
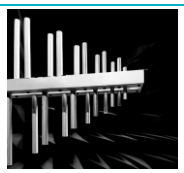
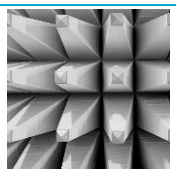

Bundesnetzagentur

BNetzA-CAB-02/21-102

TEST REPORT

Test report no.: 1-5905/18-01-02

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: http://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 (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

RFbeam Microwave GmbH
Schuppisstrasse 7
9016 St. Gallen / SWITZERLAND
Phone: +41 7 12 45 33 80
Fax: +41 7 12 45 33 81
Contact: Léon Audergon
e-mail: audergon@rfbeam.ch
Phone: +41 7 12 45 33 80

Manufacturer

RFbeam Microwave GmbH
Schuppisstrasse 7
9016 St. Gallen / SWITZERLAND

Test standard/s

47 CFR Part 15	Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 210 Issue 9	Spectrum Management and Telecommunications Radio Standards Specification - Licence-Exempt Radio Apparatus: Category I Equipment

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

Test Item

Kind of test item:	**24 GHz Analog Radar Transceiver**
Model name:	**MC-133**
FCC ID:	**WH3-MC-133-2**
IC:	**7907A-MC133**
Frequency:	24.075 GHz – 24.175 GHz
Antenna:	Integral patch antenna
Power supply:	3.15 V to 6.00 V DC
Temperature range:	-20°C to +70°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=Karsten Geraldy, o=CTC advanced GmbH, ou=GER-2017-03-14, email=Karsten.Geraldy@ctcadvanced.com, c=DE
2020.03.17 14:46:47 +01'00'

Karsten Geraldy
Lab Manager
Radio Communications & EMC

Test performed:

cn=Walla Meheza, o=ctcadvanced GmbH, ou=WAL-161220, email=meheza.walla@ctcadvanced.com, c=DE
2020.03.12 17:48:19 +01'00'

Meheza Walla
Lab Manager
Radio Communications & EMC

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2 General information

2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CTC advanced GmbH does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.
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This test report 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:	2018-01-29
Date of receipt of test item:	2018-02-12
Start of test:	2018-02-15
End of test:	2018-02-17
Person(s) present during the test:	Mr. Léon AUDERGON

2.3 Test laboratories sub-contracted

None

3 Test standard/s and references

Test standard	Date	Description
47 CFR Part 15		Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 210 Issue 9	08-2016	Spectrum Management and Telecommunications Radio Standards Specification - Licence-Exempt Radio Apparatus: Category I Equipment
RSS - Gen Issue 5	04 - 2018	Spectrum Management and Telecommunications Radio Standards Specification - General Requirements for Compliance of Radio Apparatus
RSS - 210 Issue 10	*12 - 2019*	*Spectrum Management and Telecommunications Radio Standards Specification - Licence-Exempt Radio Apparatus: Category I Equipment*

Guidance	Version	Description
ANSI C63.4-2014	-/-	American national standard for methods of measurement of radio-noise emissions from low-voltage electrical and electronic equipment in the range of 9 kHz to 40 GHz
ANSI C63.10-2013	-/-	American national standard of procedures for compliance testing of unlicensed wireless devices
ANSI C63.26-2015	-/-	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services

Accreditation	Description
D-PL-12076-01-04	Telecommunication and EMC Canada https://www.dakks.de/as/ast/d/D-PL-12076-01-04.pdf
D-PL-12076-01-05	Telecommunication FCC requirements https://www.dakks.de/as/ast/d/D-PL-12076-01-05.pdf

4 Test environment

Temperature	:	T_{nom} T_{max} T_{min}	+22 °C during room temperature tests +70 °C during high temperature tests -20 °C during low temperature tests
Relative humidity content	:		55 %
Barometric pressure	:		1021 hpa
Power supply	:	V_{nom} V_{max} V_{min}	3.30 V DC 6.00 V 3.15 V

5 Test item

5.1 General description

Kind of test item	:	24 GHz Analog Radar Transceiver
Type identification	:	MC-133
HMN	:	N/A
PMN	:	MC-133
HVIN	:	MC-133
FVIN	:	N/A
S/N serial number	:	N/A
HW hardware status	:	Rev. D
SW software status	:	N/A
Frequency band	:	24.075 GHz – 24.175 GHz
Type of modulation	:	FMCW, CW
Number of channels	:	1
Antenna	:	Integral patch antenna
Power supply	:	3.15 V to 6.00 V DC
Temperature range	:	-20°C to +70°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: 1-5905/18-01-01_AnnexA
1-5905/18-01-01_AnnexB
1-5905/18-01-01_AnnexD

Modulations tested:

- CW (with 10 % and 100 % Duty cycle)
- 10 MHz bandwidth (with 10 % and 100 % Duty cycle)
- 30 MHz bandwidth (with 10 % and 100 % Duty cycle)

Ancillaries tested with: AGD MC133 control board powered with 12 V DC.

6 Description of the test setup

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

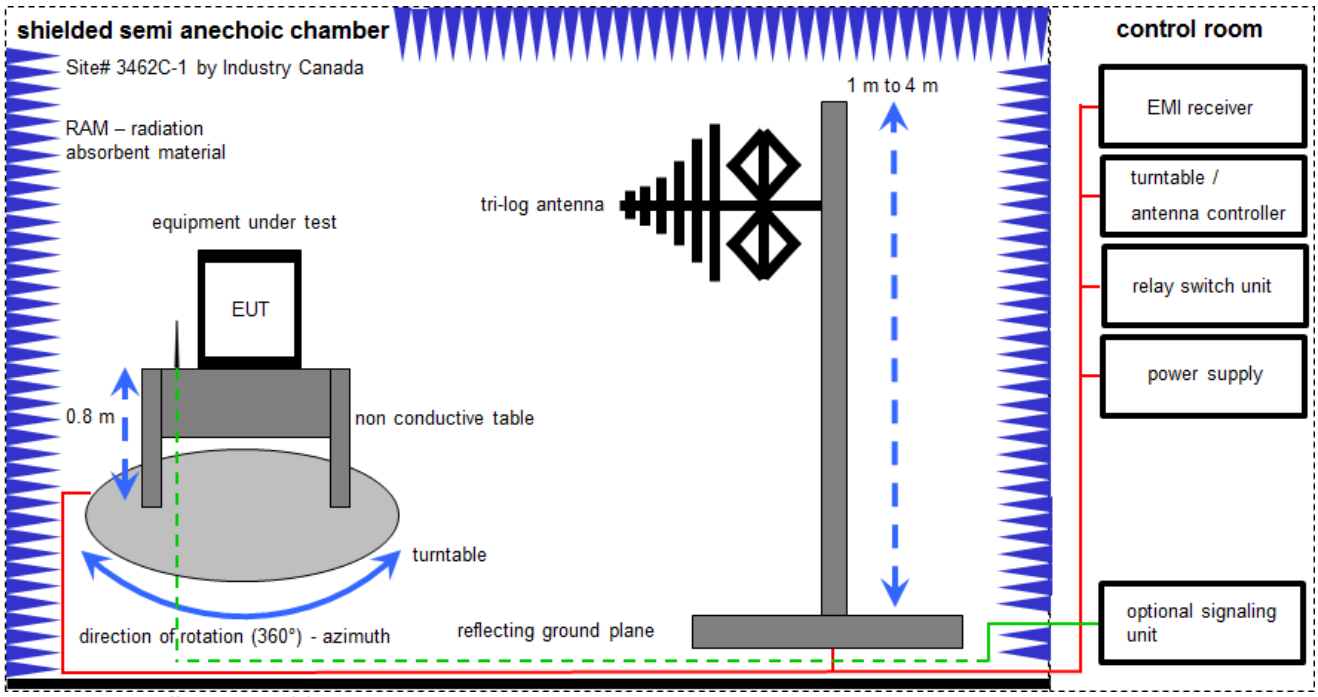
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

Agenda: Kind of Calibration

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

6.1 Shielded semi anechoic chamber

The radiated measurements are performed in vertical and horizontal plane in the frequency range from 30 MHz to 1 GHz in semi-anechoic chambers. The EUT is positioned on a non-conductive support with a height of 0.80 m above a conductive ground plane that covers the whole chamber. The receiving antennas are conform to specifications ANSI C63. These antennas can be moved over the height range between 1.0 m and 4.0 m in order to search for maximum field strength emitted from EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by spectrum analyzers where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



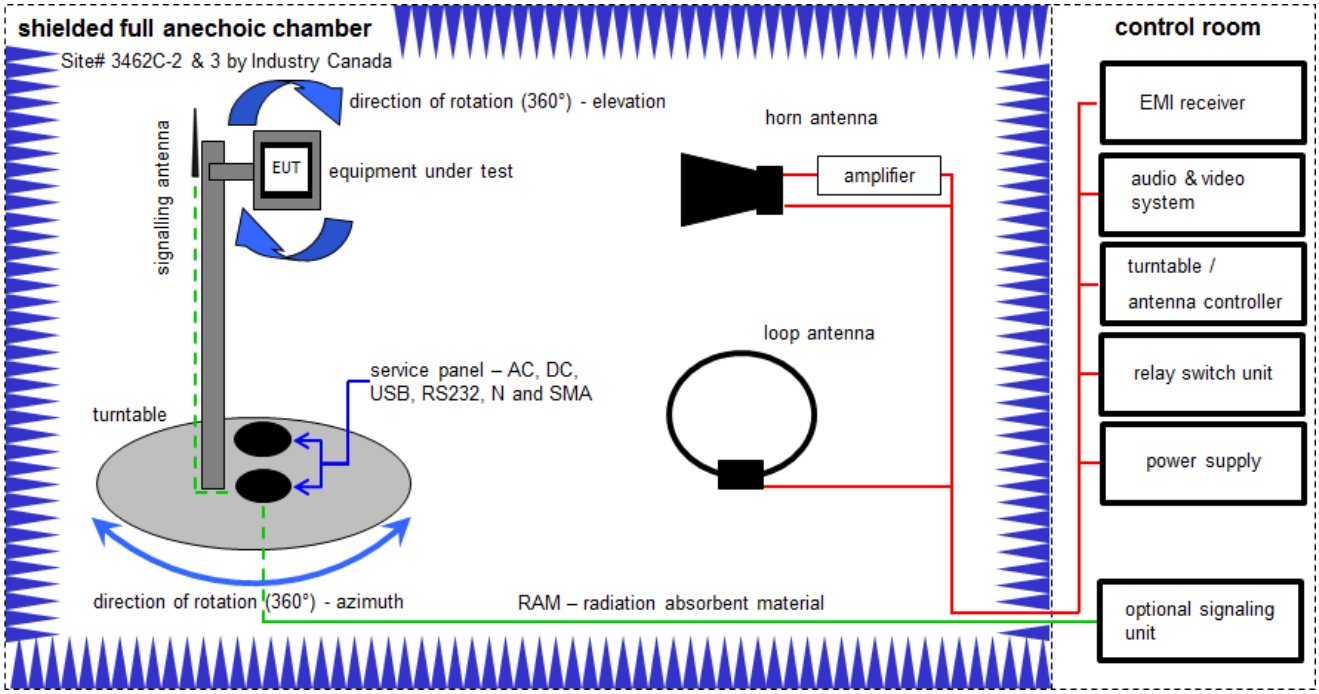
Measurement distance: tri-log antenna 10 meter

FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)
Example calculation:
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	45	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-
2	50	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2920A04466	300000580	ne	-/-	-/-
3	93	Meßkabine 1	HF-Absorberhalle	MWB AG 300023		300000551	ne	-/-	-/-
4	n. a.	EMI Test Receiver	ESCI 3	R&S	100083	300003312	k	15.12.2017	14.12.2018
5	n. a.	Analyzer-Reference-System (Harmonics and Flicker)	ARS 16/1	SPS	A3509 07/0 0205	300003314	vIKI!	15.01.2018	14.01.2020
6	n. a.	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
7	n. a.	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
8	n. a.	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
9	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck	295	300003787	k	25.04.2016	25.04.2018
10	n. a.	Spectrum-Analyzer	FSU26	R&S	200809	300003874	k	20.12.2017	19.12.2018

6.2 Shielded fully anechoic chamber



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

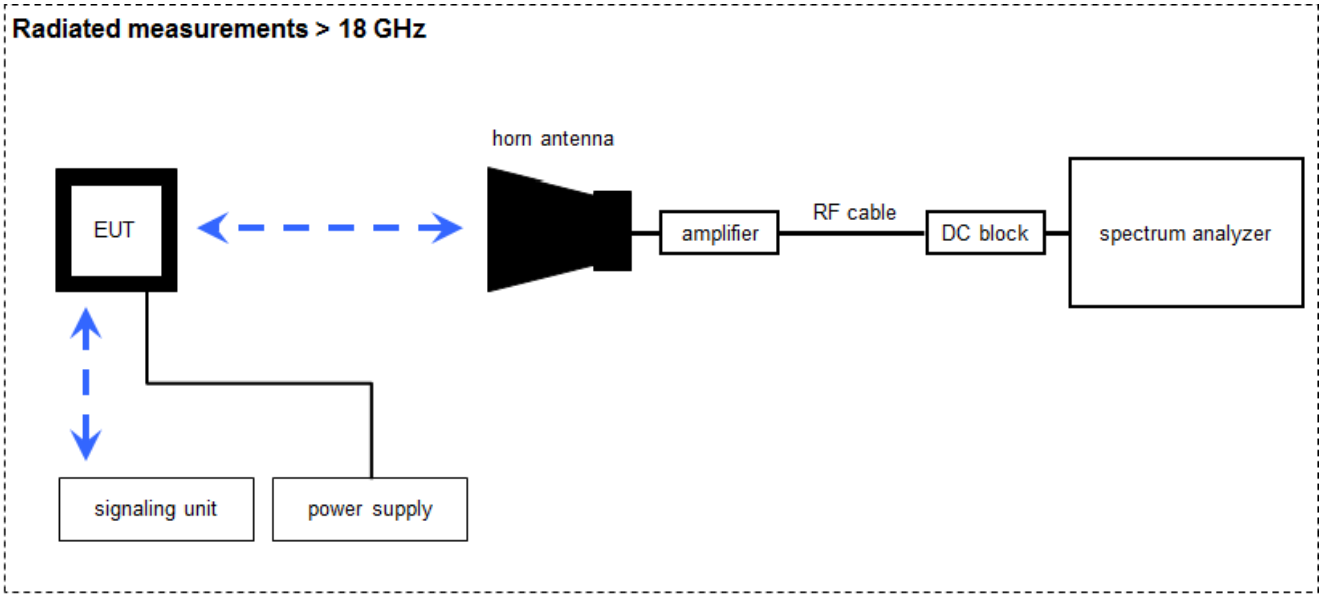
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

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

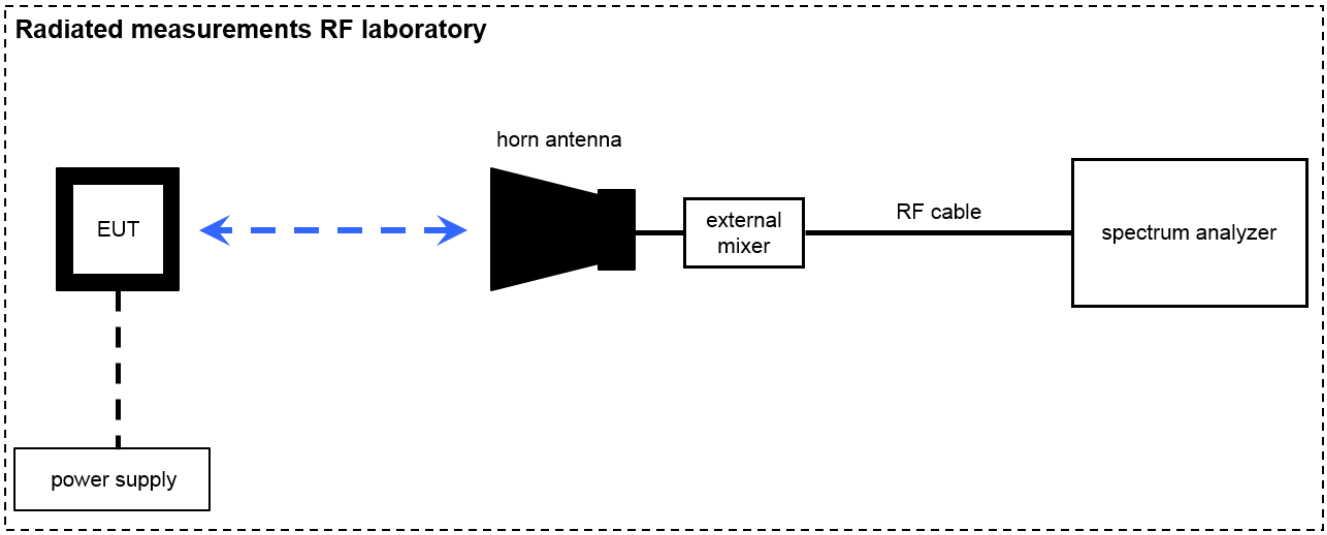
Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	n. a.	DC power supply, 60Vdc, 50A, 1200 W	6032A	HP	2818A03450	300001040	vIKI!	12.12.2017	11.12.2020
2	n. a.	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	k	07.07.2017	06.07.2019
3	n. a.	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
4	19	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	9107-3697	300001605	vIKI!	14.02.2017	13.02.2019
5	n. a.	Switch / Control Unit	3488A	HP	*	300000199	ne	-/-	-/-
6	9	Variable isolating transformer	MPL IEC625 Bus Variable isolating transformer	Erfi	91350	300001155	ne	-/-	-/-
7	n. a.	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	20.12.2017	19.12.2018
8	n. a.	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
9	n. a.	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
10	n. a.	Broadband Amplifier 5-13 GHz	CBLU5135235	CERNEX	22010	300004491	ev	-/-	-/-
11	n. a.	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
12	n. a.	NEXIO EMV-Software	BAT EMC V3.16.0.49	EMCO		300004682	ne	-/-	-/-
13	n. a.	PC	ExOne	F+W		300004703	ne	-/-	-/-
14	n. a.	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-
15	n. a.	TRILOG Broadband Test-Antenna	VULB9163	Schwarzbeck Mess Elektronik	01029	300005379	k	07.04.2017	06.04.2020

6.3 Radiated measurements > 18 GHz



6.4 Radiated measurements > 50 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)

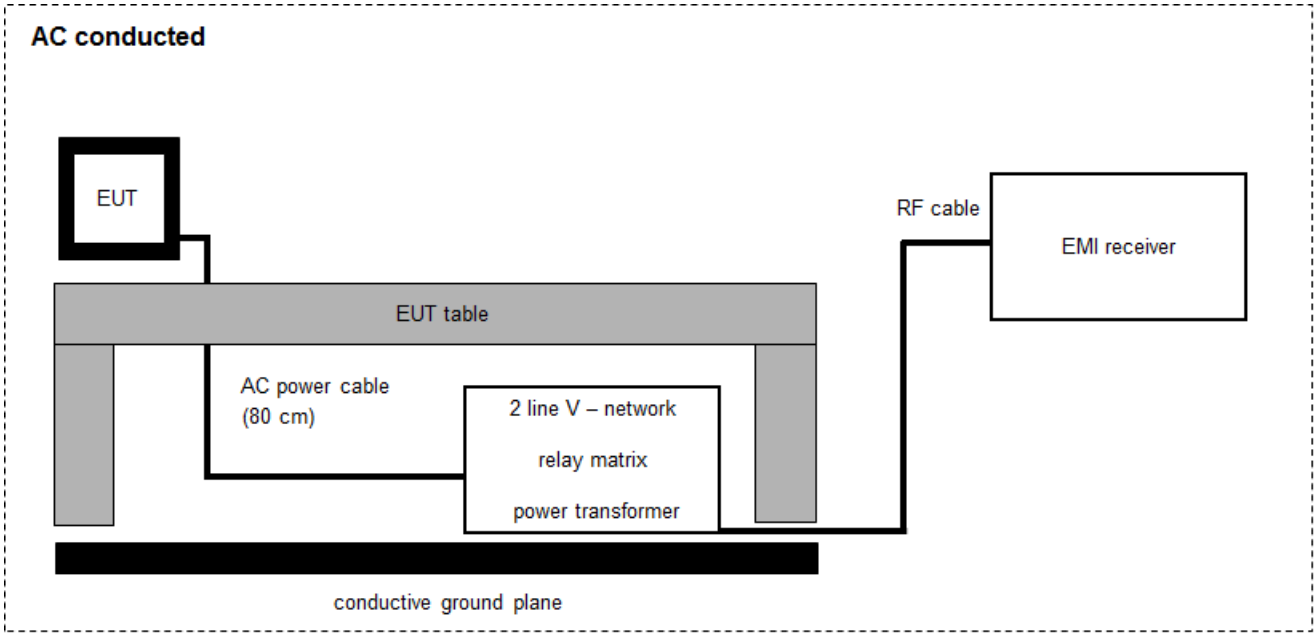
Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-60.1) [dB] + 36.74 [dB/m] = 16.64 [dBµV/m] (6.79 µV/m)

Note: conversion loss of mixer is already included in analyzer value.

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A027	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda		300000486	k	13.12.2017	12.12.2019
2	A031	Std. Gain Horn Antenna 26.5-40.0 GHz	V637	Narda	82-16	300000510	k	13.12.2017	12.12.2019
3	n. a.	Spectrum Analyzer 20 Hz - 50 GHz	FSU50	R&S	200012	300003443	k	28.10.2016	27.10.2018
4	n. a.	PXA Spectrum Analyzer 3Hz to 50GHz	N9030A PXA Signal Analyzer	Agilent Technologies	US51350267	300004338	nk	24.01.2017	
5	n. a.	Std. Gain Horn Antenna 33.0-50.1 GHz	2324-20	Flann	57	400000683	ne	-/-	-/-
6	n. a.	Broadband LNA 18-50 GHz	CBL18503070PN	CERNEX	25240	300004948	ev	-/-	-/-
7	n. a.	Harmonic Mixer, 75-110 GHz	M1970W	KEYSIGHT	MY51430848	300005115	k	05.04.2017	04.04.2018
8	n. a.	Harmonic Mixer, 50-80 GHz	M1970V	KEYSIGHT	MY51390914	300005116	k	05.04.2017	04.04.2018
9	A026	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001986	ne	-/-	-/-
10	A027	Std. Gain Horn Antenna 73.8-112 GHz	2724-20	Flann	*	300001988	ne	-/-	-/-

6.5 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	101	Two-line V-Network (LISN) 9 kHz to 30 MHz	ESH3-Z5	R&S	893045/004	300000584	k	13.12.2017	12.12.2018
2	67	RF-Filter-section	85420E	HP	3427A00162	300002214	k	27.11.2006	-/-
3	27	EM-Injection Clamp	FCC-203i	emv	232	300000626	ev	18.05.2001	-/-
4	n. a.	Magnetfeldantenne	MS 100	EM-Test	-----	300002659	ev	24.04.2000	-/-
5	n. a.	AC-Spannungsquelle variabel	MV2616-V	EM-Test	0397-12	300003259	k	11.12.2015	01.03.2018
6	n. a.	Analyzer-Reference-System (Harmonics and Flicker)	ARS 16/1	SPS	A3509 07/0 0205	300003314	vlKl!	15.01.2018	14.01.2020
7	n. a.	Hochpass 150 kHz	EZ-25	R&S	100010	300003798	ev	08.04.2008	-/-
8	n. a.	Power Supply	NGSM 32/10	R&S	3939	400000192	vlKl!	31.01.2017	30.01.2020
9	n. a.	MXE EMI Receiver 20 Hz to 26,5 GHz	N9038A	Agilent Technologies	MY51210197	300004405	k	18.12.2017	17.12.2018

7 Sequence of testing

7.1 Sequence of testing radiated spurious 9 kHz to 30 MHz

Setup

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

Premeasurement*

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna height is 1 m.
- At each turntable position the analyzer sweeps with positive-peak detector to find the maximum of all emissions.

Final measurement

- Identified emissions during the pre-measurement are maximized by the software by rotating the turntable from 0° to 360°.
- Loop antenna is rotated about its vertical axis for maximum response at each azimuth about the EUT. (For certain applications, the loop antenna plane may also need to be positioned horizontally at the specified distance from the EUT)
- The final measurement is done in the position (turntable and elevation) causing the highest emissions with quasi-peak (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. A plot with the graph of the premeasurement and the limit is stored.

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

7.2 Sequence of testing radiated spurious 30 MHz to 1 GHz

Setup

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

Premeasurement

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

Final measurement

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

7.3 Sequence of testing radiated spurious 1 GHz to 18 GHz

Setup

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

Premeasurement

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

Final measurement

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

7.4 Sequence of testing radiated spurious above 18 GHz

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet.
- The measurement distance is as appropriate (e.g. 0.5 m).
- The EUT is set into operation.

Premeasurement

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

Final measurement

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

7.5 Sequence of testing radiated spurious above 50 GHz with external mixers

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 for far field (e.g. 0.25 m).
- The EUT is set into operation.

Premeasurement

- The test antenna with external mixer is handheld and moved carefully over the EUT to cover the EUT's whole sphere and different polarizations of the antenna.
- Caution is taken to reduce the possible overloading of the external mixer.

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).
- As external mixers may generate false images care is taken to ensure that any emission measured by the spectrum analyzer does indeed originate in the EUT. Signal identification feature of spectrum analyzer is used to eliminate false mixer images (i.e., it is not the fundamental emission or a harmonic falling precisely at the measured frequency).
- Final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement and the limit is stored.

8 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	47 CFR Part 15 RSS-210, Issue 8, Annex F	Passed	2020-03-12	-/-

Test specification clause	Test case	Temperature conditions	Power source voltages	C	NC	NA	NP	Results (max.)
§15.245(b) RSS-210 Annex F	Field strength of fundamental emission	Nominal	Nominal	☒	☐	☐	☐	110.4 dBµV/m
§2.1049	Occupied bandwidth (99% bandwidth)	Nominal	Nominal	☒	☐	☐	☐	26.1 MHz
§15.209(a) / §15.245(b)(1)(2)(3) RSS-210 Annex F RSS-Gen 8.9	Field strength of emissions (radiated spurious)	Nominal	Nominal	☒	☐	☐	☐	complies
§15.207(a) RSS-Gen 8.8	Conducted emissions < 30 MHz	Nominal	Nominal	☒	☐	☐	☐	complies
§15.215(c) RSS-210 / Annex F.2.2 RSS-Gen 8.11	Frequency Stability	Nominal Extreme	Nominal Extreme	☒	☐	☐	☐	complies

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

9 Detailed measurement results

9.1 Field strength of fundamental emission

Description:

Measurement of the maximum radiated field strength of the fundamental emission.

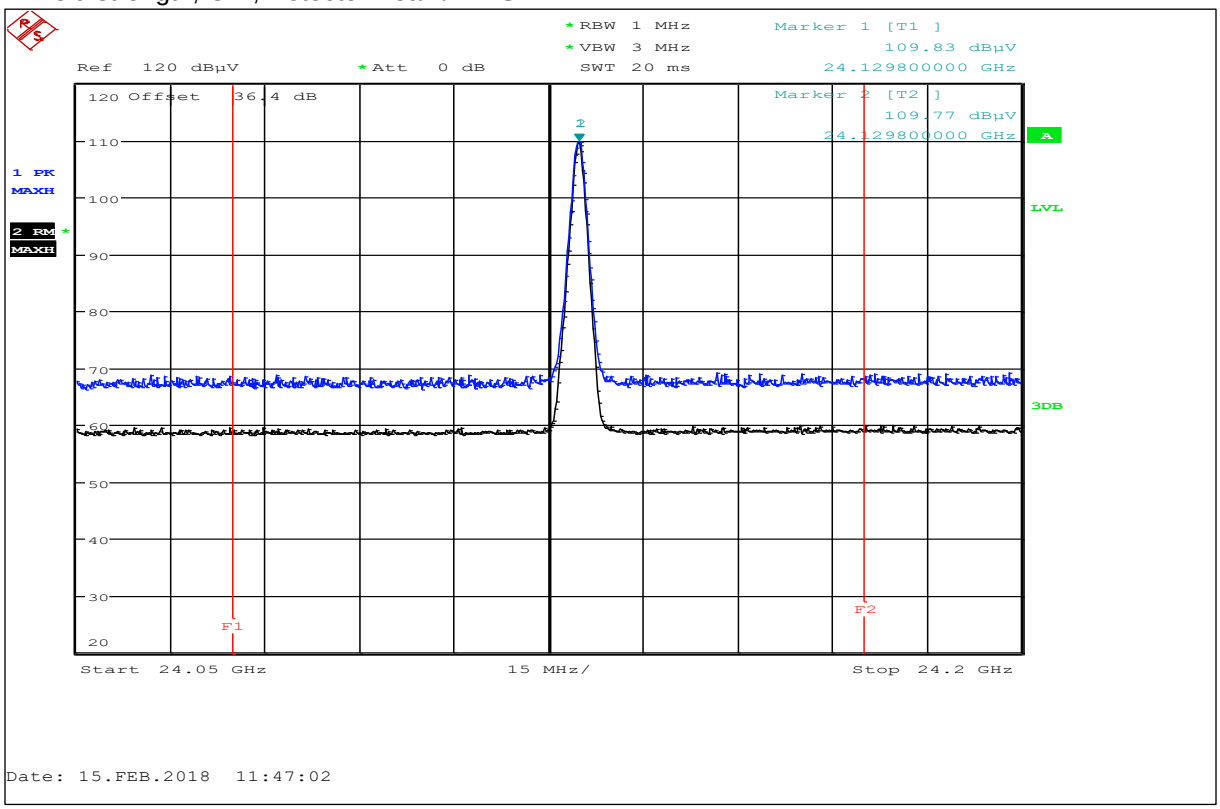
Limits:

FCC		IC
CFR Part 15.245(b)		RSS-210 Annex F
Field strength of emissions		
The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:		
Frequency [GHz]	Field Strength [dBµV/m]	Measurement distance
24.075 – 24.175	128 (Average) 148 (PEAK)	3

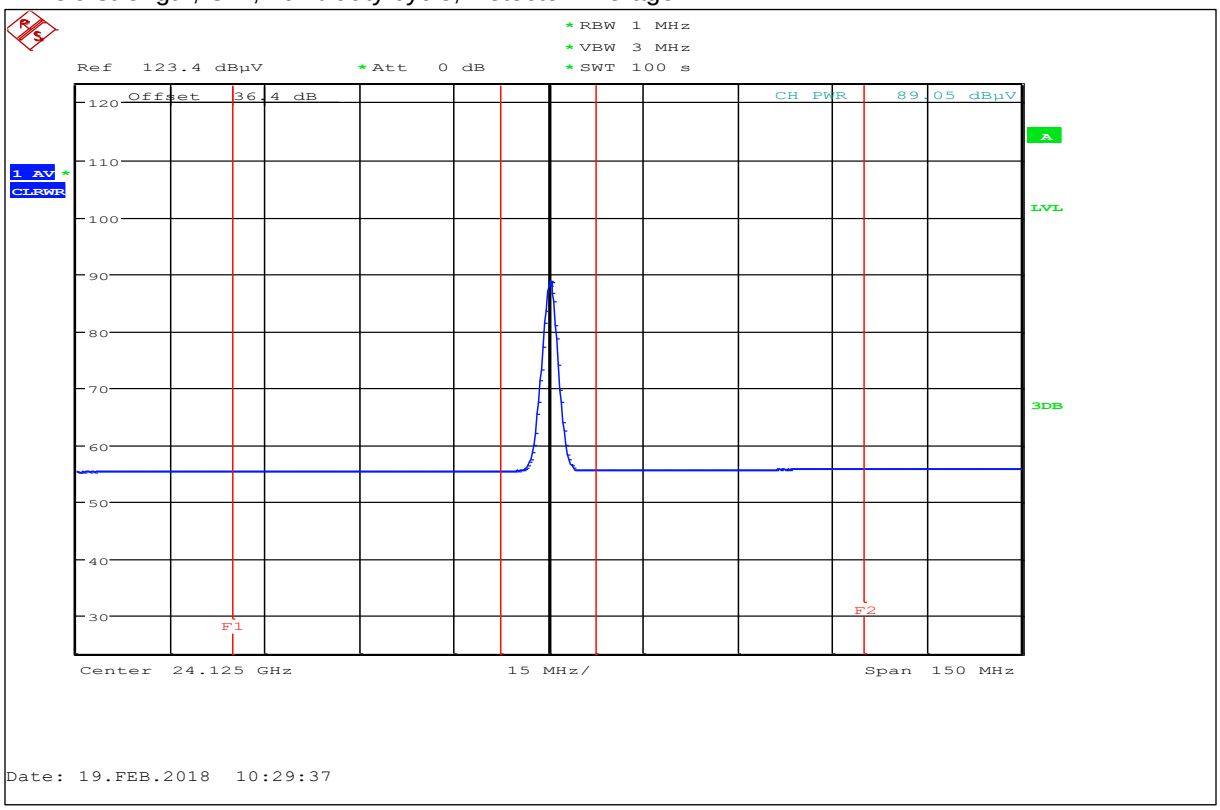
Measurement result:

TEST CONDITIONS T_{nom} / V_{nom}	Maximum field strength		
	Peak [dBµV/m]	RMS [dBµV/m]	Integrated over the entire emission bandwidth Average [dBµV/m]
CW, 10% duty cycle	109.83	99.53	89.05
CW, 100% duty cycle	109.83	109.77	107.83
10 MHz Bandwidth, 10% duty cycle	110.20	91.85	84.92
10 MHz Bandwidth, 100% duty cycle	110.23	101.90	104.15
30 MHz Bandwidth, 10% duty cycle	110.38	87.68	82.05
30 MHz Bandwidth, 100% duty cycle	110.40	97.39	100.07

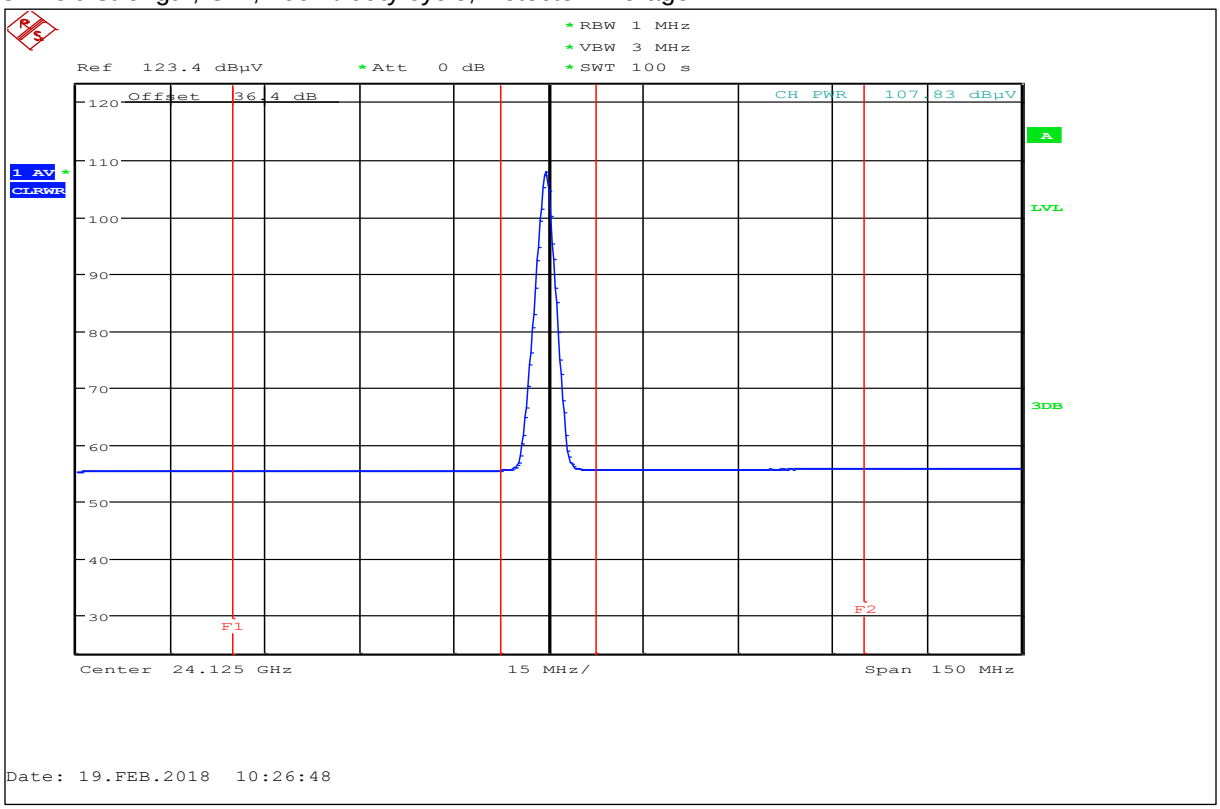
Plot 1: Field strength, CW, Detector Peak / RMS



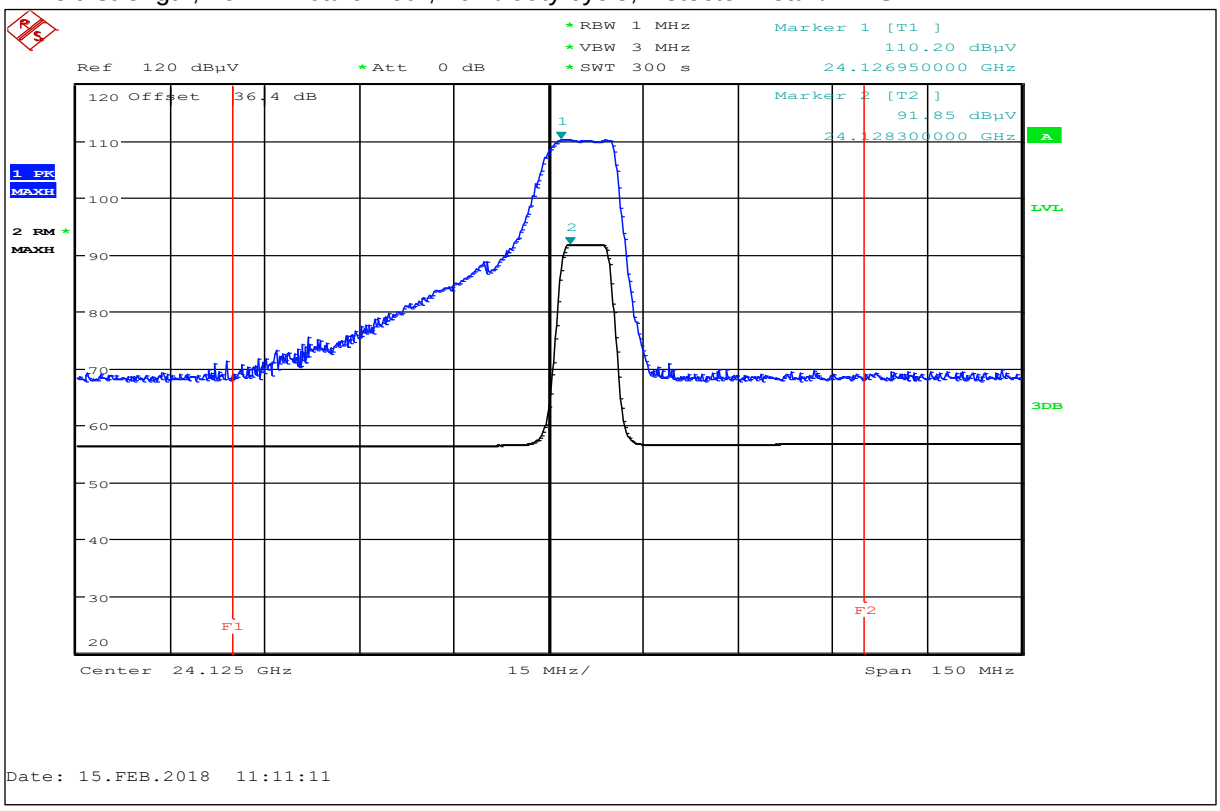
Plot 2: Field strength, CW, 10 % duty cycle, Detector Average



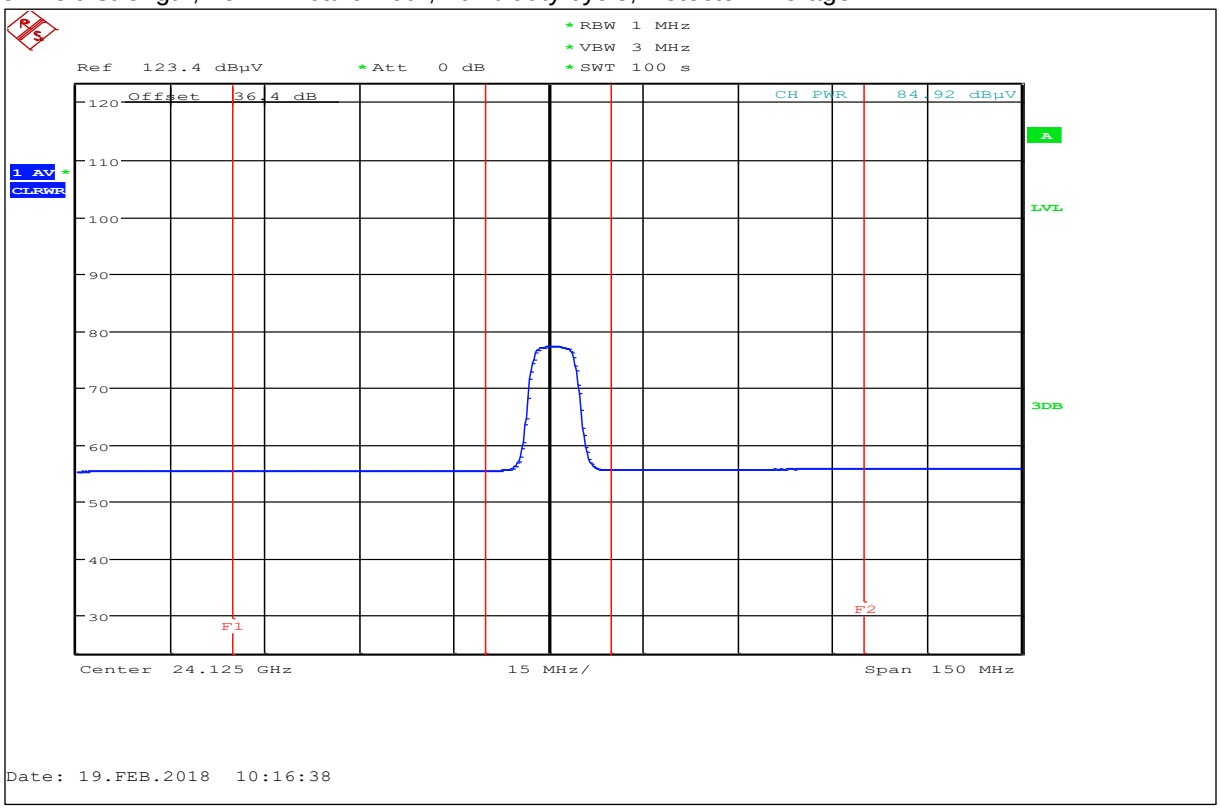
Plot 3: Field strength, CW, 100 % duty cycle, Detector Average



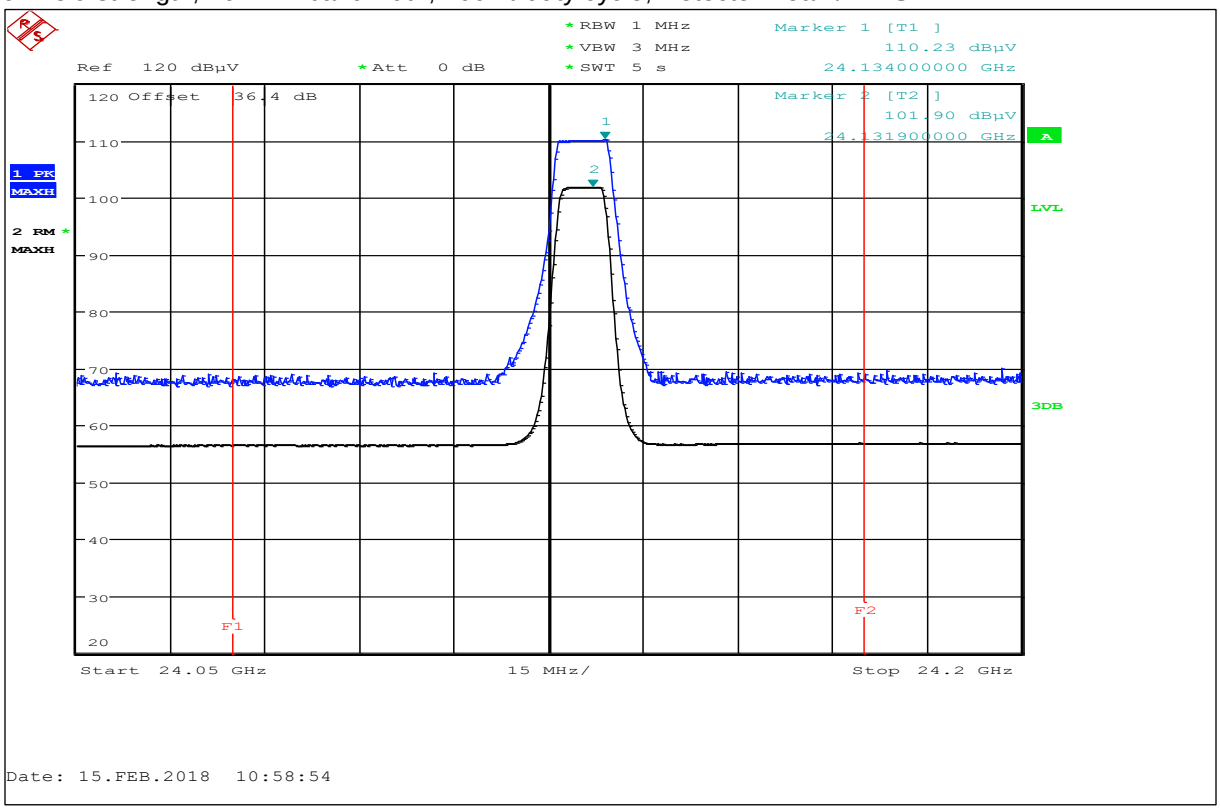
Plot 4: Field strength, 10 MHz bandwidth, 10 % duty cycle, Detector Peak / RMS



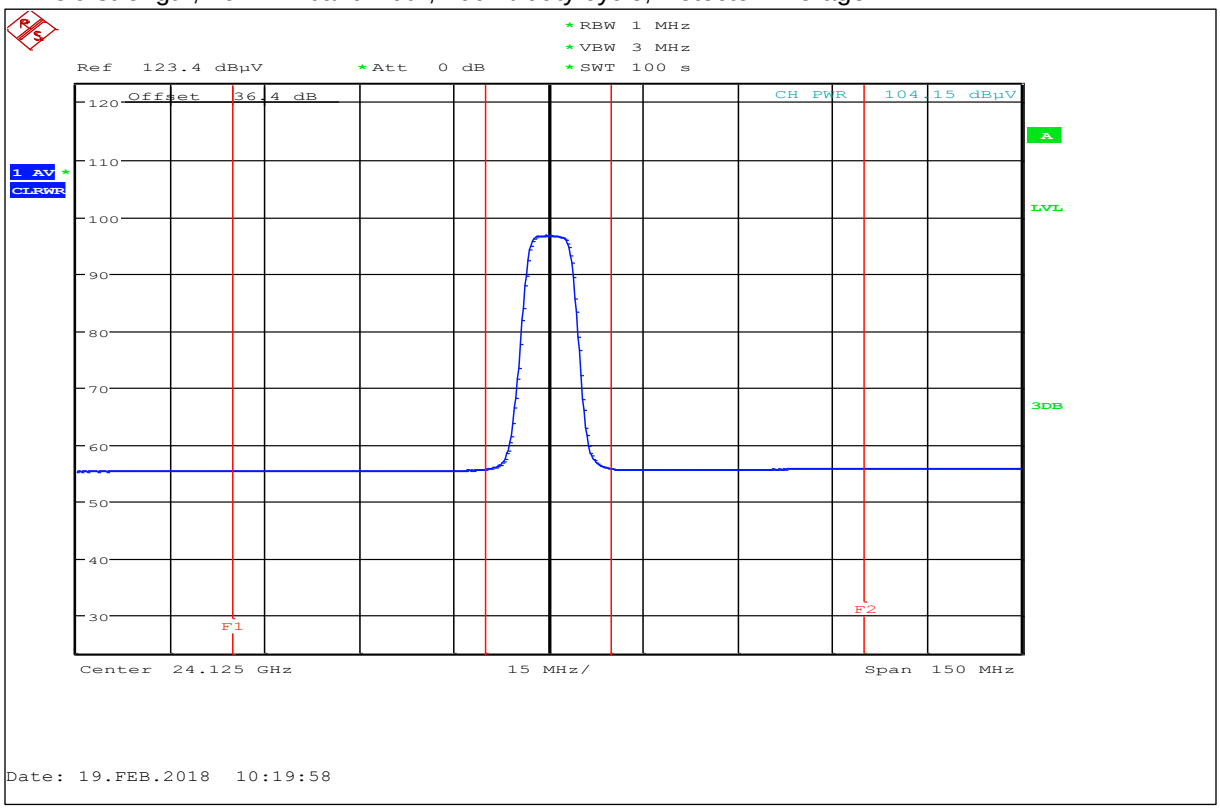
Plot 5: Field strength, 10 MHz bandwidth, 10 % duty cycle, Detector Average



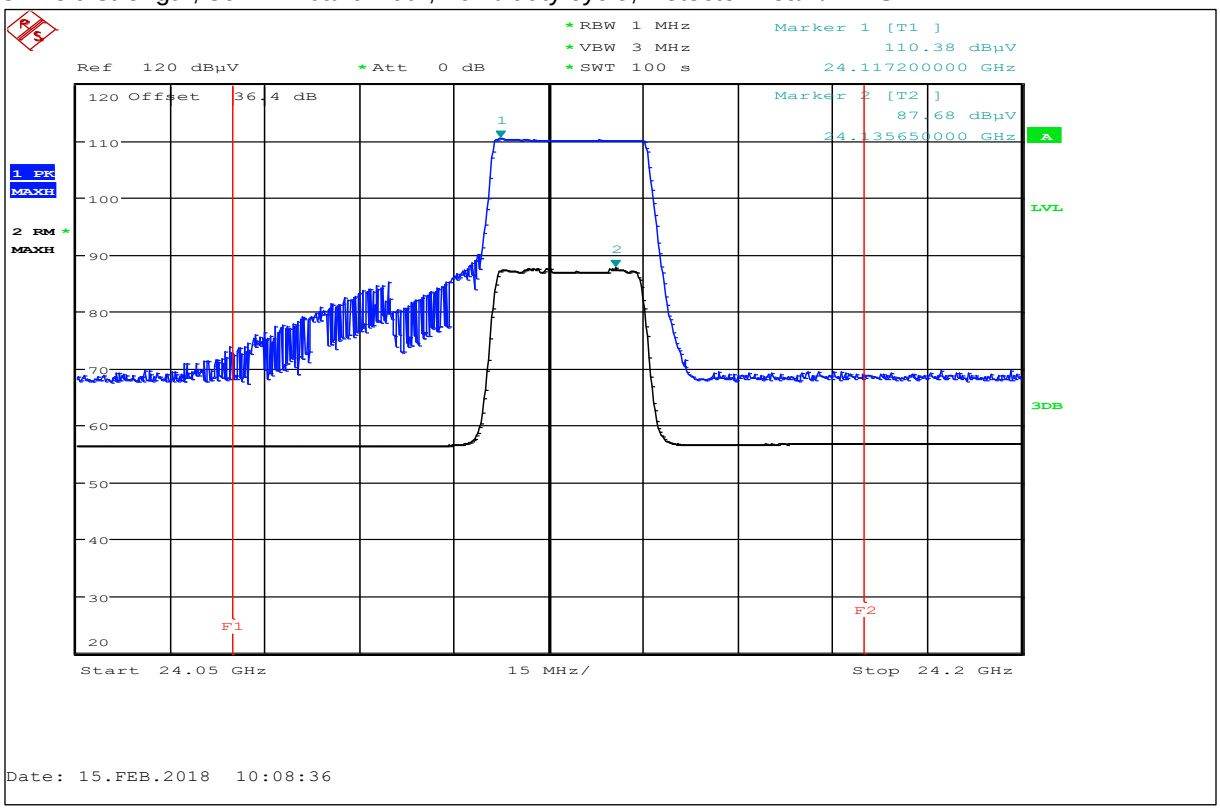
Plot 6: Field strength, 10 MHz bandwidth, 100 % duty cycle, Detector Peak / RMS



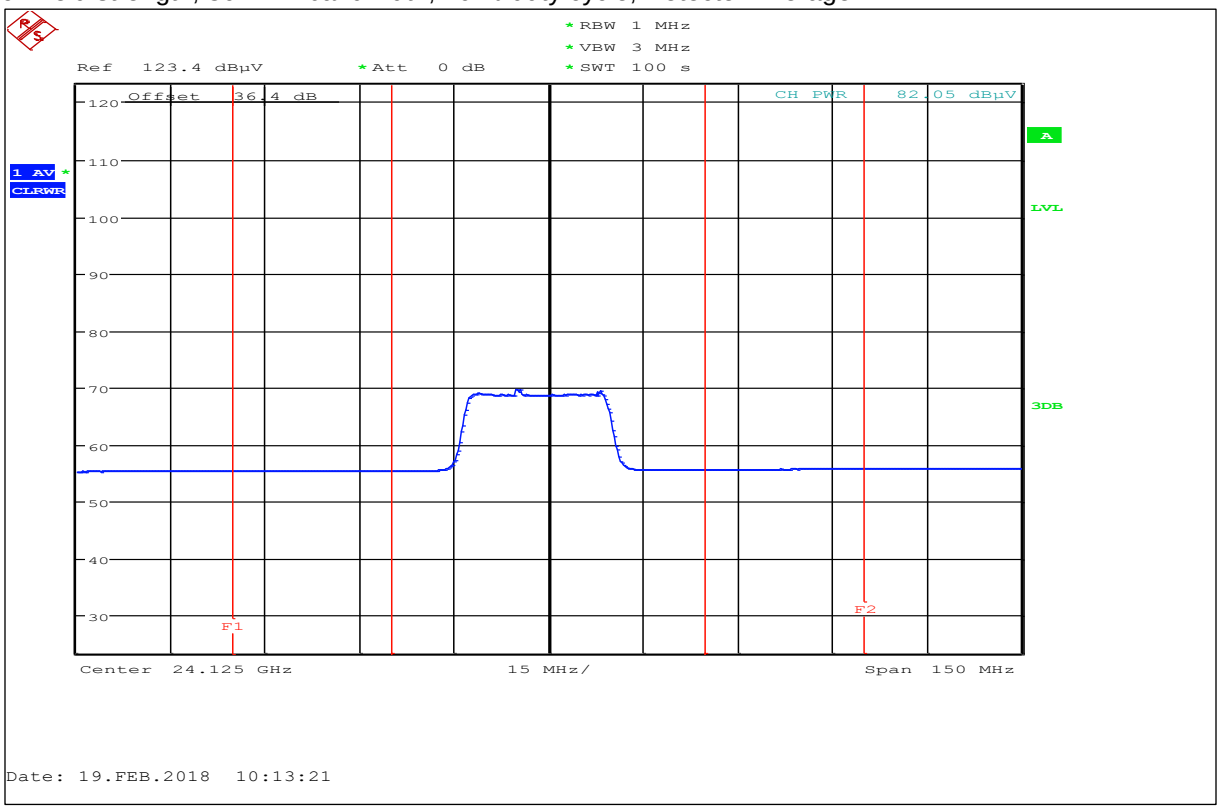
Plot 7: Field strength, 10 MHz bandwidth, 100 % duty cycle, Detector Average



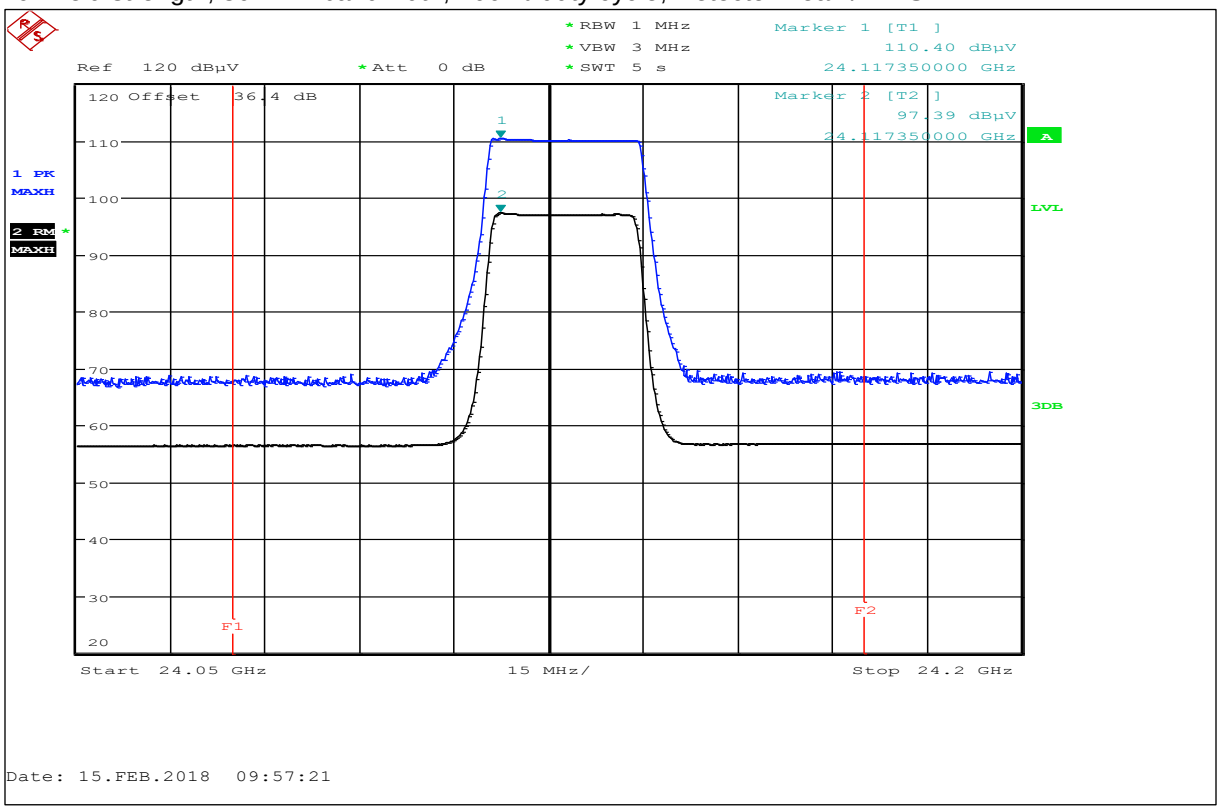
Plot 8: Field strength, 30 MHz bandwidth, 10 % duty cycle, Detector Peak / RMS



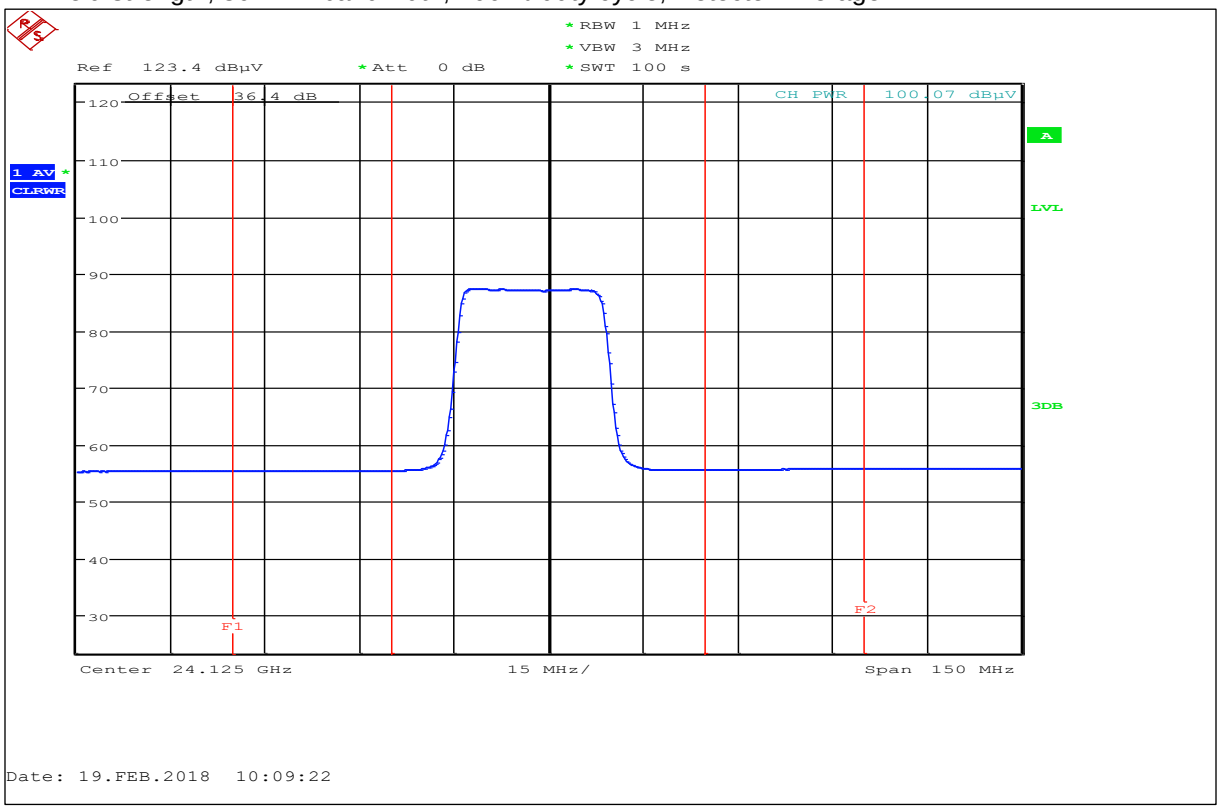
Plot 9: Field strength, 30 MHz bandwidth, 10 % duty cycle, Detector Average



Plot 10: Field strength, 30 MHz bandwidth, 100 % duty cycle, Detector Peak / RMS



Plot 11: Field strength, 30 MHz bandwidth, 100 % duty cycle, Detector Average



9.2 Occupied bandwidth (99% bandwidth)

Description:

§2.1049 The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission.

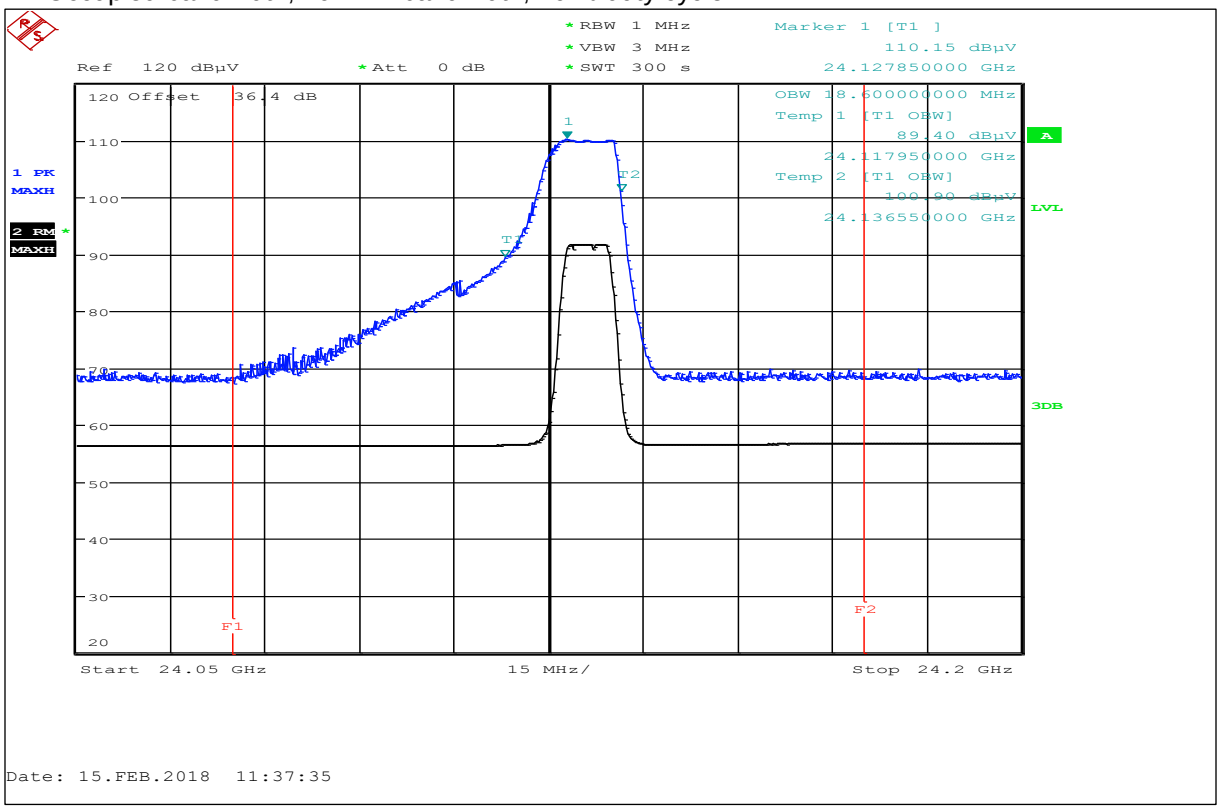
Limit:

CFR Part 15.245(b) / RSS-210 Annex F		
Frequency range	f(lowest) > 24.075 GHz	f(highest) < 24.175 GHz
100 MHz		

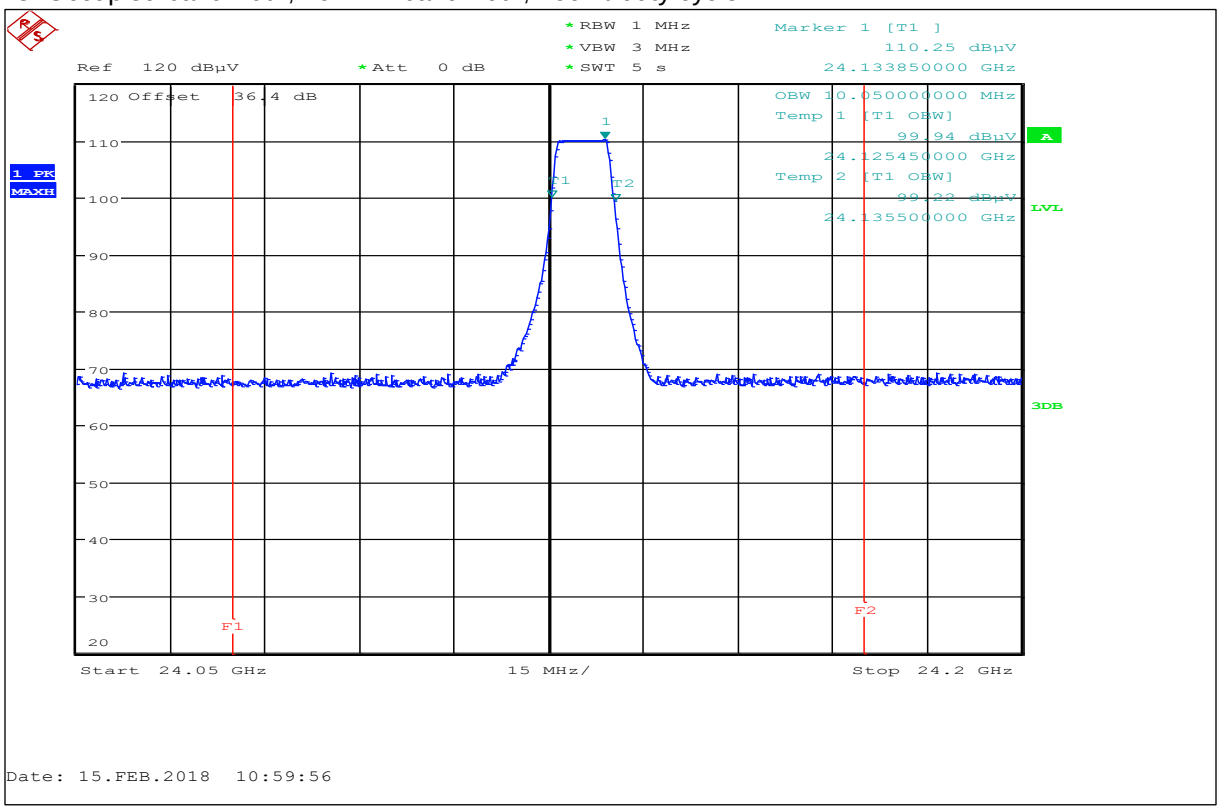
Measurement result:

TEST CONDITIONS T_{nom} / V_{nom}	Occupied Bandwidth [MHz]
10 MHz Bandwidth, 10% duty cycle	18.6
10 MHz Bandwidth, 100% duty cycle	10.0
30 MHz Bandwidth, 10% duty cycle	26.1
30 MHz Bandwidth, 100% duty cycle	25.1

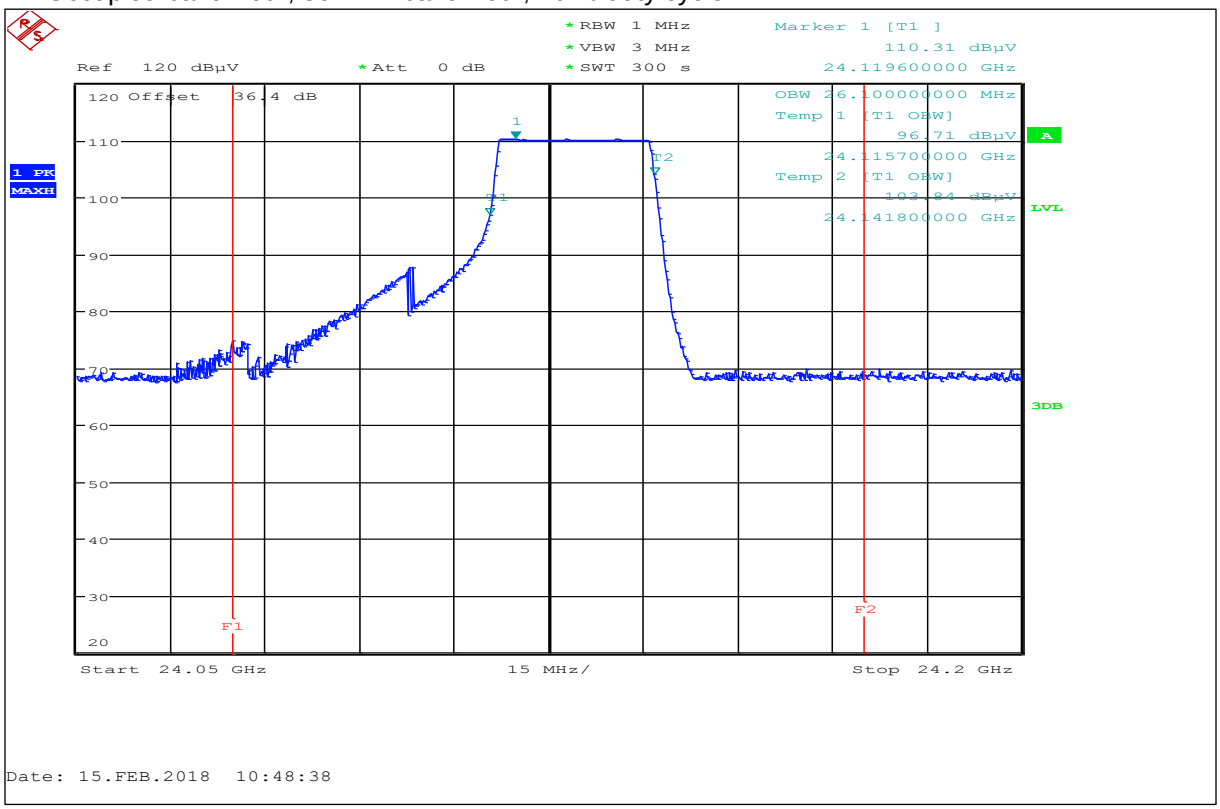
Plot 12: Occupied bandwidth, 10 MHz bandwidth, 10 % duty cycle



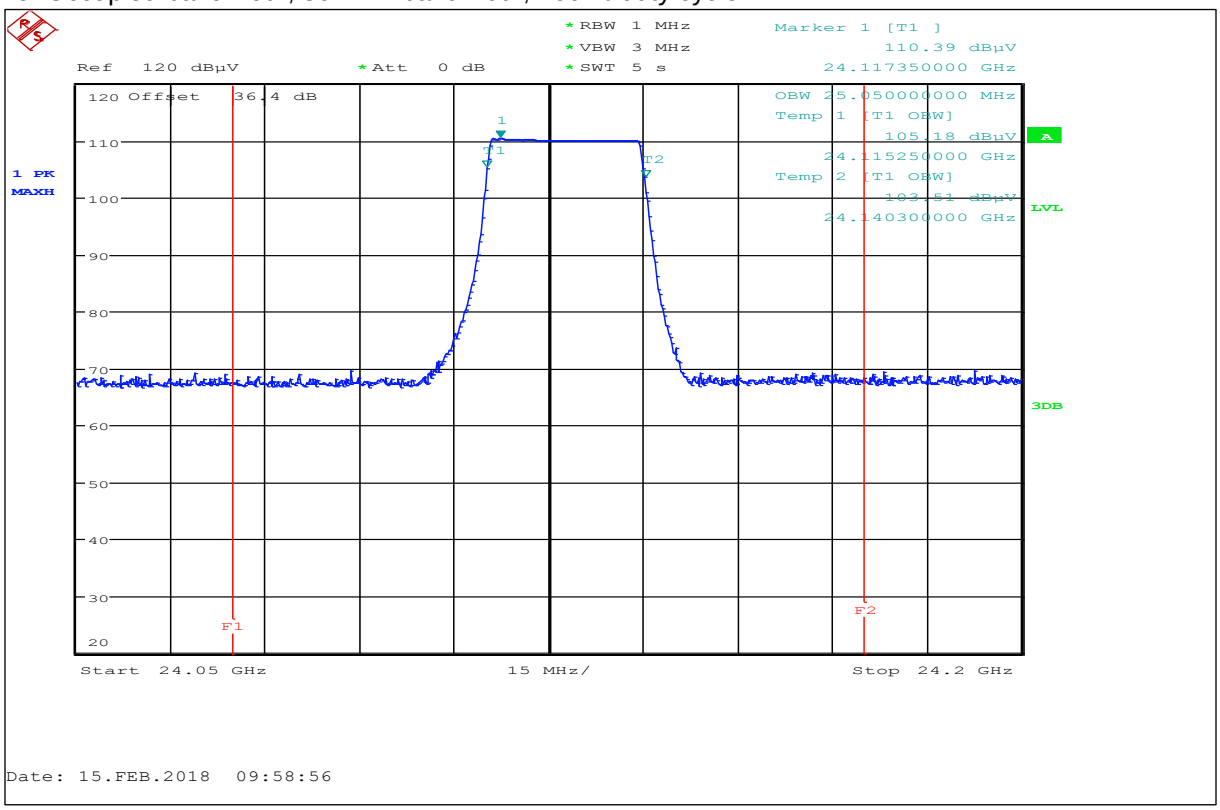
Plot 13: Occupied bandwidth, 10 MHz bandwidth, 100 % duty cycle



Plot 14: Occupied bandwidth, 30 MHz bandwidth, 10 % duty cycle



Plot 15: Occupied bandwidth, 30 MHz bandwidth, 100 % duty cycle



9.3 Field strength of emissions (radiated spurious)

Description:

Measurement of the radiated spurious emissions.

Measurement:

Measurement parameter	
Detector:	Peak / Quasi Peak / RMS (Average)
Sweep time:	Auto
Video bandwidth:	Auto
Resolution bandwidth:	F < 1 GHz: 100 kHz F > 1 GHz: 1 MHz
Trace-Mode:	Max Hold
Measurement uncertainly	± 5 dB

Limits:

FCC	IC	
CFR Part 15.209(a) / 15.245(b)	RSS-210 Annex F / RSS-Gen	
Radiated Spurious Emissions		
Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in § 15.209, whichever is the lesser attenuation.		
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
30 88	30.0	10
88 – 216	33.5	10
216 – 960	36.0	10
Above 960	54.0	3
Harmonics	108 (PEAK) 88 (AVG)	3

Measurement results (Harmonic):

CW 10% duty cycle

TX Spurious Emissions Radiated		
F [GHz]	Detector	Level [dBµV/m]
48.258	RMS	55.38

CW 100% duty cycle

TX Spurious Emissions Radiated		
F [GHz]	Detector	Level [dBµV/m]
48.258	RMS	75.82

10 MHz bandwidth, 10% duty cycle

TX Spurious Emissions Radiated		
F [GHz]	Detector	Level [dBµV/m]
48.260	RMS	55.64

10 MHz bandwidth, 100% duty cycle

TX Spurious Emissions Radiated		
F [GHz]	Detector	Level [dBµV/m]
48.260	RMS	63.55

30 MHz bandwidth, 10% duty cycle

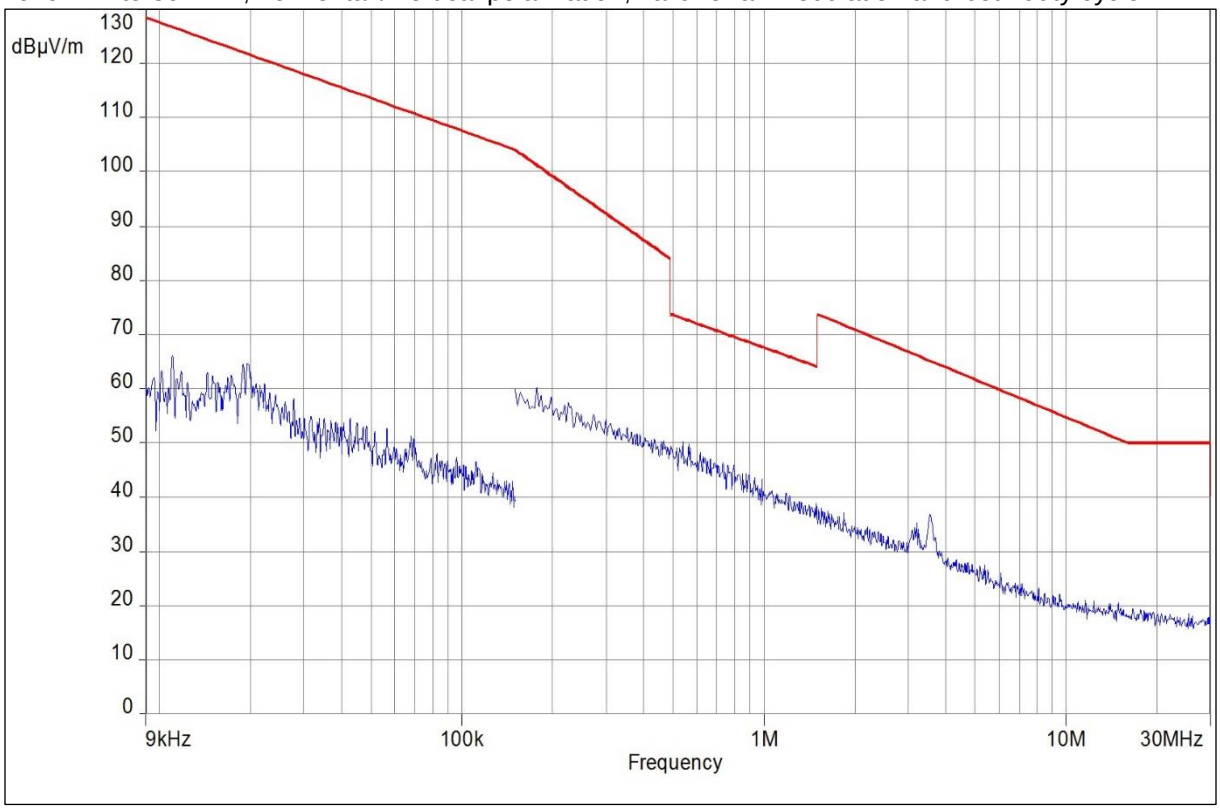
TX Spurious Emissions Radiated		
F [GHz]	Detector	Level [dBµV/m]
48.235	RMS	50.59

30 MHz bandwidth, 100% duty cycle

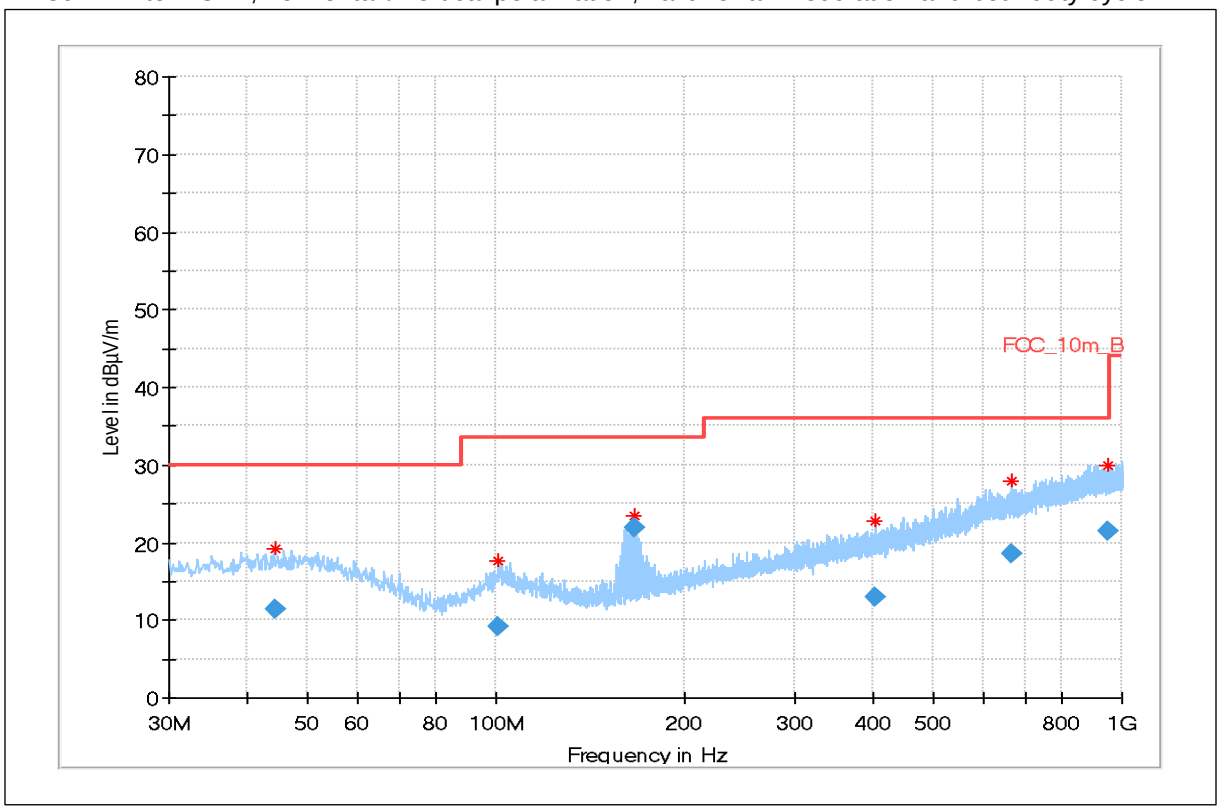
TX Spurious Emissions Radiated		
F [GHz]	Detector	Level [dBµV/m]
48.235	RMS	58.48

Note: RMS = Root Mean Square

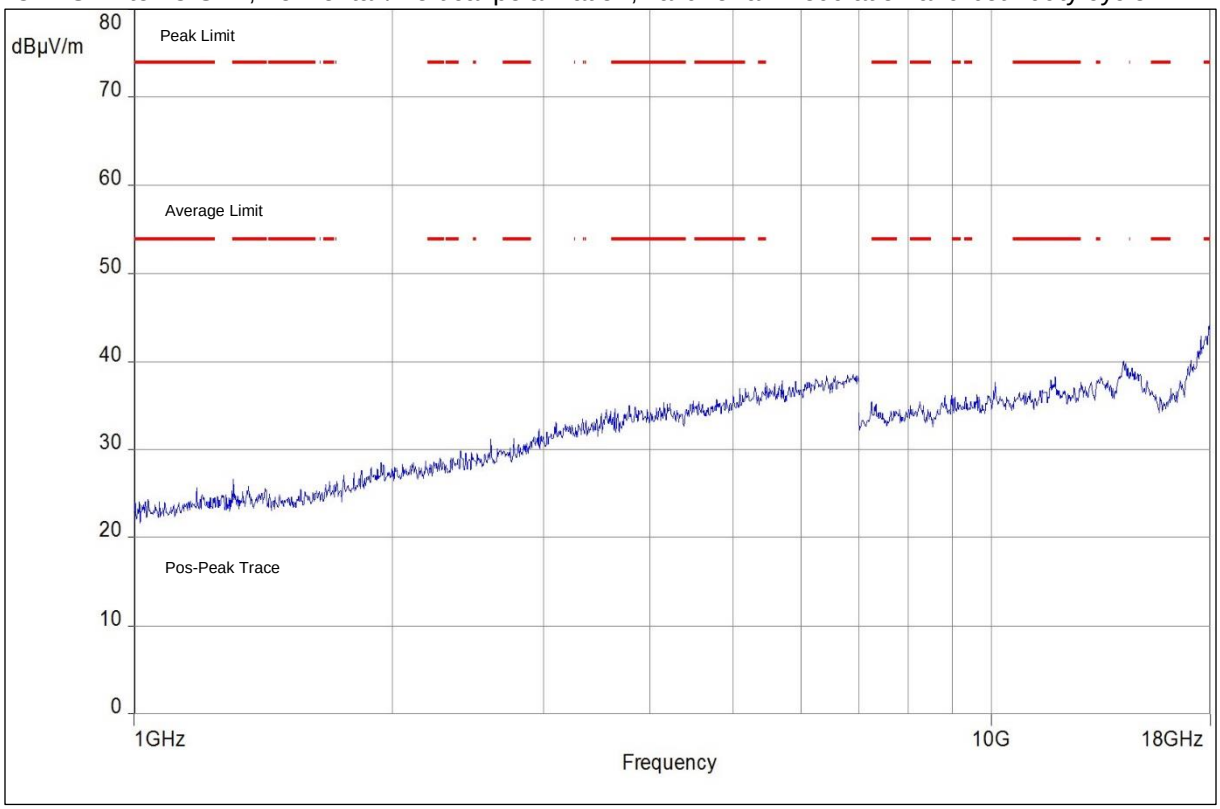
Plot 16: 9 kHz to 30 MHz, horizontal / vertical polarization, valid for all modulation and both duty cycle



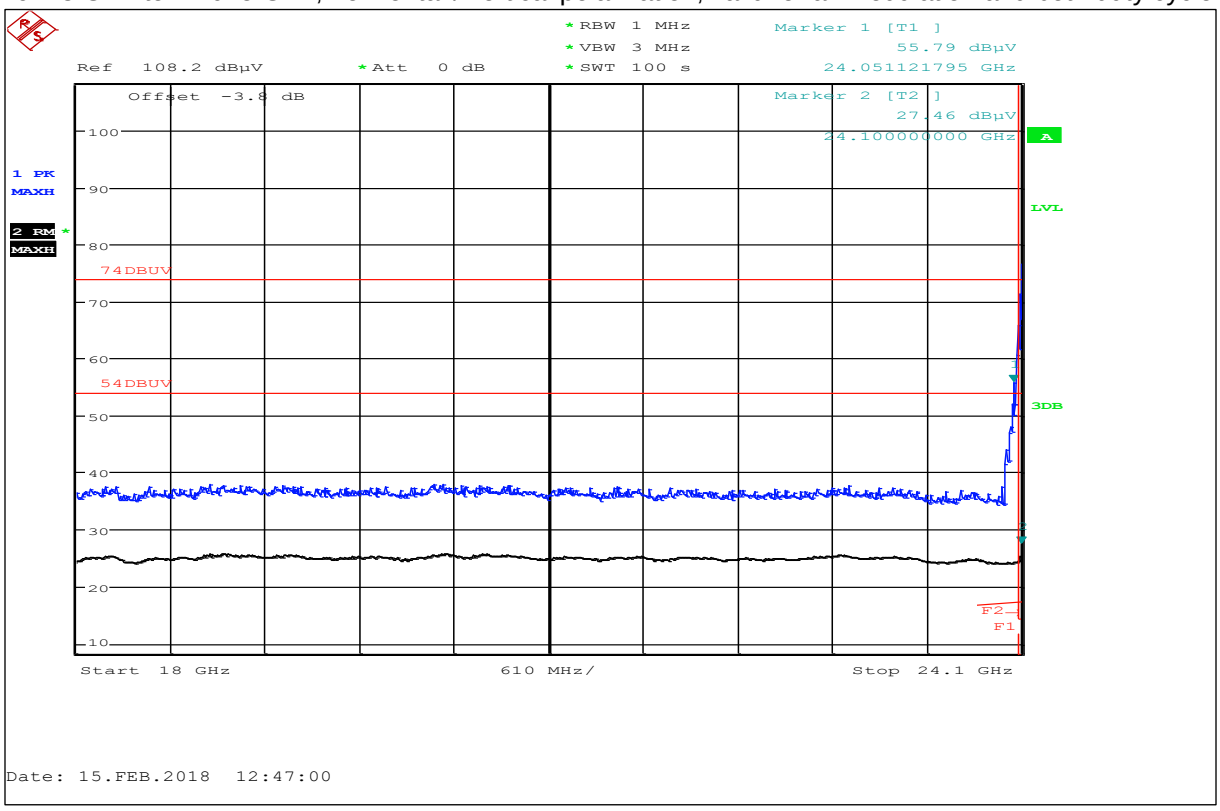
Plot 17: 30 MHz to 1 GHz, horizontal / vertical polarization, valid for all modulation and both duty cycle



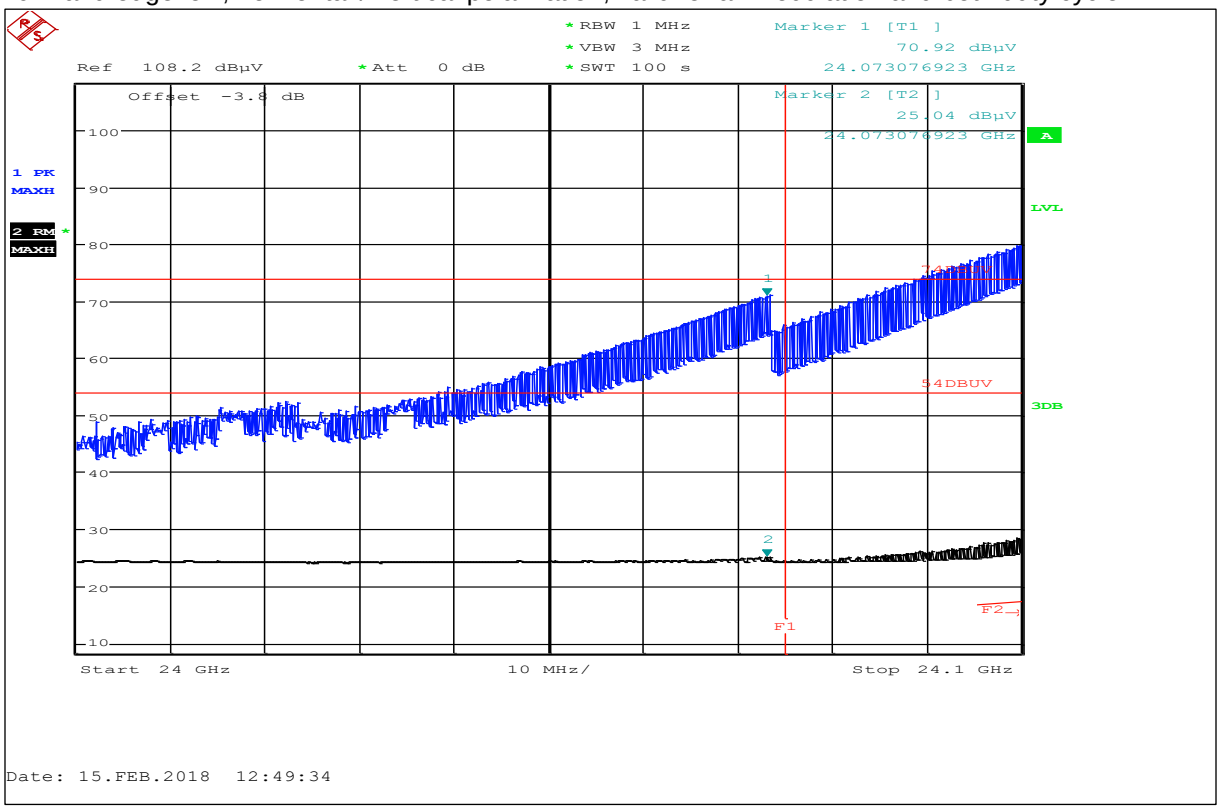
Plot 18: 1 GHz to 18 GHz, horizontal / vertical polarization, valid for all modulation and both duty cycle



Plot 19: 18 GHz to 24.075 GHz, horizontal / vertical polarization, valid for all modulation and both duty cycle

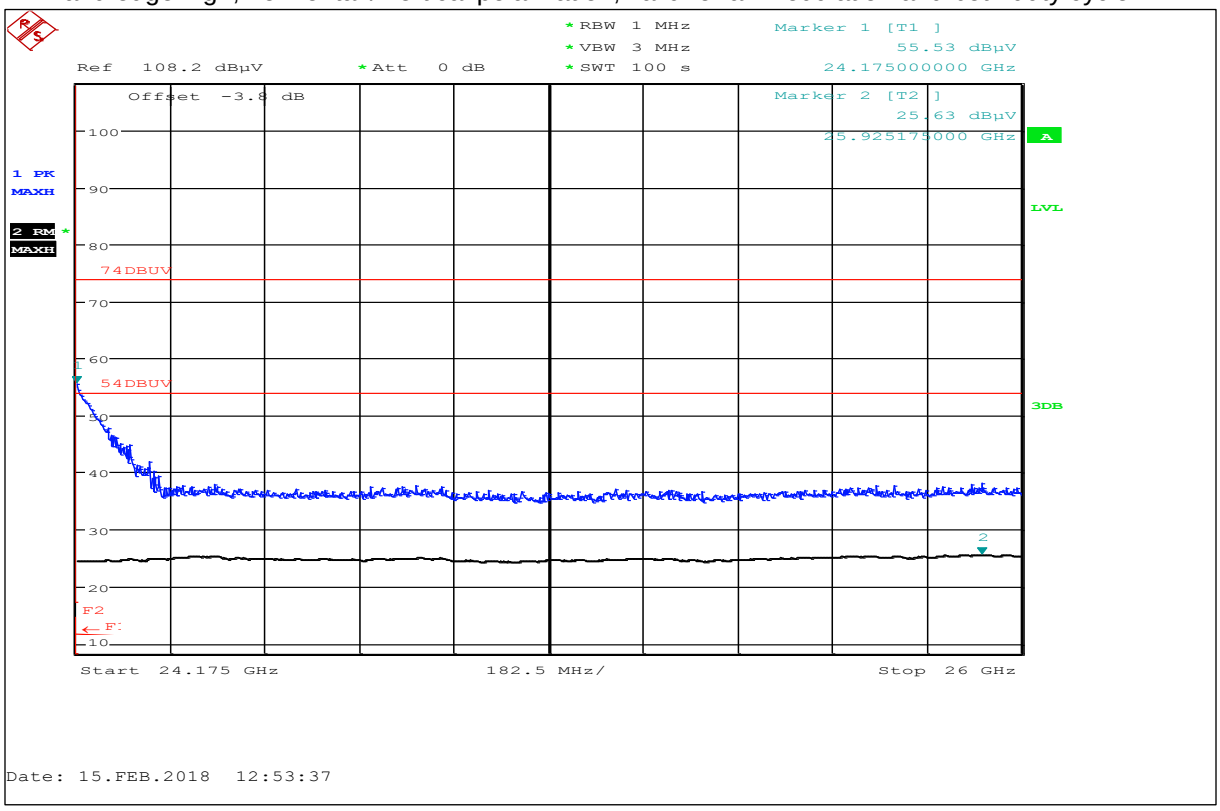


Plot 20: Band edge low, horizontal / vertical polarization, valid for all modulation and both duty cycle



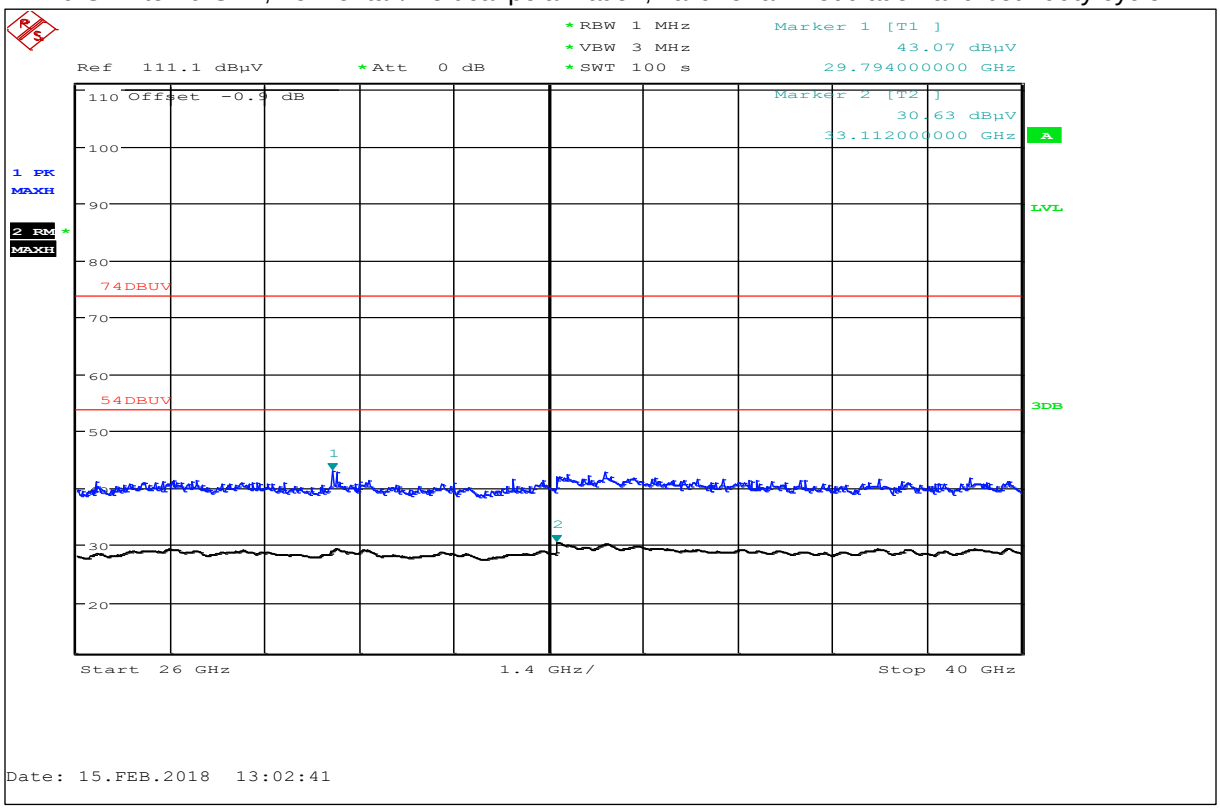
Peak @ 70.92 dBµV (Limit @ 74 dBµV) / RMS @ 25.04 dBµV (Limit @ 54 dBµV)

Plot 21: Band edge high, horizontal / vertical polarization, valid for all modulation and both duty cycle



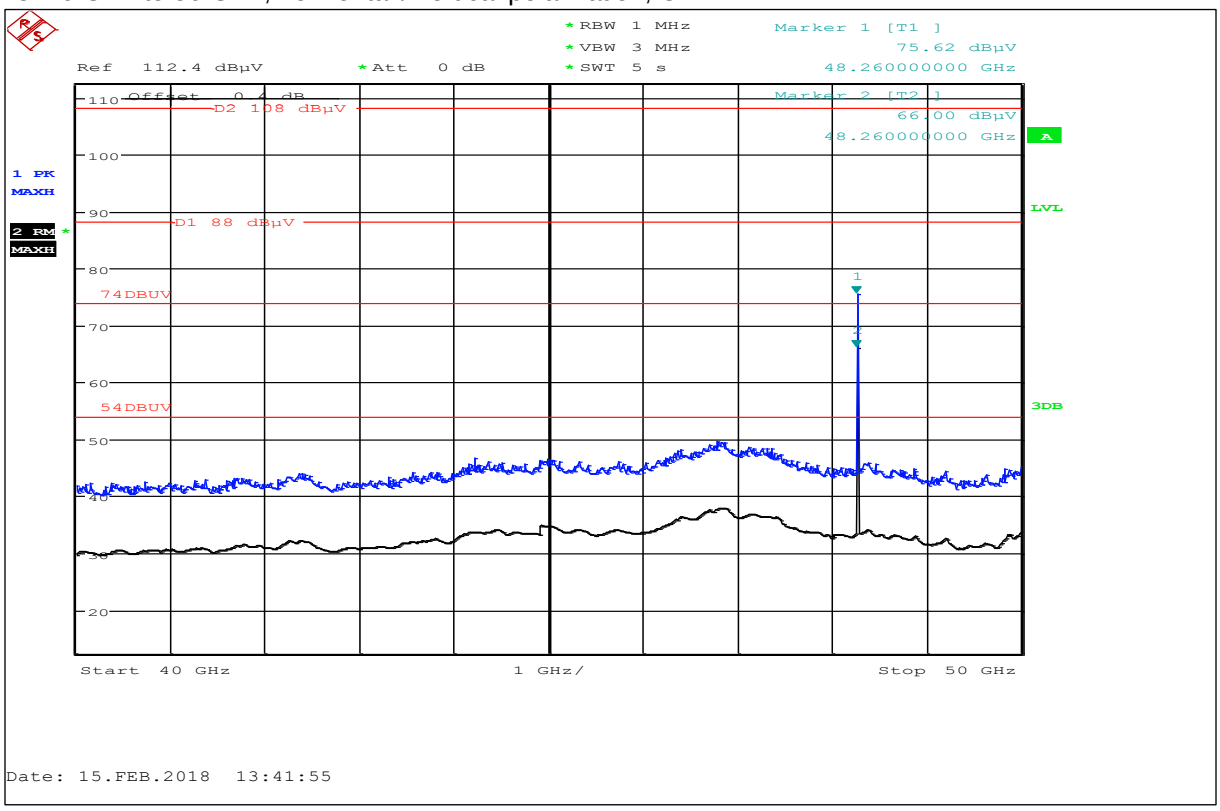
Peak @ 55.53 dBµV (Limit @ 74 dBµV) / RMS @ 25.63 dBµV (Limit @ 54 dBµV)

Plot 22: 26 GHz to 40 GHz, horizontal / vertical polarization, valid for all modulation and both duty cycle



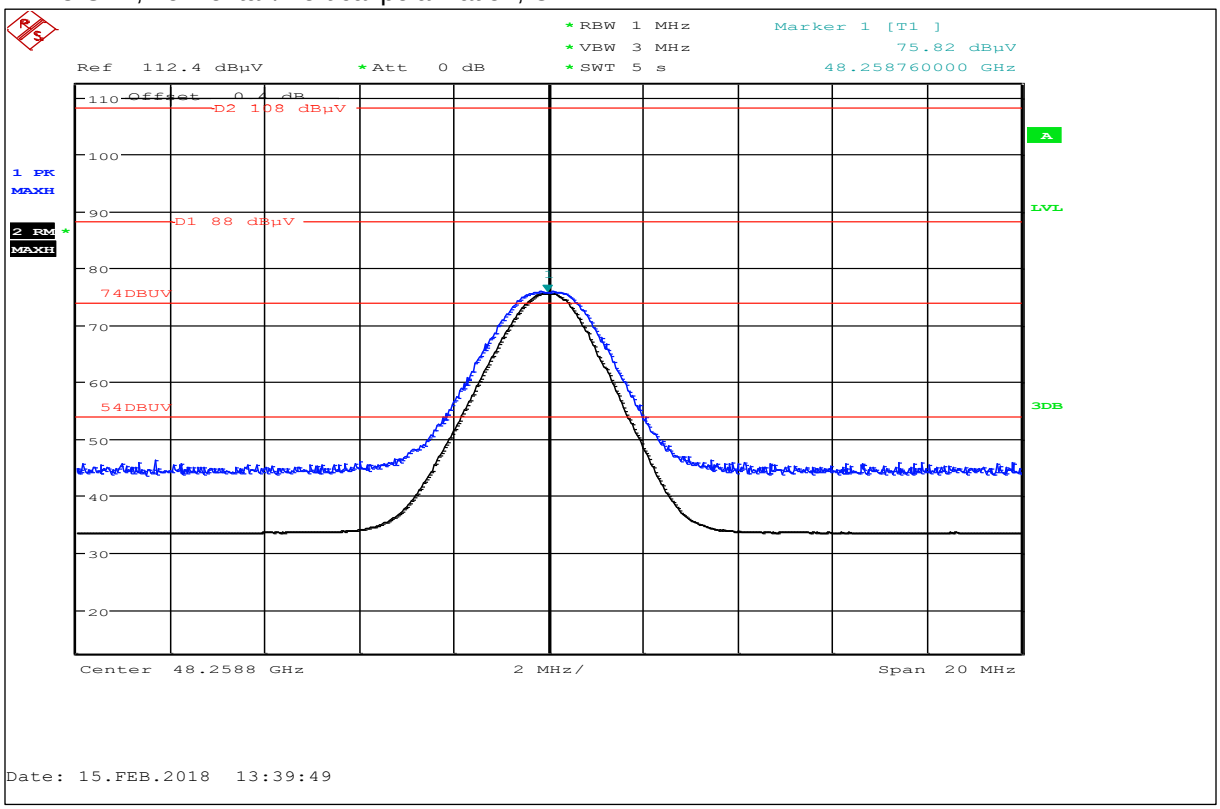
Peak @ 43.07 dBµV (Limit @ 74 dBµV) / RMS @ 30.63 dBµV (Limit @ 54 dBµV)

Plot 23: 40 GHz to 50 GHz, horizontal / vertical polarization, CW



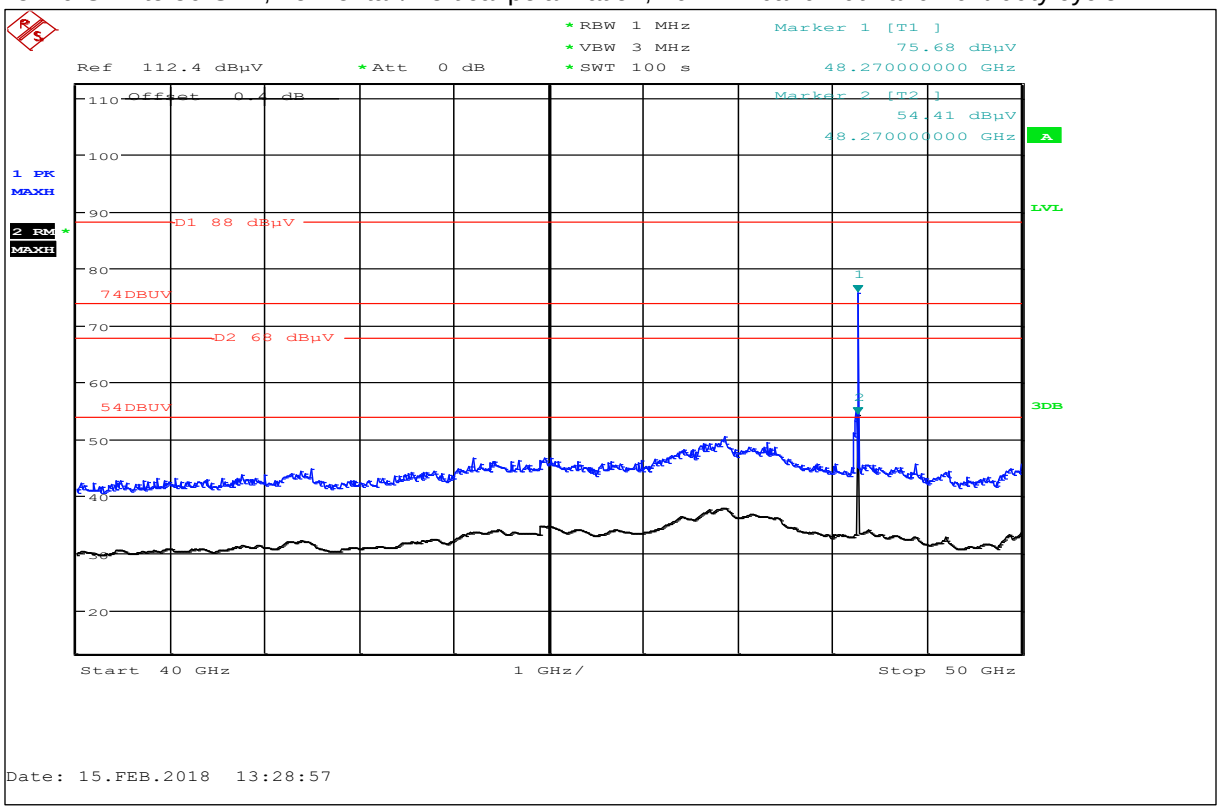
Peak @ 75.62 dBµV (Limit @ 108 dBµV) / RMS @ 66.00 dBµV (Limit @ 88 dBµV)

Plot 24: 48 GHz, horizontal / vertical polarization, CW



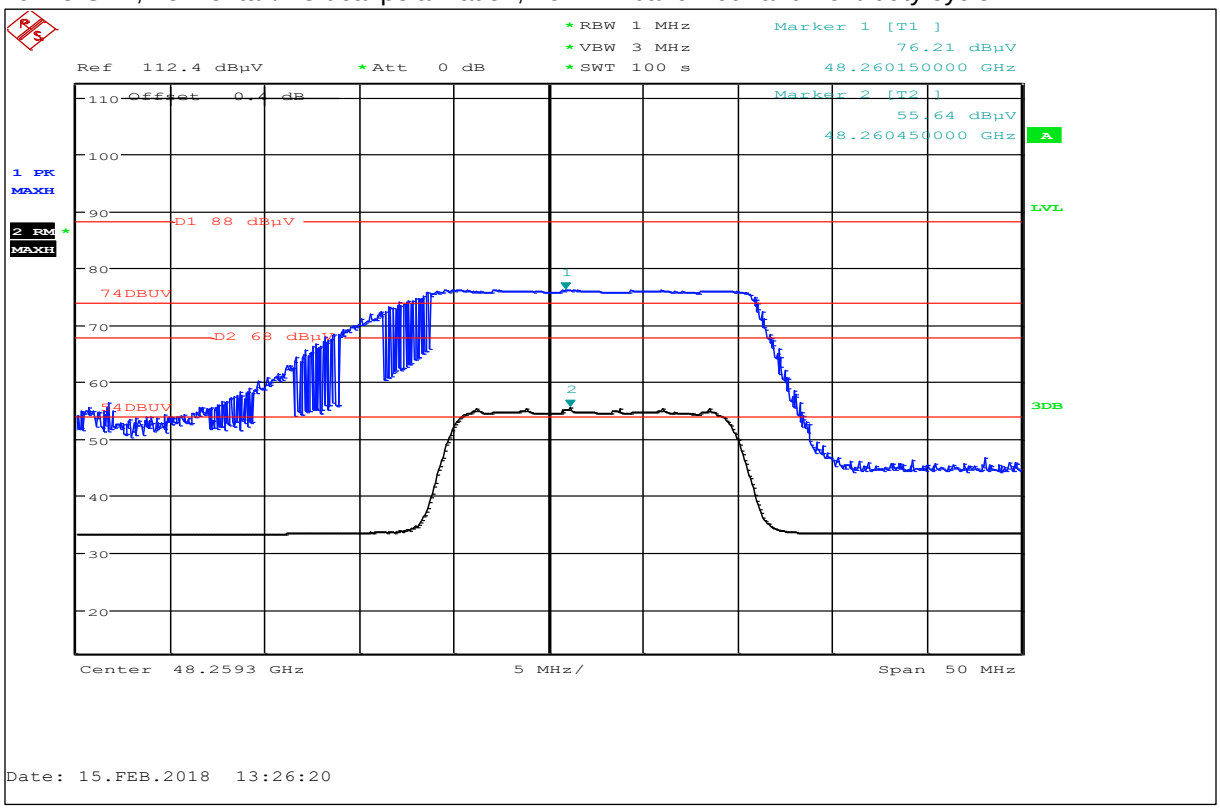
Peak @ 75.82 dBµV (Limit @ 108 dBµV) / RMS @ 75.82 dBµV (Limit @ 88 dBµV)

Plot 25: 40 GHz to 50 GHz, horizontal / vertical polarization, 10 MHz bandwidth and 10% duty cycle



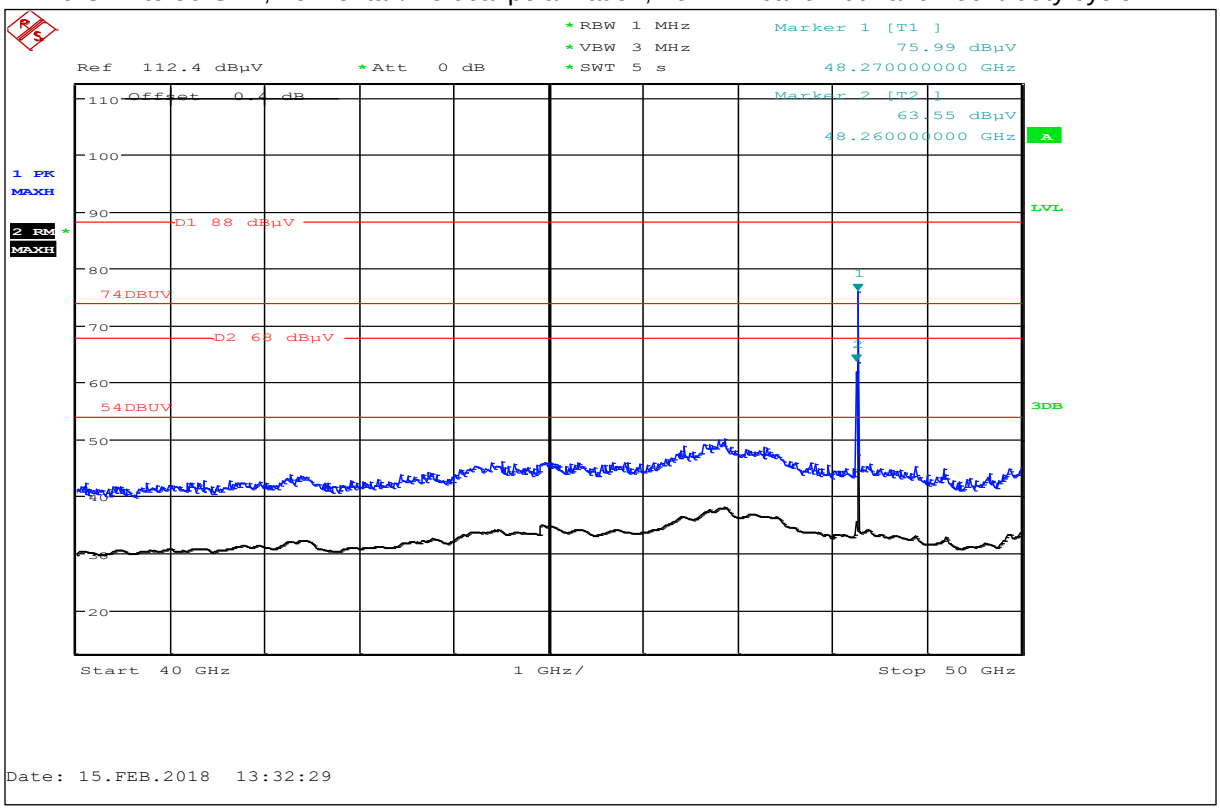
Peak @ 75.68 dBµV (Limit @ 108 dBµV) / RMS @ 54.41 dBµV (Limit @ 88 dBµV)

Plot 26: 48 GHz, horizontal / vertical polarization, 10 MHz bandwidth and 10% duty cycle



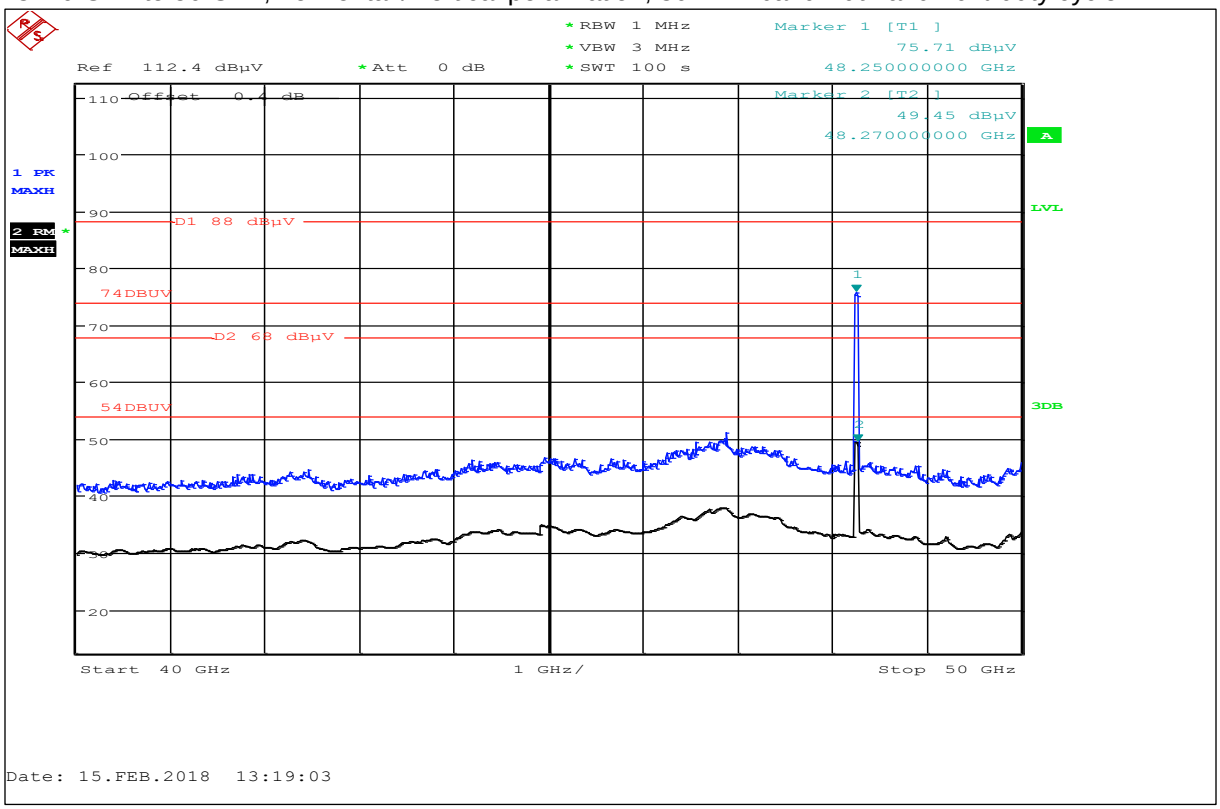
Peak @ 76.21 dBµV (Limit @ 108 dBµV) / RMS @ 55.64 dBµV (Limit @ 88 dBµV)

Plot 27: 40 GHz to 50 GHz, horizontal / vertical polarization, 10 MHz bandwidth and 100% duty cycle



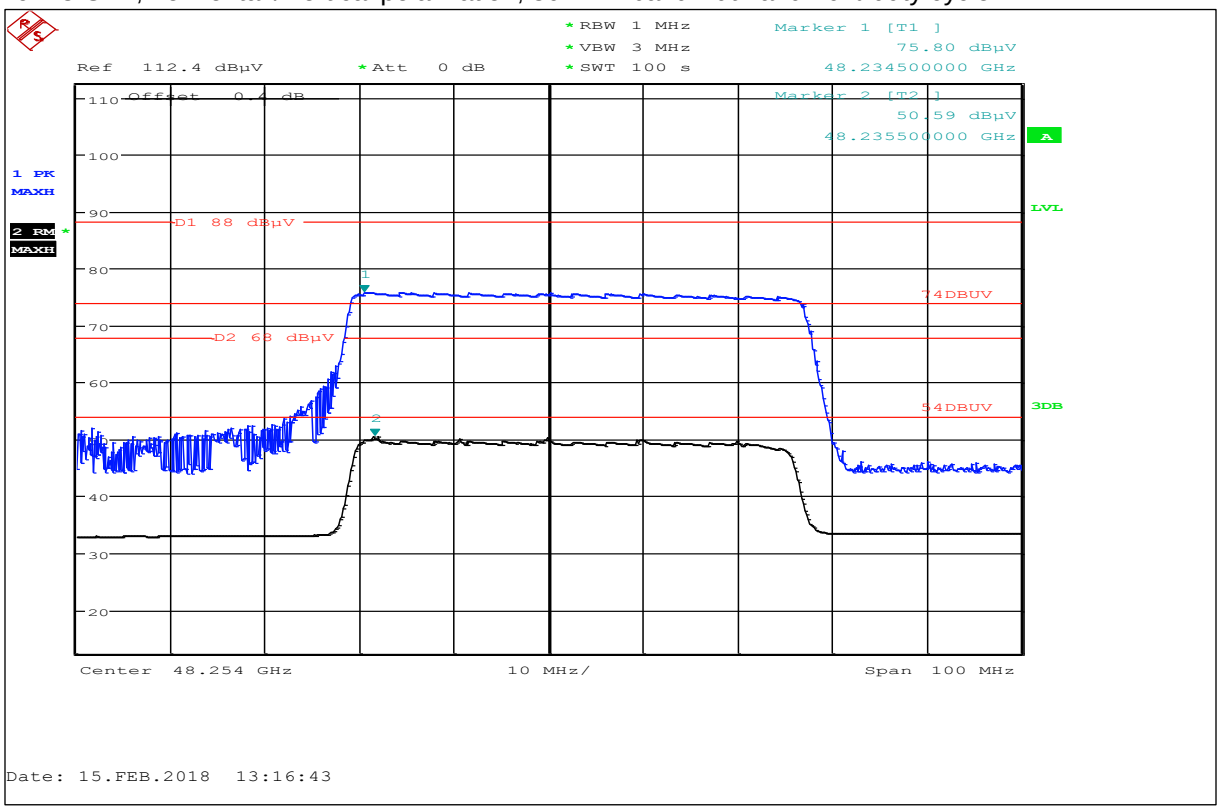
Peak @ 75.99 dBµV (Limit @ 108 dBµV) / RMS @ 63.55 dBµV (Limit @ 88 dBµV)

Plot 28: 40 GHz to 50 GHz, horizontal / vertical polarization, 30 MHz bandwidth and 10% duty cycle



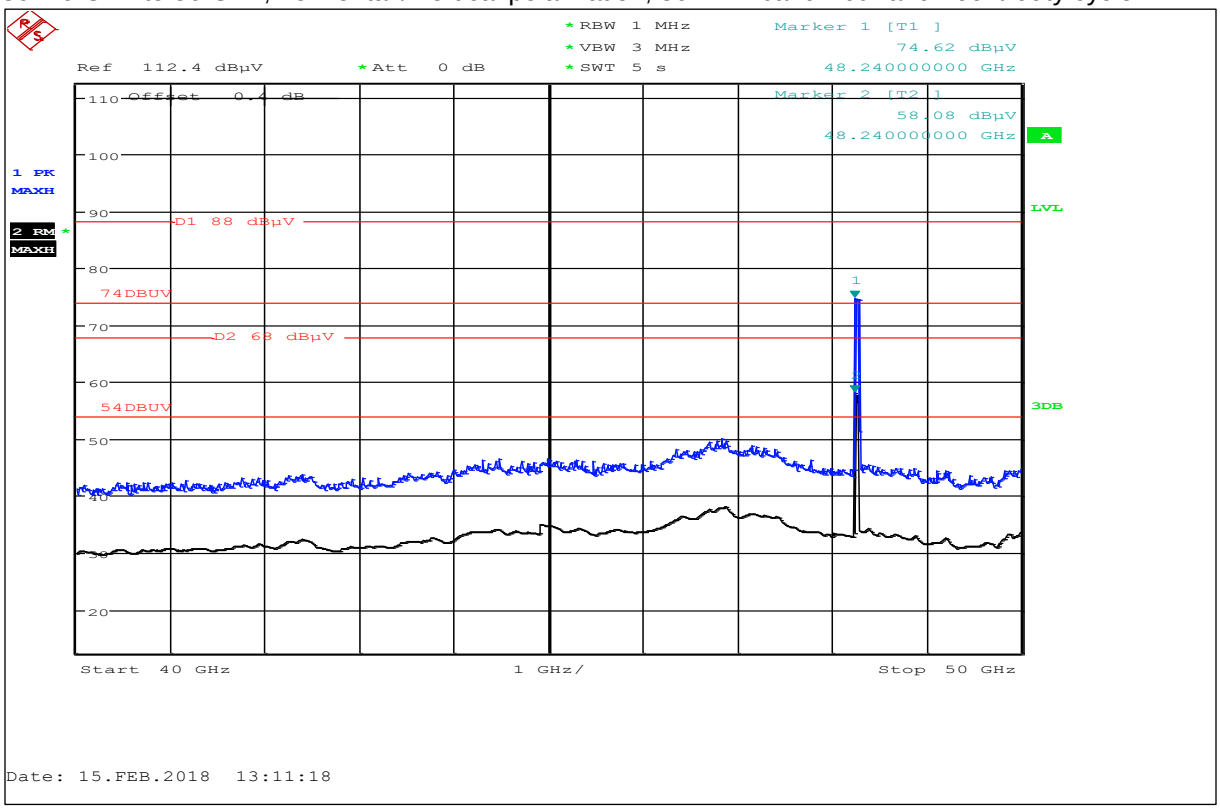
Peak @ 75.71 dBµV (Limit @ 108 dBµV) / RMS @ 49.45 dBµV (Limit @ 88 dBµV)

Plot 29: 48 GHz, horizontal / vertical polarization, 30 MHz bandwidth and 10% duty cycle



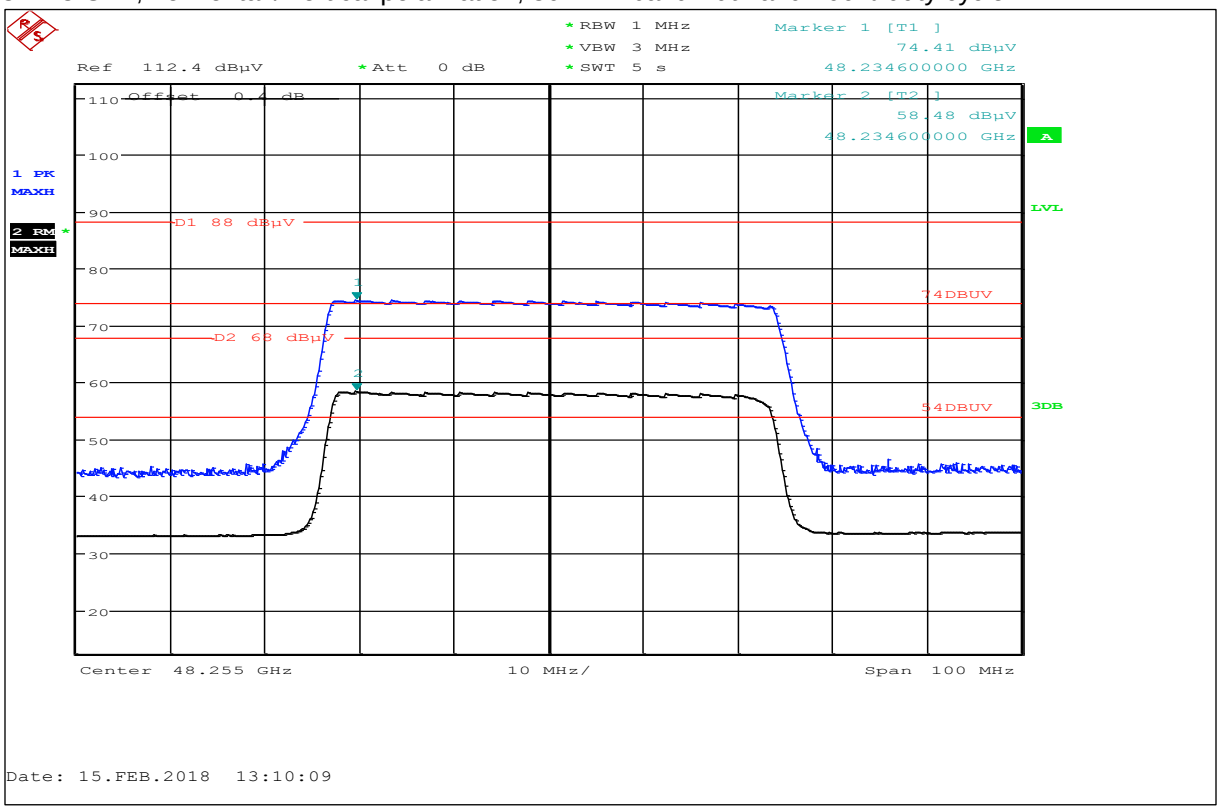
Peak @ 75.80 dBµV (Limit @ 108 dBµV) / RMS @ 50.59 dBµV (Limit @ 88 dBµV)

Plot 30: 40 GHz to 50 GHz, horizontal / vertical polarization, 30 MHz bandwidth and 100% duty cycle



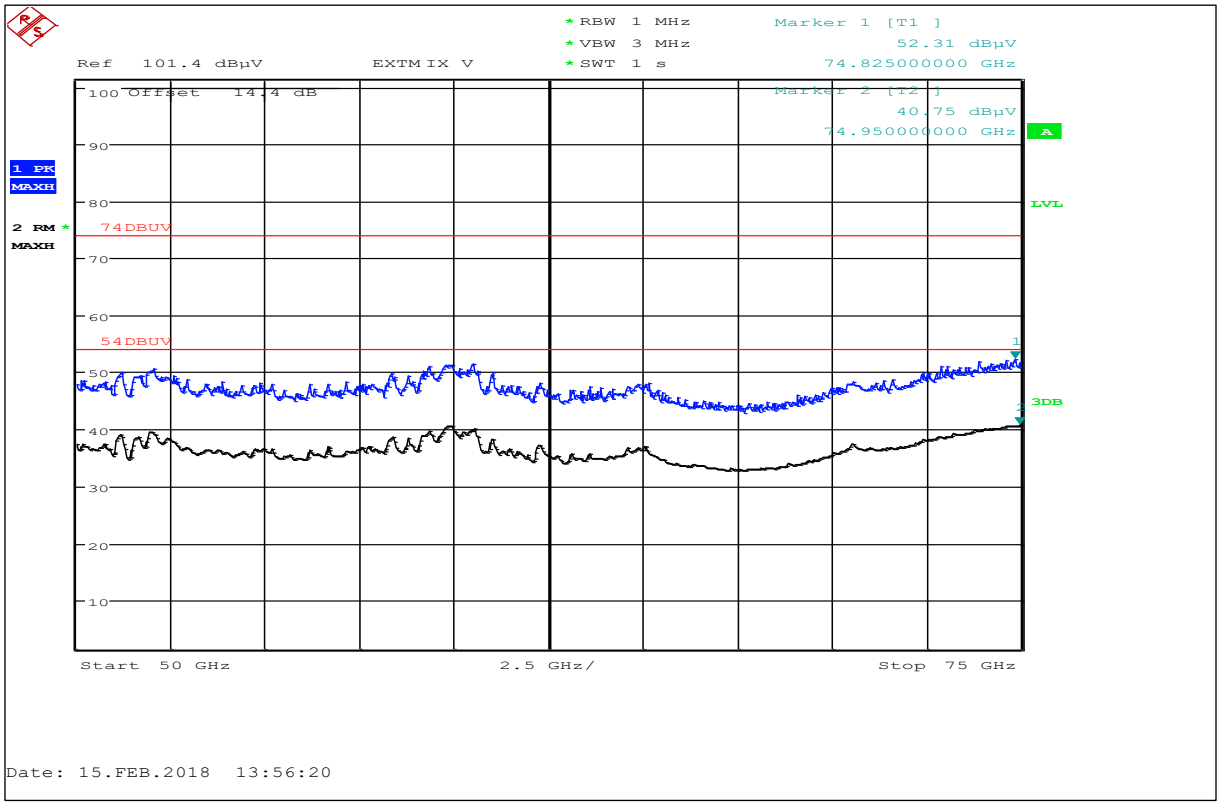
Peak @ 74.62 dBµV (Limit @ 108 dBµV) / RMS @ 58.08 dBµV (Limit @ 88 dBµV)

Plot 31: 48 GHz, horizontal / vertical polarization, 30 MHz bandwidth and 100% duty cycle



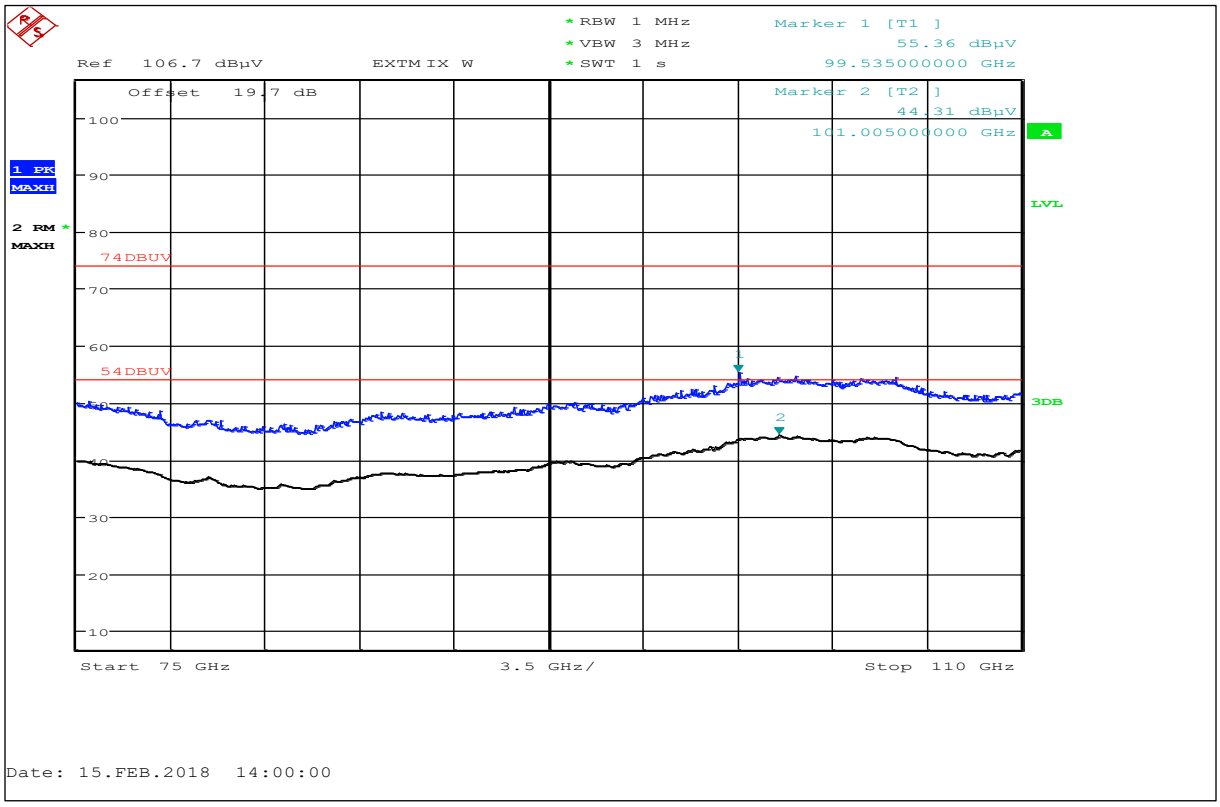
Peak @ 74.41 dBµV (Limit @ 108 dBµV) / RMS @ 58.48 dBµV (Limit @ 88 dBµV)

Plot 32: 50 GHz to 75 GHz



Peak @ 52.31 dBµV (Limit @ 74 dBµV) / RMS @ 40.75 dBµV (Limit @ 54 dBµV)

Plot 33: 75 GHz to 110 GHz



Peak @ 55.36 dBµV (Limit @ 74 dBµV) / RMS @ 44.31 dBµV (Limit @ 54 dBµV)

9.4 Conducted spurious emissions < 30 MHz

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
Video bandwidth:	F < 150 kHz: 200 Hz F > 150 kHz: 9 kHz
Resolution bandwidth:	F < 150 kHz: 1 kHz F > 150 kHz: 100 kHz
Span:	9 kHz to 30 MHz
Trace-Mode:	Max Hold

Limits:

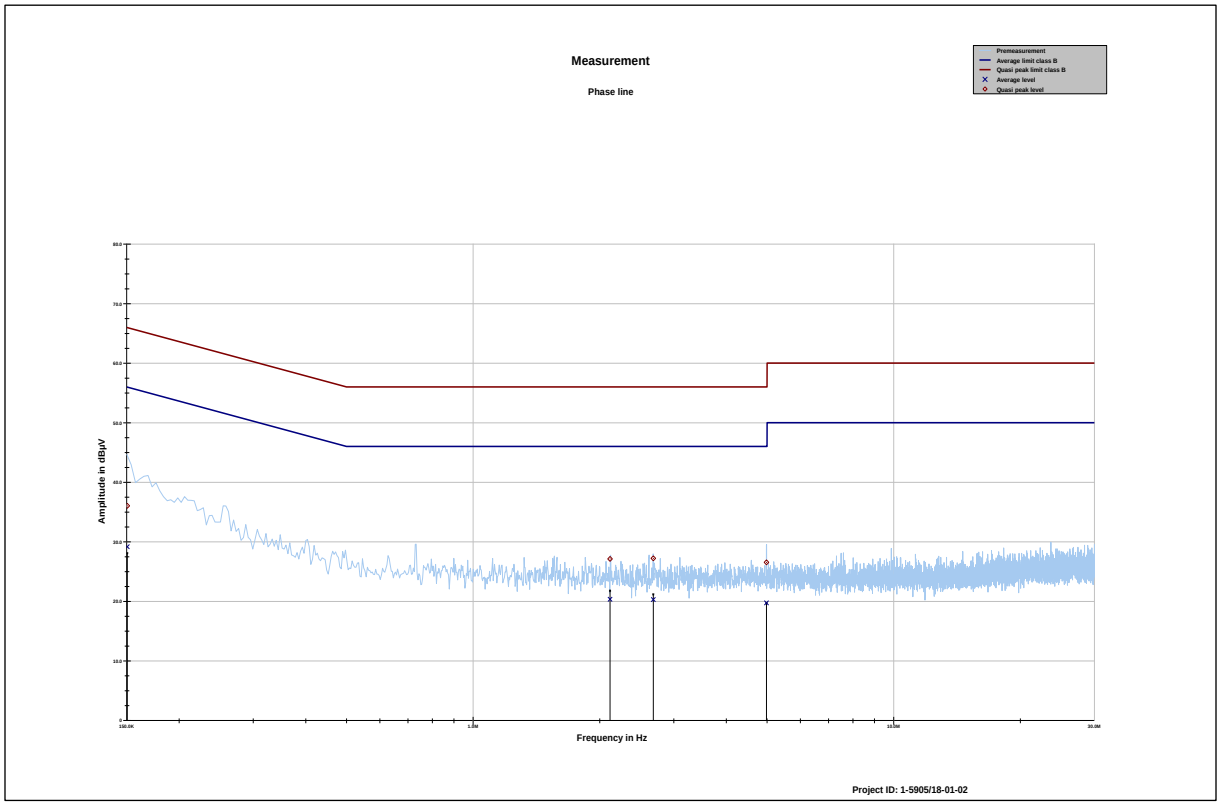
FCC		IC
CFR Part 15.207(a)		RSS-Gen 8.8
Conducted Spurious Emissions < 30 MHz		
Frequency (MHz)	Quasi-Peak (dBµV/m)	Average (dBµV/m)
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30.0	60	50

*Decreases with the logarithm of the frequency

Measurement results:

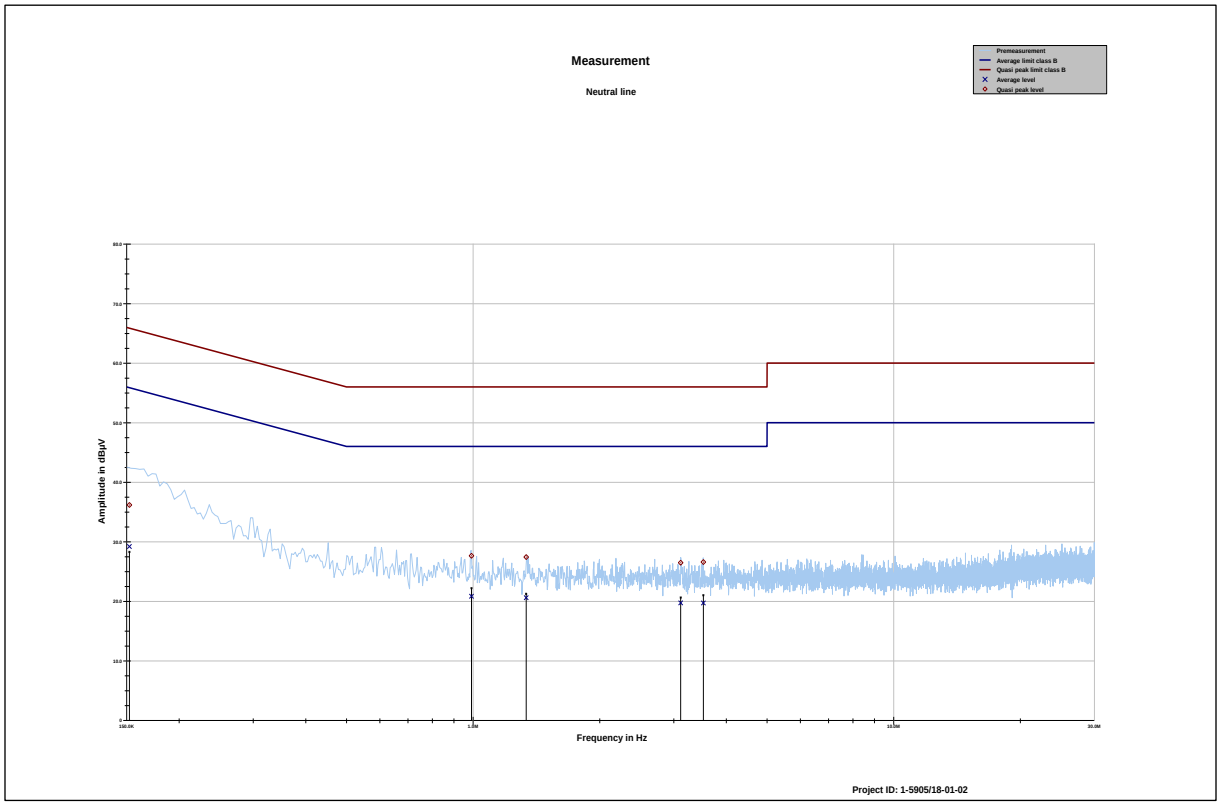
See plots below.

Plot 34: Phase line



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.150605	36.02	29.94	65.967	29.17	26.81	55.983
2.116252	27.12	28.88	56.000	20.35	25.65	46.000
2.682895	27.21	28.79	56.000	20.29	25.71	46.000
4.982775	26.55	29.45	56.000	19.74	26.26	46.000

Plot 35: Neutral line



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.152344	36.17	29.70	65.871	29.20	26.74	55.933
0.991403	27.64	28.36	56.000	20.85	25.15	46.000
1.337179	27.43	28.57	56.000	20.60	25.40	46.000
3.115103	26.48	29.52	56.000	19.73	26.27	46.000
3.527318	26.60	29.40	56.000	19.72	26.28	46.000

9.5 Frequency stability

Description:

§15.215(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

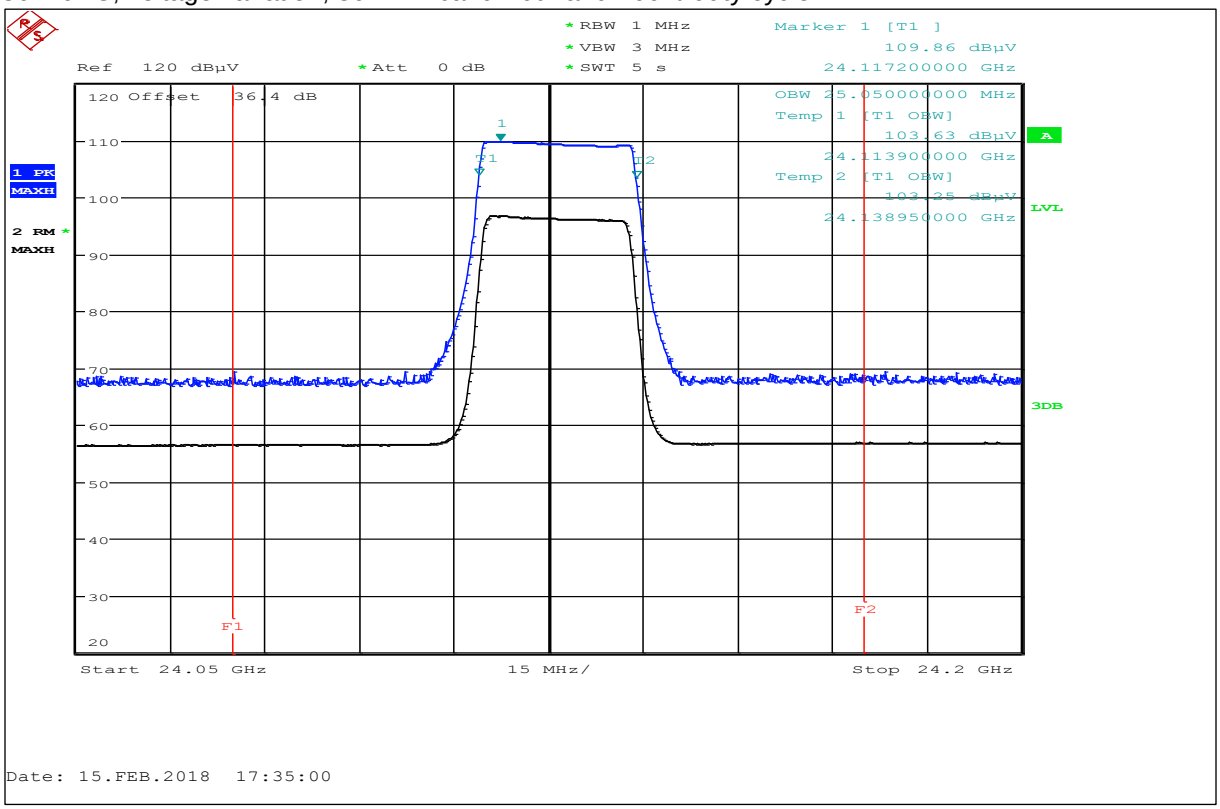
Limits:

FCC	IC
CFR Part 15.215(c)	RSS-210 Annex F / RSS-210
Frequency Stability	
As specified in Section 15.215(c), the bandwidth of the fundamental emission must be contained within the frequency band over the temperature range -20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage. Frequency stability is to be measured according to Section 2.1055 at the highest and lowest frequency of operation and with the modulation that produces the widest emission bandwidth.	
As specified in RSS-210, Section F.2.2, The frequency stability shall be sufficient to ensure that the 40 dB bandwidth stays within the operating frequency band when tested at the temperature and supply voltage variations specified the frequency stability measurement in RSS-Gen.	

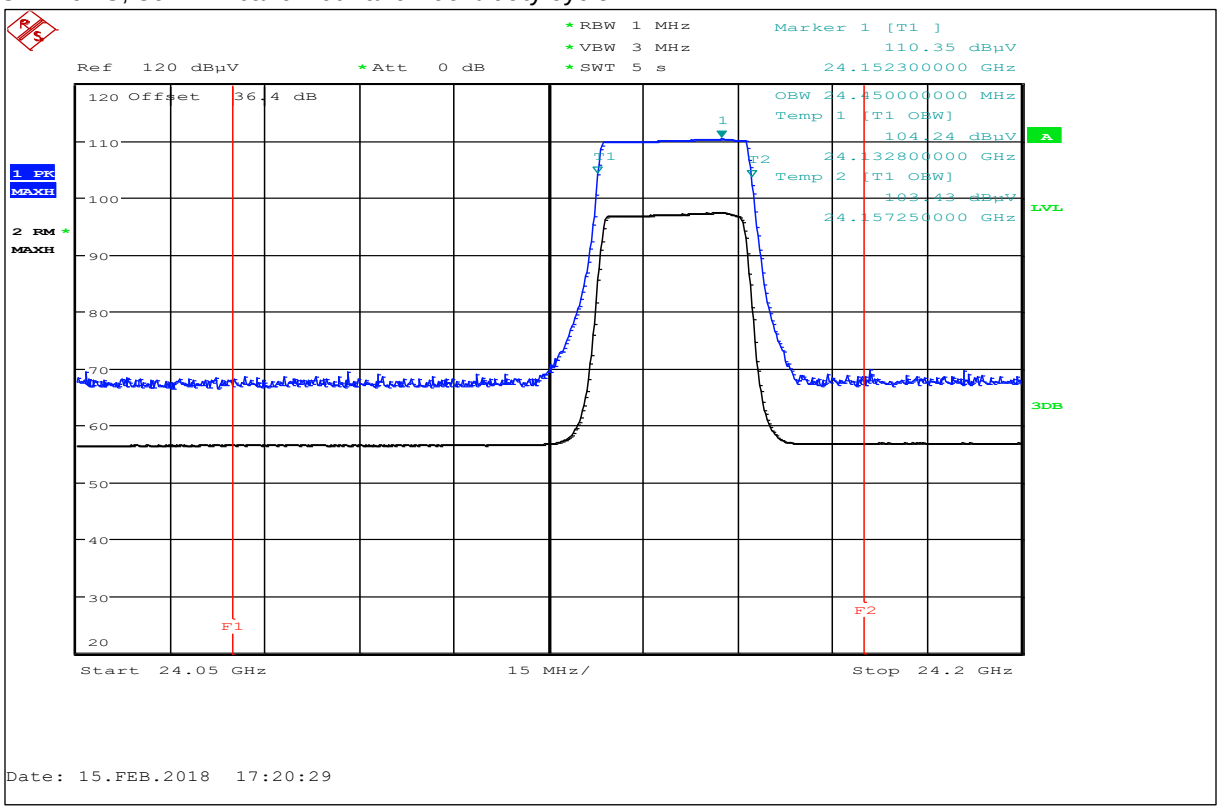
Measurement results:

Test Conditions	Frequency [GHz]	Bandwidth [MHz]
-20 °C / V_{nom}	24.132 800 (f_L), 24.157 250 (f_H)	24.45
20 °C / $V_{min/nom/max}$	24.113 900 (f_L), 24.138 950 (f_H)	25.05
70 °C / V_{nom}	24.090 800 (f_L), 24.116 300 (f_H)	25.5

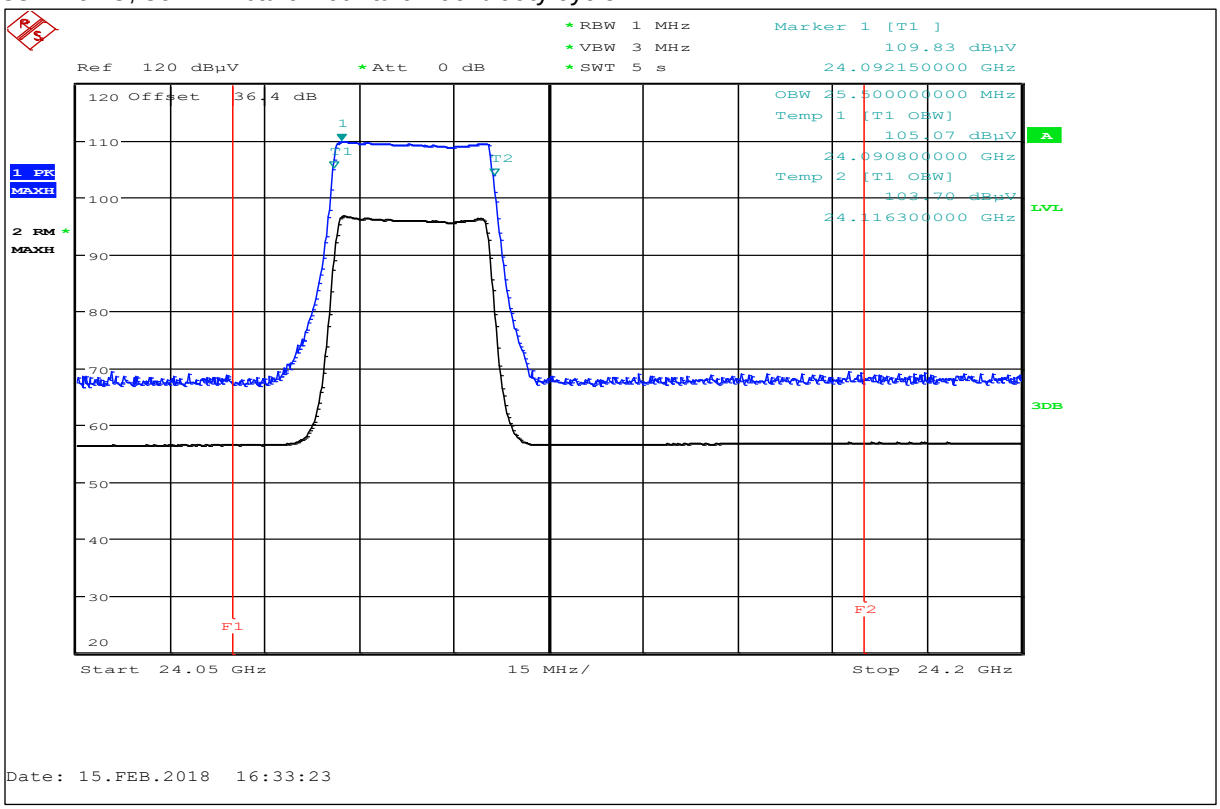
Plot 36: 20 °C, voltage variation, 30 MHz bandwidth and 100% duty cycle



Plot 37: -20 °C, 30 MHz bandwidth and 100% duty cycle



Plot 38: +70 °C, 30 MHz bandwidth and 100% duty cycle



10 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

11 Document history

Version	Applied changes	Date of release
-/-	DRAFT Initial release	2018-02-21
-/-	Update: FCC ID, IC ID, Type identification	2020-03-12

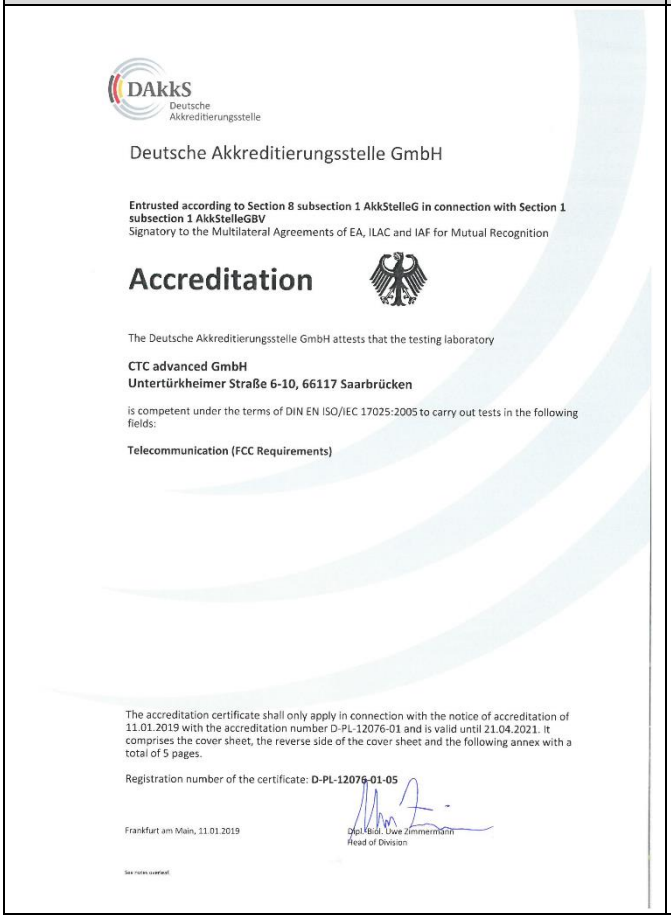
12 Accreditation Certificate – D-PL-12076-01-04

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-12076-01-04.pdf

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

first page	last page
	

DAkkS Deutsche Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

Entrusted according to Section 8 subsection 1 AkkStelleG in connection with Section 1 subsection 1 AkkStelleGBV
Signatory to the Multilateral Agreements of EA, ILAC and IAF for Mutual Recognition

Accreditation

The Deutsche Akkreditierungsstelle GmbH attests that the testing laboratory

CTC advanced GmbH
Untertürkheimer Straße 6-10, 66117 Saarbrücken

is competent under the terms of DIN EN ISO/IEC 17025:2005 to carry out tests in the following fields:

Telecommunication (FCC Requirements)

The accreditation certificate shall only apply in connection with the notice of accreditation of 11.01.2019 with the accreditation number D-PL-12076-01 and is valid until 21.04.2021. It comprises the cover sheet, the reverse side of the cover sheet and the following annex with a total of 5 pages.

Registration number of the certificate: **D-PL-12076-01-05**

Frankfurt am Main, 11.01.2019

Dipl.-Biol. Uwe Zimmermann
Head of Division

See notes overleaf.

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