

TEST REPORT

Test report no.: 1-5845/18-02-04



Testing laboratory

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Accredited Testing Laboratory:

The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2005) by the Deutsche Akkreditierungsstelle GmbH (DAkkS)

The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate with the registration number: D-PL-12076-01-03

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Manufacturer

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Test standard/s

47 CFR Part 15

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

RSS - 310 Issue 4

Spectrum Management and Telecommunications Radio Standards Specification - Licence-Exempt Radio Apparatus: Category II Equipment

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

Test Item

Kind of test item: 24GHz 3D-MIMO-RADAR

Model name: iSYS-5020

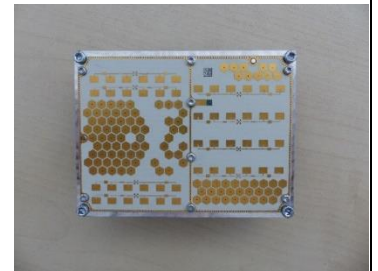
FCC ID: UXS-ISYS-5020

Frequency: 24.05 GHz – 24.25 GHz

Antenna: Integrated patch antenna

Power supply: 100 V to 240 V AC by external power supply (see chapter 5.2)

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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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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2.2 Application details

Date of receipt of order:	2018-04-17
Date of receipt of test item:	2018-04-19
Start of test:	2018-04-23
End of test:	2018-06-19
Person(s) present during the test:	-/-

2.3 Test laboratories sub-contracted

None

3 Test standard/s and references

Test standard	Date	Description
47 CFR Part 15		Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices
RSS - 310 Issue 4	07-2015	Spectrum Management and Telecommunications Radio Standards Specification - Licence-Exempt Radio Apparatus: Category II Equipment
RSS-GEN	11-2014	General Requirements for Compliance of Radio Apparatus

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

4 Test environment

Temperature	:	T_{nom} T_{max} T_{min}	+22 °C during room temperature tests +55 °C during high temperature tests -30 °C during low temperature tests
Relative humidity content	:		55 %
Barometric pressure	:		1021 hpa
Power supply	:	V_{nom} V_{max} V_{min}	110 V AC by external power supply (see chapter 5.2) 272 V 50 V

5 Test item

5.1 General description

Kind of test item	:	24GHz 3D-MIMO-RADAR
Type identification	:	iSYS-5020
S/N serial number	:	00000105 00000103
HW hardware status	:	V3_01
SW software status	:	1.0
Frequency band	:	24.05 GHz – 24.25 GHz
Type of modulation	:	FMCW
Number of modes	:	1
Antenna	:	Integrated patch antenna
Power supply	:	100 V to 240 V AC by external power supply (see chapter 5.2)
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:

1-5845/18-02-01_AnnexA
 1-5845/18-02-01_AnnexB
 1-5845/18-02-01_AnnexD

The power supply was provided by an AC/DC adapter and supplied by the customer. It has the following data:

Type	:	Switching power supply
Model	:	USPS – 1000
WEEE-Reg.-Nr.	:	DE28001718
Input	:	100 – 240 V / AC, 50/60 Hz, 0.25 A
Output	:	3/4.5/5/6/7.5/9/12 V/DC, 1 A, 12 VA

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).

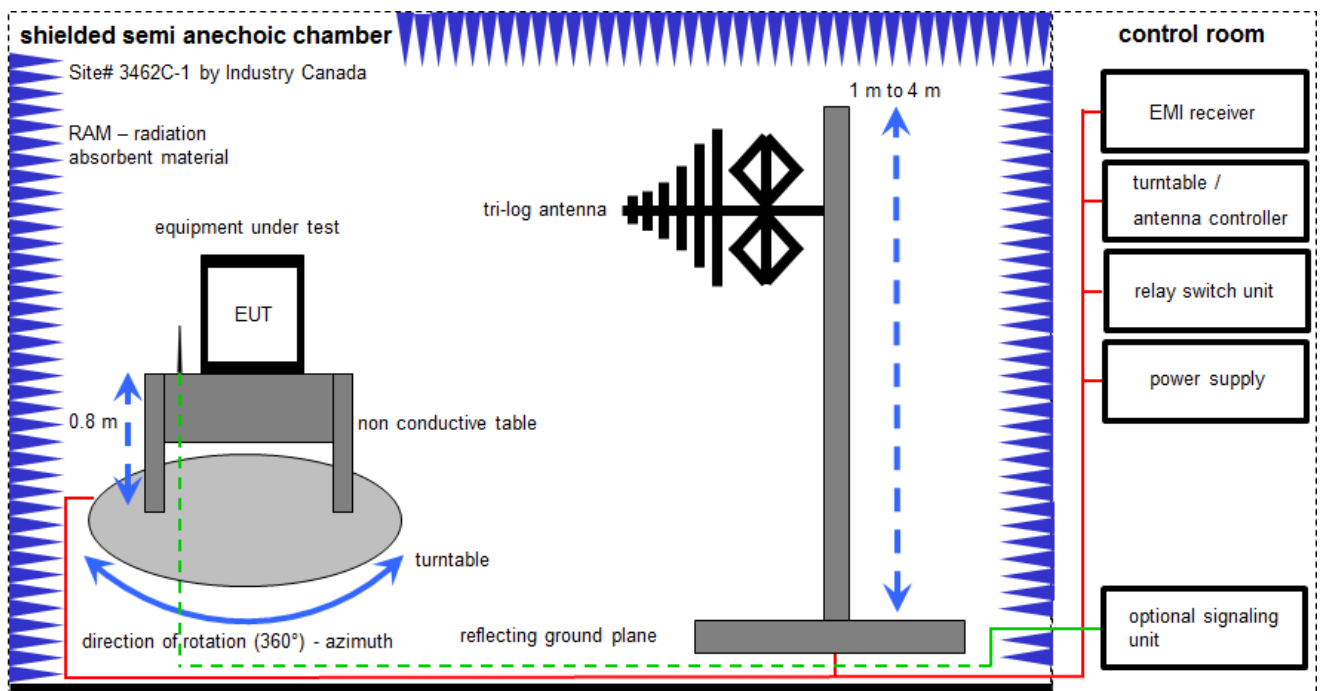
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

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
vkl!	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)

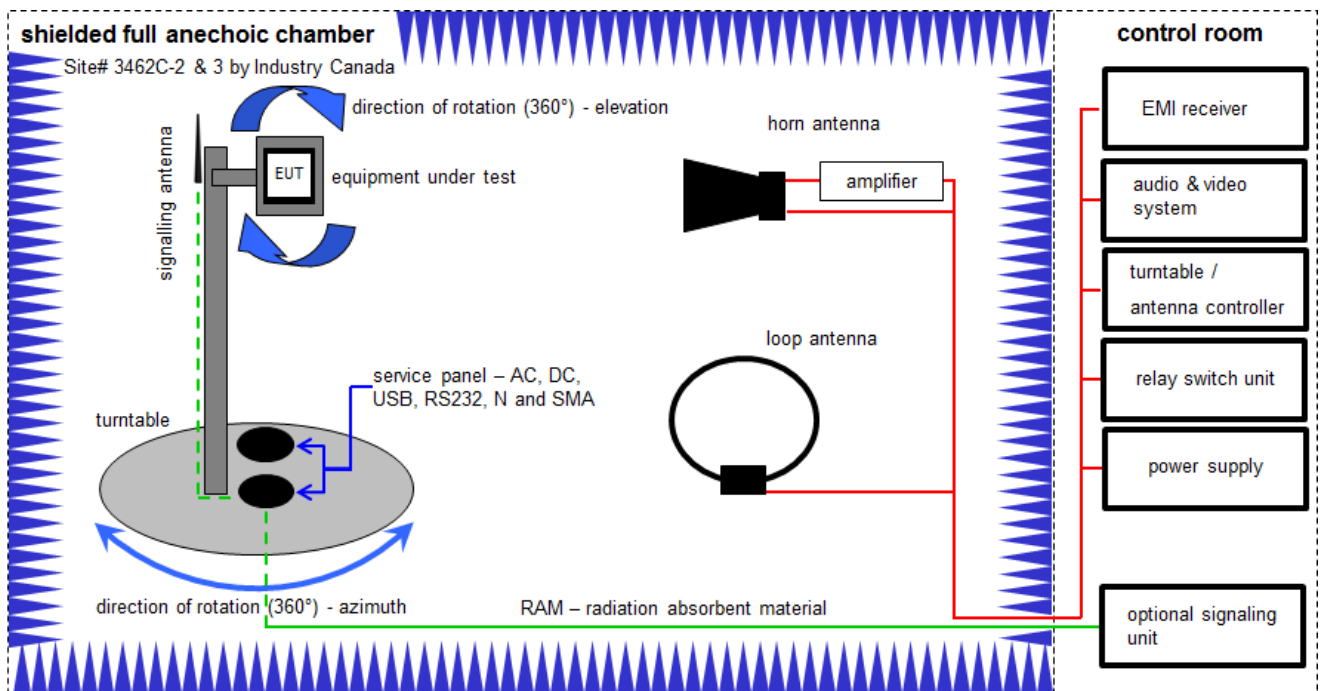
Example calculation:

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

Equipment table:

No.	Lab / Item	Equipment	Type	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	vKI!	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 Mess - Elektronik	371	300003854	vKI!	24.11.2017	23.11.2020
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:

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

$$OP = AV + D - G + CA$$

(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

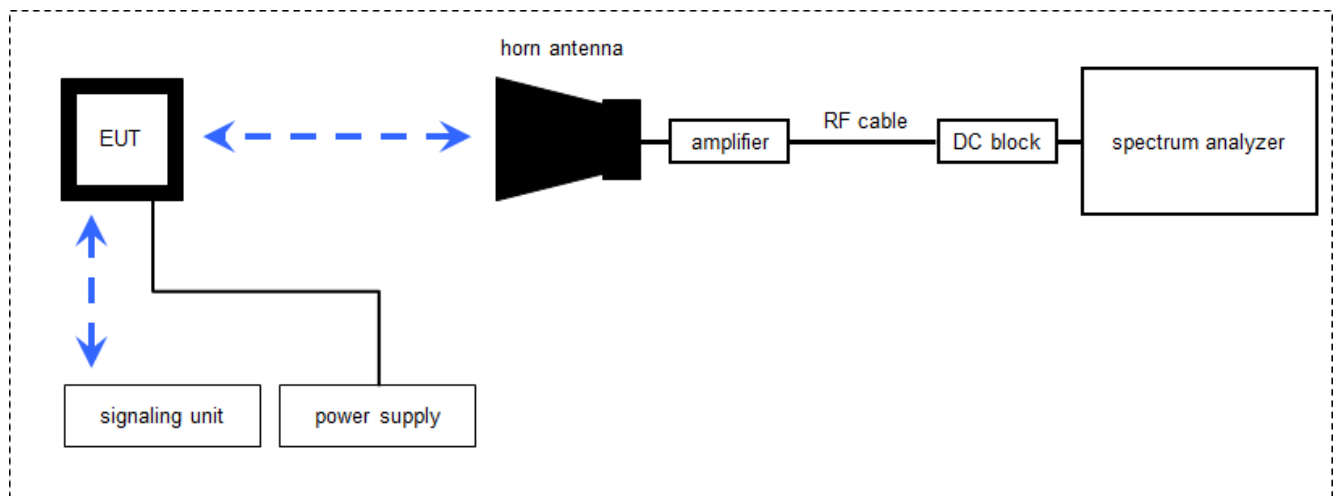
Example calculation:

$$OP [dBm] = -39.0 [dBm] + 57.0 [dB] - 12.0 [dBi] + (-36.0) [dB] = -30 [dBm] (1 \mu W)$$

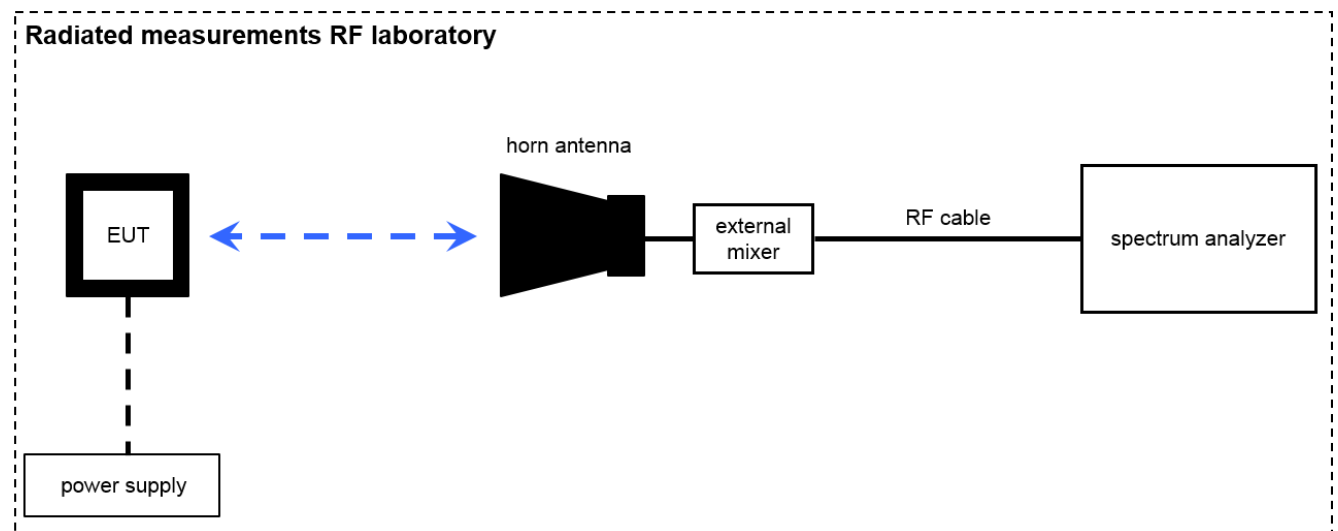
Equipment table:

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	vKI!	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	vKI!	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	Erli	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	WHK1.1/15G-10SS	Wainwright	3	300003255	ev	-/-	-/-
9	n. a.	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
10	n. a.	MXG Microwave Analog Signal Generator	N5183A	Agilent Technologies	MY47420220	300003813	k	27.01.2017	26.01.2020
11	n. a.	High Pass Filter	VHF-3500+	Mini Circuits	-/-	400000193	ne	-/-	-/-
12	n. a.	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
13	n. a.	Broadband Amplifier 5-13 GHz	CBLU5135235	CERNEX	22010	300004491	ev	-/-	-/-
14	n. a.	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
15	n. a.	NEXIO EMV-Software	BAT EMC V3.16.0.49	EMCO		300004682	ne	-/-	-/-
16	n. a.	PC	ExOne	F+W		300004703	ne	-/-	-/-
17	n. a.	Highpass Filter (Chebyshev)	WHKX10-4432.5-4925-18000-40SS	Wainwright	1	300005028	ev	-/-	-/-
18	n. a.	Lowpass Filter (Chebyshev)	WLK12-5975-6333.5-18000-40SS	Wainwright	1	400001213	ev	-/-	-/-
19	n. a.	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-
20	n. a.	TRILOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess - Elektronik	01029	300005379	vKI!	07.04.2017	06.04.2020

6.3 Radiated measurements > 18 GHz



6.4 Radiated measurements > 50/85 GHz



Measurement distance: horn antenna e.g. 25 cm

$$FS = UR + CA + AF$$

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

Example calculation:

$$FS [dB\mu V/m] = 40.0 [dB\mu V/m] + (-60.1) [dB] + 36.74 [dB/m] = 16.64 [dB\mu V/m] (6.79 \mu V/m)$$

$$OP = AV + D - G + CA$$

(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

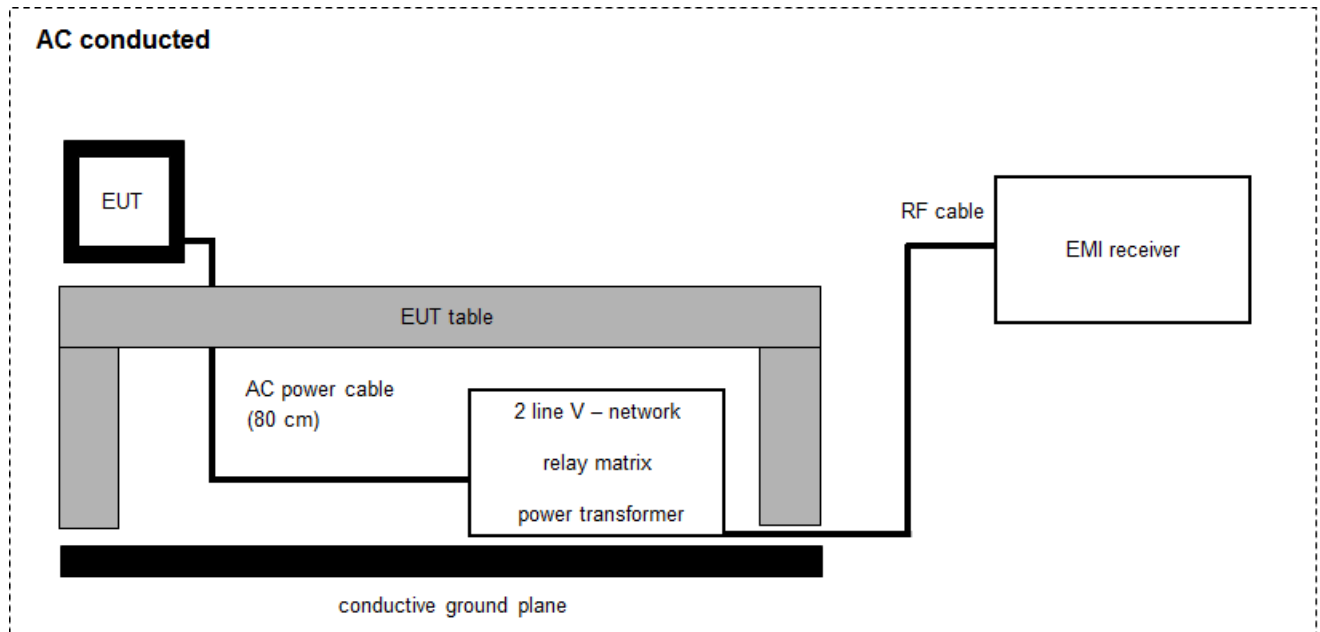
Example calculation:

$$OP [dBm] = -59.0 [dBm] + 44.0 [dB] - 20.0 [dBi] + 5.0 [dB] = -30 [dBm] (1 \mu W)$$

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	CR 79	Std. Gain Horn Antenna 26.5-40.0 GHz	V637	Narda	7911	300001751	ne	-/-	-/-
2	A025	Std. Gain Horn Antenna 49.9-75.8 GHz	2524-20	Flann	*	300001983	ne	-/-	-/-
3	A027	Std. Gain Horn Antenna 73.8-112 GHz	2724-20	Flann	*	300001988	ne	-/-	-/-
4	A027	Std. Gain Horn Antenna 18.0-26.5 GHz	638	Narda		300000486	k	13.12.2017	12.12.2019
5	n. a.	Spectrum Analyzer 2 Hz - 85 GHz	FSW85	R&S	101333	-/-	k	Jan. 2018	Jan. 2019
6	n. a.	Harmonic Mixer 2-Port, 50-75 GHz	FS-Z75	R&S	100099	300003949	k	30.06.2017	29.06.2018
7	n. a.	Std. Gain Horn Antenna 33.0-50.1 GHz	2324-20	Flann	57	400000683	ne	-/-	-/-
8	n. a.	Broadband LNA 18-50 GHz	CBL18503070PN	CERNEX	25240	300004948	ev	-/-	-/-
9	n. a.	Harmonic Mixer 3-Port, 75-110 GHz	FS-Z110	R&S	101411	300004959	k	03.07.2017	02.07.2018

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:

$$FS [dB\mu V/m] = 37.62 [dB\mu V/m] + 9.90 [dB] + 0.23 [dB] = 47.75 [dB\mu V/m] \quad (244.06 \mu V/m)$$

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	vKI!	18.12.2017	17.12.2019
6	n. a.	Analyzer-Reference-System (Harmonics and Flicker)	ARS 16/1	SPS	A3509 07/0 0205	300003314	vKI!	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	vKI!	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 $\pm 45^\circ$ and antenna height between 1 and 4 m.
- The final measurement is done with quasi-peak detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

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 50/85 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	FCC 47 CFR Part 15 RSS-310 Issue 4	Passed	2018-06-25	-/-

Test specification clause	Test case	Temperature conditions	Power source voltages	C	NC	NA	NP	Results (max.)
§15.249(a) / RSS-310, 3.10	Field strength of fundamental emission	Nominal	Nominal	☒	☐	☐	☐	
§2.1049	Occupied bandwidth (99% bandwidth)	Nominal	Nominal	☒	☐	☐	☐	
§15.209(a) / §15.249(d) / RSS-310, 3.10	Field strength of emissions (radiated spurious)	Nominal	Nominal	☒	☐	☐	☐	
§15.207(a) RSS-Gen 8.8	Conducted emissions < 30 MHz	Nominal	Nominal	☒	☐	☐	☐	
§15.215(c) RSS-Gen 8.11	Frequency Stability	Nominal Extreme	Nominal Extreme	☒	☐	☐	☐	

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

9 Measurement results

9.1 Field strength of fundamental emission

Description:

Measurement of the maximum radiated field strength of the wanted signal.

Measurement:

Measurement parameter	
Detector:	Pos-Peak / Average
Sweep time:	5 s
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Span:	300 MHz
Trace-Mode:	Max Hold
Measurement uncertainty	± 3 dB

This test was performed on a shorter test distance. A correction factor of $20 \cdot \log(x \text{ m}/3 \text{ m})$ is already considered in the plots.

Limits:

FCC		IC
CFR Part 15.249(a)		RSS-310, 3.10
Field strength of emissions		
The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:		
Frequency	Field Strength	Measurement distance
24.0 GHz – 24.25 GHz	108 dBμV/m (Average) 128 dBμV/m (PEAK)	3 m

§15.249 (e) As shown in § 15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.

§15.31 (c) Except as otherwise indicated in §15.256, for swept frequency equipment, measurements shall be made with the frequency sweep stopped at those frequencies chosen for the measurements to be reported.

Measurement results:

Test condition	Maximum field strength (Peak) (dBµV/m @3m)	Maximum field strength (Average) (dBµV/m @3m)	Maximum field strength (Average, calculated) (dBµV/m @3m)
normal operation mode	113.2	79.3	-/-
test mode - f_{low}	112.1	-/-	67.3
test mode - f_{mid}	112.7	-/-	67.9
test mode - f_{high}	111.7	-/-	66.9

Note:

Last column shows calculated AVG values for FCC test mode f_{low} / f_{mid} / f_{high} based on measured peak values. According to the KDB 890966 D01 (Sep. 2014) the average power is determined by multiplying the maximum peak power level by the average factor:

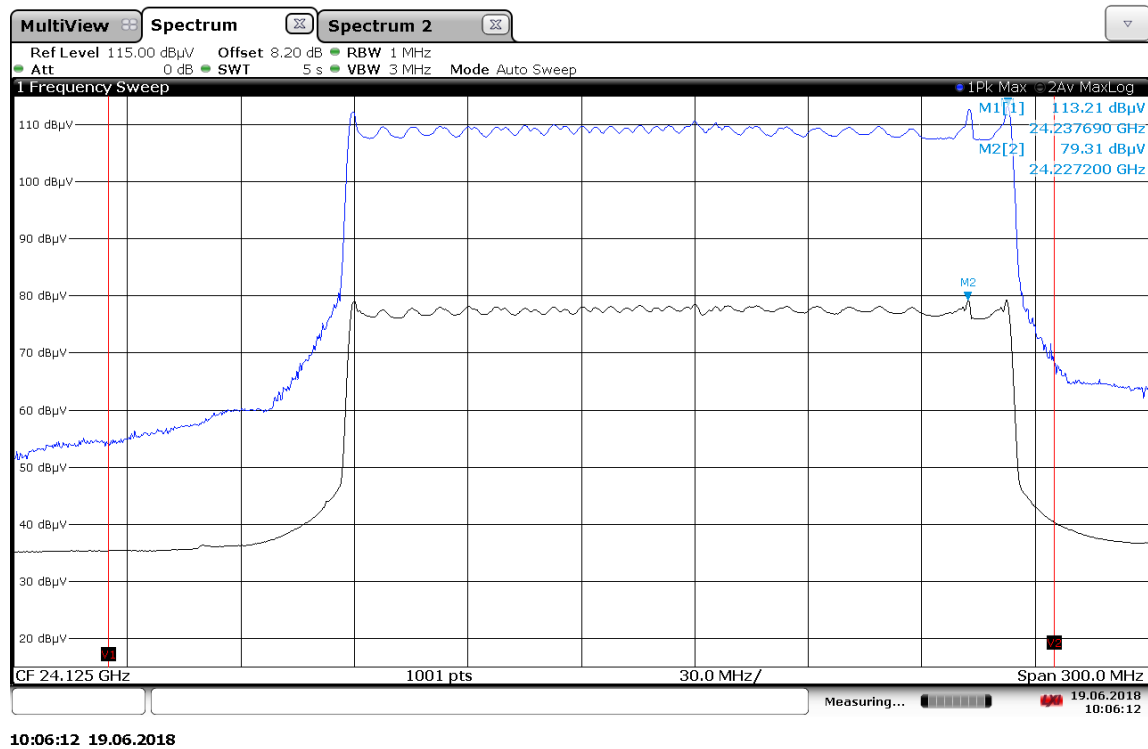
$$\text{Average factor [dB]} = 20 \cdot \log(T_s / (\Delta F \cdot \text{cycle time})) = 20 \cdot \log(40 \mu\text{s} / (174 \text{ MHz} \cdot 40 \mu\text{s})) = -44.8 \text{ dB}$$

T_s : Signal sweep frequency time in seconds

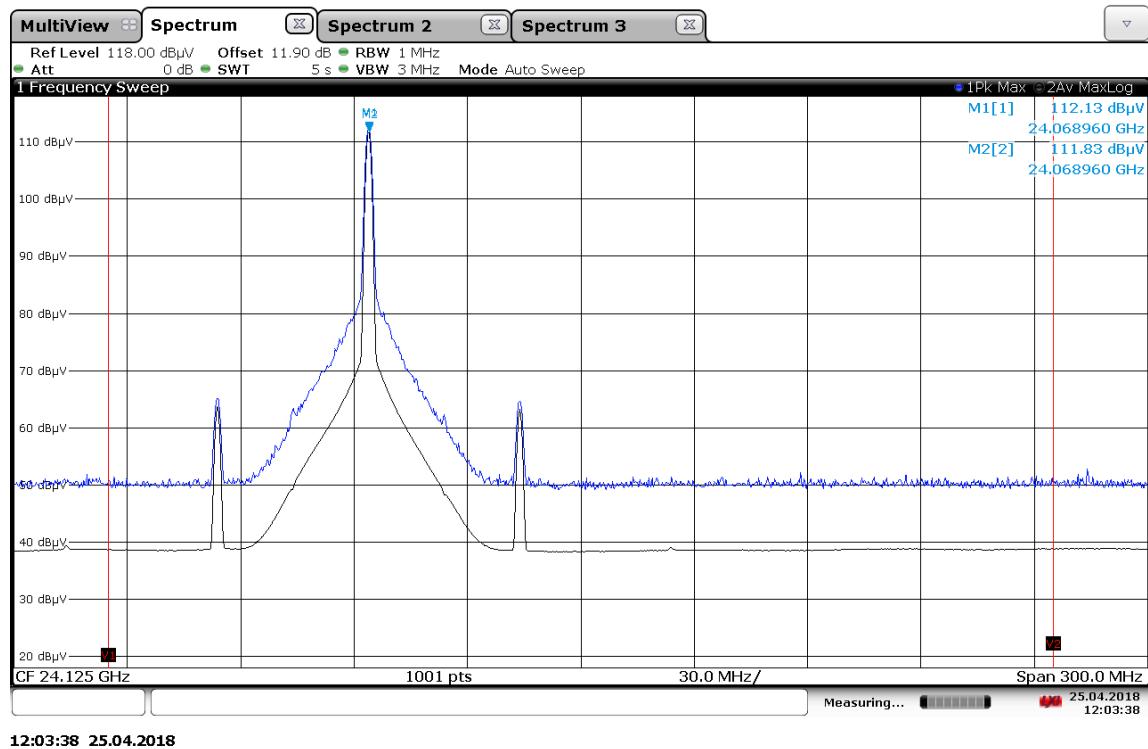
ΔF : Signal sweep frequency span in MHz

cycle time: Total time for a complete cycle of the signal including retrace and any other latency times.

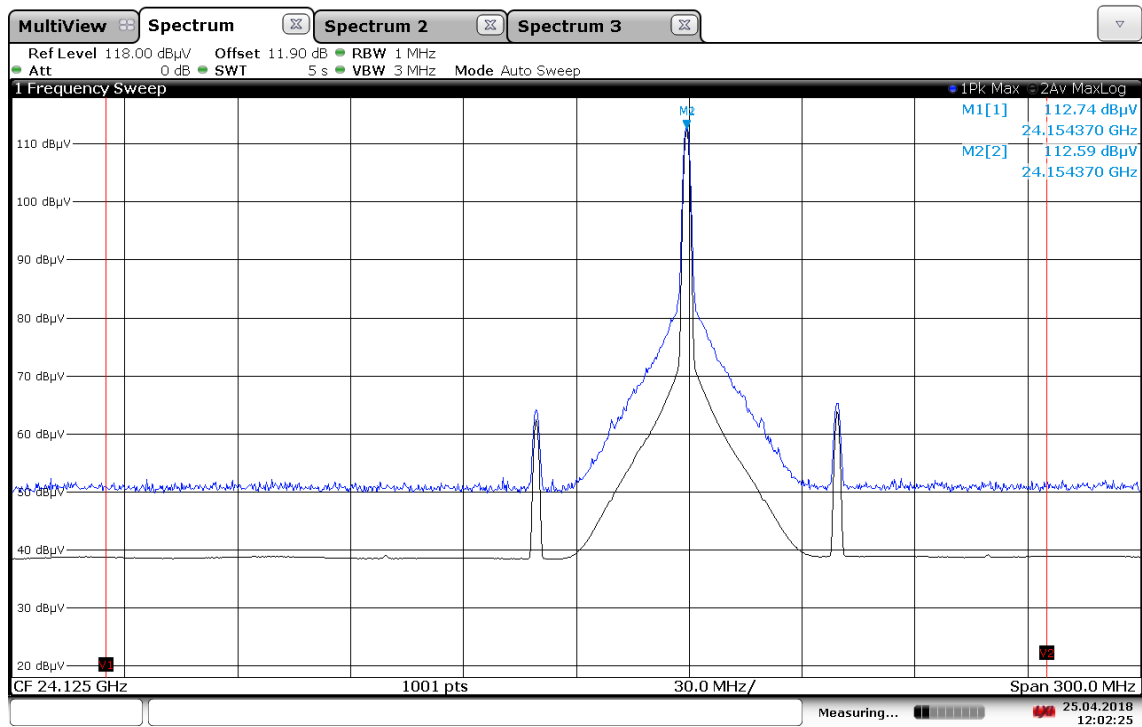
Plot No. 1: Field strength, normal operation mode, S/N: 00000103



Plot No. 2: Field strength, test mode, low frequency, S/N: 00000105

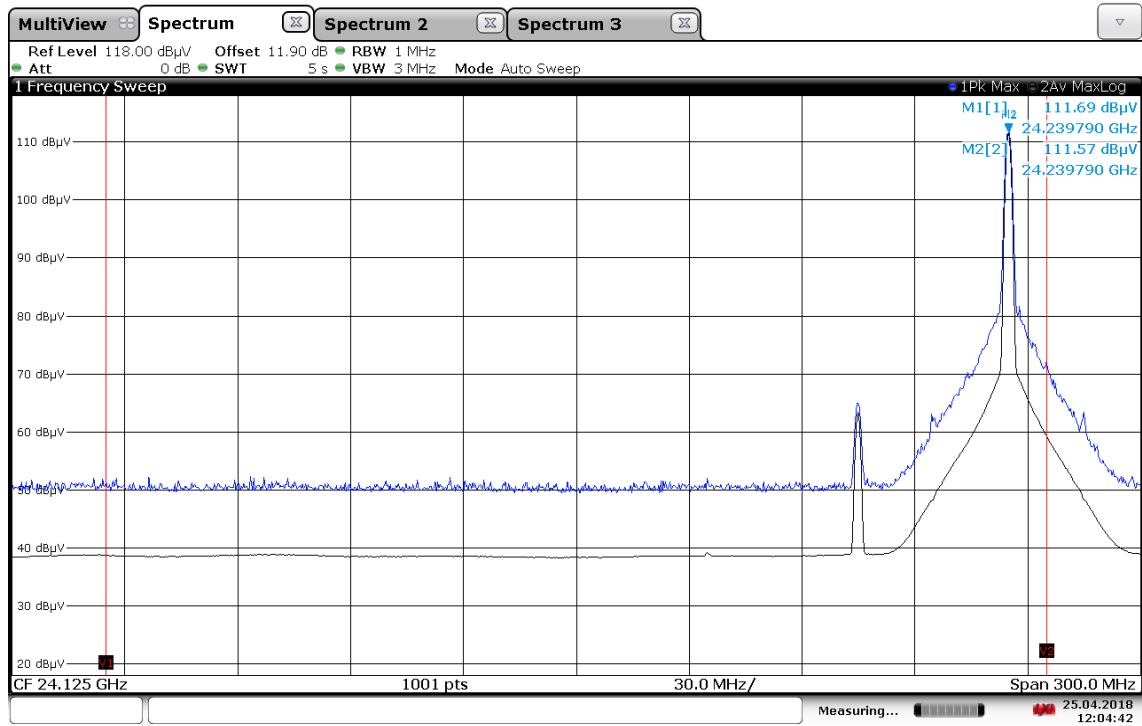


Plot No. 3: Field strength, test mode, low frequency, S/N: 00000105



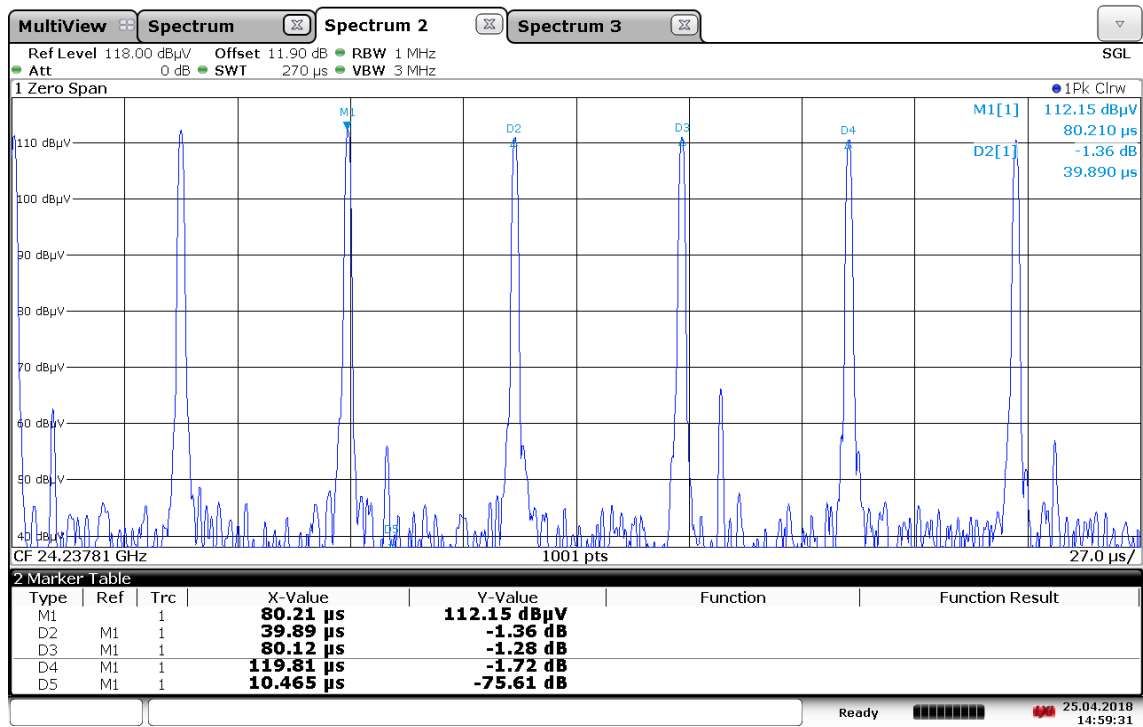
12:02:26 25.04.2018

Plot No. 4: Field strength, test mode, high frequency, S/N: 00000105



12:04:43 25.04.2018

Plot No. 5: Time domain, normal operation mode, S/N: 00000105



14:59:31 25.04.2018

9.2 Occupied bandwidth (99% bandwidth)

Description:

Measurement of the 99% bandwidth of the wanted signal.

Measurement:

Parameter	
Detector:	Pos-Peak
Sweep time:	5 s
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Span:	300 MHz
Trace-Mode:	Max Hold
Measurement uncertainty	$\pm$ Span/1000

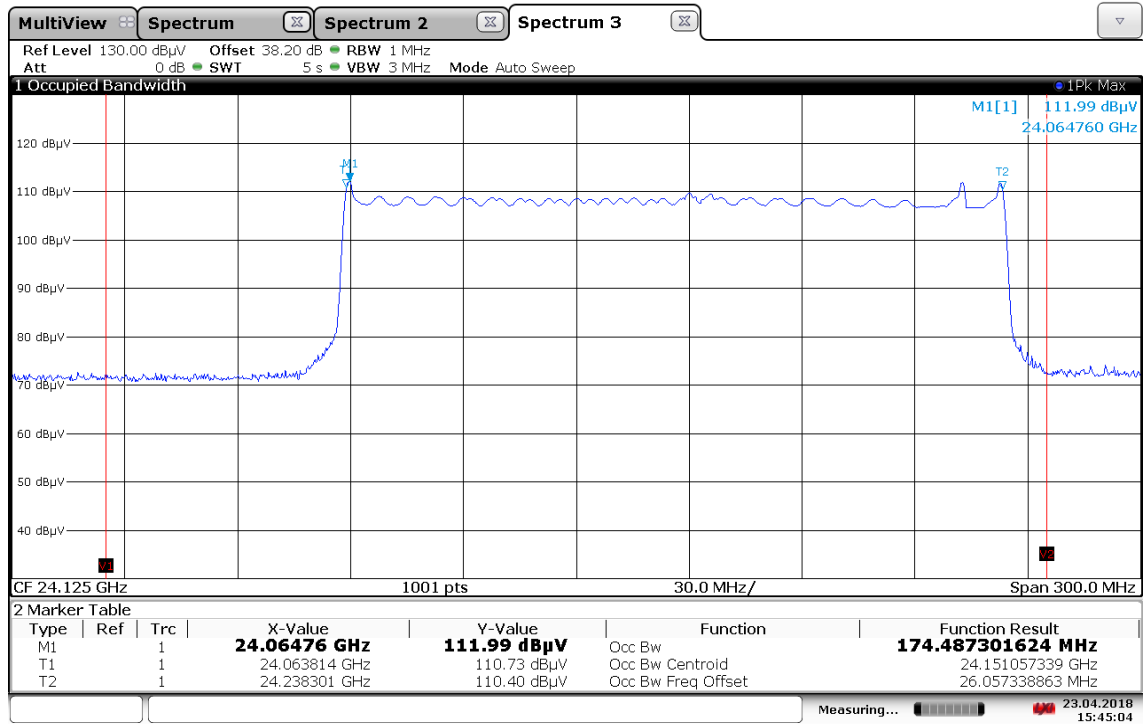
Limits:

FCC		IC	
CFR Part 15.249(a)		RSS-310, 3.10	
The field strength of emissions from intentional radiators operated within the specified frequency band shall comply with the following			
Frequency range	f _L	f _H	
250 MHz	> 24.0 GHz	< 24.25 GHz	

Measurement results:

Test condition	f_L (GHz)	f_H (GHz)	Occupied bandwidth (MHz)
99% bandwidth of the normal operation mode	24.064	24.238	174.5

Plot No. 6: OBW, normal operation mode, S/N: 00000103



15:45:04 23.04.2018

9.3 Field strength of emissions (radiated spurious)

Description:

Measurement of the radiated spurious emissions in transmit mode.

Measurement:

Parameter	
Detector:	QPeak / Pos-Peak / Average
Sweep time:	Auto
Resolution bandwidth:	100 kHz / 1 MHz
Video bandwidth:	300 kHz / 3 MHz
Trace-Mode:	Max Hold
Measurement uncertainty	± 3 dB

Limits:

FCC		IC
CFR Part 15.209(a) / CFR Part 15.249(d)		RSS - GEN
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 (µV/m)	Measurement distance (m)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

§15.249 (e) As shown in § 15.35(b), for frequencies above 1000 MHz, the field strength limits in paragraphs (a) and (b) of this section are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.

§15.31 (c) Except as otherwise indicated in §15.256, for swept frequency equipment, measurements shall be made with the frequency sweep stopped at those frequencies chosen for the measurements to be reported.

Measurement results:

Low / Mid / High frequency				
F [GHz]	Detector	Measured level [dBμV/m]	Calculated level [dBμV/m]	Margin
22.56	Peak	53.0	-/-	-21.0
22.56	AVG	49.9	5.1	-48.9
24.28	Peak	66.5	-/-	-7.5
24.28	AVG	65.5	20.7	-33.3
25.57	Peak	49.2	-/-	-24.1
25.57	AVG	41.9	-2.9	-56.9
48.48	Peak	66.2	-/-	-7.8
48.48	AVG	65.1	20.3	-33.7

Note: QP = Quasi-Peak, PK = Peak, AVG = Linear Average

Measurements above 18 GHz were performed on a short measurement distance ($\leq 1\text{m}$) to improve the minimum sensitivity of the test system. A correction factor of $20 \cdot \log(d/3\text{m})$ is already considered in the plots.

Fourth column shows calculated AVG values for FCC test mode f_{low} / f_{mid} / f_{high} based on measured peak values. According to the KDB 890966 D01 (Sep. 2014) the average power is determined by multiplying the maximum peak power level by the average factor:

$$\text{Average factor [dB]} = 20 \cdot \log(T_s / (\Delta F \cdot \text{cycle time})) = 20 \cdot \log(40 \mu\text{s} / (174 \text{ MHz} \cdot 40 \mu\text{s})) = -44.8 \text{ dB}$$

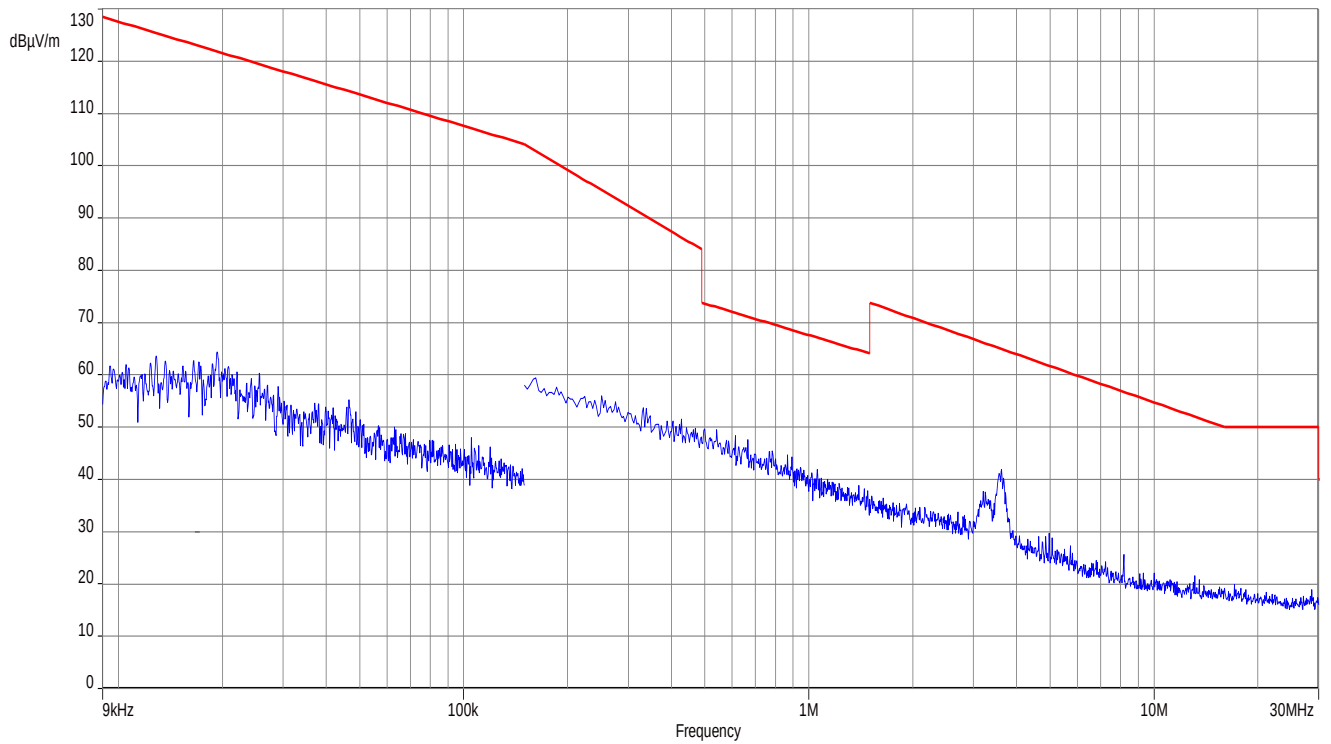
T_s : Signal sweep frequency time in seconds

ΔF : Signal sweep frequency span in MHz

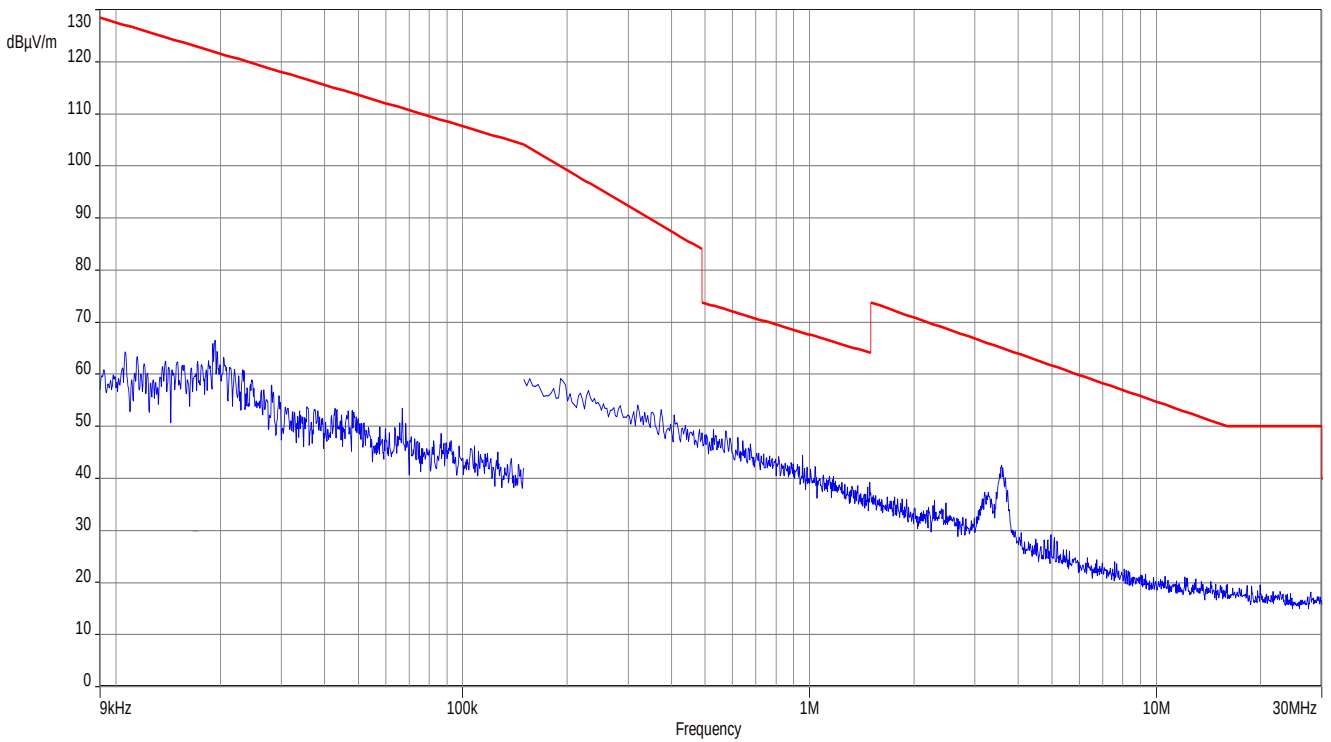
cycle time: Total time for a complete cycle of the signal including retrace and any other latency times.

For more details of emissions between 30 MHz and 1 GHz, please refer to plot 10 to 12.

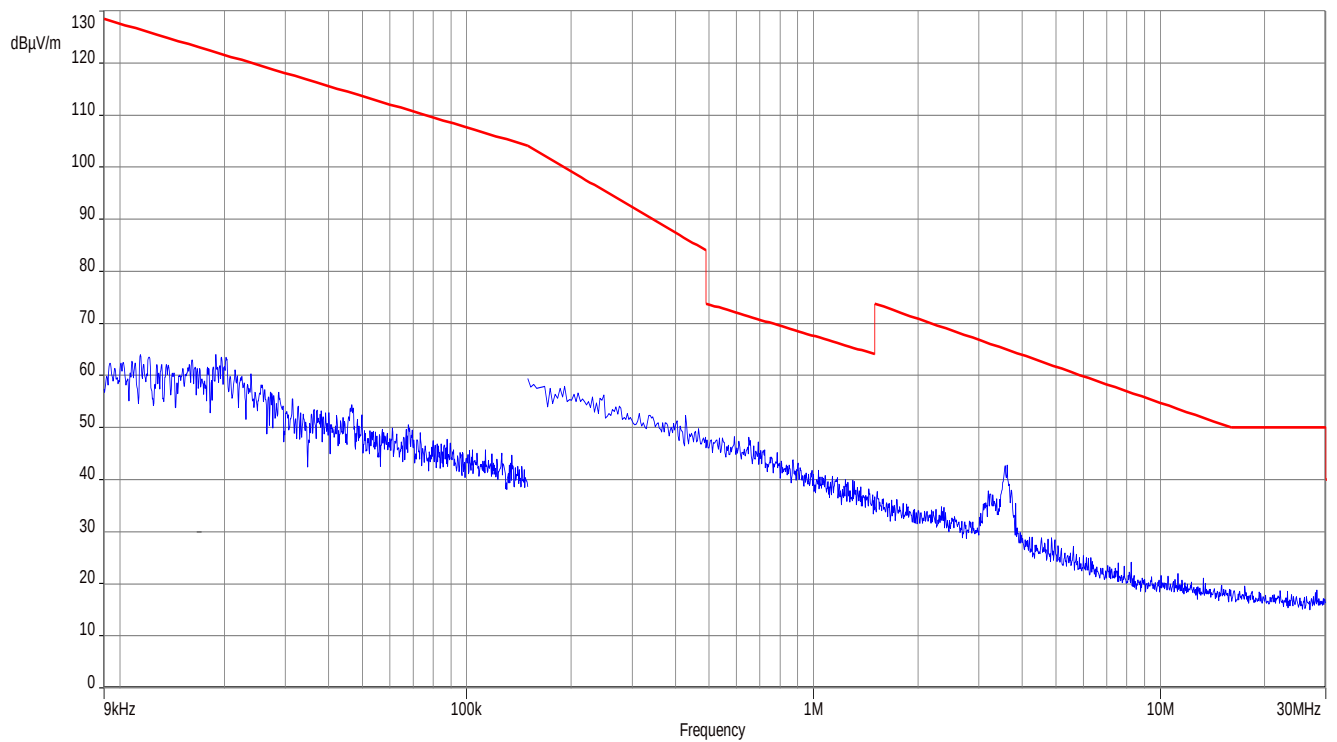
Plot No. 7: 9 kHz to 30 MHz, horizontal/vertical polarization, low frequency, S/N: 00000105



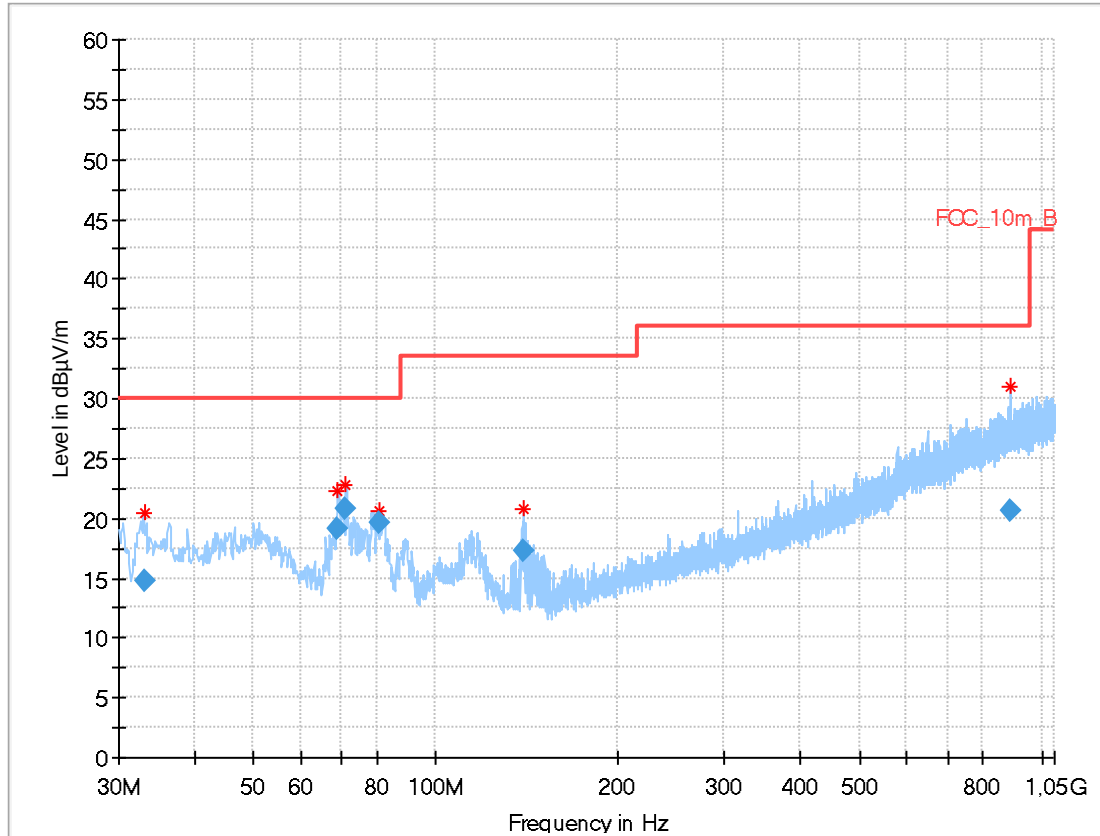
Plot No. 8: 9 kHz to 30 MHz, horizontal/vertical polarization, mid frequency, S/N: 00000105



Plot No. 9: 9 kHz to 30 MHz, horizontal/vertical polarization, high frequency, S/N: 00000105

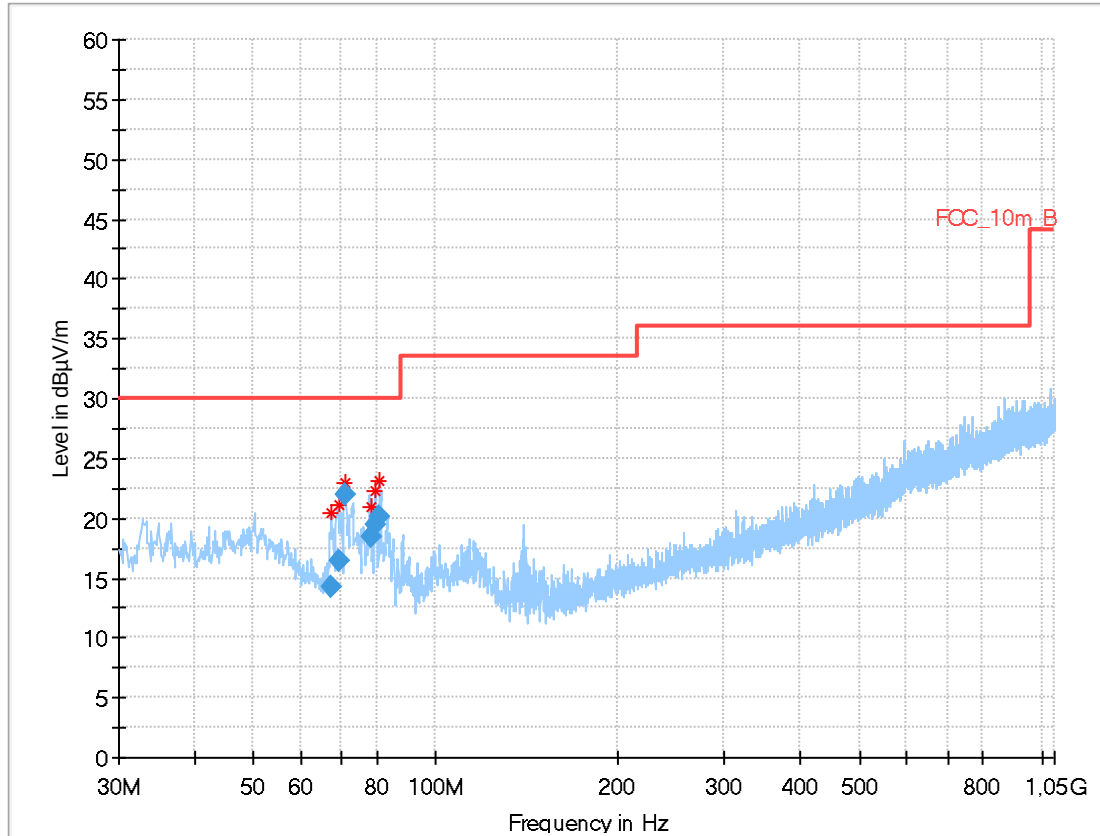


Plot No. 10: 30 MHz to 1 GHz, horizontal/vertical polarization, low frequency, S/N: 00000105



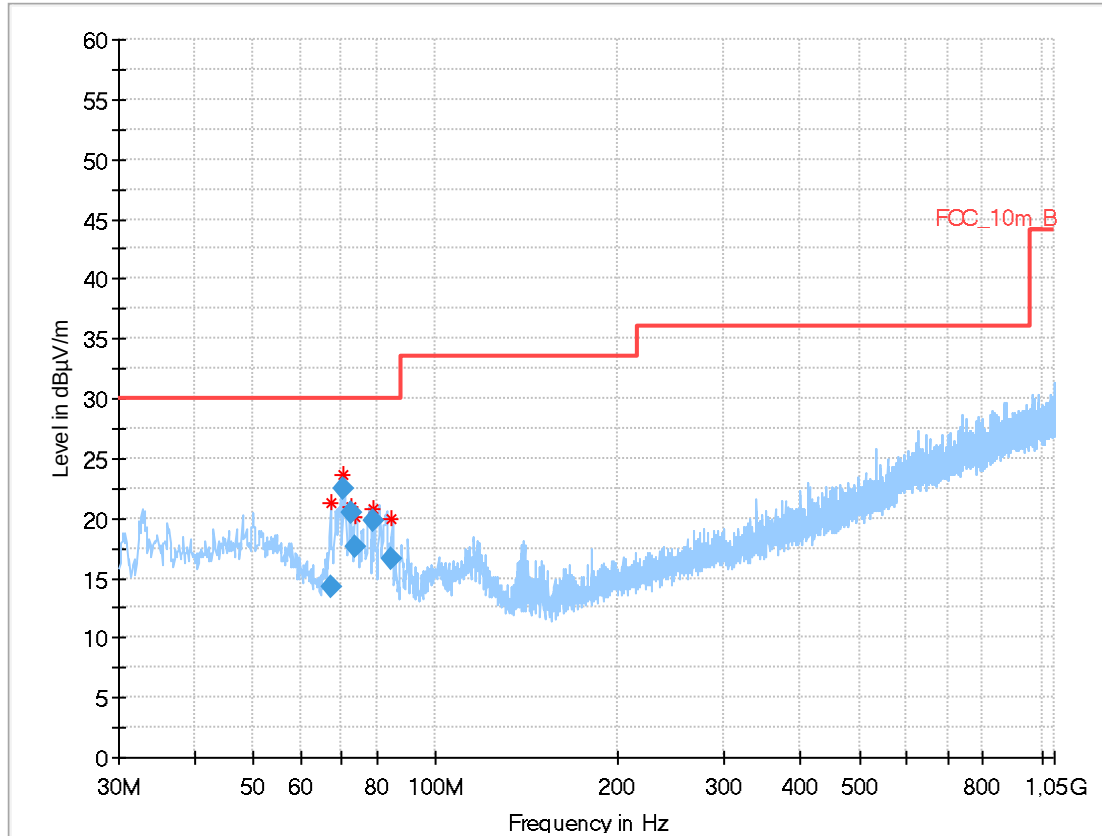
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
33.155	14.80	30.0	15.20	1000	120	103.0	V	30.0	12.4
68.581	19.06	30.0	10.94	1000	120	200.0	V	60.0	10.0
70.743	20.74	30.0	9.26	1000	120	203.0	V	105.0	9.6
80.532	19.53	30.0	10.47	1000	120	272.0	V	166.0	8.2
139.277	17.31	33.5	16.19	1000	120	104.0	V	285.0	8.9
888.560	20.64	36.0	15.36	1000	120	351.0	V	105.0	24.0

Plot No. 11: 30 MHz to 1 GHz, horizontal/vertical polarization, mid frequency, S/N: 00000105



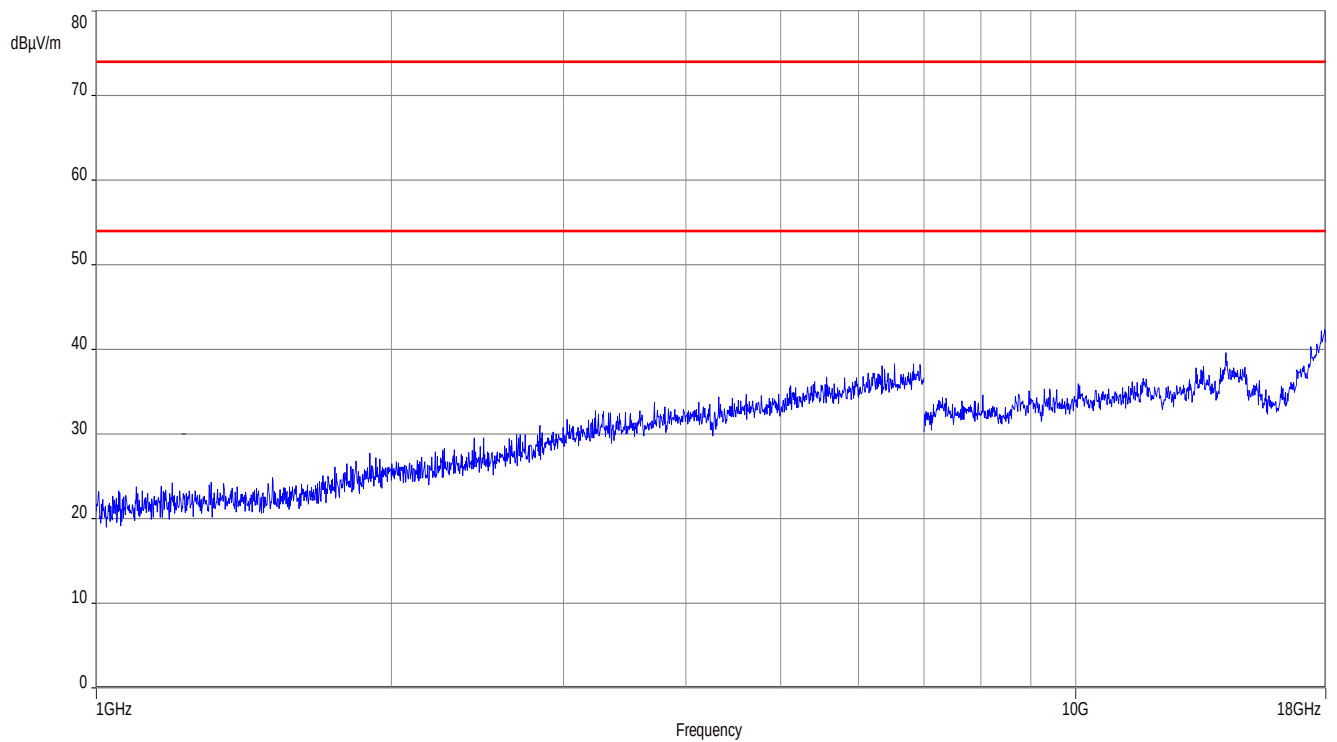
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
67.180	14.32	30.0	15.68	1000	120	173.0	V	121.0	10.3
69.186	16.46	30.0	13.54	1000	120	173.0	V	121.0	9.9
70.720	22.00	30.0	8.00	1000	120	172.0	V	84.0	9.6
77.997	18.45	30.0	11.55	1000	120	348.0	V	98.0	8.4
79.400	19.45	30.0	10.55	1000	120	350.0	V	142.0	8.2
80.984	20.14	30.0	9.86	1000	120	203.0	V	166.0	8.2

Plot No. 12: 30 MHz to 1 GHz, horizontal/vertical polarization, high frequency, S/N: 00000105

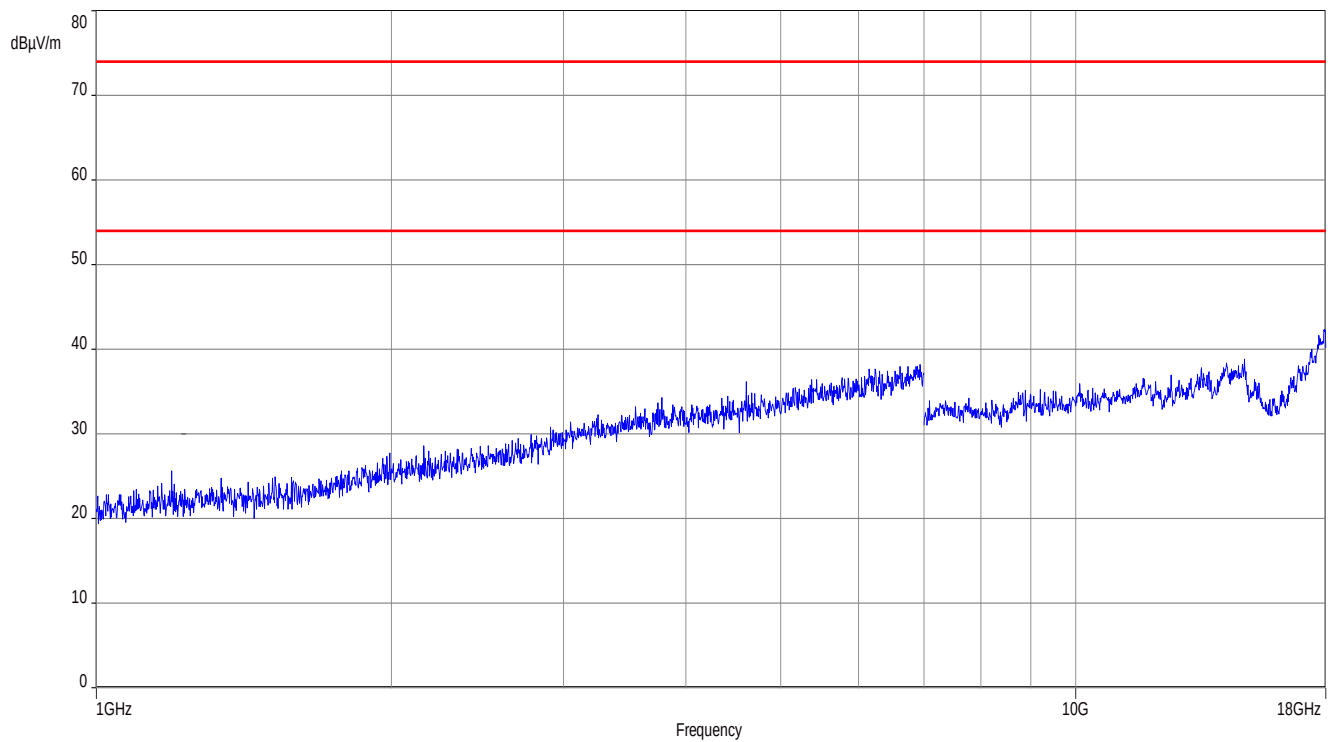


Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
67.196	14.18	30.0	15.82	1000	120	200.0	V	150.0	10.3
70.439	22.43	30.0	7.57	1000	120	200.0	V	76.0	9.7
72.380	20.51	30.0	9.49	1000	120	200.0	V	105.0	9.3
73.780	17.56	30.0	12.44	1000	120	350.0	V	165.0	9.1
78.955	19.74	30.0	10.26	1000	120	352.0	V	60.0	8.2
84.620	16.67	30.0	13.33	1000	120	272.0	V	195.0	8.7

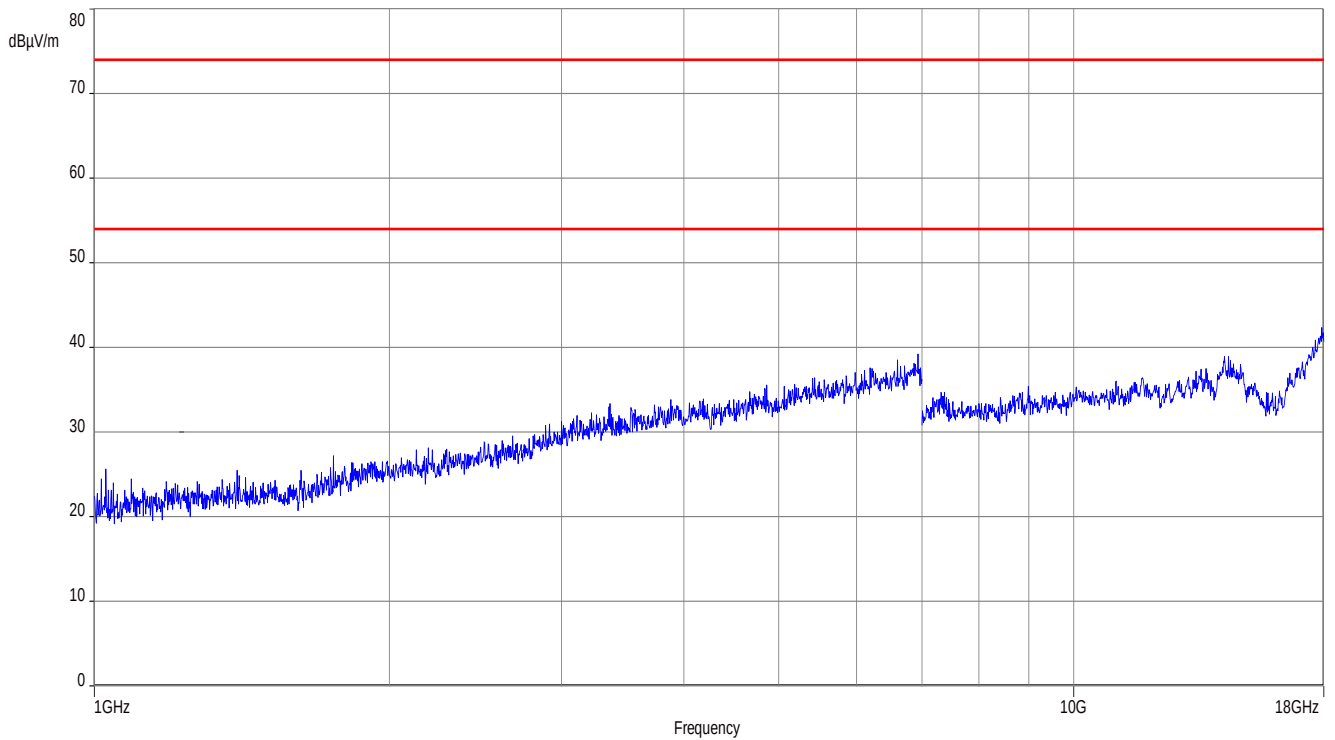
Plot No. 13: 1 GHz to 18 GHz, horizontal/vertical polarization, low frequency, S/N: 00000105



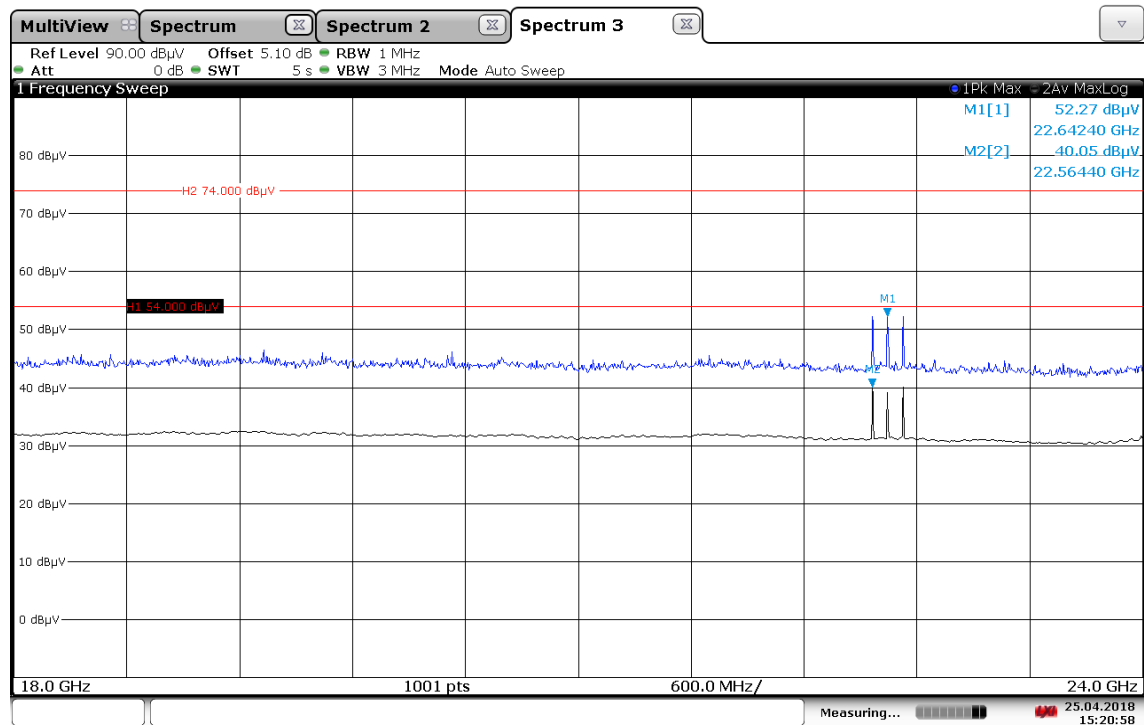
Plot No. 14: 1 GHz to 18 GHz, horizontal/vertical polarization, mid frequency, S/N: 00000105



Plot No. 15: 1 GHz to 18 GHz, horizontal/vertical polarization, high frequency, S/N: 00000105

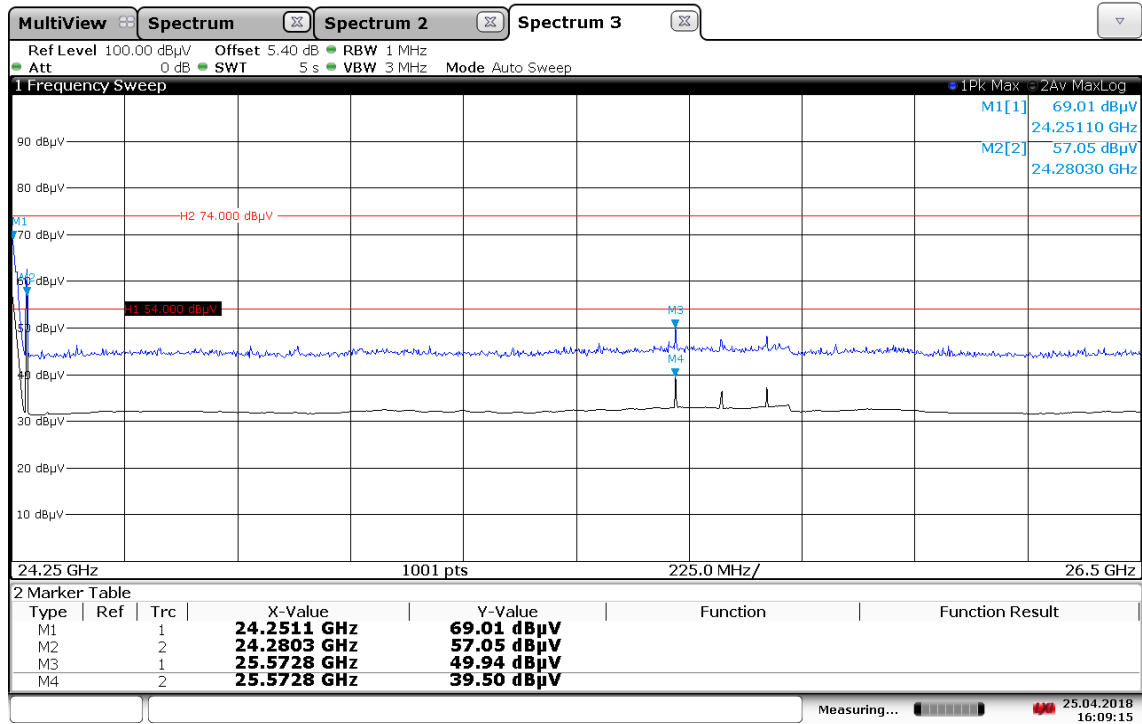


Plot No. 16: 18 GHz to 24 GHz, horizontal/vertical polarization, low/mid/high frequency, S/N: 00000105



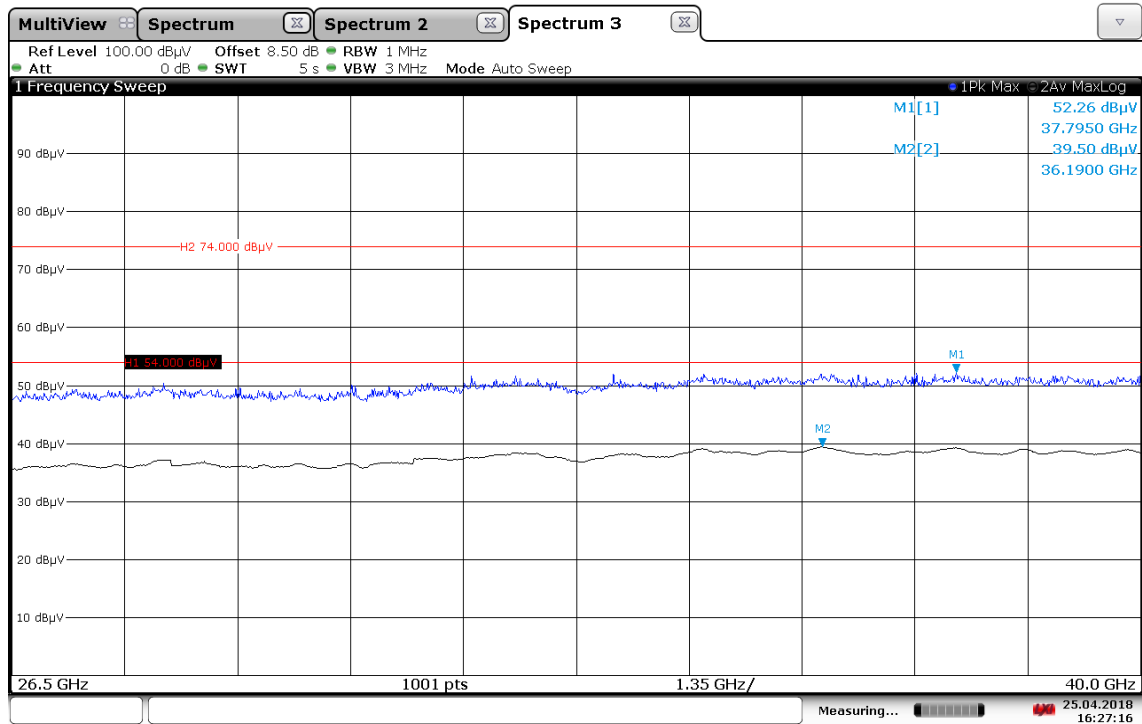
15:20:58 25.04.2018

Plot No. 17: 24.25 GHz to 26.5 GHz, horizontal/vertical polarization, low/mid/high frequency, S/N: 00000105



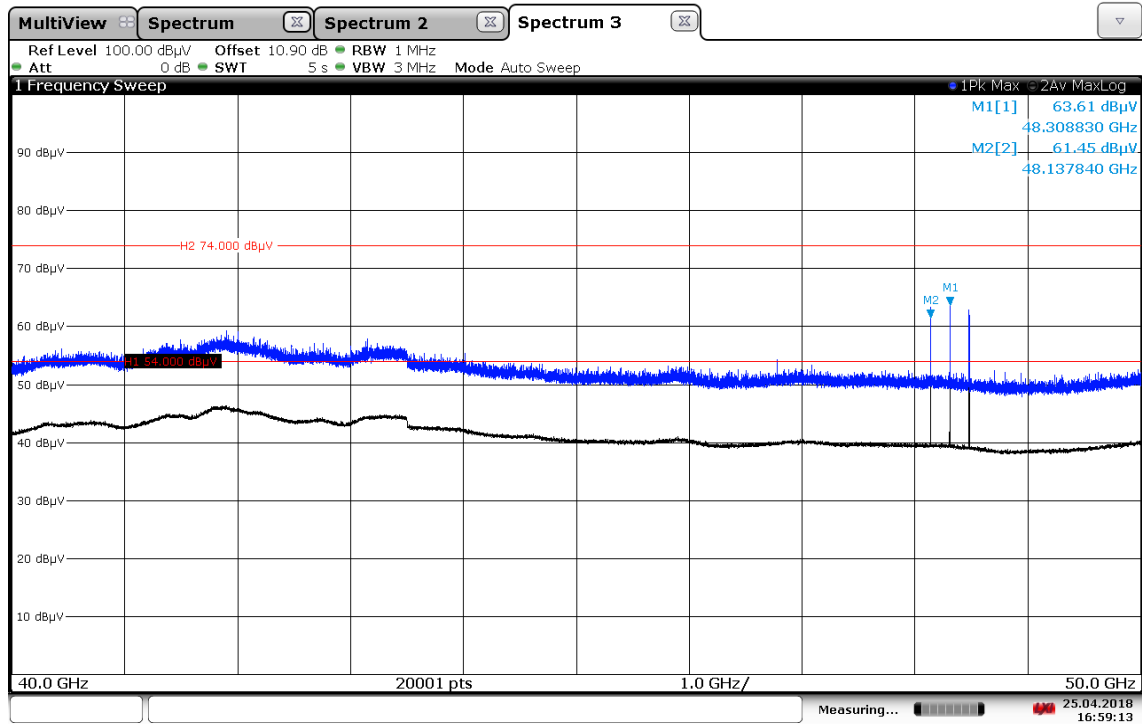
16:09:16 25.04.2018

Plot No. 18: 26.5 GHz to 40 GHz, horizontal/vertical polarization, low/mid/high frequency, S/N: 00000105



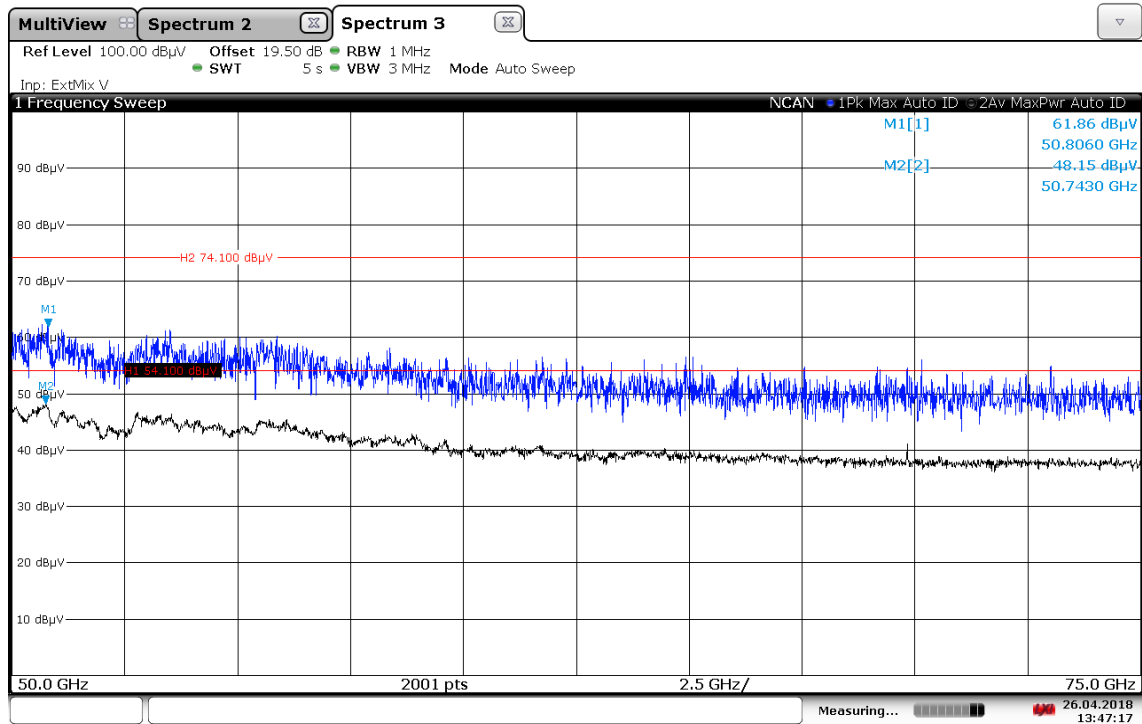
16:27:17 25.04.2018

Plot No. 19: 40 GHz to 50 GHz, horizontal/vertical polarization, low/mid/high frequency, S/N: 00000105



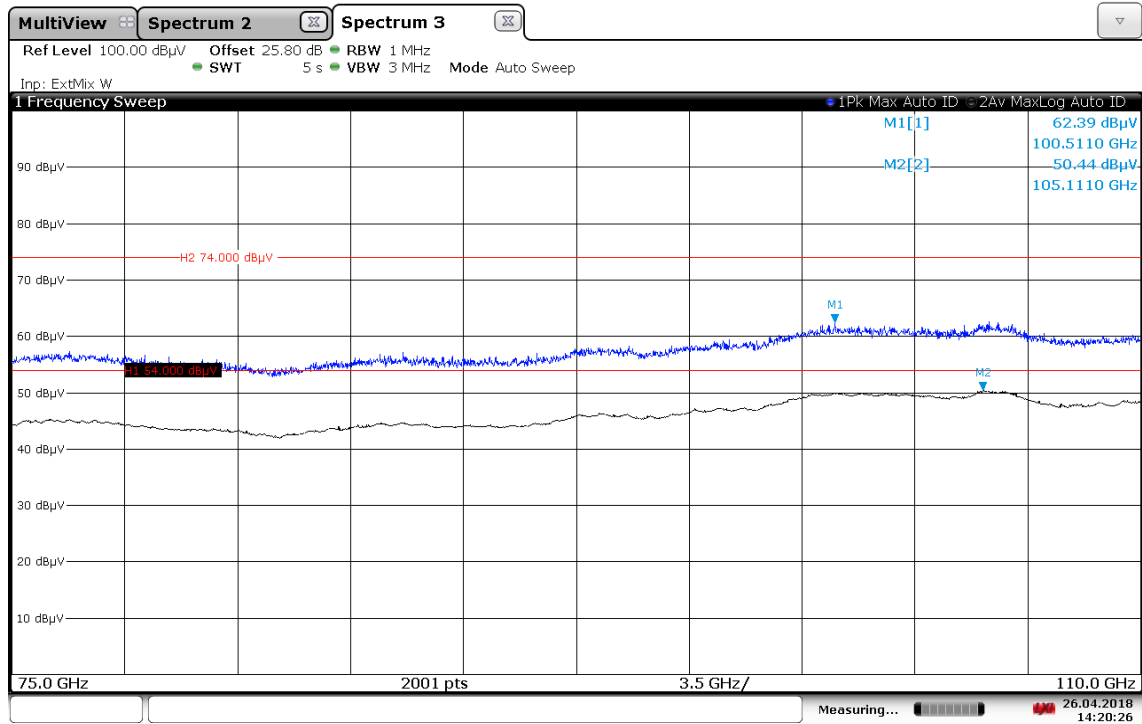
16:59:13 25.04.2018

Plot No. 20: 50 GHz to 75 GHz, horizontal/vertical polarization, low/mid/high frequency, S/N: 00000105



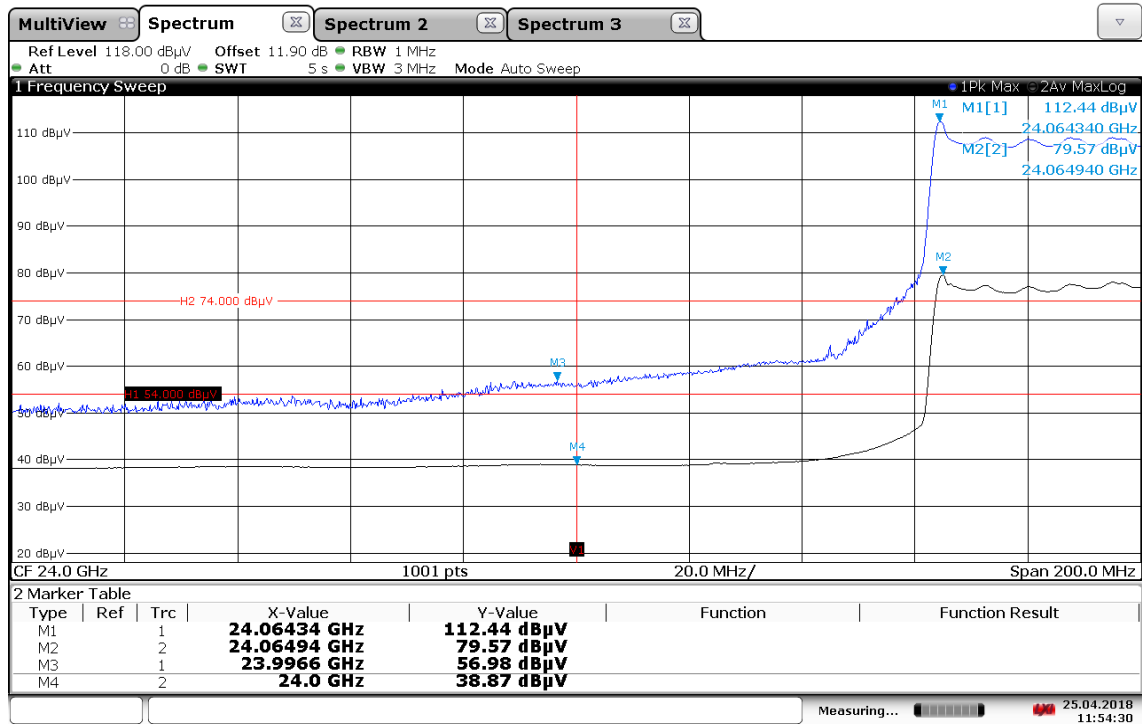
13:47:18 26.04.2018

Plot No. 21: 75 GHz to 110 GHz, horizontal/vertical polarization, low/mid/high frequency, S/N: 00000105



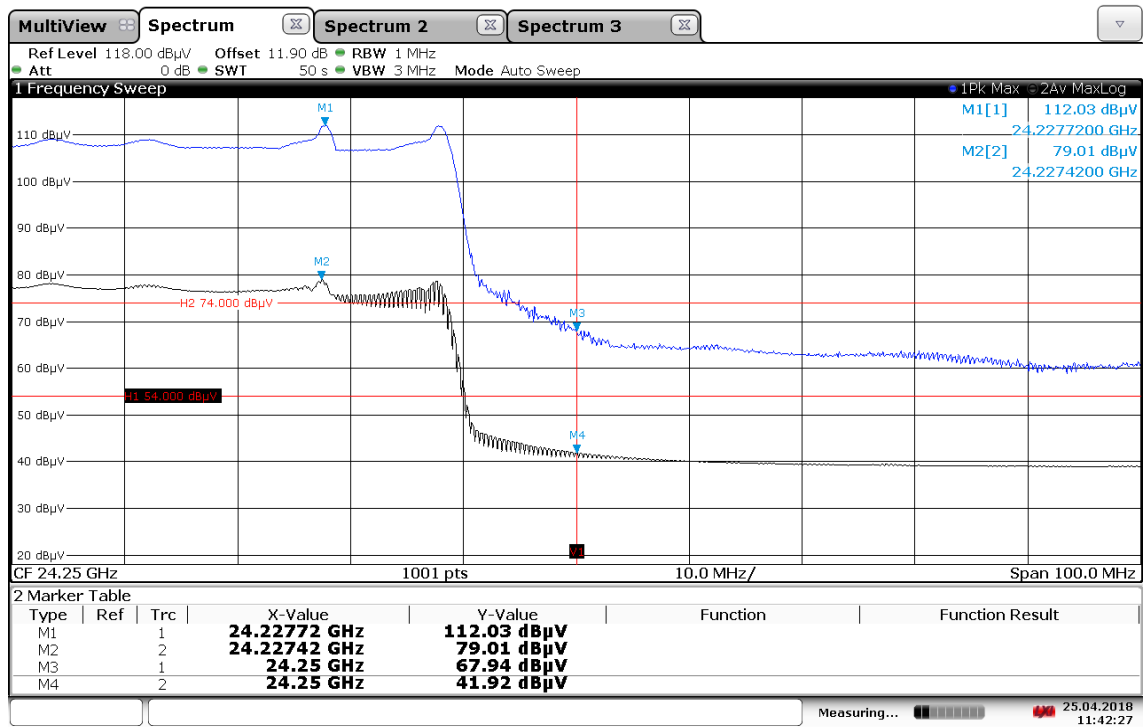
14:20:27 26.04.2018

Plot No. 22: Band-Edge-Compliance, lower band-edge, normal operation mode, S/N: 00000105



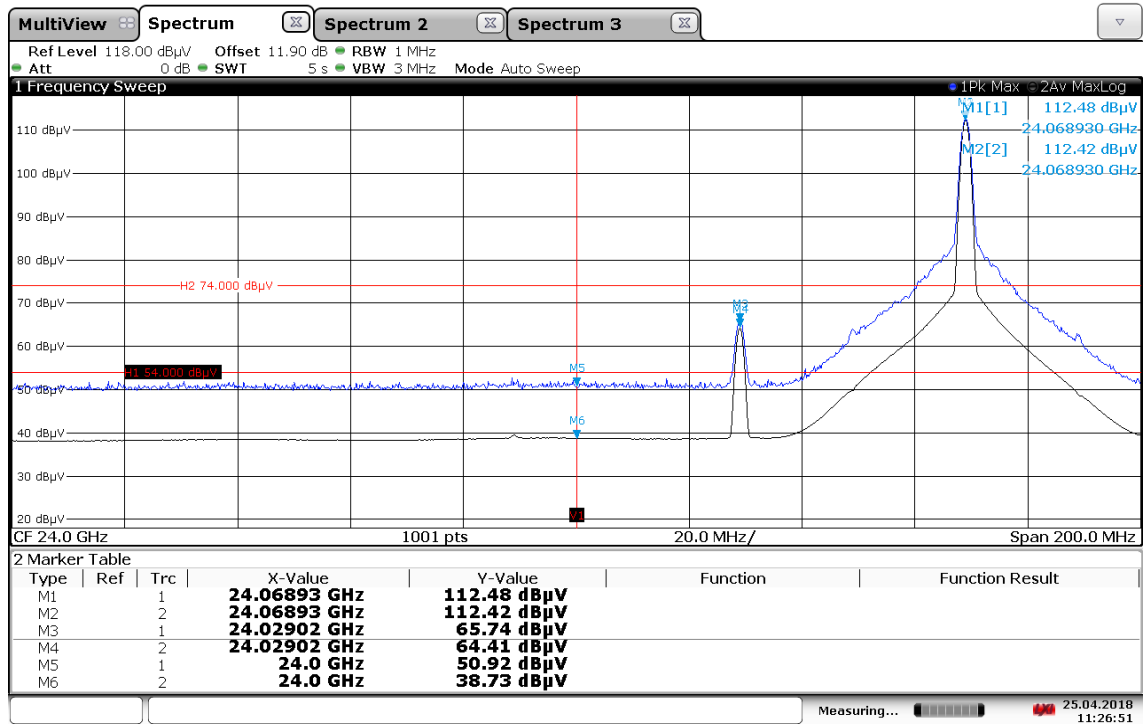
11:54:31 25.04.2018

Plot No. 23: Band-Edge-Compliance, upper band-edge, normal operation mode, S/N: 00000105



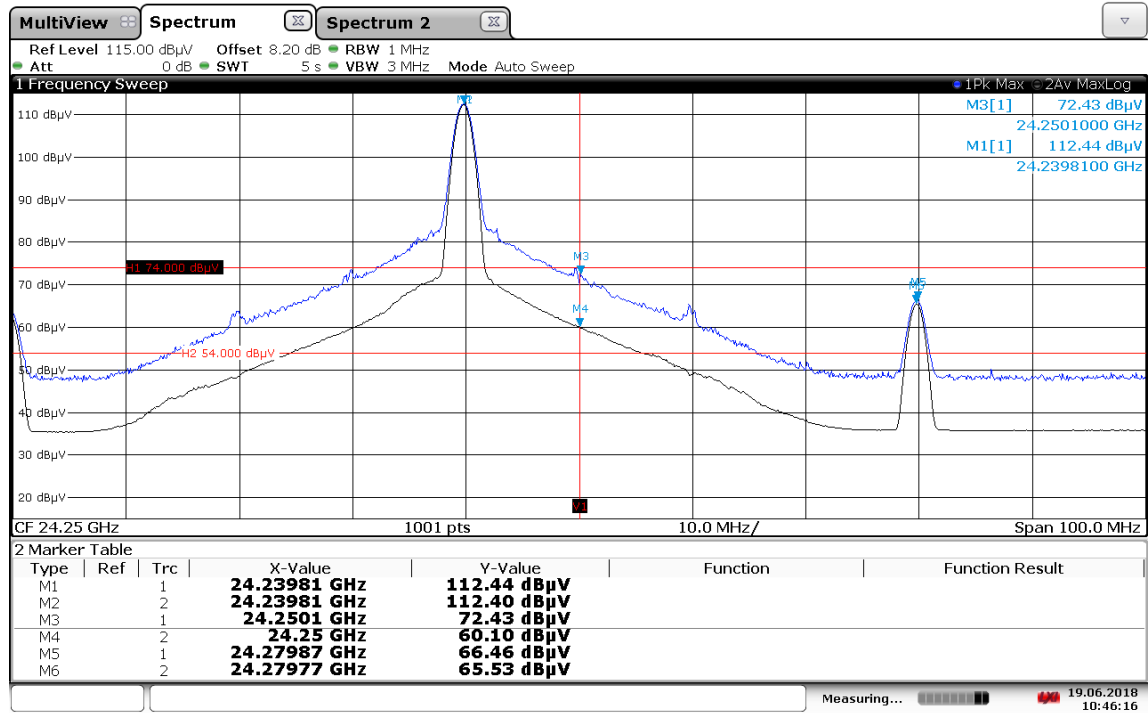
11:42:28 25.04.2018

Plot No. 24: Band-Edge-Compliance, lower band-edge, stopped mode, low frequency, S/N: 00000105



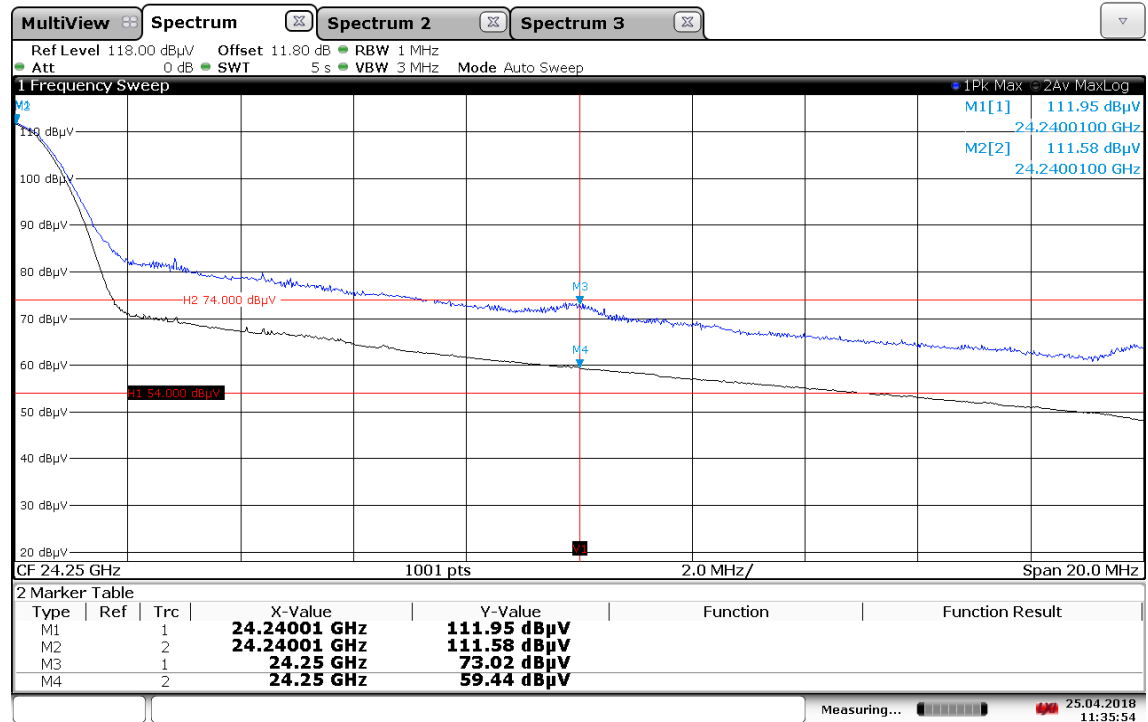
11:26:51 25.04.2018

Plot No. 25: Band-Edge-Compliance, upper band-edge, stopped mode, high frequency, S/N: 00000103



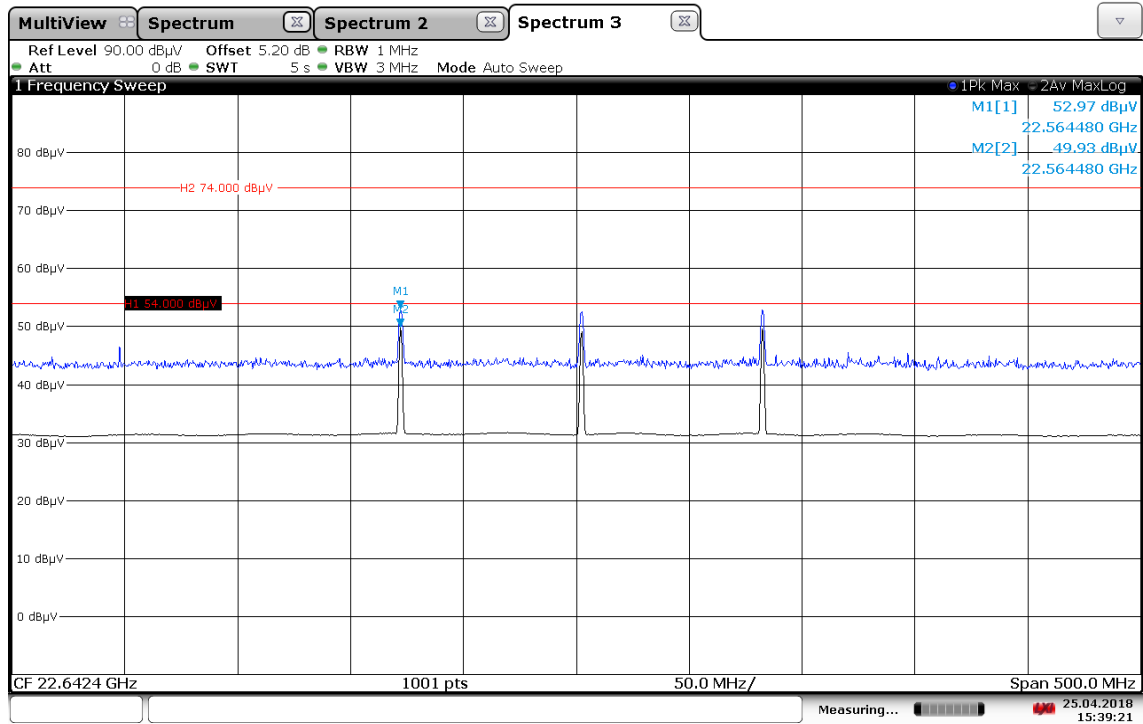
10:46:17 19.06.2018

Plot No. 26: Band-Edge-Compliance, upper band-edge, stopped mode, high frequency, S/N: 00000105

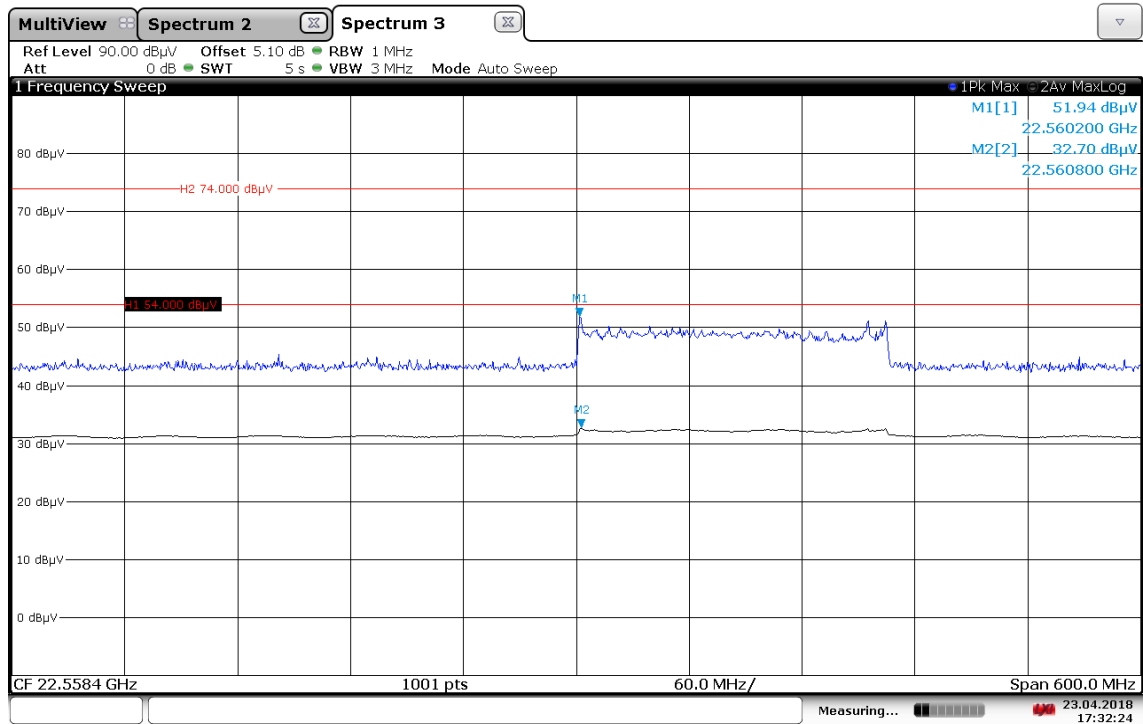


11:35:54 25.04.2018

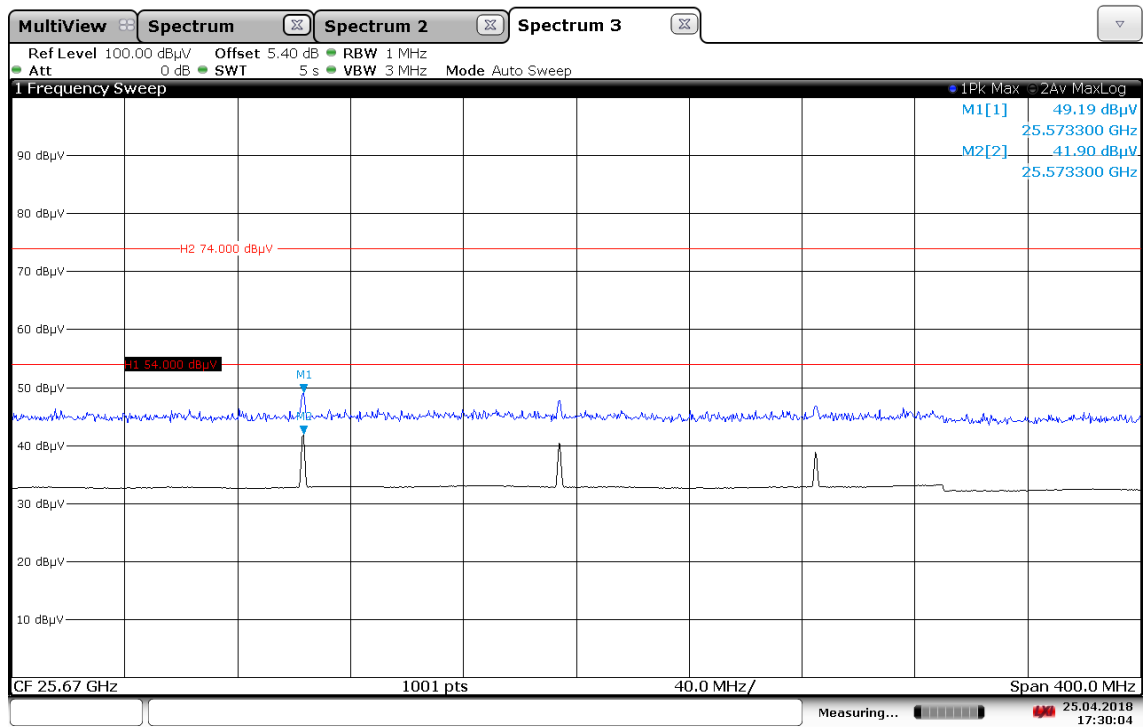
Plot No. 27: Final measurement 22.6 GHz, stopped mode, low/mid/high frequency, S/N: 00000105



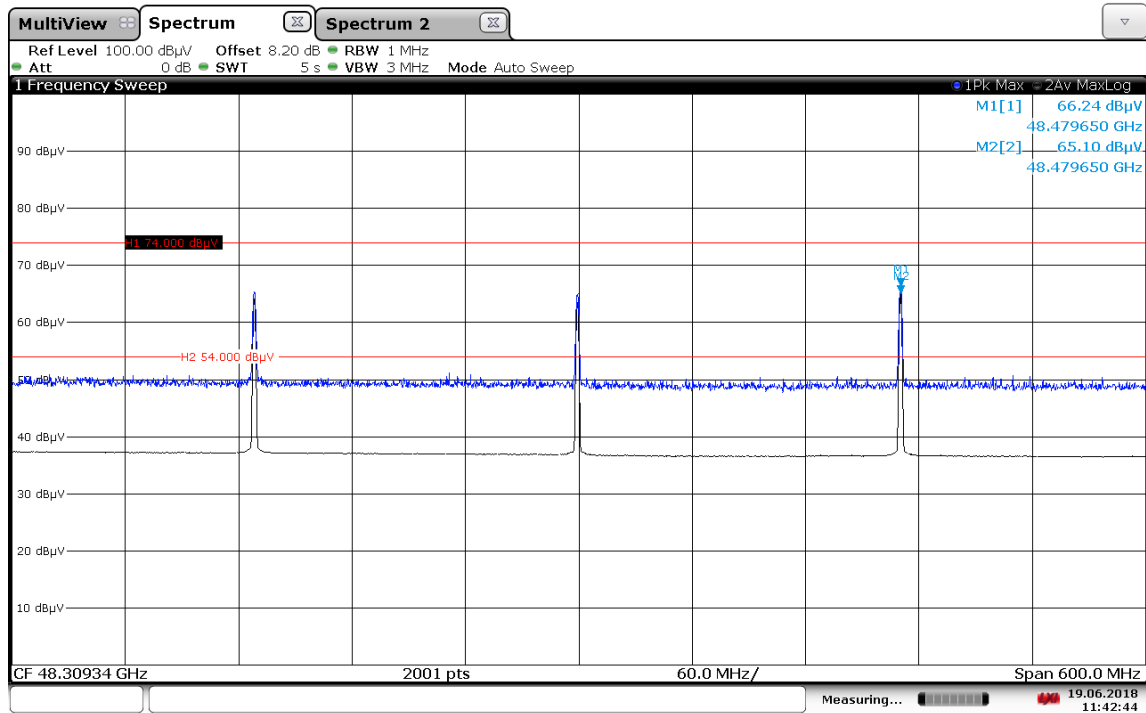
Plot No. 28: Final measurement 22.6 GHz, normal operation mode, low/mid/high frequency, S/N: 00000105



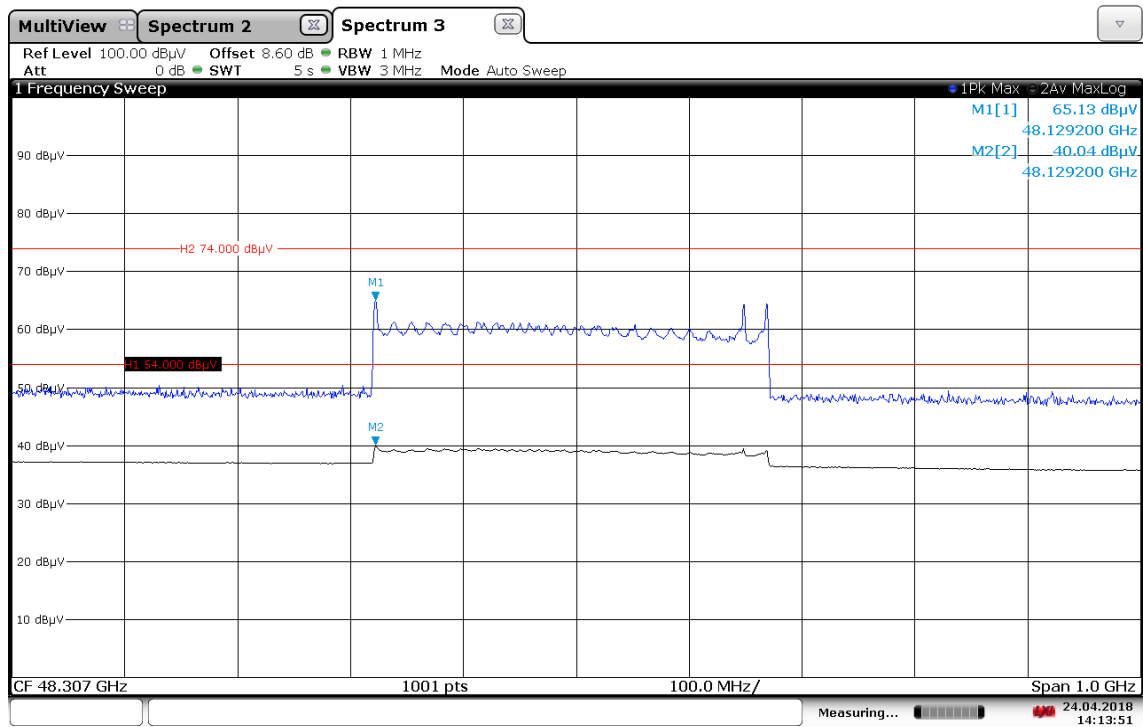
Plot No. 29: Final measurement 25.7 GHz, stopped mode, low/mid/high frequency, S/N: 00000105



17:30:05 25.04.2018

Plot No. 30: Final measurement 2nd harmonic, stopped mode, low/mid/high frequency, S/N: 00000103

11:42:45 19.06.2018

Plot No. 31: Final measurement 2nd harmonic, normal operation mode, S/N: 00000105

14:13:52 24.04.2018

9.4 Conducted 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:

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:

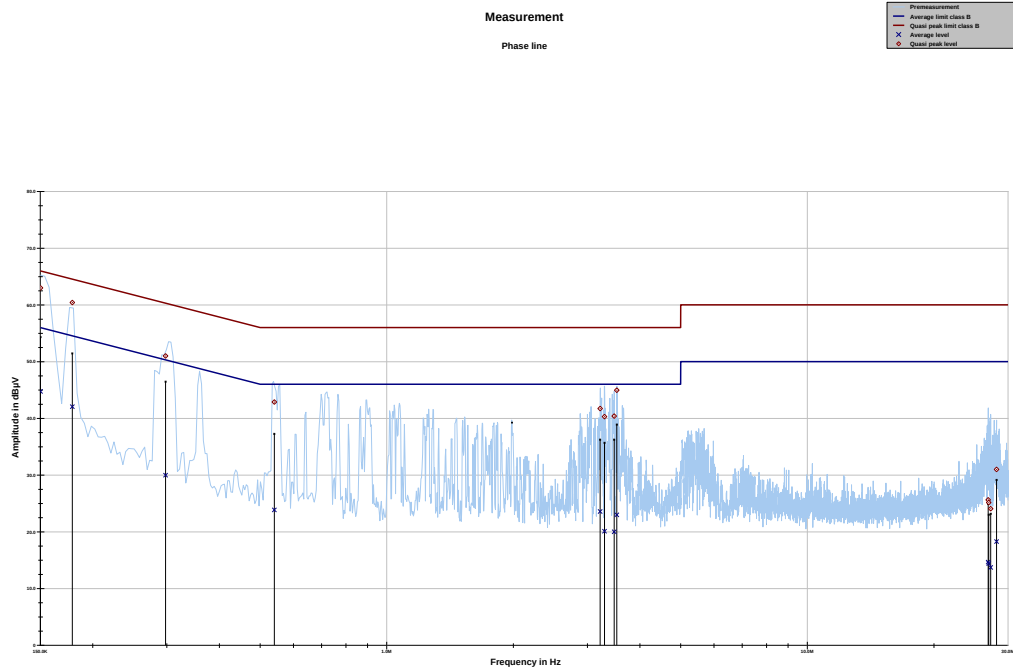
FCC		IC	
CFR Part 15.207(a)		RSS-Gen 8.8	
Conducted Spurious Emissions < 30 MHz			
Frequency (MHz)	Quasi-Peak (dBμV/m)	Average (dBμV/m)	
0.15 – 0.5	66 to 56*	56 to 46*	
0.5 – 5	56	46	
5 – 30.0	60	50	

*Decreases with the logarithm of the frequency

Measurement results:

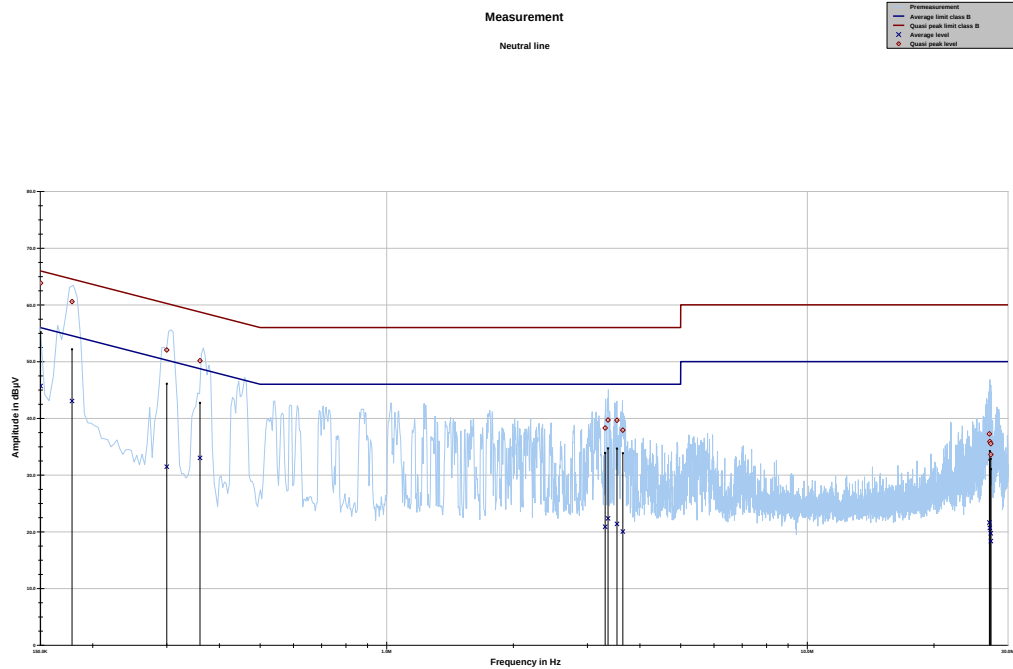
See plots below.

Plot 32: Phase line



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.150261	62.99	2.99	65.986	44.74	11.25	55.993
0.178848	60.41	4.12	64.539	42.06	13.12	55.176
0.298059	51.00	9.30	60.297	29.97	21.80	51.770
0.540536	42.88	13.12	56.000	23.84	22.16	46.000
3.217475	41.72	14.28	56.000	23.58	22.42	46.000
3.295736	40.30	15.70	56.000	20.10	25.90	46.000
3.473725	40.40	15.60	56.000	19.99	26.01	46.000
3.525247	44.96	11.04	56.000	22.99	23.01	46.000
26.922802	25.62	34.38	60.000	14.65	35.35	50.000
27.009988	25.15	34.85	60.000	14.38	35.62	50.000
27.289849	24.07	35.93	60.000	13.71	36.29	50.000
28.180772	30.99	29.01	60.000	18.27	31.73	50.000

Plot 33: Neutral line



Frequency	Quasi peak level	Margin quasi peak	Limit QP	Average level	Margin average	Limit AV
MHz	dBµV	dB	dBµV	dBµV	dB	dBµV
0.150339	63.85	2.13	65.981	45.70	10.29	55.990
0.178554	60.58	3.97	64.553	43.05	12.13	55.184
0.299967	52.05	8.19	60.244	31.47	20.24	51.715
0.359825	50.15	8.58	58.733	33.02	16.98	50.005
3.307236	38.29	17.71	56.000	20.89	25.11	46.000
3.360186	39.70	16.30	56.000	22.36	23.64	46.000
3.527319	39.66	16.34	56.000	21.39	24.61	46.000
3.643269	37.92	18.08	56.000	20.05	25.95	46.000
27.106660	37.26	22.74	60.000	21.64	28.36	50.000
27.169753	35.90	24.10	60.000	20.69	29.31	50.000
27.303945	35.54	24.46	60.000	19.74	30.26	50.000
27.324485	33.62	26.38	60.000	18.36	31.64	50.000

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.

Measurement:

Parameter	
Detector:	Pos-Peak
Sweep time:	5 s
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Trace-Mode:	Max Hold
Measurement uncertainty	Span/1000

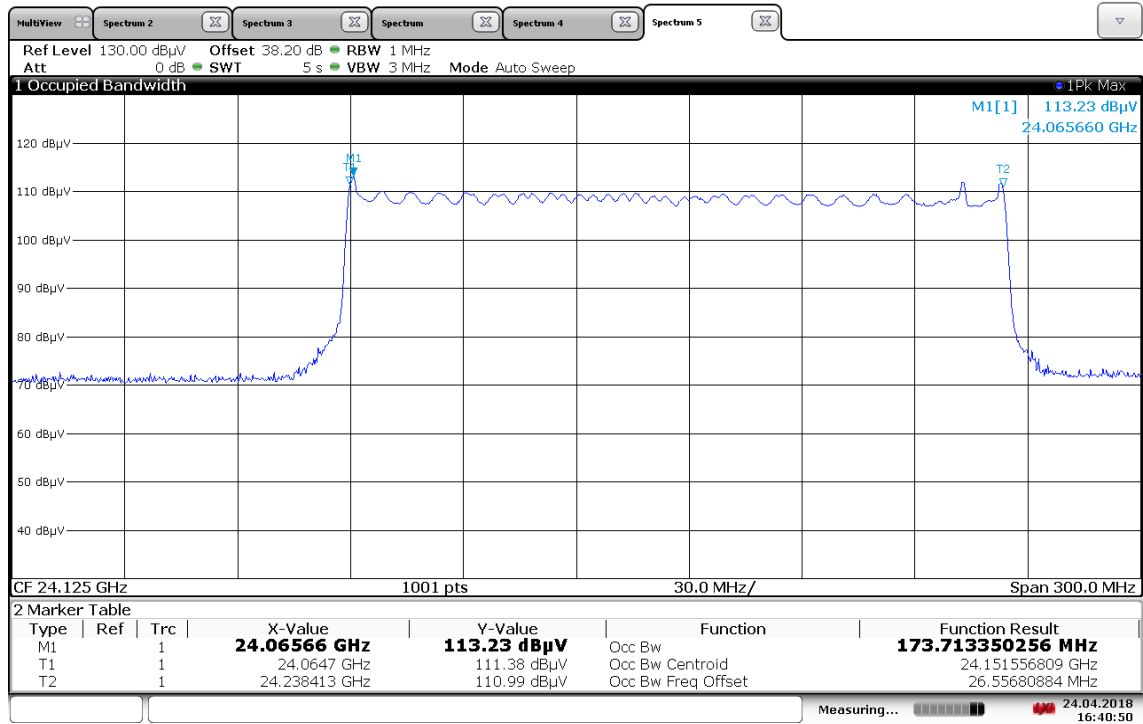
Limits:

FCC	IC
CFR Part 15.215(c)	RSS-Gen 8.11
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.	

Measurement results:

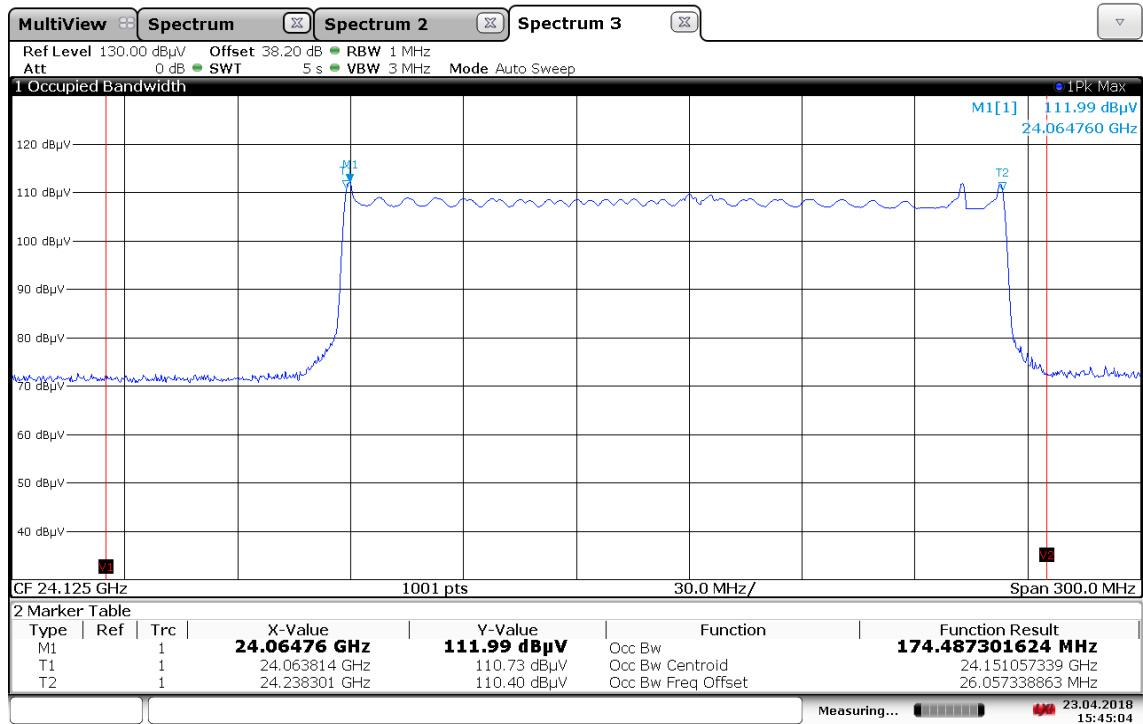
Test Conditions	Frequency (GHz)	Bandwidth (MHz)
-30 °C / V_{nom}	24.065 (f_L), 24.238 (f_H)	173.71
20 °C / $V_{min/nom/max}$	24.064 (f_L), 24.238 (f_H)	174.49
55 °C / V_{nom}	24.064 (f_L), 24.238 (f_H)	174.57

Plot 34: -30 °C, normal operation mode, S/N: 00000103



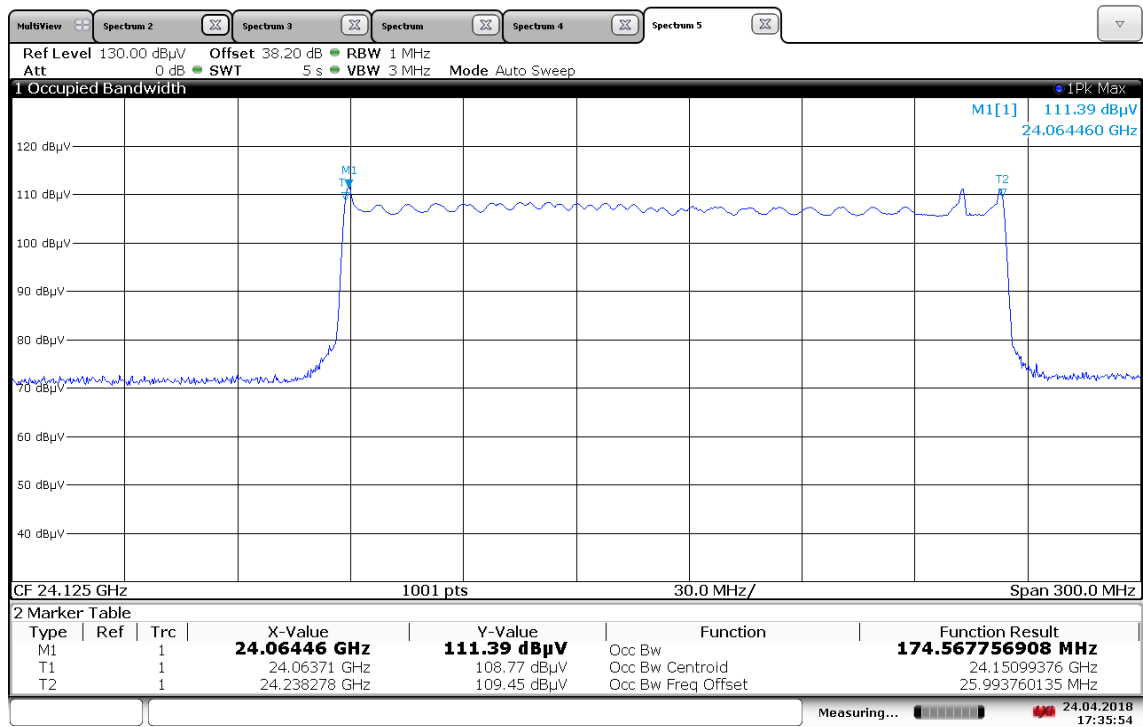
16:40:51 24.04.2018

Plot 35: 20 °C, normal operation mode, S/N: 00000103



15:45:04 23.04.2018

Plot 36: 55 °C, normal operation mode, S/N: 00000103



17:35:55 24.04.2018

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/N₀	Carrier to noise-density ratio, expressed in dB-Hz

Annex B Document history

Version	Applied changes	Date of release
-/-	Initial release - DRAFT	2018-06-21
-/-	Finalist without changes	2018-06-25

Annex C Accreditation Certificate

first page	last page
 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 The accreditation certificate shall only apply in connection with the notice of accreditation of 02.06.2017 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 43 pages. Registration number of the certificate: D-PL-12076-01-03 Frankfurt, 02.06.2017  Head of Division See notes on backsheet	Deutsche Akkreditierungsstelle GmbH Office Berlin Spittelmarkt 10 10117 Berlin Office Frankfurt am Main Europa-Allee 52 60327 Frankfurt am Main Office Braunschweig Bundesallee 100 38116 Braunschweig The publication of extracts of the accreditation certificate is subject to the prior written approval by Deutsche Akkreditierungsstelle GmbH (DAkKS). Exempted is the unchanged form of separate disseminations of the cover sheet by the conformity assessment body mentioned overleaf. No impression shall be made that the accreditation also extends to fields beyond the scope of accreditation attested by DAkKS. The accreditation was granted pursuant to the Act on the Accreditation Body (AkkStelleG) of 31 July 2009 (Federal Law Gazette I p. 2625) and the Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products (Official Journal of the European Union L 218 of 9 July 2008, p. 30). DAkKS is a signatory to the Multilateral Agreements for Mutual Recognition of the European co-operation for Accreditation (EA), International Accreditation Forum (IAF) and International Laboratory Accreditation Cooperation (ILAC). The signatories to these agreements recognise each other's accreditations. The up-to-date state of membership can be retrieved from the following websites: EA: www.european-accreditation.org ILAC: www.ilac.org IAF: www.iaf.nu

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

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