Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

Test report no.: 1-5727/18-05-02

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

Würth Elektronik eiSos GmbH & Co KG
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74638 Waldenburg / GERMANY
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Manufacturer

Würth Elektronik eiSos GmbH & Co KG
Max-Eyth-Str. 1
74638 Waldenburg / GERMANY

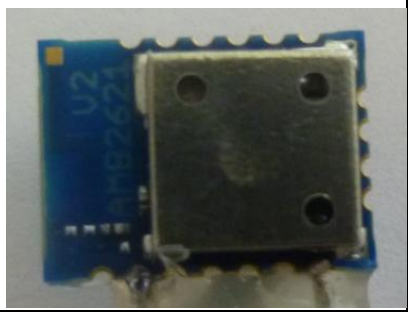
Test standard/s

FCC - Title 47 CFR Part 15	FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 247 Issue 2	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence - Exempt Local Area Network (LE-LAN) Devices
RSS - Gen Issue 5	General Requirements for Compliance of Radio Apparatus

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

Test Item

Kind of test item:	**Bluetooth Low Energy Module**
Model name:	**2608011024010/2608011124010**
FCC ID:	**R7TAMB2623**
IC:	**5136A-AMB2623**
Frequency:	DTS band 2400 MHz to 2483.5 MHz
Technology tested:	Bluetooth® LE
Antenna:	One integrated PCB antenna and one external dipole antenna
Power supply:	3.0 V DC by external power supply
Temperature range:	-40°C to +85°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.

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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:	2018-06-29
Date of receipt of test item:	2018-06-29
Start of test:	2018-06-29
End of test:	2018-09-27
Person(s) present during the test:	-/-

2.3 Test laboratories sub-contracted

None

3 Test standard/s and references

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
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 5	April 2018	General Requirements for Compliance of Radio Apparatus

Guidance	Version	Description
DTS: KDB 558074 D01	v05	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

4 Test environment

Temperature	:	T_{nom} T_{max} T_{min}	+22 °C during room temperature tests No tests under extreme conditions required. No tests under extreme conditions required.
Relative humidity content	:		46 %
Barometric pressure	:		1025 hpa
Power supply	:	V_{nom} V_{max} V_{min}	3.0 V DC by external power supply No tests under extreme conditions required. No tests under extreme conditions required.

5 Test item

5.1 General description

Kind of test item	:	Bluetooth Low Energy Module
Type identification	:	2608011024010/2608011124010
HMN	:	-/-
PMN	:	2608011024010/2608011124010
HVIN	:	2608011024010/2608011124010
FVIN	:	-/-
S/N serial number	:	Rad. 0A602A, 0A9721, 0A9722, 0A9723 (Internal antenna) 0A8729 (External antenna) Cond. 0A8729
HW hardware status	:	2.1
SW software status	:	FW version: 1.0
Frequency band	:	DTS band 2400 MHz to 2483.5 MHz (lowest channel 2402 MHz; highest channel 2480 MHz)
Type of radio transmission Use of frequency spectrum	: :	DSSS
Type of modulation	:	GFSK
Number of channels	:	40
Antenna	:	One integrated PCB antenna and one external dipole antenna
Power supply	:	3.0 V DC by external power supply
Temperature range	:	-40°C to +85°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: 1-5727/18-05-01_AnnexB
1-5727/18-05-01_AnnexD

6 Sequence of testing

6.1 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.

6.2 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.

6.3 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.

6.4 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.

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).

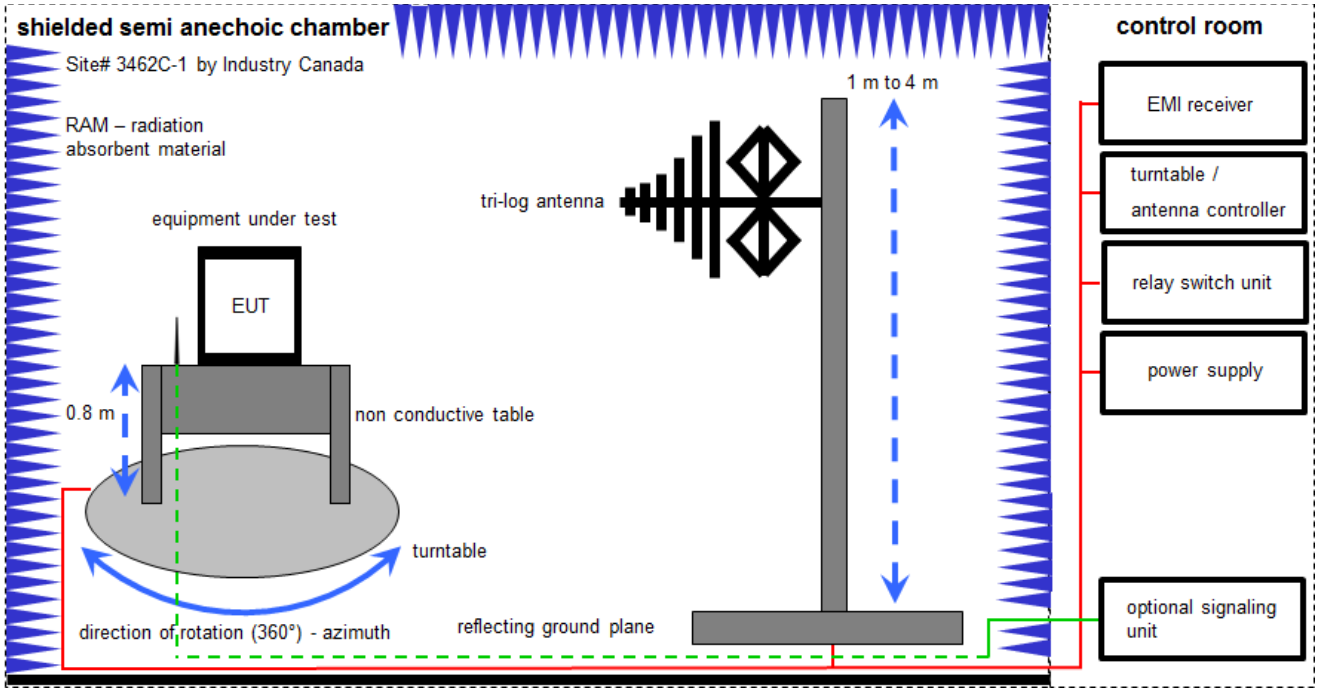
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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: 10.30.0

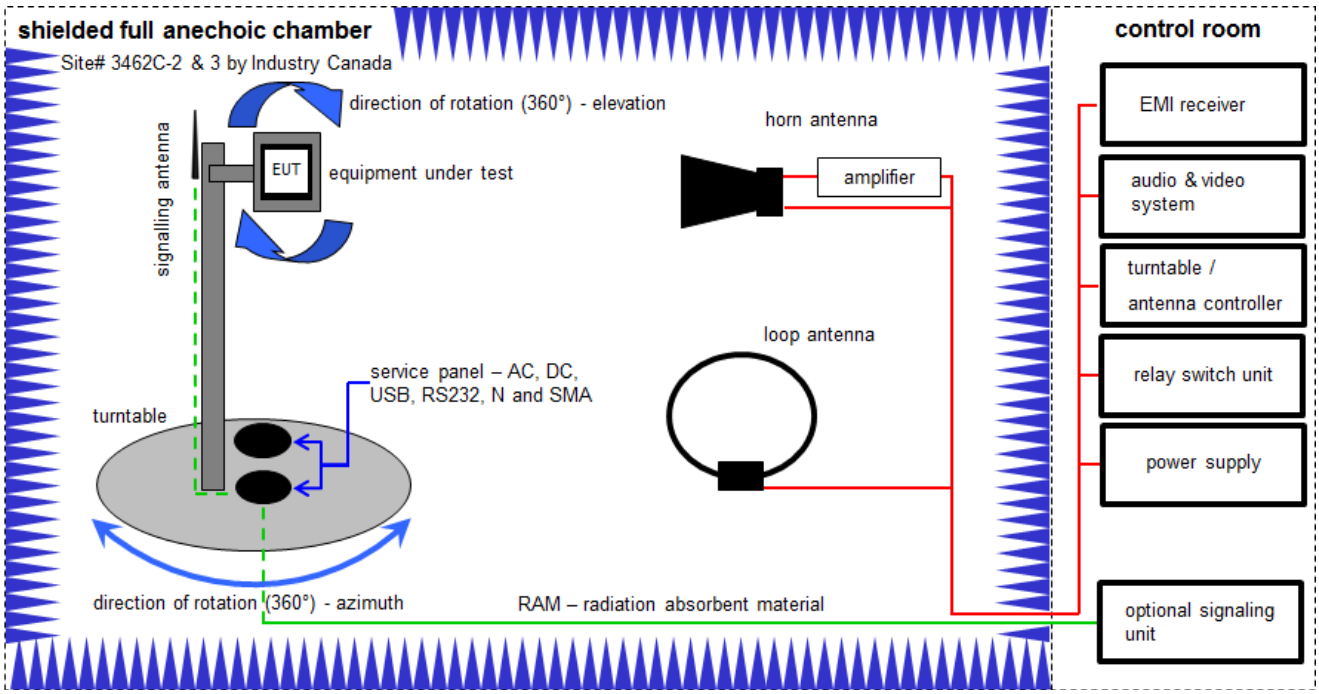
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

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	-/-	300000551	ne	-/-	-/-
3	A	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	15.12.2017	14.12.2018
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 Mess - Elektronik	371	300003854	vIKI!	24.11.2017	23.11.2020
8	A	Power Supply DC	HMP2020	Rohde & Schwarz	102123	300005235	vIKI!	11.10.2016	10.10.2018

7.2 Shielded fully anechoic chamber



Measurement distance: horn antenna 3 meter; loop antenna 3 meter
BAT-EMC software version: 3.16.0.49

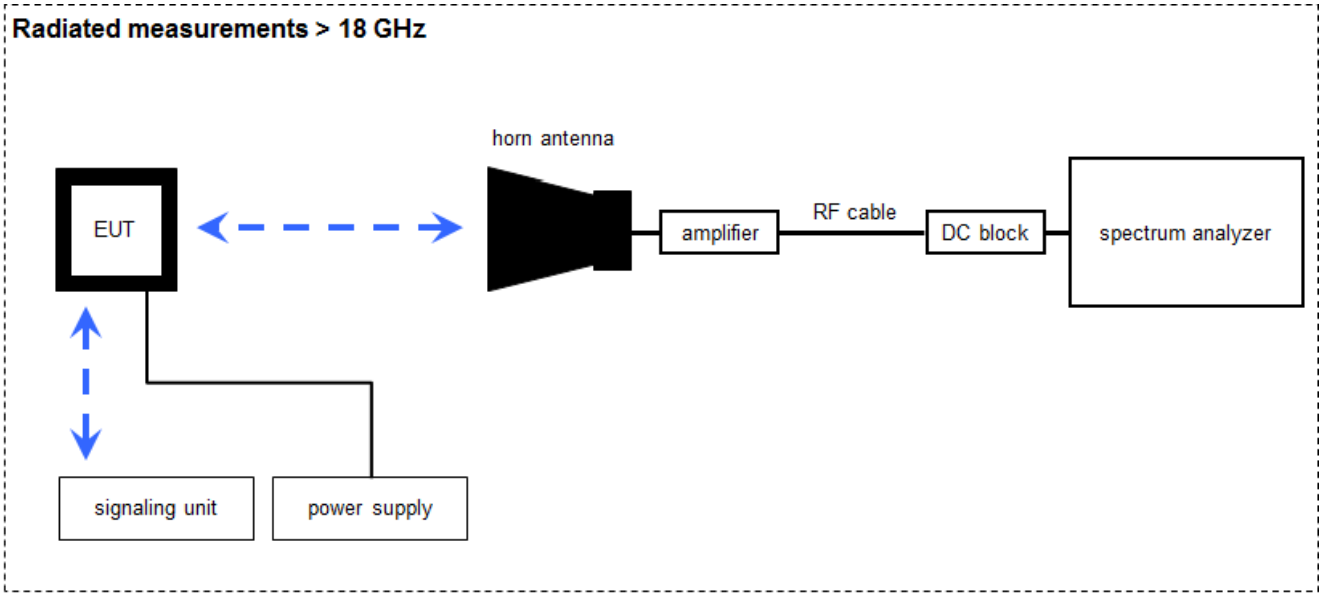
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

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, C	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
3	B, C	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3697	300001605	vIKI!	14.02.2017	13.02.2019
4	A, B, C	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
5	C	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	20.12.2017	19.12.2018
7	C	Highpass Filter	WHK1.1/15G-10SS	Wainwright	3	300003255	ev	-/-	-/-
8	C	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
9	C	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
10	A, B, C	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
11	A, B, C	NEXIO EMV-Software	BAT EMC V3.16.0.49	EMCO	-/-	300004682	ne	-/-	-/-
12	A, B, C	PC	ExOne	F+W	-/-	300004703	ne	-/-	-/-
13	A, B, C	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2818A03450	300001040	vIKI!	12.12.2017	11.12.2020

7.3 Radiated measurements > 18 GHz



Measurement distance: horn antenna 50 cm

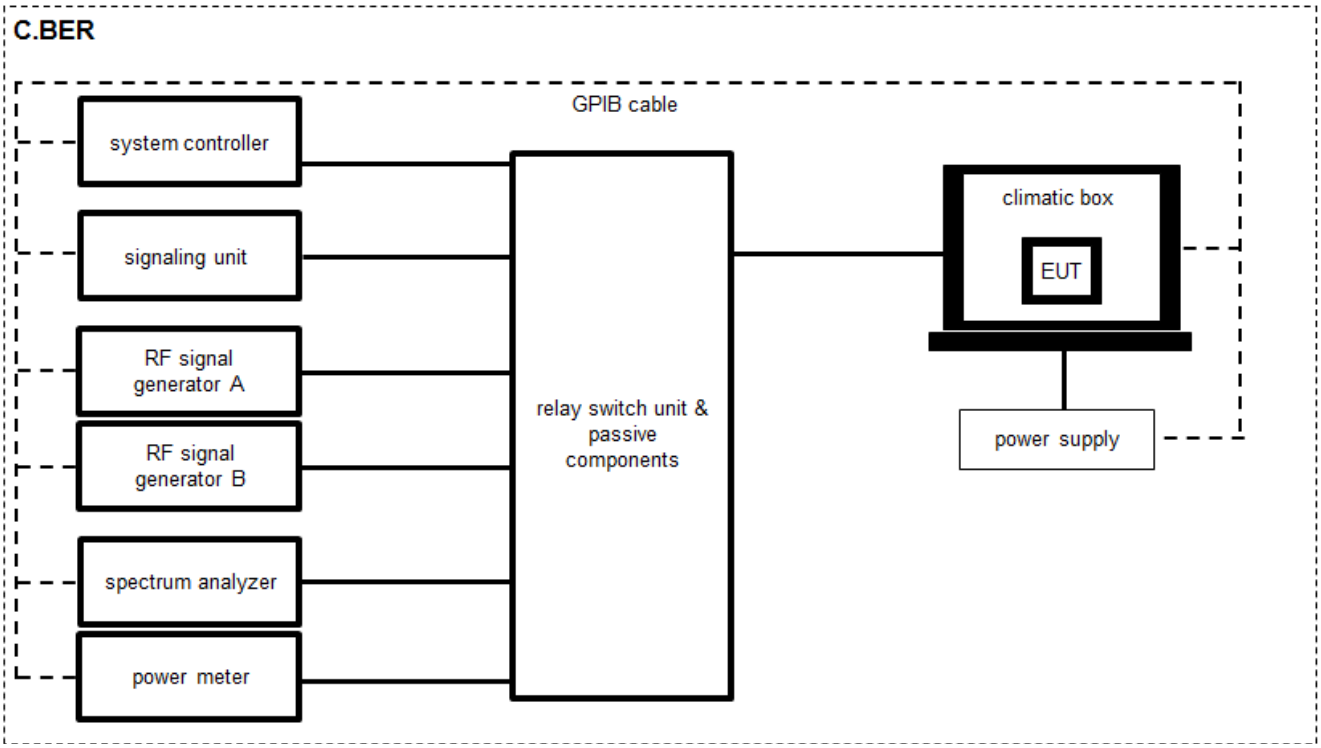
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss signal path & distance correction; AF-antenna factor)

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	Amplifier 2-40 GHz	JS32-02004000-57-5P	MITEQ	1777200	300004541	ev	-/-	-/-
2	A	RF-Cable	ST18/SMAm/SMAm/48	Huber & Suhner	Batch no. 600918	400001182	ev	-/-	-/-
3	A	RF-Cable	ST18/SMAm/SMAm/48	Huber & Suhner	Batch no. 127377	400001183	ev	-/-	-/-
4	A	DC-Blocker 0.1-40 GHz	8141A	Inmet	-/-	400001185	ev	-/-	-/-
5	A	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda	-/-	300000486	k	13.12.2017	12.12.2019
6	A	Signal Analyzer 40 GHz	FSV40	R&S	101042	300004517	k	16.01.2018	15.01.2019
7	A	Power Supply DC	NGSM 32/10	Rohde & Schwarz	3939	400000192	vIKI!	31.01.2017	30.01.2020

7.4 Conducted measurements Radiostar system



Radiostar version: 1.0.0.9

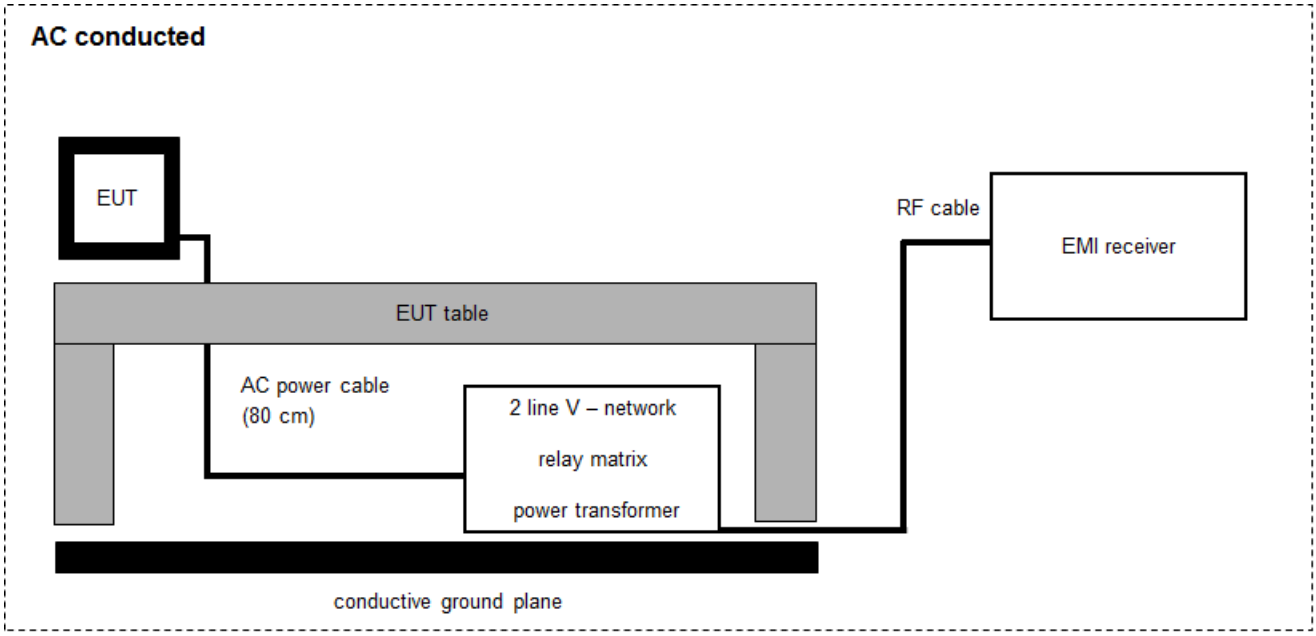
OP = AV + CA
(OP-output power; AV-analyzer value; CA-loss signal path)

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	USB/GPIB interface	82357B	Agilent Technologies	MY52103346	300004390	ne	-/-	-/-
2	A	PC	Exone	F+W		300004179	ne	-/-	-/-
3	A	Wireless Connectivity Tester	CMW270	Rohde & Schwarz	100683	300005133	k	03.01.2018	02.01.2020
4	A	Spectrum Analyzer	FSV30	Rohde & Schwarz	103809	300005359	k	04.04.2017	03.04.2019
5	A	Relay Switch Matrix	RSM-1	CTC	1	400001355	ev	07.02.2018	06.02.2019
6	A	RF-Cable	ST18/SMAm/SMAm/48	Huber & Suhner	Batch no. 699866	400001189	k	-/-	-/-
7	A	RF-Cable	ST18/SMAm/SMAm/48	Huber & Suhner	Batch no. 14844	400001190	k	-/-	-/-
8	A	Power Supply DC	NGSM 32/10	Rohde & Schwarz	3939	400000192	vIKI!	31.01.2017	30.01.2020

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.	Lab / Item	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	R&S	892475/017	300002209	k	13.12.2017	12.12.2019
2	A	RF-Filter-section	85420E	HP	3427A00162	300002214	k	-/-	-/-
3	A	AC-Spannungsquelle variabel	MV2616-V	EM-Test	0397-12	300003259	k	26.01.2018	26.01.2020
4	A	Hochpass 150 kHz	EZ-25	R&S	100010	300003798	ev	-/-	-/-
5	A	MXE EMI Receiver 20 Hz to 26,5 GHz	N9038A	Agilent Technologies	MY51210197	300004405	k	18.12.2017	17.12.2018

8 Measurement uncertainty

Measurement uncertainty	
Test case	**Uncertainty**
Antenna gain	± 3 dB
Spectrum bandwidth	± 21.5 kHz absolute; ± 15.0 kHz relative
Maximum output power	± 1 dB
Detailed conducted spurious emissions @ the band edge	± 1 dB
Band edge compliance radiated	± 3 dB
Band edge compliance conducted	± 1.5 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!	2018-10-29	-/-

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 (4)	System gain	-/-	Nominal	Nominal	1 Msps 2 Msps	☒	☐	☐	☐	-/-
§15.247(e) RSS - 247 / 5.2 (b)	Power spectral density	KDB 558074 DTS clause: 10.6	Nominal	Nominal	1 Msps 2 Msps	☒	☐	☐	☐	-/-
§15.247(a)(2) RSS - 247 / 5.2 (a)	DTS bandwidth – 6 dB bandwidth	KDB 558074 DTS clause: 8.1	Nominal	Nominal	1 Msps 2 Msps	☒	☐	☐	☐	-/-
RSS Gen	Occupied bandwidth	-/-	Nominal	Nominal	1 Msps 2 Msps	☒	☐	☐	☐	-/-
§15.247(b)(3) RSS - 247 / 5.4 (4)	Maximum output power	KDB 558074 DTS clause: 9.1.1	Nominal	Nominal	1 Msps 2 Msps	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5	Detailed spurious emissions @ the band edge - conducted	-/-	Nominal	Nominal	1 Msps 2 Msps	☒	☐	☐	☐	-/-
§15.205 RSS - 247 / 5.5 RSS - Gen	Band edge compliance cond. & rad.	KDB 558074 DTS clause: 13.3.2 and clause 12.2.2	Nominal	Nominal	1 Msps 2 Msps	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5	TX spurious emissions conducted	KDB 558074 DTS clause: 11.1 & 11.2 11.3	Nominal	Nominal	1 Msps 2 Msps	☒	☐	☐	☐	-/-
§15.209(a) RSS - Gen	Spurious emissions radiated below 30 MHz	-/-	Nominal	Nominal	1 Msps 2 Msps	☒	☐	☐	☐	-/-
15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen	Spurious emissions radiated 30 MHz to 1 GHz	-/-	Nominal	Nominal	1 Msps 2 Msps RX mode	☒	☐	☐	☐	-/-
§15.247(d) RSS - 247 / 5.5 §15.109 RSS - Gen	Spurious emissions radiated above 1 GHz	-/-	Nominal	Nominal	1 Msps 2 Msps RX mode	☒	☐	☐	☐	-/-
§15.107(a) §15.207	Conducted emissions below 30 MHz (AC conducted)	-/-	Nominal	Nominal	1 Msps	☒	☐	☐	☐	-/-

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

10 Additional comments

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Reference documents: 1-5727_18-05-02_log1_conducted.pdf
(Conducted plots from CTC measurement system)
2608011024010-Duty-Cycle.pdf

Special test descriptions: All radiated tests have been performed with both antennas.

Configuration descriptions: Before starting the tests, the command 0x840B was sent to the device in order to set the power setting to 4 dBm.

Bluetooth Low Energy	
Longest Supported payload (37 – 255 Byte)	Tx: 255, RX: 255
LE 1M PHY supported	Yes
LE 2M PHY supported	Yes
Stable Modulation Index supported (SMI)	No
LE Coded PHY supported (S=2)	No
LE Coded PHY supported (S=8)	No

Test mode:

☒ Bluetooth LE Test mode enabled
(EUT is controlled by CMW)

☐ Special software is used.
EUT is transmitting pseudo random data by itself

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.

11 Measurement results

11.1 System gain

Measurement:

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

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

Measurement parameters (conducted)	
External result file	1-5727_18-05-02_log1_conducted.pdf Common2G4 Peak Output Power conducted 3MHz_3MHz
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 8

Limits:

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

Results: Integrated antenna

T_{nom}	V_{nom}	2402 MHz	2440 MHz	2480 MHz
Conducted power [dBm] Measured with GFSK modulation (1 Msps)		3.1	2.7	2.5
Radiated power [dBm] Measured with GFSK modulation (1 Msps)		-1.8	-3.2	-4.3
Gain [dBi] Calculated		-4.9	-5.9	-6.8

Results: External antenna

T_{nom}	V_{nom}	2402 MHz	2440 MHz	2480 MHz
Conducted power [dBm] Measured with GFSK modulation (1 Msps)		3.1	2.7	2.5
Radiated power [dBm] Measured with GFSK modulation (1 Msps)		4.8	5.9	5.0
Gain [dBi] Calculated		1.7	3.2	2.5

11.2 Power spectral density

Description:

Measurement of the power spectral density of a digital modulated system.

Measurement parameters	
External result file	1-5727_18-05-02_log1_conducted.pdf FCC Part 15.247 Peak Power Spectral Density DTS
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 8

Limits:

FCC	IC
Power spectral density	
For digitally modulated systems the transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission or over 1.0 second if the transmission exceeds 1.0-second duration.	

Results:

	Frequency		
	2402 MHz	2440 MHz	2480 MHz
Power spectral density [dBm / 3kHz] 1 Msps	-12.9	-13.4	-13.6
Power spectral density [dBm / 3kHz] 2 Msps	-14.9	-15.5	-15.7

11.3 DTS bandwidth – 6 dB bandwidth

Description:

Measurement of the 6 dB bandwidth of the modulated signal.

Measurement parameters	
According to DTS clause: 8.1	
External result file	1-5727_18-05-02_log1_conducted.pdf FCC Part 15.247 Bandwidth 6dB DTS
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 8

Limits:

FCC	IC
DTS bandwidth – 6 dB bandwidth	
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:

	Frequency		
	2402 MHz	2440 MHz	2480 MHz
6 dB bandwidth [kHz] 1 Msps	710	710	714
6 dB bandwidth [kHz] 2 Msps	1150	1150	1150

11.4 Occupied bandwidth – 99% emission bandwidth

Description:

Measurement of the 99% bandwidth of the modulated signal acc. RSS-GEN.

Measurement parameters	
External result file	1-5727_18-05-02_log1_conducted.pdf FCC Part 15.247 Bandwidth 99PCT
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 8

Usage:

-/-	IC
Occupied bandwidth – 99% emission bandwidth	
OBW is necessary for emission designator	

Results:

	Frequency		
	2402 MHz	2440 MHz	2480 MHz
99% bandwidth [kHz] 1 Msps	1049	1055	1051
99% bandwidth [kHz] 2 Msps	2063	2068	2063

11.5 Maximum output power

Description:

Measurement of the maximum output power conducted. EUT in single channel mode.

Measurement parameters	
External result file	1-5727_18-05-02_log1_conducted.pdf FCC Part 15.247 Maximum Peak Conducted Output Power DTS
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 8

Limits:

FCC	IC
Maximum output power	
Conducted: 1.0 W – antenna gain max. 6 dBi	

Results:

	Frequency		
	2402 MHz	2440 MHz	2480 MHz
Maximum output power conducted [dBm] 1 Msps	3.5	3.1	2.8
Maximum output power conducted [dBm] 2 Msps	3.5	3.0	2.8

11.6 Detailed spurious emissions @ the band edge - conducted

Description:

Measurement of the conducted band edge compliance. EUT is measured at the lower and upper band edge in single channel.

Measurement parameters	
External result file	1-5727_18-05-02_log1_conducted.pdf FCC Part 15.247 TX Spurious Conduced
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 8

Limits:

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

Results:

Scenario	Spurious band edge conducted [dB]
Data rate	1 Msps
Lower band edge	> 20 dB
Upper band edge	> 20 dB
Data rate	2 Msps
Lower band edge	> 20 dB
Upper band edge	> 20 dB

11.7 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 single channel mode and the transmit frequency 2402 MHz for the lower restricted band and 2480 MHz for the upper restricted band. Measurement distance is 3m.

Measurement parameters	
Detector	Peak / RMS
Sweep time	Auto
Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Span	Lower Band: 2300 – 2400 MHz higher Band: 2480 – 2500 MHz
Trace mode	Max hold
Test setup	See sub clause 7.2 B
Measurement uncertainty	See sub clause 8

Limits:

FCC	IC
Band edge compliance radiated	
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 5.205(c)).	
54 dBµV/m AVG 74 dBµV/m Peak	

Result: Integrated antenna

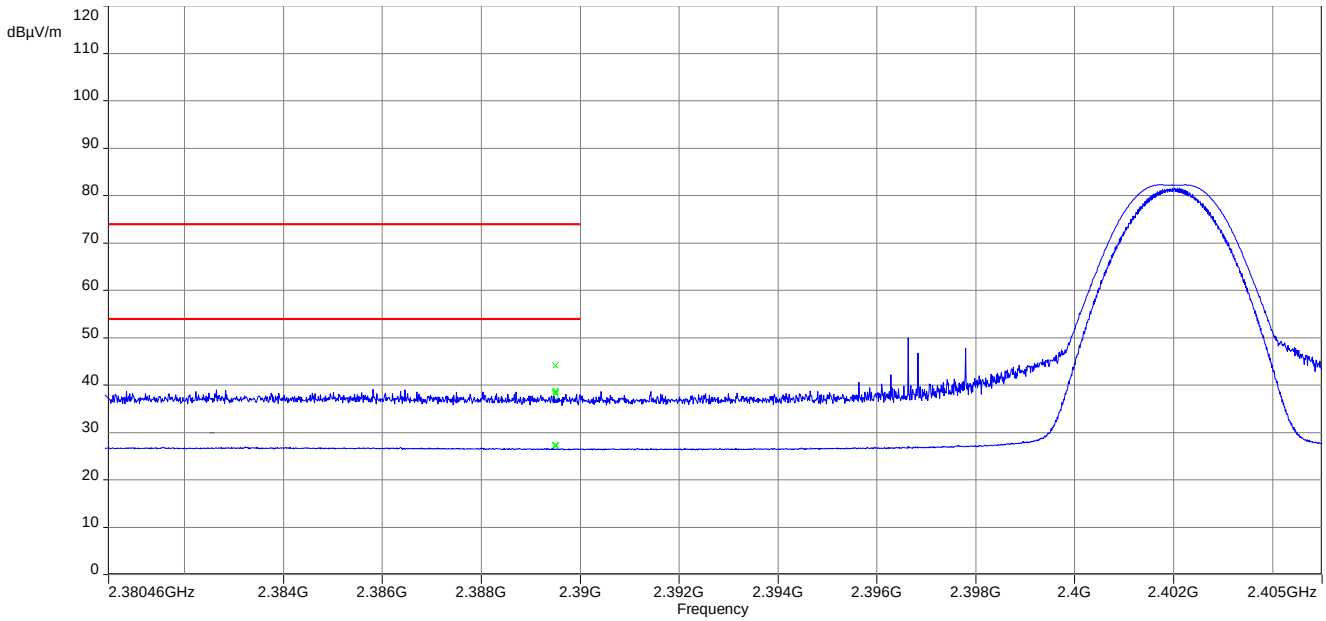
Scenario	Band edge compliance radiated [dBµV/m]
Data rate	1 Msps
Lower restricted band	27.3 dBµV/m AVG 44.1 dBµV/m Peak
Upper restricted band	33.0 dBµV/m AVG 54.5 dBµV/m Peak
Data rate	2 Msps
Lower restricted band	34.2 dBµV/m AVG 52.3 dBµV/m Peak
Upper restricted band	34.8 dBµV/m AVG 52.7 dBµV/m Peak

Result: External antenna

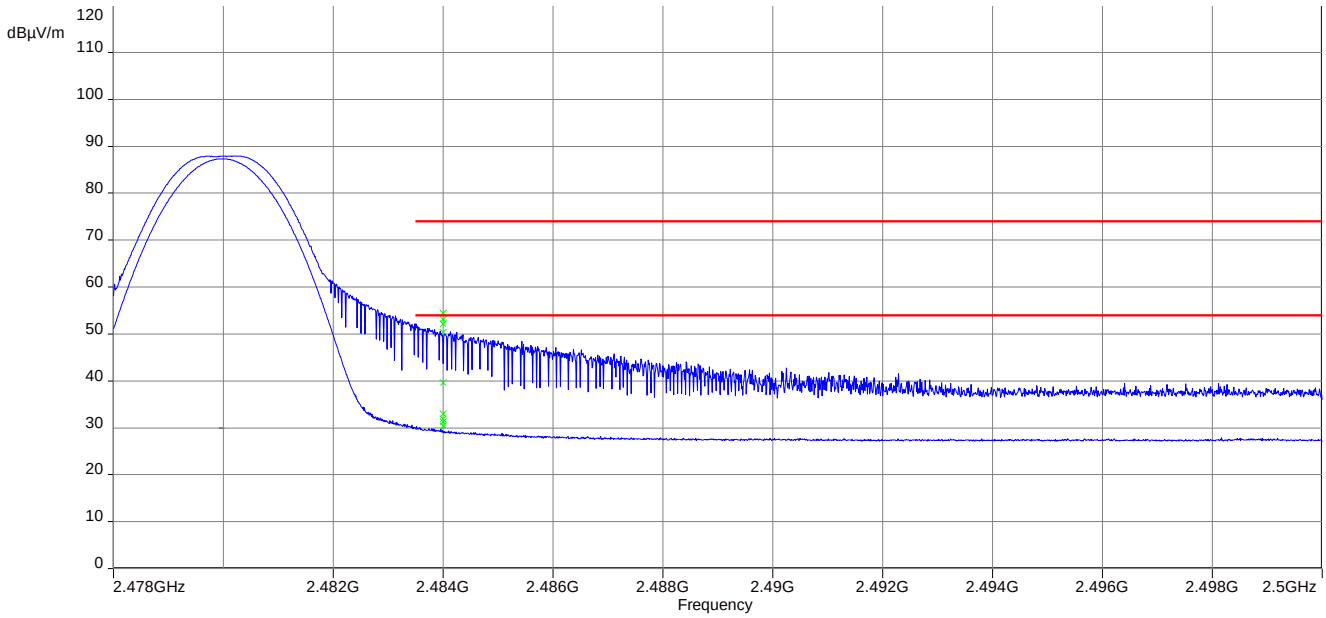
Scenario	Band edge compliance radiated [dBµV/m]
Data rate	1 Msps
Lower restricted band	30.6 dBµV/m AVG 51.6 dBµV/m Peak
Upper restricted band	39.7 dBµV/m AVG 61.7 dBµV/m Peak
Data rate	2 Msps
Lower restricted band	32.9 dBµV/m AVG 53.2 dBµV/m Peak
Upper restricted band	46.2 dBµV/m AVG 64.0 dBµV/m Peak

Plots: Integrated antenna

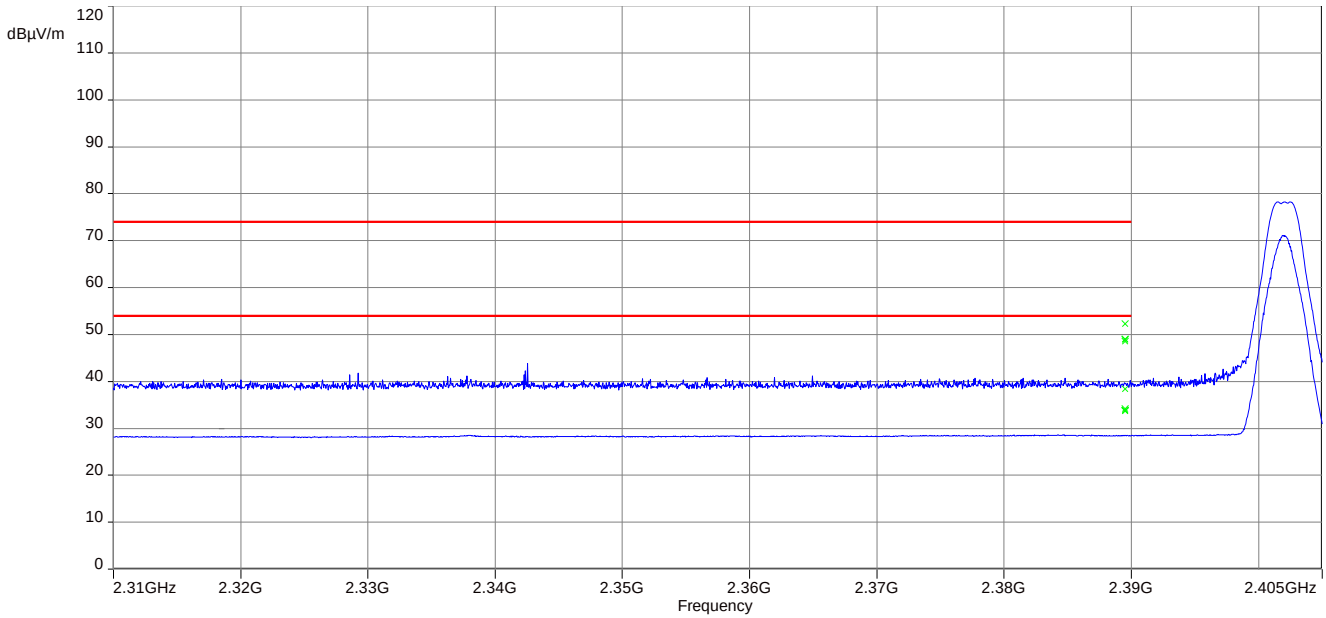
Plot 1: Lower restricted band, 1 Msps



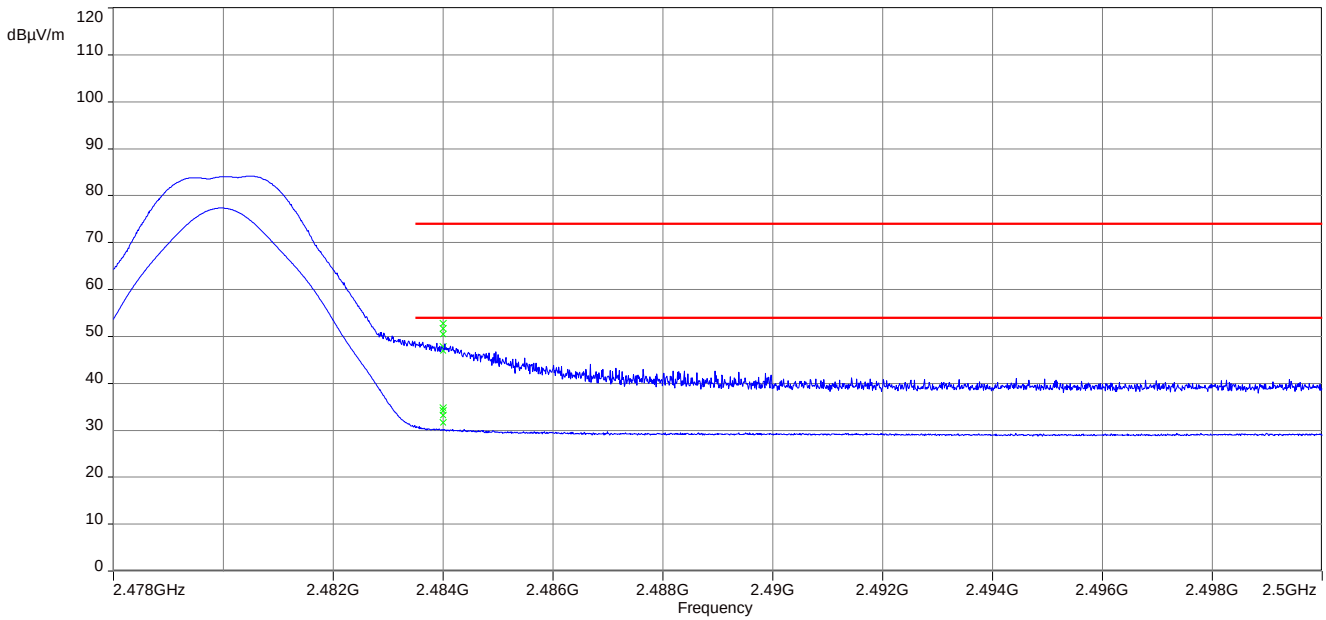
Plot 2: Upper restricted band, 1 Msps



Plot 3: Lower restricted band, 2 Msps

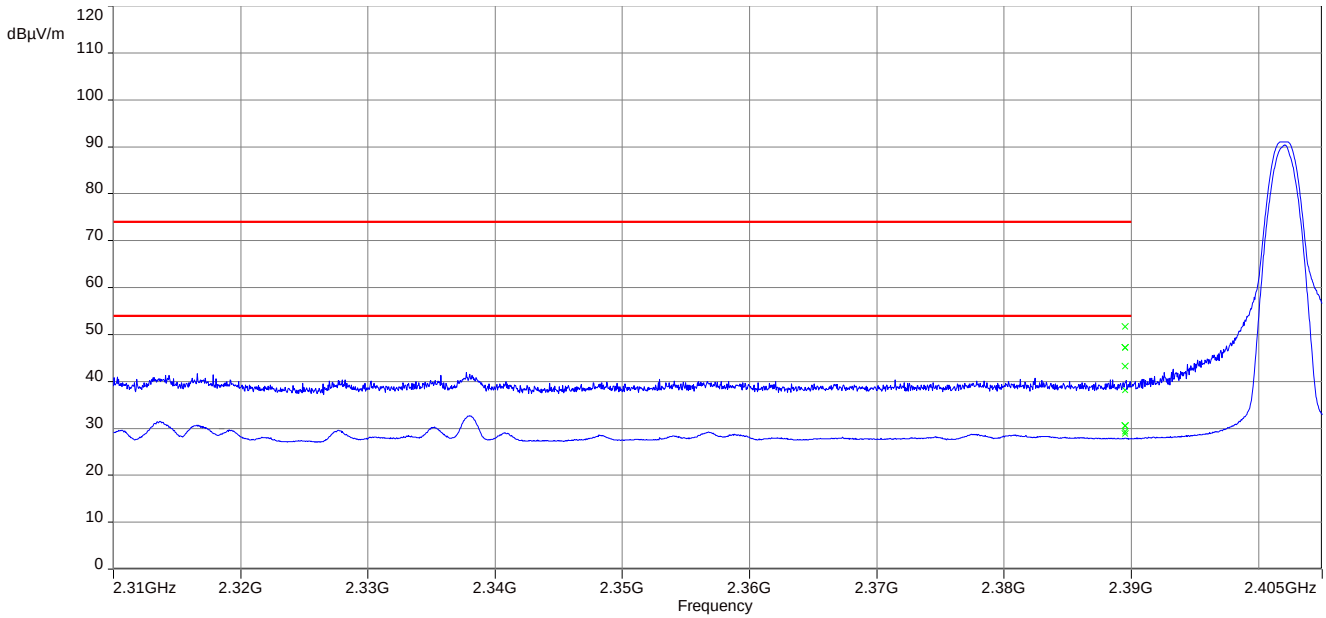


Plot 4: Upper restricted band, 2 Msps

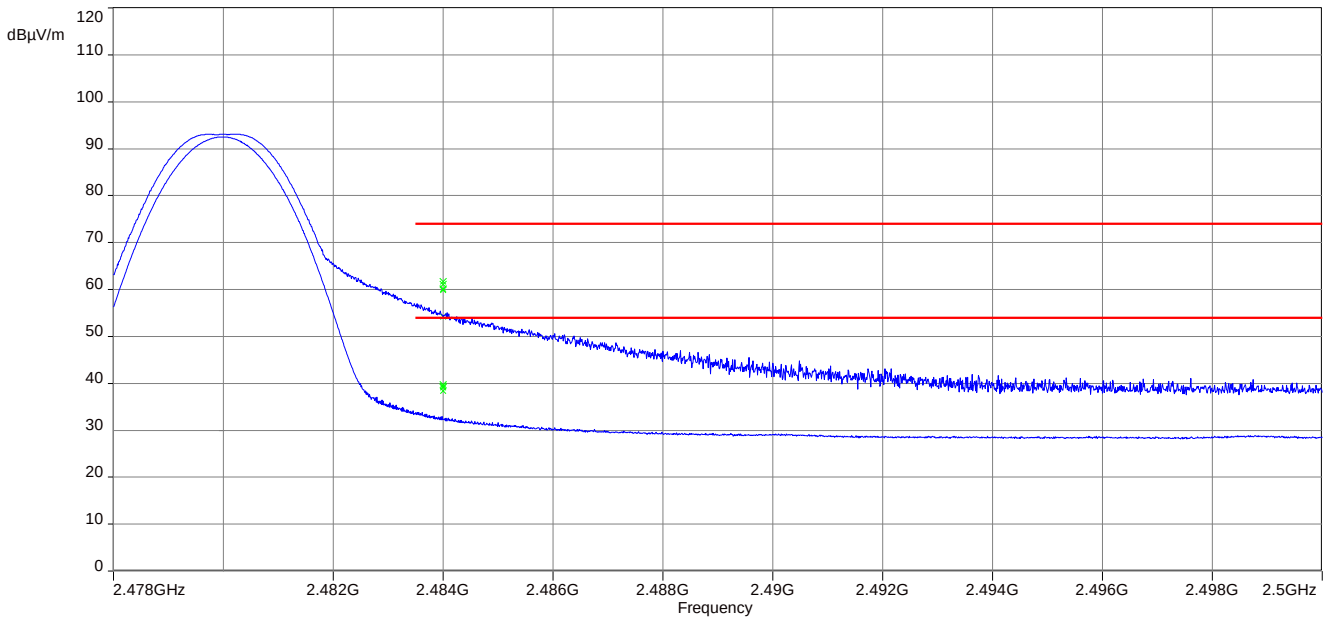


Plots: External antenna

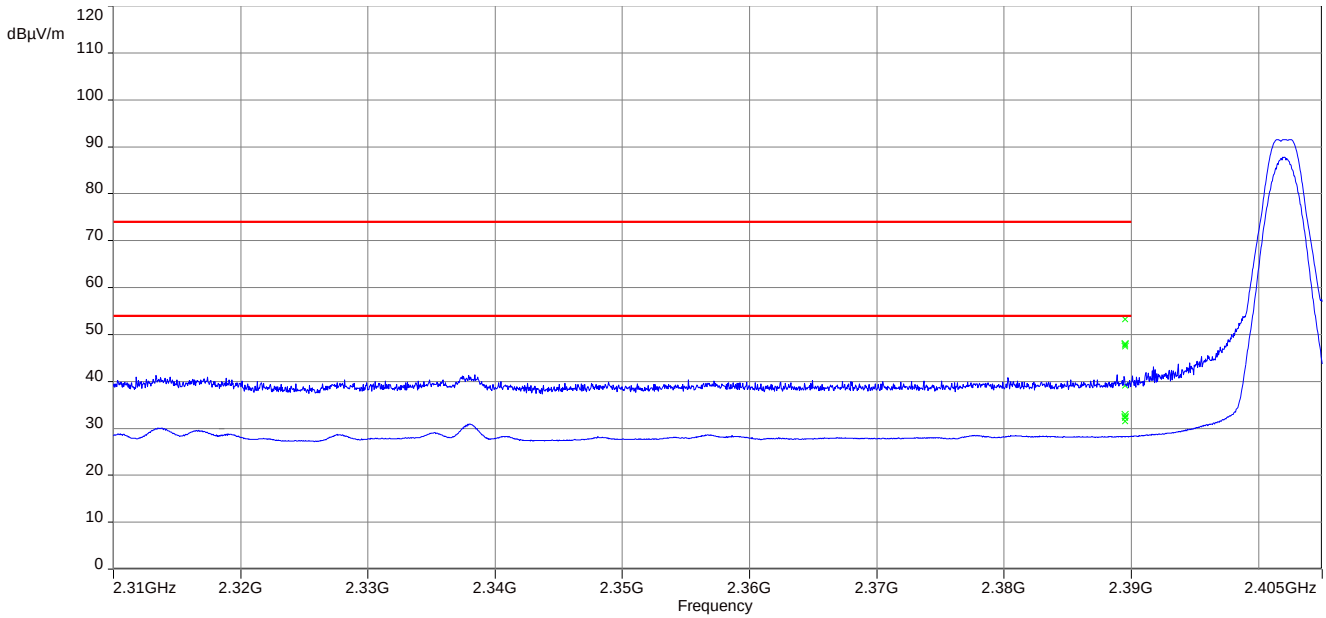
Plot 1: Lower restricted band, 1 Msps



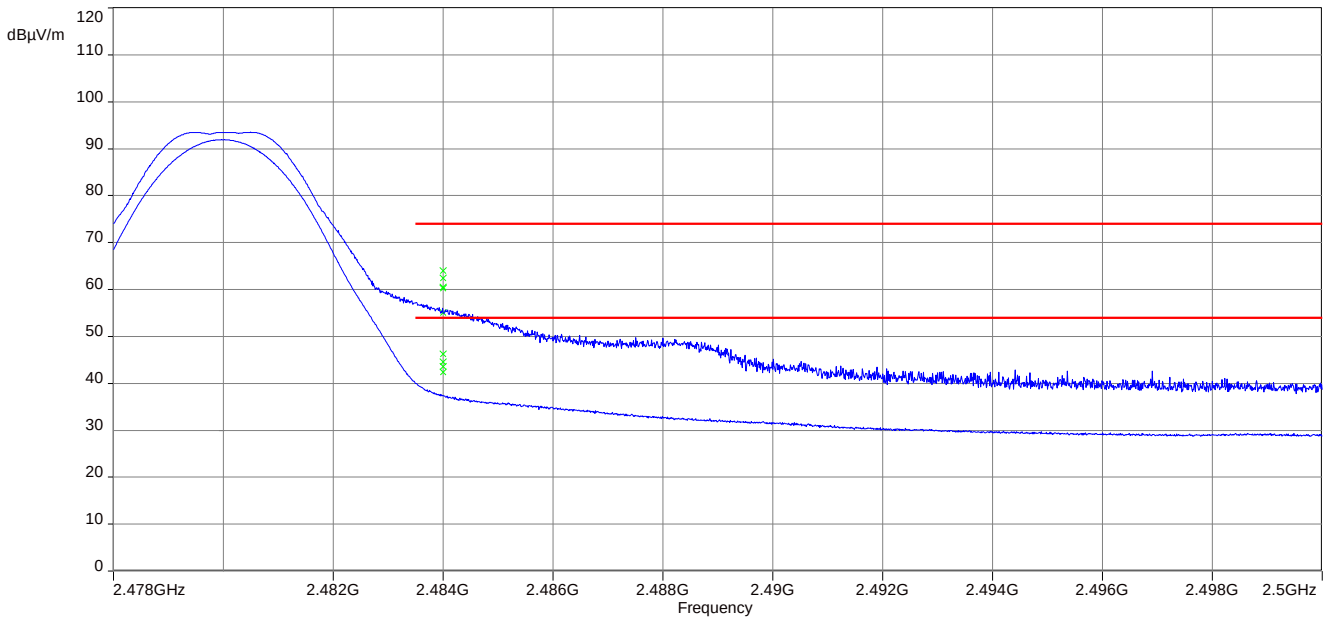
Plot 2: Upper restricted band, 1 Msps



Plot 3: Lower restricted band, 2 Msps



Plot 4: Upper restricted band, 2 Msps



11.8 TX spurious emissions conducted

Description:

Measurement of the conducted spurious emissions in transmit mode. The EUT is set to single channel mode and the transmit frequencies are 2402 MHz, 2440 MHz and 2480 MHz.

Measurement parameters	
External result file	1-5727_18-05-02_log1_conducted.pdf FCC Part 15.247 TX Spurious Conduced
Test setup	See sub clause 7.4 A
Measurement uncertainty	See sub clause 8

Limits:

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

Results: 1 Msps

TX spurious emissions conducted					
f [MHz]		amplitude of emission [dBm]	limit max. allowed emission power	actual attenuation below frequency of operation [dB]	results
2402		2.0	30 dBm		Operating frequency
All detected emissions are compliant with the -20 dBc limit!			-20 dBc		compliant
2440		1.0	30 dBm		Operating frequency
All detected emissions are compliant with the -20 dBc limit!			-20 dBc		compliant
2480		1.5	30 dBm		Operating frequency
All detected emissions are compliant with the -20 dBc limit!			-20 dBc		compliant

Results: 2 Msps

TX spurious emissions conducted					
f [MHz]		amplitude of emission [dBm]	limit max. allowed emission power	actual attenuation below frequency of operation [dB]	results
2402		-0.8	30 dBm		Operating frequency
All detected emissions are compliant with the -20 dBc limit!			-20 dBc		compliant
2440		-0.2	30 dBm		Operating frequency
All detected emissions are compliant with the -20 dBc limit!			-20 dBc		compliant
2480		-0.2	30 dBm		Operating frequency
All detected emissions are compliant with the -20 dBc limit!			-20 dBc		compliant

11.9 Spurious emissions radiated below 30 MHz

Description:

Measurement of the radiated spurious emissions in transmit mode below 30 MHz. The EUT is set to single channel mode and the transmit frequencies are 2402 MHz, 2440 MHz and 2480 MHz. The limits are recalculated to a measurement distance of 3 m according the ANSI C63.10.

Measurement parameters	
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: 30 kHz
Span	9 kHz to 30 MHz
Trace mode	Max hold
Test setup	See sub clause 7.2 A
Measurement uncertainty	See sub clause 8

Limits:

FCC		IC
TX spurious emissions radiated below 30 MHz		
Frequency (MHz)	Field strength (dBµV/m)	Measurement distance
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30

Results: Integrated antenna, 1 Msps

TX spurious emissions radiated below 30 MHz [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
All detected emissions are more than 20 dB below the limit.		

Results: Integrated antenna, 2 Msps

TX spurious emissions radiated below 30 MHz [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
All detected emissions are more than 20 dB below the limit.		

Results: External antenna, 1 Msps

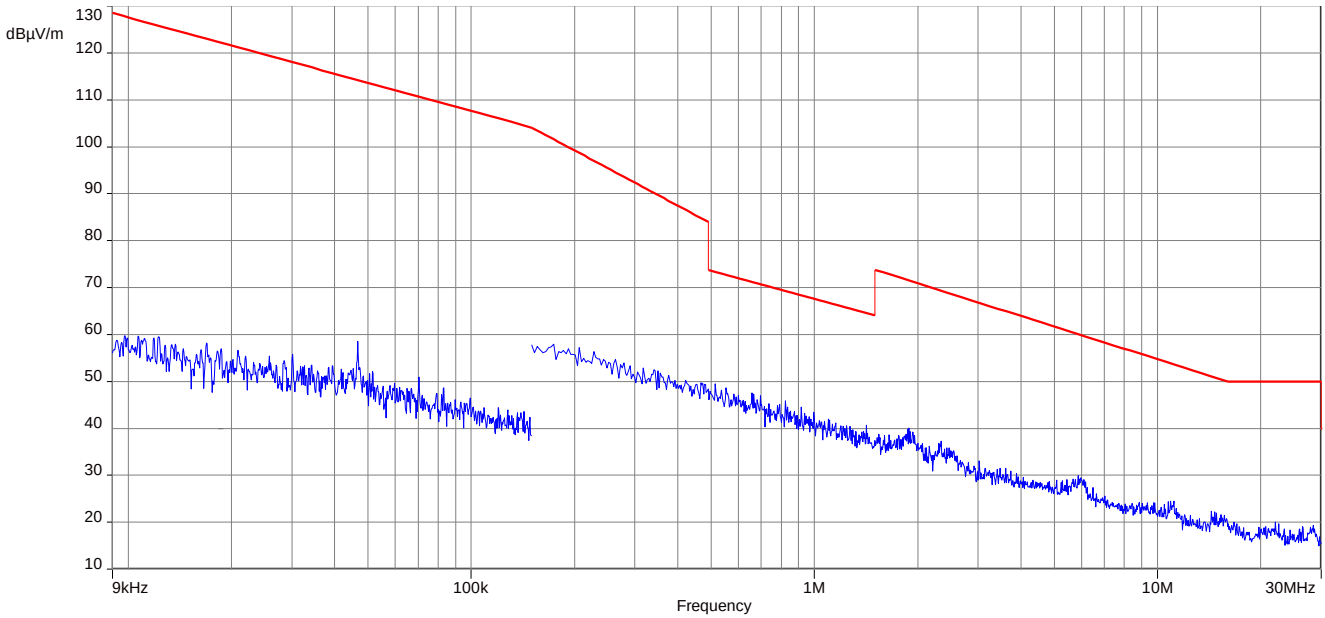
TX spurious emissions radiated below 30 MHz [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
All detected emissions are more than 20 dB below the limit.		

Results: External antenna, 2 Msps

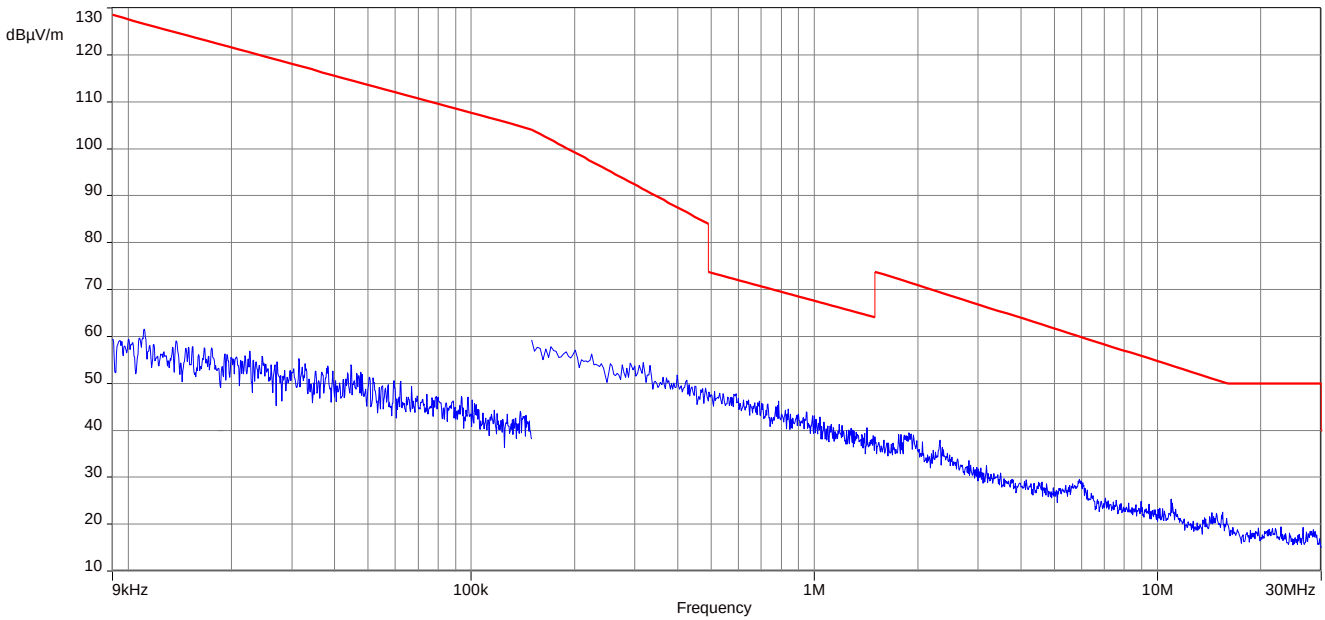
TX spurious emissions radiated below 30 MHz [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
All detected emissions are more than 20 dB below the limit.		

Plots: Integrated antenna

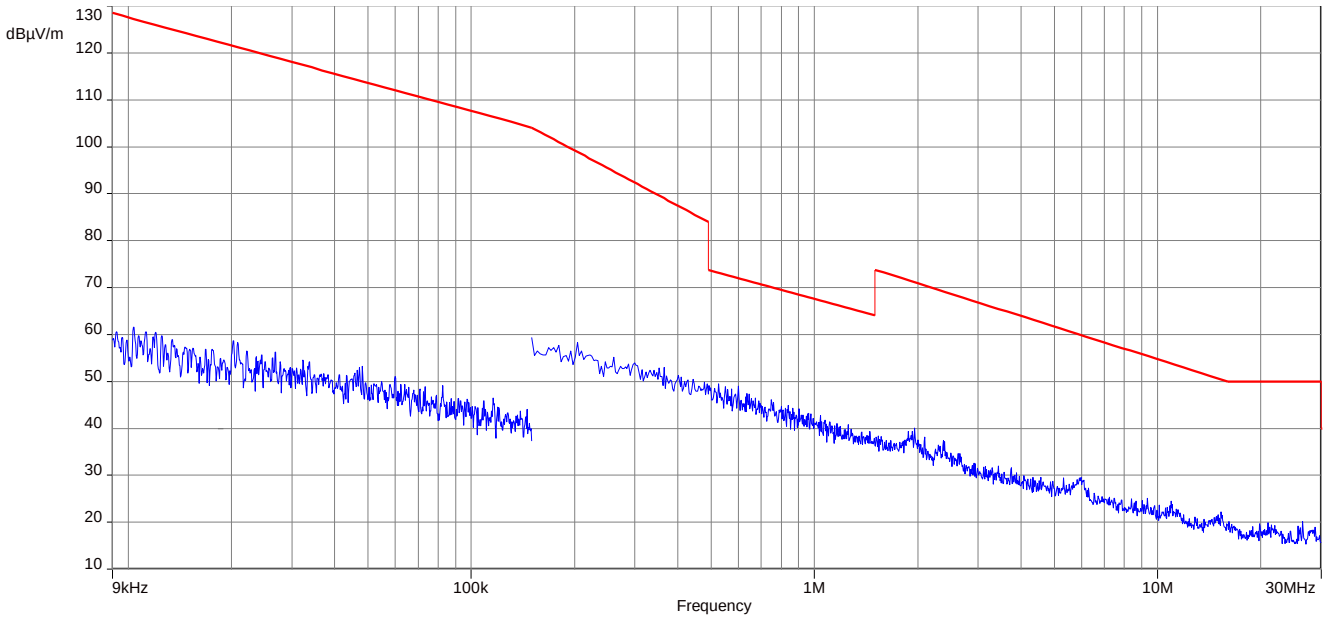
Plot 1: 9 kHz to 30 MHz, 2402 MHz, transmit mode, 1 Msps



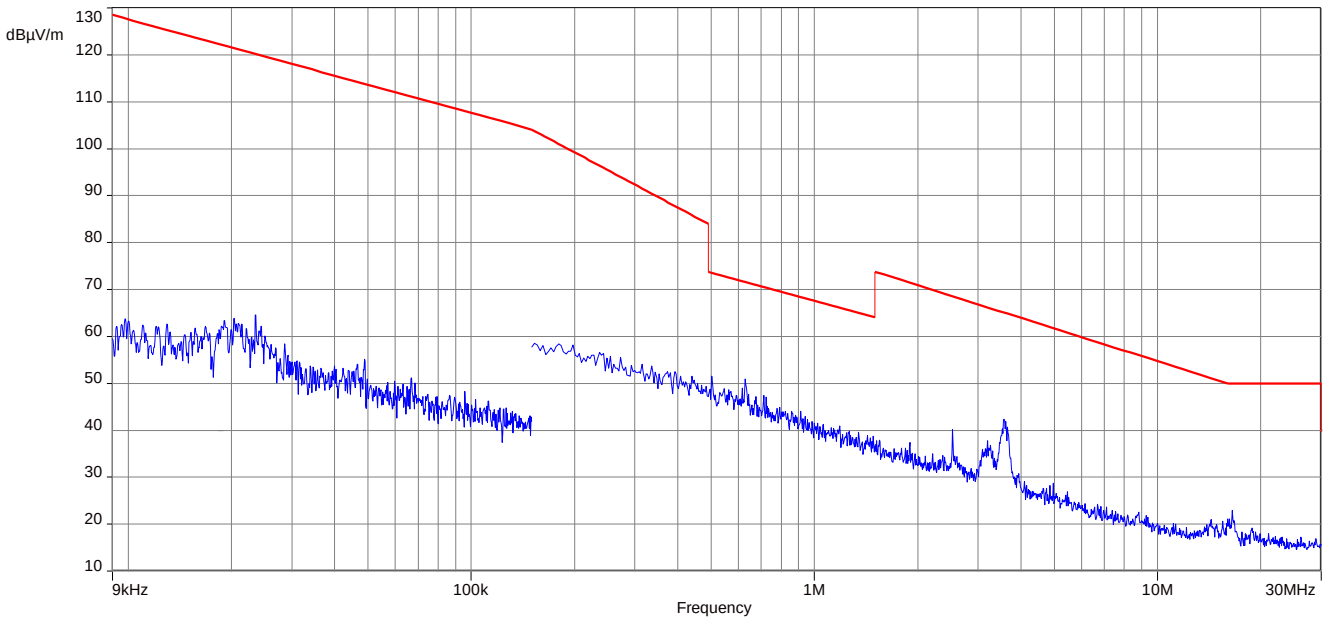
Plot 2: 9 kHz to 30 MHz, 2440 MHz, transmit mode, 1 Msps



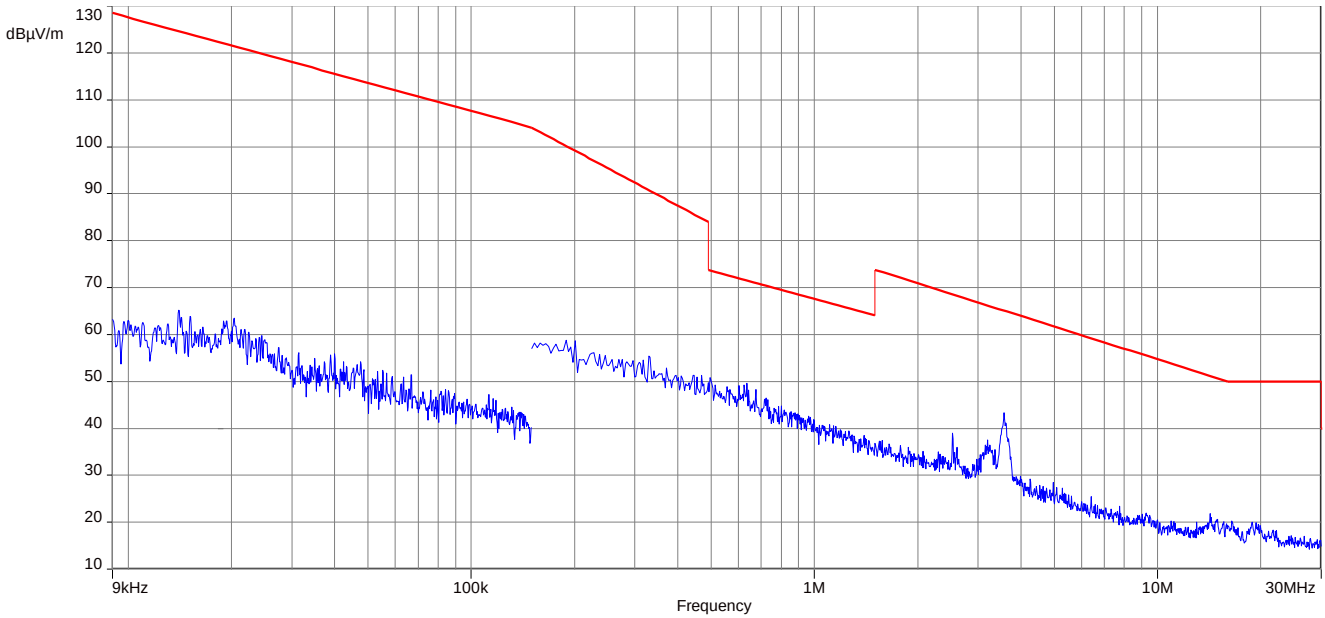
Plot 3: 9 kHz to 30 MHz, 2480 MHz, transmit mode, 1 Msps



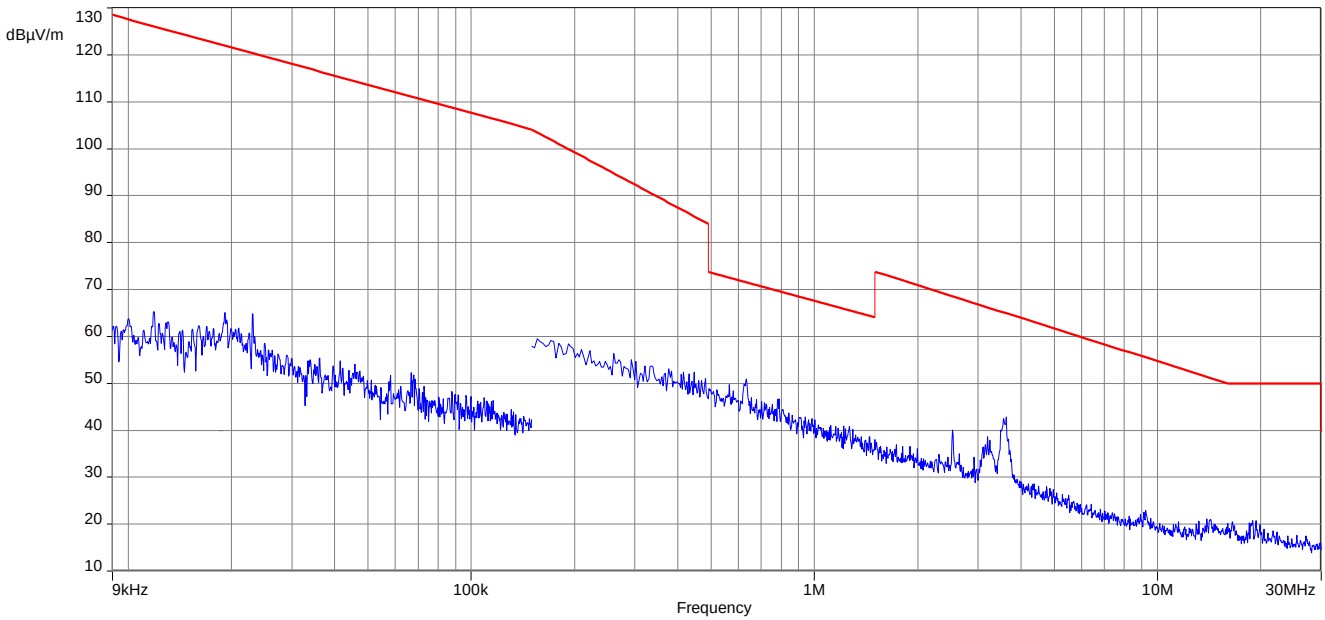
Plot 4: 9 kHz to 30 MHz, 2402 MHz, transmit mode, 2 Msps



Plot 5: 9 kHz to 30 MHz, 2440 MHz, transmit mode, 2 Msps

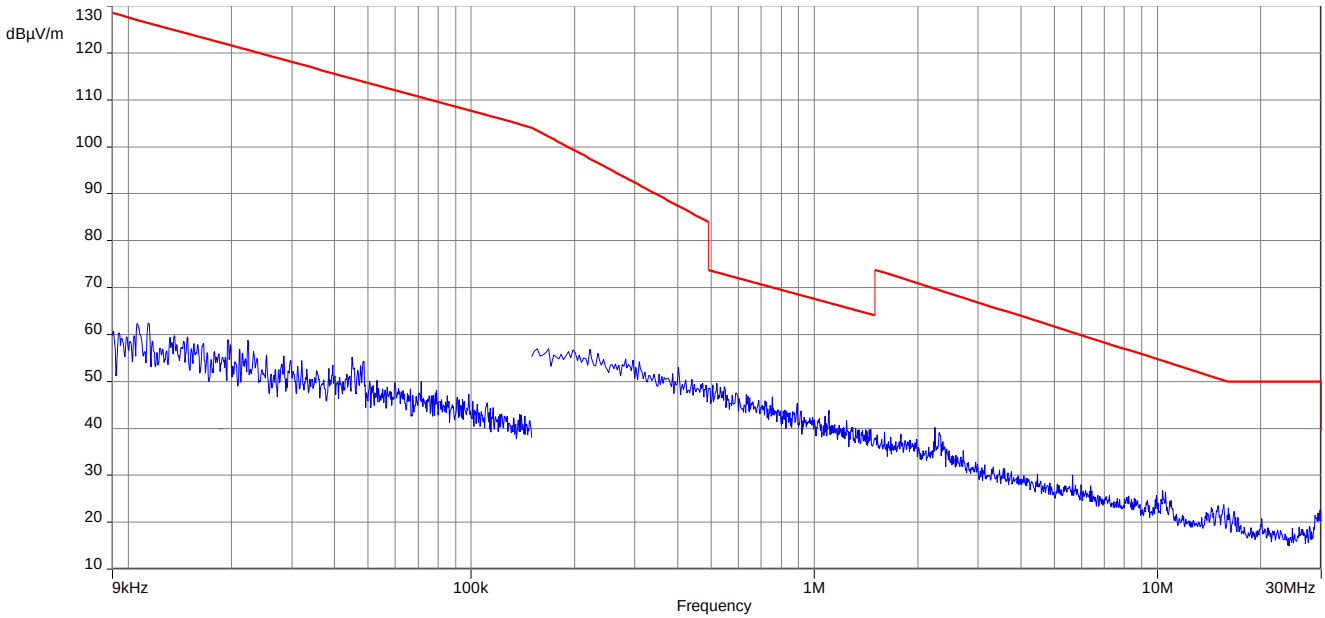


Plot 6: 9 kHz to 30 MHz, 2480 MHz, transmit mode, 2 Msps

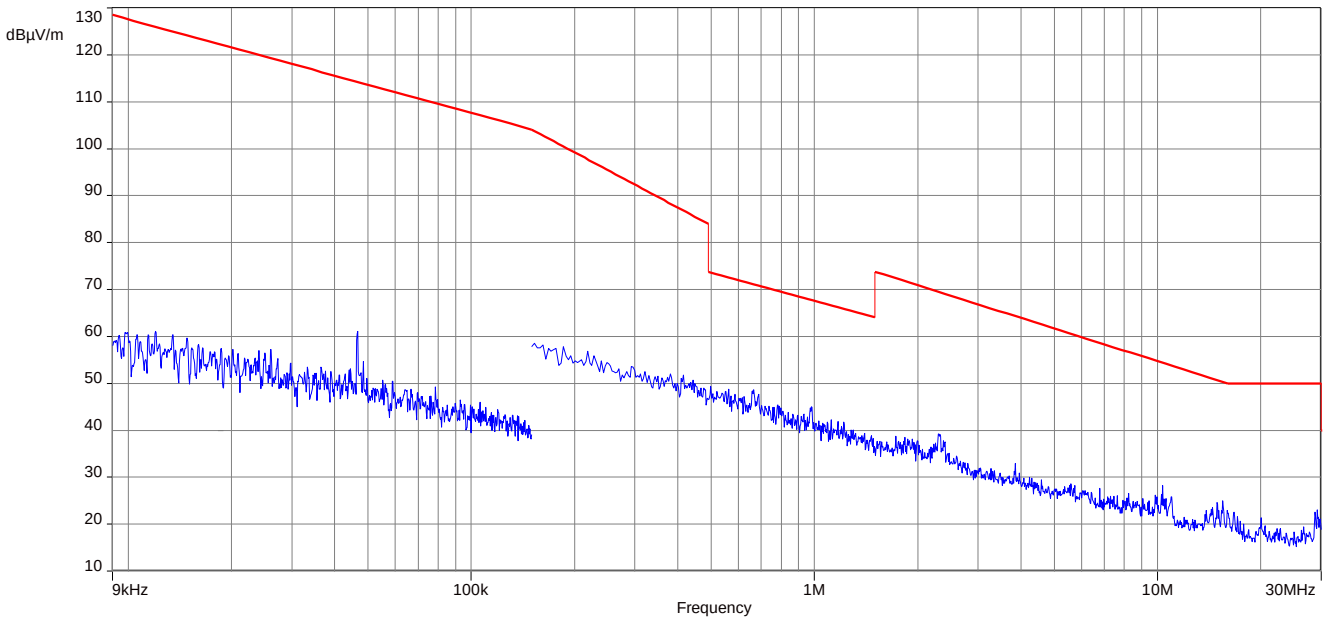


Plots: External antenna

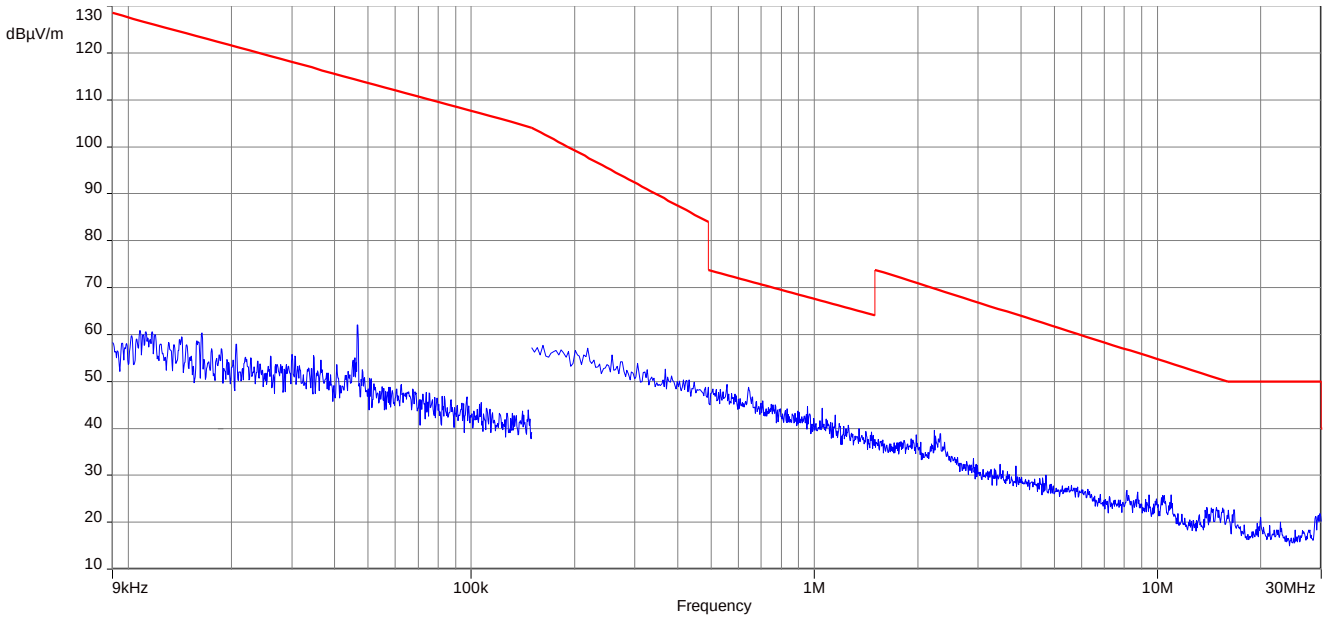
Plot 1: 9 kHz to 30 MHz, 2402 MHz, transmit mode, 1 Msps



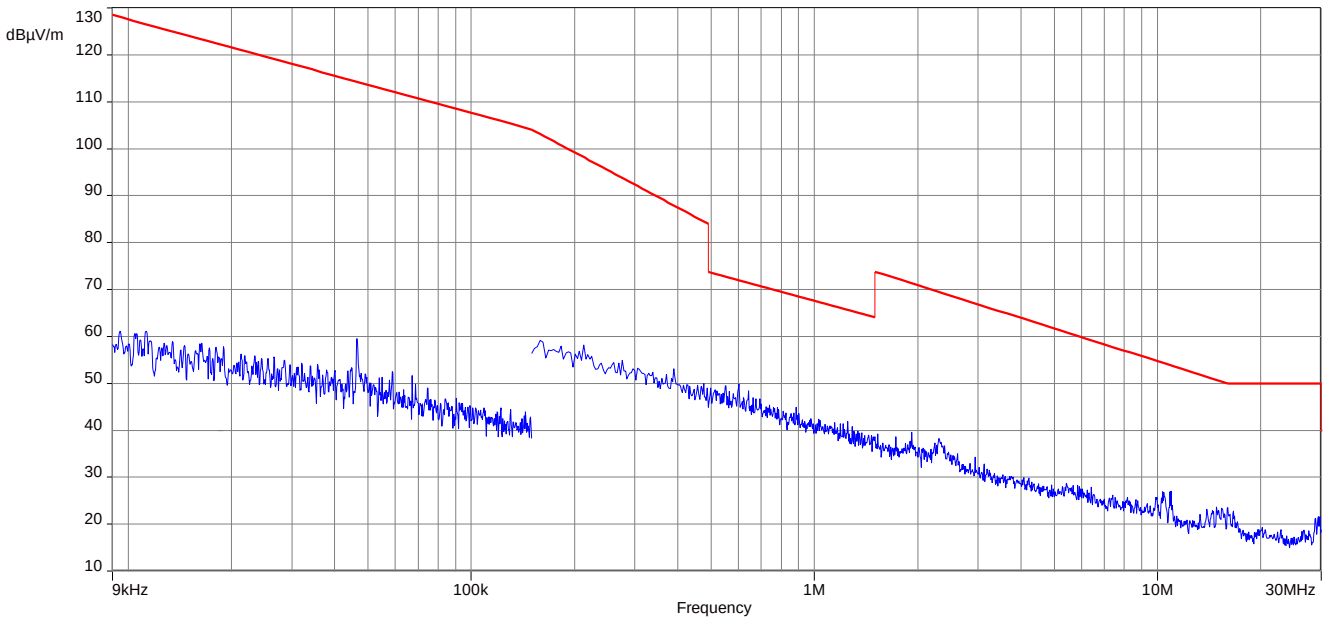
Plot 2: 9 kHz to 30 MHz, 2440 MHz, transmit mode, 1 Msps



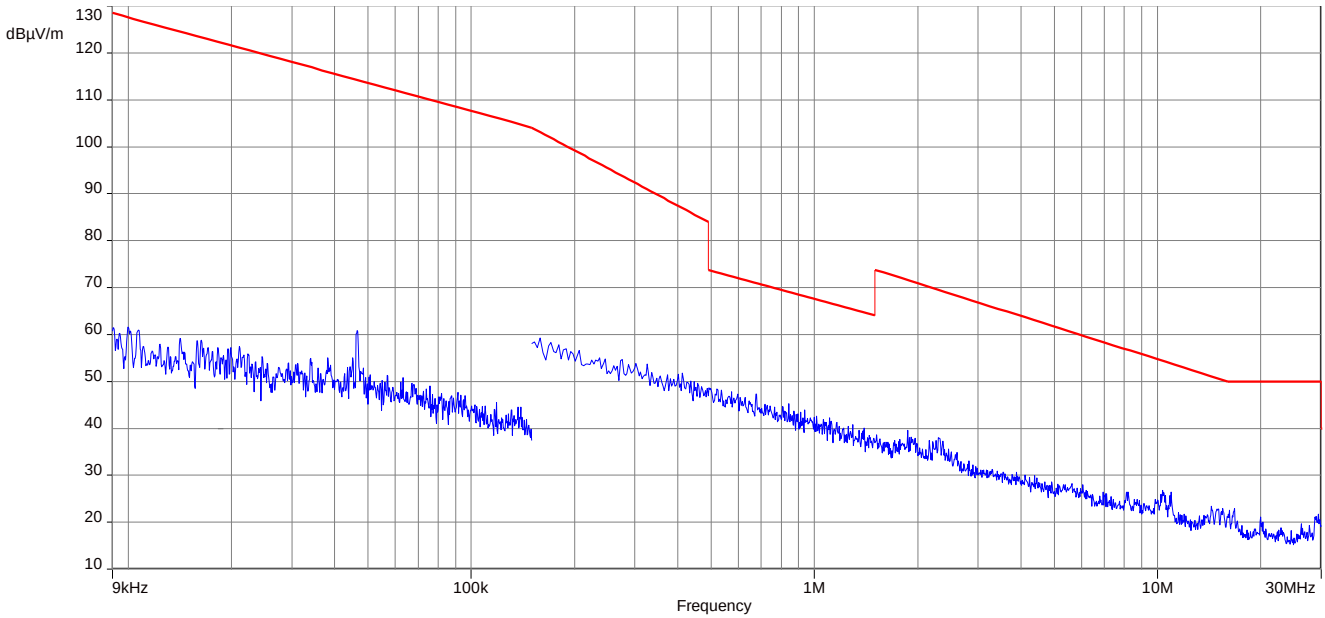
Plot 3: 9 kHz to 30 MHz, 2480 MHz, transmit mode, 1 Msps



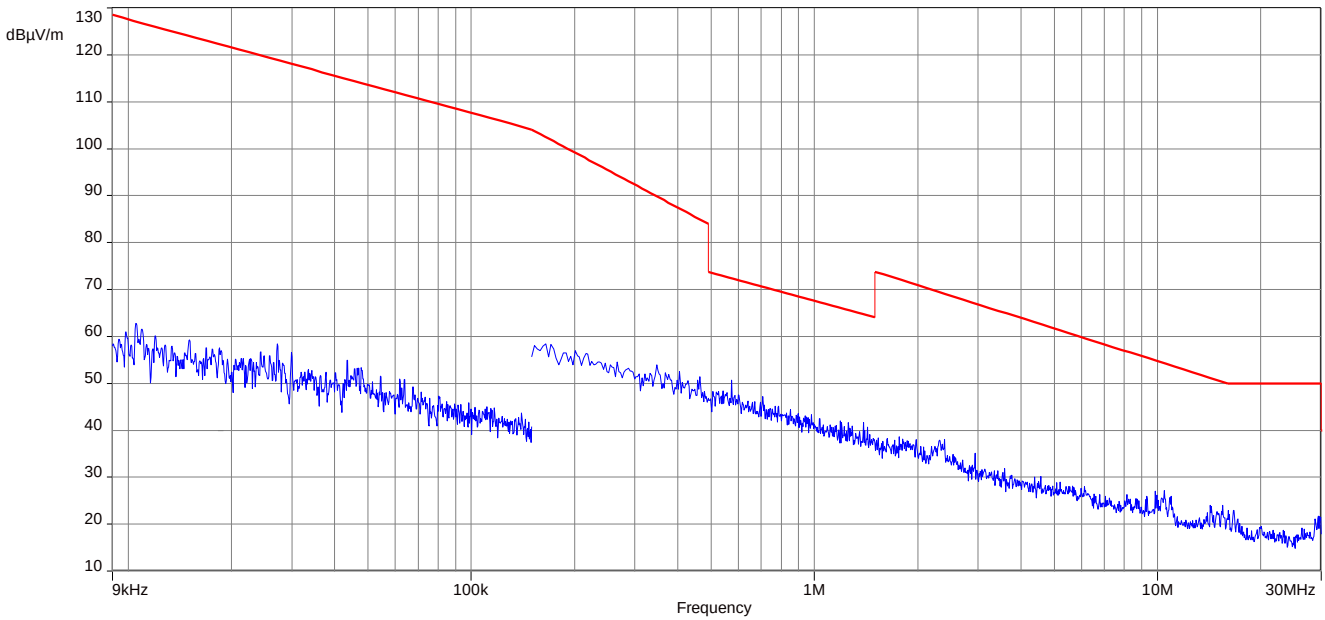
Plot 4: 9 kHz to 30 MHz, 2402 MHz, transmit mode, 2 Msps



Plot 5: 9 kHz to 30 MHz, 2440 MHz, transmit mode, 2 Msps



Plot 6: 9 kHz to 30 MHz, 2480 MHz, transmit mode, 2 Msps



11.10 Spurious emissions radiated 30 MHz to 1 GHz

Description:

Measurement of the radiated spurious emissions in transmit mode. The EUT is set to single channel mode and the transmit frequencies are 2402 MHz, 2440 MHz and 2480 MHz.

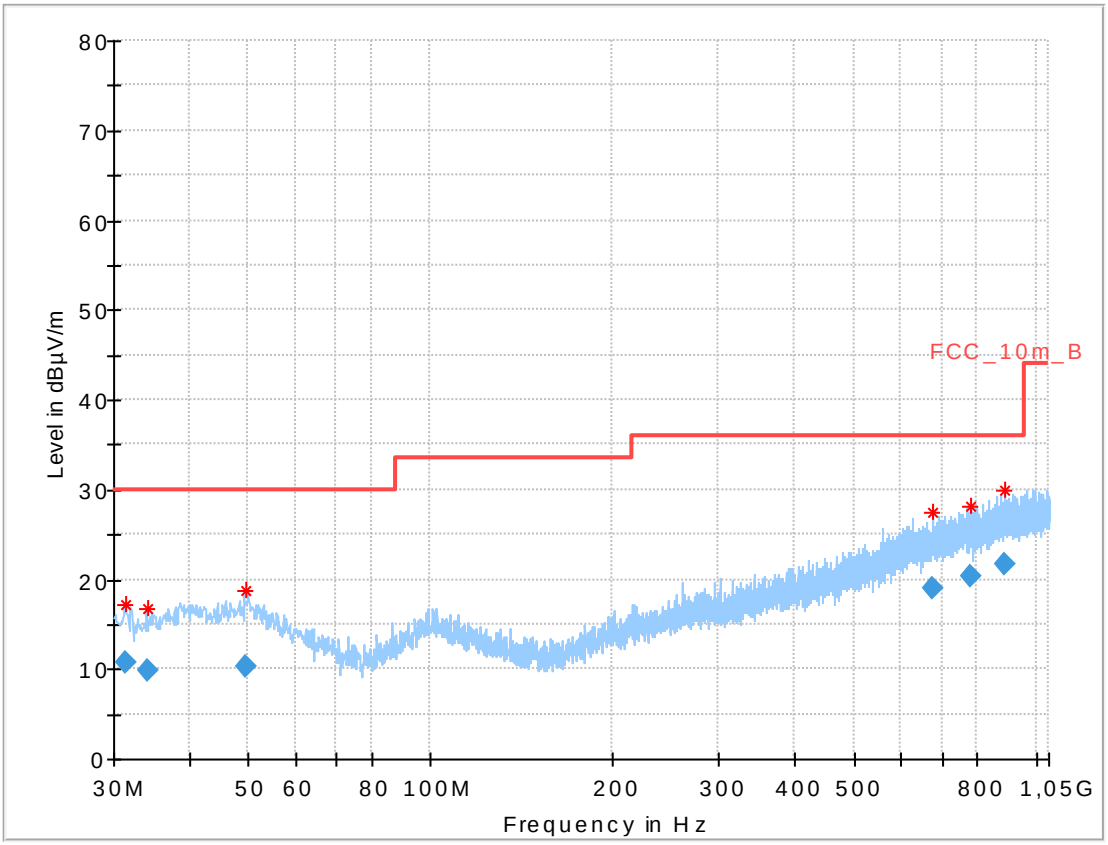
Measurement parameters	
Detector	Peak / Quasi Peak
Sweep time	Auto
Resolution bandwidth	120 kHz
Video bandwidth	3 x RBW
Span	30 MHz to 1 GHz
Trace mode	Max hold
Measured modulation	GFSK
Test setup	See sub clause 7.1 A
Measurement uncertainty	See sub clause 8

Limits:

FCC		IC
TX spurious emissions radiated		
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).		
§15.209		
Frequency (MHz)	Field strength (dBµV/m)	Measurement distance
30 - 88	30.0	10
88 – 216	33.5	10
216 – 960	36.0	10
Above 960	54.0	3

Plots: Transmit mode, integrated antenna

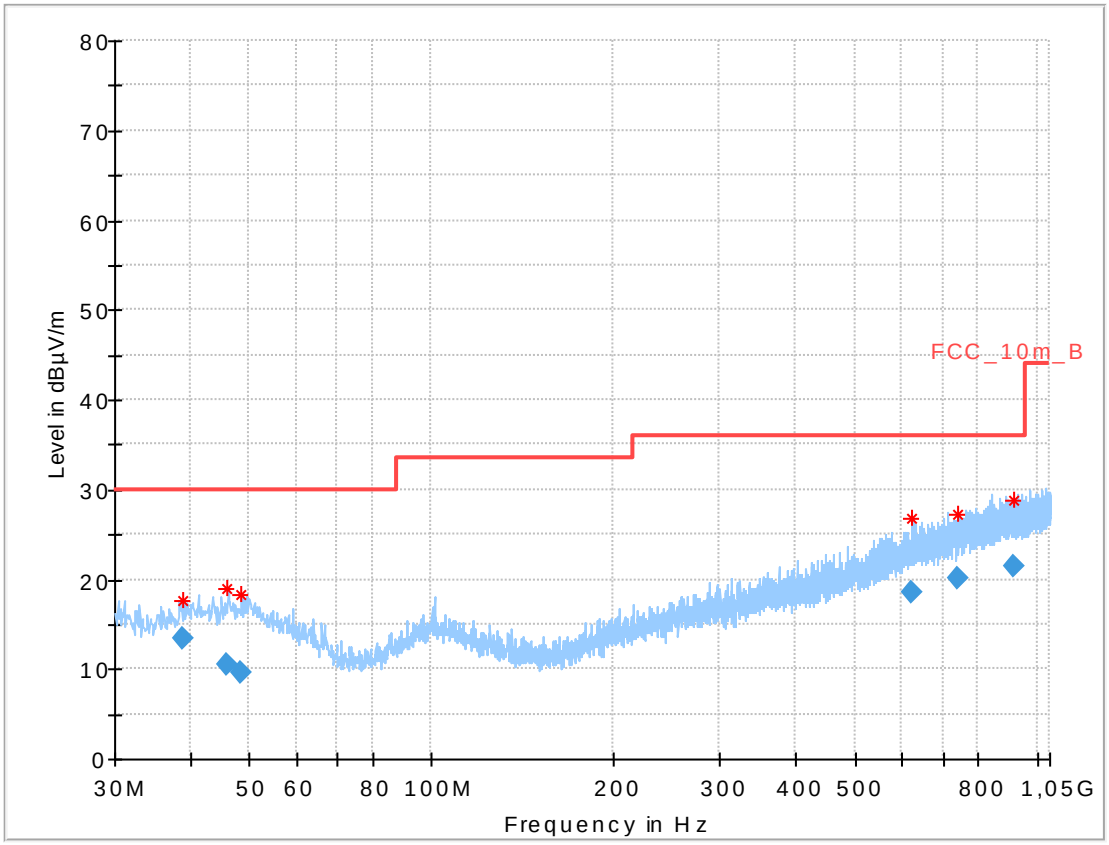
Plot 1: 30 MHz to 1 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
31.365900	10.80	30.00	19.20	1000.0	120.000	101.0	V	-10.0	11.8
34.036350	9.75	30.00	20.25	1000.0	120.000	101.0	V	10.0	11.7
49.535700	10.28	30.00	19.72	1000.0	120.000	98.0	H	-9.0	13.6
677.343300	19.04	36.00	16.96	1000.0	120.000	170.0	V	-10.0	21.3
781.234350	20.29	36.00	15.71	1000.0	120.000	170.0	H	280.0	22.7
886.967700	21.63	36.00	14.37	1000.0	120.000	170.0	V	10.0	23.9

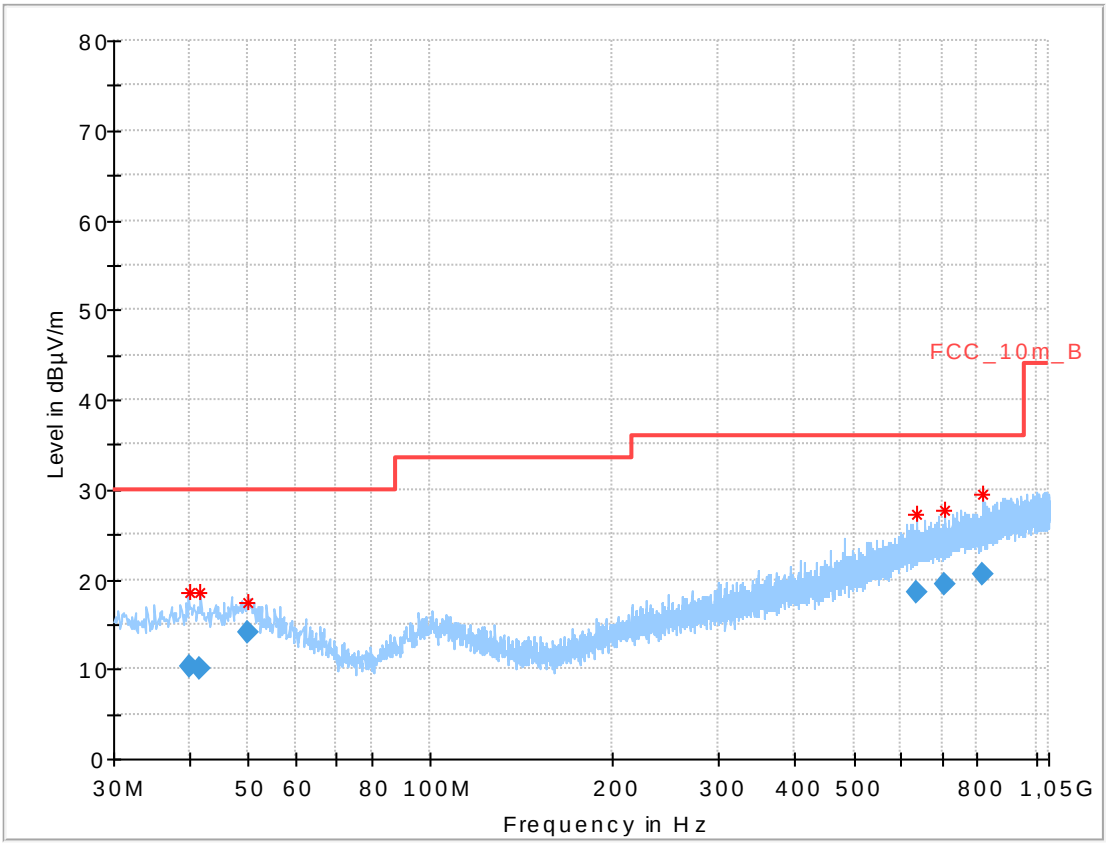
Plot 2: 30 MHz to 1 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
38.719800	13.40	30.00	16.60	1000.0	120.000	101.0	V	10.0	12.8
45.786600	10.41	30.00	19.59	1000.0	120.000	101.0	V	280.0	12.9
48.519600	9.63	30.00	20.37	1000.0	120.000	98.0	H	190.0	13.4
622.173300	18.49	36.00	17.51	1000.0	120.000	170.0	V	260.0	20.9
740.431050	20.14	36.00	15.86	1000.0	120.000	170.0	H	-10.0	22.5
913.053450	21.55	36.00	14.45	1000.0	120.000	170.0	H	171.0	24.2

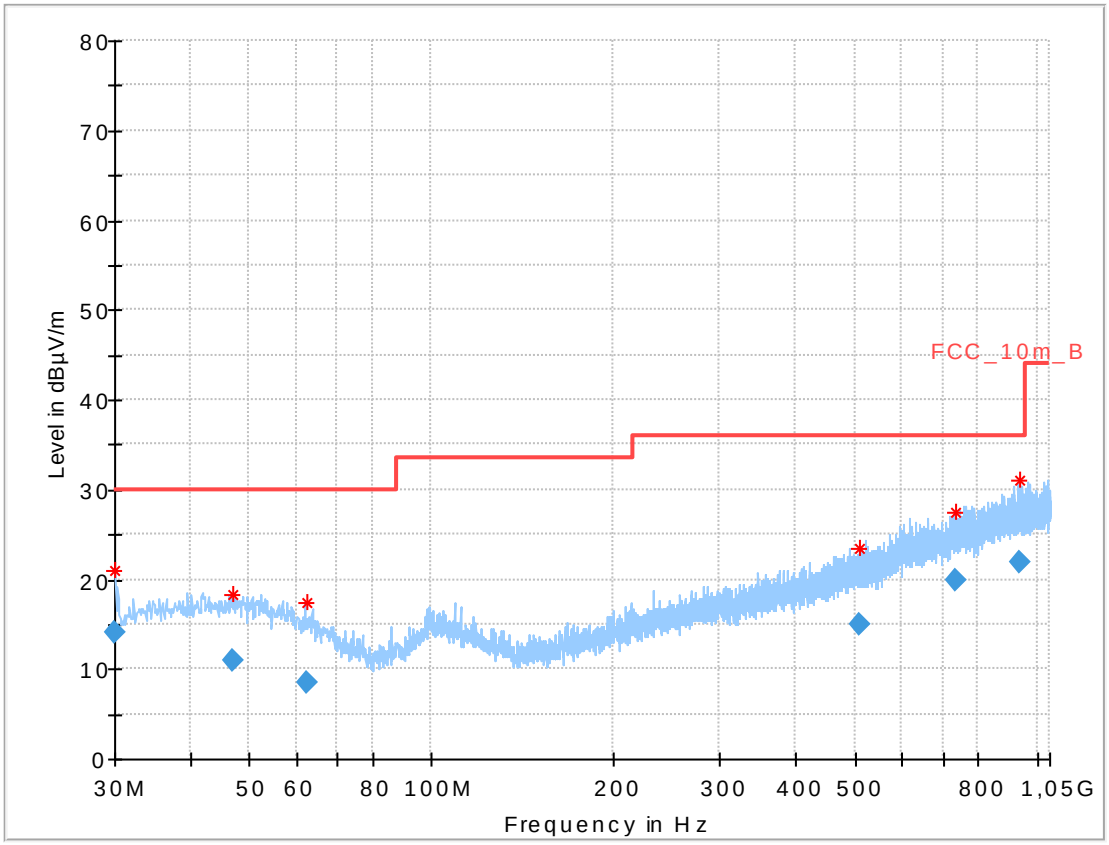
Plot 3: 30 MHz to 1 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 1 Msps



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
40.040550	10.32	30.00	19.68	1000.0	120.000	170.0	H	260.0	13.2
41.565600	10.10	30.00	19.90	1000.0	120.000	101.0	V	-10.0	13.1
49.949850	14.14	30.00	15.86	1000.0	120.000	101.0	V	280.0	13.7
635.043300	18.62	36.00	17.38	1000.0	120.000	98.0	H	280.0	21.0
707.765550	19.42	36.00	16.58	1000.0	120.000	170.0	H	100.0	21.7
818.945100	20.67	36.00	15.33	1000.0	120.000	98.0	V	261.0	23.0

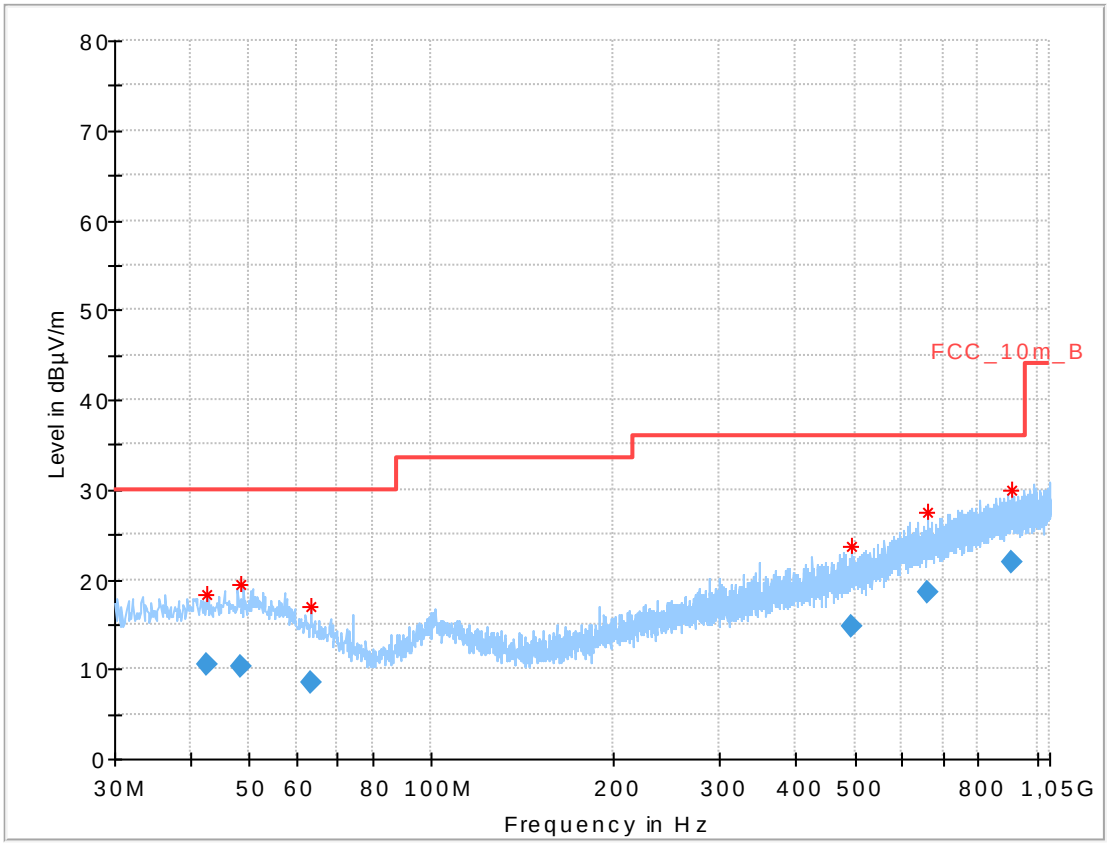
Plot 4: 30 MHz to 1 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 2 Msps



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
30.072	14.07	30.0	15.93	1000	120	101.0	V	180.0	12.1
46.892	10.87	30.0	19.13	1000	120	101.0	H	270.0	14.0
62.237	8.45	30.0	21.55	1000	120	101.0	H	270.0	11.6
509.162	14.91	36.0	21.09	1000	120	170.0	H	90.0	18.8
735.017	19.87	36.0	16.13	1000	120	170.0	V	180.0	22.6
937.487	21.93	36.0	14.07	1000	120	170.0	H	180.0	24.7

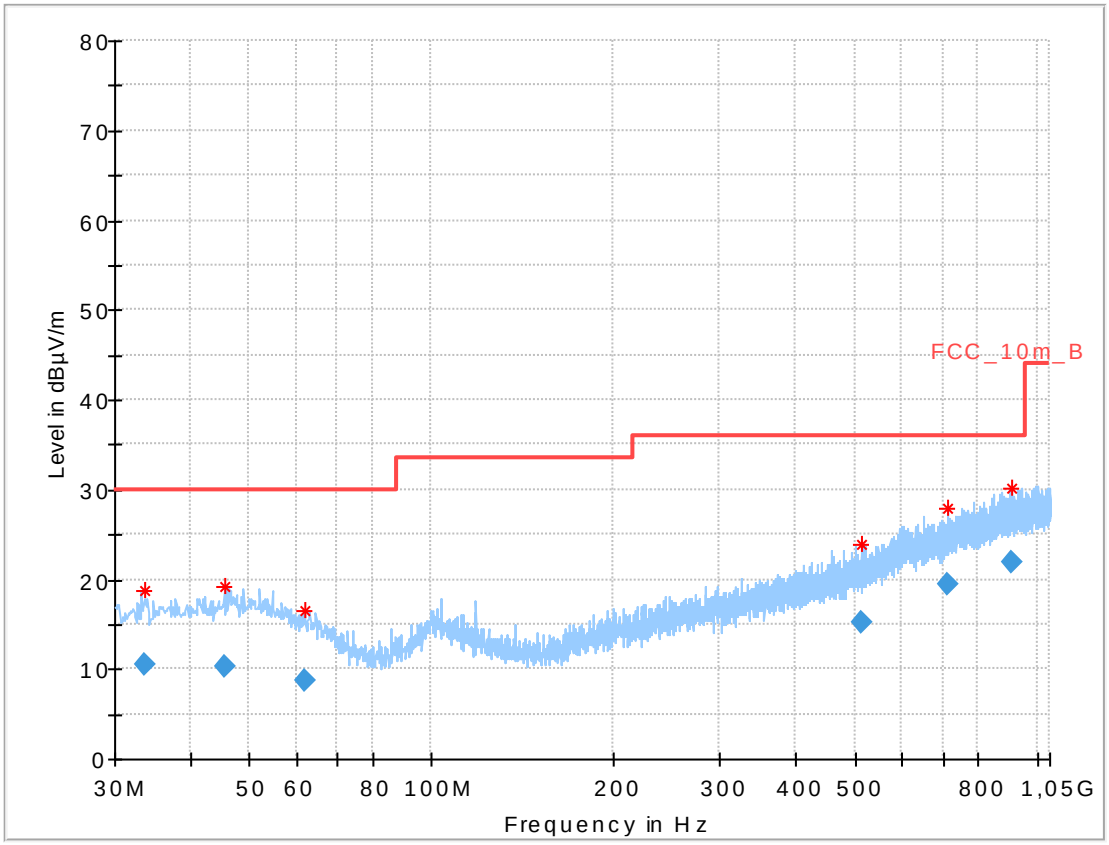
Plot 5: 30 MHz to 1 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 2 Msps



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
42.683	10.51	30.0	19.49	1000	120	170.0	H	0.0	13.7
48.538	10.31	30.0	19.69	1000	120	170.0	V	0.0	14.0
63.078	8.40	30.0	21.60	1000	120	100.0	H	90.0	11.5
492.739	14.72	36.0	21.28	1000	120	98.0	H	270.0	18.6
660.682	18.65	36.0	17.35	1000	120	170.0	H	0.0	21.4
909.171	21.82	36.0	14.18	1000	120	170.0	V	0.0	24.6

Plot 6: 30 MHz to 1 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 2 Msps

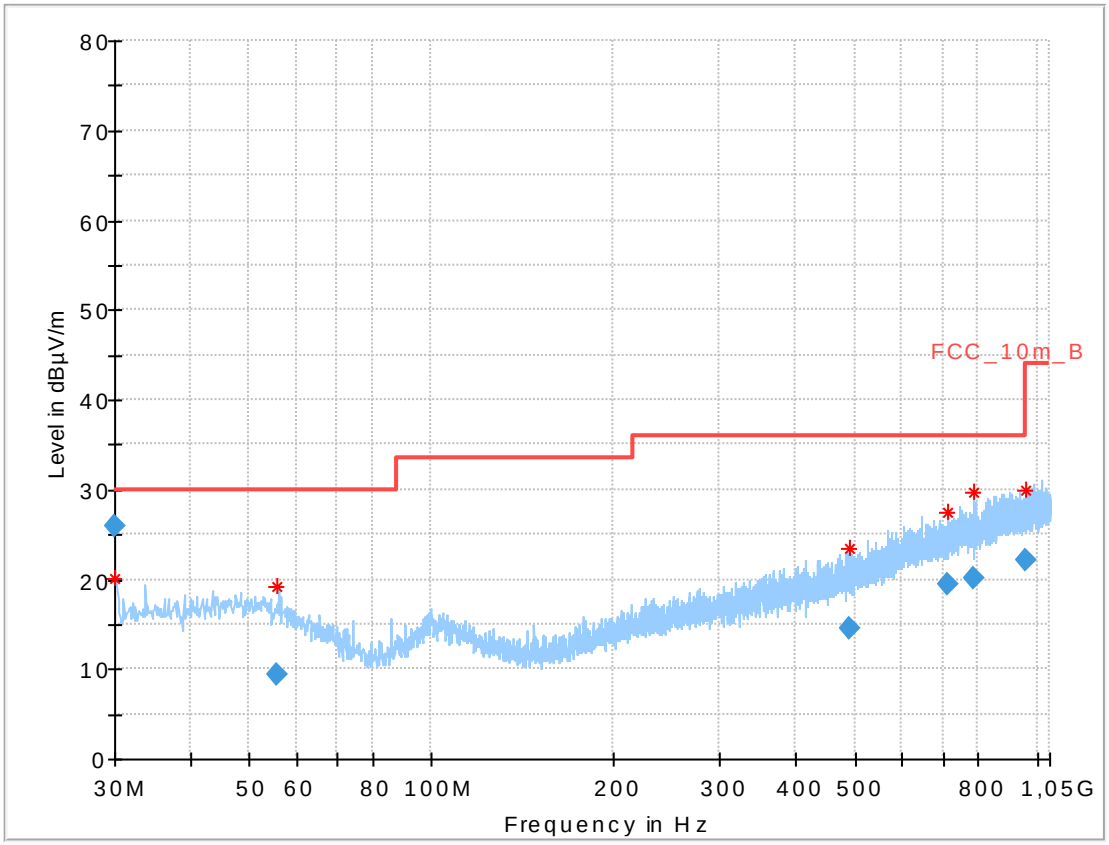


Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
33.577	10.61	30.0	19.39	1000	120	101.0	V	180.0	12.7
45.672	10.39	30.0	19.61	1000	120	100.0	H	180.0	13.9
61.926	8.82	30.0	21.18	1000	120	101.0	V	0.0	11.7
511.581	15.26	36.0	20.74	1000	120	170.0	H	0.0	18.9
711.830	19.44	36.0	16.56	1000	120	170.0	V	0.0	22.0
907.303	21.84	36.0	14.16	1000	120	170.0	H	270.0	24.6

Plots: Receiver mode, integrated antenna

Plot 1: 30 MHz to 1 GHz, RX / idle – mode, vertical & horizontal polarization

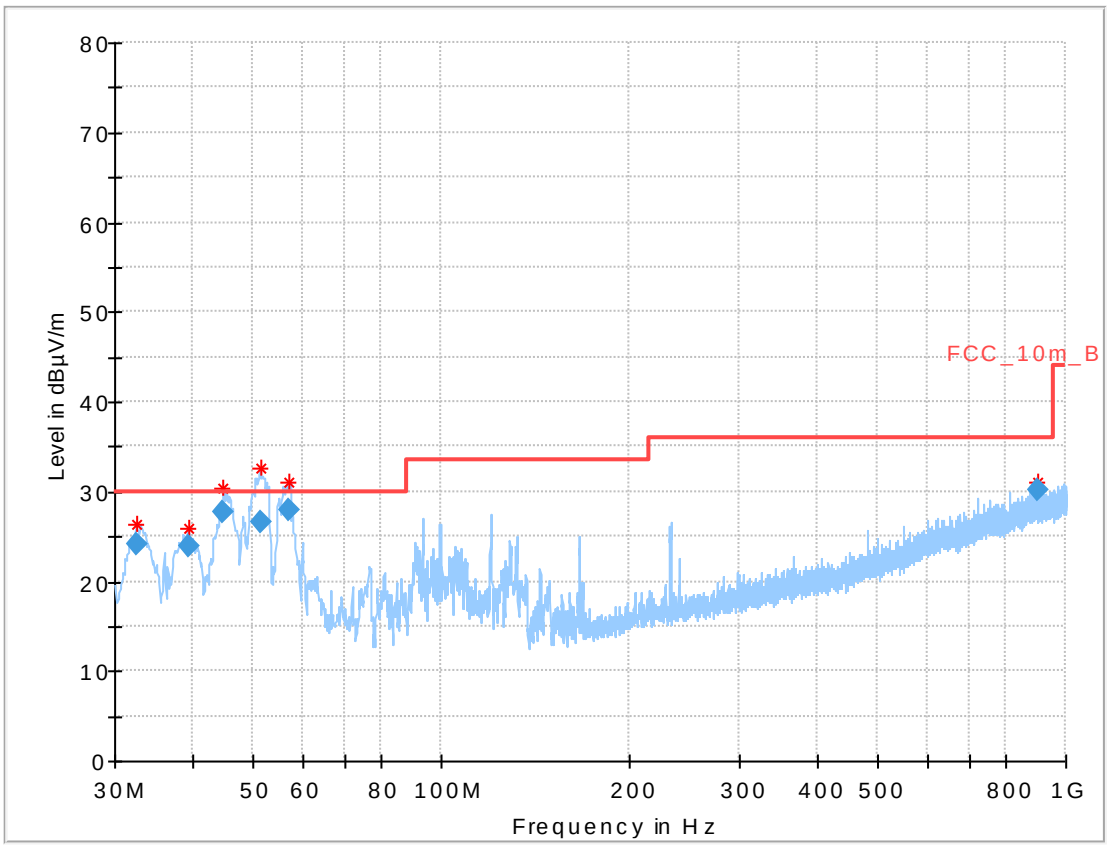


Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
30.091	25.90	30.0	4.10	1000	120	170.0	V	0.0	12.1
55.552	9.36	30.0	20.64	1000	120	101.0	V	90.0	13.3
491.409	14.62	36.0	21.38	1000	120	101.0	V	90.0	18.5
714.444	19.53	36.0	16.47	1000	120	170.0	H	180.0	22.1
784.316	20.20	36.0	15.80	1000	120	98.0	V	0.0	23.0
958.019	22.14	36.0	13.86	1000	120	101.0	H	0.0	24.9

Plots: Transmit mode, external antenna

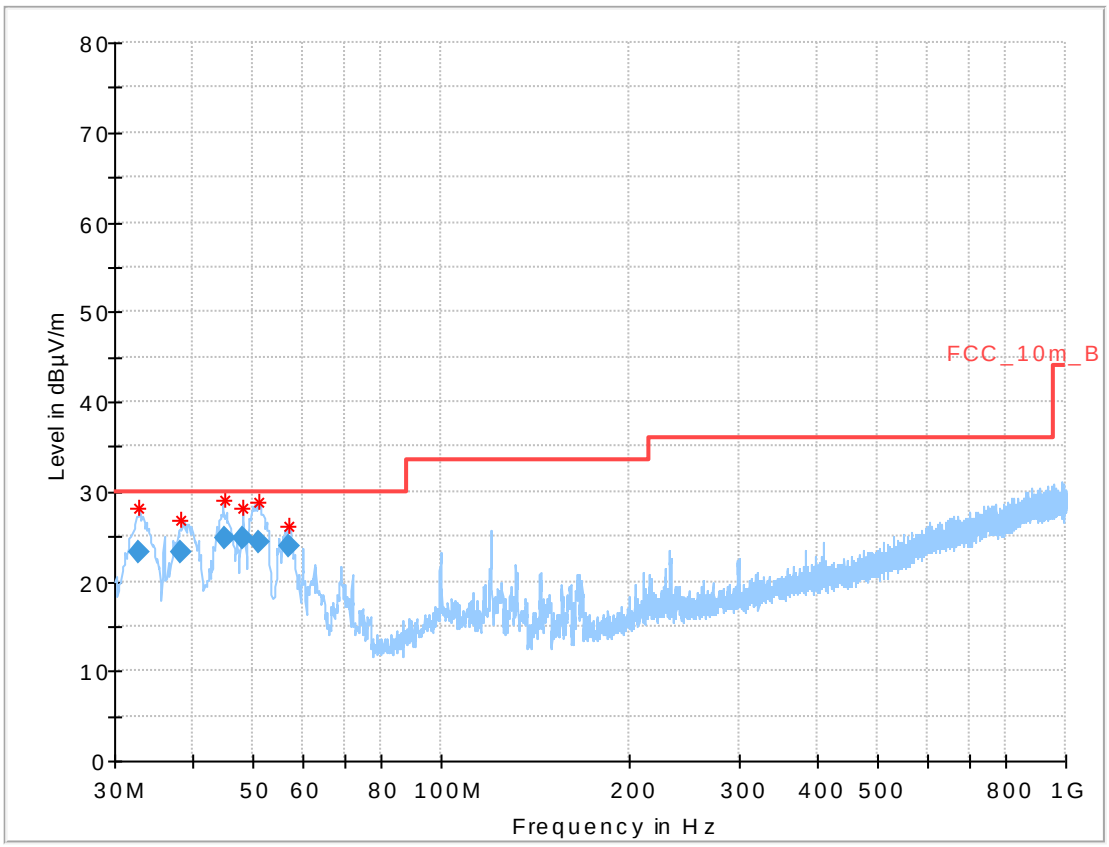
Plot 1: 30 MHz to 1 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
32.580	24.09	30.0	5.91	1000	120	170.0	V	286.0	12.6
39.425	24.01	30.0	5.99	1000	120	98.0	V	295.0	13.5
44.704	27.82	30.0	2.18	1000	120	98.0	V	238.0	13.9
51.285	26.57	30.0	3.43	1000	120	98.0	V	-1.0	13.9
56.951	28.04	30.0	1.96	1000	120	98.0	V	214.0	12.9
900.839	30.19	36.0	5.81	1000	120	170.0	H	112.0	24.6

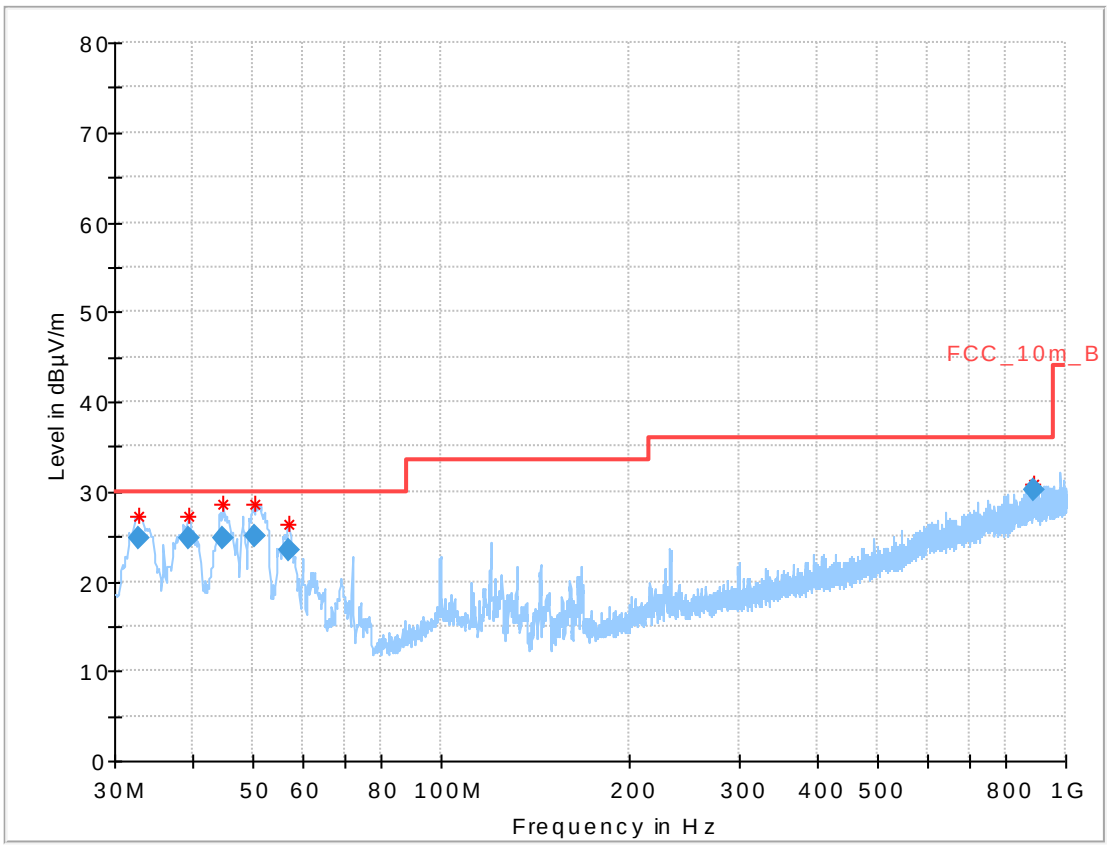
Plot 2: 30 MHz to 1 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
32.723	23.25	30.0	6.75	1000	120	170.0	V	272.0	12.6
38.276	23.32	30.0	6.68	1000	120	98.0	V	-8.0	13.3
44.863	24.82	30.0	5.18	1000	120	170.0	V	339.0	13.9
48.079	24.74	30.0	5.26	1000	120	98.0	V	280.0	14.0
51.014	24.41	30.0	5.59	1000	120	170.0	V	53.0	13.9
57.180	23.90	30.0	6.10	1000	120	98.0	V	89.0	12.8

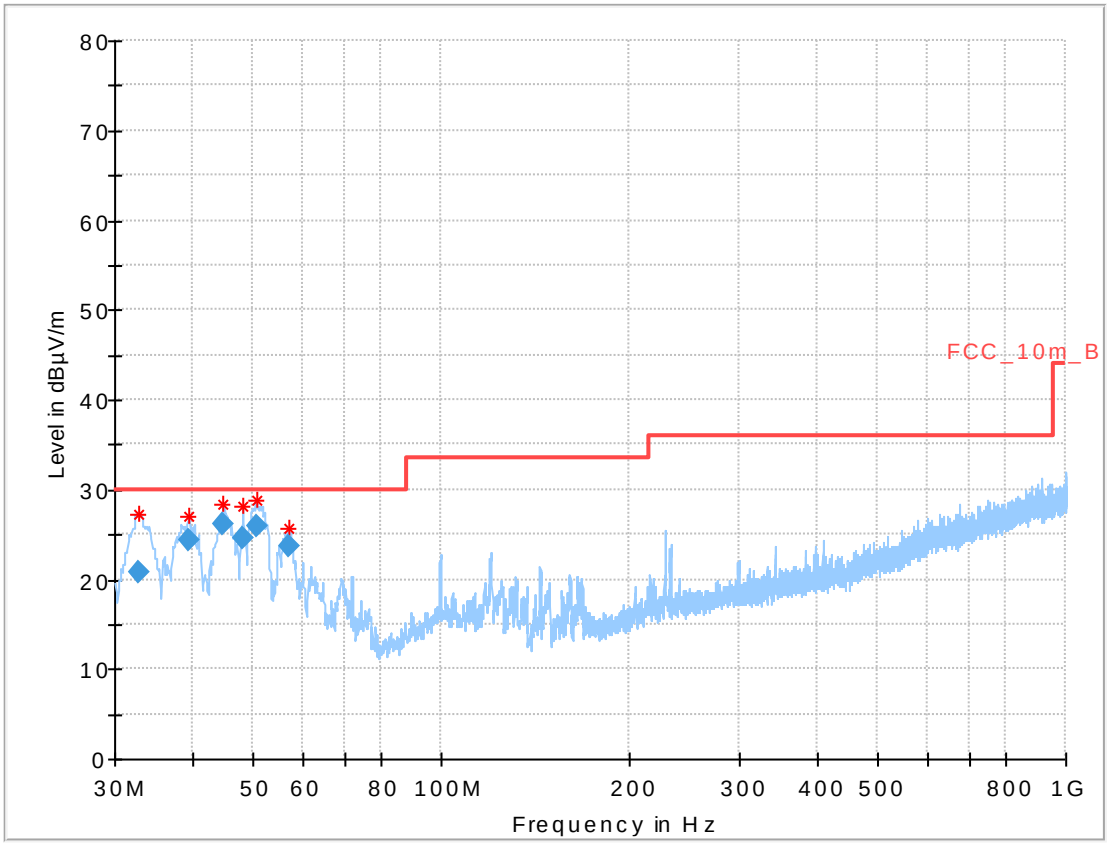
Plot 3: 30 MHz to 1 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 1 Msps



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
32.745	24.71	30.0	5.29	1000	120	101.0	V	168.0	12.6
39.342	24.84	30.0	5.16	1000	120	98.0	V	286.0	13.4
44.711	24.71	30.0	5.29	1000	120	170.0	V	53.0	13.9
50.447	24.94	30.0	5.06	1000	120	170.0	V	324.0	14.0
56.834	23.50	30.0	6.50	1000	120	98.0	V	202.0	12.9
890.823	30.13	36.0	5.87	1000	120	101.0	H	167.0	24.5

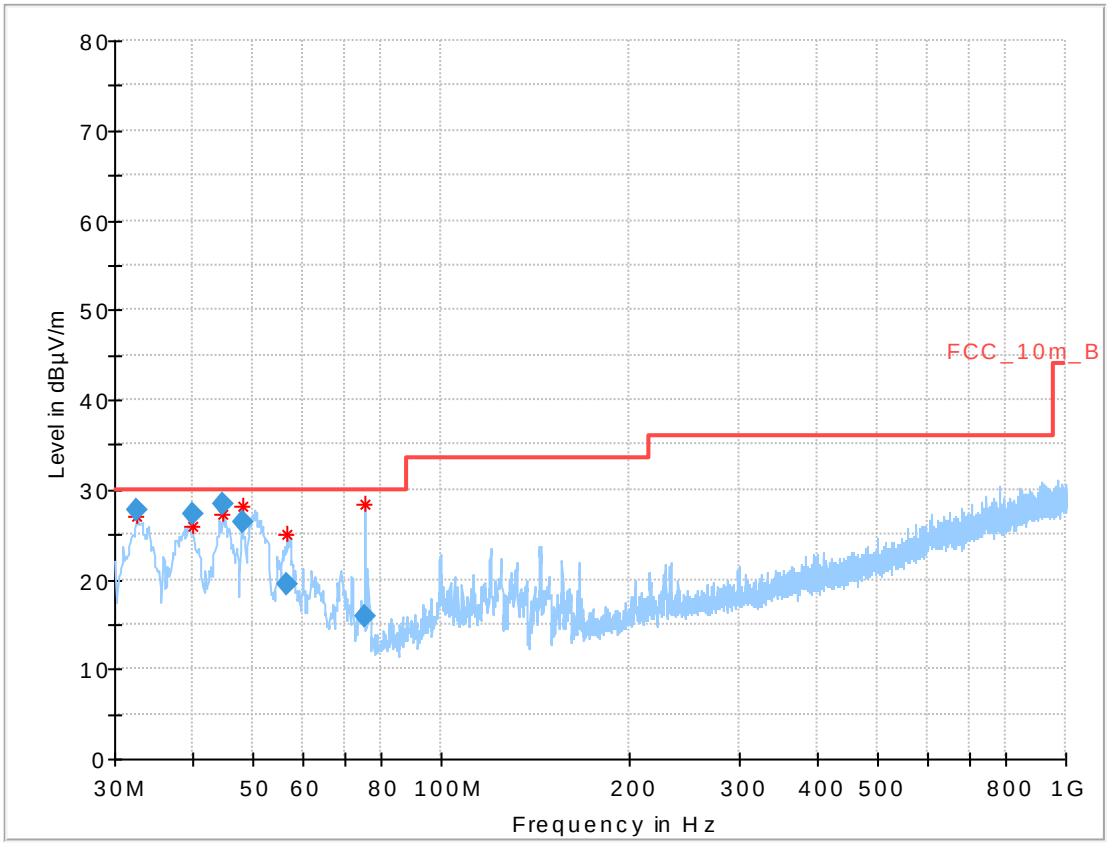
Plot 4: 30 MHz to 1 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 2 Msps



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
32.830	20.79	30.0	9.21	1000	120	170.0	V	73.0	12.6
39.426	24.43	30.0	5.57	1000	120	101.0	V	211.0	13.5
44.729	26.15	30.0	3.85	1000	120	98.0	V	204.0	13.9
48.081	24.65	30.0	5.35	1000	120	98.0	V	309.0	14.0
50.492	25.87	30.0	4.13	1000	120	98.0	V	271.0	14.0
56.958	23.76	30.0	6.24	1000	120	98.0	V	153.0	12.9

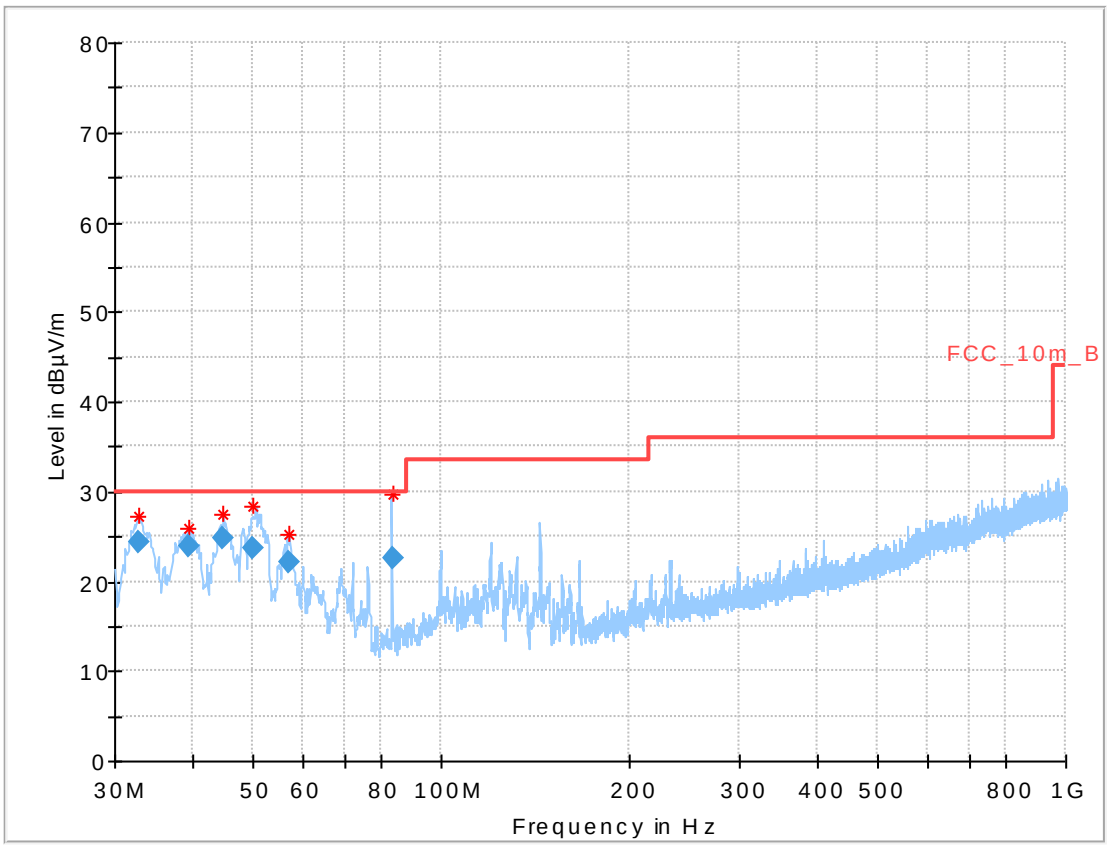
Plot 5: 30 MHz to 1 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 2 Msps



Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
32.657	27.65	30.0	2.35	1000	120	98.0	V	322.0	12.6
39.891	27.26	30.0	2.74	1000	120	101.0	V	171.0	13.5
44.806	28.45	30.0	1.55	1000	120	98.0	V	162.0	13.9
48.062	26.33	30.0	3.67	1000	120	98.0	V	261.0	14.0
56.508	19.49	30.0	10.51	1000	120	101.0	V	145.0	13.0
75.419	15.80	30.0	14.20	1000	120	170.0	V	241.0	9.1

Plot 6: 30 MHz to 1 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 2 Msps

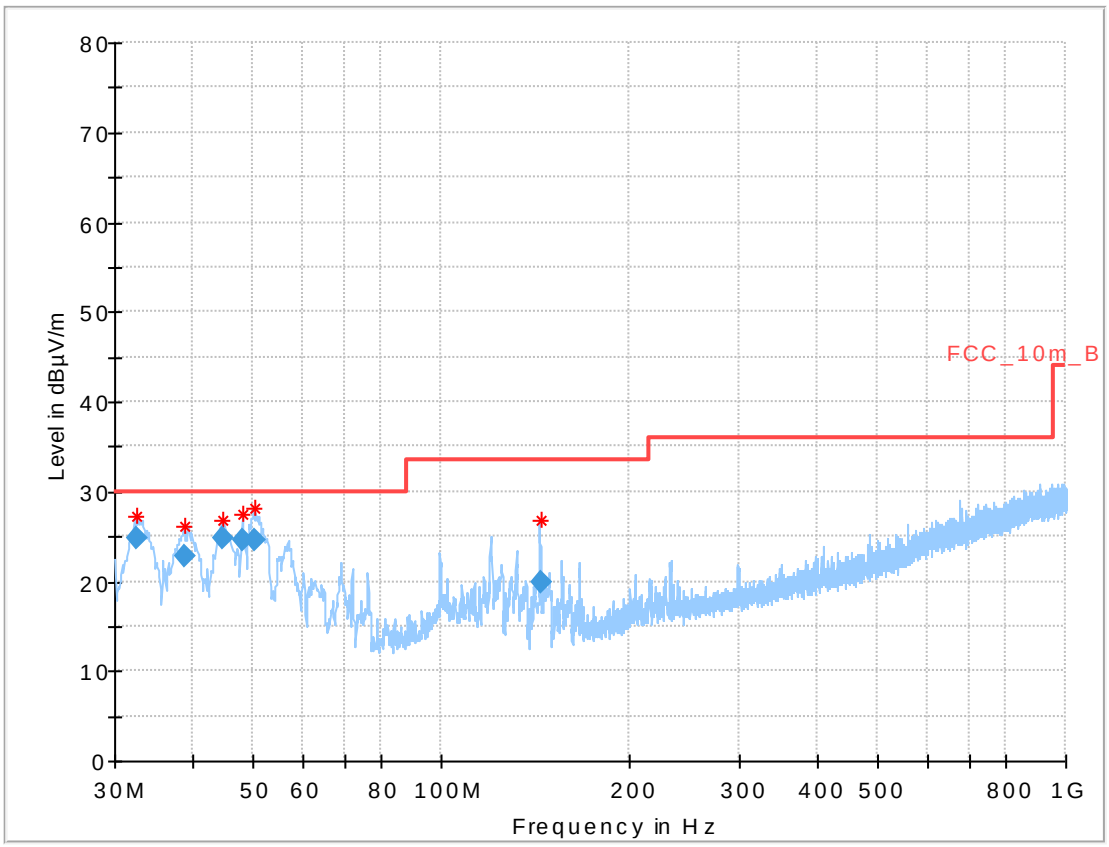


Final results:

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
32.712	24.38	30.0	5.62	1000	120	101.0	V	233.0	12.6
39.323	23.83	30.0	6.17	1000	120	98.0	V	53.0	13.4
44.849	24.80	30.0	5.20	1000	120	98.0	V	62.0	13.9
50.103	23.62	30.0	6.38	1000	120	170.0	V	289.0	14.0
57.216	22.09	30.0	7.91	1000	120	170.0	V	189.0	12.8
83.404	22.67	30.0	7.33	1000	120	101.0	V	197.0	8.8

Plots: Receiver mode, external antenna

Plot 1: 30 MHz to 1 GHz, RX / idle – mode, 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)
32.588	24.70	30.0	5.30	1000	120	98.0	V	267.0	12.6
38.780	22.90	30.0	7.10	1000	120	170.0	V	-10.0	13.4
44.659	24.87	30.0	5.13	1000	120	98.0	V	152.0	13.9
48.056	24.49	30.0	5.51	1000	120	98.0	V	115.0	14.0
50.284	24.47	30.0	5.53	1000	120	101.0	V	341.0	14.0
144.185	19.89	33.5	13.61	1000	120	98.0	V	234.0	9.1

11.11 Spurious emissions radiated above 1 GHz

Description:

Measurement of the radiated spurious emissions in transmit mode. The EUT is set to single channel mode and the transmit frequencies are 2402 MHz, 2440 MHz and 2480 MHz.

Measurement parameters	
Detector	Peak / RMS
Sweep time	Auto
Resolution bandwidth	1 MHz
Video bandwidth	3 x RBW
Span	1 GHz to 26 GHz
Trace mode	Max hold
Measured modulation	GFSK
Test setup	See sub clause 7.2 C (1 GHz - 18 GHz) See sub clause 7.3 A (18 GHz - 26 GHz)
Measurement uncertainty	See sub clause 8

Limits:

FCC		IC
TX spurious emissions radiated		
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).		
§15.209		
Frequency (MHz)	Field strength (dBµV/m)	Measurement distance
Above 960	54.0 (Average)	3
Above 960	74.0 (Peak)	3

Results: Transmitter mode, integrated antenna, 1 Msps

TX spurious emissions radiated [dBµV/m]								
2402 MHz			2440 MHz			2480 MHz		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
4804	Peak	57.5	4880	Peak	60.2	4959	Peak	58.9
	AVG	43.5*		AVG	46.2*		AVG	44.9*
7206	Peak	No restricted band	7320	Peak	60.3	7439	Peak	62.7
	AVG			AVG	46.3*		AVG	48.7*
	Peak			Peak			Peak	
	AVG			AVG			AVG	

Results: Transmitter mode, integrated antenna, 2 Msps

TX spurious emissions radiated [dBµV/m]								
2402 MHz			2440 MHz			2480 MHz		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
7206	Peak	No restricted band	4880	Peak	51.8	7439	Peak	58.3
	AVG			AVG	37.8*		AVG	44.3*
	Peak		7319	Peak	63.8		Peak	
	AVG			AVG	49.8*		AVG	
	Peak			Peak			Peak	
	AVG			AVG			AVG	

*) Average emission adjusting factor:

F = 20 * log (dwell time* / 100 ms)
*with TXon time as dwell time!

According to the "2608011024010-Duty-Cycle.pdf" document, the customer declares the maximum duty cycle and packet lengths:

During 100 ms a total of 14 packets + 14 acknowledges is possible:

14*1.2 ms + 14*0.2 ms = 19.6 ms ~ 20 ms

→ F = 20 * log (20 ms / 100 ms) = -14.0 dB

Results: Receiver mode, integrated antenna

RX spurious emissions radiated [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
-/-	Peak	-/-
	AVG	-/-

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

Results: Transmitter mode, external antenna, 1 Msps

TX spurious emissions radiated [dBµV/m]								
2402 MHz			2440 MHz			2480 MHz		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
2274	Peak	52.9	2312	Peak	52.2	4960	Peak	56.0
	AVG	47.2		AVG	45.2		AVG	42.0*
4804	Peak	59.4	4879	Peak	57.6	7439	Peak	55.0
	AVG	45.4*		AVG	43.6*		AVG	41.0*
12012	Peak	48.4	7319	Peak	53.7		Peak	
	AVG	34.4*		AVG	39.7*		AVG	

Results: Transmitter mode, external antenna, 2 Msps

TX spurious emissions radiated [dBµV/m]								
2402 MHz			2440 MHz			2480 MHz		
F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]	F [MHz]	Detector	Level [dBµV/m]
2274	Peak	51.9	2312	Peak	51.8	2352	Peak	50.5
	AVG	45.7		AVG	45.5		AVG	44.4
4803	Peak	59.3	4879	Peak	57.9	4961	Peak	56.9
	AVG	45.3*		AVG	43.9*		AVG	42.9*
12008	Peak	49.7	7318	Peak	54.1	7441	Peak	55.6
	AVG	35.7*		AVG	40.1*		AVG	41.6*

*) Average emission adjusting factor:

F = 20 * log (dwell time* / 100 ms)
*with TXon time as dwell time!

According to the "2608011024010-Duty-Cycle.pdf" document, the customer declares the maximum duty cycle and packet lengths:

During 100 ms a total of 14 packets + 14 acknowledges is possible:

14*1.2 ms + 14*0.2 ms = 19.6 ms ~ 20 ms

→ **F = 20 * log (20 ms / 100 ms) = -14.0 dB**

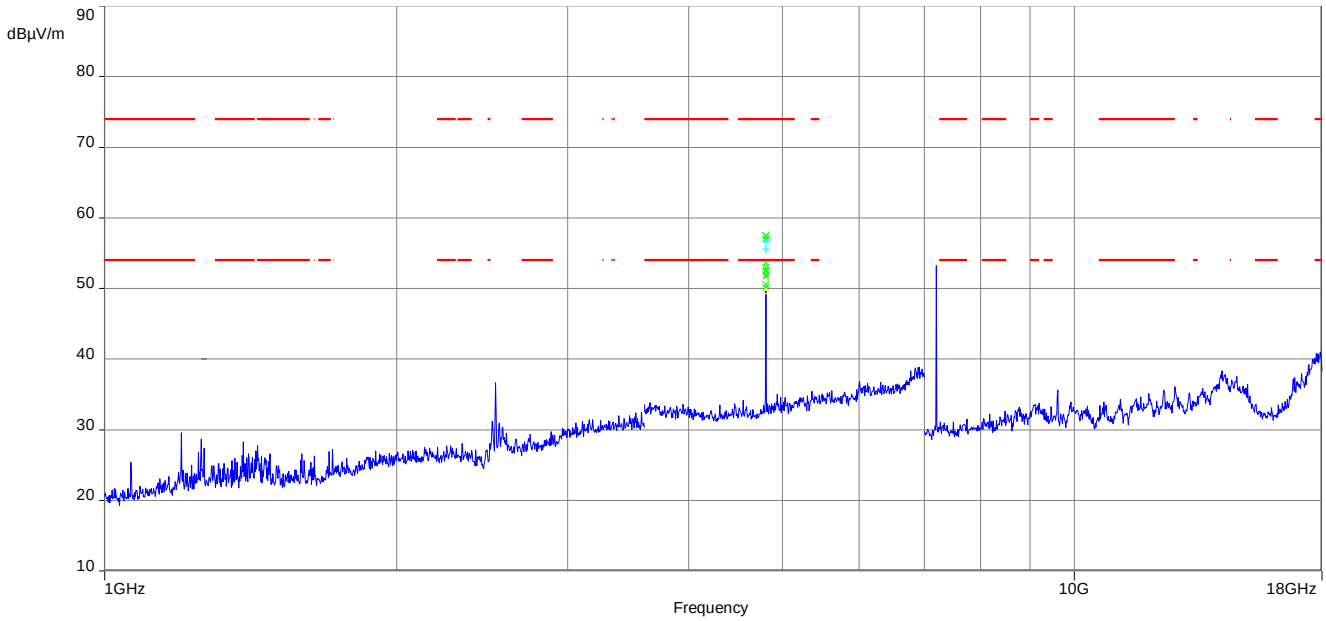
Results: Receiver mode, external antenna

RX spurious emissions radiated [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
4802	Peak	50.3
	AVG	44.4

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

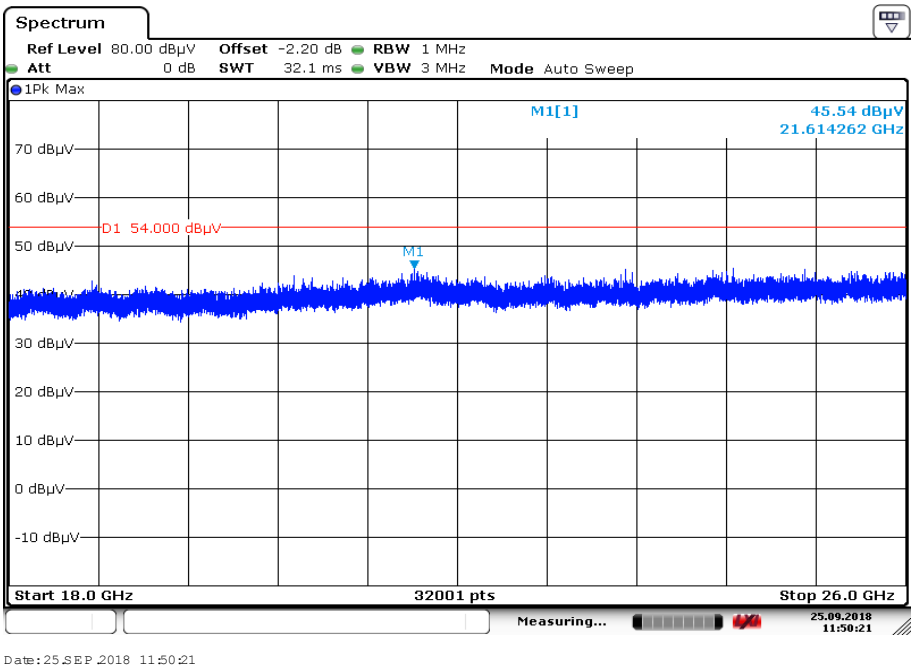
Plots: Transmitter mode, integrated antenna

Plot 1: 1 GHz to 18 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps

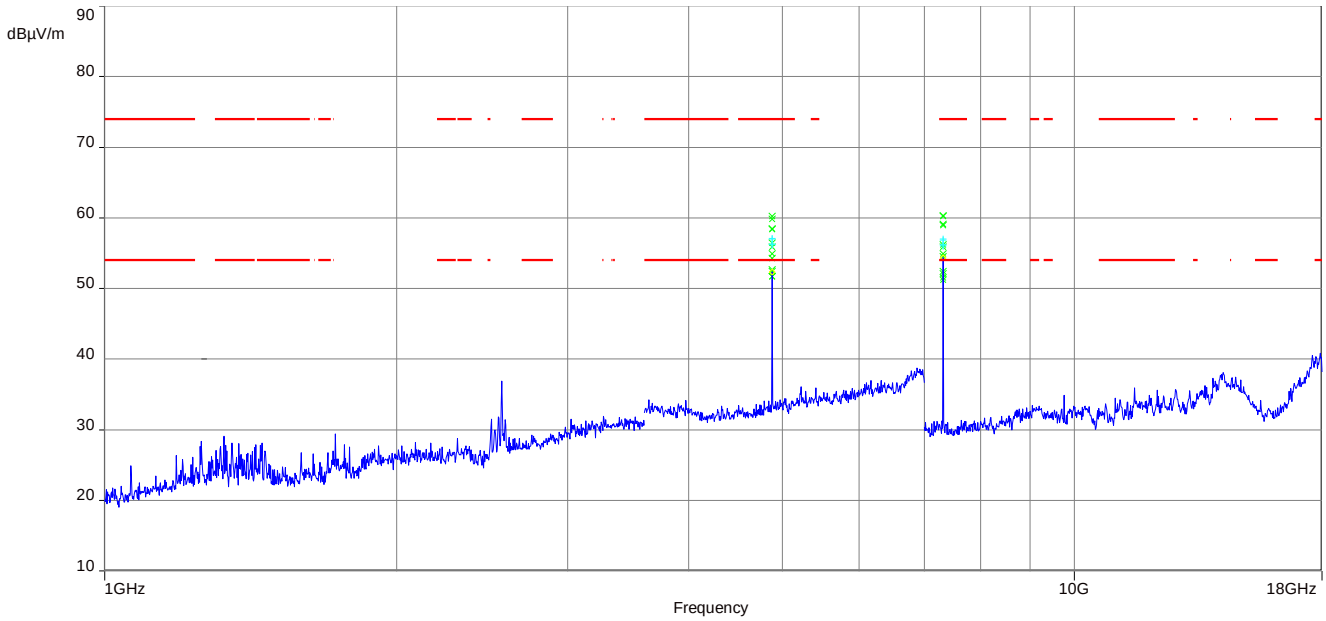


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 2: 18 GHz to 26 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps

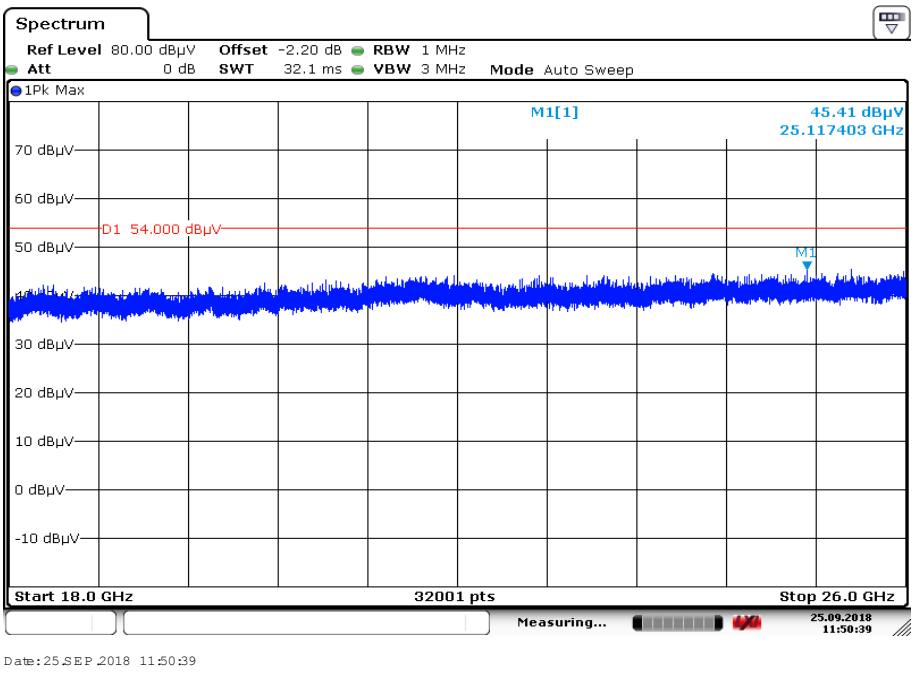


Plot 3: 1 GHz to 18 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps

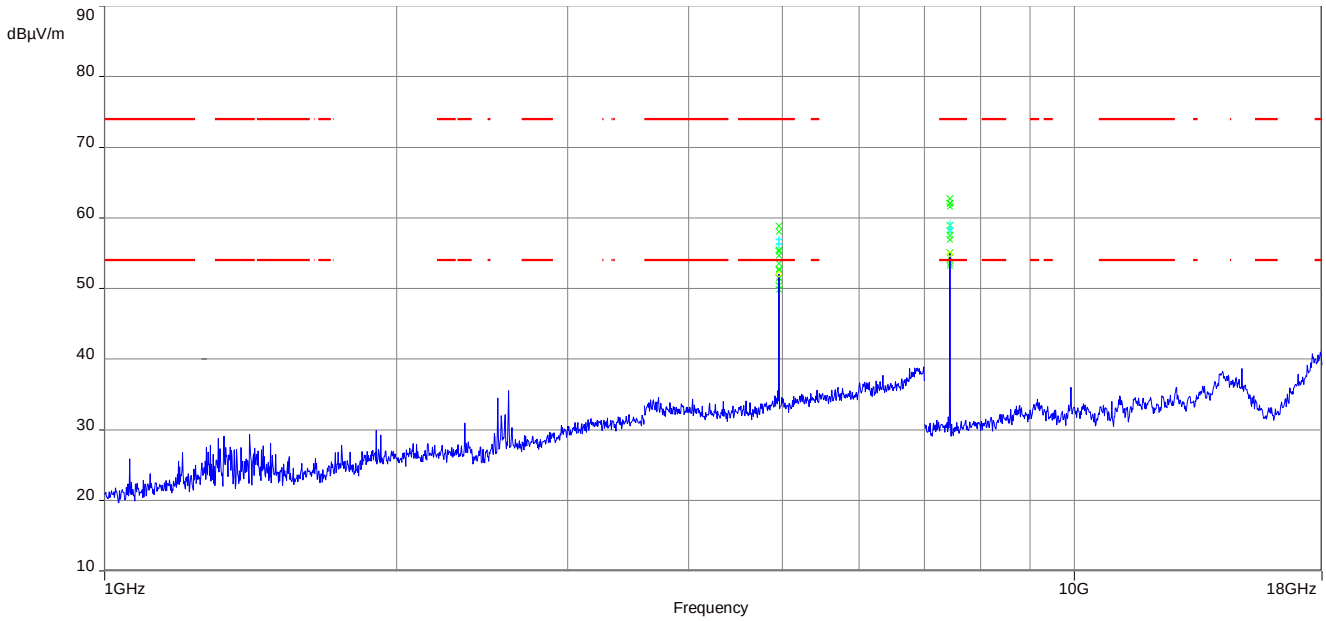


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 4: 18 GHz to 26 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps

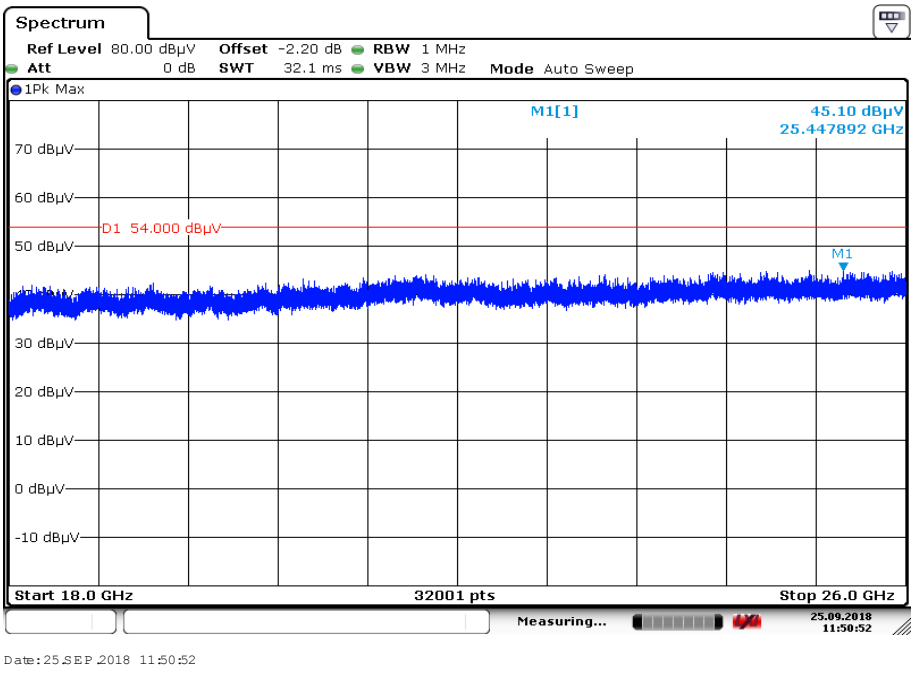


Plot 5: 1 GHz to 18 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 1 Msps

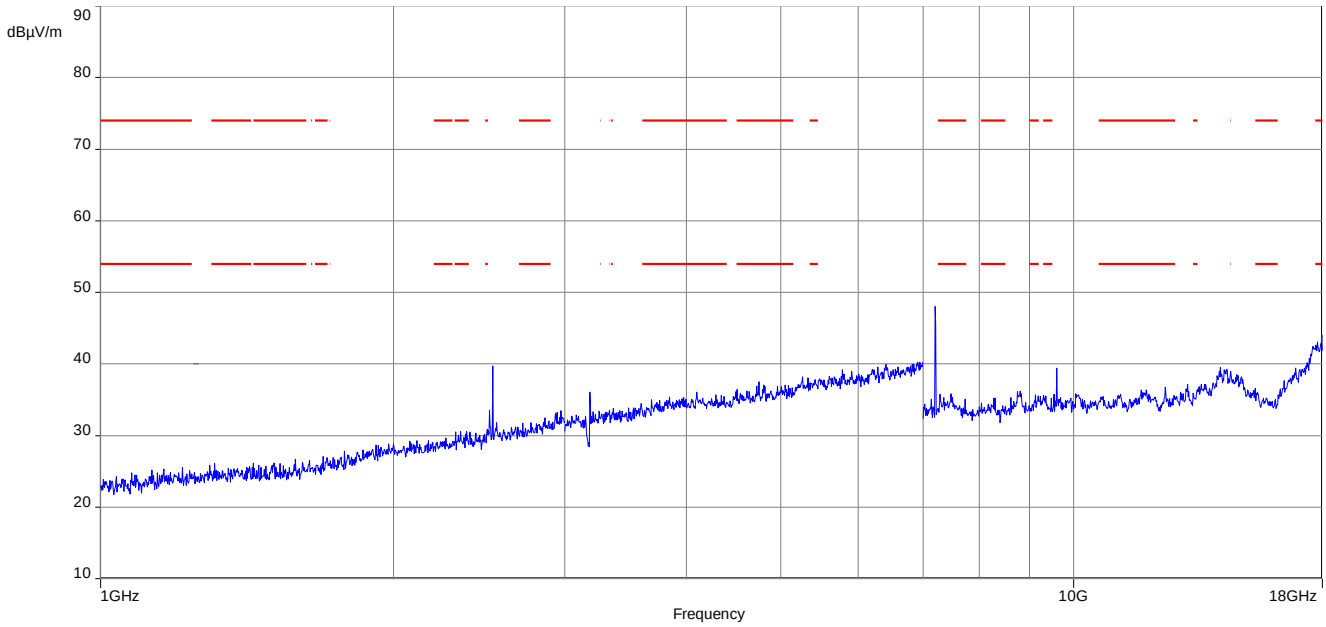


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 6: 18 GHz to 26 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 1 Msps

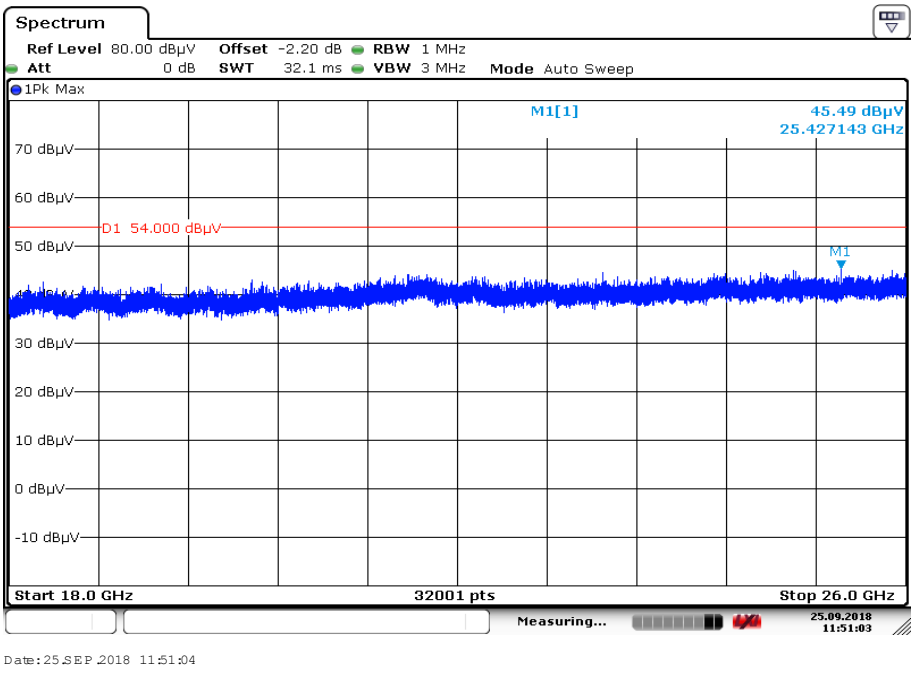


Plot 7: 1 GHz to 18 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 2 Msps

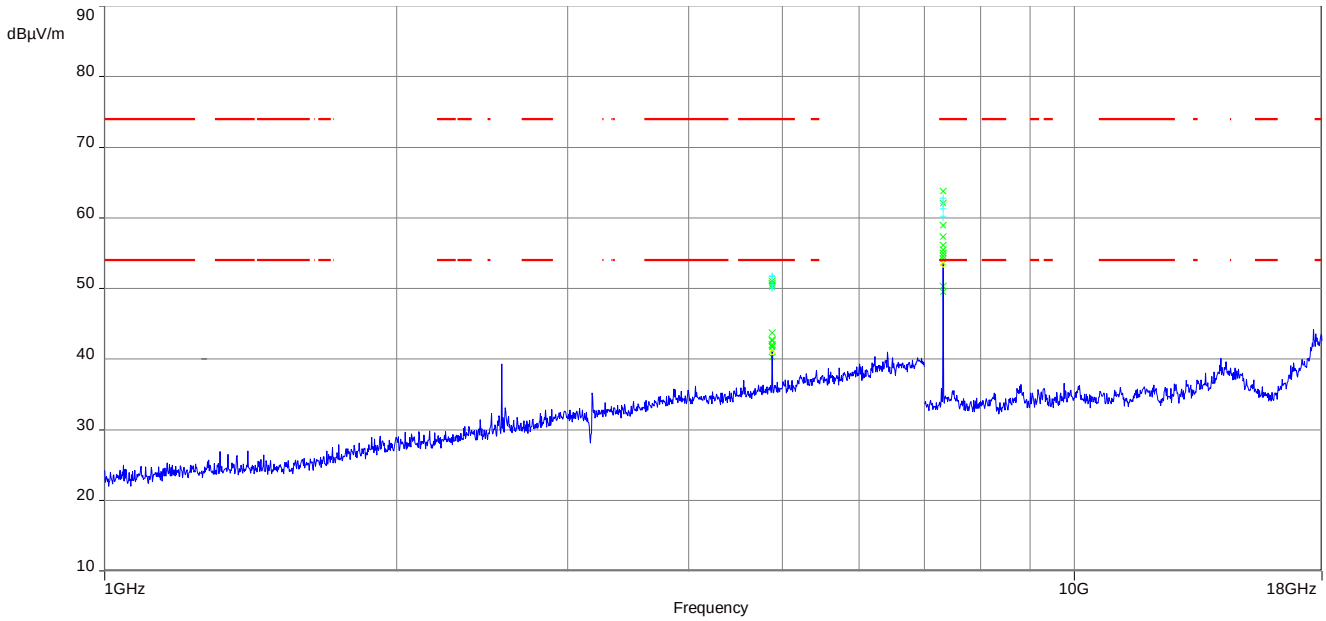


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 8: 18 GHz to 26 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 2 Msps

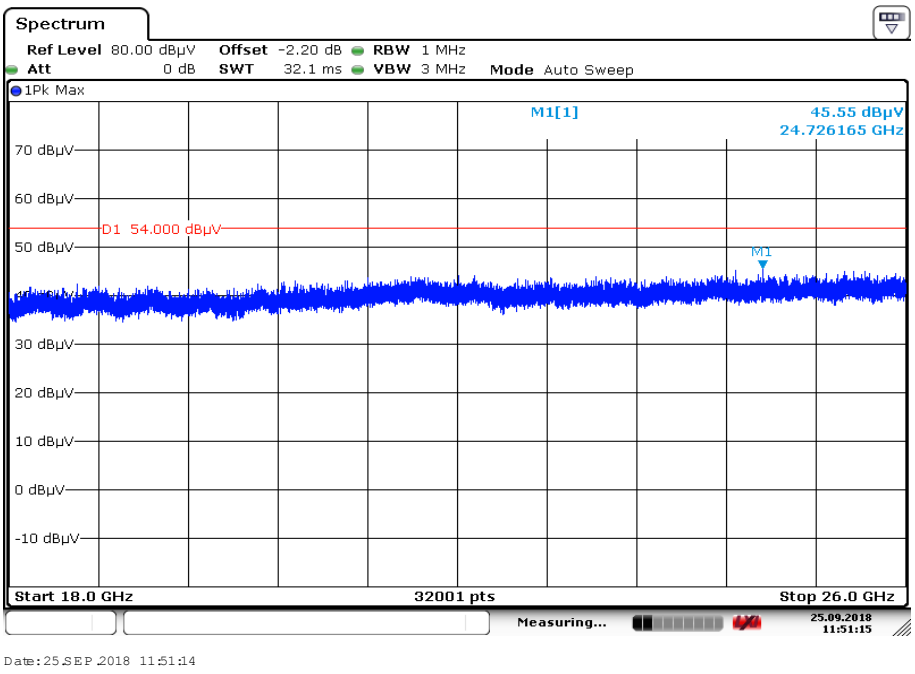


Plot 9: 1 GHz to 18 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 2 Msps

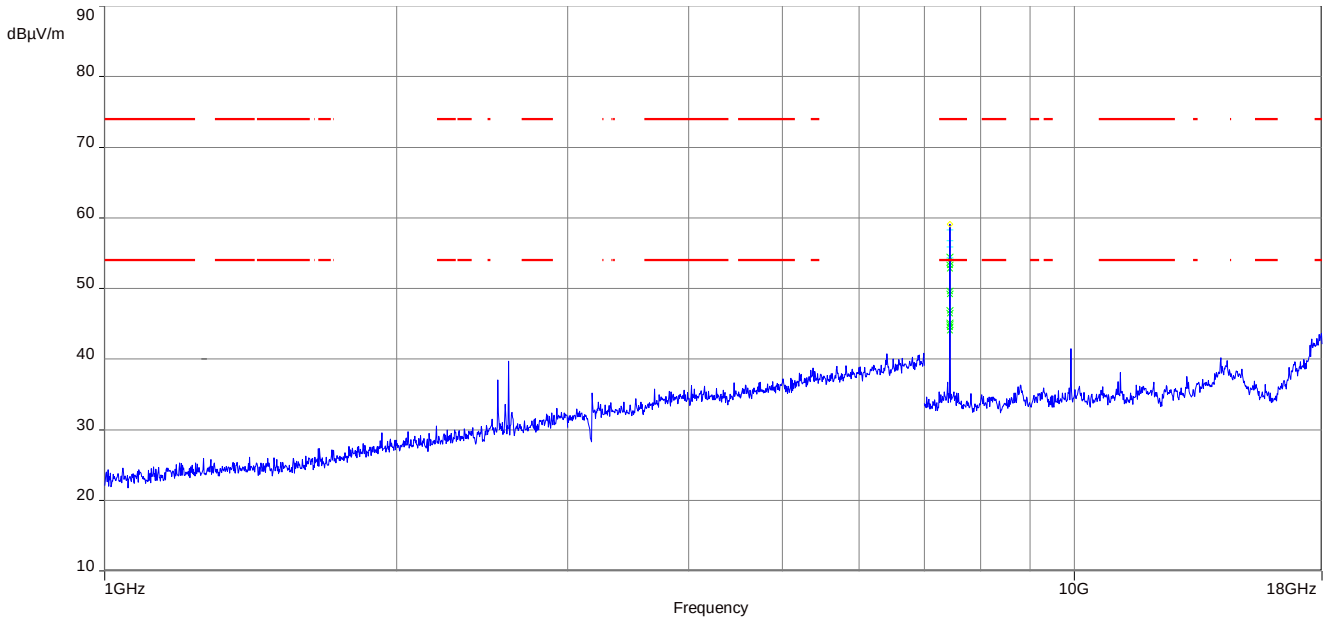


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 10: 18 GHz to 26 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 2 Msps

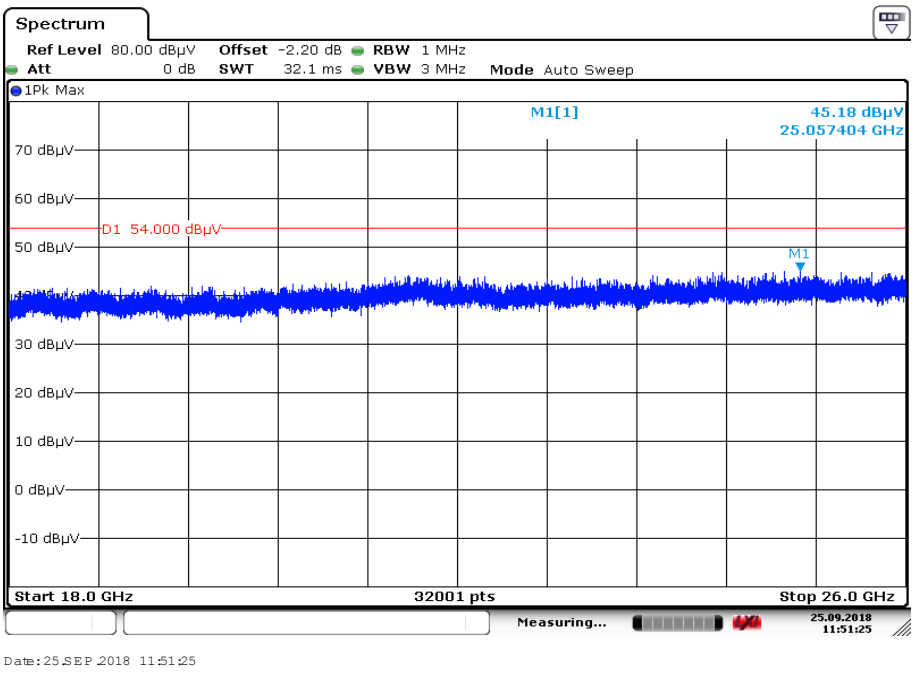


Plot 11: 1 GHz to 18 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 2 Msps



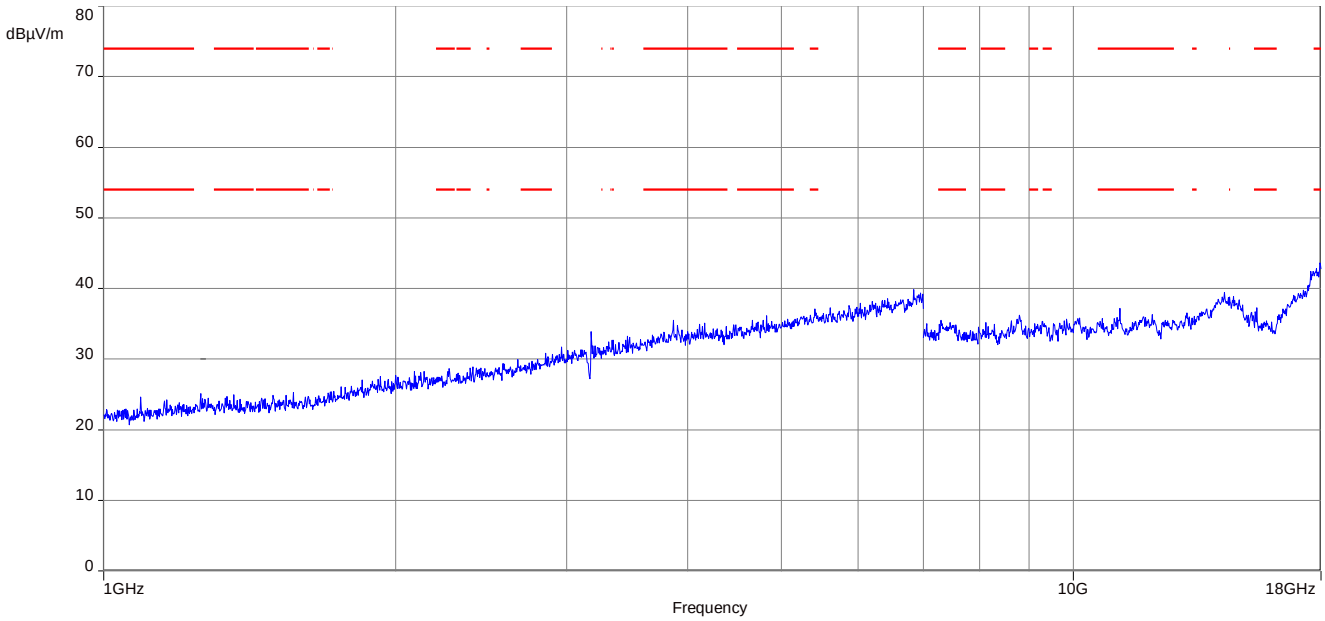
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 12: 18 GHz to 26 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 2 Msps

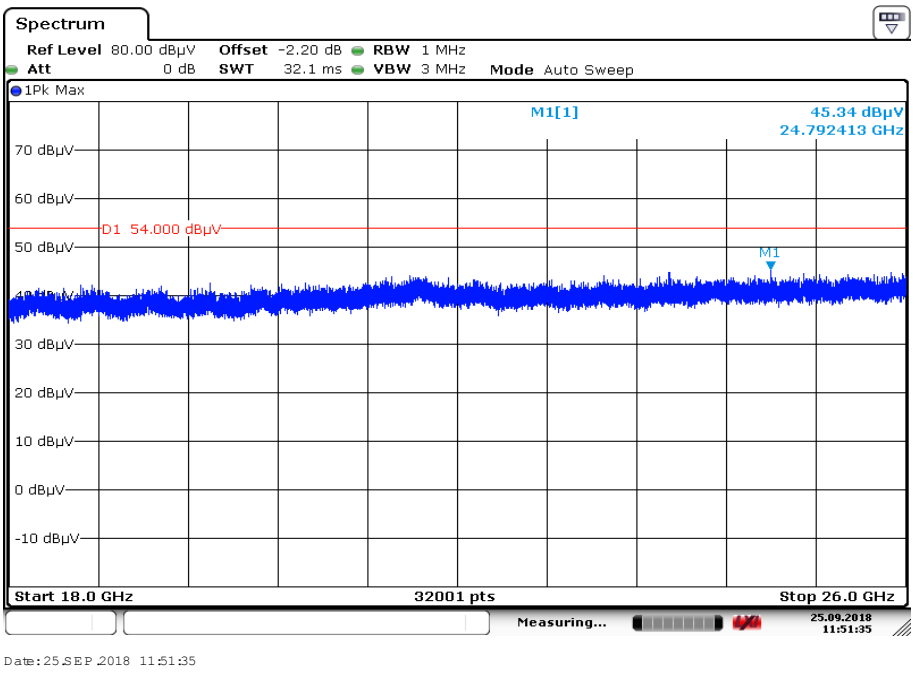


Plots: Receiver mode, integrated antenna

Plot 1: 1 GHz to 18 GHz, RX / idle – mode, vertical & horizontal polarization

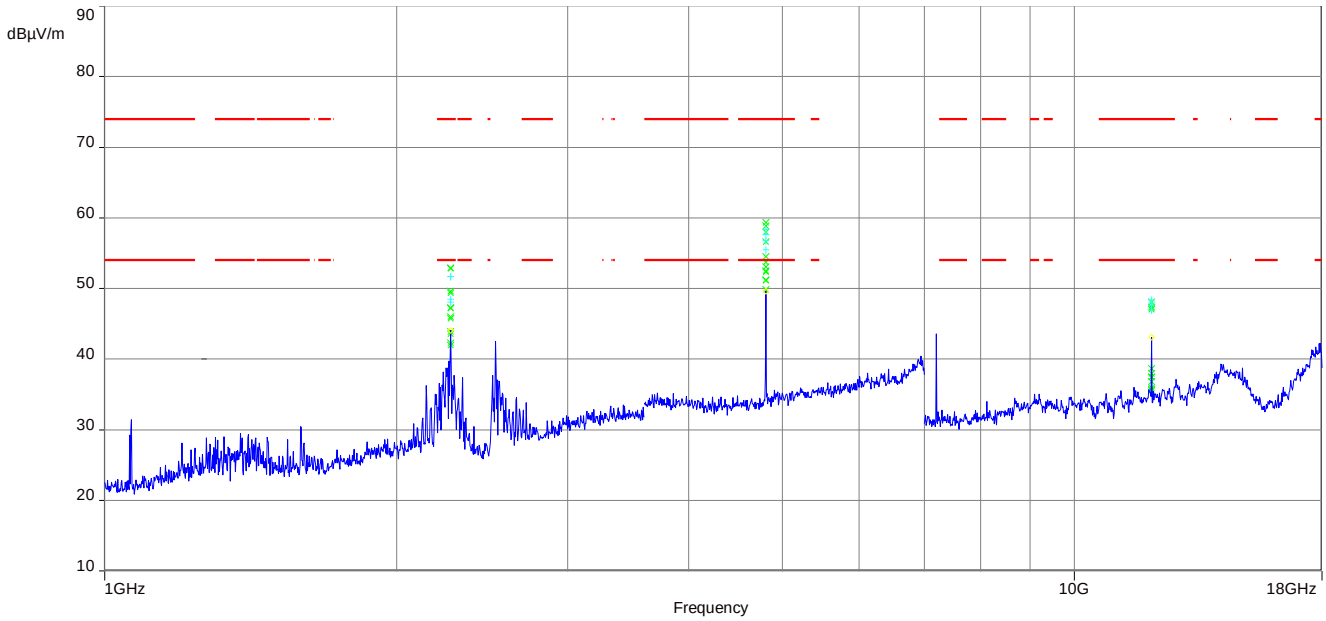


Plot 2: 18 GHz to 26 GHz, RX / idle – mode, vertical & horizontal polarization



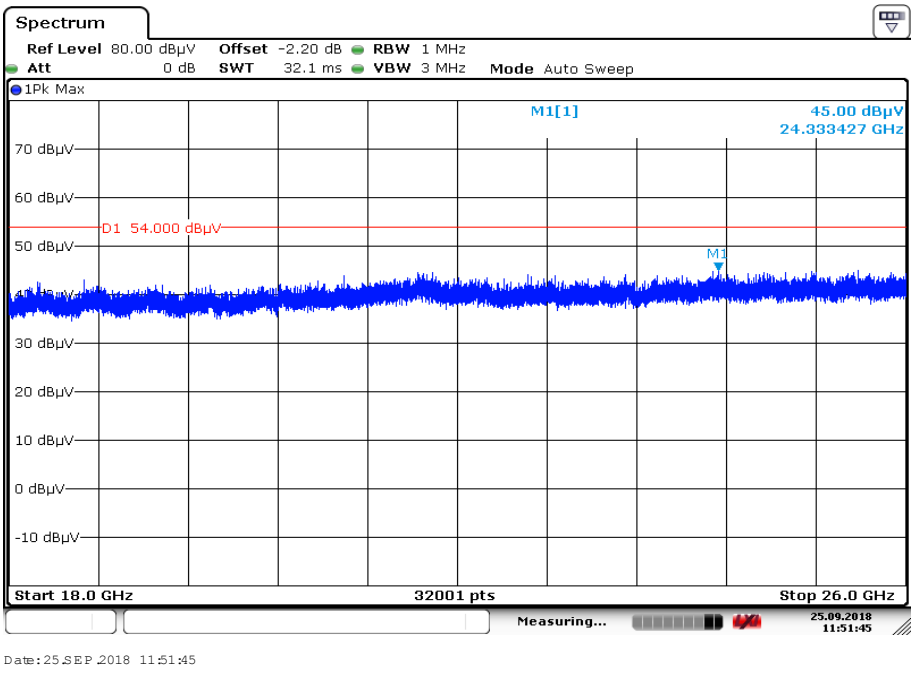
Plots: Transmitter mode, external antenna

Plot 1: 1 GHz to 18 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps

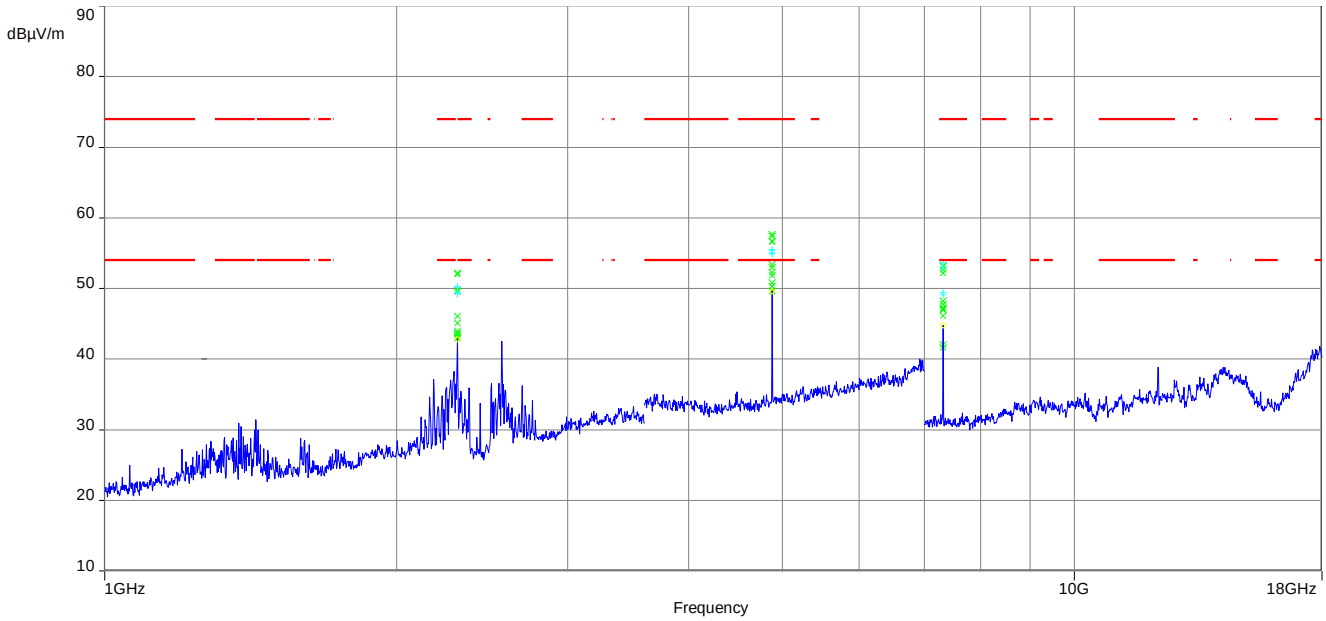


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 2: 18 GHz to 26 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 1 Msps

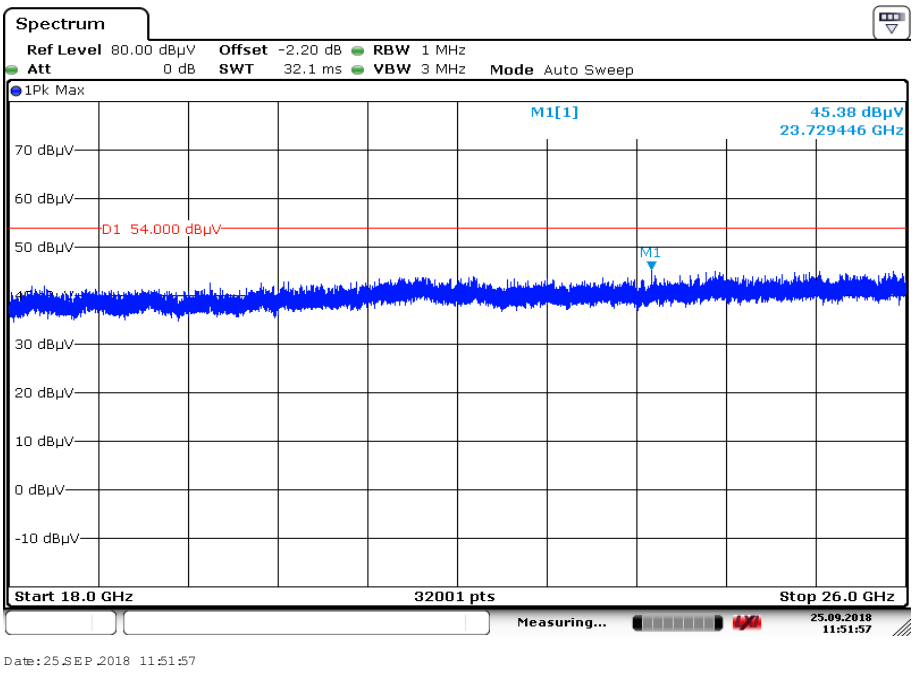


Plot 3: 1 GHz to 18 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps

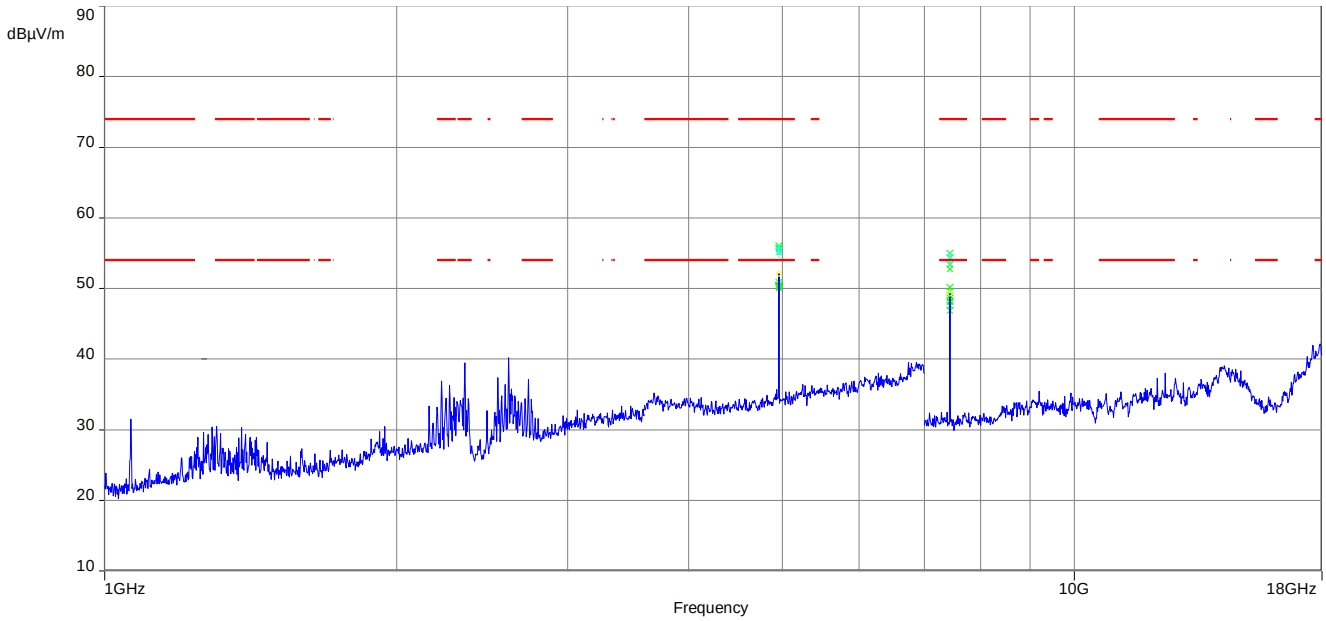


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 4: 18 GHz to 26 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 1 Msps

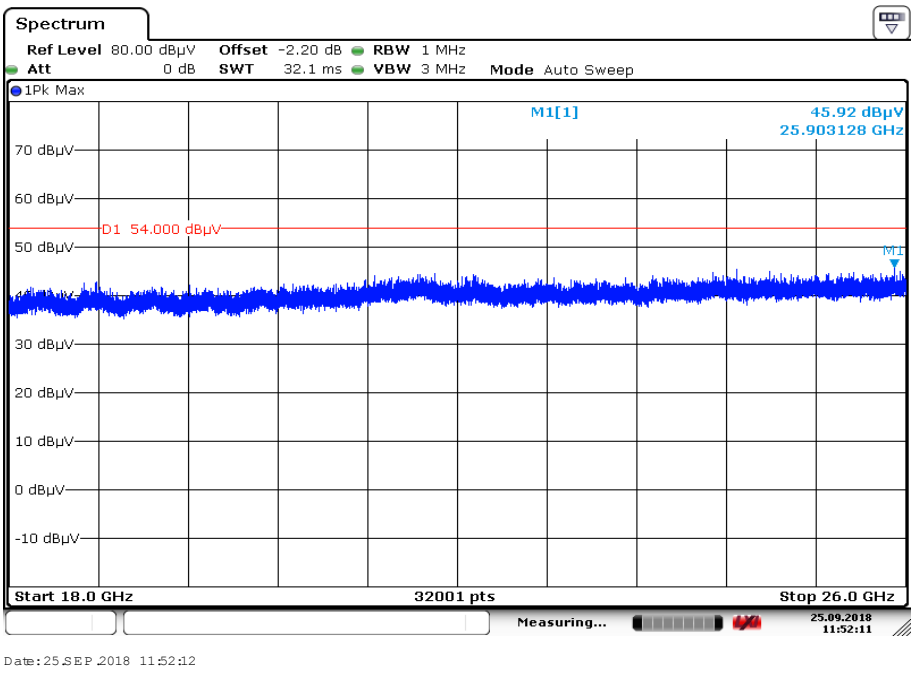


Plot 5: 1 GHz to 18 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 1 Msps

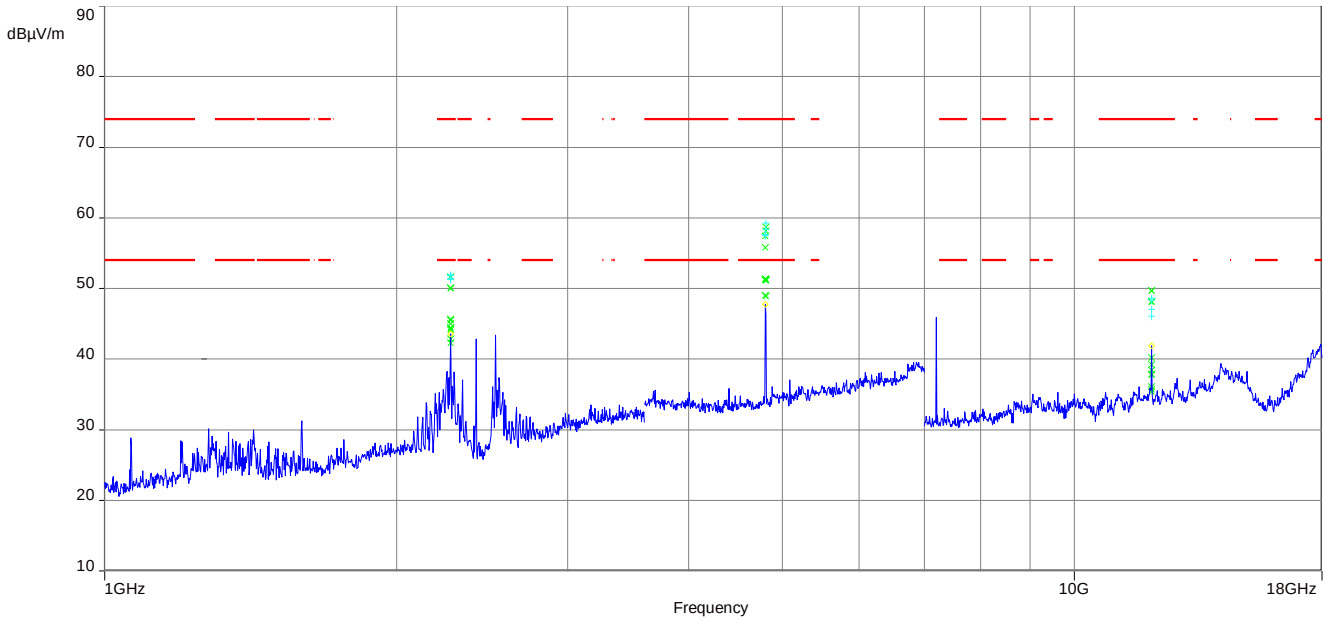


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 6: 18 GHz to 26 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 1 Msps

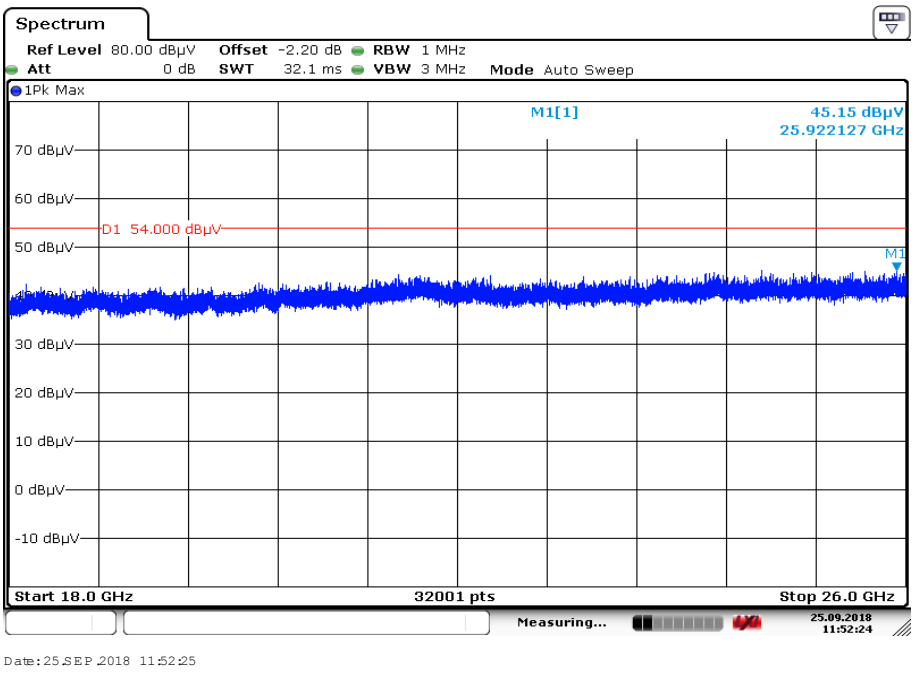


Plot 7: 1 GHz to 18 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 2 Msps

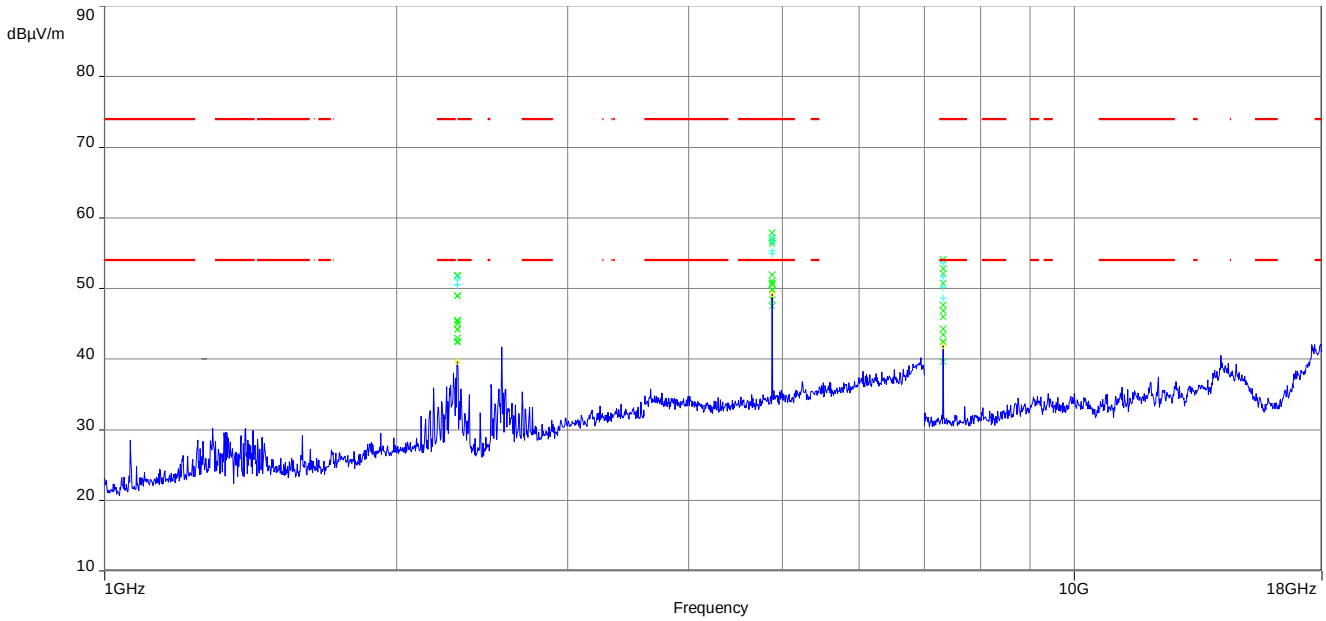


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 8: 18 GHz to 26 GHz, TX mode, 2402 MHz, vertical & horizontal polarization, 2 Msps

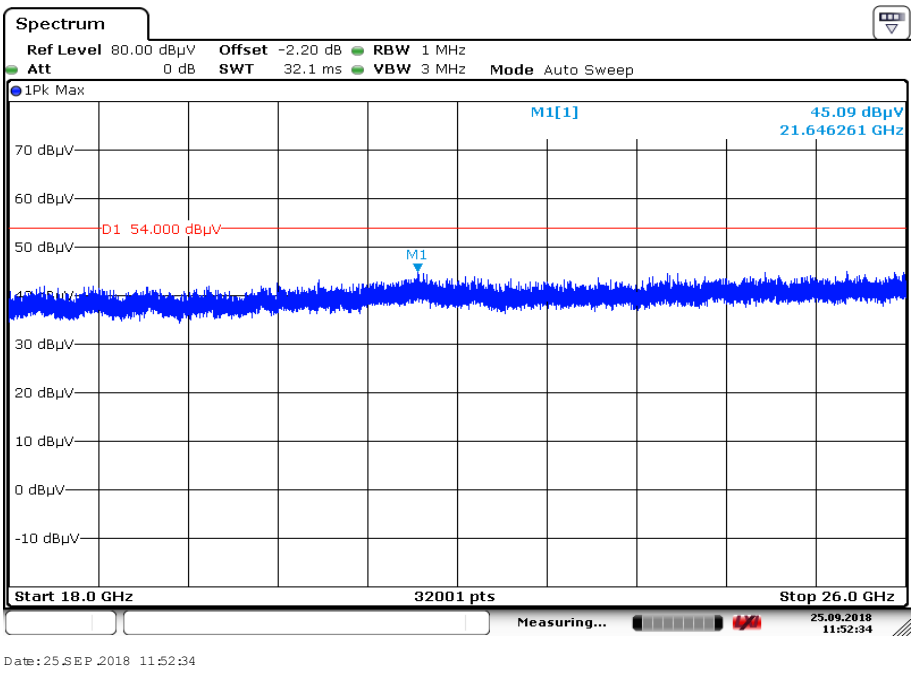


Plot 9: 1 GHz to 18 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 2 Msps

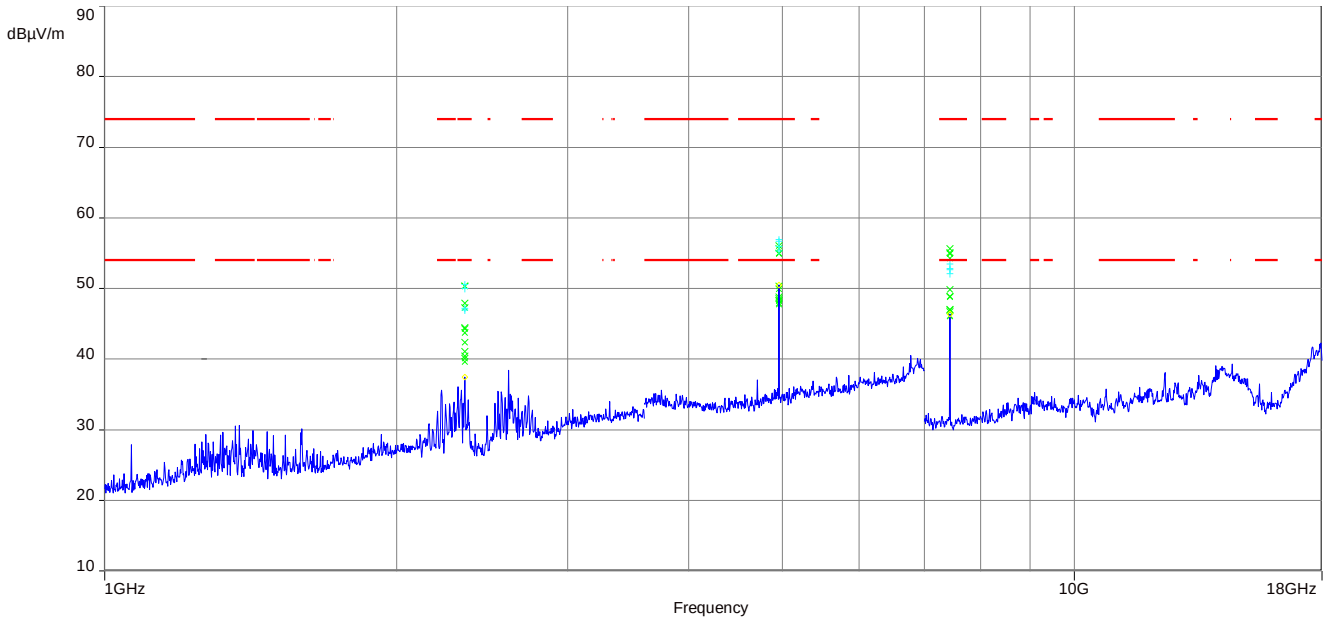


The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 10: 18 GHz to 26 GHz, TX mode, 2440 MHz, vertical & horizontal polarization, 2 Msps

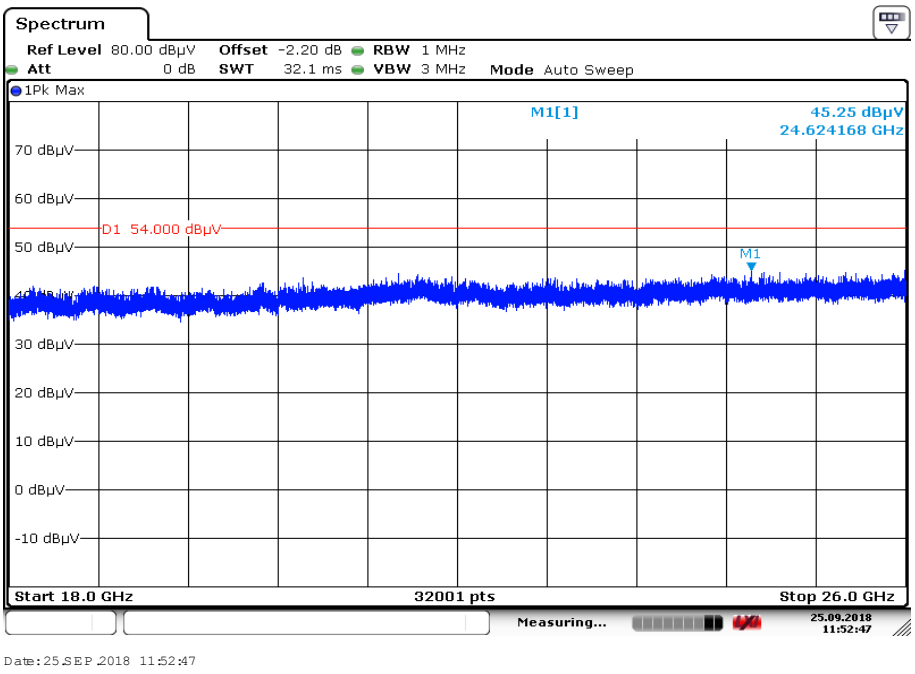


Plot 11: 1 GHz to 18 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 2 Msps



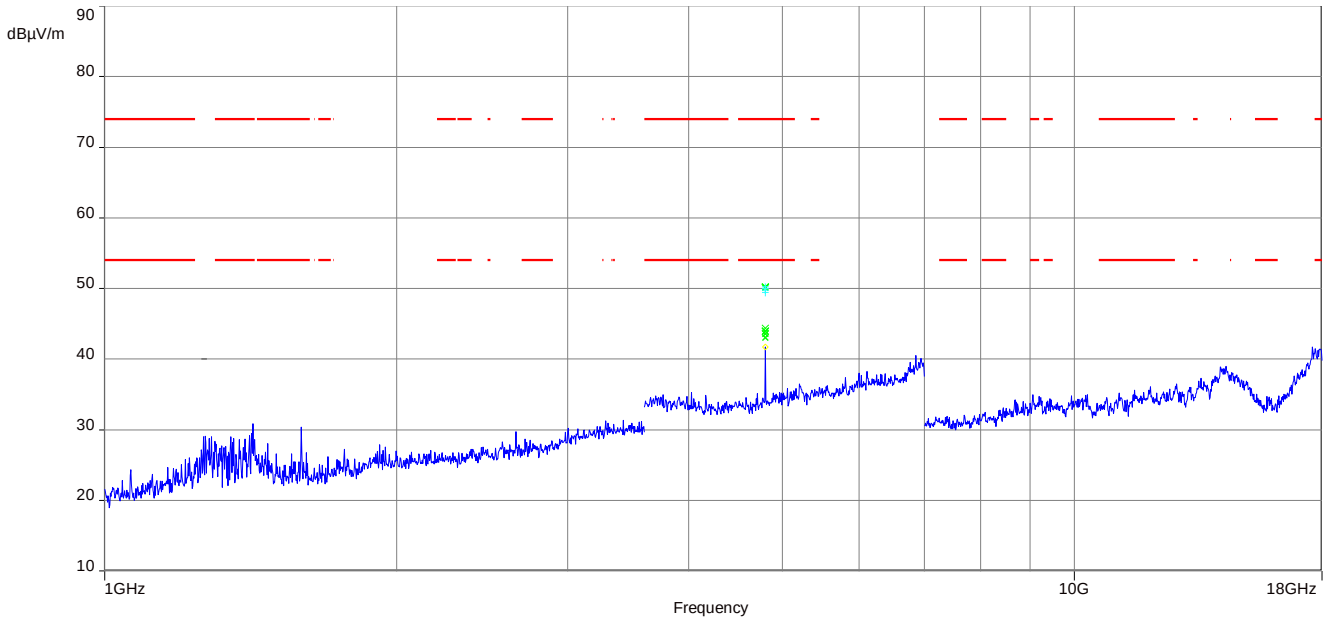
The carrier signal is notched with a 2.4 GHz band rejection filter.

Plot 12: 18 GHz to 26 GHz, TX mode, 2480 MHz, vertical & horizontal polarization, 2 Msps

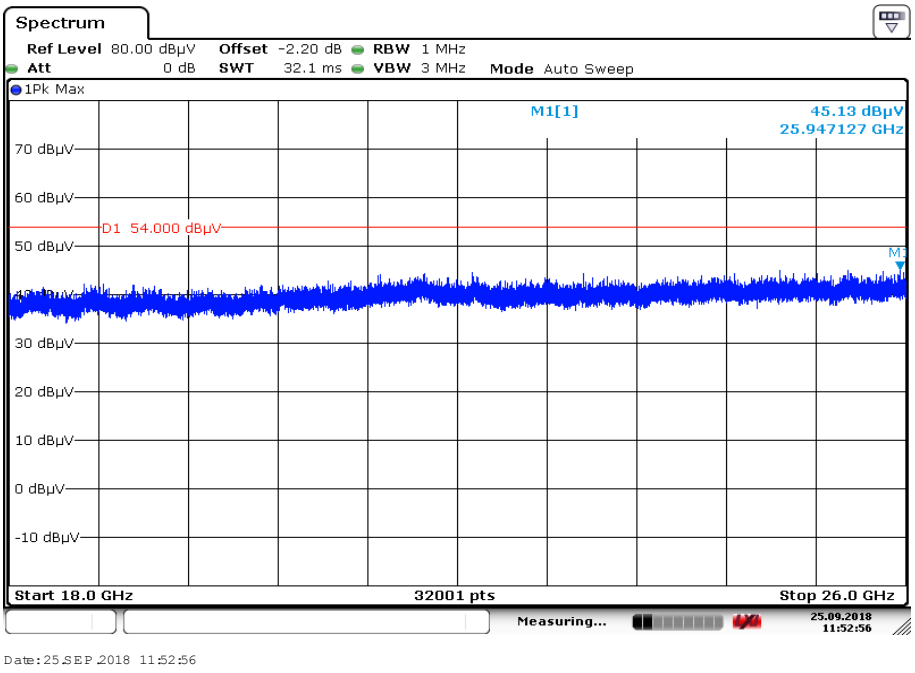


Plots: Receiver mode, external antenna

Plot 1: 1 GHz to 18 GHz, RX / idle – mode, vertical & horizontal polarization



Plot 2: 18 GHz to 26 GHz, RX / idle – mode, vertical & horizontal polarization



11.12 Spurious emissions conducted below 30 MHz (AC conducted)

Description:

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. The EUT is set to single channel mode and the transmit frequency is 2440 MHz. This measurement is representative for all channels and modes. If critical peaks are found frequency 2402 MHz and 2480 MHz will be measured too. The measurement is performed in the mode with the highest output power. Both power lines, phase and neutral line, are measured. Found peaks are remeasured with average and quasi peak detection to show compliance to the limits.

Measurement parameters	
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 sub clause 7.5. A
Measurement uncertainty	See sub clause 8

Limits:

FCC		IC
TX spurious emissions conducted < 30 MHz		
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

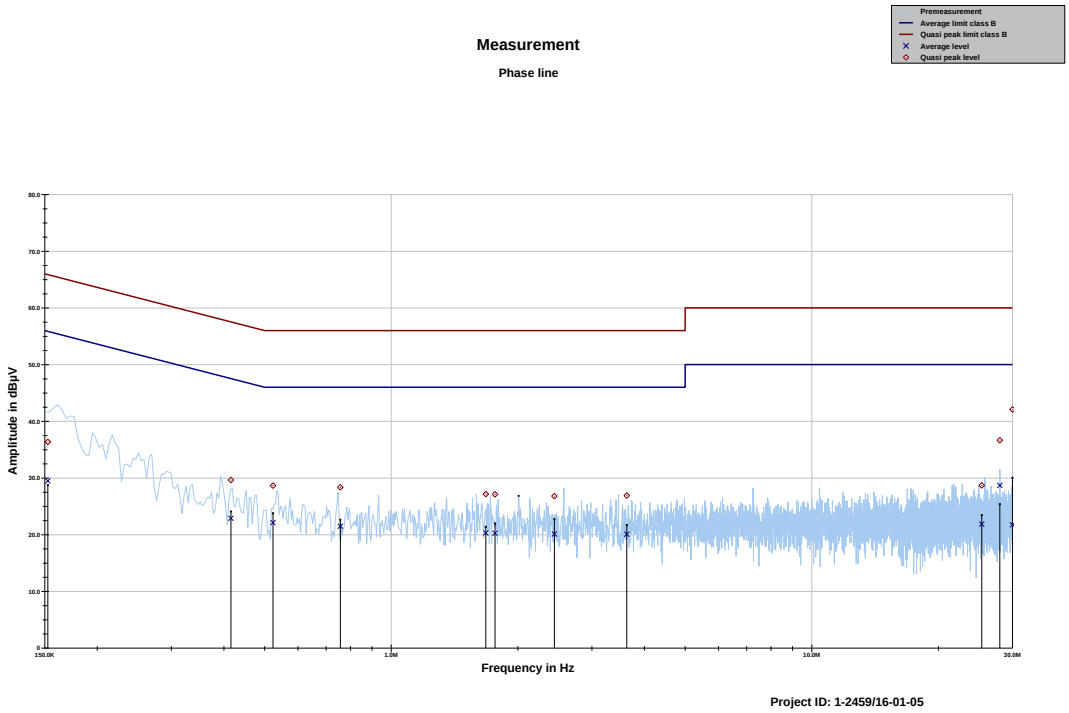
*Decreases with the logarithm of the frequency

Results:

Spurious emissions conducted < 30 MHz [dBµV/m]		
F [MHz]	Detector	Level [dBµV/m]
No emissions detected		

Plots:

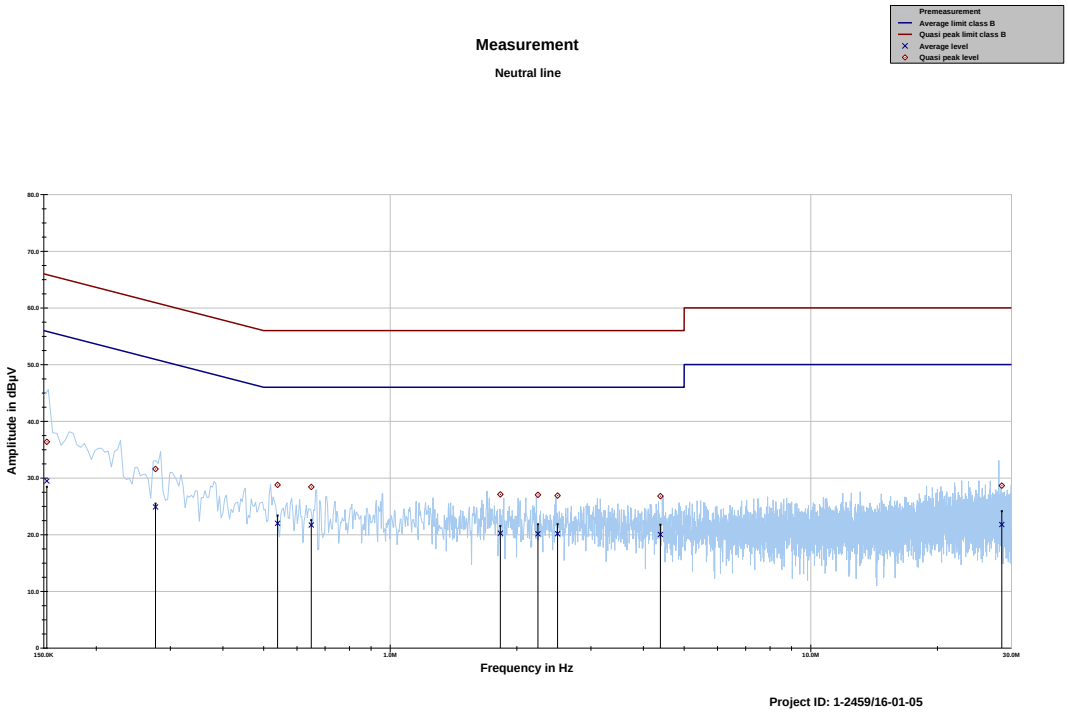
Plot 1: 150 kHz to 30 MHz, phase line



Final results:

Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.152561	36.36	29.50	65.859	29.47	26.46	55.927
0.415801	29.64	27.89	57.532	22.89	25.52	48.406
0.523547	28.65	27.35	56.000	22.12	23.88	46.000
0.757093	28.36	27.64	56.000	21.49	24.51	46.000
1.678156	27.15	28.85	56.000	20.30	25.70	46.000
1.765186	27.10	28.90	56.000	20.27	25.73	46.000
2.442893	26.80	29.20	56.000	20.12	25.88	46.000
3.631296	26.90	29.10	56.000	20.08	25.92	46.000
25.363972	28.70	31.30	60.000	21.86	28.14	50.000
27.999210	36.65	23.35	60.000	28.69	21.31	50.000
30.000000	42.09	17.91	60.000	21.74	28.26	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
0.152563	36.39	29.47	65.859	29.46	26.46	55.927
0.276686	31.58	29.33	60.915	24.88	27.50	52.380
0.539643	28.78	27.22	56.000	22.00	24.00	46.000
0.649005	28.42	27.58	56.000	21.71	24.29	46.000
1.827253	27.11	28.89	56.000	20.27	25.73	46.000
2.245598	27.03	28.97	56.000	20.14	25.86	46.000
2.499994	26.90	29.10	56.000	20.16	25.84	46.000
4.389911	26.80	29.20	56.000	20.03	25.97	46.000
28.465937	28.65	31.35	60.000	21.79	28.21	50.000

Annex A 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

Annex B Document history

Version	Applied changes	Date of release
-/-	Initial release	2018-10-29

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

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