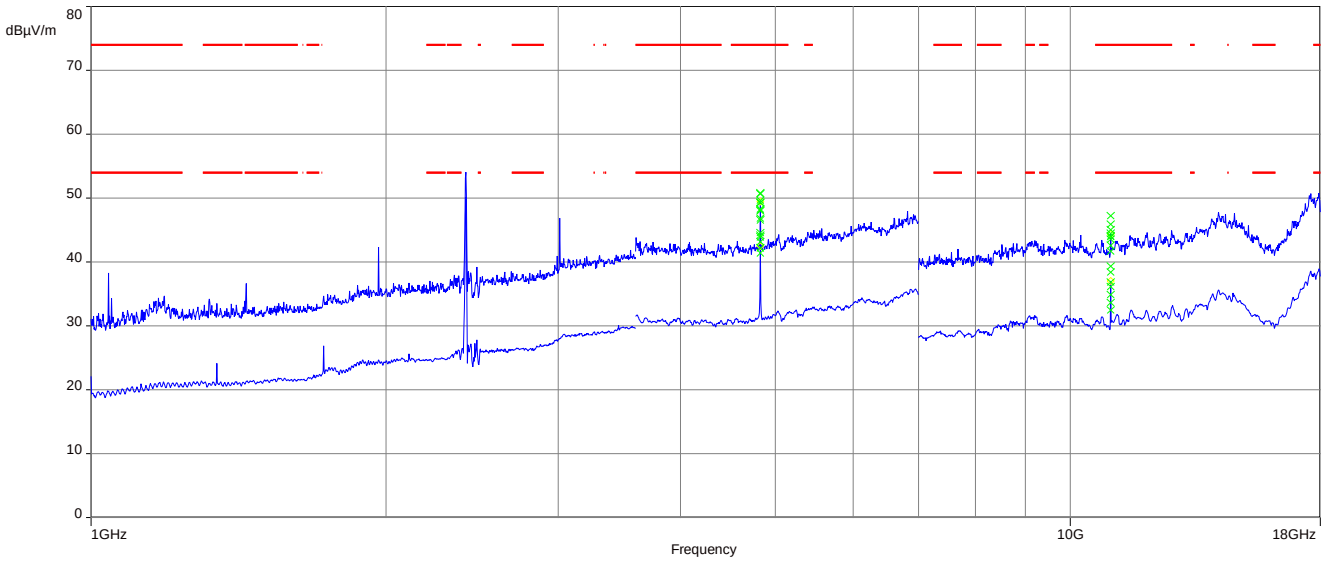
TX spurious emissions radiated / dBµV/m @ 3 m								
lowest channel			middle channel			highest channel		
f / MHz	Detector	Level / dBµV/m	f / MHz	Detector	Level / dBµV/m	f / MHz	Detector	Level / dBµV/m
4824	Peak	53.9	4874	Peak	57.4	4924	Peak	61.4
	AVG	48.5		AVG	52.0		AVG	53.9
-/-	Peak	-/-	-/-	Peak	-/-	-/-	Peak	-/-
	AVG	-/-		AVG	-/-		AVG	-/-

Results: 802.11b, HL antennas

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
4824	Peak	52.5	4874	Peak	58.1	4924	Peak	57.4
	AVG	48.3		AVG	52.2		AVG	51.5
-/-	Peak	-/-	-/-	Peak	-/-	-/-	Peak	-/-
	AVG	-/-		AVG	-/-		AVG	-/-

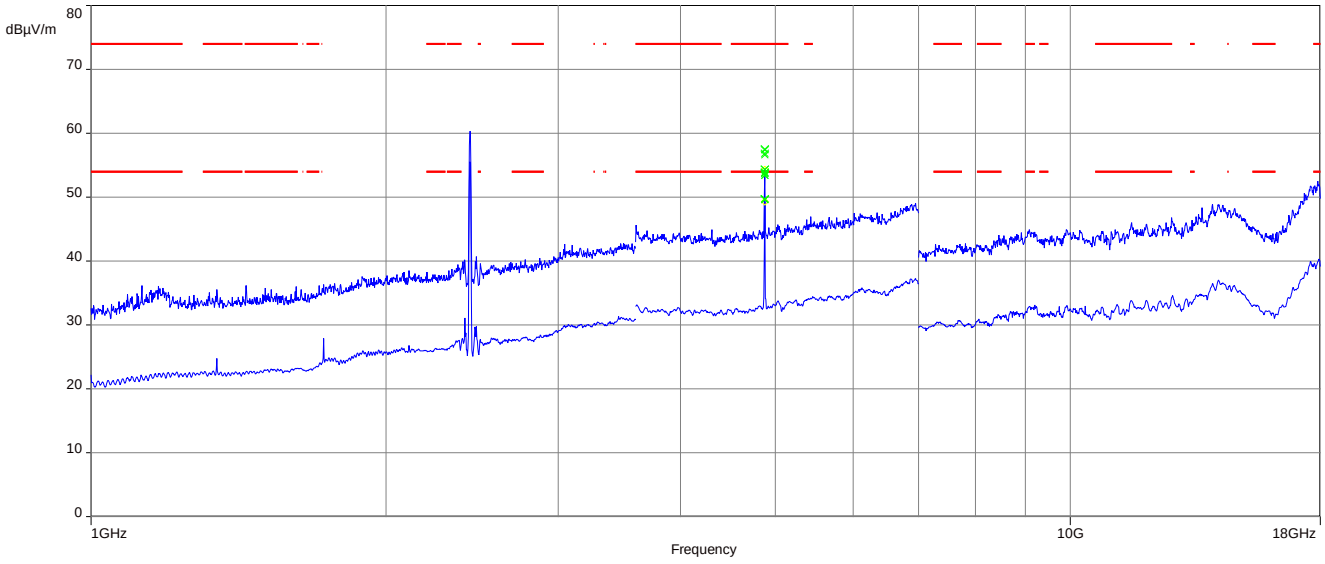
Plots: 802.11b, COLFLY antennas

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



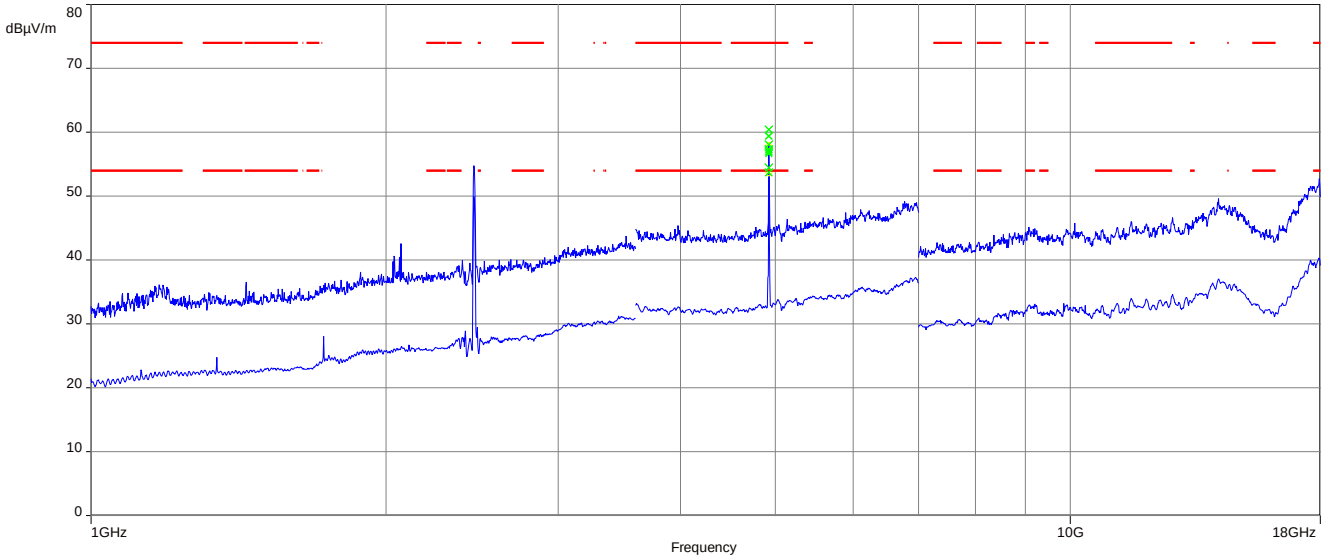
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 2: Middle channel, 1 GHz to 18 GHz, vertical & horizontal polarization



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

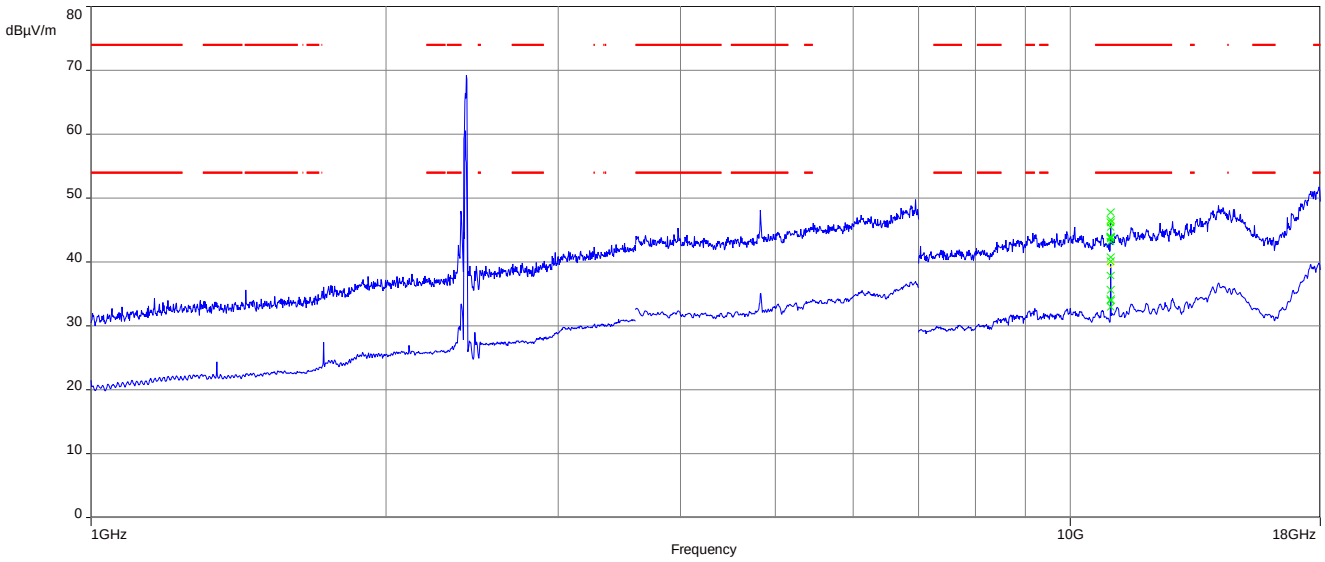
Plot 3: Highest channel, 1 GHz to 18 GHz, vertical & horizontal polarization



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

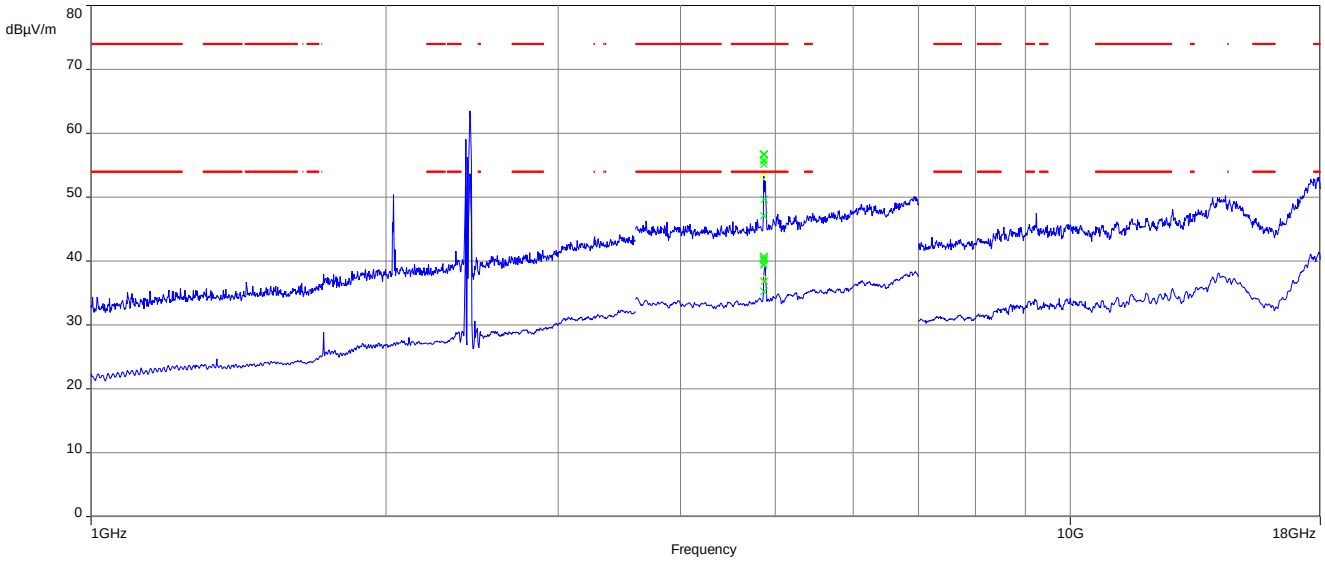
Plots: 802.11g, COLFLY antennas

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



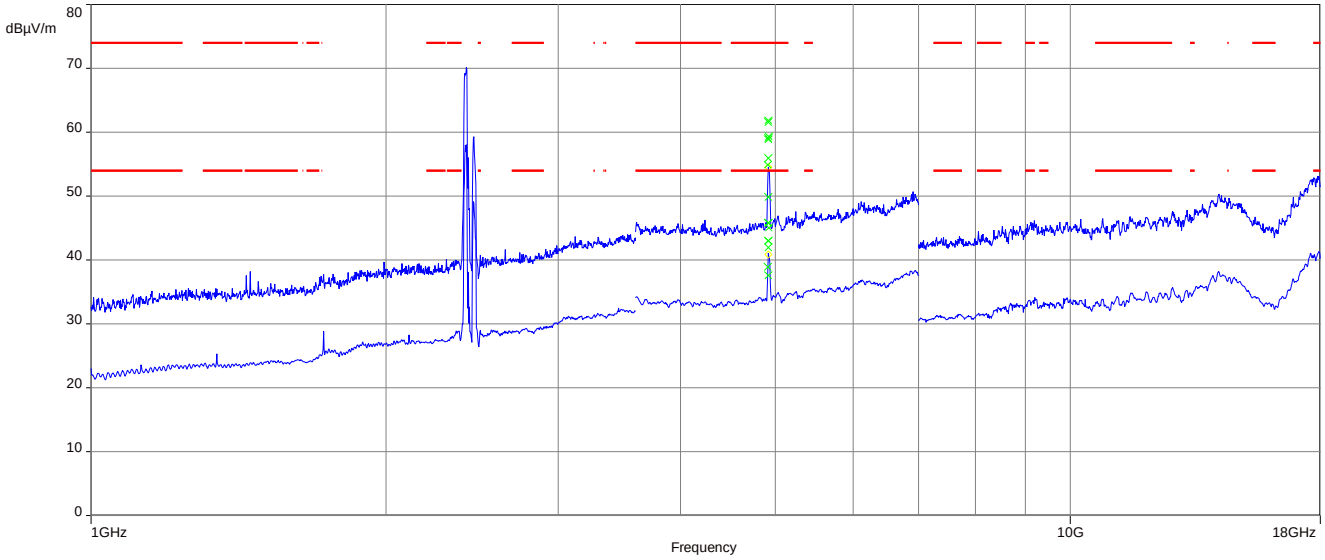
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 2: Middle channel, 1 GHz to 18 GHz, vertical & horizontal polarization



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

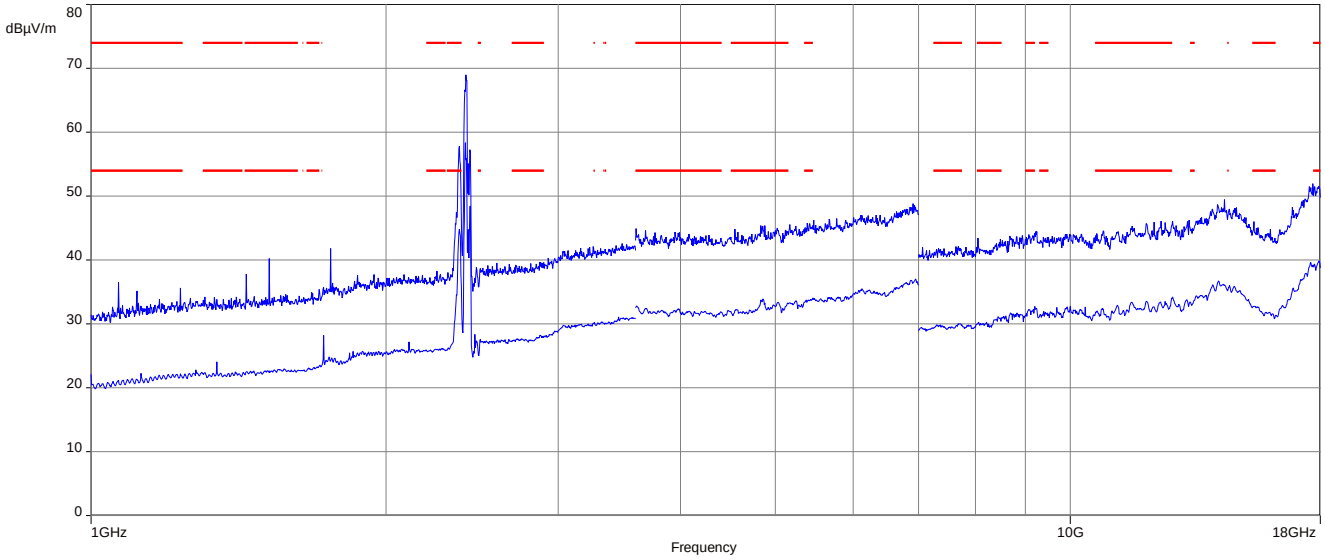
Plot 3: Highest channel, 1 GHz to 18 GHz, vertical & horizontal polarization



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

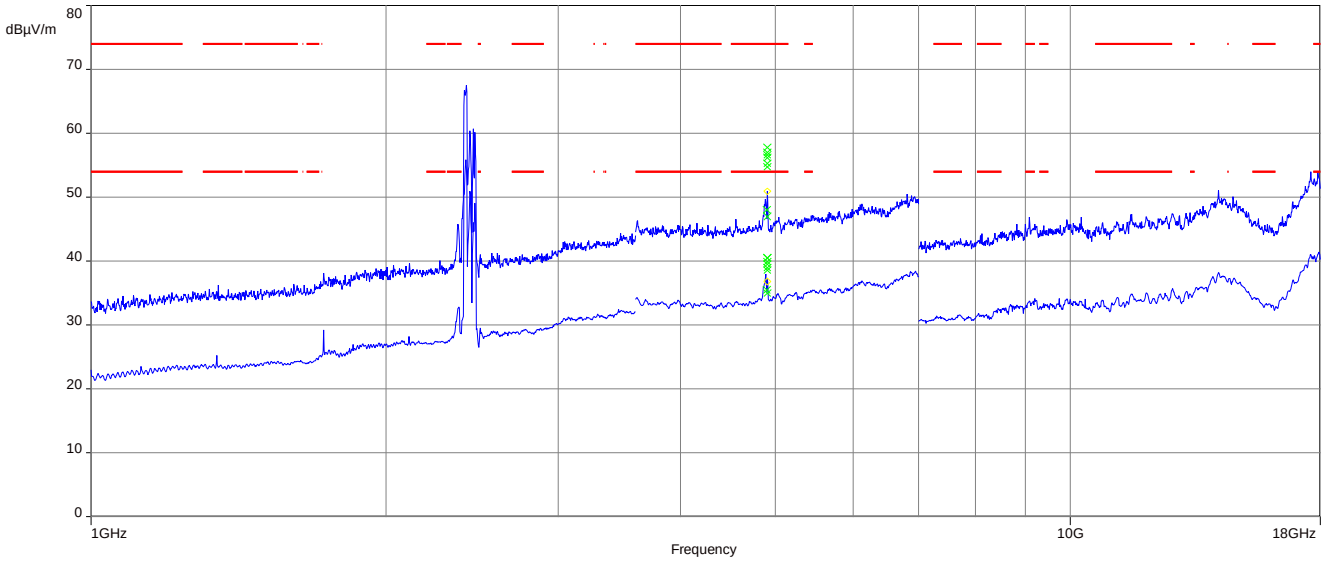
Plots: 802.11ax HE40, COLFLY antennas

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



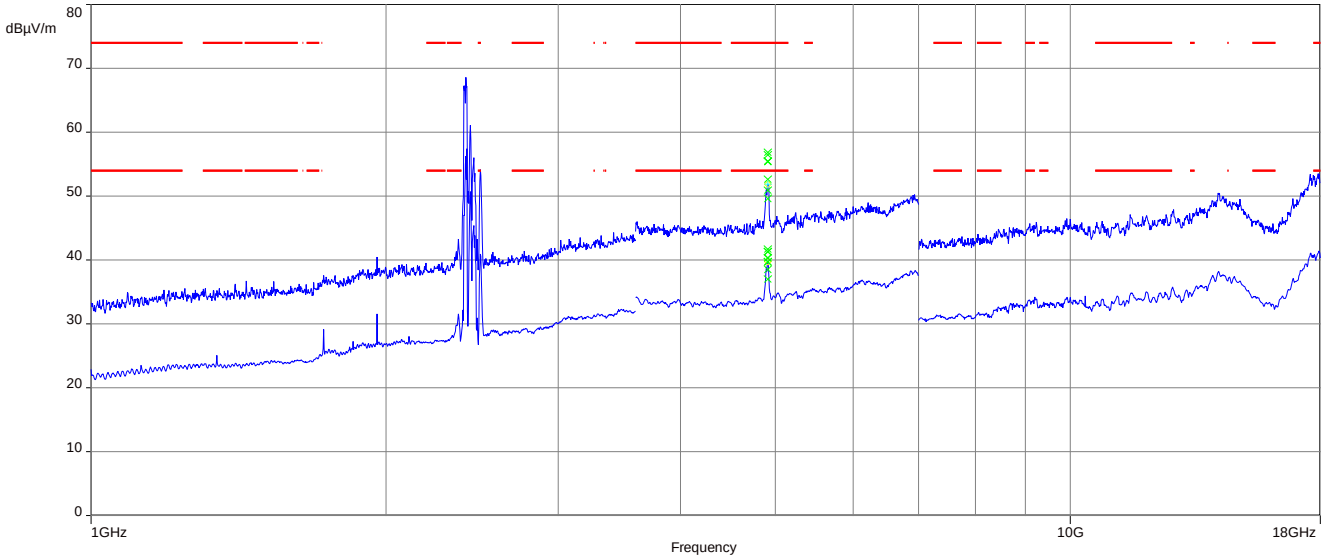
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 2: Middle channel, 1 GHz to 18 GHz, vertical & horizontal polarization



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

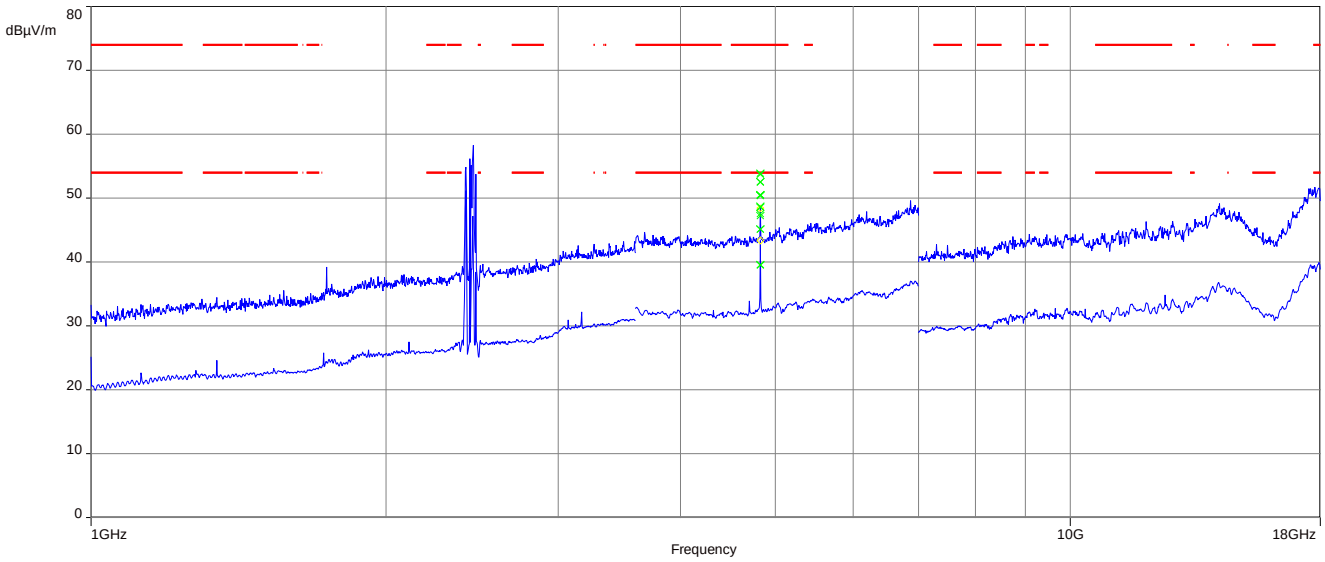
Plot 3: Highest channel, 1 GHz to 18 GHz, vertical & horizontal polarization



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

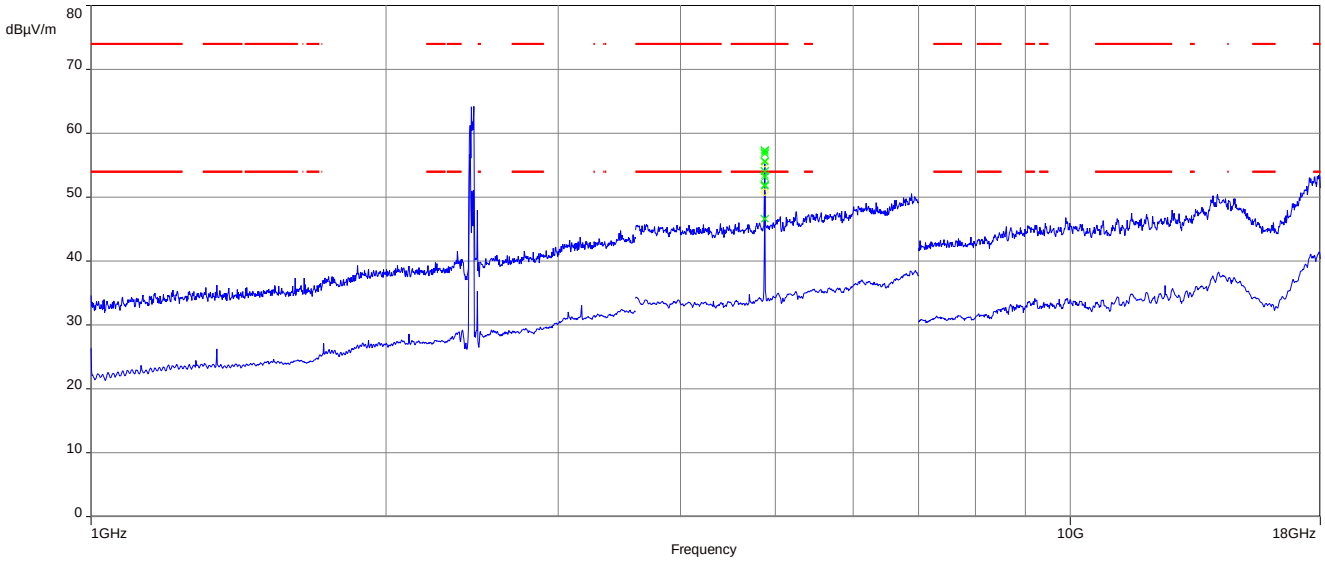
Plots: 802.11b, WALSIN antennas

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



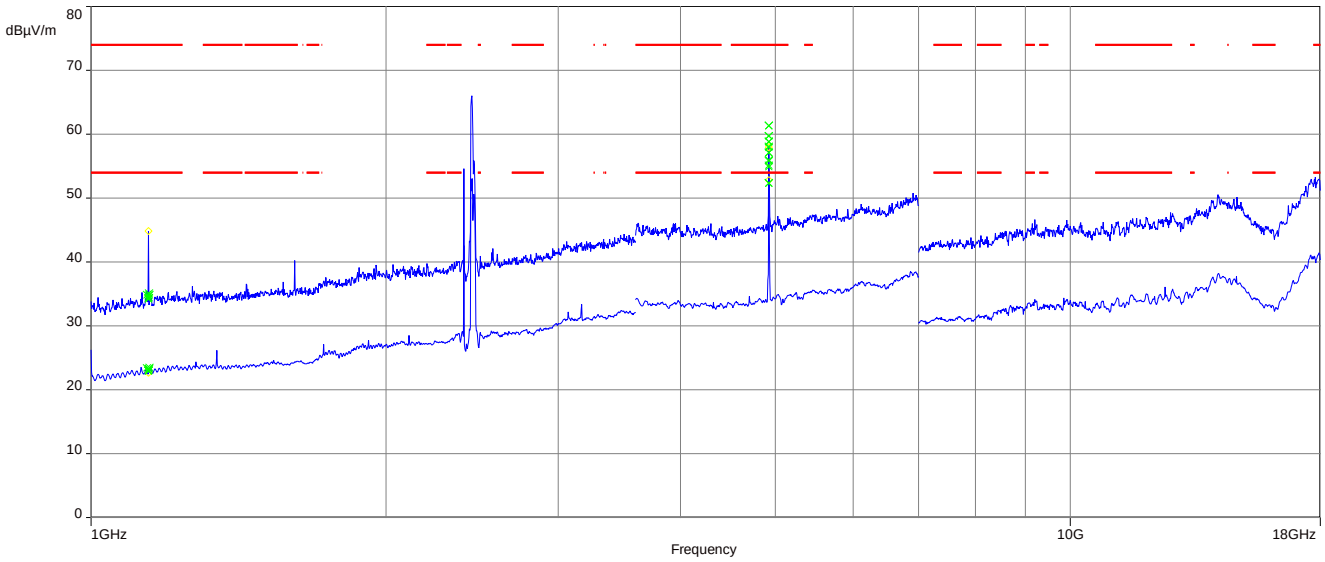
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 2: Middle channel, 1 GHz to 18 GHz, vertical & horizontal polarization



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

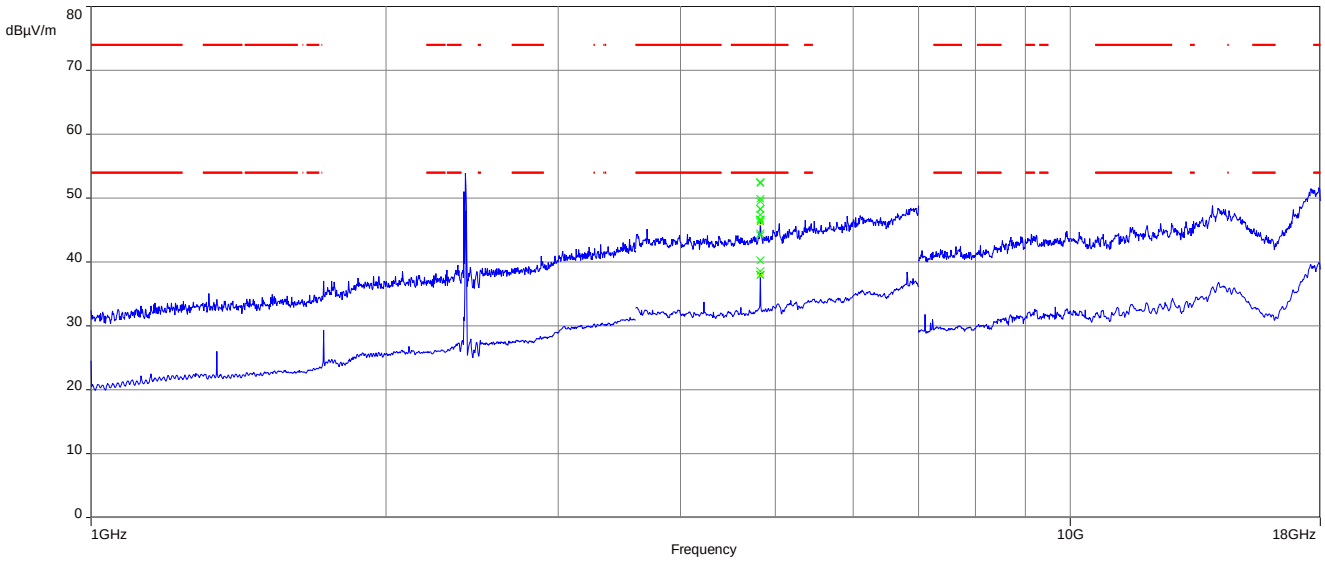
Plot 3: Highest channel, 1 GHz to 18 GHz, vertical & horizontal polarization



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

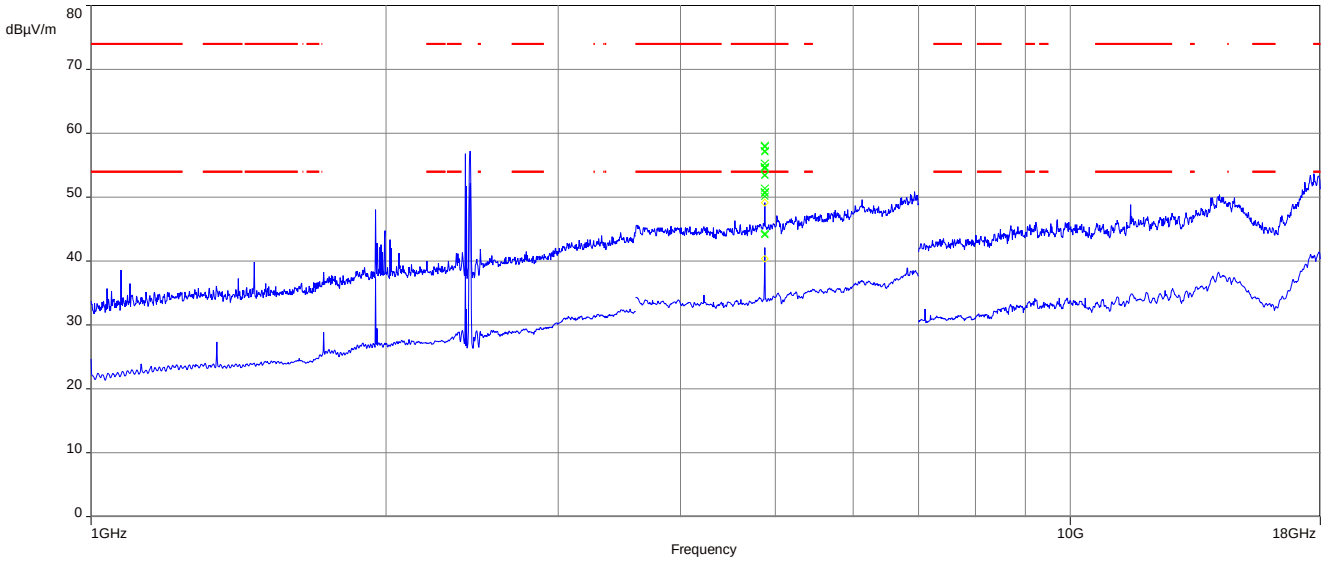
Plots: 802.11b, HL antennas

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



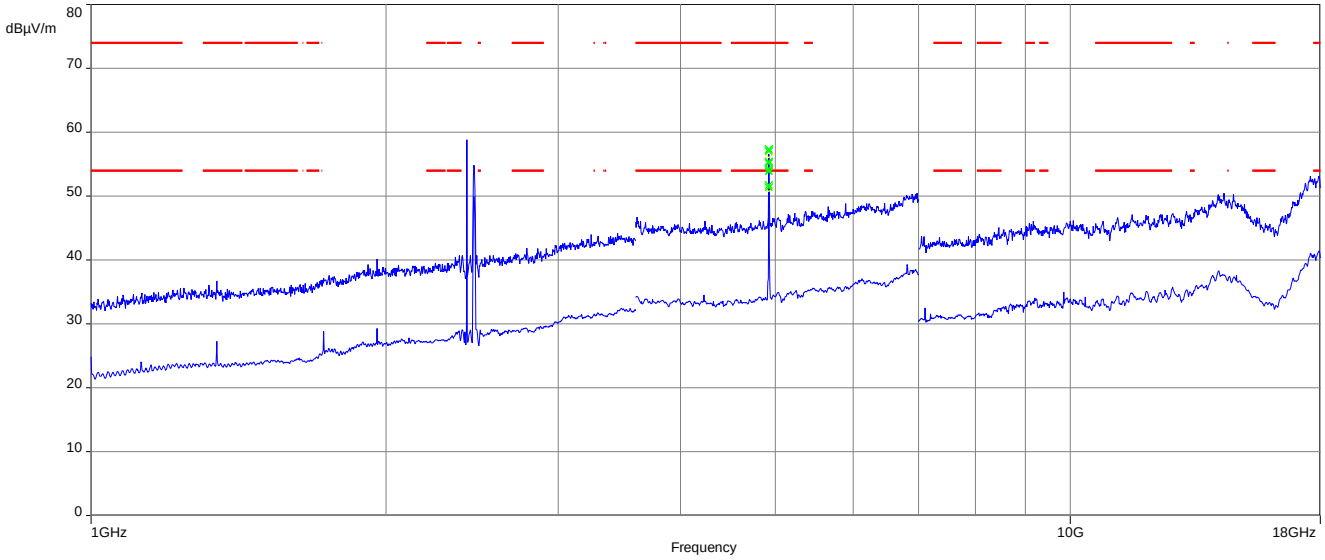
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 2: Middle channel, 1 GHz to 18 GHz, vertical & horizontal polarization



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

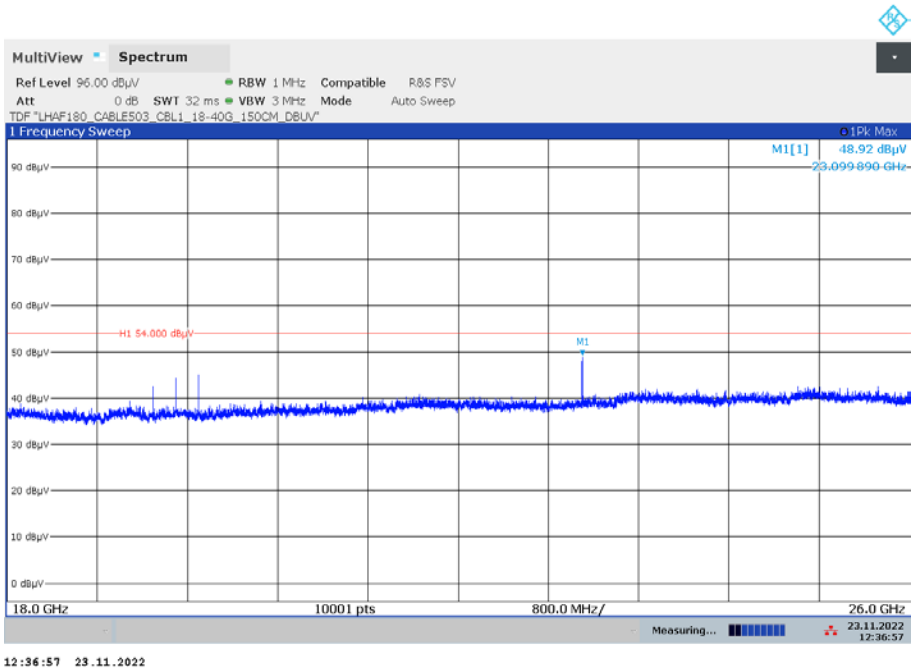
Plot 3: Highest channel, 1 GHz to 18 GHz, vertical & horizontal polarization



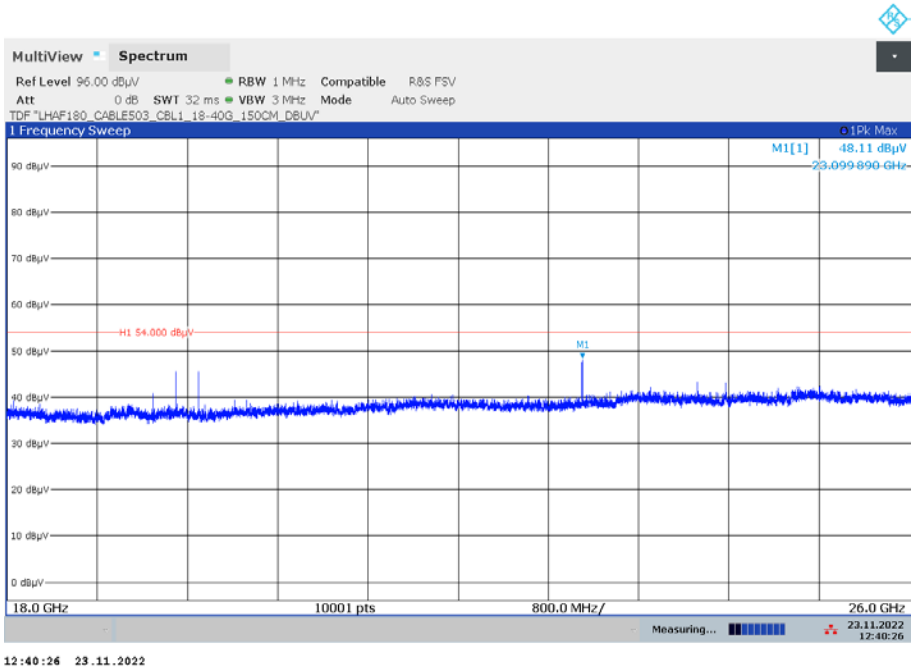
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plots: 18 - 26 GHz, COLFLY antennas

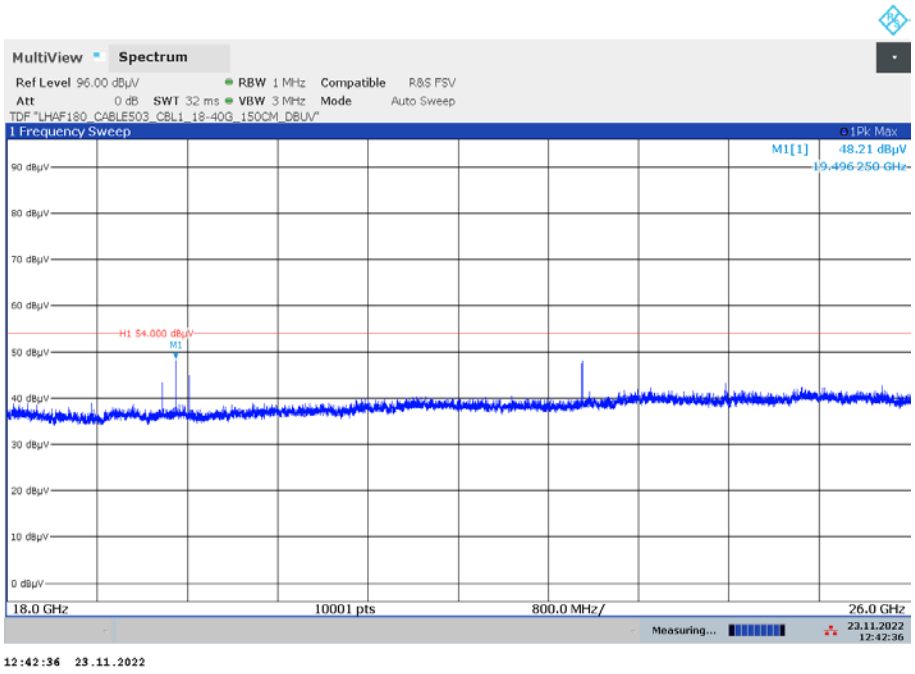
Plot 1: 1 GHz to 18 GHz, vertical & horizontal polarization, valid for all channels in b-mode



Plot 2: 1 GHz to 18 GHz, vertical & horizontal polarization, valid for all channels of all 20 MHz OFDM modes

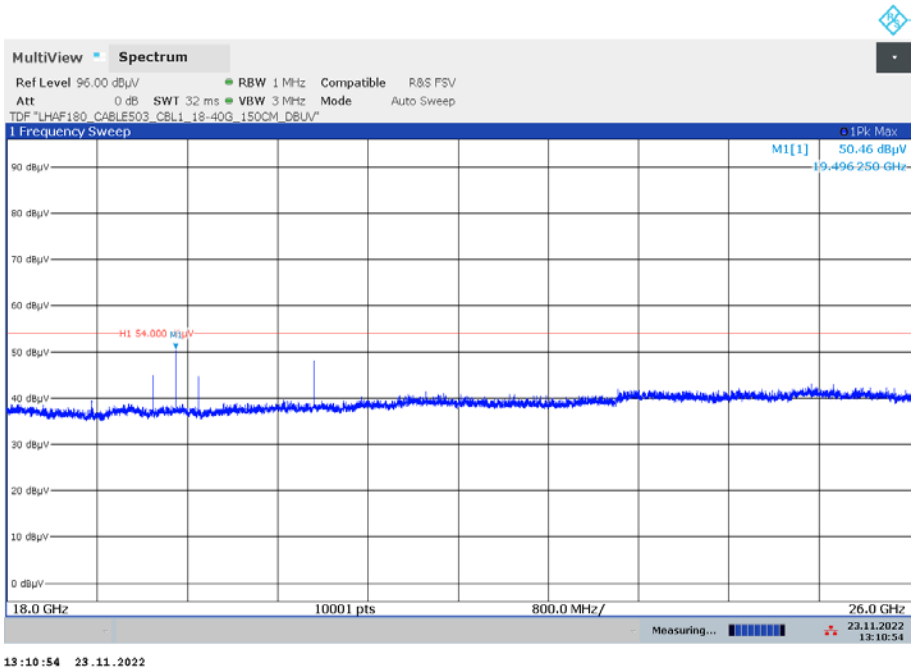


Plot 3: 1 GHz to 18 GHz, vertical & horizontal polarization, valid for all channels of all 40 MHz OFDM modes

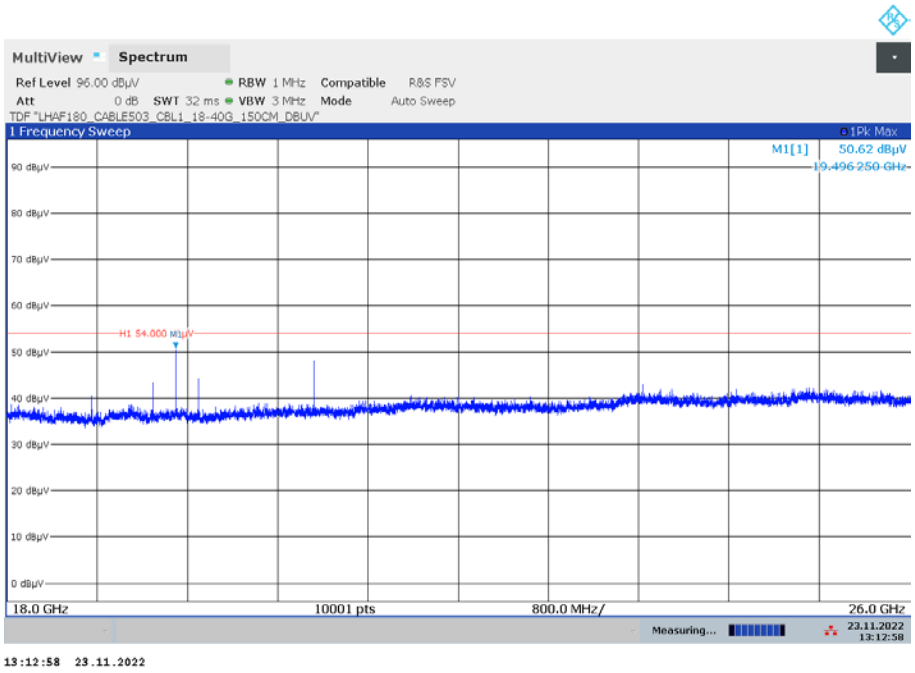


Plots: 18 - 26 GHz, WALSIN antennas

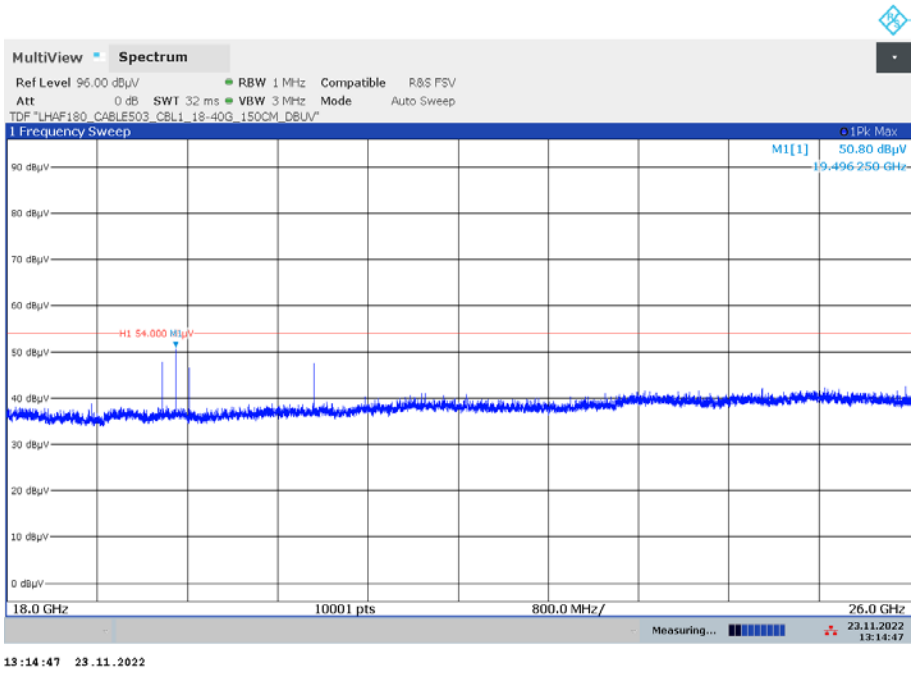
Plot 1: 1 GHz to 18 GHz, vertical & horizontal polarization, valid for all channels in b-mode



Plot 2: 1 GHz to 18 GHz, vertical & horizontal polarization, valid for all channels of all 20 MHz OFDM modes

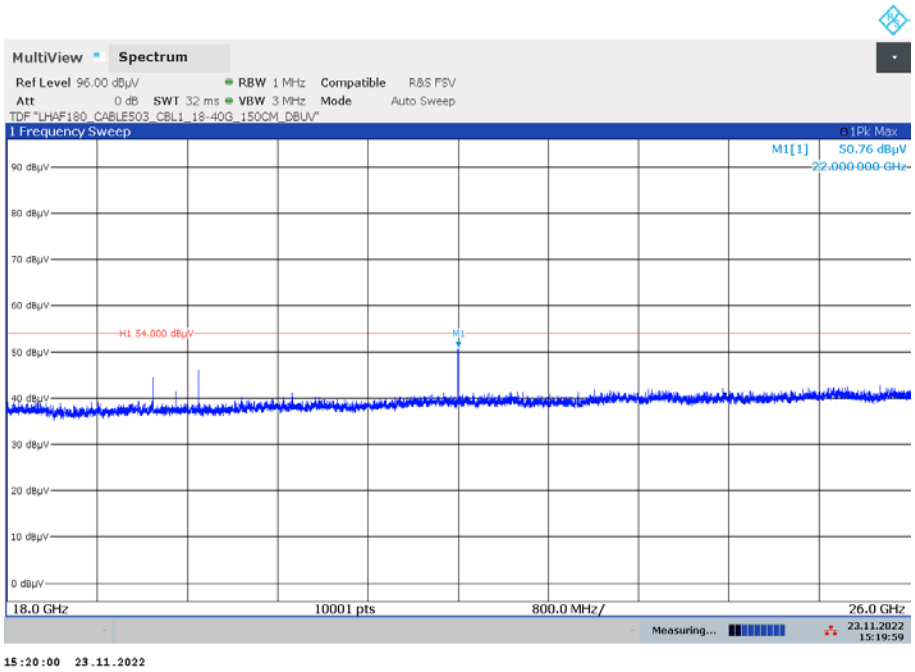


Plot 3: 1 GHz to 18 GHz, vertical & horizontal polarization, valid for all channels of all 40 MHz OFDM modes

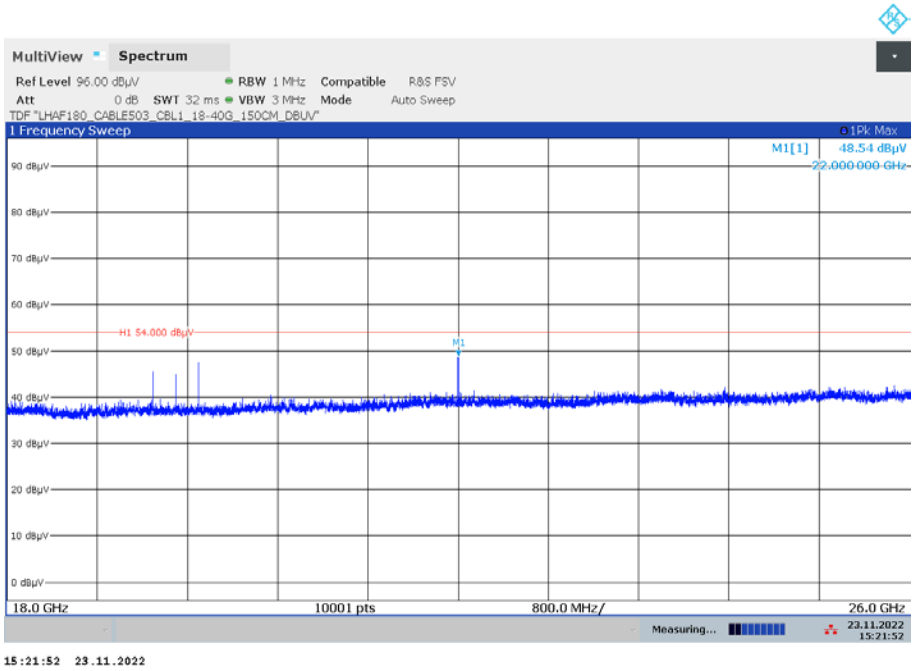


Plots: 18 - 26 GHz, HL antennas

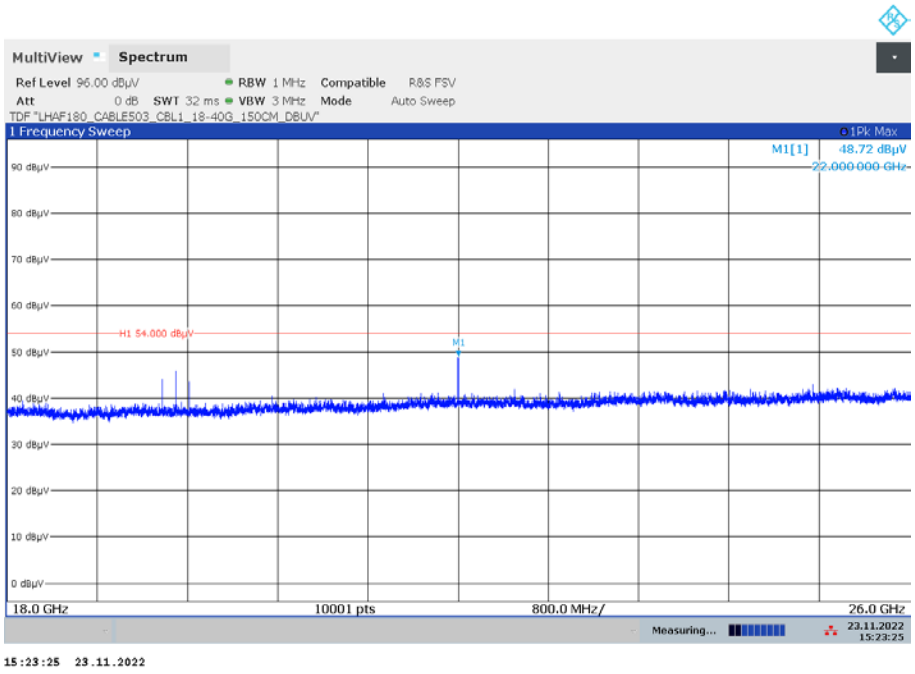
Plot 1: 1 GHz to 18 GHz, vertical & horizontal polarization, valid for all channels in b-mode



Plot 2: 1 GHz to 18 GHz, vertical & horizontal polarization, valid for all channels of all 20 MHz OFDM modes



Plot 3: 1 GHz to 18 GHz, vertical & horizontal polarization, valid for all channels of all 40 MHz OFDM modes



13.13 Spurious emissions conducted below 30 MHz (AC conducted)

Description:

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. Both power lines, phase and neutral line, are measured. Found peaks are re-measured with average and quasi peak detection to show compliance to the limits.

Measurement:

Measurement parameter	
Detector	Peak - Quasi Peak / Average
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 7.5 setup A
Measurement uncertainty	See chapter 9

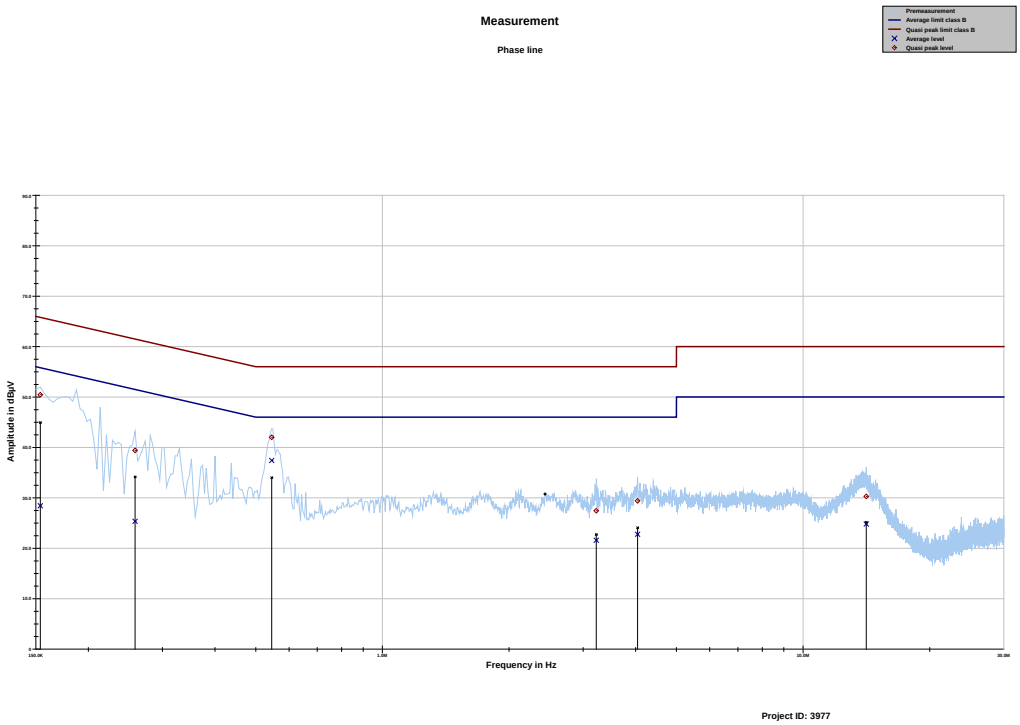
Limits:

FCC		
Frequency / MHz)	Quasi-Peak / (dBµV / m)	Average / (dBµV / m)
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30.0	60	50

*Decreases with the logarithm of the frequency

Plots:

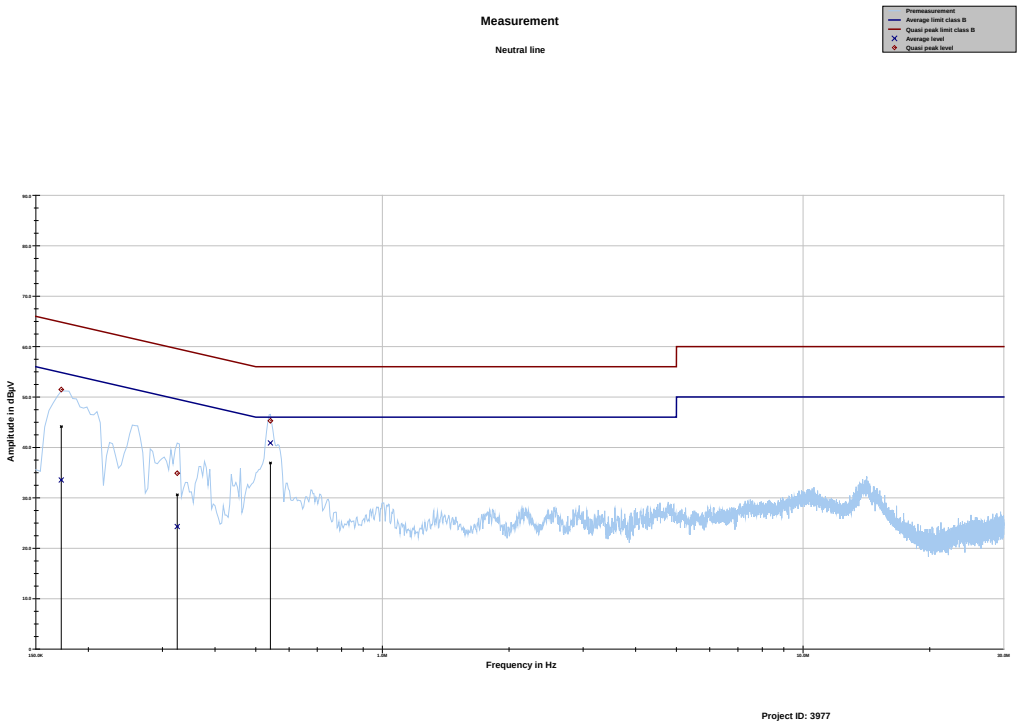
Plot 1: 150 kHz to 30 MHz, phase line



Final results:

Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin Average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.153731	50.45	15.35	65.796	28.43	27.47	55.893
0.258206	39.41	22.08	61.489	25.33	27.58	52.908
0.545512	42.00	14.00	56.000	37.41	8.59	46.000
3.224550	27.44	28.56	56.000	21.59	24.41	46.000
4.041694	29.40	26.60	56.000	22.77	23.23	46.000
14.130994	30.29	29.71	60.000	24.80	25.20	50.000

Plot 2: 150 kHz to 30 MHz, neutral line



Final results:

Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin Average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.172387	51.49	13.36	64.845	33.53	21.83	55.360
0.325369	34.88	24.69	59.569	24.31	26.68	50.989
0.541781	45.28	10.72	56.000	40.88	5.12	46.000

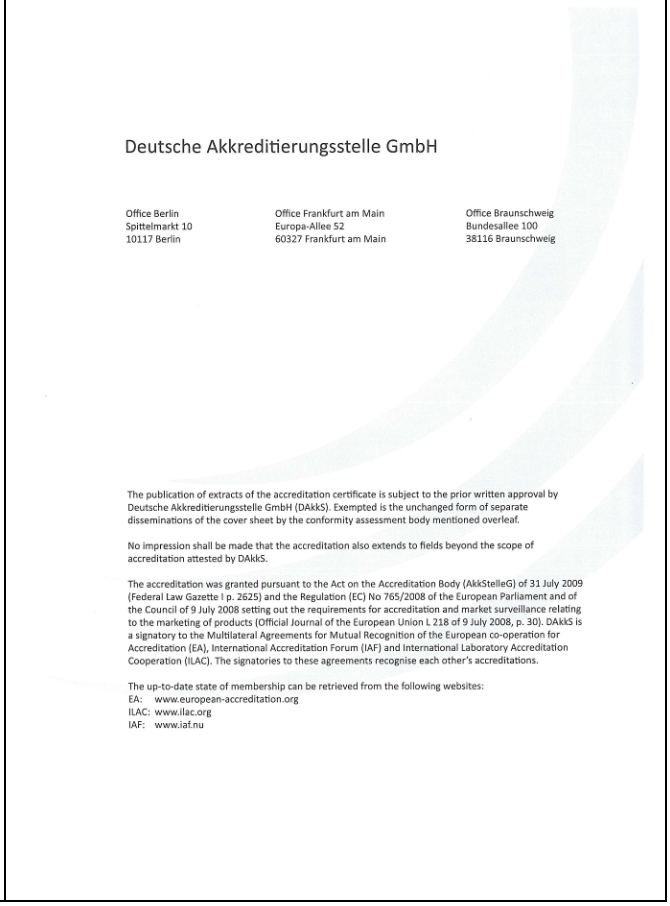
14 Glossary

EUT	Equipment under test
DUT	Device under test
UUT	Unit under test
GUE	GNSS User Equipment
ETSI	European Telecommunications Standards Institute
EN	European Standard
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
WLAN	Wireless local area network
RLAN	Radio local area network
DSSS	Dynamic sequence spread spectrum
OFDM	Orthogonal frequency division multiplexing
FHSS	Frequency hopping spread spectrum
GNSS	Global Navigation Satellite System
C/N_0	Carrier to noise-density ratio, expressed in dB-Hz

15 Document history

Version	Applied changes	Date of release
-/-	Initial release	2022-12-19

16 Accreditation Certificate – D-PL-12076-01-05

first page	last page
	

Note: The current certificate annex is published on the websites (link see below).

https://www.dakks.de/files/data/as/pdf/D-PL-12076-01-05e.pdf

or

https://ctcadvanced.com/app/uploads/2020/06/D-PL-12076-01-05_TCB_USA.pdf

################################ END OF TEST REPORT ################################