ECL-TA Test Report No.: 20-007

Designation:	CAP MX AC 6/7E/80-85/17E/19/23/25T
Manufacturer:	Andrew
Serial No(s):	8
ID No.	7830127-0001, Rev.: 00
Test Specification(s):	ANSI 63.26:2015 FCC Rules and Regulations as listed in 47 CFR, Part 20:2019-10-01 FCC Rules and Regulations as listed in 47 CFR, Part 90.219:2019-10-01
Test Plan:	Measurement of Band 14/LMR 750, downlink.
Test Result:	**Passed**

Date of issue:	2020-09-23		Signature:
Version:	01	Technical Reviewer:	Thomas Hufnagel Test Engineer Digitally signed by Thomas Hufnagel DN: cn=Thomas Hufnagel, o=Bureau Veritas CPS Germany GmbH, ou=ECL, email=thomas.hufnagel@de.bureauveritas.com, c=DE Date: 2020.10.26 10:51:40 +01'00'
Date of delivery:	2020-07		
Performance date:	2020-07-21. – 2020-09-10	Report Reviewer:	Thomas Gerngroß Test Engineer Digitally signed by Thomas Gerngroß DN: cn=Thomas Gerngroß, o=Bureau Veritas CPS Germany GmbH, ou=ECL, email=thomas.gerngross@bureauveritas.com, c=DE Date: 2020.10.23 15:38:53 +02'00'

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1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Type of Authorization
Certification for an Industrial Signal Booster.

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 20, 27. The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 20, Commercial Mobiles Services

§ 20.21 Signal Boosters

Part 90; Private Land Mobile Radio Services

Subpart R – Regulations Governing the Licensing and Use fo Frequencies in the 763 – 775, and 793 – 805 MHz Bands

§ 90.635 – Limitations on power and antenna height

Subpart I – General Technical Standards

§ 90.213 – Frequency Stability
§ 90.219 – Use of signal boosters
$ 90.691 – Emission mask requirements for EA-based systems

The tests were selected and performed with reference to:

- FCC Public Notice 935210 applying "Signal Boosters Basic Certification Requirements" 935210 D02, 2019-15-04.
- FCC Public Notice 935210 applying "Measurement guidance for industrial and non-consumer signal booster, repeater and amplifier devices"
- 935210 D05, 2019-04-03.
- FCC Public Notice 971168 applying "Measurement guidance for certification of licensed digital transmitters" 971168 D01, 2019-04-09.
- ANSI C63.26: 2015

Summary Test Results:

The EUT complies with all performed tests as listed in chapter 1.3 Measurement Summary / Signatures.

1.1 FCC TABLE

Table of FCC references for Industrial Signal Booster

Measurement	FCC reference
Effective radiated power, mean output power and zone enhancer gain	§ 2.1046 § 90.542 KDB 935210 D05 v01r04: 3.5
Peak to Average Ratio	§ 2.1049
Occupied bandwidth Input-versus-output spectrum	§ 2.1049 KDB 935210 D05 v01r04: 3.4
Conducted spurious Emission at Antenna Terminal	§ 2.1051 § 90.219 KDB 935210 D05 v01r04: 3.6
Out-of-band emissions limits	§ 2.1051 § 90.219 KDB 935210 D05 v01r04: 3.6
Frequency stability	§ 2.1055 § 27.54
Field strength of spurious radiation	§ 2.1053 § 90.219
Out-of-band rejection	KDB 935210 D05 v01r04: 3.3
Noise and noise figure	§ 90.219
All measurements	ANSI 63.26

1.2 MEASUREMENT SUMMARY/SIGNATURES

47 CFR CHAPTER I FCC PART 90 Subpart R [Base Stations/Repeater]	**§ 2.1046, § 90.542 (a), KDB 935210 D02 II (p)(4)**
Effective Radiated Power, mean output power and zone enhancer gain The measurement was performed according to ANSI C63.26, KDB 935210 D05 v01r04: 3.5	**Final Result**
OP-Mode Frequency Band, Direction, Input Power, Signal Type	
LMR 750, RF downlink, 0.3 dB < AGC, Narrowband	Passed
LMR 750, RF downlink, 0.3 dB < AGC, Wideband	Passed
LMR 750, RF downlink, 3 dB > AGC, Narrowband	Passed
LMR 750, RF downlink, 3 dB > AGC, Wideband	Passed

47 CFR CHAPTER I FCC PART 90 Subpart R/I [Base Stations/Repeater]	**§ 2.1049, KDB 935210 D02 II (p)(3)**
Peak to Average Ratio The measurement was performed according to ANSI C63.26	**Final Result**
OP-Mode Frequency Band, Direction, Input Power, Signal Type	
LMR 750, RF downlink, 0.3 dB < AGC, Narrowband	Passed
LMR 750, RF downlink, 0.3 dB < AGC, Wideband	Passed
LMR 750, RF downlink, 3 dB > AGC, Narrowband	Passed
LMR 750, RF downlink, 3 dB > AGC, Wideband	Passed

47 CFR CHAPTER I FCC PART 90 Subpart R/I [Base Stations/Repeater]	**§ 2.1049, KDB 935210 D02 II (p)(3)**
Occupied Bandwidth/Input-versus-output Spectrum The measurement was performed according to ANSI C63.26, KDB 935210 D05 v01r04: 3.4	**Final Result**
OP-Mode Frequency Band, Direction, Input Power, Signal Type	
LMR 750, RF downlink, 0.3 dB < AGC, Narrowband	Passed
LMR 750, RF downlink, 0.3 dB < AGC, Wideband	Passed
LMR 750, RF downlink, 3 dB > AGC, Narrowband	Passed
LMR 750, RF downlink, 3 dB > AGC, Wideband	Passed

47 CFR CHAPTER I FCC PART 90 Subpart R / I [Base Stations / Repeater]	**§ 2.1051, § 90.219**
Conducted spurious emissions at antenna terminals The measurement was performed according to ANSI C63.26	**Final Result**

OP-Mode Frequency Band, Direction, Input Power, Signal Type	
LMR 750, RF downlink, 0.3 dB < AGC, Narrowband	Passed
LMR 750, RF downlink, 0.3 dB < AGC, Wideband	Passed
LMR 750, RF downlink, 3 dB > AGC, Narrowband	Passed
LMR 750, RF downlink, 3 dB > AGC, Wideband	Passed

47 CFR CHAPTER I FCC PART 90 Subpart R / I [Base Stations / Repeater]	**§ 2.1051, § 90.219, KDB 935210 D02 II (p)(2)**
Out-of-band emission limits The measurement was performed according to ANSI C63.26, KDB 935210 D05 v01r04: 3.6	**Final Result**

OP-Mode Band Edge, Frequency Band, Number of signals, Direction, Input Power, Signal Type	
Lower, LMR 750, 1, RF downlink, 0.3 dB < AGC, Narrowband	Passed
Lower, LMR 750, 1, RF downlink, 0.3 dB < AGC, Wideband	Passed
Lower, LMR 750, 1, RF downlink, 3 dB > AGC, Narrowband	Passed
Lower, LMR 750, 1, RF downlink, 3 dB > AGC, Wideband	Passed
Lower, LMR 750, 2, RF downlink, 0.3 dB < AGC, Narrowband	Passed
Lower, LMR 750, 2, RF downlink, 0.3 dB < AGC, Wideband	Passed
Lower, LMR 750, 2, RF downlink, 3 dB > AGC, Narrowband	Passed
Lower, LMR 750, 2, RF downlink, 3 dB > AGC, Wideband	Passed

47 CFR CHAPTER I FCC PART 90 Subpart R / I [Base Stations / Repeater]	**KDB 935210 D02 II (p)(2)**
Out-of-band rejection The measurement was performed according to ANSI C63.26, 935210 D05 v01r04: 3.3	**Final Result**

OP-Mode Frequency Band, Direction	**Setup**
LMR 750, RF downlink	Passed

47 CFR CHAPTER I FCC PART 90 Subpart R / I [Base Stations / Repeater]	**§ 90.219 (d) (6) (i) / (ii) / (iii), e (3)**

Noise and noise figure

The measurement was performed according to ANSI C63.26

OP-Mode	**Setup**	**Final Result**
Frequency Band, Direction, Test Step		
LMR 750, RF downlink, passband		Passed
LMR 750, RF downlink, out of passband		Passed
LMR 750, RF downlink, noise figure		Passed

47 CFR CHAPTER I FCC PART 27 Subpart C [Base Stations / Repeater]	**§ 2.1053, § 90.543**

Field strength of spurious radiation

The measurement was performed according to ANSI C63.26

OP-Mode	**Final Result**
Frequency Band, Test Frequency, Direction	
LMR 750, high, RF downlink	Passed
LMR 750, low, RF downlink	Passed
LMR 750, mid, RF downlink	Passed

The test case frequency stability was not performed, since the EUT is not equipped with signal processing capabilities.

2 ADMINISTRATIVE DATA

2.1 TESTING LABORATORY

Bureau Veritas Consumer Products Services Germany GmbH
Thurn-und-Taxis-Straße 18
D-90411 Nürnberg
Tel.: +49 40 74041 0
Fax: +49 40 74041-2755

2.2 APPLICANT DATA

Company Name:	Commscope Andrew Wireless Systems GmbH
Address:	Industriering 10 86675 Buchdorf Germany
Contact Person:	Mr. Frank Futter

2.3 MANUFACTURER DATA

Company Name:	Please see applicant data.
Address:	

3 TEST OBJECT DATA

3.1 GENERAL EUT DESCRIPTION

Kind of Device product description	Cellular Repeater
Product name	Cellular Repeater
Type	
Declared EUT data by the supplier	
General Product Description	The EUT is an industrial signal booster supporting the following: Band 5/CELL 850 LMR 750/USA 700E LMR 750/USA 700E Band 14/LMR 750 Band 25/PCS 1900 Band 27/LMR 750 Band 30/WCS 2300 Band 41/BRS Band 66/AWS 1700E (partly) LMR 750/LMR 750 Band 71/USA 600 A RF operation is only supported for the downlink.
Booster Type	Industrial Signal Booster
Voltage Type	AC/50 Hz – 60 Hz
Voltage Level	100 V - 240 V
Maximum Output Donor Port [Uplink]	-
Nominal Output Server Port [Downlink]	All bands: 33 dBm
Nominal Gain [Uplink]	-
Nominal Gain [Downlink]	All bands: 33 dB

The main components of the EUT are listed and described in chapter 3.2 EUT Main components.

3.2 EUT MAIN COMPONENTS

Sample Name	**FCC-ID**	
	XS5-CAPMX	
Sample Parameter	**Value**	
Serial Number	8	
HW Version	7830127-0001 Rev.: 00	
SW Version	2.9.0.292	
Comment	-----	

NOTE: The short description is used to simplify the identification of the EUT in this test report.

3.3 ANCILLARY EQUIPMENT

For the purposes of this test report, ancillary equipment is defined as equipment which is used in conjunction with the EUT to provide operational and control features to the EUT. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Ancillary Equipment can influence the test results.

Device	**Details (Manufacturer, Type Model, OUT Code)**	**Description**
-	-	-

3.4 AUXILIARY EQUIPMENT

For the purposes of this test report, auxiliary equipment is defined as equipment which is used temporarily to enable operational and control features especially used for the tests of the EUT which is not used during normal operation or equipment that is used during the tests in combination with the EUT but is not subject of this test report. It is necessary to configure the system in a typical fashion, as a customer would normally use it.
But nevertheless Auxiliary Equipment can influence the test results.

Device	**Details (Manufacturer; Type; S/N)**	**Description**
AUX1	Commscope/General Electric; ION-E PSU Shelf, AC; DM77662	Rack in Conjunction with AUX 2
AUX2	Commsope/General Electric; Power Supply Unit; LBGEPE17KZ39047532	Power Supply
AUX3	Commscope; ION-E WCS-2; SZAEAJ1952A0032	Subrack in Conjunction with AUX 4, 5,6, 7 and 8
AUX4	Commscope; ION-E OPT; SZBEAD1951A0011	Optical Card
AUX5	Commscope; ION-E SUI; SZBEAC1746A0015	LAN System Interface
AUX6	Commscope; ION-E RFD; SZBEAP1920A0057	RF Card
AUX7	Commscope; ION-E RFD; SZBEAP1924A0023	RF Card
AUX 8	Commscope; ION-E RFD; SZBEAP1946A0003	RF Card

3.5 EUT SETUPS

This chapter describes the combination of EUTs and equipment used for testing. The rationale for selecting the EUTs, ancillary and auxiliary equipment and interconnecting cables, is to test a representative configuration meeting the requirements of the referenced standards.

Setup	Combination of EUTs	Description and Rationale
	,	Setup for all tests

OPERATING MODES
This chapter describes the operating modes of the EUT used for testing.

3.5.1 TEST CHANNELS

Band	Direction	Lower Frequency Band Edge [MHz]	Upper Frequency Band Edge [MHz]	Center Frequency [MHz]	Port
14/LMR 750	Downlink	758.00	768.00	763.00	Donor

3.5.2 AUTOMATIC GAIN CONTROL LEVELS

AGC Levels							
Band	Direction	Signal Type	AGC Start Pin [dBm]	AGC Start Pin -0.3 dB [dBm]	AGC Start Pin +3 dB [dBm]	Frequency [MHz]	Frequency
14	Downlink	Narrowband	-2.2	-2.5	0.8	763.00	Mid
14	Downlink	Wideband	-1.8	-2.1	1.2	763.00	
14	Downlink	Narrowband	-2.0	-2.3	1.0	758.20	Low
14	Downlink	Wideband	-2.0	-2.3	1.0	760.50	
14	Downlink	Narrowband	-1.2	-1.5	1.8	767.80	High
14	Downlink	Wideband	-1.6	-1.9	1.4	765.50	
14	Downlink	Narrowband	-2.4	-2.7	0.6	759.03	Max.Power
14	Downlink	Wideband	-2.0	-2.3	1.0	760.50	

Remark:

If the measured frequency f_0 for the max power has a too low distance to the band edges, because in the tests modulated signals must be used: The next possible frequency to the according band edge is used.
For example for minimum distances to the band edges:
GSM-Signal (narrowband): 0.2 MHz
AWGN-signal (wideband): 2.5 MHz

3.6 PRODUCT LABELLING

3.6.1 FCC ID LABEL

Please refer to the documentation of the applicant.

3.6.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

4 TEST RESULTS

4.1 EFFECTIVE RADIATED POWER, MEAN OUTPUT POWER AND ZONE ENHANCER GAIN

Standard FCC Part 27, § 27.50

The test was performed according to:
ANSI C63.26, KDB 935210 D05 v01r04: 3.5

Test date: .2020-07-21; 2020-10-12

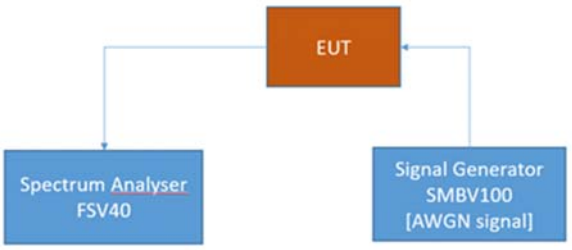
Environmental conditions: 25 ° C, 40 % r. F. (21st July); 22 °C, 33 % r. F. (12th October)

Test engineer: Thomas Hufnagel; Thomas Gerngroß

4.1.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the signal booster power and gain limits and requirements for industrial signal boosters per FCC § 90.542.

The EUT was connected to the test setup according to the following diagram:



FCC Part 22/24/27/90 Industrial signal booster – Test Setup; RF Output Power / Gain

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

4.1.2 TEST REQUIREMENTS/LIMITS: ABSTRACTS FROM STANDARDS

Part 27; Miscellaneous Wireless Communication Services

Subpart C – Technical standards

§ 90.542

LMR 750:

Abstract § 90.542 from FCC:

§90.542 (a)(3)

(a) The following power limits apply to the 758-768/788-798 MHz band:

(3) Fixed and base stations transmitting a signal in the 758-768 MHz band with an emission bandwidth greater than 1 MHz must not exceed an ERP of 1000 watts/MHz and an antenna height of 305 m HAAT, except that antenna heights greater than 305 m HAAT are permitted if power levels are reduced below 1000 watts/MHz ERP accordance with Table 3 of this section.

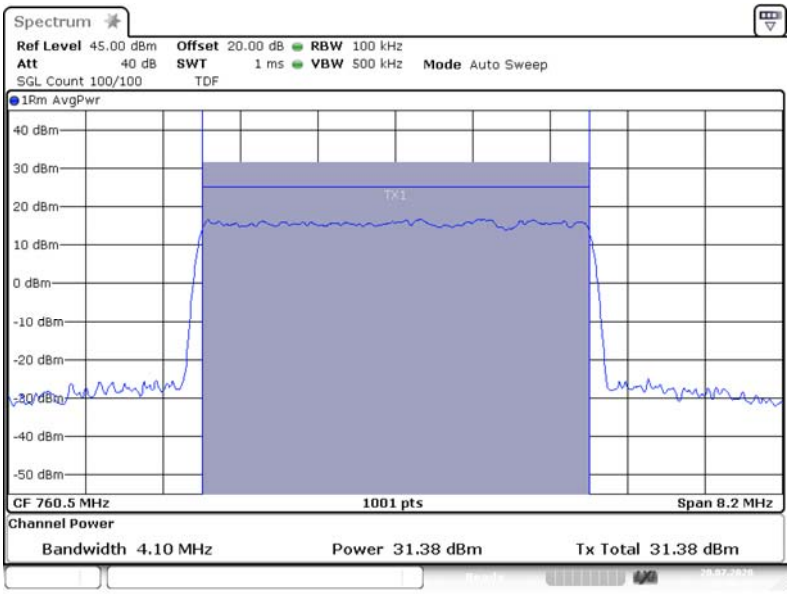
4.1.3 TEST PROTOCOL

LMR 750, downlink							
Signal Type	**Input Power**	**Frequency [MHz]**	**Input Power [dBm]**	**Maximum Average Output Power [dBm]**	**Limit Average Output Power [dBm]**	**Margin to Limit [dB]**	**Gain [dB]**
Wideband	0.3 dB < AGC	760.50	-2.3	31.4	60.0	28.6	33.7
Wideband	3 dB > AGC	760.50	1.0	31.7	60.0	28.3	30.7
Narrowband	0.3 dB < AGC	759.03	-2.7	31.3	60.0	28.7	34.0
Narrowband	3 dB > AGC	759.03	0.6	31.3	60.0	28.8	30.7

Remarks: Please see next sub-clause for the measurement plot.

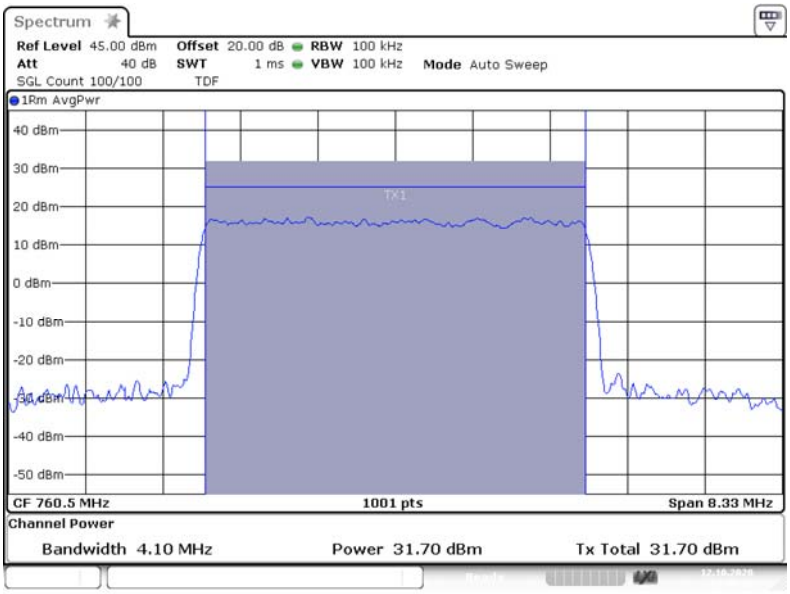
4.1.4 MEASUREMENT PLOT

Band: LMR 750; Frequency: 760.5000 MHz; Band Edge: f0; Mod: AWGN; Output Power 0.3 dB < AGC



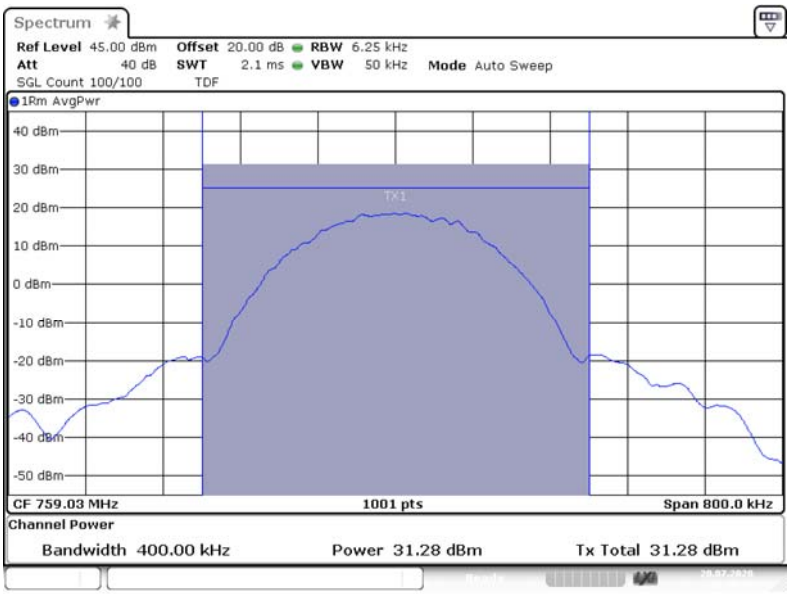
3.5.3 Power AWGN Out -0.3 760.50000M

Band: LMR 750; Frequency: 760.5000 MHz; Band Edge: f0; Mod: AWGN; Output Power 3 dB > AGC



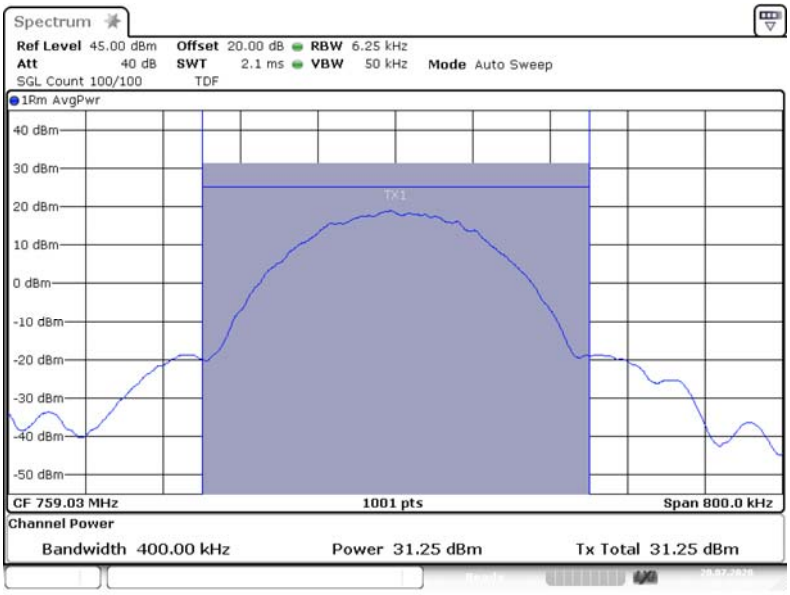
3.5.3 Power AWGN Out +3 760.5000M

Band: LMR 750; Frequency: 759.0300 MHz; Band Edge: f0; Mod: GSM; Output Power 0.3 dB < AGC



3.5.3 Power GSM Out -0.3 759.03000M

Band: LMR 750; Frequency: 759.0300 MHz; Band Edge: f0; Mod: GSM; Output Power 3 dB > AGC



3.5.3 Power GSM Out +3 759.03000M

4.1.5 TEST EQUIPMENT USED

- Conducted

4.2 PEAK TO AVERAGE RATIO

Standard FCC Part 27, § 27.50

The test was performed according to:
ANSI C63.26

Test date: .2020-07-20 to 2020-07-21

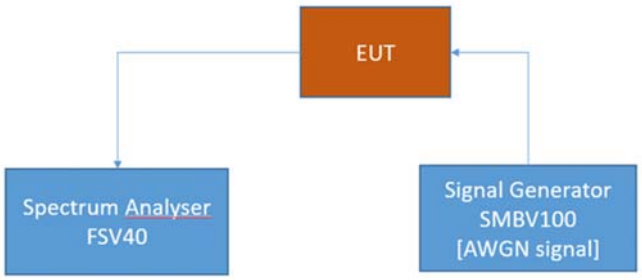
Environmental conditions: 25 ° C; 40 % r. F.

Test engineer: Thomas Hufnagel

4.2.1 TEST DESCRIPTION

This test case is intended to measure the peak to average ratio.

The EUT was connected to the test setup according to the following diagram:



FCC Part 22/24/27/90 Industrial signal booster – Test Setup; RF Output Power / Gain

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

4.2.2 TEST REQUIREMENTS/LIMITS

There is no requirement for the Peak-to-Average value in the applicable rule parts.

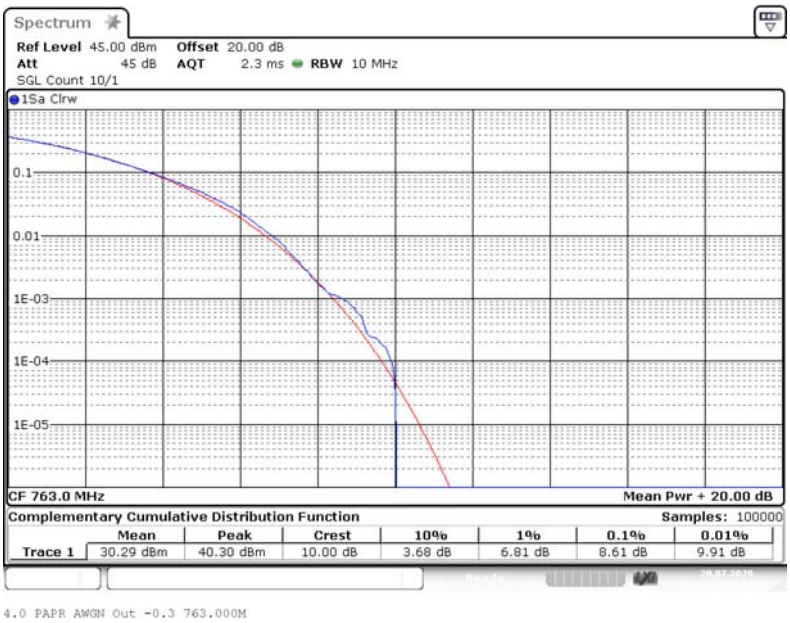
4.2.3 TEST PROTOCOL

LMR 750, downlink						
Signal Type	**Input Power**	**Frequency [MHz]**	**Input Power [dBm]**	**PAPR [dB]**	**Fictive Limit PAPR [dB]**	**Margin to Limit [dB]**
Wideband	0.3 dB < AGC	763.00	-2.1	8.6	13.0	4.4
Wideband	3 dB > AGC	763.00	1.2	8.5	13.0	4.5
Narrowband	0.3 dB < AGC	763.00	-2.5	0.2	13.0	12.8
Narrowband	3 dB > AGC	763.00	0.8	0.2	13.0	12.8

Remark: Please see next sub-clause for the measurement plot.

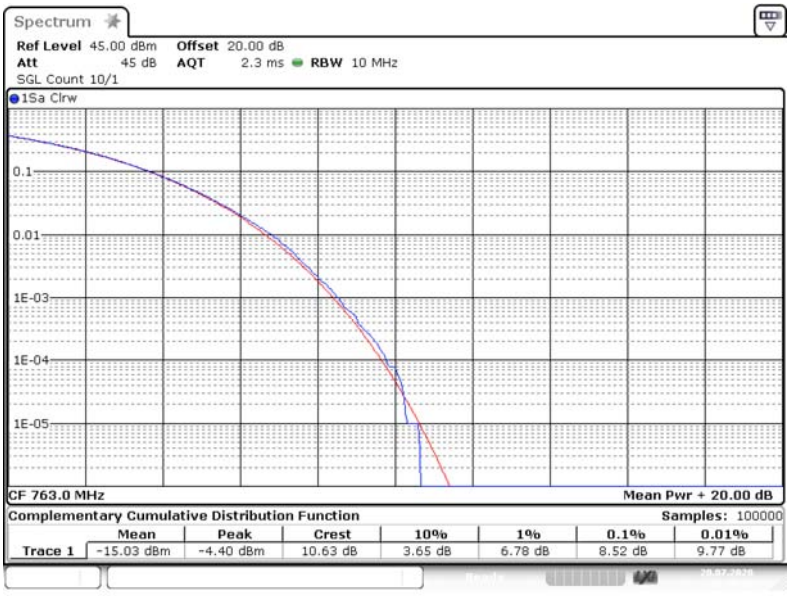
4.2.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

Band: LMR 750; Frequency: 763.0000 MHz; Band Edge: mid; Mod: AWGN; PAPR 0.3 dB < AGC



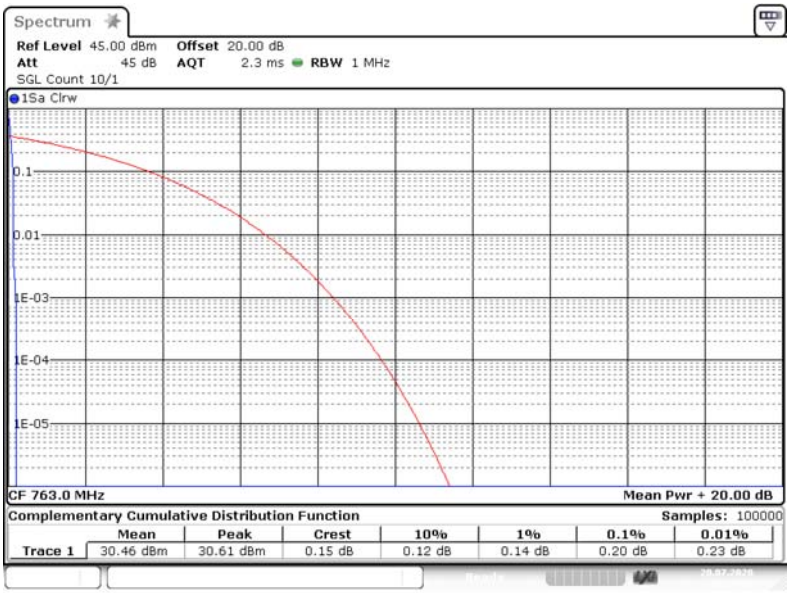
4.0 PAPR AWGN Out -0.3 763.000M

Band: LMR 750; Frequency: 763.0000 MHz; Band Edge: mid; Mod: AWGN; PAPR 3 dB > AGC



4.0 PAPR AWGN Out +3 763.000M

Band: LMR 750; Frequency: 763.0000 MHz; Band Edge: mid; Mod: GSM; PAPR 0.3 dB < AGC



4.0 PAPR GSM Out -0.3 763.000M

Band: LMR 750; Frequency: 763.0000 MHz; Band Edge: mid; Mod: GSM; PAPR 3 dB > AGC

4.2.5 TEST EQUIPMENT USED

- Conducted

4.3 OCCUPIED BANDWIDTH/INPUT-VERSUS-OUTPUT SPECTRUM

Standard FCC Part 2.1049; Occupied Bandwidth

The test was performed according to:
ANSI C63.26, KDB 935210 D05 v01r04: 3.4

Test date: .2020-07-20 to 2020-07-21

Environmental conditions: 25 ° C; 40 % r. F.

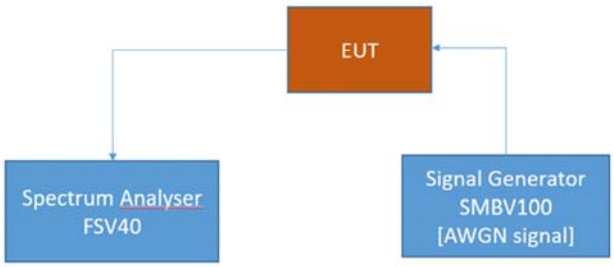
Test engineer: Thomas Hufnagel

4.3.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable conducted spurious emission limits per FCC § 2.1049 and FCC § 90.219.

The EUT was connected to the test setups according to the following diagram:

FCC Part 22/24/27/90; Industrial Signal Booster
Test Setup step 1: Measuring characteristics of test signals



FCC Part 22/24/27/90; Industrial Signal Booster
Test Setup step 2; Occupied Bandwidth/Input-versus-output spectrum

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

4.3.2 TEST REQUIREMENTS/LIMITS

Abstract § 2.1049 from FCC:

FCC Part 2.1049; Occupied Bandwidth:

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.3 percent of the total mean power radiated by a given emission shall be measured under the following conditions as applicable:

(h) Transmitters employing digital modulation techniques—when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the occupied bandwidth shall be shown for operation with any devices used for modifying the spectrum when such devices are optional at the discretion of the user.

(i) Transmitters designed for other types of modulation—when modulated by an appropriate signal of sufficient amplitude to be representative of the type of service in which used. A description of the input signal should be supplied.

Abstract § 90.219 from FCC:

FCC Part 90; §90.219(e)(ii)

There is no change in the occupied bandwidth of the signal.

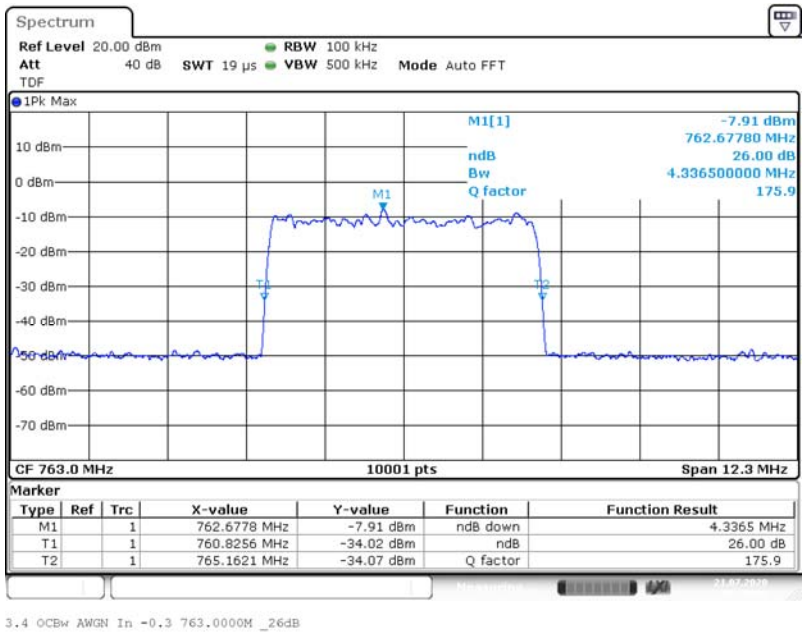
4.3.3 TEST PROTOCOL

LMR 750, downlink							
Signal Type	**Input Power**	**Signal Frequency [MHz]**	**Occupied Bandwidth SG [kHz]**	**Occupied Bandwidth Booster [kHz]**	**Delta Occupied Bandwidth [kHz]**	**Limit Delta Occupied Bandwidth [kHz]**	**Margin to Limit [kHz]**
Wideband	0.3 dB < AGC	763.00	4336.5	4330.4	6.1	205.0	198.9
Wideband	3 dB > AGC	763.00	4335.3	4330.4	4.9	205.0	200.1
Narrowband	0.3 dB < AGC	763.00	315.3	320.1	4.8	10.0	5.2
Narrowband	3 dB > AGC	763.00	317.6	317.0	0.6	10.0	9.4

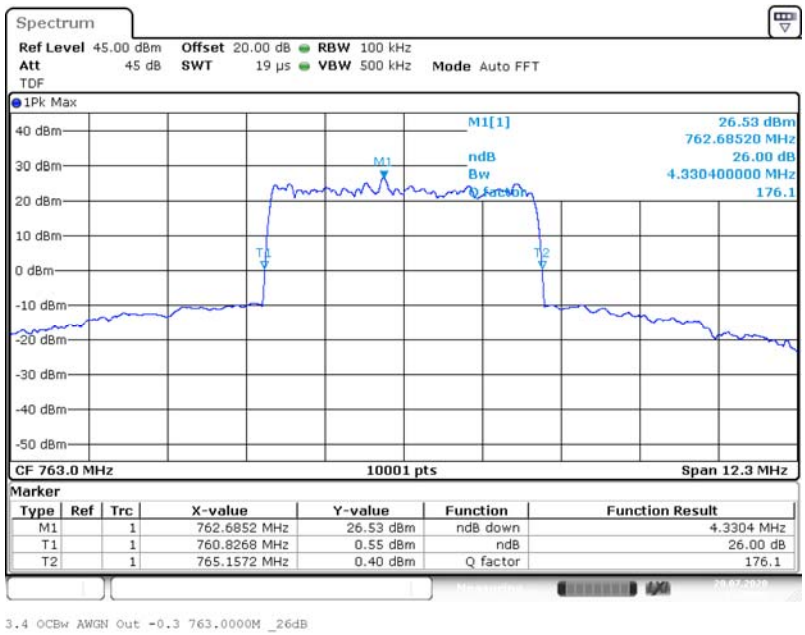
Remark: Please see next sub-clause for the measurement plot.

4.3.4 MEASUREMENT PLOT

Band: LMR 750; Frequency: 763.0000 MHz; Band Edge: mid; Mod: AWGN; Input OCBw 0.3 dB < AGC

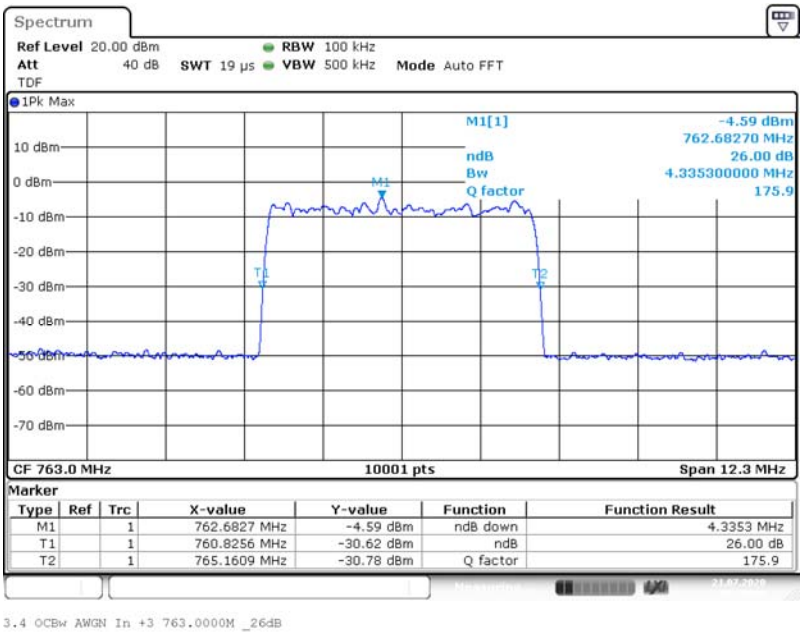


Input Signal

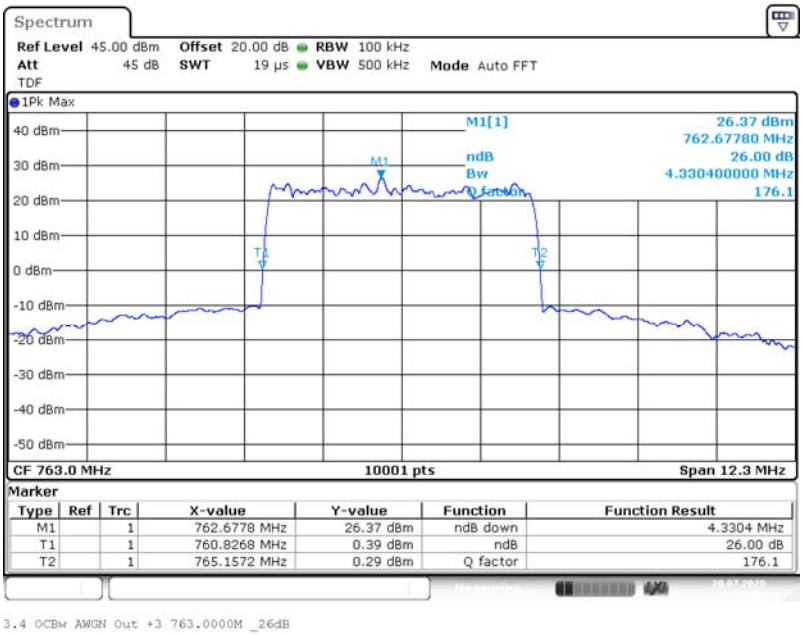


Output Signal

Band: LMR 750; Frequency: 763.0000 MHz; Band Edge: mid; Mod: AWGN; Input OCBw 3 dB > AGC

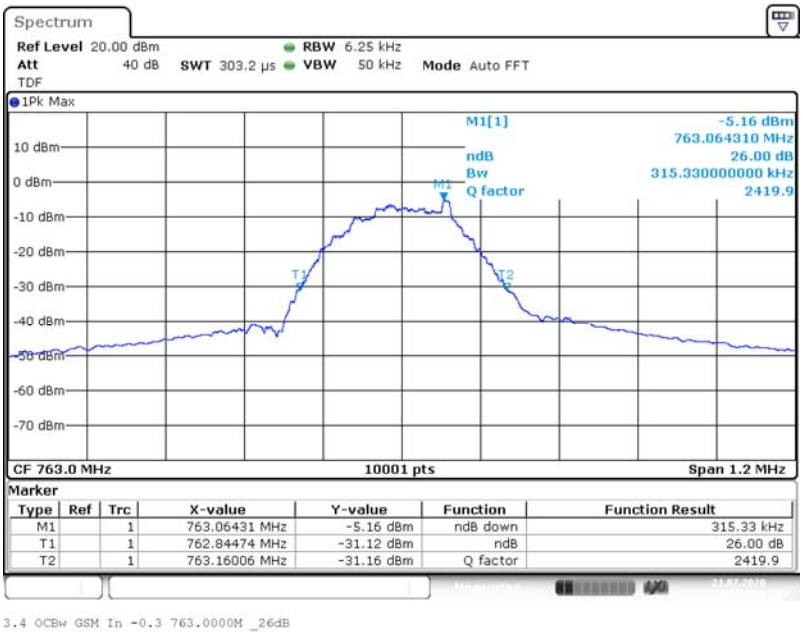


Input Signal

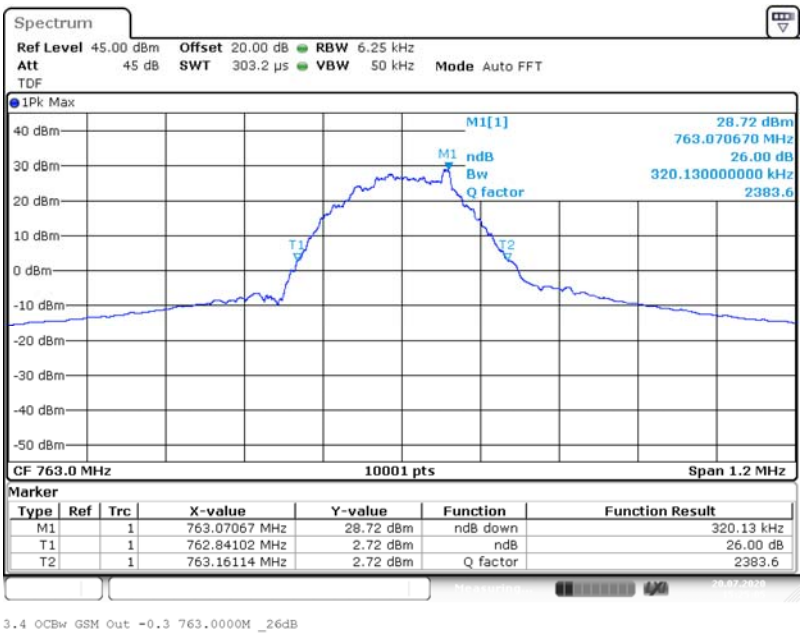


Output Signal

Band: LMR 750; Frequency: 763.0000 MHz; Band Edge: mid; Mod: GSM; Input OCBw 0.3 dB < AGC

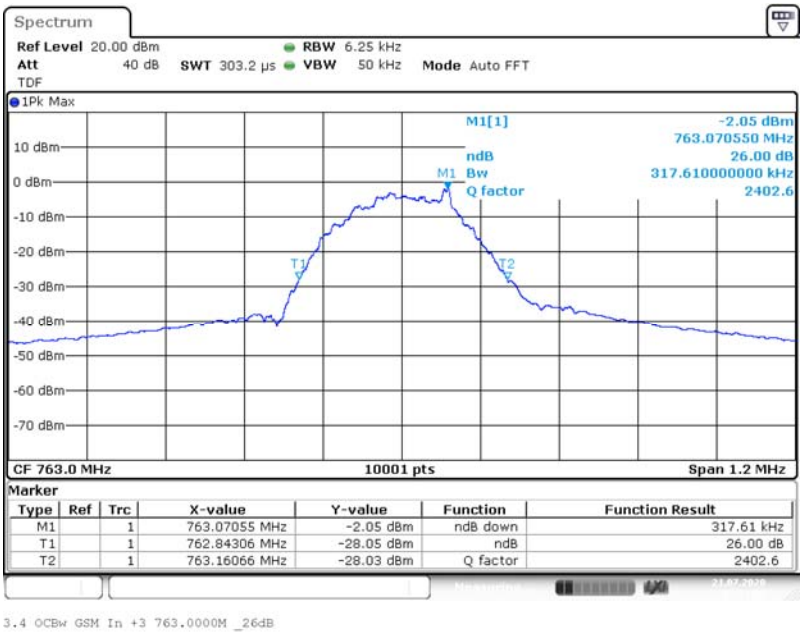


Input Signal

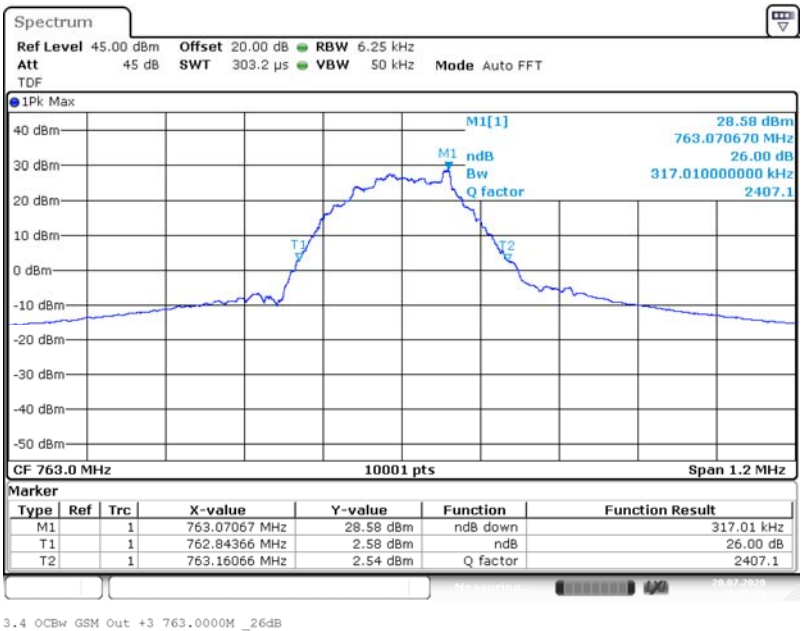


Output Signal

Band: LMR 750; Frequency: 763.0000 MHz; Band Edge: mid; Mod: GSM; Input OCBw 3 dB > AGC



Input Signal



Output Signal

4.3.5 TEST EQUIPMENT USED

- Conducted

4.4 CONDUCTED SPURIOUS EMISSIONS AT ANTENNA TERMINALS

Standard FCC Part § 2.1051, § 27.53

The test was performed according to:
ANSI C63.26, KDB 935210 D05 v01r04: 3.6

Test date: 2020-09-09

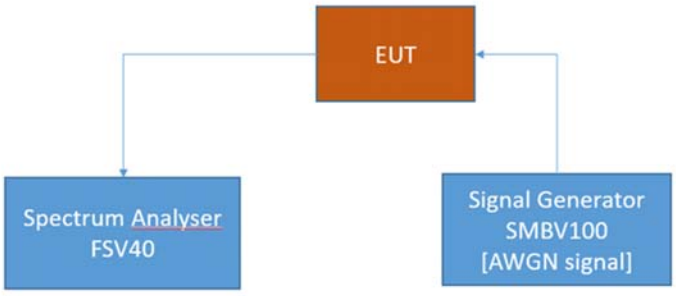
Environmental conditions: 24 ° C; 43 % r. F.

Test engineer: Thomas Hufnagel

4.4.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the signal booster power and gain limits and requirements for industrial signal boosters per FCC § 2.1051 and FCC § 90.219.

The EUT was connected to the test setup according to the following diagram:



FCC Part 22/24/27/90 Industrial signal booster – Test Setup; RF Output Power / Gain

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

4.4.2 TEST REQUIREMENTS/LIMITS

Abstract § 2.1051 from FCC:

FCC Part 2.1051; Measurement required: Spurious emissions at antenna terminal:

The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in § 2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

Abstract § 90.219 FCC:

§90.219 – Use of signal boosters

(e)(3) Spurious emissions from a signal booster must not exceed −13 dBm within any 100 kHz measurement bandwidth.

(d)(6)(i) In general, the ERP of intermodulation products should not exceed −30 dBm in 10 kHz measurement bandwidth.

4.4.3 TEST PROTOCOL

LMR 750, downlink							
Test Frequency	**Signal Type**	**Spurious Freq. [MHz]**	**Spurious Level [dBm]**	**Detector**	**RBW [kHz]**	**Limit [dBm]**	**Margin to Limit [dB]**
low	Wideband	0,0487098	-59,5	RMS	1	-33,0	26,5
low	Wideband	0,0574988	-52,4	RMS	10	-23,0	29,4
low	Wideband	1.209.653	-45,2	RMS	100	-13,0	32,2
low	Wideband	706,9334	-44,7	RMS	100	-13,0	31,7
low	Wideband	757,7526	-35,5	RMS	10	-13,0	22,5
low	Wideband	768,5822	-45,9	RMS	10	-13,0	32,9
low	Wideband	950,986	-43,5	RMS	100	-13,0	30,5
low	Wideband	6845,9	-31,0	RMS	1000	-13,0	18,0
mid	Wideband	0,0093072	-59,7	RMS	1	-33,0	26,7
mid	Wideband	0,0874937	-53,2	RMS	10	-23,0	30,2
mid	Wideband	72,1705	-45,3	RMS	100	-13,0	32,3
mid	Wideband	719,7309	-44,4	RMS	100	-13,0	31,4
mid	Wideband	757,3178	-43,0	RMS	10	-13,0	30,0
mid	Wideband	768,5523	-44,2	RMS	10	-13,0	31,2
mid	Wideband	952,1357	-42,9	RMS	100	-13,0	29,9
mid	Wideband	6882,9	-31,1	RMS	1000	-13,0	18,1
high	Wideband	0,0272063	-61,0	RMS	1	-33,0	28,0
high	Wideband	0,2374687	-53,2	RMS	10	-23,0	30,2
high	Wideband	65,8212	-45,0	RMS	100	-13,0	32,0
high	Wideband	702,4844	-44,2	RMS	100	-13,0	31,2
high	Wideband	757,3028	-44,5	RMS	10	-13,0	31,5
high	Wideband	768,5972	-39,7	RMS	10	-13,0	26,7
high	Wideband	955,385	-43,2	RMS	100	-13,0	30,2
high	Wideband	6803,4	-31,1	RMS	1000	-13,0	18,1

LMR 750, downlink

Test Frequency	Signal Type	Spurious Freq. [MHz]	Spurious Level [dBm]	Detector	RBW [kHz]	Limit [dBm]	Margin to Limit [dB]
low	Narrowband	0,0093891	-60,8	RMS	1	-33,0	27,8
low	Narrowband	0,0674971	-55,7	RMS	10	-23,0	32,7
low	Narrowband	66,8211	-45,1	RMS	100	-13,0	32,1
low	Narrowband	733,2282	-44,6	RMS	100	-13,0	31,6
low	Narrowband	749,9969	-45,8	RMS	10	-13,0	32,8
low	Narrowband	770,6611	-56,4	RMS	10	-13,0	43,4
low	Narrowband	951,3359	-43,2	RMS	100	-13,0	30,2
low	Narrowband	6885,4	-30,6	RMS	1000	-13,0	17,6
mid	Narrowband	0,0092253	-59,8	RMS	1	-33,0	26,8
mid	Narrowband	0,1574821	-55,2	RMS	10	-23,0	32,2
mid	Narrowband	121,1653	-45,0	RMS	100	-13,0	32,0
mid	Narrowband	737,9772	-40,8	RMS	100	-13,0	27,8
mid	Narrowband	749,9969	-45,4	RMS	10	-13,0	32,4
mid	Narrowband	769,1969	-52,5	RMS	10	-13,0	39,5
mid	Narrowband	952,9356	-43,7	RMS	100	-13,0	30,7
mid	Narrowband	6983,4	-30,8	RMS	1000	-13,0	17,8
high	Narrowband	0,0096758	-61,7	RMS	1	-33,0	28,7
high	Narrowband	0,0524996	-55,3	RMS	10	-23,0	32,3
high	Narrowband	118,7656	-45,3	RMS	100	-13,0	32,3
high	Narrowband	723,1802	-44,9	RMS	100	-13,0	31,9
high	Narrowband	749,9969	-46,0	RMS	10	-13,0	33,0
high	Narrowband	768,1025	-54,4	RMS	10	-13,0	41,4
high	Narrowband	953,2355	-43,2	RMS	100	-13,0	30,2
high	Narrowband	6797,9	-31,0	RMS	1000	-13,0	18,0

Remark: Please see next sub-clause for the measurement plot.

General considerations concerning the measurement plots:

The measuring bandwidth of 100 kHz was chosen according the test requirements exept at the band edges: At the band edges reducing of measurement bandwidth was necessary to prevent overlaying the RF-signal over the spurious emissions.
Also outside the downlink frequency band ath lower frequencies the measurement bandwidths were reduced to have the possibility to record the spurious emissions at these lower frequencies.

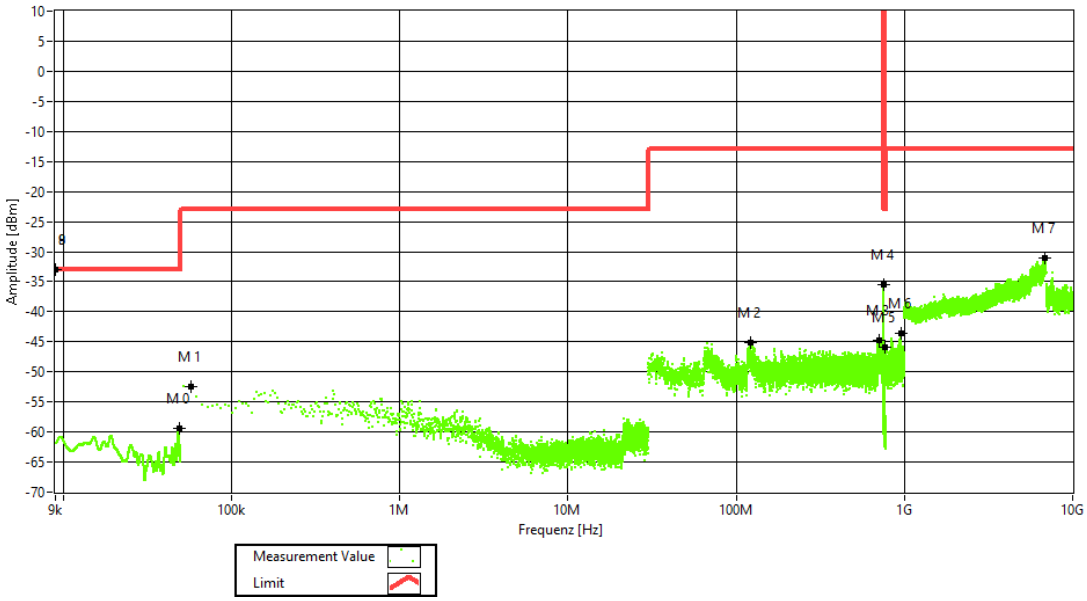
At frequencies were measuring bandwidths were reduced also the border lines were reduced acoording the given formula:

$$p\ RBWreduced\ [dBm] = 10 * \log\left(RBWreduced\ [kHz] — 100\ kHz\right) + pRBW\ 100\ kHz[dBm]$$

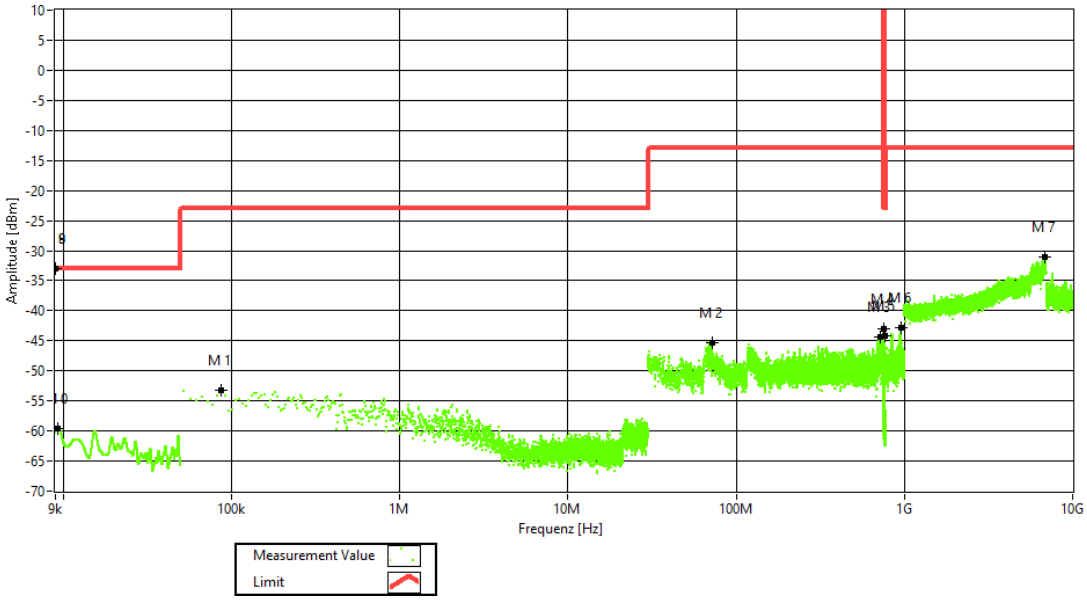
Hereby "p" are the border lines' values.

4.4.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

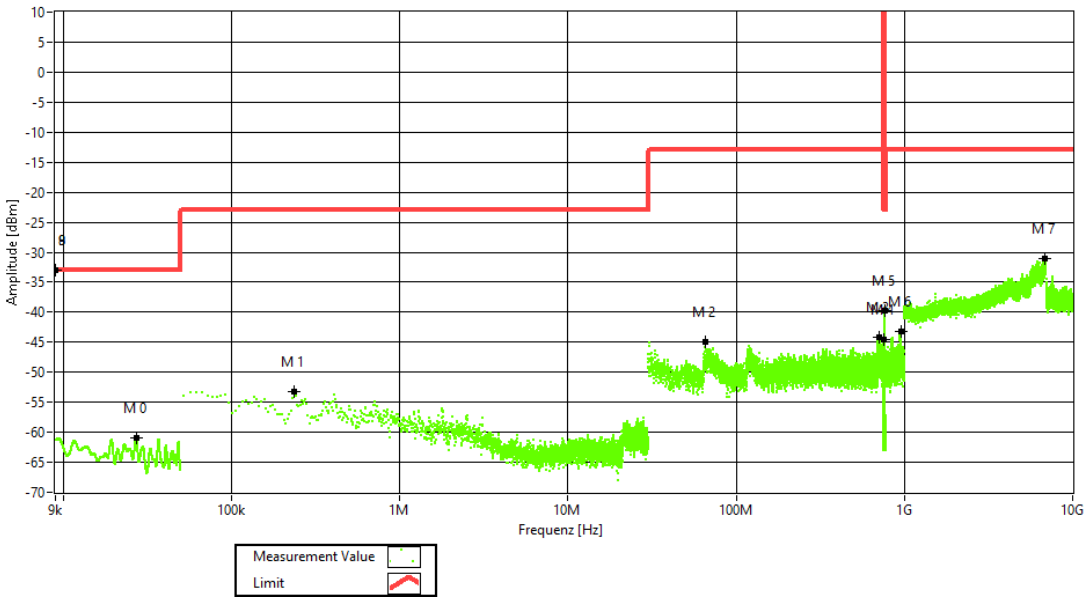
Frequency Band = LMR 750, Test Frequency = low, Direction = RF downlink, Signal Type = AWGN



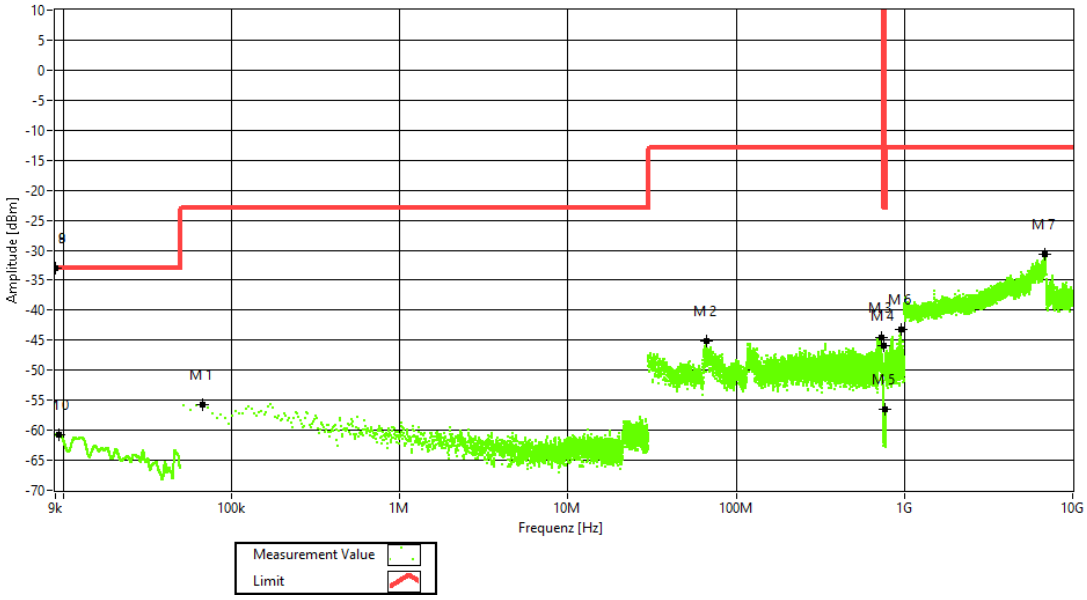
Frequency Band = LMR 750, Test Frequency = mid, Direction = RF downlink, Signal Type = AWGN



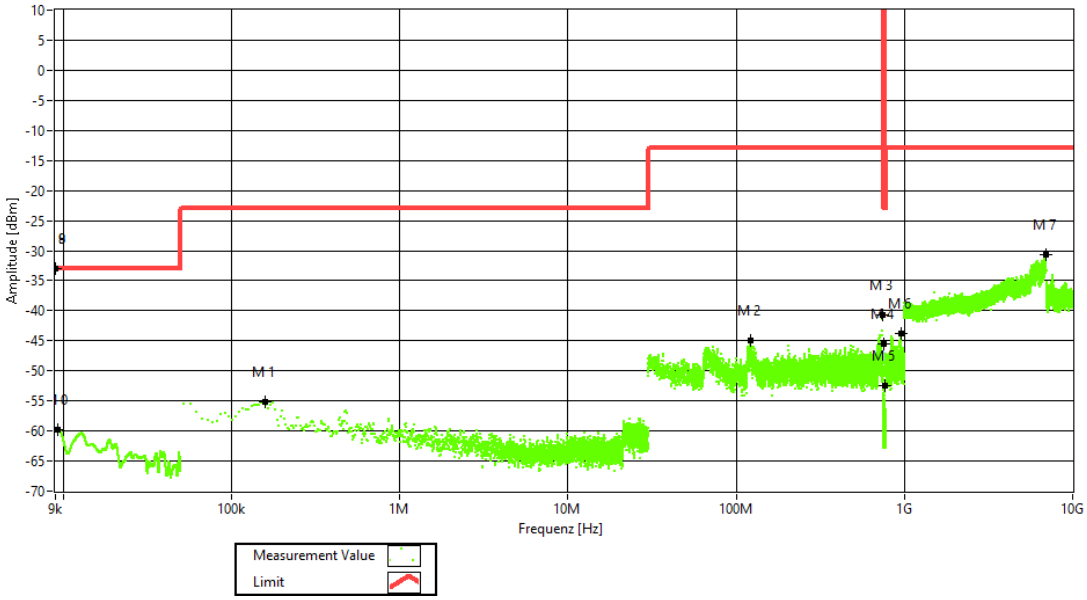
Frequency Band = LMR 750, Test Frequency = high, Direction = RF downlink, Signal Type = AWGN



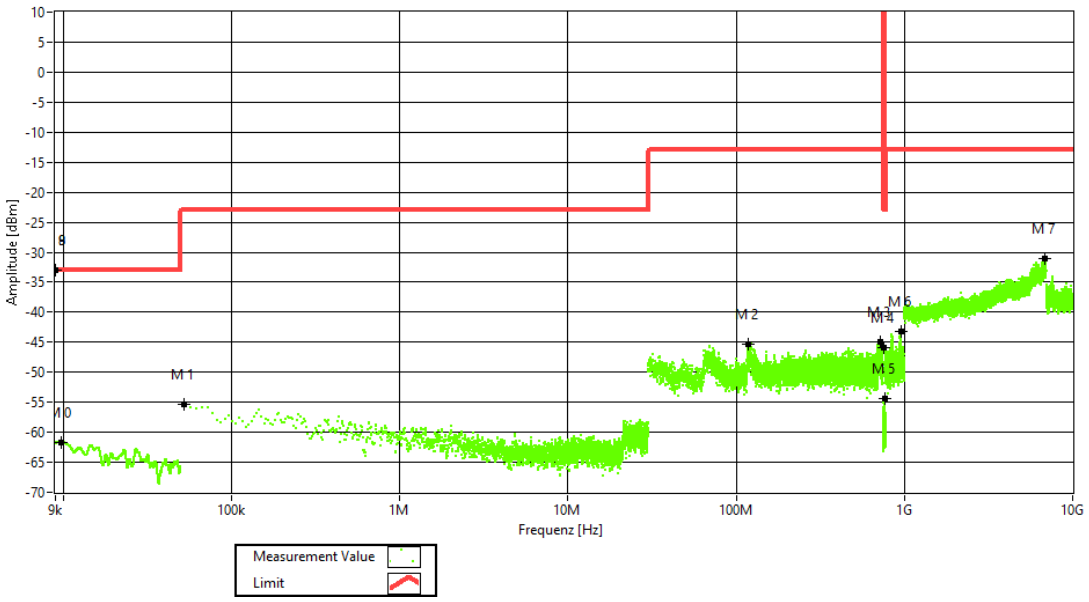
Frequency Band = LMR 750, Test Frequency = low, Direction = RF downlink, Signal Type = GSM



Frequency Band = LMR 750, Test Frequency = mid, Direction = RF downlink, Signal Type = GSM



Frequency Band = LMR 750, Test Frequency = high, Direction = RF downlink, Signal Type = GSM



4.4.5 TEST EQUIPMENT USED

- Conducted

4.5 OUT-OF-BAND EMISSION LIMITS

Standard FCC Part § 2.1051, § 27.53

The test was performed according to:
ANSI C63.26, KDB 935210 D05 v01r04: 3.6

Test date: .2020-07-20 to 2020-07-21

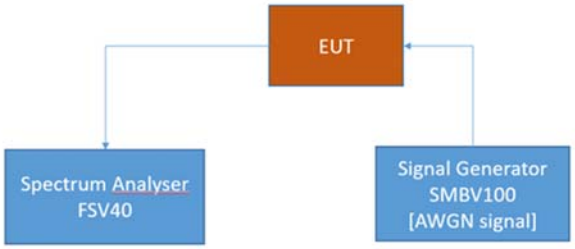
Environmental conditions: 25 ° C; 40 % r. F.

Test engineer: Thomas Hufnagel

4.5.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the out-of-band emission limit for industrial signal boosters. The limits itself come from the applicable rule part for each operating band per FCC § 2.1053 and FCC § 90.219.

The EUT was connected to the test setup according to the following diagram:



FCC Part 22/24/27/90 Industrial signal booster – Test Setup; Out-of-band emissions

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

4.5.2 TEST REQUIREMENTS/LIMITS

Abstract § 2.1051 from FCC:

FCC Part 2.1051; Measurement required: Spurious emissions at antenna terminal:

The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in § 2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

Abstract § 90.219 FCC:

§90.219 – Use of signal boosters

(e)(3) Spurious emissions from a signal booster must not exceed −13 dBm within any 100 kHz measurement bandwidth.

(d)(6)(i) In general, the ERP of intermodulation products should not exceed −30 dBm in 10 kHz measurement bandwidth.

4.5.3 TEST PROTOCOL

LMR 750, downlink, Number of input signals = 1							
Signal Type	**Input Power**	**Band Edge**	**Signal Frequency [MHz]**	**Input Power [dBm]**	**Maximum Out-of-band Power [dBm]**	**Limit Out-of-band Power [dBm]**	**Margin to Limit [dB]**
Wideband	-0.3 dB < AGC	upper	765.50	-1.9	-30.9	-13.0	17.9
Wideband	3 dB > AGC	upper	765.50	1.4	-37.0	-13.0	24.0
Narrowband	-0.3 dB < AGC	upper	767.80	-2.7	-30.7	-13.0	17.7
Narrowband	3 dB > AGC	upper	767.80	0.6	-31.0	-13.0	18.0
Wideband	-0.3 dB < AGC	lower	760.50	-2.3	-29.1	-13.0	16.1
Wideband	3 dB > AGC	lower	760.50	1.0	-37.3	-13.0	24.3
Narrowband	-0.3 dB < AGC	lower	758.20	-2.3	-30.7	-13.0	17.7
Narrowband	3 dB > AGC	lower	758.20	1.0	-30.4	-13.0	17.4

LMR 750, downlink, Number of input signals = 2								
Signal Type	**Input Power**	**Band Edge**	**Signal Frequency f1 [MHz]**	**Signal Frequency f2 [MHz]**	**Input Power [dBm]**	**Maximum Out-of-band Power [dBm]**	**Limit Out-of-band Power [dBm]**	**Margin to Limit [dB]**
WB	-0.3 dB < AGC	upper	765.50	763.00	-1.9	-33.1	-13.0	20.1
WB	3 dB > AGC	upper	765.50	763.00	1.4	-33.2	-13.0	20.2
NB	-0.3 dB < AGC	upper	767.80	767.60	-2.7	-32.5	-13.0	19.5
NB	3 dB > AGC	upper	767.80	767.60	0.6	-50.5	-13.0	37.5
WB	-0.3 dB < AGC	lower	760.50	763.00	-2.3	-37.0	-13.0	24.0
WB	3 dB > AGC	lower	760.50	763.00	1.0	-37.1	-13.0	24.1
NB	-0.3 dB < AGC	lower	758.20	758.40	-2.3	-31.4	-13.0	18.4
NB	3 dB > AGC	lower	758.20	758.40	1.0	-50.7	-13.0	37.7

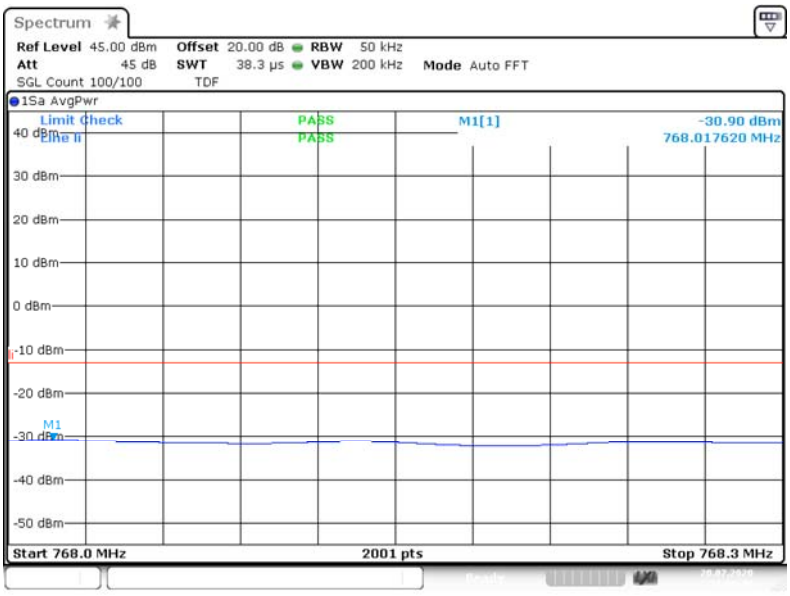
Remark: Please see next sub-clause for the measurement plot.

Explanations concering table with two input signals:

"WB" means Wideband.
"NB" means Narrowband.

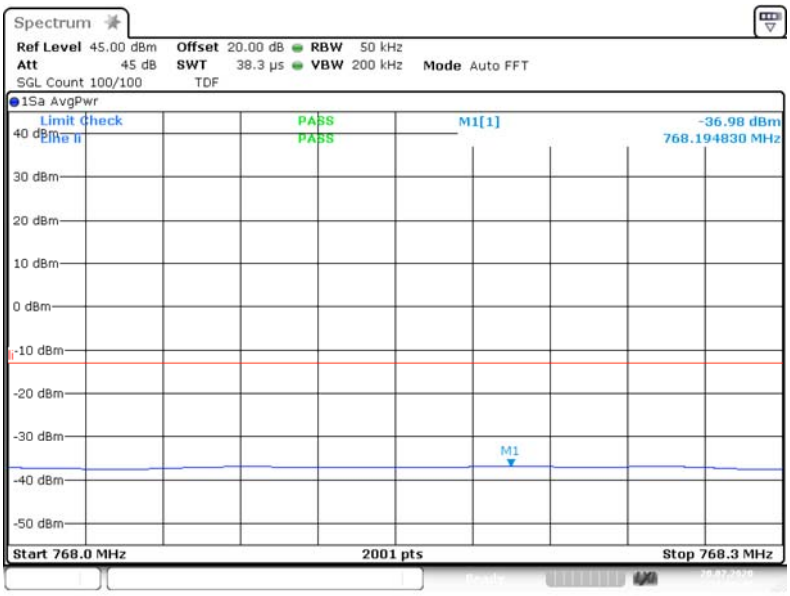
4.5.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: upper; Mod: AWGN; Input Power = 0.3 dB < AGC; Number of signals 1



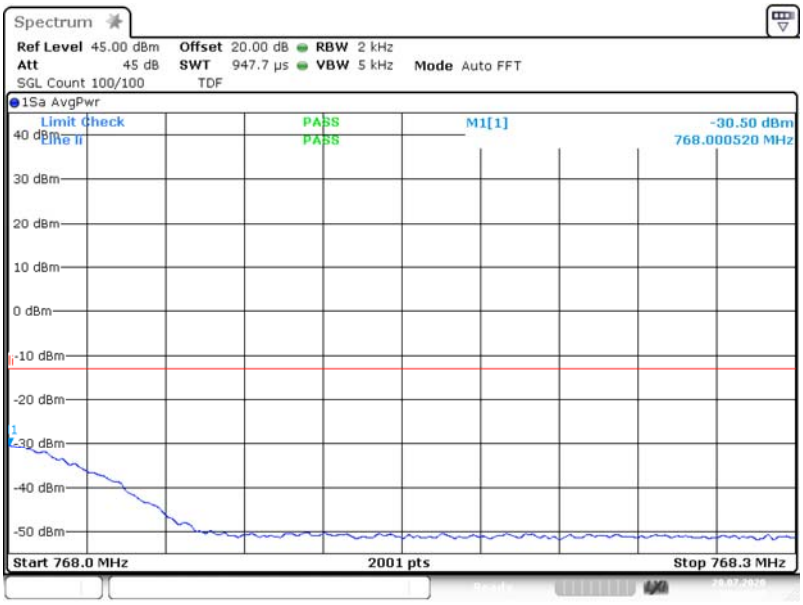
3.6.2 out of band emi LMR750 AWGN upper 1carrier -0.3 dB 768
.000M 768.300M

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: upper; Mod: AWGN; Input Power = 3 dB > AGC; Number of signals 1



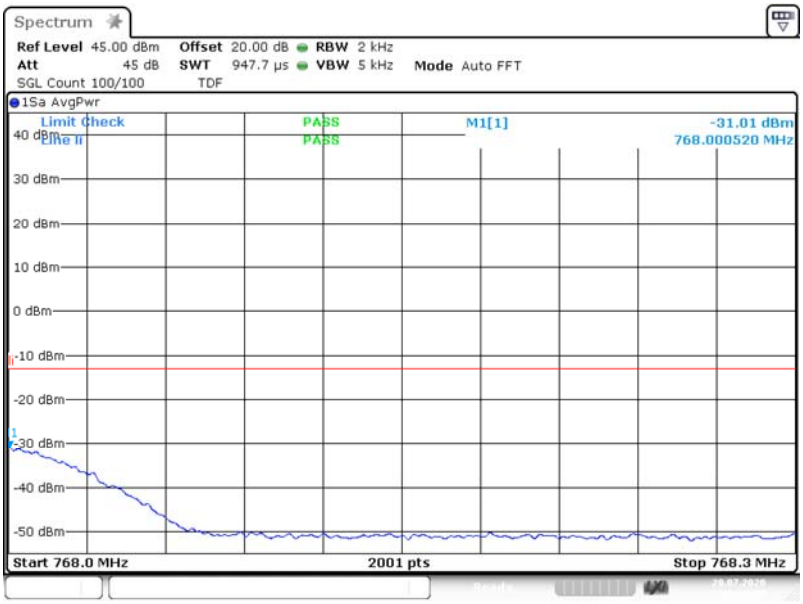
3.6.2 out of band emi LMR750 AWGN upper 1carrier +3.0 dB 768
.000M 768.300M

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: upper; Mod: GSM; Input Power = 0.3 dB < AGC; Number of signals 1



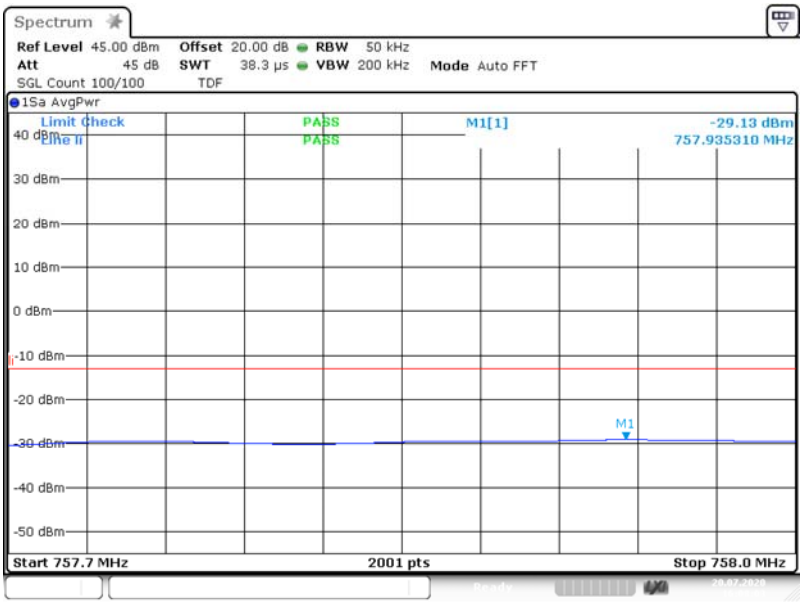
3.6.2 out of band emi LMR750 GSM upper 1carrier -0.3 dB 768.
000M 768.300M

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: upper; Mod: GSM; Input Power = 3 dB > AGC; Number of signals 1



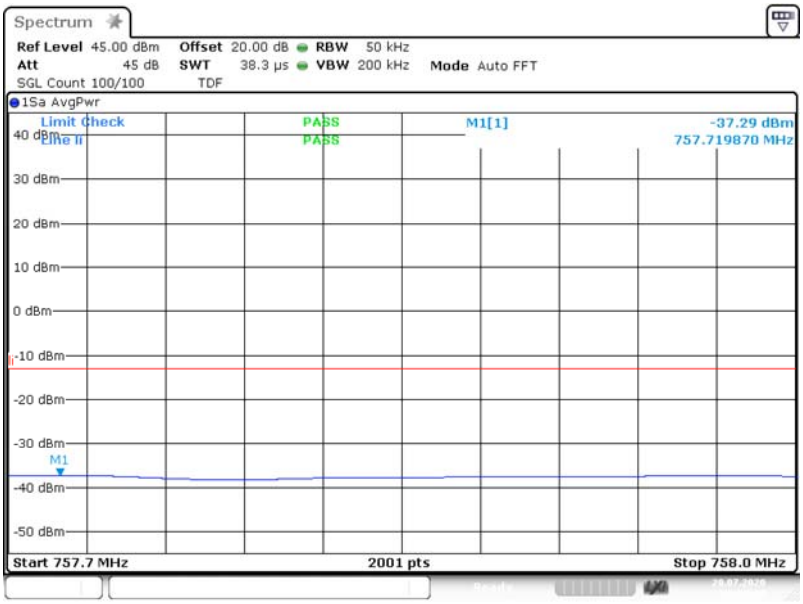
3.6.2 out of band emi LMR750 GSM upper 1carrier +3.0 dB 768.
000M 768.300M

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: lower; Mod: AWGN; Input Power = 0.3 dB < AGC; Number of signals 1



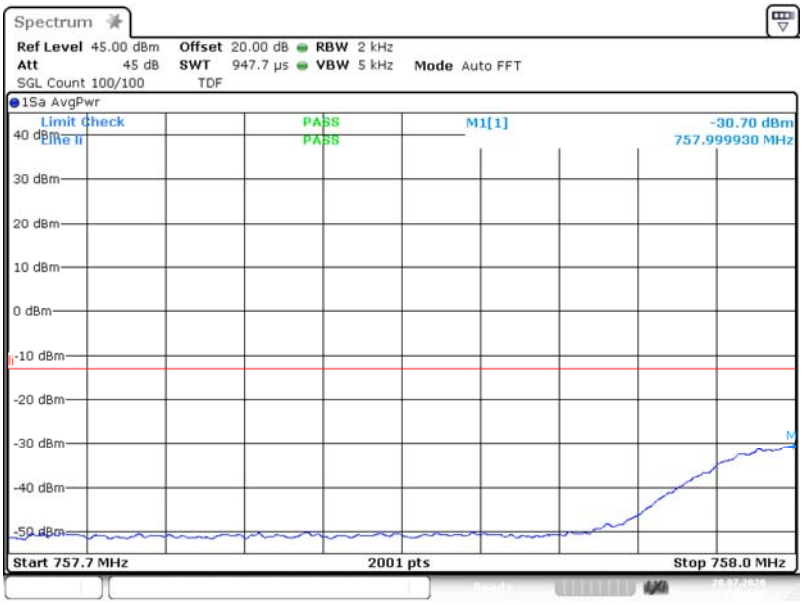
3.6.2 out of band emi LMR750 AWGN lower 1carrier -0.3 dB 757
.700M 758.000M

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: lower; Mod: AWGN; Input Power = 3 dB > AGC; Number of signals 1



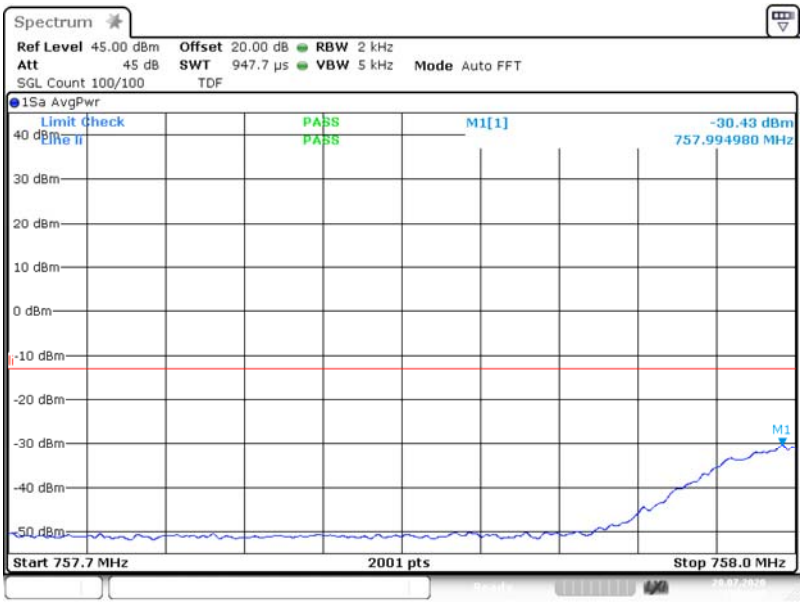
3.6.2 out of band emi LMR750 AWGN lower 1carrier +3.0 dB 757
.700M 758.000M

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: lower; Mod: GSM; Input Power = 0.3 dB < AGC; Number of signals 1



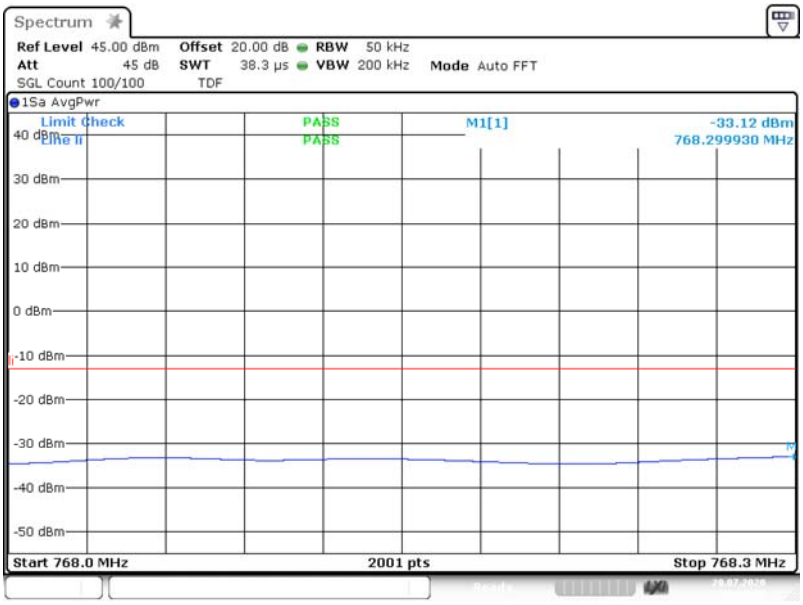
3.6.2 out of band emi LMR750 GSM lower 1carrier -0.3 dB 757.
700M 758.000M

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: lower; Mod: GSM; Input Power = 3 dB > AGC; Number of signals 1



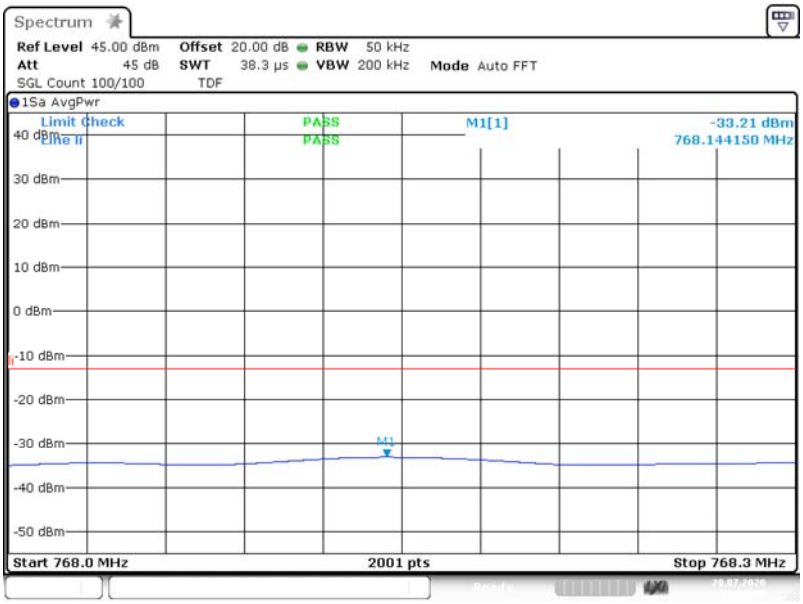
3.6.2 out of band emi LMR750 GSM lower 1carrier +3.0 dB 757.
700M 758.000M

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: upper; Mod: AWGN; Input Power = 0.3 dB < AGC; Number of signals 2



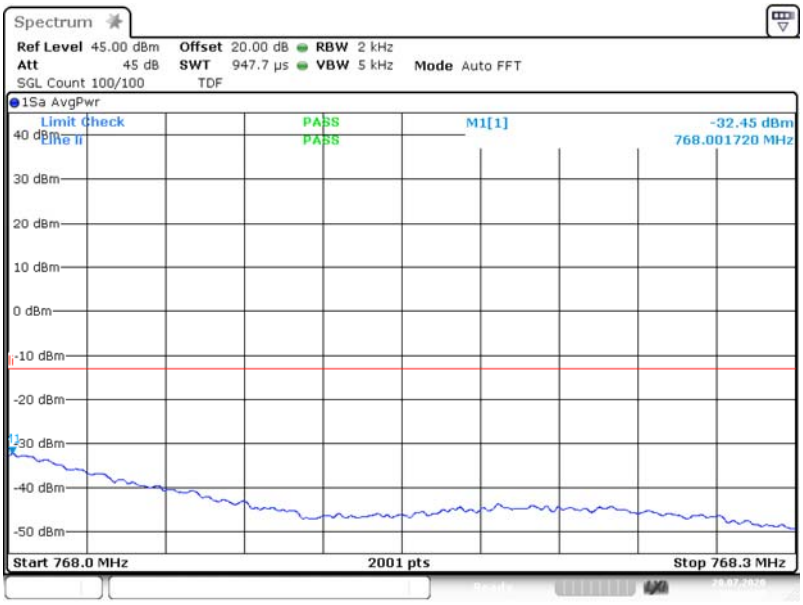
3.6.2 out of band emi LMR750 AWGN upper 2carriers -0.3 dB 76
8.000M 768.300M

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: upper; Mod: AWGN; Input Power = 3 dB > AGC; Number of signals 2



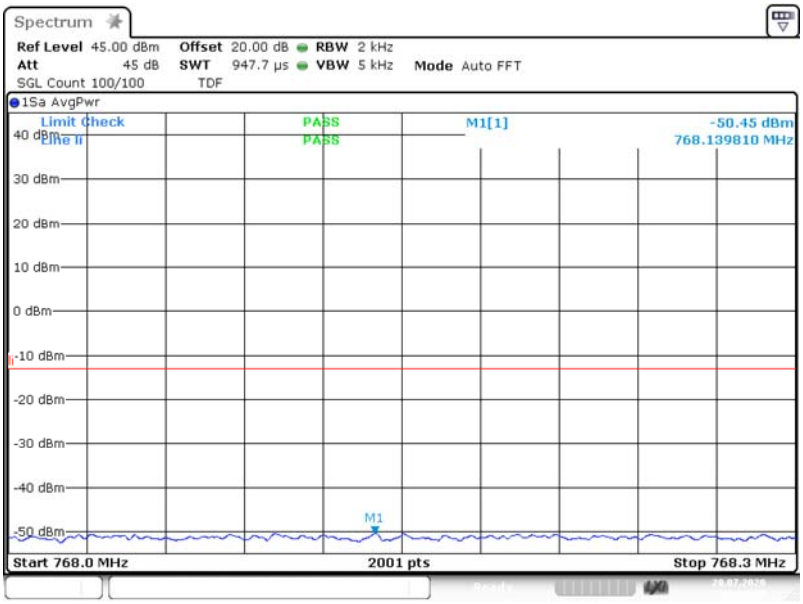
3.6.2 out of band emi LMR750 AWGN upper 2carriers +3.0 dB 76
8.000M 768.300M

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: upper; Mod: GSM; Input Power = 0.3 dB < AGC; Number of signals 2



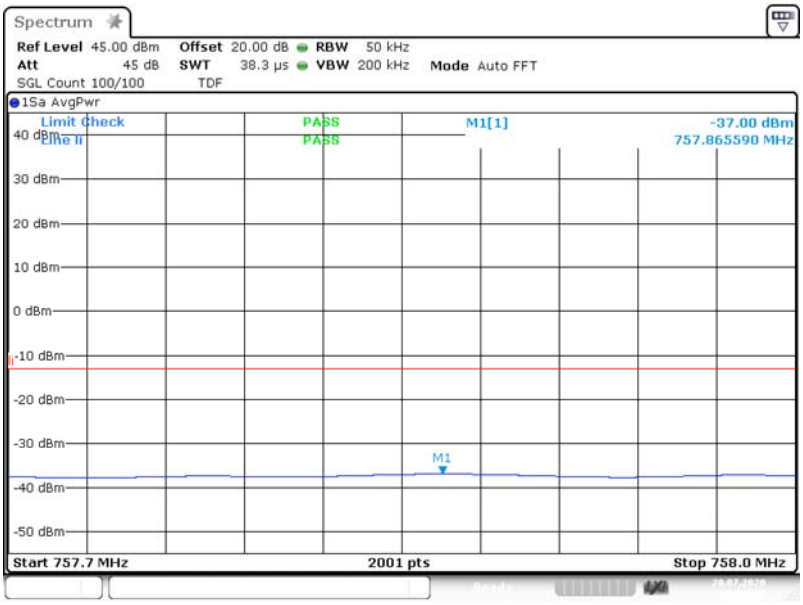
3.6.2 out of band emi LMR750 GSM upper 2carriers -0.3 dB 768
.000M 768.300M

Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: upper; Mod: GSM; Input Power = 3 dB > AGC; Number of signals 2

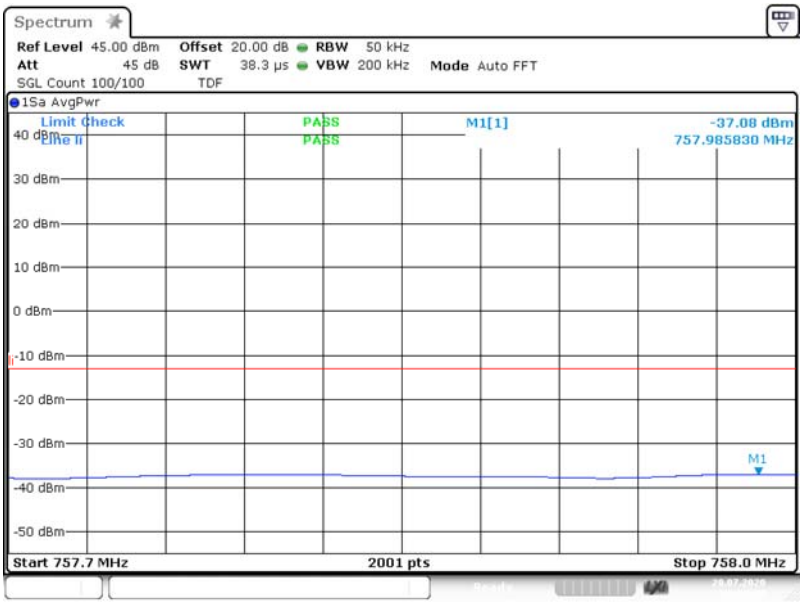


3.6.2 out of band emi LMR750 GSM upper 2carriers +3.0 dB 768
.000M 768.300M

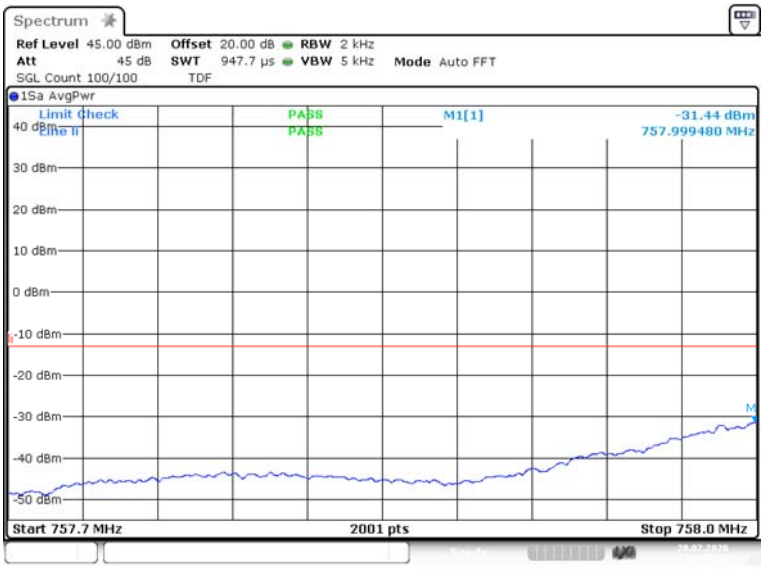
Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: lower; Mod: AWGN; Input Power = 0.3 dB < AGC; Number of signals 2



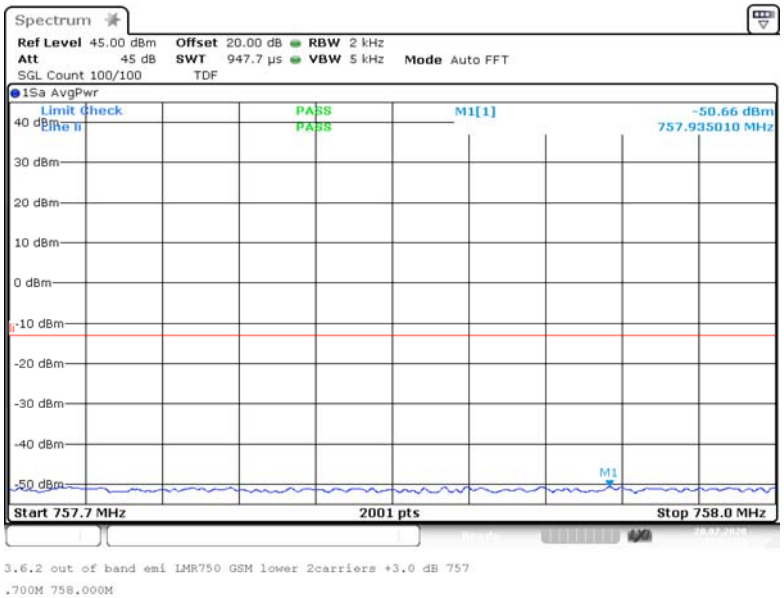
Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: lower; Mod: AWGN; Input Power = 3 dB > AGC; Number of signals 2



Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: lower; Mod: GSM; Input Power = 0.3 dB < AGC; Number of signals 2



Band: LMR750; Frequency: 758.0000 MHz to 768.0000 MHz; Band Edge: lower; Mod: GSM; Input Power = 3 dB > AGC; Number of signals 2



4.5.5 TEST EQUIPMENT USED

- Conducted

4.6 OUT-OF-BAND REJECTION

Standard FCC Part 27

The test was performed according to:
ANSI C63.26; KDB 935210 D05

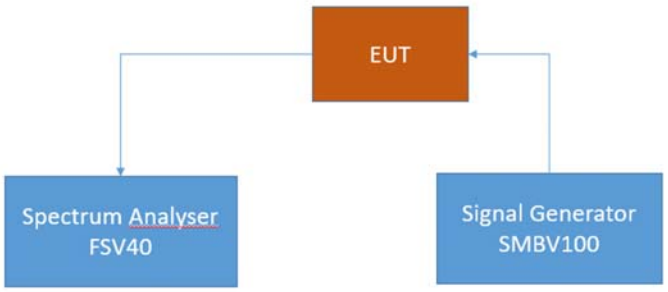
Test date: .2020-07-20 to 2020-07-21

Environmental conditions: 25 ° C; 40 % r. F.

Test engineer: Thomas Hufnagel

4.6.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the out-of-band rejection test case for industrial signal boosters.
The EUT was connected to the test setup according to the following diagram:



FCC Part 22/24/27/90 Industrial signal booster – Test Setup; Out-of-band rejection

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyzer settings can be directly found in the measurement diagrams.

4.6.2 TEST REQUIREMENTS/LIMITS

For this test case exists no applicable limit

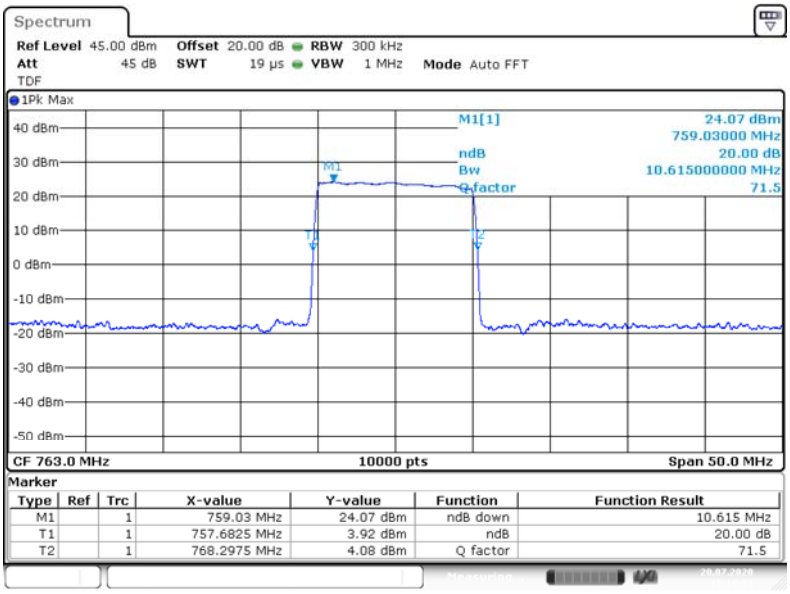
4.6.3 TEST PROTOCOL

LMR 750, downlink				
Highest Power Frequency [MHz]	**Output Power [dBm]**	**Lower Highest Power -20 dB Frequency [MHz]**	**Upper Highest Power -20 dB Frequency [MHz]**	**20 dB Bandwidth [MHz]**
859.03	24.07	757.6825	768.2975	10.6150

Remark: Please see next sub-clause for the measurement plot.

4.6.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

Frequency Band = LMR 750, Direction = RF downlink



3.3 Out of band rejection LMR750 763.00000M
_20dB

4.6.5 TEST EQUIPMENT USED

- Conducted

4.7 NOISE AND NOISE FIGURE

Standard FCC Part 90, § 90.219,

The test was performed according to:
ANSI C63.26

Test date: 2020-10-09

Environmental conditions: 23 ° C; 46 % r. F.

Test engineer: Thomas Gerngroß

4.7.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to noise limit for industrial signal boosters. per FCC § 90.219 and RSS-131 with subpartd 6.3 and 6.4.

The EUT was connected to the test setup according to the following diagram:

FCC Part 22/24/27/90 Industrial signal booster – Test Setup; Noise

The attenuation of the measuring and stimulus path are known for each measured frequency and are considered.

The Spectrum Analyser settings can be directly found in the measurement diagrams.

4.7.2 TEST REQUIREMENTS / LIMITS

Abstract § 90.219 from FCC

§ 90.219 – Use of signal boosters

(d)(6)

Good engineering practice must be used in regard to the radiation of intermodulation products and noise, such that interference to licensed communications systems is avoided. In the event of harmful interference caused by any given deployment, the FCC may require additional attenuation or filtering of the emissions and/or noise from signal boosters or signal booster systems, as necessary to eliminate the interference.

(d) (6) (i)
In general, the ERP of intermodulation products should not exceed −30 dBm in 10 kHz measurement bandwidth.

(d) (6) (ii)
In general, the ERP of noise within the passband should not exceed −43 dBm in 10 kHz measurement bandwidth.

(d) (6) (iii)
In general, the ERP of noise on spectrum more than 1 MHz outside of the passband should not exceed −70 dBm in a 10 kHz measurement bandwidth.

(e)(2)
The noise figure of a signal booster must not exceed 9 dB in either direction.

Abstract RSS-131:

RSS131; 6.3 Intermodulation

The effective radiated power (ERP) of intermodulation products should not exceed −30 dBm in a 10 kHz measurement bandwidth.

RSS-131; 6.4 Noise

The ERP of noise within the passband should not exceed −43 dBm in a 10 kHz measurement bandwidth.

The ERP of noise in spectrum more than 1 MHz outside of the passband should not exceed −70 dBm in a 10 kHz measurement bandwidth.

The noise figure of a zone enhancer shall not exceed 9 dB in either direction.

Customer declaration concerning the noise figure:

- The noise power at the output of a RF 2-port is dependent on noise figure NF and gain G; i.e a high NF does not mean necessarily high noise power at the output;
- FCC limits the noise figure NF of a signal booster to max. 9 dB (also in DL)
- FCC defines: " "signal boosters" as all manners of amplifiers, repeaters, boosters, distributed antenna systems and in-building radiation that serve to amplify signals between a device and a wireless network ";
- Noise figure NF is a useful and common manner for the characterization of a noisy RF 2-port;

— The DUT is **attenuating** till the position after the D/A converter; only from the position after the
D/A converter to the output of the CAP-L the DUT is **amplifying**
(this chain of RF components is the only
complete and cohesive chain with predominantly amplifying stages (including the output port)
(output port shall be included, since noise power at the output is of interest));
— above mentioned FCC definition of signal boosters ("serve to amplify signals") + definition of "noise
figure" for RF 2-ports entail to set the reference planes for determining NF of the DL at the position
after the D/A converter and the output of the CAP-L;
This means that NF of the DUT in DL has to be determined between these two reference planes (NF of
the amplification stages between output of the D/A converter and output of the CAP-L);

This noise figure is below 9 dB!

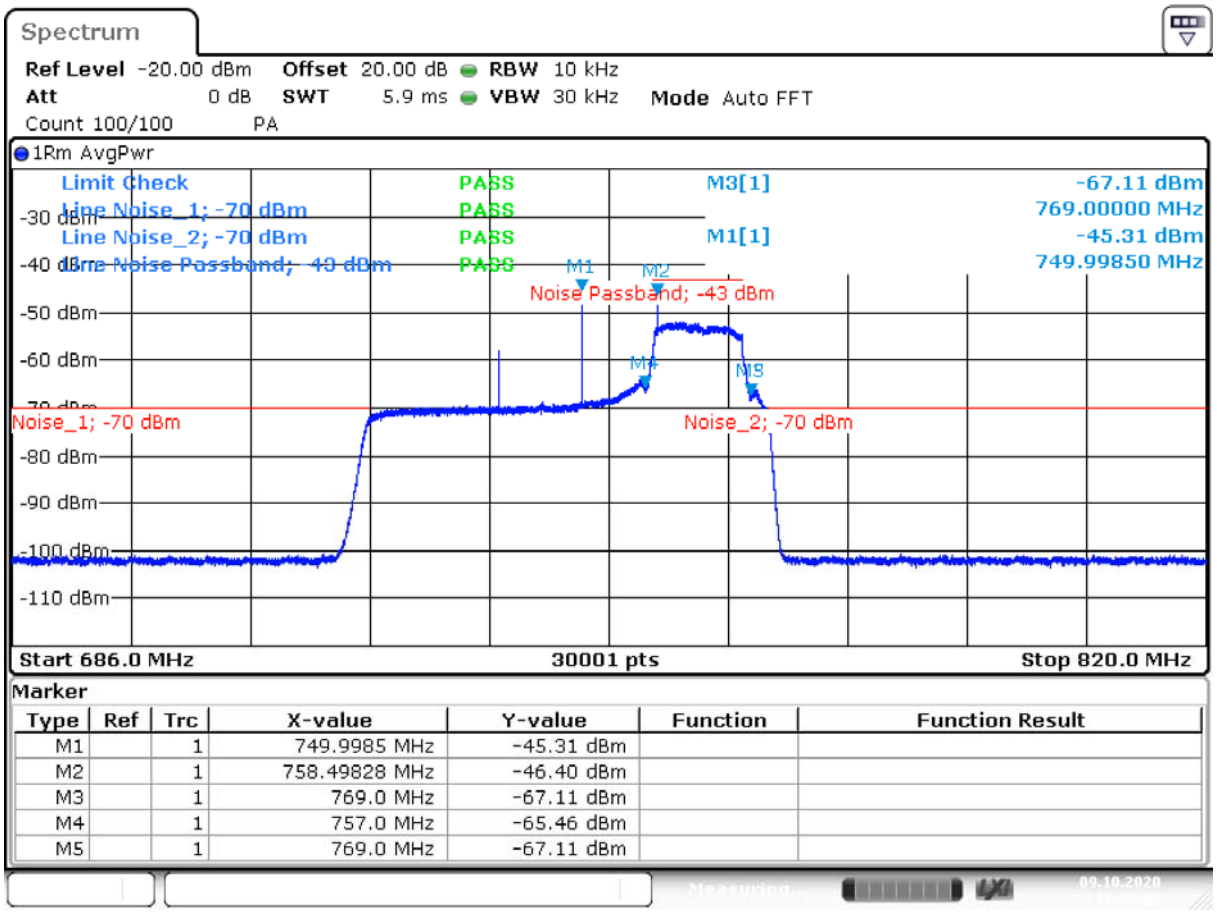
To verify this fact, it would be necessary to carry out a second NF measurement with a reference CAP-L, containing only the D/A converter.
Knowing both noise figures (complete DUT + reference CAP-L), NF of the required amplification stages can be calculated.
Another way to get the NF of the required amplification stages, is to accept line up calculation. This should be acceptable, since NF of the amplification stages is sufficiently lower than 9 dB.
In addition to that, the output noise level, which is crucial, was measured and is significant below the limit.

4.7.3 TEST PROTOCOL OF NOISE

Band LMR 750 (758 MHz to 768 MHz), downlink		
Test step	**Limit**	**Result**
Passband	≤ -43 dBm	Passed
Out of passband	≤ -70 dBm	Passed
Remark	The peaks in the curve in the measurement plots are intermodulation products and no noise. The border line of intermodulation products is at -30 dBm.	

4.7.4 MEASUREMENT PLOT

Frequency Band = LMR 750, Direction = RF downlink, Test Step = passband



Noise Downlink, Band LMR 750

Remarks:

The markers M3 and M4 show the 1 MHz distance points from the band edge frequencies.
M1 shows the highest intermodulation peak value.

The peaks in the curve are intermodulation products and the curve from under 757 MHz of the band LMR 750 to about 726 MHz is the suppressed line of the neigbour band.

4.8 FIELD STRENGTH OF SPURIOUS RADIATION

Standard FCC Part 27, § 24.53

The test was performed according to:
ANSI C63.26

Test date: 2020-09-09

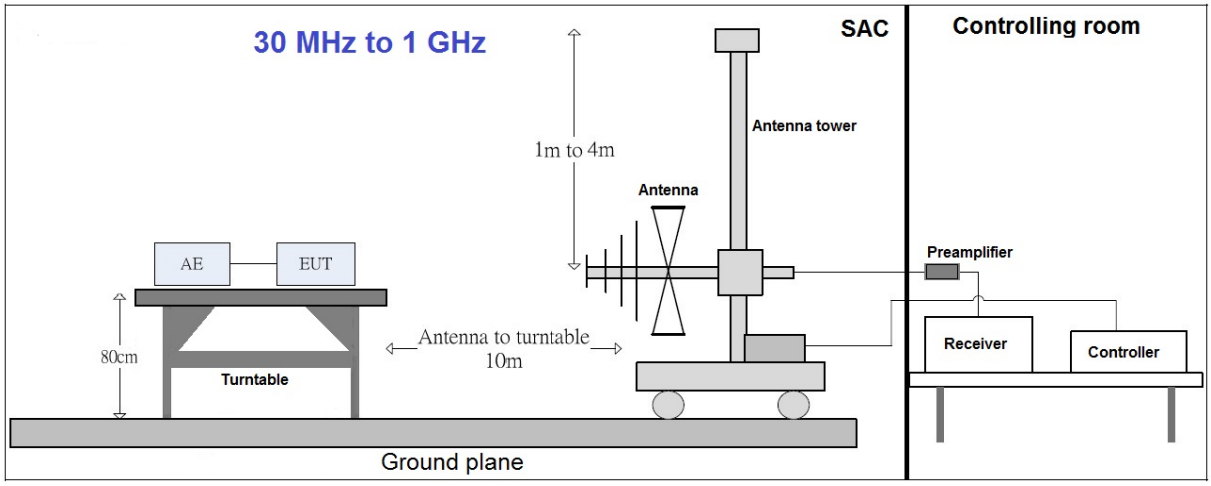
Environmental conditions: 23 ° C; 46 % r. F.

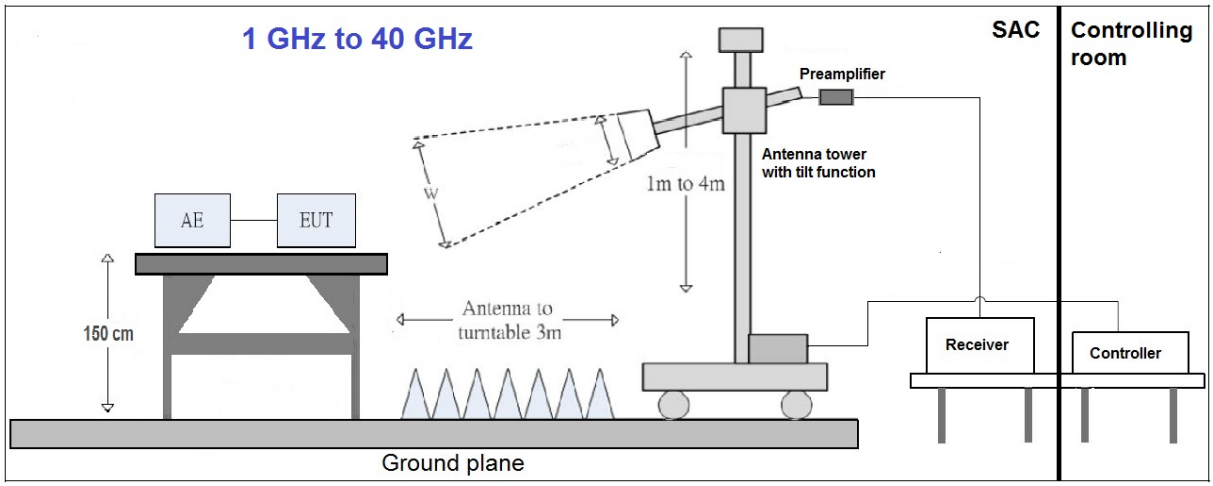
Test engineer: Thomas Hufnagel

4.8.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable radiated spurious emission measurements per FCC § 2.1053 and FCC § 90.543.

The EUT was connected to the test setup according to the following diagram:





The test set-up was made in accordance to the general provisions of ANSI C63.4 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.5 x 1.5 m² in the semi-anechoic chamber, 0.8 meter above the ground or floor-standing arrangement shall be placed on the horizontal ground reference plane.. The influence of the EUT support table that is used between 30–1000 MHz was evaluated. For the initial measurements, the receiving antenna is varied from 1-4 meter height and is changed in the vertical plane from vertical to horizontal polarization at each frequency. The highest emissions between 30 MHz to 1000 MHz were analyzed in details by operating the spectrum analyzer and/or EMI receiver in quasi-peak mode to determine the precise amplitude of the emissions.

The measurement procedure is implemented into the EMI test software BAT EMC from NEXIO. Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is also performed at 3 axes. A pre-check is performed while the EUT is powered by a DC power source. ?

1. Measurement above 30 MHz and up to 1 GHz

Step 1: Preliminary scan
This is a preliminary test to identify the highest amplitudes relative to the limit.
Settings for step 1:
- Antenna distance: 10 m
- Detector: Peak-Maxhold/RMS (FFT-based)
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF–Bandwidth: 120 kHz
- Measuring time/Frequency step: 5 ms
- Turntable angle range: –180° to 180°
- Turntable step size: 30°
- Height variation range: 1 – 4 m
- Height variation step size: 1 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: Adjustment measurement
In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.
For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary by ± 45° around this value. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary by ± 100 cm around the antenna height determined. During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.
- Detector: Peak – Maxhold; RMS
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range: ± 30 ° around the determined value
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector
With the settings determined in step 3, the final measurement will be performed:
EMI receiver settings for step 4:
- Detector: Quasi-Peak (< 1 GHz); RMS; Peak
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

3. Measurement above 1 GHz
The following modifications apply to the measurement procedure for the frequency range above 1 GHz:
Step 1:
The Equipment Under Test (EUT) was set up on a non-conductive support at 1.5 m height in the semi-anechoic chamber. Absorbers are placed around and between the turn table and the antenna tower.
All steps were performed with one height (1.5 m) of the receiving antenna only.
The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 30 °.
The turn table step size (azimuth angle) for the preliminary measurement is 15 °.
Step 2:
The maximum RFI field strength was determined during the measurement by rotating the turntable (±180 degrees) and varying the height of the receive antenna (h = 1 ... 4 m) with a additional tilt function of the antenna.The turn table azimuth will slowly vary by ± 15°.
EMI receiver settings (for all steps):
- Detector: Peak, Average
- IF Bandwidth = 1 MHz

Step 3:
Spectrum analyser settings for step 3:
- Detector: Peak/Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 1 MHz
- Measuring time: 1 s

4.8.2 TEST REQUIREMENTS/LIMITS

Abstract from FCC Part § 2.1053:

FCC Part 2.1053; Measurement required: Field strength of spurious radiation:

Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of § 2.1049, as appropriate.

§90.543 – Emission limitations

(e) For operations in the 758-768 MHz and the 788-798 MHz bands, the power of any emission outside the 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, in accordance with the following:

(1) On all frequencies between 769-775 MHz and 799-805 MHz, by a factor not less than 76 + 10 log (P) dB in a 6.25 kHz band segment, for base and fixed stations.

(3) On any frequency between 775-788 MHz, above 805 MHz, and below 758 MHz, by at least 43 + 10 log (P) dB.

(f) For operations in the 758-775 MHz and 788-805 MHz bands, all emissions including harmonics in the band 1559-1610 MHz shall be limited to −70 dBW/MHz equivalent isotropically radiated power (EIRP) for wideband signals, and −80 dBW EIRP for discrete emissions of less than 700 Hz bandwidth. For the purpose of equipment authorization, a transmitter shall be tested with an antenna that is representative of the type that will be used with the equipment in normal operation.Abstract RSS-119 5.8.9.2 from ISED:

4.8.3 TEST PROTOCOL

30 MHz to 1 GHz:

LMR 750, downlink;						
Spurious Freq. [MHz]	**Spurious Level [dBm]**	**Pin (Sum Level) [dBm]**	**Detector**	**RBW [kHz]**	**Limit [dBm]**	**Margin to Limit [dB]**
36.23	-65.9	-2.0	PEAK	120	-13.0	52.9
74.73	-56.5	-2.0	PEAK	120	-13.0	43.5
133.47	-64.6	-2.0	PEAK	120	-13.0	51.6
272.21	-53.3	-2.0	PEAK	120	-13.0	40.3
600.01	-62.6	-2.0	PEAK	120	-13.0	49.6
758.2	-54.5	-2.0	PEAK	120	-13.0	41.5

Above 1 GHz:

LMR 750, downlink;						
Spurious Freq. [MHz]	**Spurious Level [dBm]**	**Pin (Sum Level) [dBm]**	**Detector**	**RBW [kHz]**	**Limit [dBm]**	**Margin to Limit [dB]**
2852.88	-43.8	-2.0	PEAK	1000	-13.0	30.8
3532.70	-41.5	-2.0	PEAK	1000	-13.0	28.5
5265.3	-34.9	-2.0	PEAK	1000	-13.0	21.9
16198.8	-21.7	-2.0	PEAK	1000	-13.0	8.7
16746.7	-20.1	-2.0	PEAK	1000	-13.0	7.1
17795.9	-20.3	-2.0	PEAK	1000	-13.0	7.3

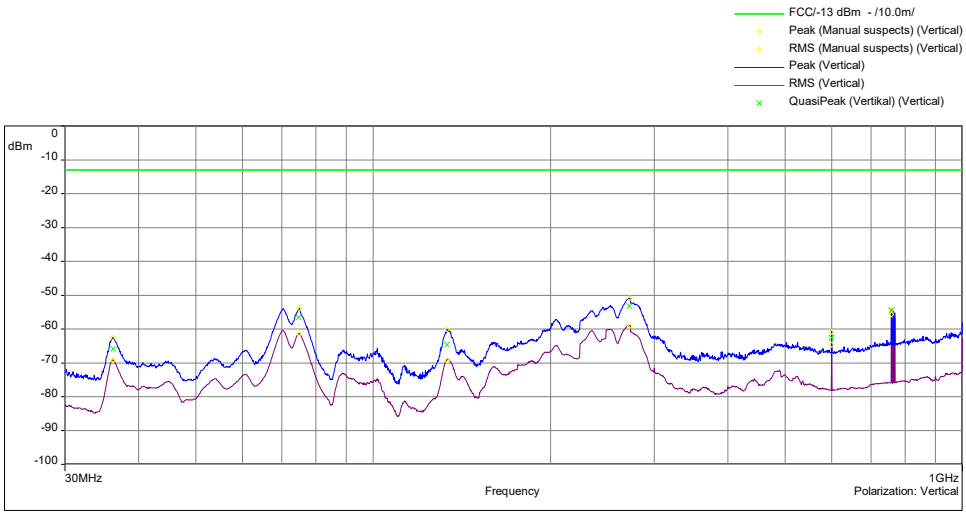
Remarks: Please see next sub-clause for the measurement plot.

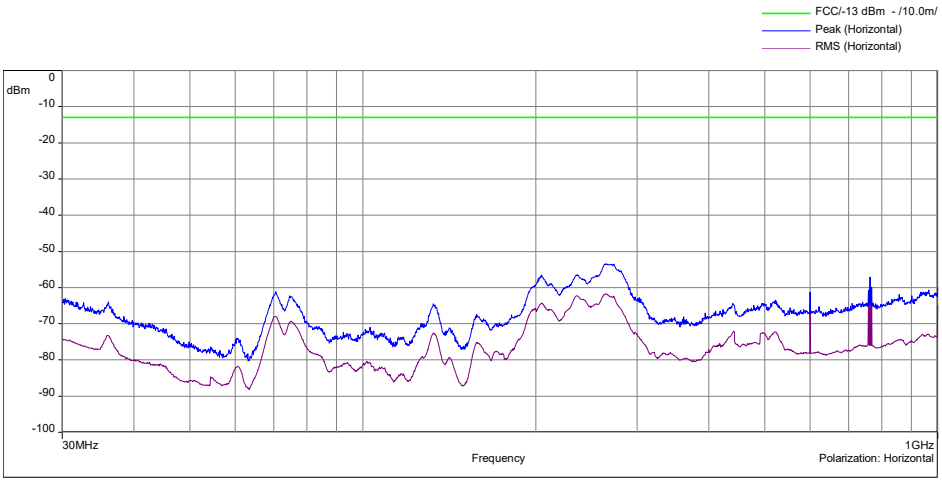
Although ususally a RMS detector is used for measruements in this cases a PEAK detector was used.
The limits are values for use of a RMS detector, but it is so, that the use of a PEAK detector results in readings with higher measured levels. Because the levels with the higher values with PEAK detector are in tolerance, the limits with a RMS detector are definately also in tolerance.

4.8.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

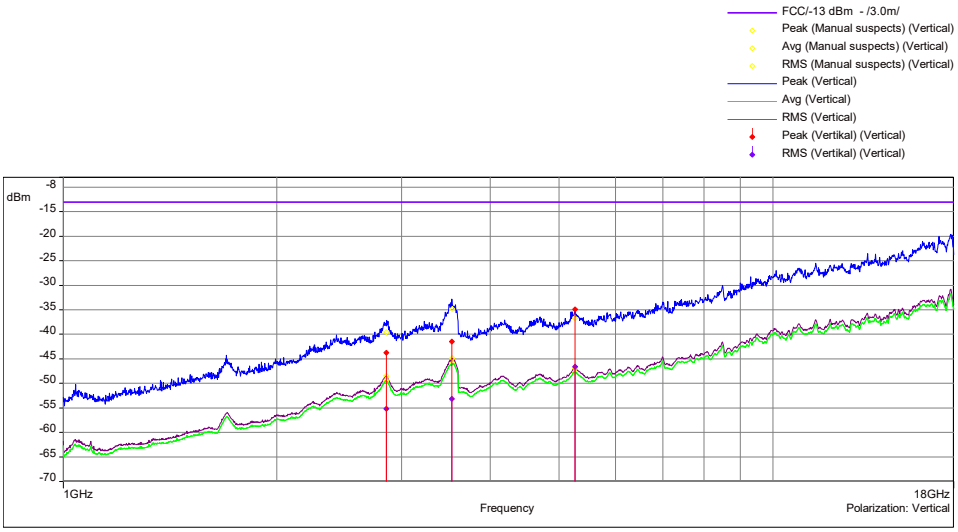
Frequency Band = LMR 750, Test Frequency = low, Direction = RF downlink

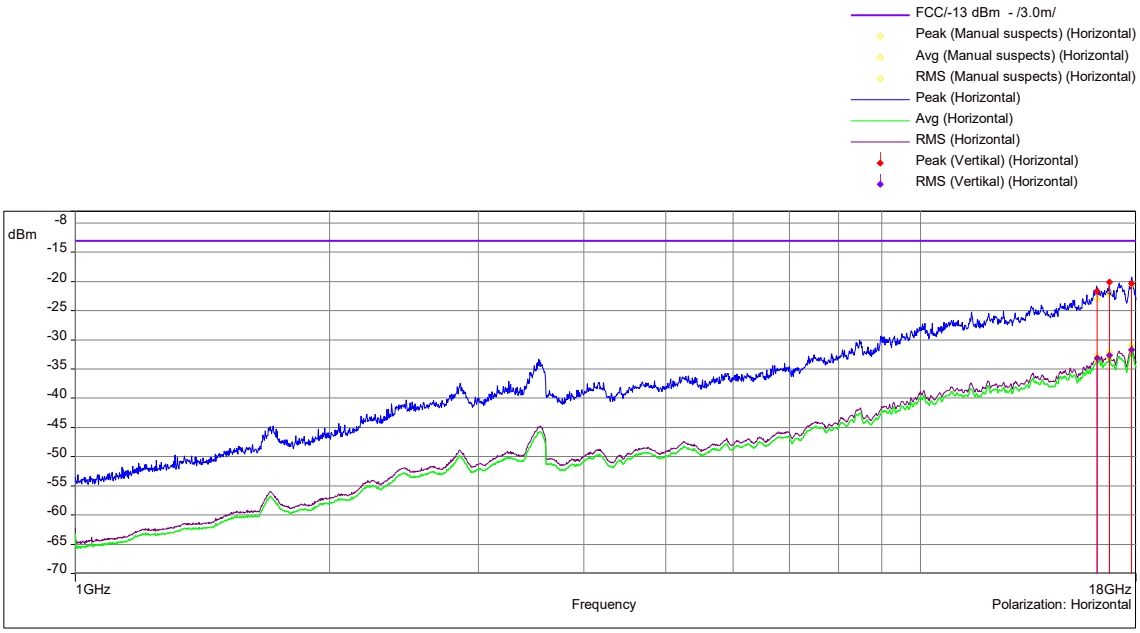
30 MHz - 1 GHz





1 GHz - 18 GHz


FCC/-13 dBm - /3.0m/
Peak (Manual suspects) (Vertical)
Avg (Manual suspects) (Vertical)
RMS (Manual suspects) (Vertical)
Peak (Vertical)
Avg (Vertical)
RMS (Vertical)
Peak (Vertikal) (Vertical)
RMS (Vertikal) (Vertical)
dBm
-8
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
1GHz
Frequency
18GHz
Polarization: Vertical


FCC/-13 dBm - /3.0m/
Peak (Manual suspects) (Horizontal)
Avg (Manual suspects) (Horizontal)
RMS (Manual suspects) (Horizontal)
Peak (Horizontal)
Avg (Horizontal)
RMS (Horizontal)
Peak (Vertikal) (Horizontal)
RMS (Vertikal) (Horizontal)
dBm
-8
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
1GHz
Frequency
18GHz
Polarization: Horizontal

4.8.5 FIELD STRENGTH CALCULATIONS

FS = SA + AF + CL + PA

Where as:

FS = Field strength
SA = EMC test receiver reading
AF = Antenna factor
CL = Cable loss
PA = Preamplifier

4.8.6 TEST EQUIPMENT USED

- Radiated Emissions

5 TEST EQUIPMENT

1 Conducted

Ref.No.	Type	Description	Manufacturer	Inventory no.	Last Calibration	Calibration Due
1.1	FSV40	Signal Analyzer 10 Hz - 40 GHz	Rohde & Schwarz	E2050	2019-10	2020-10
1.2	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	G2089	2017-08/ 2020-08	2022-08
1.3	SMIQ	Vector Signal Generator 9 kHz – 3.3 GHz	Rohde & Schwarz	G1509	2018-10	2021-10
1.4	SMIQ	Vector Signal Generator 9 kHz – 3.3 GHz	Rohde & Schwarz	G1510	2018-10	2021-10
1.5	ESH3-Z5	Line Impedance Stabilisation Network (LISN) 150 Hz – 30 MHz	Rohde & Schwarz	K794	2019-02	2020-10
1.6	30.3015	ThermoHygro Datalogger	TFA	X 507	2018-08	2021-08
1.7	BAT-EMC	Software	Nexio	V3.17.0.26	---	---

2 Radiated Emissions

Ref.No.	Type	Description	Manufacturer	Inventory no.	Last Calibration	Calibration Due
2.1	ESU40	EMI test receiver 10 Hz - 40 GHz	Rohde & Schwarz	E2025	2018-10	2020-10
2.2	HFH2-Z2	Antenna 9 kHz – 30 MHz	Rohde & Schwarz	K549	2018-10	2020-10
2.3	CBL 6111C	Antenna 30 MHz – 1 GHz	Chase	K1026	2020-01	2021-01
2.4	HL 025	Antenna 1 GHz - 18 GHz	Rohde & Schwarz	K1114	2019-06	2021-06
2.5	MWH-1826/B	Antenna 18 GHz – 26.5 GHz	ARA Inc.	K1042	2018-11	2020-11
2.6	MWH-2640/B	Antenna 26 GHz - 40 GHz	ARA Inc.	K1043	2018-11	2020-11
2.7	AM1431	Pre amplifier 10 kHz – 1 GHz	Miteq	K1721	2019-10	2020-10
2.8	AFS4-00102000	Preamplifier 100 MHz - 20 GHz	Miteq	K817	2019-08	2021-08.
2.9	AFS4-00102000	Preamplifier 100 MHz - 20 GHz	Miteq	K838	2019-10	2020-10
2.10	JS43-1800-4000	Preamplifier 18 GHz - 40 GHz	Miteq	K1104	2019-05	2020-10
2.11	BAT-EMC	Software	Nexio	V3.17.0.26	---	---

6 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

This chapter contains the antenna factors with their corresponding path loss of the used measurement path for all antennas.

6.1 ANTENNA CHASE CBL 6111C (30 MHZ – 1 GHZ)

(d = 10 m)

Frequency	AF Horizontal R&S CBL 6111C	AF Vertikal R&S CBL 6111C	Corr.	cable loss (antenna - pre-amp)	pre-amp	cable loss (inside chamber)	cable loss (to receiver)
30	47.9	38.1	-38.1	-0,01	-38.3	0.0	0.1
50	34.4	26.4	-38.0	0,28	-38.4	0.3	0.1
100	31.6	32.8	-38.0	0,52	-38.7	0.5	0.2
150	33.7	33.9	-37.9	0,73	-38.8	0.7	0.2
200	30.3	32.8	-37.7	0,95	-38.9	1.0	0.3
250	33.6	36.5	-37.5	1,10	-38.9	1.1	0.3
300	34.5	36.8	-37.1	1,20	-38.6	1.2	0.3
350	36.3	37.2	-37.0	1,29	-38.6	1.3	0.3
400	36.9	38.3	-36.8	1,36	-38.5	1.4	0.3
450	38.0	39.6	-36.5	1,42	-38.2	1.4	0.4
500	39.2	40.4	-36.0	1,48	-37.9	1.5	0.4
550	41.2	42.1	-35.9	1,54	-37.8	1.5	0.4
600	41.6	41.7	-35.7	1,60	-37.7	1.6	0.4
650	41.9	42.9	-35.9	1,64	-38.0	1.6	0.5
700	42.3	43.4	-35.6	1,71	-37.8	1.7	0.5
750	43.5	43.9	-35.7	1,76	-38.0	1.8	0.5
800	43.6	44.6	-36.0	1,80	-38.3	1.8	0.5
850	45.0	45.1	-36.1	1,84	-38.4	1.8	0.5
900	45.2	45.1	-36.6	1,91	-39.0	1.9	0.5
950	46.4	46.4	-36.4	1,93	-38.9	1.9	0.6
1000	45.8	47.0	-36.0	1,99	-38.6	2.0	0.6

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
distance correction = -20 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

6.2 ANTENNA ROHDE & SCHWARZ HL 025 (1 GHZ – 18 GHZ)

Frequency	AF R&S HL 025	Corr.	pre-amp	cable loss (to receiver)
MHz	dB (1/m)	dB	dB	dB
1000	33.2	-18.9	-20.92	2.01
2000	39.4	-17.8	-20.60	2.78
3000	42.8	-17.0	-20.44	3.42
4000	45.1	-16.6	-20.58	3.99
5000	46.8	-16.6	-21.08	4.46
6000	48.5	-16.7	-21.53	4.87
7000	50.2	-16.2	-21.53	5.35
8000	50.4	-15.3	-20.97	5.66
9000	51.9	-14.4	-20.44	6.05
10000	53.8	-14.0	-20.43	6.45
11000	54.5	-14.1	-20.84	6.69
12000	55.3	-14.4	-21.41	7.04
13000	55.7	-14.7	-22.09	7.36
14000	56.5	-14.8	-22.48	7.66
15000	56.4	-14.7	-22.56	7.90
16000	57.2	-14.3	-22.49	8.20
17000	57.6	-14.5	-22.90	8.45
18000	57.6	-14.6	-23.27	8.71

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

6.3 ANTENNA ARA INC. MWH-1826-B (18 GHZ – 26.5 GHZ) PARTIALLY IN CONJUNCTION WITH PRE-AMPLIFIER MITEQ JS43-1800-4000: THE USE OF THE PRE-AMPLIFIER IS DEPENDENT FROM THE FIELD STRENGTH

Frequency	AF EMCO 3160-09	Corr.	pre-amp	cable loss (to receiver)
MHz	dB (1/m)	dB	dB	dB
18000	44.3	-37.5	-46.2	8.7
18500	43.9	-37.6	-46.4	8.8
19000	44.4	-36.9	-45.9	9.0
19500	44.1	-36.1	-45.2	9.1
20000	44.6	-36.3	-45.6	9.3
20500	44.9	-36.1	-45.5	9.4
21000	45.2	-35.9	-45.3	9.4
21500	45.0	-35.7	-45.3	9.7
22000	45.1	-35.3	-45.1	9.8
22500	45.4	-35.0	-44.8	9.8
23000	45.7	-35.6	-45.5	9.9
23500	45.8	-34.3	-44.4	10.1
24000	45.3	-34.8	-45.0	10.2
24500	45.3	-35.0	-45.3	10.4
25000	46.1	-34.3	-44.8	10.5
25500	46.5	-34.2	-44.7	10.5
26000	46.7	-34.8	-45.4	10.6
26500	46.5	-34.4	-45.1	10.7
27000	46.4	-35.1	-46.0	10.9

Sample calculation

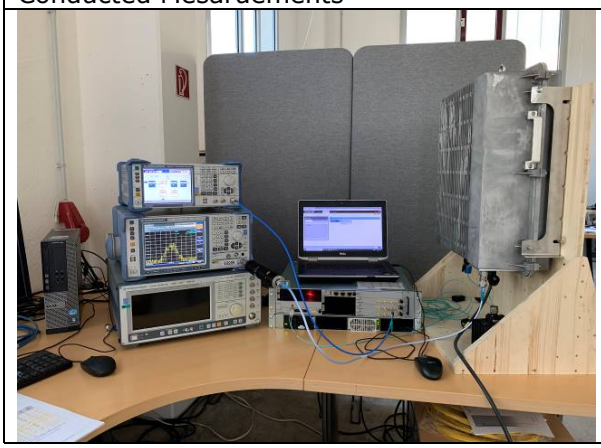
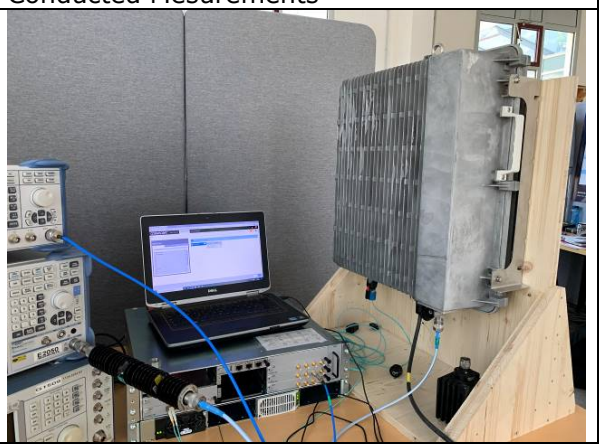
E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values.

7 MEASUREMENT UNCERTAINTIES

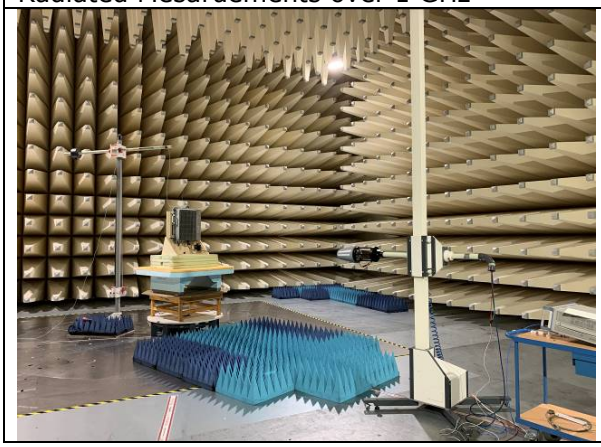
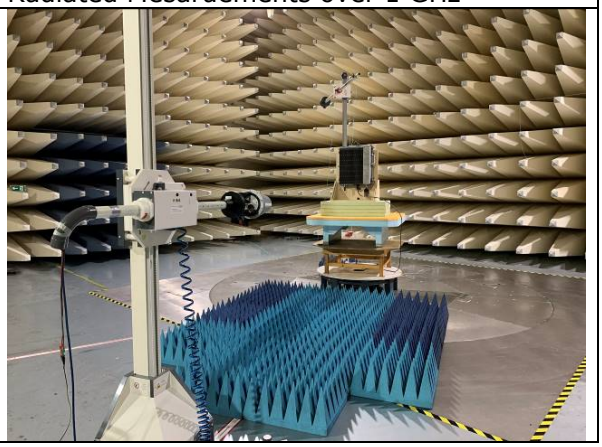
KDB 935210 D05	ECL
Power measurement	0,68 dB
Measuring AGC threshold level	0,90 dB
Out of band rejection	0,90 dB
Input-versus-output signal comparison	0,91 dB
Mean power output	0,90 dB
Measuring out-of-band/out-of-block (including intermodulation) emissions and spurious emissions	0,90 dB
Out-of-band/out-of-block emissions conducted measurements	0,90 dB
Spurious emissions conducted	2,18 dB
Spurious emissions radiated mesurements	5,38 dB
Total frequency uncertainty	2×10^{-7}

reference : ECL-MU5.4.6.3-EMC-14-001-V03.00 MU Wireless.xlsx

8 PHOTO REPORT

Conducted Mesaruements	Conducted Mesurements
	

Radiated Mesaruements 30 MHz up to 1 GHz	Radiated Mesaruements 30 MHz up to 1 GHz
	

Radiated Mesaruements over 1 GHz	Radiated Mesaruements over 1 GHz
	

Annex A: Accreditation certificate (for information)

The accreditation relates to competences stated on the accreditation certificate. The current certificate is available on the homepage of the DAkkS and can be downloaded under accredited bodies with the processing number:
https://www.dakks.de/en

Annex B: Additional information provided by client

None.

****** End of test report *****