



TEST REPORT

Test report no.: 1-3977/22-03-20

BNNetzA-CAB-02/21-102

Testing laboratory

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Accredited Testing Laboratory:

The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2018-03) by the Deutsche Akkreditierungsstelle GmbH (DAkkS)

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

Applicant

SAGEMCOM BROADBAND SAS

250, route de l' Empereur

92848 Rueil-Malmaison Cedex / FRANCE

Phone: -/-

Contact: Ludovic Bomba

e-mail: ludovic.bomba@sagemcom.com

Manufacturer

SAGEMCOM BROADBAND SAS

250, route de l' Empereur

92848 Rueil-Malmaison Cedex / FRANCE

Test standard/s

FCC - Title 47 CFR Part 27 FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 27 - Miscellaneous wireless communications services

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

Test Item

Kind of test item:	Gateway
Model name:	F5688W
FCC ID:	VW3F5688W
Frequency:	Band 71
Technology tested:	5G NR
Antenna:	4 integrated antennas
Power supply:	120 V AC by power supply unit
Temperature range:	0°C to +50°C

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

Test report authorized:

Michael Dorongovski
Lab Manager
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Test performed:

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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:	2022-12-07
Date of receipt of test item:	2022-09-27
Start of test:*	2022-10-04
End of test:*	2022-12-14
Person(s) present during the test:	-/-

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

2.3 Test laboratories sub-contracted

None

3 Test standard/s, references and accreditations

Test standard	Date	Description
FCC - Title 47 CFR Part 27		FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 27 - Miscellaneous wireless communications services

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 C63.26-2015	-/-	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
Power Meas License Systems: KDB 971168 D01	v03r01	Measurement Guidance for Certification of Licensed Digital Transmitters

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



FCC designation number: DE0002

4 Reporting statements of conformity – decision rule

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3.

The measurement uncertainty is mentioned in this test report, see chapter 9, but is not taken into account - neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong."

measured value, measurement uncertainty, verdict



5 Test environment

Temperature	:	T_{nom} +22 °C during room temperature tests T_{max} +50 °C during high temperature tests T_{min} -30 °C during low temperature tests
Relative humidity content	:	55 %
Barometric pressure	:	1021 hpa
Power supply	:	V_{nom} 120 V AC by power supply unit. V_{max} 138 V AC by external power supply. V_{min} 102 V AC by external power supply.

6 Test item

6.1 General description

Kind of test item	:	Gateway
Model name	:	F5688W
S/N serial number	:	Radiated unit: QS2212959002899 (IMEI: 359509840135591) – WAL SIN QS2212959002968 (IMEI: 359509840060641) – COLFLY QS2212959002883 (IMEI: 359509840060278) – HL Conducted units: IMEI: 359509840061128
Hardware status	:	V1.2
Software status	:	SG520TMDAR02A02M4G_01.001.01.001_V01
Firmware status	:	SG520TMDAR02A02M4G_01.001.01.001_V01
Frequency band	:	Band 71
Type of radio transmission	:	Modulated carrier
Use of frequency spectrum	:	
Type of modulation	:	BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM
Antenna	:	4 integrated antennas
Power supply	:	120 V AC by power supply unit
Temperature range	:	0°C to +50°C

6.2 Additional information

The content of the following annexes is defined in the QA. It may be that not all of the listed annexes are necessary for this report, thus some values in between may be missing.

Test setup and EUT photos are included in test report: 1-3977/22-03-01_AnnexA
 1-3977/22-03-01_AnnexB
 1-3977/22-03-01_AnnexC

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.

8 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).

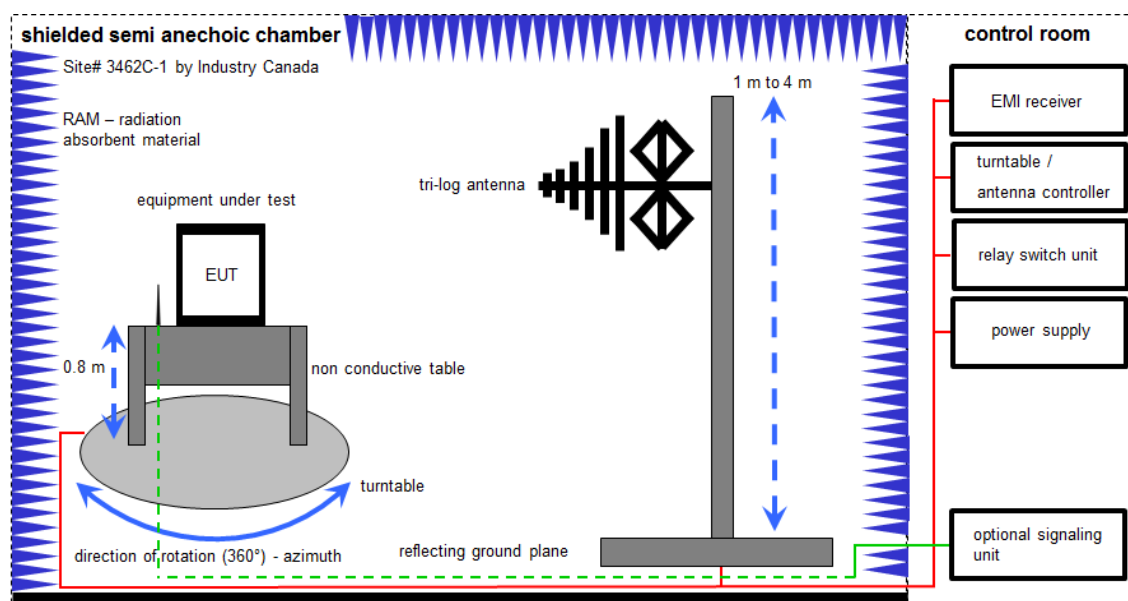
Each block diagram listed can contain several test setup configurations. All devices belonging to a test setup are identified with the same letter syntax. For example: Column Setup and all devices with an A.

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

8.1 Shielded semi anechoic chamber

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



Measurement distance: tri-log antenna 10 meter; EMC32 software version: 10.59.00

$$FS = UR + CL + AF$$

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

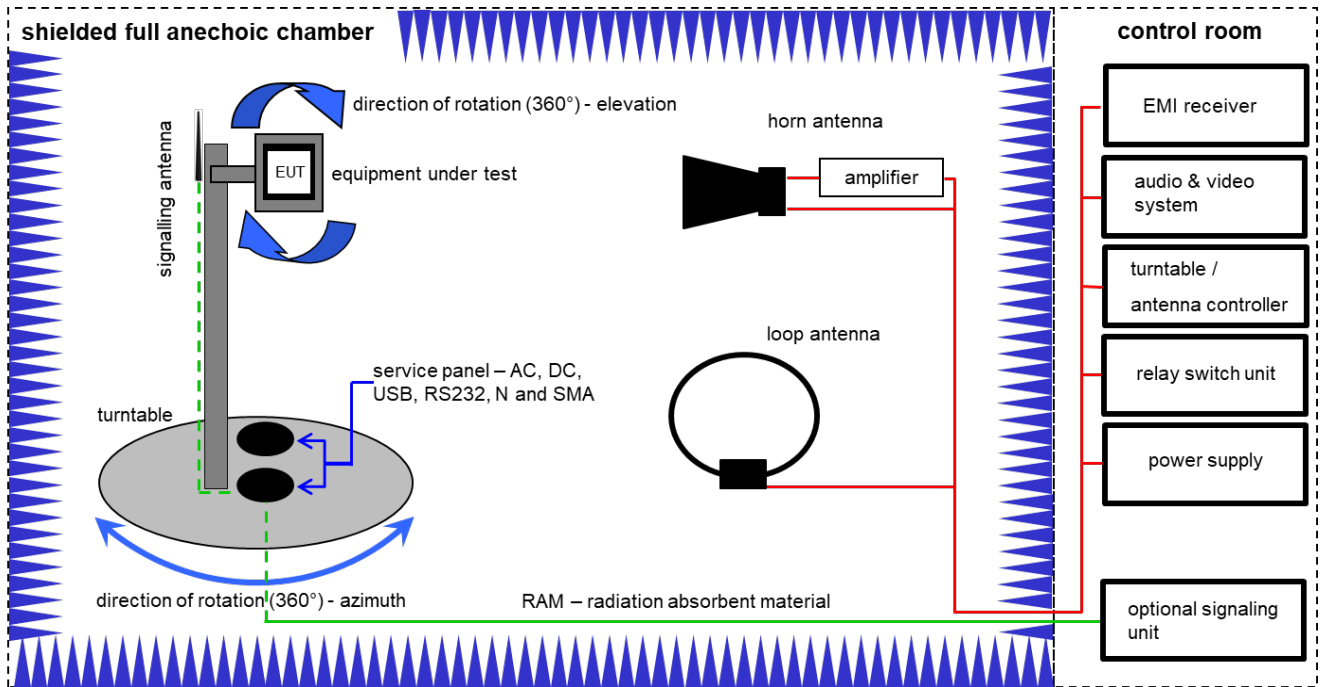
Example calculation:

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

Equipment table:

No.	Lab / Item	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Switch-Unit	3488A	HP	2719A14505	300000368	ev	-/-	-/-
2	A	Meßkabine 1	HF-Absorberhalle	MWB AG 300023	Batch no. 699714	300000551	ne	-/-	-/-
3	A	Antenna Tower	Model 2175	ETS-Lindgren	64762	300003745	izw	-/-	-/-
4	A	Positioning Controller	Model 2090	ETS-Lindgren	64672	300003746	izw	-/-	-/-
5	A	Turntable Interface-Box	Model 105637	ETS-Lindgren	44583	300003747	izw	-/-	-/-
6	A	TRIALOG Broadband Test-Antenna 30 MHz - 3 GHz	VULB9163	Schwarzbeck Mess-Elektronik	295	300003787	vKI!	21.04.2021	20.04.2023
7	A	EMI Test Receiver	ESR3	Rohde & Schwarz	102587	300005771	k	20.05.2022	31.05.2023
8	A	Wideband Radio Communication Tester	CMW500	Rohde & Schwarz	170616	300006251	k	16.09.2021	30.09.2023

8.2 Shielded fully anechoic chamber



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

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

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

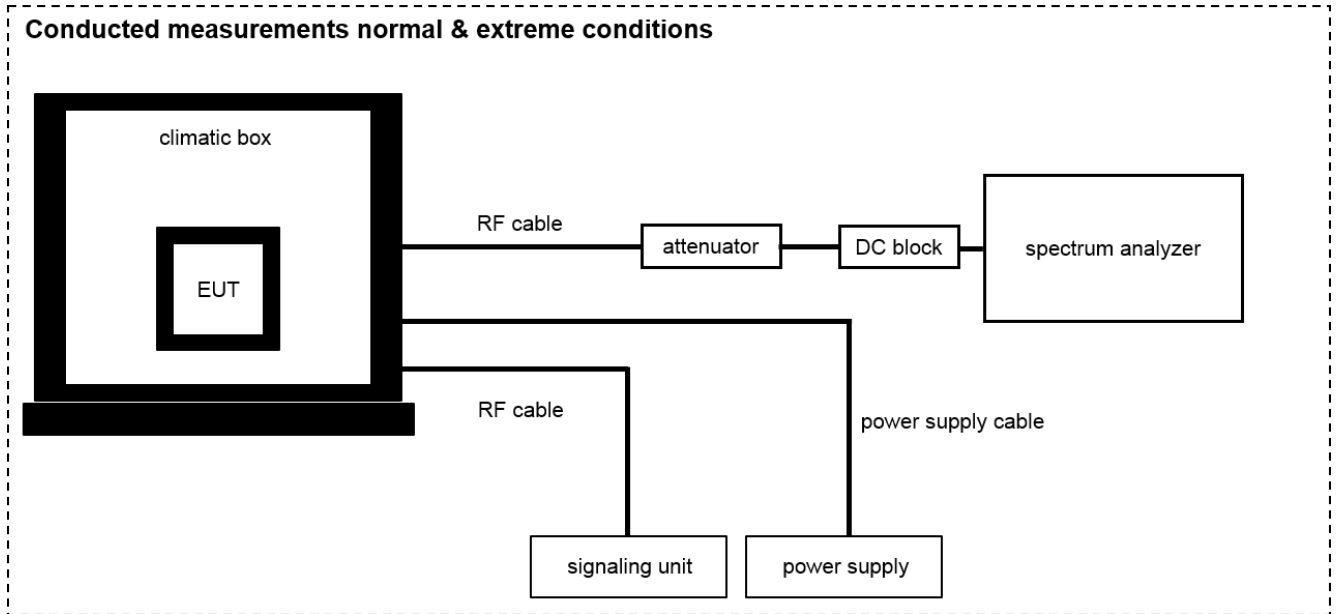
Example calculation:

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

Equipment table:

No.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	B	Active Loop Antenna 9 kHz to 30 MHz	6502	EMCO	2210	300001015	vKI!	01.07.2021	31.07.2023
2	A, B	Anechoic chamber	FAC 3/5m	MWB / TDK	87400/02	300000996	ev	-/-	-/-
3	A	Double-Ridged Waveguide Horn Antenna 1-18.0GHz	3115	EMCO	8812-3089	300000307	vKI!	11.02.2022	29.02.2024
4	A, B	EMI Test Receiver 20Hz- 26,5GHz	ESU26	R&S	100037	300003555	k	09.12.2021	31.12.2022
5	A, B	Highpass Filter	WHK1.1/15G-10SS	Wainwright	3	300003255	ev	-/-	-/-
6	A, B	Highpass Filter	WHKX7.0/18G-8SS	Wainwright	19	300003790	ne	-/-	-/-
7	A	Broadband Amplifier 0.5-18 GHz	CBLU5184540	CERNEX	22049	300004481	ev	-/-	-/-
8	A, B	4U RF Switch Platform	L4491A	Agilent Technologies	MY50000037	300004509	ne	-/-	-/-
9	A, B	NEXIO EMV-Software	BAT EMC V3.21.0.27	EMCO		300004682	ne	-/-	-/-
10	A	RF-Amplifier	AMF-6F06001800-30-10P-R	NARDA-MITEQ Inc	2011572	300005241	ev	-/-	-/-
11	A, B	Wideband Radio Communication Tester	CMW500	Rohde & Schwarz	170616	300006251	k	16.09.2021	30.09.2023

8.3 Conducted measurements normal and extreme conditions



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

Example calculation:

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

Equipment table:

No.	Setup	Equipment	Type	Manufacturer	Serial No.	INV. No.	Kind of Calibration	Last Calibration	Next Calibration
1	A	Signal analyzer	FSV40	Rohde&Schwarz	101042	300004517	k	25.01.2022	31.01.2023
2	A	Teststand	Teststand Custom Sequence Editor	National Instruments GmbH		300004590	ne	-/-	-/-
3	A	RF-Cable	ST18/SMAm/SMAm /72	Huber & Suhner	Batch no. 699714	400001184	ev	-/-	-/-
4	A	DC-Blocker 0.1-40 GHz	8141A	Inmet		400001185	ev	-/-	-/-
5	A	RF-Cable	ST18/SMAm/SMAm /36	Huber & Suhner	Batch no. 601494	400001309	ev	-/-	-/-
6	A	Temperature Test Chamber	T-40/50	CTS GmbH	064023	300003540	ev	09.05.2022	08.05.2024
7	A	Wideband Radio Communication Tester	CMW500	Rohde & Schwarz	170616	300006251	k	16.09.2021	30.09.2023

9 Measurement uncertainty

Measurement uncertainty		
Test case	Uncertainty	
Antenna gain	± 3 dB	
99 % bandwidth	± RBW	
-26 dB bandwidth	± RBW	
Frequency stability	10 ⁻⁶	
Maximum output power conducted	± 1.56 dB	
Block edge compliance	± 1.56 dB	
Spurious emissions conducted	> 3.6 GHz	± 1.56 dB
	> 7 GHz	± 1.56 dB
	> 18 GHz	± 2.31 dB
	≥ 40 GHz	± 2.97 dB
Spurious emissions radiated below 30 MHz	± 3 dB	
Spurious emissions radiated 30 MHz to 1 GHz	± 3 dB	
Spurious emissions radiated 1 GHz to 12.75 GHz	± 3.7 dB	
Spurious emissions radiated above 12.75 GHz	± 4.5 dB	

10 Additional information and comments

Reference documents: Customer Questionnaire_F5688W_Sagemcom_v3.docx
F5866WTMO_ANTENNA MAPPING_v2.xlsx
1-3977_22-03-20_Annex_MR_A1

Special test descriptions: Although the device has 4 integrated antennas, only antenna 1 (LTE_M) is used for TX mode for 5G.
Supported bandwidths for 5G NR band 71: 5 MHz, 10 MHz, 15 MHz and 20 MHz
CP-OFDM and DFT-s-OFDM were investigated and DFT-s-OFDM was found to be the worst case.
For 5G NR tests the MT8000A from Anritsu was used.

Configuration descriptions: None

EUT selection:

- Only one device available
- Devices selected by the customer
- Devices selected by the laboratory (Randomly)

11 Summary of measurement results

<input checked="" type="checkbox"/>	No deviations from the technical specifications were ascertained
<input type="checkbox"/>	There were deviations from the technical specifications ascertained
<input type="checkbox"/>	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: CFR Part 2 & Part 27	See table!	2023-01-18	-/-

11.1 Part 27: 5G NR band 71

Test Case	temperature conditions	power source voltages	C	NC	NA	NP	Remark
RF Output Power	Nominal	Nominal	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
Frequency Stability	Extreme	Extreme	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
Spurious Emissions Radiated	Nominal	Nominal	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
Spurious Emissions Conducted	Nominal	Nominal	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
Block Edge Compliance	Nominal	Nominal	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-
Occupied Bandwidth	Nominal	Nominal	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	-/-

Notes:

C	Compliant	NC	Not compliant	NA	Not applicable	NP	Not performed
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12 RF measurements

12.1 Description of test setup

For the spurious measurements we use the substitution method according TIA/EIA 603.

12.2 Results 5G NR band 71

The EUT was set to transmit the maximum power.

Channel bandwidth

	Band 71	-/-
		-/-
[MHz]		
5	☒	
10	☒	
15	☒	
20	☒	

12.2.1 RF output power

Description:

This paragraph contains average power, peak output power and EIRP measurements for the mobile station. In all cases, the peak output power is within the required mask (this mask is specified in the JTC standards, TIA PN3389 Vol. 1 Chap 7, and is no FCC requirement).

Measurement:

The mobile was set up for the maximum output power with pseudo random data modulation.

To determine the Peak-To-Average Power Ratio (PAPR) the measurement was performed with the Power Complementary Cumulative Distribution Function (CCDF).

Measurement parameters	
Detector:	Sample
AQT:	See plot
Resolution bandwidth:	40 MHz
Used equipment:	See chapter 8.1 setup A & 8.3 setup A
Measurement uncertainty:	See chapter 9
Measurement procedure:	FCC: § 2.1046

Limits:

FCC
§27.50(c)(10)
Portable stations (hand-held devices) in the 600 MHz uplink band and the 698-746 MHz band, and fixed and mobile stations in the 600 MHz uplink band are limited to 3 watts ERP.
Power: 34.77 dBm ERP PAPR: Reporting only

Results:

Output Power (conducted)							
Bandwidth (MHz)	Channel No. / Frequency (MHz)	Resource block allocation	Average Output Power (dBm) BPSK	Average Output Power (dBm) QPSK	Average Output Power (dBm) 16-QAM	Average Output Power (dBm) 64-QAM	Average Output Power (dBm) 256-QAM
5	133100 / 665.5	1 RB low	23.0	22.4	21.5	20.6	19.1
		1 RB low+1	23.7	23.5	22.8	20.6	18.8
		1 RB high-1	23.4	22.8	22.0	21.0	18.9
		1 RB high	23.9	24.0	23.0	21.1	18.8
		50% RB mid	24.0	23.8	23.0	21.5	19.4
		100% RB	23.3	22.9	21.8	21.3	19.3
	136100 / 680.5	1 RB low	23.4	22.9	22.1	20.9	19.1
		1 RB low+1	23.9	24.1	23.1	21.1	19.0
		1 RB high-1	23.4	22.9	22.0	21.1	18.9
		1 RB high	23.8	23.9	23.1	20.9	18.9
		50% RB mid	23.9	24.0	22.9	21.4	19.4
		100% RB	23.4	22.9	21.9	21.4	19.4
	139100 / 695.5	1 RB low	23.4	23.0	22.0	21.2	19.1
		1 RB low+1	23.9	24.0	23.2	21.2	19.0
		1 RB high-1	23.3	22.9	22.0	20.9	18.8
		1 RB high	23.8	24.0	23.2	21.0	19.1
		50% RB mid	24.0	24.0	23.0	21.5	19.4
		100% RB	23.4	22.9	21.9	21.4	19.4
10	133600 / 668.0	1 RB low	23.3	22.9	22.0	21.0	19.0
		1 RB low+1	23.6	23.6	22.8	21.2	18.9
		1 RB high-1	23.9	24.1	23.0	21.1	18.9
		1 RB high	23.9	24.0	23.3	21.2	18.9
		50% RB mid	23.9	23.8	22.9	21.3	19.2
		100% RB	23.3	22.8	21.8	21.3	19.2
	136100 / 680.5	1 RB low	23.5	23.0	22.2	21.1	19.1
		1 RB low+1	23.9	24.0	23.1	20.9	18.8
		1 RB high-1	23.9	23.9	23.2	21.0	18.8
		1 RB high	23.9	24.1	23.1	21.0	18.9
		50% RB mid	23.9	24.0	22.9	21.4	19.3
		100% RB	23.4	22.9	21.8	21.4	19.4
	138600 / 693.0	1 RB low	23.6	23.0	22.1	21.3	19.0
		1 RB low+1	23.9	24.0	23.1	21.0	18.8
		1 RB high-1	23.9	24.0	23.1	21.1	18.9
		1 RB high	23.9	24.0	23.1	20.9	18.9
		50% RB mid	24.0	23.9	22.8	21.3	19.3
		100% RB	23.5	22.8	21.8	21.3	19.4
15	134100 / 670.5	1 RB low	23.1	23.1	22.0	21.2	19.2
		1 RB low+1	23.9	23.8	22.8	21.2	19.4

Output Power (conducted)							
Bandwidth (MHz)	Channel No. / Frequency (MHz)	Resource block allocation	Average Output Power (dBm) BPSK	Average Output Power (dBm) QPSK	Average Output Power (dBm) 16-QAM	Average Output Power (dBm) 64-QAM	Average Output Power (dBm) 256-QAM
		1 RB high-1	24.0	24.1	23.2	21.3	18.9
		1 RB high	24.0	24.2	23.1	21.4	19.2
		50% RB mid	24.1	24.1	23.2	21.2	19.0
		100% RB	23.7	23.0	22.0	21.5	19.6
	136100 / 680.5	1 RB low	23.6	23.2	22.2	21.3	19.2
		1 RB low+1	24.1	24.1	23.2	21.3	19.1
		1 RB high-1	24.0	24.1	23.2	21.2	19.0
		1 RB high	24.0	24.1	23.3	21.0	19.0
		50% RB mid	24.1	24.1	23.2	21.2	19.0
		100% RB	23.6	23.1	22.1	21.7	19.5
	138100 / 690.5	1 RB low	23.6	23.0	22.3	21.1	19.3
		1 RB low+1	24.0	24.2	23.2	21.2	19.3
		1 RB high-1	24.0	24.0	23.2	21.2	19.1
		1 RB high	23.9	23.9	23.2	21.3	18.9
		50% RB mid	24.0	24.1	23.3	21.1	19.1
100% RB		23.5	22.9	22.0	21.5	19.4	
20	134600 / 673.0	1 RB low	23.7	23.0	22.2	21.2	18.7
		1 RB low+1	24.0	23.8	22.8	21.2	19.1
		1 RB high-1	24.0	24.1	23.3	21.1	19.1
		1 RB high	24.0	24.0	23.2	21.2	19.1
		50% RB mid	24.1	24.1	23.0	21.6	19.5
		100% RB	23.6	23.0	22.0	21.5	19.5
	136100 / 680.5	1 RB low	23.6	23.3	22.4	21.3	19.0
		1 RB low+1	24.1	24.2	23.3	21.3	19.0
		1 RB high-1	23.9	24.0	23.2	20.9	19.1
		1 RB high	23.9	24.0	23.1	21.0	19.0
		50% RB mid	24.1	24.0	22.9	21.6	19.5
		100% RB	23.6	23.0	21.9	21.6	19.6
	137600 / 688.0	1 RB low	23.6	23.2	22.2	21.3	19.3
		1 RB low+1	24.0	24.1	23.2	21.2	19.0
		1 RB high-1	23.9	24.1	23.2	21.0	19.0
		1 RB high	24.0	24.1	23.1	21.1	19.3
		50% RB mid	24.2	24.0	22.9	21.6	19.5
		100% RB	23.6	23.0	22.0	21.5	19.5

The radiated output power is measured in the mode with the highest conducted output power.

Output Power (ERP)						
Bandwidth (MHz)	Channel / Frequency (MHz)	Average Output Power (dBm)	Average Output Power (dBm)	Average Output Power (dBm)	Average Output Power (dBm)	Average Output Power (dBm)
		BPSK	QPSK	16-QAM	64-QAM	256-QAM
5	133100 / 665.5	25.1	25.1	24.1	22.6	20.5
	136100 / 680.5	25.0	25.2	24.2	22.5	20.5
	139100 / 695.5	25.1	25.1	24.3	22.6	20.5
10	133600 / 668.0	25.0	25.2	24.4	22.4	20.3
	136100 / 680.5	25.0	25.2	24.3	22.5	20.5
	138600 / 693.0	25.1	25.1	24.2	22.4	20.5
15	134100 / 670.5	25.2	25.3	24.3	22.6	20.7
	136100 / 680.5	25.2	25.2	24.4	22.8	20.6
	138100 / 690.5	25.1	25.3	24.4	22.6	20.5
20	134600 / 673.0	25.2	25.2	24.4	22.7	20.6
	136100 / 680.5	25.2	25.3	24.4	22.7	20.7
	137600 / 688.0	25.3	25.2	24.3	22.7	20.6

PAPR (conducted)							
Bandwidth (MHz)	Channel / Frequency (MHz)	Resource block allocation	Peak to Average Ratio (dB)	Peak to Average Ratio (dB)	Peak to Average Ratio (dB)	Peak to Average Ratio (dB)	Peak to Average Ratio (dB)
		RB Allocation	BPSK	QPSK	16-QAM	64-QAM	256-QAM
5	133100 / 665.5	100% RB	4.00	4.67	5.77	6.09	6.55
	136100 / 680.5	100% RB	4.00	4.55	5.74	6.06	6.46
	139100 / 695.5	100% RB	4.06	4.70	5.91	6.14	6.49
10	133600 / 668.0	100% RB	3.97	4.87	5.91	6.23	6.52
	136100 / 680.5	100% RB	3.86	4.52	5.65	6.06	6.67
	138600 / 693.0	100% RB	4.12	4.75	5.88	6.23	6.70
15	134100 / 670.5	100% RB	4.00	4.90	5.86	6.20	6.75
	136100 / 680.5	100% RB	4.06	5.04	6.00	6.35	6.67
	138100 / 690.5	100% RB	4.26	4.87	5.86	6.29	6.72
20	134600 / 673.0	100% RB	4.06	5.22	5.54	6.00	6.67
	136100 / 680.5	100% RB	4.12	4.95	5.93	6.02	6.60
	137600 / 688.0	100% RB	4.26	5.01	5.99	6.22	6.39

12.2.2 Frequency stability

Description:

In order to measure the carrier frequency under the condition of AFC lock, it is necessary to make measurements with the mobile station in a "call mode". This is accomplished with the use of a MT8000A DIGITAL RADIOCOMMUNICATION TESTER.

1. Measure the carrier frequency at room temperature.
2. Subject the mobile station to overnight soak at -30 C.
3. With the mobile station, powered with V_{nom} , connected to the MT8000A and in a simulated call on channel 133297 (center channel), measure the carrier frequency. These measurements should be made within two minutes of powering up the mobile station, to prevent significant self warming.
4. Repeat the above measurements at 10°C increments from -30°C to +50°C. Allow at least 1.5 hours at each temperature, unpowered, before making measurements.
5. Re-measure carrier frequency at room temperature with V_{nom} . Vary supply voltage from V_{min} to V_{max} , in 0.1 Volt steps re-measuring carrier frequency at each voltage. Pause at V_{nom} for 1.5 hours unpowered, to allow any self heating to stabilize, before continuing.
6. At all temperature levels hold the temperature to +/- 0.5°C during the measurement procedure.

Measurement:

Measurement parameters	
Detector:	Measured with MT8000A
Sweep time:	
Video bandwidth:	
Resolution bandwidth:	
Span:	
Trace mode:	
Used equipment:	See chapter 8.3 setup A
Measurement uncertainty:	See chapter 9
Measurement procedure:	FCC: § 2.1055

Limits:

FCC
§27.54
The frequency stability shall be sufficient to ensure that the fundamental emissions stay within the authorized bands of operation.

Results:**AFC FREQ ERROR versus VOLTAGE**

Voltage (V)	Frequency Error (Hz)	Frequency Error (ppm)
102	-9	-0.0132
120	3	0.0044
138	4	0.0059

AFC FREQ ERROR versus TEMPERATURE

Temperature (°C)	Frequency Error (Hz)	Frequency Error (ppm)
-30	-10	-0.0147
-20	-10	-0.0147
-10	-9	-0.0132
± 0	3	0.0044
10	-8	-0.0118
20	-8	-0.0118
30	-9	-0.0132
40	-9	-0.0132
50	-10	-0.0147

12.2.3 Spurious emissions radiated

Description:

The following steps outline the procedure used to measure the radiated emissions from the mobile station. The site is constructed in accordance with ANSI C63.4:2014 requirements and is recognized by the FCC to be in compliance for a 3 and a 10 meter site. The spectrum was scanned from 30 MHz to the 10th harmonic of the highest frequency generated within the equipment. The resolution bandwidth is set as outlined in Part 27.53. The spectrum was scanned with the mobile station transmitting at carrier frequencies that pertain to low, middle and highest channels of the 5G NR band 71.

Measurement:

Measurement parameters	
Detector:	Peak
Sweep time:	2 sec.
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Span:	100 MHz Steps
Trace mode:	Max Hold
Used equipment:	See chapter 8.1 setup A & 8.2 setup A+B
Measurement uncertainty:	See chapter 9
Measurement procedure	FCC: § 2.1053

Limits:

FCC
§ 27.53 (g)
For operations in the 600 MHz band and the 698-746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least $43 + 10 \log (P)$ dB. Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kilohertz or greater. However, in the 100 kilohertz bands immediately outside and adjacent to a licensee's frequency block, a resolution bandwidth of at least 30 kHz may be employed
-13 dBm

Results:

BPSK:

Spurious Emission Level					
Lowest channel		Middle channel		Highest channel	
Spurious emissions	Level [dBm]	Spurious emissions	Level [dBm]	Spurious emissions	Level [dBm]
-/-		-/-		-/-	

QPSK:

Spurious Emission Level					
Lowest channel		Middle channel		Highest channel	
Spurious emissions	Level [dBm]	Spurious emissions	Level [dBm]	Spurious emissions	Level [dBm]
-/-		-/-		-/-	

16-QAM:

Spurious Emission Level					
Lowest channel		Middle channel		Highest channel	
Spurious emissions	Level [dBm]	Spurious emissions	Level [dBm]	Spurious emissions	Level [dBm]
-/-		-/-		-/-	

64-QAM:

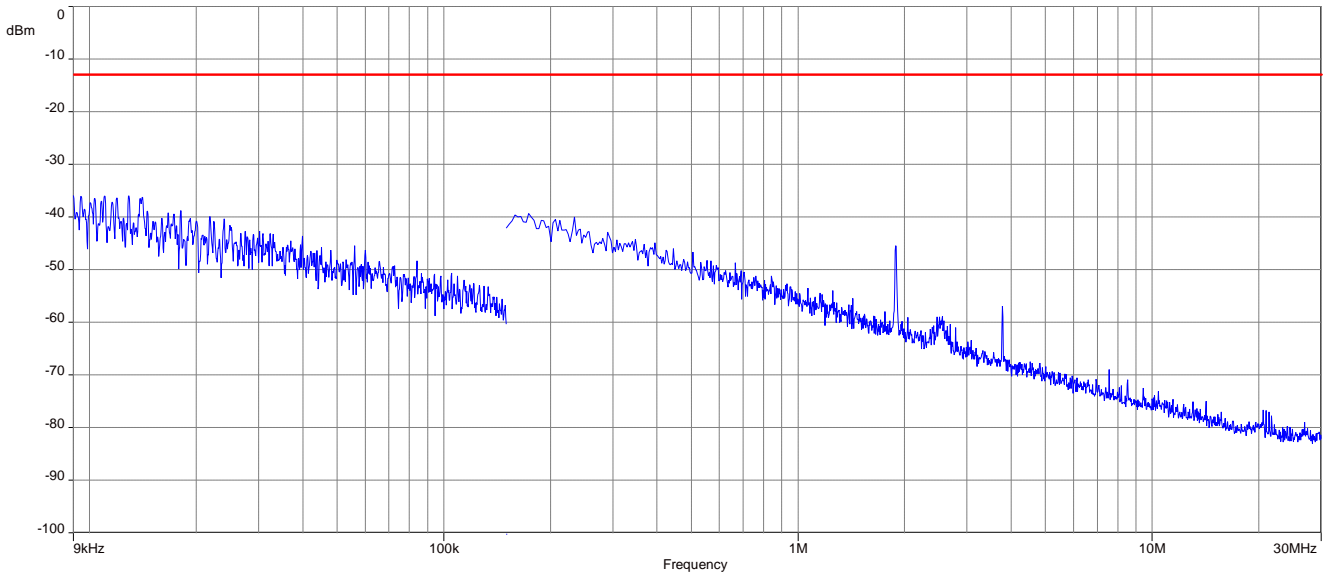
Spurious Emission Level					
Lowest channel		Middle channel		Highest channel	
Spurious emissions	Level [dBm]	Spurious emissions	Level [dBm]	Spurious emissions	Level [dBm]
-/-		-/-		-/-	

256-QAM:

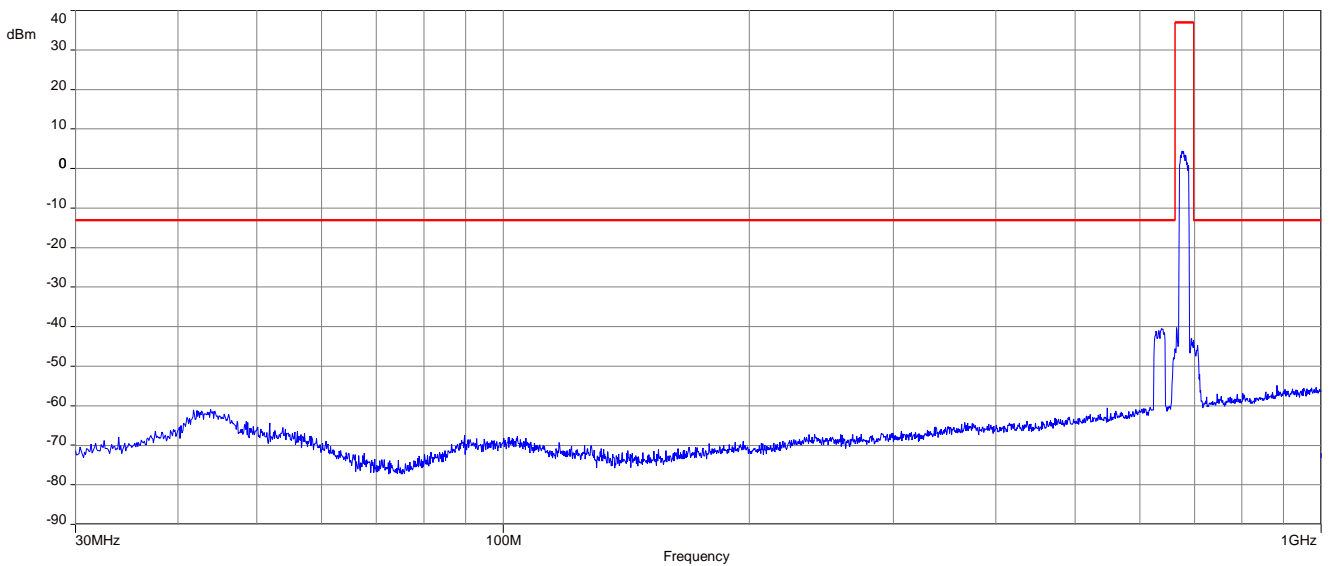
Spurious Emission Level					
Lowest channel		Middle channel		Highest channel	
Spurious emissions	Level [dBm]	Spurious emissions	Level [dBm]	Spurious emissions	Level [dBm]
-/-		-/-		-/-	

Plots:

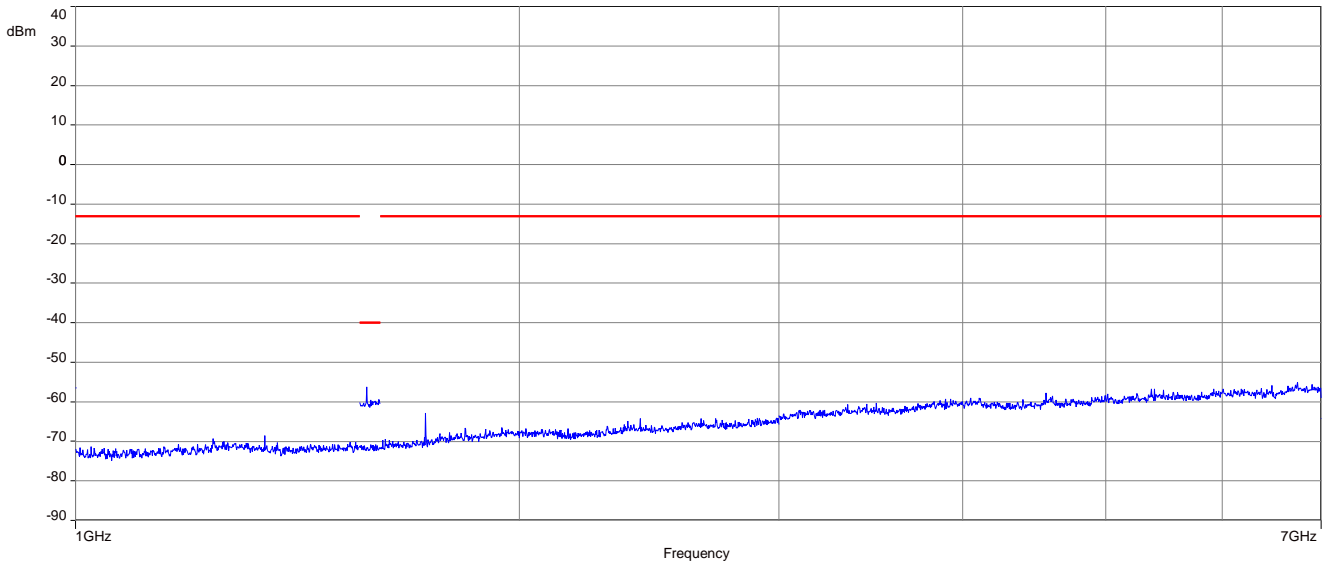
Plot 1: BPSK - Middle channel (9 kHz - 30 MHz)



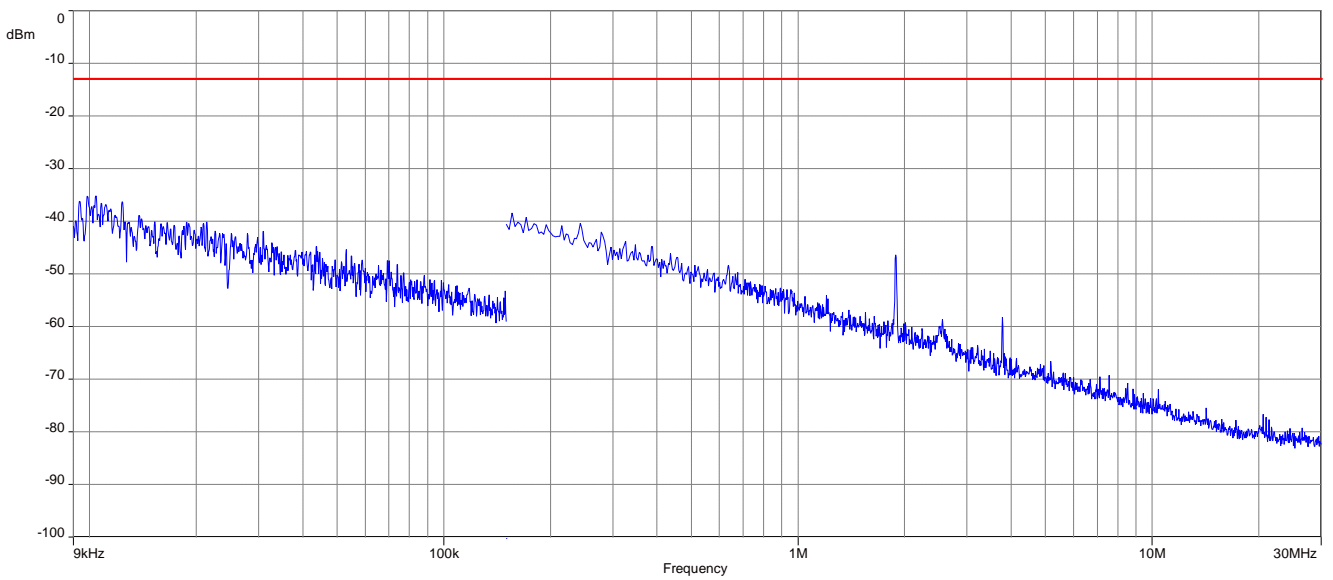
Plot 2: BPSK - Middle channel (30 MHz – 1 GHz)



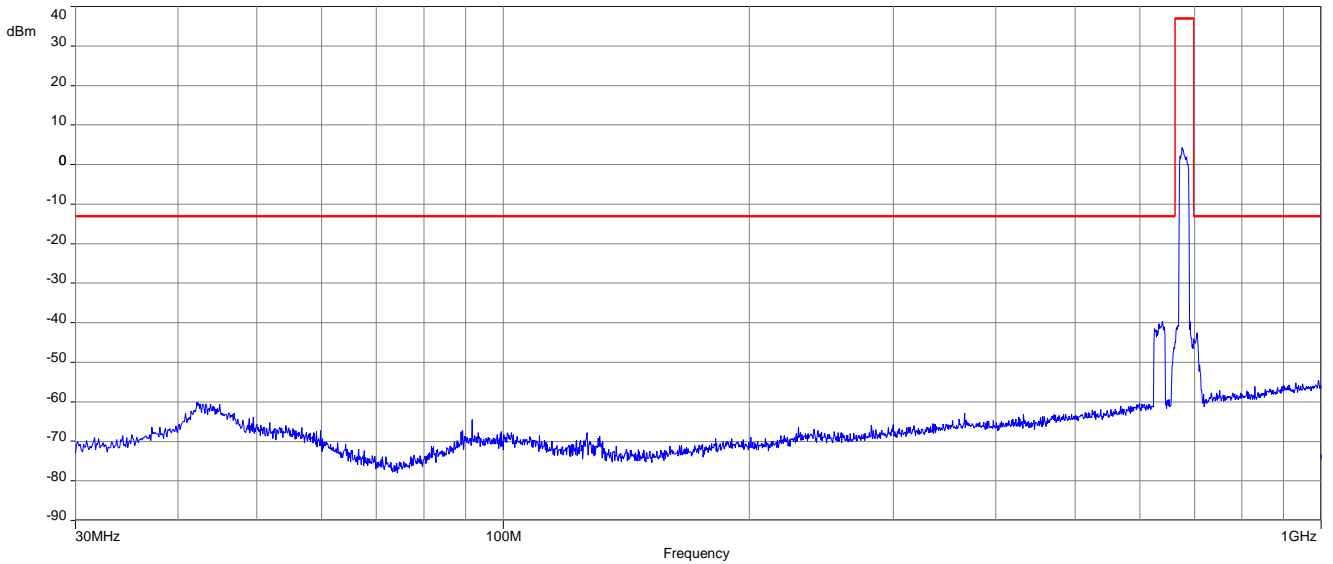
Plot 3: BPSK - Middle channel (1 GHz – 7 GHz)



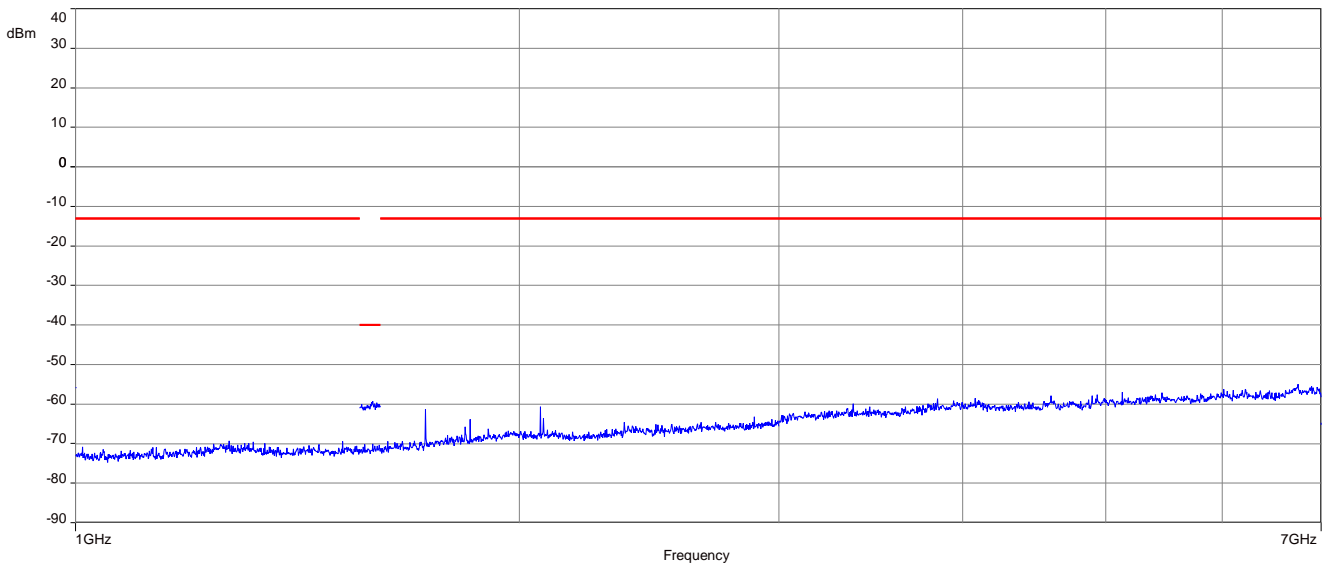
Plot 4: QPSK - Middle channel (9 kHz - 30 MHz)



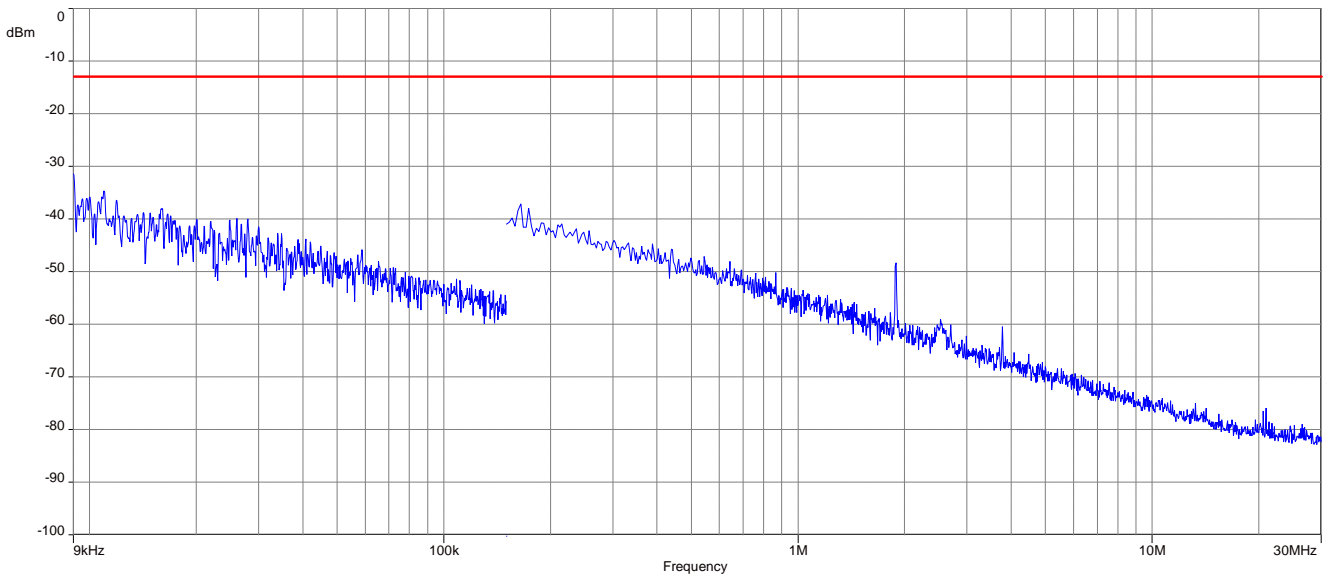
Plot 5: QPSK - Middle channel (30 MHz – 1 GHz)



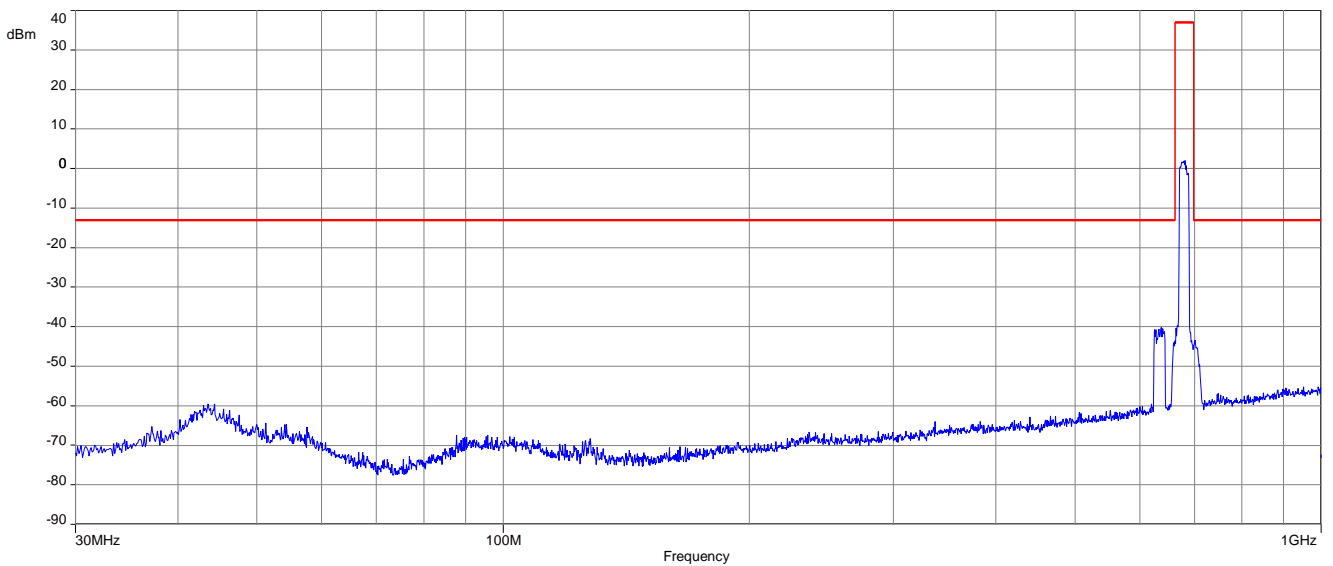
Plot 6: QPSK - Middle channel (1 GHz – 7 GHz)



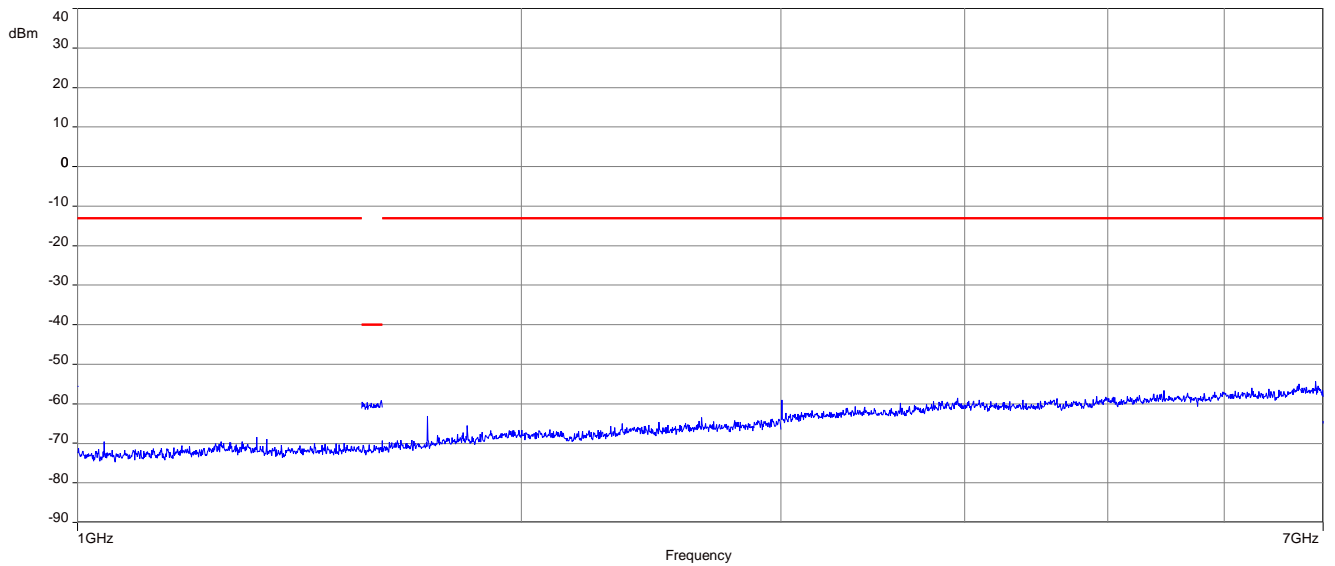
Plot 1: 16-QAM - Middle channel (9 kHz - 30 MHz)



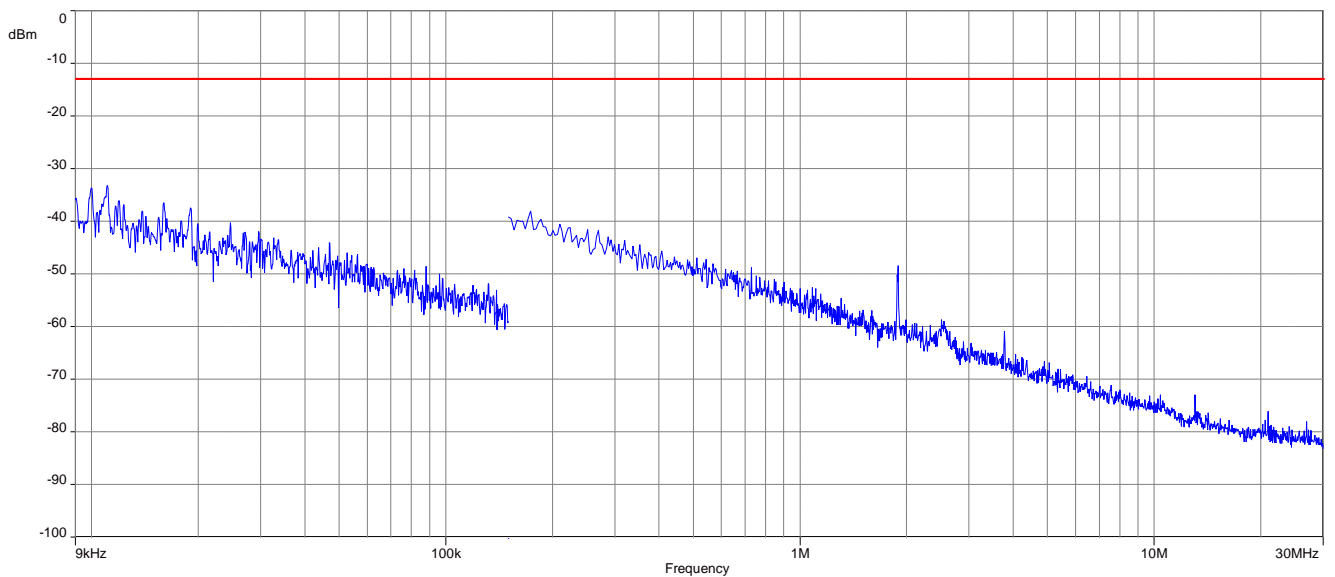
Plot 2: 16-QAM - Middle channel (30 MHz – 1 GHz)



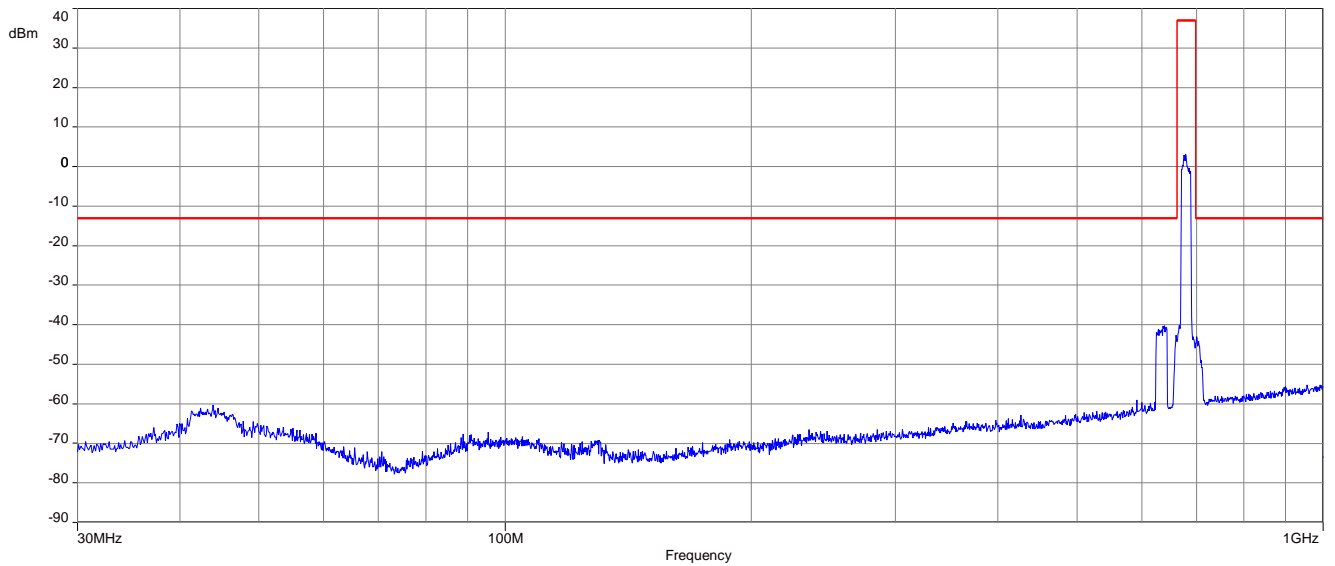
Plot 3: 16-QAM - Middle channel (1 GHz – 7 GHz)



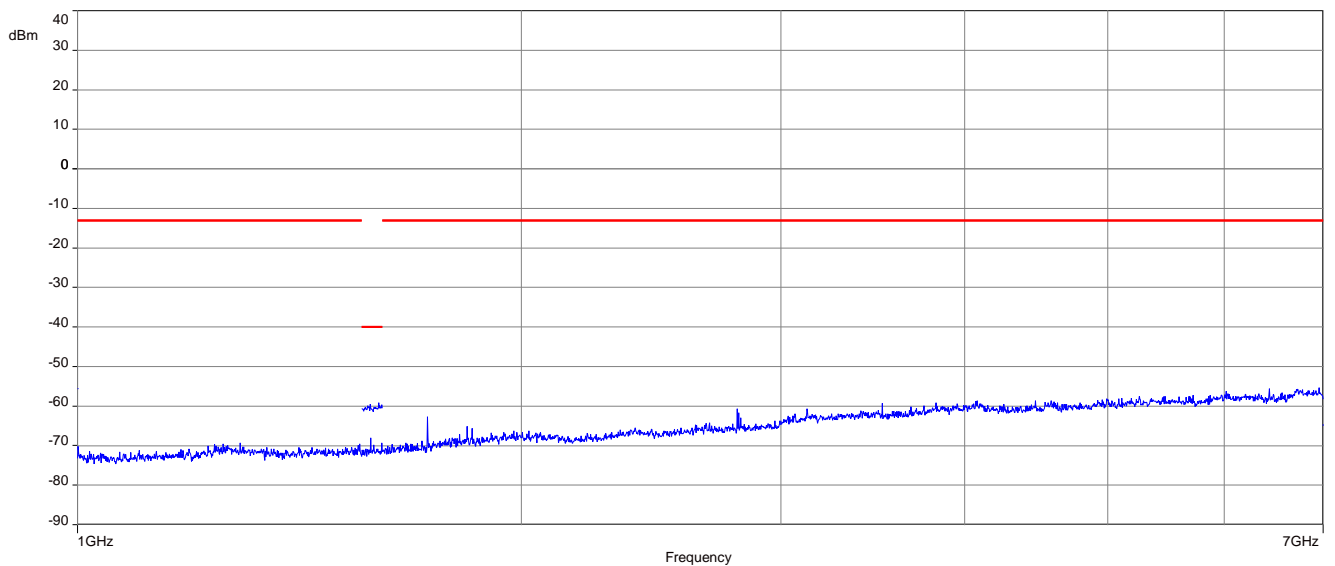
Plot 4: 64-QAM - Middle channel (9 kHz - 30 MHz)



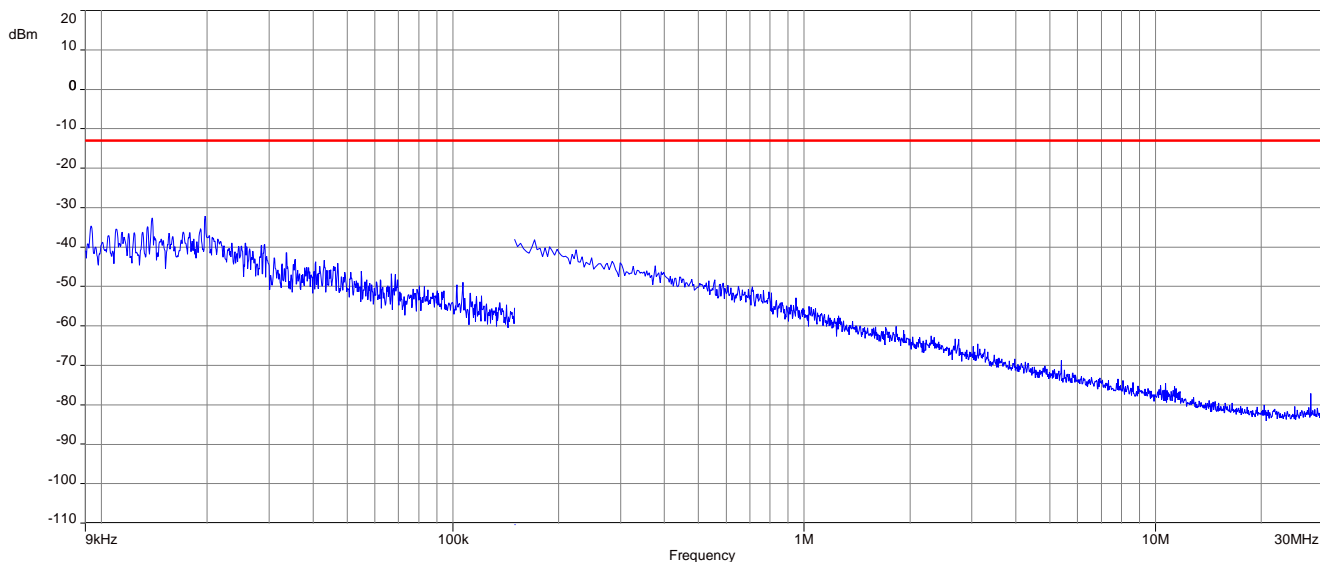
Plot 5: 64-QAM - Middle channel (30 MHz – 1 GHz)



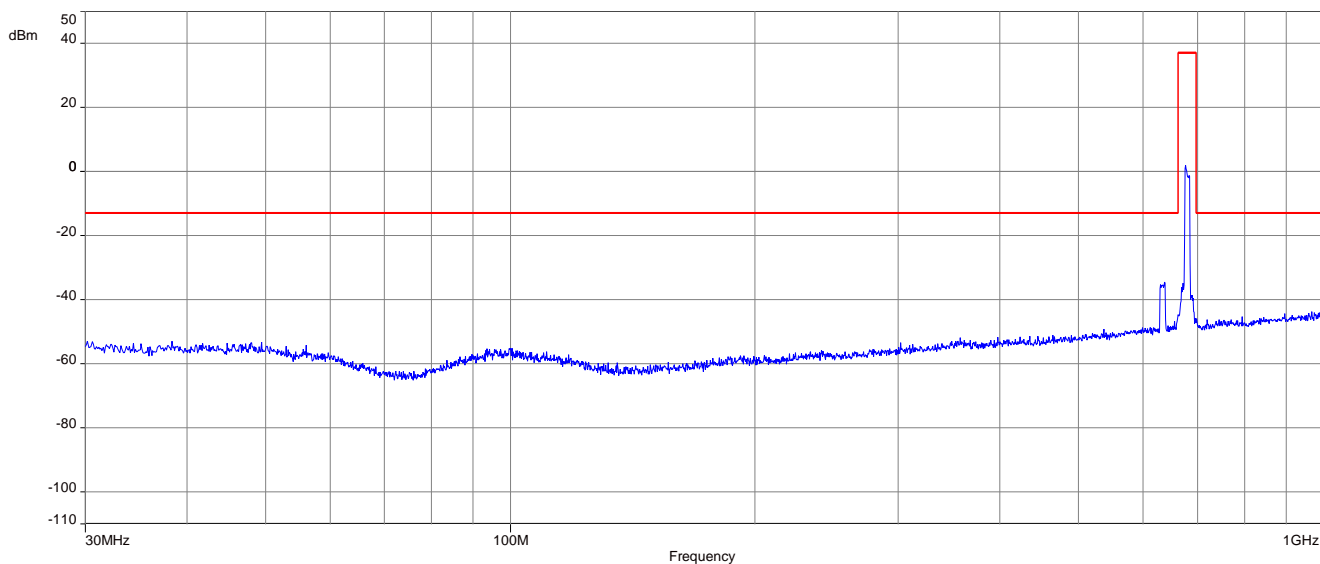
Plot 6: 64-QAM - Middle channel (1 GHz – 7 GHz)



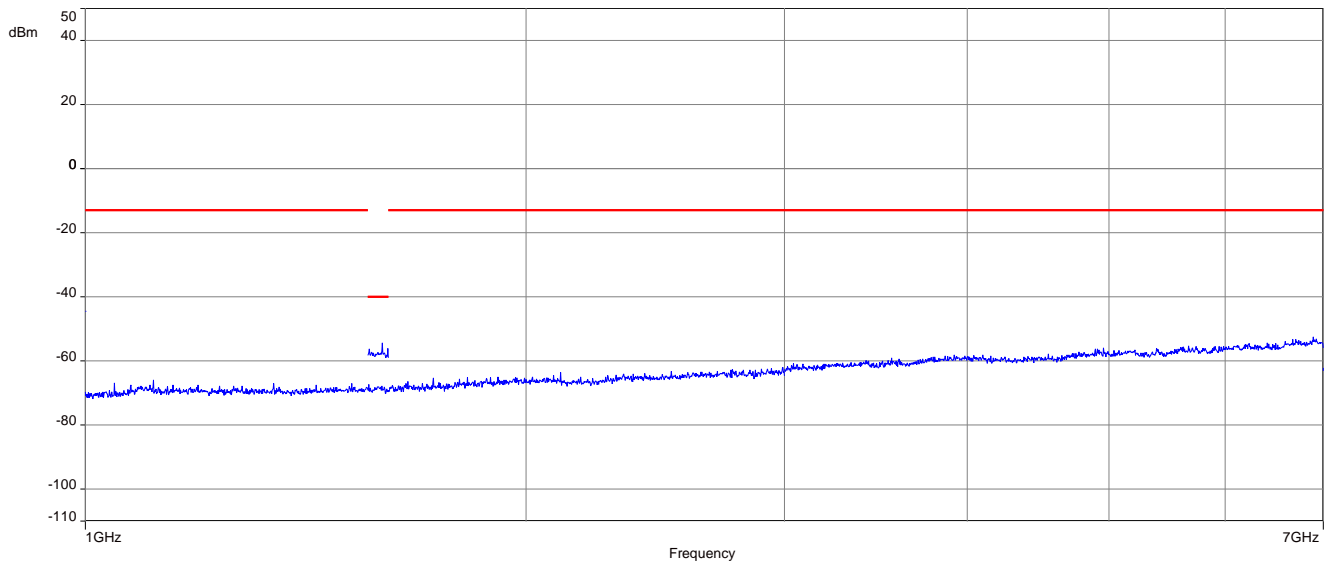
Plot 7: 256-QAM - Middle channel (9 kHz - 30 MHz)



Plot 8: 256-QAM - Middle channel (30 MHz – 1 GHz)



Plot 9: 256-QAM - Middle channel (1 GHz – 7 GHz)



12.2.4 Spurious emissions conducted

Description:

The following steps outline the procedure used to measure the conducted emissions from the mobile station.

1. Determine frequency range for measurements: From § 2.1057 the spectrum should be investigated from the lowest radio frequency generated in the equipment up to at least the 10th harmonic of the carrier frequency.
2. Determine mobile station transmits frequencies: below outlines the band edge frequencies pertinent to conducted emissions testing.

Measurement:

Measurement parameters	
Detector:	Peak
Sweep time:	Auto
Video bandwidth:	300 kHz
Resolution bandwidth:	100 kHz
Span:	30 MHz – 26 GHz
Log file:	1-3977_22-02-20_Annex_MR_A1
Trace mode:	Max Hold
Used equipment:	See chapter 8.3 setup A
Measurement uncertainty:	see chapter 9
Measurement procedure	FCC: § 2.1051

Limits:

FCC
§ 27.53 (g)
For operations in the 600 MHz band and the 698-746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least $43 + 10 \log (P)$ dB. Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kilohertz or greater. However, in the 100 kilohertz bands immediately outside and adjacent to a licensee's frequency block, a resolution bandwidth of at least 30 kHz may be employed
-13 dBm

Results:

BPSK modulation	Lowest channel		Middle channel		Highest channel	
Bandwidth (MHz)	Spurious emissions (MHz)	Level (dBm)	Spurious emissions (MHz)	Level (dBm)	Spurious emissions (MHz)	Level (dBm)
5 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
10 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
15 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
20 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-

QPSK modulation	Lowest channel		Middle channel		Highest channel	
Bandwidth (MHz)	Spurious emissions (MHz)	Level (dBm)	Spurious emissions (MHz)	Level (dBm)	Spurious emissions (MHz)	Level (dBm)
5 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
10 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
15 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
20 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-

16-QAM modulation	Lowest channel		Middle channel		Highest channel	
Bandwidth (MHz)	Spurious emissions (MHz)	Level (dBm)	Spurious emissions (MHz)	Level (dBm)	Spurious emissions (MHz)	Level (dBm)
5 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
10 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
15 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
20 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-

64-QAM modulation	Lowest channel		Middle channel		Highest channel	
Bandwidth (MHz)	Spurious emissions (MHz)	Level (dBm)	Spurious emissions (MHz)	Level (dBm)	Spurious emissions (MHz)	Level (dBm)
5 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
10 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
15 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
20 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-

256-QAM modulation	Lowest channel		Middle channel		Highest channel	
Bandwidth (MHz)	Spurious emissions (MHz)	Level (dBm)	Spurious emissions (MHz)	Level (dBm)	Spurious emissions (MHz)	Level (dBm)
5 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
10 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
15 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-
20 MHz	-/-	-/-	-/-	-/-	-/-	-/-
	-/-	-/-	-/-	-/-	-/-	-/-

12.2.5 Block edge compliance

Description:

The spectrum at the band edges must comply with the spurious emissions limits.

Measurement:

Measurement parameters	
Detector:	RMS
Sweep time:	See plots
Video bandwidth:	See plots
Resolution bandwidth:	See plots
Span:	1 MHz steps
Trace mode:	Max Hold
Log file:	1-3977_22-02-20_Annex_MR_A1
Used equipment:	See chapter 8.4 setup A
Measurement uncertainty:	See chapter 9
Measurement procedure	FCC: § 2.1051

Limits:

FCC
§ 27.53 (g)
For operations in the 600 MHz band and the 698-746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least $43 + 10 \log (P)$ dB. Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kilohertz or greater. However, in the 100 kilohertz bands immediately outside and adjacent to a licensee's frequency block, a resolution bandwidth of at least 30 kHz may be employed
-13 dBm

Results: PASS (See log files)

12.2.6 Occupied bandwidth

Description:

Measurement of the occupied bandwidth of the transmitted signal.

Measurement:

Similar to conducted emissions, occupied bandwidth measurements are only provided for selected frequencies in order to reduce the amount of submitted data. Data were taken at the extreme and mid frequencies of the 5G NR band 71 frequency band. The table below lists the measured 99% power and -26dBc occupied bandwidths. Spectrum analyzer plots are included on the following pages.

Measurement parameters	
Detector:	Peak
Sweep time:	See plots
Video bandwidth:	See plots
Resolution bandwidth:	See plots
Span:	2 x nominal bandwidth
Log file:	1-3977_22-02-20_Annex_MR_A1
Trace mode:	Max Hold
Used equipment:	See chapter 8.4 setup A
Measurement uncertainty:	See chapter 9
Measurement procedure	FCC: § 2.1049

Limits:

FCC
§ 2.1049
Reporting only

Results:

Occupied Bandwidth – BPSK			
Bandwidth	Channel	99% OBW (kHz)	-26 dBc BW (kHz)
5.0	low	4520	5163
	mid	4496	5113
	high	4483	5150
10.0	low	8941	9725
	mid	8941	9750
	high	8966	9850
15.0	low	13374	14363
	mid	13412	14513
	high	13449	14587
20.0	low	17932	19200
	mid	17932	19300
	high	17932	19200

Occupied Bandwidth – QPSK			
Bandwidth	Channel	99% OBW (kHz)	-26 dBc BW (kHz)
5.0	low	4508	5137
	mid	4508	5225
	high	4508	5188
10.0	low	8966	9725
	mid	8966	9775
	high	9016	9850
15.0	low	13412	14475
	mid	13412	14663
	high	13487	14475
20.0	low	17932	19300
	mid	17932	19250
	high	17932	19300

Occupied Bandwidth – 16-QAM			
Bandwidth	Channel	99% OBW (kHz)	-26 dBc BW (kHz)
5.0	low	4496	5212
	mid	4496	5175
	high	4496	5075
10.0	low	8941	9750
	mid	8991	9775
	high	8991	9825
15.0	low	13487	14625
	mid	13449	14475
	high	13487	14550
20.0	low	18032	19450
	mid	18032	19450
	high	17982	19350

Occupied Bandwidth – 64-QAM			
Bandwidth	Channel	99% OBW (kHz)	-26 dBc BW (kHz)
5.0	low	4520	5188
	mid	4508	5150
	high	4496	5075
10.0	low	8966	9950
	mid	8991	9925
	high	9041	9975
15.0	low	13412	14362
	mid	13449	14475
	high	13449	14438
20.0	low	17932	19300
	mid	17982	19300
	high	17982	19250

Occupied Bandwidth – 256-QAM			
Bandwidth	Channel	99% OBW (kHz)	-26 dBc BW (kHz)
5.0	low	4483	5062
	mid	4508	5225
	high	4520	5200
10.0	low	8916	9825
	mid	8966	9900
	high	9016	9950
15.0	low	13412	14362
	mid	13449	14550
	high	13487	14512
20.0	low	17932	19300
	mid	17932	19250
	high	17932	19200

13 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

14 Document history

Version	Applied changes	Date of release
-/-	Initial release	2023-01-18

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

first page	last page
 <p>The first page of the accreditation certificate includes the DAKKS logo, the name of the accreditation body (Deutsche Akkreditierungsstelle GmbH), and the accreditation details for CTC advanced GmbH. It states that the laboratory is competent under the terms of DIN EN ISO/IEC 17025:2018 for telecommunication (FCC Requirements). The certificate is signed by Dipl.-Ing. (FH) Ralf Egner, Head of Division, on 09.06.2020 in Frankfurt am Main.</p>	 <p>The last page of the accreditation certificate lists the office addresses for Berlin, Frankfurt am Main, and Braunschweig. It also contains information regarding the publication of extracts, the accreditation granted pursuant to the Act on the Accreditation Body (AkkStelleG) of 31 July 2009, and the up-to-date state of membership.</p>

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

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

or

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

END OF TEST REPORT