

EMV TESTHAUS GmbH

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Accreditation:



FCC facility registration number: 221458 Test Firm Type "2.948 listed": Valid until 2017-04-22 Test Firm Type "accredited": Valid until 2017-06-09 MRA US-EU, FCC designation number: DE0010 BnetzA-CAB-02/21-02/04 Valid until 2018-11-27

Industry Canada test site numbers with registration expiry date: 3472A-1, expiring 2018-11-09 3472A-2, expiring 2018-11-12

Test Laboratory:

EMV **TESTHAUS** GmbH Gustav-Hertz-Straße 35 94315 Straubing Germany

The technical accuracy is guaranteed through the quality management of the EMV **TESTHAUS** GmbH



EMV **TESTHAUS** GmbH Gustav-Hertz-Straße 35 94315 Straubing Germany GMMC GmbH 13.56 MHz Multi Standard - Multi Antenna Reader/Writer SANGOMA-MSMA 2v5

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1 Test regulations

47 CFR Part 2: 03-2017	Code of Federal Regulations Part 2 - Frequency allocation and radio treaty matters; General rules and regulations
47 CFR Part 15: 03-2017	Code of Federal Regulations Part 15 - Radio Frequency Devices
ANSI C63.10:2013-06	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
FCC KDB 174176 D01 June 3, 2015	AC power-line conducted emissions Frequently Asked Questions
ICES-003 Issue 6, January 2016	Spectrum Management and Telecommunications Interference-Causing Equipment Standard Information Technology Equipment (ITE) – Limits and methods of measurement
RSS-Gen Issue 4, November 2014	Spectrum Management and Telecommunications Radio Standards Specification General Requirements and Information for the Certification of Radiocommunication Equimpment
RSS-210 Issue 9, August 2016	Spectrum Management and Telecommunications Radio Standards Specification Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment



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2 Summary of test results

Standard

47 CFR Part 15, sections 15.207 and 15.225

RSS-210 Issue 9 Section 4.3 and Annex B6 (with appropriate references to RSS-Gen Issue 4)

Test result

Passed

Passed

Straubing, March 31, 2017

Martin Müller
 Test engineer
 EMV TESTHAUS GmbH

Christian Kiermeier Technical executive EMV TESTHAUS GmbH



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3 Equipment under Test (EUT)

Product type:	13.56 MHz Multi Standard - Multi Antenna Reader/Writer
Model Name:	SANGOMA-MSMA 2v5
Applicant:	GMMC GmbH
Manufacturer:	GMMC GmbH
Serial number:	#1
FCC ID:	2AKHW-SANGMSMA4
IC certification number:	22202-SANGMSMA4
Application frequency band:	13.110 to 14.010 MHz
Frequency range:	13.560 MHz
Operating frequency:	13.560 MHz
Number of RF-channels:	1
Modulation:	ASK
Antenna types:	PCB antennas
	oxtimes detachable $oxtimes$ not detachable
Power supply:	USB powered nominal: 5.0 VDC ± 15 %
Temperature range:	-20°C to +85°C

Remark: The tests were performed with 120V AC / 60Hz.



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3.1 Photo documentation

For external photos of the EUT see annex B, for internal ones see annex C. For photos taken during testing and including EUT-positions see annex A.

3.2 Short description of the EUT

EUT is a RFID reader/writer operating at the frequency of 13.56 MHz.

3.3 Operation mode

During the pre-tests it was observed that the "continuous-wave-mode" is the respective worstcase. Therefore this mode was selected for final testing.

Because EUT supports 4 antennas tests were performed as follows:

		Test			
Mode	AC power line conducted emissions	Radiated emissions according to 47 CFR, Part 15, section 15.209	Radiated emissions according to 47 CFR, Part 15, section 15.225	Bandwidth tests	
Antenna 2010, stand alone	not performed ¹	performed	performed	performed	
Antenna Jay, stand alone	not performed ¹	performed	performed	performed	
Antenna 4040, stand alone	not performed ¹	performed	performed	performed	
Antenna 7248, stand alone	not performed ¹	performed	performed	performed	
Antenna switching	performed	performed	not performed	not performed	

Note1: Antenna switching mode performed as worst-case.

EUT is not able to use two or more antennas at the same time (no simultaneous operation possible).

The EUT was tested in 3 orthogonal positions. This is documented in annex A.



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3.4 Configuration

The following peripheral devices and interface cables were connected during the tests:

Device	Model:	Serial or inventory no.
13.56 MHz Multi Standard - Multi Antenna Reader/Writer	SANGOMA-MSMA 2v5	#1
RFID antenna	2010	
RFID antenna	Jay	
RFID antenna	4040	
RFID antenna	7248	
Notebook	Lifebook A531	E00521
Power supply notebook	ADP-65JH AD	S26113-E557-V55-01
PC	Esprimo P9900 (Fujitsu)	YL6K001113
Monitor	Belinea 1930 S2	BA10002
DC power supply ²	Statron 3231.1	E00017
AC power supply (120V / 60Hz)	61602	ABP000000730

Note2: Used for test "carrier frequency stability" only.

3.5 Used cables

Count	Description (type / lengths / remarks)	Serial no.
4	Antenna cable (unshielded / 2.0 m)	
1	USB cable (shielded / 0.3 m)	
2	DC power supply cable (unshielded / 1.0 m) 3	

Note3: Used for test "carrier frequency stability" only.



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4 AC power line conducted emissions

according to 47 CFR Part 15, section 15.207, and RSS-210, section 3.1 with RSS-Gen, section 8.8

4.1 Test location

Description	Manufacturer	Inventory No.
Shielded room	Siemens - Matsushita	E00107

4.2 Test instruments

	Description	Manufacturer	Inventory No.
\boxtimes	ESCS 30	Rohde & Schwarz	E00003
	ESU 26	Rohde & Schwarz	W00002
	ESCI	Rohde & Schwarz	E00001
	ESH3-Z2	Rohde & Schwarz	E00028
	ESH2-Z5	Rohde & Schwarz	E00004
\boxtimes	ESH2-Z5	Rohde & Schwarz	E00005
\boxtimes	Cable set shielded room	Huber + Suhner	E00424

4.3 Limits

Frequency [MHz]	Quasi-peak [dBµV]	Avarage [dΒμV]
0.15 – 0.5	66 – 56	56 – 46
0.5 – 5.0	56	46
5 – 30	60	50



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4.4 Test procedure

The AC power line conducted emissions test method refers to section 6.2 of ANSI C63.10 and shall be as follows:

The tests of conducted emission are carried out in a shielded room using a line impedance stabilization network (LISN) 50 μ H/50 Ohms and a EMI test receiver. The EMI test receiver is connected to the LISN and set to a measurement bandwidth of 9 kHz in the frequency range from 0.15 MHz to 30 MHz. The EUT is placed on a wooden table and connected to the LISN. For prescan covering the whole frequency range from 0.15 MHz to 30 MHz the detector function oft he EMI test receiver is set to peak. After that, all peak values with less margin than 10 dB to quasi-peak limit or exceeding the limit are marked and re-measured with quasi-peak detector. If all values are below the average limit no additional measurement is necessary. Otherwise these values are re-measured using an average detector.

All peripheral devices are decoupled by connecting them to an additional line stabilization network.

According to ANSI C63.10, section 6.2.2 testing of intentional radiators with detachable antennas shall be done with a dummy load otherwise the tests should be done with connected antenna and if adjustable fully extended.



4.5 Test setup





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Freq.		Limit	delta_U rdB1	U_AV	Limit	delta_U raei	Corr.	Rem	ark
0,15	46,7	66,0	19,3	27,8	56,0	28,2	0,0	StoS	D-11.E10
0,15	46,0	65,8	19,8	27,6	55,8	28,2	0,0		
0,19	41,1	64,1	23,0	20,4	54,1	33,7	0,0		
0,21	38,7	63,3	24,7	17,3	53,3	36,0	0,0		
0,25	33,1	61,7	28,6	18,3	51,7	33,3	0,0		
U,28	30,6	61,U 60.2	30,4	13,2	51,U 50,2	37,8	0,0		
0.32	27,9	60,3 59,7	32,5	13,4 16.0	50,3 49.7	30,9 33.7	0,0		
0,32	30.5	58.1	27.6	70,0 24.6	48.1	23.4	0,0		
0,52	26,9	56,0	29,1	19,7	46,0	26,3	0,0		
0,78	23,7	56,0	32,3	15,3	46,0	30,7	0,0		
3,53	23,2	56,0	32,8	13,8	46,0	32,2	0,0		
3,83	26,5	56,0	29,5	11,6	46,0	34,4	0,0		
3,95	20,1	56,0	35,9	9,6	46,0	36,4	0,0		
13,56	63,5	60,0	-3,5	56,3	50,0	-6,3	0,0		
13,77	35,3	60,0	24,8	20,4	50,0	29,6	0,0		
15,37	32,9	60,0	27,2	26,6	50,0	23,4	0,0		
17,55	31,4 29.7	60,0 60,0	28,5	25,6 24,5	50,0 50,0	24,4	0,0		
19,63	23,7 35.0	0,00	25.0	24,3 29.9	50,0	20,0	0,0		
27.12	43.7	60,0	16.3	40,9	50,0	9.1	0,0		
-									
Р	icture 3: Ta	ible - Co	onducted	emission	on mai	ins, phase	e 1 (with	nout t	ermination)
						10			IC GmbH
ESTH	AUS	EMV 1	ESTHAUS	GmbH		13.	56 MHZ I	Nulti S Rea	itandard - Multi Antenn der/Writer
		Gusta	V-Hertz-Straub	aise 35 ing			SA	NGON	MA-MSMA 2v5
		94	Germany	шy	┝				
			Connuny		1				1



0,15 0,17 0,19 0,20 0,28 0,29 0,38 0,51 0,80 1,20 1,60 1,73 1,79 2,20 2,59 2,99 3,59 3,59 3,59 3,77 3,99 13,56 18,78 19,69 27,12	48,0 46,3 42,6 41,2 32,2 30,2 29,0 27,2 28,5 29,4 31,5 29,7 29,0	65,8 65,1 63,9 63,5 61,0 60,4 58,2 56,0 56,0 56,0	17,7 18,8 21,3 22,2 28,8 30,3 29,2 28,8	28,6 25,3 24,9 26,9 15,5 16,4	55,8 55,1 53,9 53,5 51,0	27,2 29,8 29,0 26,6	0,0 0,0 0,0	StöSp N.E10	
0,17 0,19 0,20 0,28 0,29 0,38 0,51 0,80 1,20 1,60 1,73 1,79 1,99 2,59 2,99 3,59 3,77 3,99 13,56 18,78 19,69 27,12	46,3 42,6 41,2 30,2 29,0 27,2 28,5 29,4 31,5 29,7 29,0	65,1 63,9 63,5 61,0 60,4 58,2 56,0 56,0 56,0	18,8 21,3 22,2 28,8 30,3 29,2 28,8	25,3 24,9 26,9 15,5 16,4	55,1 53,9 53,5 51,0	29,8 29,0 26,6	0,0 0,0		
0,19 0,20 0,28 0,29 0,38 0,51 0,80 1,20 1,60 1,73 1,79 1,99 2,20 2,59 2,99 3,59 3,59 3,77 3,99 13,56 18,78 19,69 2,7,12	42,6 41,2 30,2 29,0 27,2 28,5 29,4 31,5 29,7 29,0	63,9 63,5 61,0 60,4 58,2 56,0 56,0	21,3 22,2 28,8 30,3 29,2 28,8	24,9 26,9 15,5 16,4	53,9 53,5 51,0	29,0 26,6	0,0		
0,20 0,28 0,29 0,38 0,51 0,80 1,20 1,60 1,73 1,79 2,20 2,59 2,99 3,59 3,59 3,77 3,99 13,56 18,78 19,69 2,7,12	41,2 32,2 29,0 27,2 28,5 29,4 31,5 29,7 29,0	63,5 61,0 60,4 58,2 56,0 56,0	22,2 28,8 30,3 29,2 28,8	26,9 15,5 16,4	53,5 51,0	26,6	l		
0,28 0,29 0,38 0,51 0,80 1,20 1,60 1,73 1,79 2,20 2,59 2,99 3,59 3,59 3,59 3,77 3,99 13,56 18,78 19,69 27,12	32,2 30,2 29,0 27,2 28,5 29,4 31,5 29,7 29,0	61,0 60,4 58,2 56,0 56,0 56,0	28,8 30,3 29,2 28,8	15,5 16,4	51,0	the second se	0,0		
0,29 0,38 0,51 0,80 1,20 1,60 1,73 1,79 1,99 2,20 2,59 2,99 3,59 3,59 3,59 3,77 3,99 13,56 18,78 19,69 27,12	30,2 29,0 27,2 28,5 29,4 31,5 29,7 29,7	60,4 58,2 56,0 56,0 56,0	30,3 29,2 28,8	16,4		35,5	0,0		
0,38 0,51 0,80 1,20 1,60 1,73 1,79 1,99 2,20 2,59 2,99 3,559 3,77 3,99 13,56 18,78 19,69 27,12	29,0 27,2 28,5 29,4 31,5 29,7 29,0	58,2 56,0 56,0 56,0	29,2 28,8	22.2	50,4	34,0	0,0		
0,51 0,80 1,20 1,60 1,73 1,79 2,20 2,59 2,99 3,559 3,77 3,99 13,56 18,78 19,69 27,12	27,2 28,5 29,4 31,5 29,7 29,0	56,0 56,0 56,0	28,8	22,3	48,2	25,9	0,0		
0,80 1,20 1,60 1,73 1,79 2,20 2,59 2,99 3,59 3,77 3,99 13,56 18,78 19,69 27,12	28,5 29,4 31,5 29,7 29,0	56,0 56,0		19,4	46,0	26,7	0,0		
1,20 1,60 1,73 1,79 2,20 2,59 2,99 3,59 3,77 3,99 13,56 18,78 19,69 27,12	29,4 31,5 29,7 29,0	56,0	27,5	25,4	46,0	20,7	0,0		
1,50 1,73 1,79 2,20 2,59 2,99 3,59 3,77 3,99 13,56 18,78 19,69 27,12	31,5 29,7 29,0	<pre>20</pre>	26,6	27,2	46,U 46,0	18,8	0,0		
1,73 1,79 1,99 2,20 2,59 2,99 3,59 3,77 3,99 13,56 18,78 19,69 27,12	29,0	56,0 56,0	24,5	29,1 15 0	40,0 46.0	30.5	0,0		
1,99 2,20 2,59 2,99 3,59 3,77 3,99 13,56 18,78 19,69 27,12	23,0	56.0	20,5	20.5	40,0	25.5	0,0		
1,00 2,20 2,99 3,59 3,77 3,99 13,56 18,78 19,69 27,12	31.8	56.0	24.0	20,3	40,0 46.0	20,0	0,0		
2,59 2,99 3,59 3,77 3,99 13,56 18,78 19,69 27,12	30.9	56.0	25.1	20,0	46.0	21.6	0,0		
2,99 3,59 3,77 3,99 13,56 18,78 19,69 27,12	26,3	56,0	29,7	22.0	46.0	24.0	0.0		
3,59 3,77 3,99 13,56 18,78 19,69 27,12	27.4	56.0	28.6	22.9	46.0	23,1	0.0		
3,77 3,99 13,56 18,78 19,69 27,12	27,7	56,0	28,3	20,6	46,0	25,5	0,0		
3,99 13,56 18,78 19,69 27,12	29,9	56,0	26,1	14,8	46,0	31,2	0,0		
13,56 18,78 19,69 27,12	30,8	56,0	25,2	23,0	46,0	23,0	0,0		
18,78 19,69 27,12	59,1	60,0	0,9	52,1	50,0	-2,1	0,0		
19,69 27,12	35,1	60,0	24,9	29,8	50,0	20,2	0,0		
27,12	33,7	60,0	26,3	27,9	50,0	22,1	0,0		
r e s t h a	E S T H A U S Gustav-Hertz-Straße 35							01 1 1 1 1 1 1 1	



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Interference Voltage Test Freq. U_CISPR Limit delta_U U_AV Limit delta_U Corr. Remark [MHz] [dBµV] [dBµV] [dB] [dBµV] [dB] [dB] Stats - 11 - 270hm 015 46.1 66.0 19.9 27.2 56.0 28.8 0.0

[MHz]	 [dBμV]	[dBµ V]	 [dB]	 [dBµV]	[dBµV]	_ [dB]	[dB]	StöSp-L1-270hm.E10
0,15	46,1	66,0	19,9	27,2	56,0	28,8	0,0	
0,21	38,3	63,3	25,0	17,2	53,3	36,1	0,0	
0,22	37,3	62,8	25,5	31,2	52,8	21,6	0,0	
0,23	35,4	62,4	27,0	17,1	52,4	35,3	0,0	
0,25	32,7	61,7	29,0	18,0	51,7	33,7	0,0	
0,27	31,4	61,2	29,8	24,9	51,2	26,3	0,0	
0,31	26,8	59,9	33,1	14,7	49,9	35,3	0,0	
0,33	25,8	59,5	33,6	17,1	49,5	32,3	0,0	
0,34	25,2	59,2	34,1	16,5	49,2	32,7	0,0	
0,34	25,2	59,1	33,9	16,7	49,1	32,4	0,0	
0,38	28,7	58,3	29,6	20,8	48,3	27,5	0,0	
0,39	30,0	58,0	28,0	24,1	48,0	23,9	0,0	
0,38	28,3	58,2	30,0	20,5	48,2	27,8	0,0	
0,52	26,6	56,0	29,4	19,8	46,0	26,3	0,0	
0,78	23,4	56,0	32,6	15,4	46,0	30,6	0,0	
1,07	21,3	56,0	34,7	14,4	46,0	31,6	0,0	
1,60	20,1	56,0	35,9	13,8	46,0	32,2	0,0	
1,73	21,3	56,0	34,7	13,6	46,0	32,5	0,0	
1,80	19,2	56,0	36,8	15,3	46,0	30,7	0,0	
2,00	22,3	56,0	33,7	13,1	46,0	32,9	0,0	
2,20	20,8	56,0	35,2	17,8	46,0	28,2	0,0	
2,60	22,5	56,0	33,5	17,1	46,0	28,9	0,0	
2,80	21,6	56,0	34,4	14,7	46,0	31,3	0,0	
3,01	23,0	56,0	33,0	17,3	46,0	28,7	0,0	
3,24	21,8	56,0	34,2	9,3	46,0	36,7	0,0	
3,55	22,9	56,0	33,1	11,3	46,0	34,7	0,0	
3,78	27,5	56,0	28,6	14,8	46,0	31,2	0,0	
4,00	18,1	56,0	37,9	10,0	46,0	36,1	0,0	
4,25	19,8	56,0	36,3	15,4	46,0	30,6	0,0	
13,56	32,2	60,0	27,8	25,6	50,0	24,4	0,0	
14,55	30,3	60,0	29,7	22,5	50,0	27,5	0,0	
14,99	29,1	60,0	30,9	20,5	50,0	29,5	0,0	
15,38	29,9	60,0	30,1	23,2	50,0	26,8	0,0	
16,17	28,9	60,0	31,2	21,8	50,0	28,2	0,0	
16,99	26,3	60,0	33,7	13,6	50,0	36,4	0,0	
17,75	25,6	60,0	34,4	17,6	50,0	32,4	0,0	
18,38	25,8	60,0	34,2	16,1	50,0	33,9	0,0	
18,69	24,3	60,0	35,7	19,3	50,0	30,7	0,0	
18,96	26,5	60,0	33,5	20,9	50,0	29,1	0,0	
19,18	24,2	60,0	35,8	18,6	50,0	31,4	0,0	

Picture 7: Table1 - Conducted emission on mains, phase 1 (with termination 27 Ω)



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20,10 21,6 60,0 38,5 15,7 50,0 34,3 0,0 20,76 26,8 60,0 33,2 21,4 50,0 28,6 0,0 21,56 23,1 60,0 36,9 16,0 50,0 34,0 0,0 21,76 21,1 60,0 38,9 16,1 50,0 33,9 0,0 21,76 21,1 60,0 38,9 16,1 50,0 33,9 0,0	24,0 21,6 60,0 38,5 15,7 50,0 34,3 0,0 28,76 23,1 60,0 38,3 16,0 50,0 38,9 0,0 21,76 21,1 60,0 38,3 16,1 50,0 33,9 0,0 21,76 21,1 60,0 38,3 16,1 50,0 33,9 0,0
20,76 26,8 60,0 33,2 21,4 50,0 28,6 0,0 21,36 23,1 60,0 36,9 16,0 50,0 34,0 0,0 21,76 21,1 60,0 38,9 16,1 50,0 33,9 0,0	28,76 28,8 60,0 33,2 21,4 50,0 28,6 0,0 21,6 23,1 60,0 38,8 16,0 50,0 34,0 0,0 21,76 21,1 60,0 38,8 16,1 50,0 33,8 0,0 21,76 21,1 60,0 38,8 16,1 50,0 33,8 0,0
21,56 23,1 60,0 36,9 16,0 50,0 34,0 0,0 21,76 21,1 60,0 38,9 16,1 50,0 33,9 0,0 1 ,1 50,0 33,0 0,0 1 ,1 50,0 30,0 0,0 1 ,1 50,0 1,1 50,0	21,1 60,0 36,9 16,0 50,0 34,0 0,0 21,76 21,1 60,0 38,9 16,1 50,0 33,9 0,0 Image: Second state of the second sta
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	Ficture 8: Table2 - Conducted emission on mains, phase 1 (with termination 27 Ω)
Picture 8: Table2 - Conducted emission on mains, phase 1 (with termination 27 Ω)	

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Interference Voltage Test

Freq.	U_CISPR	Limit	delta_U	U_AV	Limit	delta_U	Corr.	Remark
[MHz]	[dBµV]	[dBµ V]	[dB]	[dBµV]	[dBµV]	[dB]	[dB]	StöSp N 270hm.E10
0,15	48,2	66,0	17,8	29,1	56,0	26,9	0,0	
0,19	43,4	64,3	20,8	22,6	54,3	31,6	0,0	
0,25	35,2	61,8	26,6	18,0	51,8	33,8	0,0	
0,28	30,9	60,7	29,8	17,7	50,7	33,0	0,0	
0,30	29,5	60,3	30,8	15,7	50,3	34,7	0,0	
0,31	28,5	60,1	31,5	18,7	50,1	31,3	0,0	
0,32	27,1	59,7	32,6	18,3	49,7	31,4	0,0	
0,36	27,7	58,8	31,2	23,4	48,8	25,4	0,0	
0,39	28,0	58,1	30,1	21,8	48,1	26,4	0,0	
0,44	25,1	57,0	31,9	20,1	47,0	27,0	0,0	
0,51	27,1	56,0	28,9	18,3	46,0	27,7	0,0	
0,60	25,8	56,0	30,2	24,2	46,0	21,8	0,0	
0,80	28,2	56,0	27,8	25,2	46,0	20,8	0,0	
1,00	25,2	56,0	30,8	20,7	46,0	25,3	0,0	
1,20	29,6	56,0	26,4	27,0	46,0	19,0	0,0	
1,56	28,9	56,0	27,1	18,9	46,0	27,1	0,0	
1,60	33,1	56,0	22,9	28,0	46,0	18,0	0,0	
1,73	30,4	56,0	25,6	17,1	46,0	28,9	0,0	
1,80	27,1	56,0	29,0	22,8	46,0	23,2	0,0	
1,99	32,7	56,0	23,4	25,7	46,0	20,3	0,0	
2,20	26,5	56,0	29,5	23,0	46,0	23,0	0,0	
2,60	26,6	56,0	29,4	23,4	46,0	22,6	0,0	
2,99	29,3	56,0	26,7	23,6	46,0	22,4	0,0	
3,33	26,6	56,0	29,4	14,0	46,0	32,0	0,0	
3,59	28,3	56,0	27,7	20,9	46,0	25,1	0,0	
400	25,1	56,0	30,9	18.6	46.0	27.5	0.0	
5,79	18,1	60,0	41,9	14,8	50,0	35,2	0,0	
8,93	24.3	60.0	35.7	20.7	50.0	29.3	0.0	
13.56	28.9	60.0	31.1	21.9	50.0	28.1	0.0	
1400	28.1	60.0	31.9	20.1	50.0	30.0	0.0	
1455	29.6	60.0	30.4	22.2	50.0	27.8	0.0	
15.18	30.2	60.0	29.8	24.3	50.0	25.7	0.0	
15.77	29.7	60.0	30.3	23.7	50.0	26.3	0.0	
17.77	29.3	60.0	30.7	23.1	50.0	26.9	0.0	
18,97	26.8	60.0	33.2	21.8	50.0	28.2	0.0	
19.37	27.2	60.0	32.8	20.5	50.0	29.5	0.0	
19,78	29.2	60.0	30.8	23.0	50.0	27.0	0.0	
		1=		1*	1*		-1-	

Picture 10: Table - Conducted emission on mains, neutral (with termination 27 Ω)



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5 Radiated emission measurement (<1 GHz)

according to 47 CFR Part 15, section 15.205(a), 15.209(a), 15.225(a) to (e), and RSS-210, section 4.3 and Annex B6 with RSS-Gen, sections 8.9 and 8.10

5.1 Test Location

- \boxtimes Scan with peak detector in 3 m CDC.
- Final CISPR measurement with quasi peak detector on 3 m open area test site.

Description	Manufacturer	Inventory No.
CDC	Albatross Projects	E00026
Open area test site (OATS)	EMV TESTHAUS GmbH	E00354

5.2 Test instruments

	Description	Manufacturer	Inventory No.
\boxtimes	ESCI (OATS)	Rohde & Schwarz	E00552
	ESU 26	Rohde & Schwarz	W00002
\boxtimes	ESCI (CDC)	Rohde & Schwarz	E00001
\boxtimes	VULB 9163 (OATS)	Schwarzbeck	E00013
\boxtimes	VULB 9160 (CDC)	Schwarzbeck	E00011
\boxtimes	HFH2-Z2	Rohde & Schwarz	E00060
\boxtimes	Cable set CDC	Huber + Suhner	E00459, E00460
	Cable set OATS 3 m	Huber + Suhner	E00453, E00456, E00458
	Cable set OATS 10 m	Huber + Suhner	E00453, E00455, E00458



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5.3 Limits

The field strength of any emissions appearing outside of the 13.110 to 14.010 MHz band including spurious emissions falling into restricted bands as specified in 15.205(a) shall not exceed the general radiated emission limits as specified in 15.209.

Frequency [MHz]	Field strength Fs [µV/m]	Field strength [dBµV/m]	Measurement distance d [m]
0.009 - 0.490	266.6 - 4.9	48.5 – 13.8	300
0.490 – 1.705	48.98 – 14.08	33.8 – 22.97	30
1.705 – 30.0	30	29.54	30
30 - 88	100	40	3
88 – 216	150	43.5	3
216 - 960	200	46	3
Above 960	500	54	3

As noted in 15.205(d)(7) devices according to 15.225 are exempt from complying with restricted band requirements for the 13.36 to 13.41 MHz band. Instead they have to comply with the limits as specified in 15.225 (a) to (d):

Frequency [MHz]	Field strength Fs [μV/m]	Field strength [dBµV/m]	Measurement distance d [m]
13.553 - 13.567	15.848	84	30
13.410 - 13.553	334	50.47	30
13.567 - 13.710	334	50.47	30
13.110 - 13.410	106	40.51	30
13.710 - 14.010	106	40.51	30
f < 13.110		andia a ta linaita in 645.00	0
f > 14.010	acco	ording to limits in §15.20	9



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5.4 Test procedure < 30 MHz

The test method for radiated emissions below 30 MHz refers to section 6.4 of ANSI C63.10 and shall be as follows:

- 1. EUT is configured according to ANSI C63.10. It is placed on the turntable 0.8 meter above ground. The receiving antenna is located 3 meters from the EUT. The test setup is placed inside a compact diagnostic chamber.
- 2. EUT and all peripherals are powered on.
- 3. The loop antenna is set in parallel with the antenna of the EUT.
- 4. The EMI receiver performs a scan from 9 kHz to 30 MHz with peak detector and measurement bandwidth set to 200 Hz for frequencies up to 150 kHz and 9 or 10 kHz for frequencies above.
- 5. The turn table is rotated to 8 different positions (360° / 8).
- 6. The antenna is set in line with the antenna of the EUT and steps 4 and 5 are repeated.
- 7. Then the test setup is placed in an OATS with 3 m distance and all peak values over the limit or with less margin than 10 dB are marked and re-measured with a quasi-peak detector except for the frequency bands 9 to 90 kHz and 110 to 490 k Hz, where average detector applies.
- 8. The turntable is rotated by 360 degrees to determine the position of the highest radiation.
- 9. The highest value for each frequency is recorded.



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5.5 Test procedure < 1 GHz

The test method for radiated emissions from 30 MHz to 1 GHz refers to section 6.5 of ANSI C63.10 and shall be as follows:

- 1. EUT is configured according to ANSI C63.10. It is placed on the turntable 0.8 meter above ground. The receiving antenna is located 3 meters from the EUT. The test setup is placed inside a compact diagnostic chamber.
- 2. EUT and all peripherals are powered on.
- 3. The broadband antenna is set to vertical polarization.
- 4. The EMI receiver performs a scan from 30 MHz to 1000 MHz with peak detector and measurement bandwidth set to 120 kHz.
- 5. The turn table is rotated to 6 different positions (360° / 6).
- 6. The antenna polarization is changed to horizontal and steps 4 and 5 are repeated.
- 7. Then the test setup is placed in an OATS at 3 m distance and all peak values over the limit or with less margin than 10 dB are marked and re-measured with a quasi-peak detector.
- 8. The turntable is rotated by 360 degrees to determine the position of the highest radiation.
- 9. The height of the broadband receiving antenna is varied between 1 meter and 4 meters above ground to find the maximum emission field strength of both horizontal and vertical polarization.
- 10. The highest value for each frequency is recorded.

5.6 Test procedure "Spectrum mask"

The EUT was placed in a fully anechoic chamber and the testing was performed in accordance with ANSI C63.10 and 47 CFR Part 15, section 15.225 (a) to (d). The measurement distance was 3 m. To find the closest margin of the spectrum to the limit mask adapted to the test distance the EUT was rotated by 360 degrees with detector of the test receiver set to peak. The loop antenna placed in a fixed height of 1 meter was rotated by 360 degrees to get the maximum of emission. In case of exceeding the limits the detector is switched to quasi peak for final testing in position of maximum emission.



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5.9 Test results "antenna 2010"

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-28

Radiated Emission Measurement 9 kHz - 30 MHz

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$, or

f_{MHz}

= 47.77 / d_{near field}

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

f _{MHz} (300 m)	≈ 0.159 MHz
f _{MHz} (30 m)	≈ 1.592 MHz
f _{MHz} (3 m)	≈ 15.923 MHz

For 9 kHz \leq f \leq 159 kHz and 490 kHz < f \leq 1.592 MHz: Recalculation factor = -40 log(d_{limit} / d_{measure})

For 159 kHz < f \leq 490 kHz and 1.592 MHz < f \leq 15.923 MHz:

Recalculation factor = -40 $\log(d_{\text{near field}} / d_{\text{measure}})$ - 20 $\log(d_{\text{limit}} / d_{\text{near field}})$

For f > 15.923 MHz:

Recalculation factor = -20 log(d_{limit} / d_{measure})

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.



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Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	🗆 m
Polarisation:	□ parallel	oxtimes in line	□ angle:°	
EUT Position:	☑ Position 1	\Box Position 2	\Box Position 3	

Frequency range	Step	IF	Detector		Measurer	Preamplifier	
	size	Bandwidth	Prescan	Final scan	Prescan	Final scan	
9 kHz – 90 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
90 kHz – 110 kHz	80 Hz	200 Hz	PK	QPK	1 ms	1 s	off
110 kHz – 150 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
150 kHz – 490 kHz	4 kHz	9 kHz	PK	AV	1 ms	1 s	off
490 kHz – 30 MHz	4 kHz	9 kHz	PK	QPK	1 ms	1 s	off



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Picture 13: Radiated emission 9 kHz - 30 MHz antenna 2010

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.562	44.68	QPK	-21.40	23.28	84.00	-60.72	Pass
27.122	40.69	QPK	-20.00	20.69	29.54	-8.85	Pass

Remark: Emissions below carrier frequency (13.562 MHz) are ambient noise level or from peripheral devices (e.g. notebook).



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Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$

Recalculation factor = -40 $\log(d_{near field} / d_{measure})$ - 20 $\log(d_{limit} / d_{near field})$

f _{мнz}	d _{near field}	d _{measure}	d _{limit}	Recalculation	
[MHz]	[m]	[m]	[m]	factor [dB]	
13.562	3.523	3.000	30.000	-21.40	

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$

Recalculation factor = $-20 \log(d_{\text{limit}} / d_{\text{measure}})$

f _{мнz}	d _{near field}	d _{measure}	d _{limit}	Recalculation
[MHz]	[m]	[m]	[m]	factor [dB]
27.122	1.761	3.000	30.000	-20.00



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Radiated Emission Measurement 30 MHz - 1000 MHz

Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	□ m
Polarisation:	⊠ horizontal	⊠ vertical		
EUT Position:	□ Position 1	☑ Position 2	Position 3	

Frequency	Polari-	Step	IF Band-	Detector		Measurement Time		Pre-
range	sation	size	width	Prescan	Final scan	Prescan	Final scan	amplifier
30 MHz – 1 GHz	H/V	60 kHz	120 kHz	PK	QPK	1 ms	1 s	20 dB





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f [MHz]	E _{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
30.60	23.20	40.00	100	1.3	V	Pass
94.92	32.76	43.52	100	348.6	Н	Pass
189.84	28.77	43.52	100	350.9	Н	Pass
199.74	19.95	43.52	100	161.5	V	Pass
203.40	23.94	43.52	100	245.9	V	Pass
216.96	28.51	46.02	100	106.1	V	Pass
231.96	25.02	46.02	100	48.7	V	Pass
244.56	25.94	46.02	100	129.4	V	Pass
266.58	26.55	46.02	100	75.1	Н	Pass
279.18	32.69	46.02	100	82.3	Н	Pass
298.32	29.12	46.02	100	88.3	Н	Pass
314.82	25.96	46.02	100	98.0	Н	Pass
348.54	36.19	46.02	100	245.6	Н	Pass
384.84	27.52	46.02	100	263.7	Н	Pass
398.34	27.00	46.02	100	166.7	V	Pass
487.92	28.19	46.02	100	11.2	V	Pass
696.96	31.62	46.02	100	40.5	Н	Pass
734.70	29.82	46.02	100	358.3	Н	Pass
766.74	30.95	46.02	100	347.8	Н	Pass

Picture 14: Radiated emission 30 MHz - 1000MHz antenna 2010



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Spectrum Mask

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$, or

f_{MHz}

 $= 47.77 / d_{\text{near field}}$

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

f _{MHz} (300 m)	≈ 0.159 MHz
f _{MHz} (30 m)	≈ 1.592 MHz
f _{MHz} (3 m)	≈ 15.923 MHz

For 9 kHz \leq f \leq 159 kHz and 490 kHz < f \leq 1.592 MHz: Recalculation factor = -40 log(d_{limit} / d_{measure}) For 159 kHz < f \leq 490 kHz and 1.592 MHz < f \leq 15.923 MHz: Recalculation factor = -40 log(d_{near field} / d_{measure}) - 20 log(d_{limit} / d_{near field}) For f > 15.923 MHz: Recalculation factor = -20 log(d_{limit} / d_{measure})

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.



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Test distance:	Prescan:	🛛 3 m		
	Final scan:	🛛 3 m	🗆 10 m	🗆 m
Polarisation:	□ parallel	imes in line	□ angle:°	
EUT Position:	Position 1	\boxtimes Position 2	Position 3	

Frequency range	Step	IF	Detector		Measurement Time		Preamplifier
	size	Bandwidth	Prescan	Final scan	Prescan	Final scan	
490 kHz – 30 MHz	4 kHz	9 kHz	PK	QPK	1 ms	1 s	off





Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	45.95	PK	-21.40	24.55			Pass
13.560	45.34	QPK	-21.40	23.94	84.00	-60.06	Pass



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Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	48.98	PK	-21.40	27.58			Pass
13.560	48.94	QPK	-21.40	27.54	84.00	-56,46	Pass



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Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{\text{near field}}$

= 47.77 / f_{MHz}

Recalculation factor = -40 $\log(d_{near field} / d_{measure})$ - 20 $\log(d_{limit} / d_{near field})$

f _{мнz}	d _{near field}	d _{measure}	d _{limit}	Recalculation
[MHz]	[m]	[m]	[m]	factor [dB]
13.560	3.523	3.000	30.000	-21.40



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5.10 Test results "antenna Jay"

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-28

Radiated Emission Measurement 9 kHz - 30 MHz

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$, or

f_{MHz}

= 47.77 / d_{near field}

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

f _{MHz} (300 m)	≈ 0.159 MHz
f _{MHz} (30 m)	≈ 1.592 MHz
f _{MHz} (3 m)	≈ 15.923 MHz

For 9 kHz \leq f \leq 159 kHz and 490 kHz < f \leq 1.592 MHz: Recalculation factor = -40 log(d_{limit} / d_{measure})

For 159 kHz < f \leq 490 kHz and 1.592 MHz < f \leq 15.923 MHz:

Recalculation factor = -40 $\log(d_{\text{near field}} / d_{\text{measure}})$ - 20 $\log(d_{\text{limit}} / d_{\text{near field}})$

For f > 15.923 MHz:

Recalculation factor = -20 log(d_{limit} / d_{measure})

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.



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Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	□ m
Polarisation:	□ parallel	oxtimes in line	□ angle:°	
EUT Position:	☑ Position 1	\Box Position 2	\Box Position 3	

Frequency range	Step	IF	Dete	ector	Measurer	nent Time	Preamplifier
	size	Bandwidth	Prescan	Final scan	Prescan	Final scan	
9 kHz – 90 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
90 kHz – 110 kHz	80 Hz	200 Hz	PK	QPK	1 ms	1 s	off
110 kHz – 150 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
150 kHz – 490 kHz	4 kHz	9 kHz	PK	AV	1 ms	1 s	off
490 kHz – 30 MHz	4 kHz	9 kHz	PK	QPK	1 ms	1 s	off



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Picture 17: Radiated emission 9 kHz – 30 MHz antenna Jay

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.558	56.28	QPK	-21.40	34.88	84.00	-49.12	Pass
27.122	41.68	QPK	-20.00	21.68	29.54	-7.86	Pass

Remark: Emissions below carrier frequency (13.562 MHz) are ambient noise level or from peripheral devices (e.g. notebook).



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Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$

Recalculation factor = -40 $\log(d_{near field} / d_{measure})$ - 20 $\log(d_{limit} / d_{near field})$

f _{мнz}	d _{near field}	d _{measure}	d _{limit}	Recalculation
[MHz]	[m]	[m]	[m]	factor [dB]
13.558	3.523	3.000	30.000	-21.40

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$

Recalculation factor = $-20 \log(d_{\text{limit}} / d_{\text{measure}})$

f _{мнz}	d _{near field}	d _{measure}	d _{limit}	Recalculation
[MHz]	[m]	[m]	[m]	factor [dB]
27.122	1.761	3.000	30.000	-20.00



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Radiated Emission Measurement 30 MHz - 1000 MHz

Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	□ m
Polarisation:	🛛 horizontal	⊠ vertical		
EUT Position:	□ Position 1	☑ Position 2	Position 3	

Frequency	Polari-	Step	IF Band-	Dete	ector	Measurer	nent Time	Pre-
range	sation	size	width	Prescan	Final scan	Prescan	Final scan	amplifier
30 MHz – 1 GHz	H/V	60 kHz	120 kHz	PK	QPK	1 ms	1 s	20 dB





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f [MHz]	E _{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
30.54	23.14	40.00	100	3.4	V	Pass
40.68	25.96	40.00	100	340.7	Н	Pass
94.92	31.61	43.52	100	358.6	Н	Pass
162.72	26.88	43.52	100	135.1	Н	Pass
189.84	32.28	43.52	100	358.7	Н	Pass
203.40	24.30	43.52	100	238.1	V	Pass
216.96	32.18	46.02	100	113.8	V	Pass
244.08	35.65	46.02	100	17.4	Н	Pass
266.58	26.98	46.02	100	74.6	Н	Pass
271.20	33.60	46.02	100	17.5	Н	Pass
279.60	35.63	46.02	100	89.9	Н	Pass
298.32	30.90	46.02	100	16.9	Н	Pass
313.68	26.34	46.02	100	98.5	Н	Pass
349.86	35.59	46.02	100	246.0	Н	Pass
383.40	27.90	46.02	100	256.5	Н	Pass
398.34	27.12	46.02	100	175.3	V	Pass
487.92	28.05	46.02	100	0.2	V	Pass
627.30	28.33	46.02	100	72.1	V	Pass
662.10	28.51	46.02	100	98.2	V	Pass
696.96	31.78	46.02	100	40.6	Н	Pass
732.36	29.42	46.02	100	358.6	Н	Pass
766.62	30.70	46.02	100	277.8	V	Pass
922.14	36.52	46.02	100	129.8	V	Pass

Picture 18: Radiated emission 30 MHz - 1000MHz antenna Jay



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Spectrum Mask

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$, or

f_{MHz}

 $= 47.77 / d_{\text{near field}}$

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

f _{MHz} (300 m)	≈ 0.159 MHz
f _{MHz} (30 m)	≈ 1.592 MHz
f _{MHz} (3 m)	≈ 15.923 MHz

For 9 kHz \leq f \leq 159 kHz and 490 kHz < f \leq 1.592 MHz: Recalculation factor = -40 log(d_{limit} / d_{measure}) For 159 kHz < f \leq 490 kHz and 1.592 MHz < f \leq 15.923 MHz: Recalculation factor = -40 log(d_{near field} / d_{measure}) - 20 log(d_{limit} / d_{near field}) For f > 15.923 MHz: Recalculation factor = -20 log(d_{limit} / d_{measure})

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.



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Test distance:	Prescan:	🛛 3 m		
	Final scan:	🖂 3 m	🗆 10 m	🗆 m
Polarisation:	□ parallel	imes in line	□ angle:°	
EUT Position:	\boxtimes Position 1	Position 2	□ Position 3	

Frequency range	Step	IF	Detector		Measurement Time		Preamplifier
	size	Bandwidth	Prescan	Final scan	Prescan	Final scan	
490 kHz – 30 MHz	4 kHz	9 kHz	PK	QPK	1 ms	1 s	off





Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	58.36	PK	-21.40	36.96			Pass
13.560	57.94	QPK	-21.40	36.54	84.00	-47.46	Pass



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Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	60,82	PK	-21.40	39,42			Pass
13.560	60,76	QPK	-21.40	39,36	84.00	-44.64	Pass



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Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{\text{near field}}$

= 47.77 / f_{MHz}

Recalculation factor = -40 $\log(d_{near field} / d_{measure})$ - 20 $\log(d_{limit} / d_{near field})$

f _{мнz}	d _{near field}	l _{near field} d _{measure}		Recalculation
[MHz]	[m]	[m] [m]		factor [dB]
13.560	3.523	3.000	30.000	-21.40



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5.11 Test results "antenna 4040"

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-28

Radiated Emission Measurement 9 kHz - 30 MHz

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$, or

f_{MHz}

= 47.77 / d_{near field}

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

f _{MHz} (300 m)	≈ 0.159 MHz
f _{MHz} (30 m)	≈ 1.592 MHz
f _{MHz} (3 m)	≈ 15.923 MHz

For 9 kHz \leq f \leq 159 kHz and 490 kHz < f \leq 1.592 MHz: Recalculation factor = -40 log(d_{limit} / d_{measure})

For 159 kHz < f \leq 490 kHz and 1.592 MHz < f \leq 15.923 MHz:

Recalculation factor = -40 log($d_{near field} / d_{measure}$) - 20 log($d_{limit} / d_{near field}$)

For f > 15.923 MHz:

Recalculation factor = -20 log(d_{limit} / d_{measure})

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.



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Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	🗆 m
Polarisation:	□ parallel	oxtimes in line	□ angle:°	
EUT Position:	\Box Position 1	\boxtimes Position 2	\Box Position 3	

Frequency range	Step	IF	Detector		Measurement Time		Preamplifier
	size	Bandwidth	Prescan	Final scan	Prescan	Final scan	
9 kHz – 90 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
90 kHz – 110 kHz	80 Hz	200 Hz	PK	QPK	1 ms	1 s	off
110 kHz – 150 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
150 kHz – 490 kHz	4 kHz	9 kHz	PK	AV	1 ms	1 s	off
490 kHz – 30 MHz	4 kHz	9 kHz	PK	QPK	1 ms	1 s	off



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Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.562	64.38	QPK	-21.40	42.98	84.00	-41.02	Pass
27.122	42.62	QPK	-20.00	22.62	29.54	-6.92	Pass

Remark: Emissions below carrier frequency (13.562 MHz) are ambient noise level or from peripheral devices (e.g. notebook).



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Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$

Recalculation factor = -40 $\log(d_{near field} / d_{measure})$ - 20 $\log(d_{limit} / d_{near field})$

f _{мнz}	d _{near field}	d _{measure}	d _{limit}	Recalculation	
[MHz]	[m]	[m]	[m]	factor [dB]	
13.562	3.523	3.000	30.000	-21.40	

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$

Recalculation factor = $-20 \log(d_{\text{limit}} / d_{\text{measure}})$

f _{мнz}	d _{near field}	d _{measure}	d _{limit}	Recalculation
[MHz]	[m]	[m]	[m]	factor [dB]
27.122	1.761	3.000	30.000	-20.00



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Radiated Emission Measurement 30 MHz - 1000 MHz

Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	□ m
Polarisation:	🛛 horizontal	⊠ vertical		
EUT Position:	□ Position 1	☑ Position 2	Position 3	

Frequency	Polari-	Step	IF Band-	Dete	ector	Measurer	nent Time	Pre-
range	sation	size	width	Prescan	Final scan	Prescan	Final scan	amplifier
30 MHz – 1 GHz	H/V	60 kHz	120 kHz	PK	QPK	1 ms	1 s	20 dB





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f [MHz]	E _{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
30.60	23.32	40	100	1.8	V	Pass
40.68	24.61	40	100	353.9	Н	Pass
94.92	29.11	43.52	100	256.0	V	Pass
108.48	25.85	43.52	100	238.4	V	Pass
176.28	25.06	43.52	100	11.2	Н	Pass
189.84	30.75	43.52	100	340.1	Н	Pass
210.00	22.21	43.52	100	74.3	V	Pass
216.96	31.94	46.02	100	96.3	V	Pass
233.10	25.30	46.02	100	59.1	V	Pass
244.08	34.63	46.02	100	34.5	Н	Pass
266.34	26.05	46.02	100	72.3	Н	Pass
271.20	32.03	46.02	100	27.1	Н	Pass
279.12	34.87	46.02	100	72.8	Н	Pass
298.32	28.79	46.02	100	97.8	Н	Pass
313.68	25.77	46.02	100	88.4	Н	Pass
349.86	35.49	46.02	100	264.0	Н	Pass
383.34	27.78	46.02	100	246.2	Н	Pass
399.84	26.93	46.02	100	263.5	Н	Pass
489.84	27.98	46.02	100	356.1	V	Pass
697.02	31.93	46.02	100	40.7	Н	Pass
734.70	29.80	46.02	100	0.1	Н	Pass
922.14	36.04	46.02	100	130.0	V	Pass

Picture 22: Radiated emission 30 MHz - 1000MHz antenna 4040



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Spectrum Mask

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$, or

f_{MHz}

 $= 47.77 / d_{\text{near field}}$

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

f _{MHz} (300 m)	≈ 0.159 MHz
f _{MHz} (30 m)	≈ 1.592 MHz
f _{MHz} (3 m)	≈ 15.923 MHz

For 9 kHz \leq f \leq 159 kHz and 490 kHz < f \leq 1.592 MHz: Recalculation factor = -40 log(d_{limit} / d_{measure}) For 159 kHz < f \leq 490 kHz and 1.592 MHz < f \leq 15.923 MHz: Recalculation factor = -40 log(d_{near field} / d_{measure}) - 20 log(d_{limit} / d_{near field}) For f > 15.923 MHz: Recalculation factor = -20 log(d_{limit} / d_{measure})

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.



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Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	□ m
Polarisation:	□ parallel	oxtimes in line	□ angle:°	
EUT Position:	\boxtimes Position 1	Position 2	Position 3	

Frequency range	Step	IF	Detector		Measurer	Preamplifier	
	size	Bandwidth	Prescan	Final scan	Prescan	Final scan	
490 kHz – 30 MHz	4 kHz	9 kHz	PK	QPK	1 ms	1 s	off



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Picture 23: Spectrum mask for 13.56 MHz antenna 4040 (cable 200 cm)

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.348	36.97	QPK	-21.53	15.44	40.51	-25.07	Pass
13.560	65.85	PK	-21.40	44.45			Pass
13.560	65.60	QPK	-21.40	44.20	84.00	-39.80	Pass
13.772	38.28	QPK	-21.26	17.02	40.51	-23.49	Pass



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Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	72,11	PK	-21.40	50,71			Pass
13.560	72,05	QPK	-21.40	50,65	84.00	-33.35	Pass



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Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{\text{near field}}$

$$= 47.77 \ / \ f_{MHz}$$

Recalculation factor = -40 $\log(d_{near field} / d_{measure})$ - 20 $\log(d_{limit} / d_{near field})$

f _{мнz} [MHz]	d _{near field} [m]	d _{measure} [m]	d _{limit} [m]	Recalculation factor [dB]
13.348	3.579	3.000	30.000	-21.53
13.560	3.523	3.000	30.000	-21.40
13.772	3.469	3.000	30.000	-21.26



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5.12 Test results "antenna 7248"

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-28

Radiated Emission Measurement 9 kHz - 30 MHz

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$, or

f_{MHz}

= 47.77 / d_{near field}

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

f _{MHz} (300 m)	≈ 0.159 MHz
f _{MHz} (30 m)	≈ 1.592 MHz
f _{MHz} (3 m)	≈ 15.923 MHz

For 9 kHz \leq f \leq 159 kHz and 490 kHz < f \leq 1.592 MHz: Recalculation factor = -40 log(d_{limit} / d_{measure})

For 159 kHz < f \leq 490 kHz and 1.592 MHz < f \leq 15.923 MHz:

Recalculation factor = -40 log($d_{near field} / d_{measure}$) - 20 log($d_{limit} / d_{near field}$)

For f > 15.923 MHz:

Recalculation factor = -20 log(d_{limit} / d_{measure})

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.



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Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	□ m
Polarisation:	□ parallel	oxtimes in line	□ angle:°	
EUT Position:	☑ Position 1	\Box Position 2	\Box Position 3	

Frequency range	Step	IF	Detector		Measurer	Preamplifier	
	size	Bandwidth	Prescan	Final scan	Prescan	Final scan	
9 kHz – 90 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
90 kHz – 110 kHz	80 Hz	200 Hz	PK	QPK	1 ms	1 s	off
110 kHz – 150 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
150 kHz – 490 kHz	4 kHz	9 kHz	PK	AV	1 ms	1 s	off
490 kHz – 30 MHz	4 kHz	9 kHz	PK	QPK	1 ms	1 s	off



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Picture 25: Radiated emission 9 kHz - 30 MHz antenna 7248

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.562	69.38	QPK	-21.40	47.98	84.00	-36.02	Pass
27.122	39.32	QPK	-20.00	19.32	29.54	-10.22	Pass

Remark: Emissions below carrier frequency (13.562 MHz) are ambient noise level or from peripheral devices (e.g. notebook).



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Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$

Recalculation factor = -40 $\log(d_{near field} / d_{measure})$ - 20 $\log(d_{limit} / d_{near field})$

f _{мнz}	d _{near field}	d _{measure}	d _{limit}	Recalculation
[MHz]	[m]	[m]	[m]	factor [dB]
13.562	3.523	3.000	30.000	-21.40

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$

Recalculation factor = $-20 \log(d_{\text{limit}} / d_{\text{measure}})$

f _{мнz}	d _{near field}	d _{measure}	d _{limit}	Recalculation
[MHz]	[m]	[m]	[m]	factor [dB]
27.122	1.761	3.000	30.000	-20.00



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Radiated Emission Measurement 30 MHz - 1000 MHz

Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	□ m
Polarisation:	⊠ horizontal	⊠ vertical		
EUT Position:	□ Position 1	\boxtimes Position 2	□ Position 3	

Frequency	Polari-	Step	IF Band-	Dete	ector	Measurer	Pre-	
range	sation	size	width	Prescan	Final scan	Prescan	Final scan	amplifier
30 MHz – 1 GHz	H/V	60 kHz	120 kHz	PK	QPK	1 ms	1 s	20 dB



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f [MHz]	E _{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
30.60	23.35	40	100	356.5	V	Pass
81.36	24.17	40	100	340.5	Н	Pass
94.92	29.55	43.52	100	0.1	Н	Pass
108.48	26.18	43.52	100	240.3	V	Pass
189.84	28.10	43.52	100	1.5	Н	Pass
199.62	19.57	43.52	100	222.5	V	Pass
209.88	27.53	43.52	100	82.7	Н	Pass
216.96	31.03	46.02	100	9.1	Н	Pass
233.22	25.77	46.02	100	67.0	Н	Pass
244.92	28.35	46.02	100	48.9	Н	Pass
279.12	33.70	46.02	100	82.5	Н	Pass
298.32	29.79	46.02	100	174.6	Н	Pass
313.68	25.89	46.02	100	98.3	Н	Pass
348.54	35.41	46.02	100	246.3	Н	Pass
383.34	27.76	46.02	100	263.7	Н	Pass
398.34	26.68	46.02	100	184.7	V	Pass
489.84	28.13	46.02	100	356.2	V	Pass
696.96	31.89	46.02	100	40.5	Н	Pass
731.88	29.75	46.02	100	358.7	Н	Pass
922.14	36.29	46.02	100	129.9	V	Pass

Picture 26: Radiated emission 30 MHz - 1000MHz antenna 7248



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Spectrum Mask

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$, or

f_{MHz}

 $= 47.77 / d_{near field}$

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

f _{MHz} (300 m)	≈ 0.159 MHz
f _{MHz} (30 m)	≈ 1.592 MHz
f _{MHz} (3 m)	≈ 15.923 MHz

For 9 kHz \leq f \leq 159 kHz and 490 kHz < f \leq 1.592 MHz: Recalculation factor = -40 log(d_{limit} / d_{measure}) For 159 kHz < f \leq 490 kHz and 1.592 MHz < f \leq 15.923 MHz: Recalculation factor = -40 log(d_{near field} / d_{measure}) - 20 log(d_{limit} / d_{near field}) For f > 15.923 MHz: Recalculation factor = -20 log(d_{limit} / d_{measure})

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.



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Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	□ m
Polarisation:	□ parallel	imes in line	□ angle:°	
EUT Position:	\Box Position 1	⊠ Position 2	Position 3	

Frequency range	Step	IF	Dete	ector	Measurement Time		Preamplifier
	size	Bandwidth	Prescan	Final scan	Prescan	Final scan	
490 kHz – 30 MHz	4 kHz	9 kHz	PK	QPK	1 ms	1 s	off



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Picture 27: Spectrum mask for 13.56 MHz antenna 7248 (cable 200 cm)

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
12.928	30.16	QPK	-21.81	8.35	29.54	-21.19	Pass
13.004	28.53	QPK	-21.76	6.77	29.54	-22.77	Pass
13.348	40.52	QPK	-21.53	18.99	40.51	-21.52	Pass
13.560	69.59	PK	-21.40	48.19			Pass
13.560	69.40	QPK	-21.40	48.00	84.00	-36.00	Pass
13.772	42.16	QPK	-21.26	20.90	40.51	-19.61	Pass
14.060	29.86	QPK	-21.08	8.78	29.54	-20.76	Pass
14.120	32.38	QPK	-21.04	11.34	29.54	-18.20	Pass
14.196	35.40	QPK	-21.00	14.40	29.54	-15.14	Pass
14.540	30.27	QPK	-20.79	9.48	29.54	-20.06	Pass
14.620	32.54	QPK	-20.74	11.80	29.54	-17.74	Pass



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Picture 28: Spectrum mask for 13.56 MHz antenna 7248 (cable 10 cm)

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.560	75,93	PK	-21.40	54,53			Pass
13.560	75,90	QPK	-21.40	54,50	84.00	-29,5	Pass



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Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{\text{near field}}$

Recalculation factor

= -40 $\log(d_{near field} / d_{measure})$ - 20 $\log(d_{limit} / d_{near field})$

f _{мнz} [MHz]	d _{near field} [m]	d _{measure} d _{limit} [m] [m]		Recalculation factor [dB]
12.928	3.695	3.000	30.000	-21.81
13.004	3.673	3.000	30.000	-21.76
13.348	3.579	3.000	30.000	-21.53
13.560	3.523	3.000	30.000	-21.40
13.772	3.469	3.000	30.000	-21.26
14.060	3.398	3.000	30.000	-21.08
14.120	3.383	3.000	30.000	-21.04
14.196	3.365	3.000	30.000	-21.00
14.540	3.285	3.000	30.000	-20.79
14.620	3.267	3.000	30.000	-20.74



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5.13 Test results "antenna-switching-mode"

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-28

Radiated Emission Measurement 9 kHz - 30 MHz

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$, or

f_{MHz}

= 47.77 / d_{near field}

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula for determining the recalculation factor:

f _{MHz} (300 m)	≈ 0.159 MHz
f _{MHz} (30 m)	≈ 1.592 MHz
f _{MHz} (3 m)	≈ 15.923 MHz

For 9 kHz \leq f \leq 159 kHz and 490 kHz < f \leq 1.592 MHz: Recalculation factor = -40 log(d_{limit} / d_{measure}) For 159 kHz < f \leq 490 kHz and 1.592 MHz < f \leq 15.923 MHz:

Recalculation factor = -40 log($d_{near field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near field}$)

For f > 15.923 MHz:

Recalculation factor = -20 log(d_{limit} / d_{measure})

The limits in the graphics and value lists are derived from the general radiated emission limits as specified in 15.209 using the recalculation factor as described above.



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Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	□ m
Polarisation:	□ parallel	\Join in line	□ angle:°	
EUT Position:	☑ Position 1	\Box Position 2	\Box Position 3	

Frequency range	Step	IF	Detector		Measurement Time		Preamplifier
	size	Bandwidth	Prescan	Final scan	Prescan	Final scan	
9 kHz – 90 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
90 kHz – 110 kHz	80 Hz	200 Hz	PK	QPK	1 ms	1 s	off
110 kHz – 150 kHz	80 Hz	200 Hz	PK	AV	1 ms	1 s	off
150 kHz – 490 kHz	4 kHz	9 kHz	PK	AV	1 ms	1 s	off
490 kHz – 30 MHz	4 kHz	9 kHz	PK	QPK	1 ms	1 s	off



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Picture 29: Radiated emission 9 kHz - 30 MHz antenna-switching-mode

Frequency [MHz]	Measured value [dBµV/m]	Detector	Recalculation factor [dB]	Field strength [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
13.562	67.47	QPK	-21.40	46.07	84.00	-37.93	Pass
27.122	40.99	QPK	-20.00	20.99	29.54	-8.55	Pass

Remark: Emissions below carrier frequency (13.562 MHz) are ambient noise level or from peripheral devices (e.g. notebook).



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Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{near field} = 47.77 / f_{MHz}$

Recalculation factor = -40 $\log(d_{near field} / d_{measure})$ - 20 $\log(d_{limit} / d_{near field})$

f _{мнz}	d _{near field}	d _{measure}	d _{limit}	Recalculation
[MHz]	[m]	[m]	[m]	factor [dB]
13.562	3.523	3.000	30.000	-21.40

Recalculation factor is determined according to ANSI C63.10, section 6.4.4.2 "Extrapolation from the measurement of a single point":

 $d_{\text{near field}} = 47.77 / f_{\text{MHz}}$

Recalculation factor = $-20 \log(d_{\text{limit}} / d_{\text{measure}})$

f _{мнz}	d _{near field}	d _{measure}	d _{limit}	Recalculation
[MHz]	[m]	[m]	[m]	factor [dB]
27.122	1.761	3.000	30.000	-20.00



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Radiated Emission Measurement 30 MHz - 1000 MHz

Test distance:	Prescan: Final scan:	⊠ 3 m ⊠ 3 m	□ 10 m	□ m
Polarisation:	🛛 horizontal	⊠ vertical		
EUT Position:	□ Position 1	Position 2	Position 3	

Frequency	Polari-	Step	IF Band-	Dete	ector	Measurer	nent Time	Pre-
range	sation	size	width	Prescan	Final scan	Prescan	Final scan	amplifier
30 MHz – 1 GHz	H/V	60 kHz	120 kHz	PK	QPK	1 ms	1 s	20 dB





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f [MHz]	E _{final} [dBV/m]	Limit [dBµV/m]	Height [cm]	TT [°]	Polarisation	Result
30.66	23.04	40.00	100	357.4	V	Pass
40.68	24.83	40.00	100	135.6	Н	Pass
81.36	23.23	40.00	100	358.7	Н	Pass
94.92	31.99	43.52	100	348.5	Н	Pass
108.48	25.53	43.52	100	240.4	V	Pass
189.84	31.19	43.52	100	358.6	Н	Pass
216.96	31.10	46.02	100	95.9	V	Pass
232.62	25.49	46.02	100	129.9	V	Pass
237.48	27.26	46.02	100	56.9	Н	Pass
244.38	28.95	46.02	100	74.7	Н	Pass
271.26	29.53	46.02	100	17.0	Н	Pass
279.48	33.67	46.02	100	64.2	Н	Pass
298.32	27.08	46.02	100	324.5	V	Pass
314.82	26.04	46.02	100	98.4	Н	Pass
349.86	36.11	46.02	100	245.5	Н	Pass
384.84	27.865	46.02	100	263.6	Н	Pass
398.34	27.23	46.02	100	177.3	V	Pass
418.14	24.60	46.02	100	158.9	V	Pass
433.92	27.71	46.02	100	59.3	V	Pass
489.90	26.91	46.02	100	1.3	V	Pass
696.96	31.41	46.02	100	359.9	Н	Pass
731.82	29.89	46.02	100	0.0	Н	Pass
922.14	36.07	46.02	100	130.2	V	Pass

Picture 30: Radiated emission 30 MHz - 1000MHz antenna-switching-mode



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6 Radiated emission measurement (>1 GHz)

according to 47 CFR Part 15, section 15.209(a), RSS-210, section 4.3 with RSS-Gen, section 8.9

Remark:

This measurement needs not to be applied because

- the intentional radiator operates below 10 GHz and tenth harmonic of the highest fundamental frequency is lower than 1 GHz (see 47 CFR Part 15, section 15.33(a)(1), and RSS-Gen, section 6.13), and
- the digital part of the device does not generate or use internal frequencies higher than 108 MHz (see 47 CFR Part 15 section 15.33(b)(1), and RSS-Gen, section 2.3.3 with ICES-003, section 6.2).



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7 Carrier frequency stability

according to CFR 47 Part 15, section 15.225(e), and RSS-210, Annex B6 with RSS-Gen, section 6.11

7.1 Test Location

	Description	Manufacturer	Inventory No.
	Climatic chamber VC 4100	Vötsch Industrietechnik	C00014
\boxtimes	Climatic chamber VC ³ 4034	Vötsch Industrietechnik	C00015

7.2 Test instruments

	Description	Manufacturer	Inventory No.
	ESU 26	Rohde & Schwarz	W00002
\boxtimes	ESCI 3	Rohde & Schwarz	E00552
\boxtimes	RF-R 400-1	Langer EMV-Technik	E00270

7.3 Limits

The frequency tolerance of the carrier signal shall be maintained within $\pm 0.01\%$ (100 ppm) of the operating frequency over a temperature variation of -20 degrees to +50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C.

For battery operated equipment, the equipment tests shall be performed using a new battery. Alternatively, an external supply voltage can be used and set at the battery nominal voltage, and again at the battery operating end point voltage which must be specified by the equipment manufacturer.



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7.4 Test procedure

 If possible EUT is operating providing an unmodulated carrier. The peak detector of the spectrum analyzer is selected and resolution as well as video bandwidth are set to values appropriate to the shape of the spectrum of the EUT. The frequency counter mode of the spectrum analyzer is used to maximize the accuracy of the measured frequency tolerance.

If an unmodulated carrier is not available a significant and stable point on the spectrum is selected and the span is reduced to a value that delivers an accuracy which shall be better than 1% of the maximum frequency tolerance allowed for the carrier signal. This method may be performed as long as the margin to the frequency tolerance allowed is larger than the uncertainty of the measured frequency tolerance.

- 2. The carrier frequency is measured depending on the variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment an external supply voltage can be used and set at the battery nominal voltage, and again at the battery operating end point voltage which must be specified by the equipment manufacturer. Alternatively, tests shall be performed using a new battery.
- 3. The carrier frequency is measured over a temperature variation of -20 degrees to +50 degrees C at normal supply voltage.

7.5 Test setup



Picture 31: Test setup for carrier frequency stability measurement

7.6 Test deviation

There is no deviation from the standards referred to.



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Temperature:	20°C		Humidity:		41%	
Tested by:	Martin N	Nüller	Test date:		2017-03-29	
Carrier frequ	uency stabi	lity vs. ten	nperature			
	Tolerance	Jpper Limit –	-Lower Limit			
150,0						
100,0						
(mdd) 50,0						
lance						
			◆ ◆	•	•	
Su -50,0						
Ū						
-100,0						
-150,0	, ₁ ,	L 1	1 I I			
-100,0 -150,0 -20	-10		+10 +2(Temperature (°() +30 C)	+40	+50
-100,0 -150,0 -20	-10 5 V	±0 Frequ	+10 +2(Temperature (°(ency under nom	0 +30 C) inal conditions:	+40	+50 560647 MI
Letter -100,0 -150,0 -20 Supply voltage: Temperature	-10 5 V Frequency	±0 Frequ	+10 +2(Temperature (°(ency under nom) +30 C) inal conditions: Upper Limit	+40 13, Lower Limit	+50 560647 MI Margin
Letter -100,0 -150,0 -20 Supply voltage: Temperature (°C)	-10 5 V Frequency (MHz)	±0 Frequ Frequency (Hz)	+10 +2(Temperature (°(ency under nomi Tolerance (ppm)) +30 C) inal conditions: Upper Limit (ppm)	+40 13, Lower Limit (ppm)	+50 560647 MI Margin (ppm)
-100,0 -150,0 -20 Supply voltage: Temperature (°C) -20	-10 -10 5 V Frequency (MHz) 13,560706	±0 Frequ Frequency (Hz) 59	+10 +2(Temperature (°(ency under nomi 7 Tolerance (ppm) 4,4) +30 C) inal conditions: Upper Limit (ppm) +100,0	+40 13, Lower Limit (ppm) -100,0	+50 560647 MI Margin (ppm) 95,6
-100,0 -150,0 -20 Supply voltage: Temperature (°C) -20 -10	-10 -10 5 V Frequency (MHz) 13,560706 13,560698	±0 Frequ Frequency (Hz) 59 51	+10 +20 Temperature (°0 ency under nomi 7 Tolerance (ppm) 4,4 3,8	0 +30 C) inal conditions: Upper Limit (ppm) +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0	+50 560647 MI Margin (ppm) 95,6 96,2
-100,0 -150,0 -20 Supply voltage: Temperature (°C) -20 -10 ±0	-10 5 V Frequency (MHz) 13,560706 13,560698 13,560674	±0 Frequency (Hz) 59 51 27	+10 +20 Temperature (°0 ency under nomi 7 Tolerance (ppm) 4,4 3,8 2,0	0 +30 C) inal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0	+50 560647 MI Margin (ppm) 95,6 96,2 98,0
-100,0 -150,0 -20 Supply voltage: Temperature (°C) -20 -10 ±0 +10	-10 5 V Frequency (MHz) 13,560706 13,560698 13,560654 13,560654	±0 Frequency (Hz) 59 51 27 7	+10 +2(Temperature (°(ency under nom 7 Tolerance (ppm) 4,4 3,8 2,0 0,5) +30 C) inal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0	+50 560647 MI Margin (ppm) 95,6 96,2 98,0 99,5
-100,0 -150,0 -20 Supply voltage: Temperature (°C) -20 -10 ±0 +10 +20	-10 5 V Frequency (MHz) 13,560706 13,560698 13,560654 13,560647	±0 Frequency (Hz) 59 51 27 7 0	+10 +20 Temperature (°0 ency under nomi 7 Tolerance (ppm) 4,4 3,8 2,0 0,5 0,0	0 +30 C) inal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0	+50 560647 MI Margin (ppm) 95,6 96,2 98,0 99,5 100,0
u u u u u u u u u u u u u u	-10 -10 Frequency (MHz) 13,560706 13,560698 13,560674 13,560647 13,560643 13,560643	±0 Frequency (Hz) 59 51 27 7 0 -4	+10 +20 Temperature (°0 ency under nomi 7 Tolerance (ppm) 4,4 3,8 2,0 0,5 0,0 -0,3	0 +30 C) inal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0	+50 560647 MI Margin (ppm) 95,6 96,2 98,0 99,5 100,0 99,7
L -100,0 -150,0 -150,0 -20 Supply voltage: Temperature (°C) -20 -10 ±0 +10 +20 +30 +40 -20	-10 5 V Frequency (MHz) 13,560706 13,560698 13,560674 13,560647 13,560643 13,560643 13,560648	±0 Frequency (Hz) 59 51 27 7 0 -4 1	+10 +20 Temperature (°0 ency under nomi 7 Tolerance (ppm) 4,4 3,8 2,0 0,5 0,0 -0,3 0,1) +30 C) inal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0	+50 560647 MI Margin (ppm) 95,6 96,2 98,0 99,5 100,0 99,7 99,9
$ \begin{array}{c} \overset{u}{} & -100,0 \\ -150,0 \\ -20 \\ \end{array} $ Supply voltage: $ \begin{array}{c} \text{Temperature} \\ (^{\circ}\text{C}) \\ -20 \\ -10 \\ \underline{+0} \\ +10 \\ \underline{+20} \\ +30 \\ \underline{+40} \\ +50 \\ \end{array} $	-10 5 V Frequency (MHz) 13,560706 13,560698 13,560674 13,560647 13,560643 13,560643 13,560648 13,560648	±0 Frequency (Hz) 59 51 27 7 0 -4 1 1 -25	+10 +2(Temperature (°(ency under nomi 7 Tolerance (ppm) 4,4 3,8 2,0 0,5 0,0 -0,3 0,1 -1,8) +30 C) inal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0	+50 560647 MI Margin (ppm) 95,6 96,2 98,0 99,5 100,0 99,7 99,9 98,2
L -100,0 -150,0 -150,0 -20 Supply voltage: Temperature (°C) -20 -10 ±0 +10 +20 +30 +40 +50 +60 -20	-10 5 V Frequency (MHz) 13,560706 13,560698 13,560674 13,560647 13,560643 13,560643 13,560643 13,560643 13,560643	±0 Frequency (Hz) 59 51 27 7 0 -4 1 -25 -32	+10 +2(Temperature (°(ency under nom 7 Tolerance (ppm) 4,4 3,8 2,0 0,5 0,0 -0,3 0,1 -1,8 -2,4) +30 C) inal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0	+50 560647 MI Margin (ppm) 95,6 96,2 98,0 99,5 100,0 99,7 99,9 98,2 97,6 97,6
$ \begin{array}{c} \underline{5}\\ -100,0\\ -150,0\\ -20\\ \end{array} $ Supply voltage: $ \begin{array}{c} Temperature \\ (°C)\\ -20\\ -10\\ \underline{+0}\\ +20\\ \underline{+10}\\ \underline{+20}\\ \underline{+30}\\ \underline{+40}\\ \underline{+50}\\ \underline{+60}\\ \underline{+70}\\ \underline{-20}\\ \underline{-20}$	-10 5 V Frequency (MHz) 13,560706 13,560698 13,560698 13,560647 13,560647 13,560643 13,560643 13,560648 13,560648 13,560615 13,560621	±0 Frequency (Hz) 59 51 27 7 0 -4 1 -25 -32 -26	+10 +2(Temperature (°(ency under nom 7 Tolerance (ppm) 4,4 3,8 2,0 0,5 0,0 -0,3 0,1 -1,8 -2,4 -1,9	0 +30 C) inal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0	+50 560647 MI Margin (ppm) 95,6 96,2 98,0 99,5 100,0 99,7 99,9 99,7 99,9 98,2 97,6 98,1

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Femperature:	20°C		Humidity:		41%	
Fested by:	Martin N	Müller	Test date:		2017-03-29	
Carrier freq	uency stabi	lity vs. te	emperature			
150,0						
100,0						
udo roo						
9 50,0 H						
· ·						
≥ 50.0						
-50,0						
-50,0 -50,0						
-50,0 -50,0 -100,0						
-100,0						
-50,0 -100,0 -150,0 -20	-10		+10 +:		+40	+50
Cuenting Line -50,0 -100,0 -150,0 -20	-10	 	+10 +2 Temperature (+40	+50
Cuento -50,0 -100,0 -150,0 -20	-10	±0	+10 +: Temperature (20 +30 (°C)	+40	+50
Cuerche -50,0 -100,0 -150,0 -20	-10 5 V	±0 Fre	+10 +: Temperature (quency under nor	20 +30 °C) ninal conditions:	+40	+50 560652 MF
-50,0 -100,0 -150,0 -20	-10 5 V	±0 Free	+10 +2 Temperature (quency under nor	20 +30 °C) ninal conditions:	+40 13,	+50 560652 Mł
Supply voltage:	-10 5 V Frequency (MHz)	±0 Frequen (Hz)	+10 +: Temperature (quency under nor icy Tolerance	20 +30 °C) ninal conditions: Upper Limit (ppm)	+40 13, Lower Limit (ppm)	+50 560652 Mł Margin (ppm)
Current -50,0 -100,0 -150,0 -150,0 -20 Cupply voltage: Temperature (°C) -20	-10 -10 5 V Frequency (MHz) 13,560759	±0 Frequen (Hz) 107	+10 +: Temperature (quency under nor ncy Tolerance (ppm) 7,9	20 +30 °C) ninal conditions: Upper Limit (ppm) +100.0	+40 13, Lower Limit (ppm) -100.0	+50 560652 MH Margin (ppm) 92.1
Supply voltage: Temperature (°C) -100,0 -150,0 -20	-10 -10 5 V Frequency (MHz) 13,560759 13,560708	±0 Frequent (Hz) 107 56	+10 +: Temperature (quency under nor icy Tolerance (ppm) 7,9 4,1	20 +30 °C) ninal conditions: Upper Limit (ppm) +100,0 +100,0	+40 +40 13, Lower Limit (ppm) -100,0 -100,0	+50 560652 MF Margin (ppm) 92,1 95,9
Supply voltage: Temperature (°C) -10 -20 -20 -20 -20 -10 ±0	-10 -10 5 V Frequency (MHz) 13,560759 13,560708 13,560693	±0 Frequen (Hz) 107 56 41	+10 +2 Temperature (quency under nor icy Tolerance (ppm) 7,9 4,1 3,0	20 +30 °C) ninal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0	+50 560652 MF Margin (ppm) 92,1 95,9 97,0
Supply voltage: Temperature (°C) -10 -20 -150,0 -20 -20 -20 -10 ±0 +10	-10 5 V Frequency (MHz) 13,560759 13,560708 13,560693 13,560672	±0 Frequent (Hz) 107 56 41 20	+10 +2 Temperature (quency under nor icy Tolerance (ppm) 7,9 4,1 3,0 1,5	20 +30 20 +30 °C) ninal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0	+50 560652 MH Margin (ppm) 92,1 95,9 97,0 98,5
Supply voltage: Temperature (°C) -20 -10 -20 -20 -10 ±0 +10 +20	-10 5 V Frequency (MHz) 13,560759 13,560693 13,560693 13,560672 13,560652	±0 Frequen (Hz) 107 56 41 20 0	+10 +2 Temperature (quency under nor icy Tolerance (ppm) 7,9 4,1 3,0 1,5 0,0	20 +30 °C) ninal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0	+50 560652 MF Margin (ppm) 92,1 95,9 97,0 98,5 100,0
Supply voltage: Temperature (°C) -20 -10,0 -20 -20 -10 ±0 +10 +20 +30	-10 -10 5 V Frequency (MHz) 13,560759 13,560672 13,560652 13,560652 13,560654	±0 Frequen (Hz) 107 56 41 20 0 2	+10 +2 Temperature (quency under nor icy Tolerance (ppm) 7,9 4,1 3,0 1,5 0,0 0,1	20 +30 °C) ninal conditions: Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0	+40 13, Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0 -100,0	+50 560652 Mł Margin (ppm) 92,1 95,9 97,0 98,5 100,0 99,9

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13,560605

13,560617

13,560640

13,560678

-47

-35

-12

26

-3,5

-2,6

-0,9

1,9

+60

+70

+80

+85

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-100,0

-100,0

-100,0

-100,0

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+100,0

+100,0

+100,0

+100,0

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96,5

97,4

99,1

98,1



emperature:	20°C		Humidity:		41%	
Fested by:	Martin M	1üller	Test date:		2017-03-29	
Carrier freg	uencv stabil	itv vs. ten	nperature			
150,0	,					
100.0						
<u>c</u>						
udd) 50,0						
0,0	•		-		•	
→ → → -50.0						
edne						
··· -100,0						
-150,0						
-20	-10	±0	+10 +2	20 +30	+40	+50
			l'emperature (°C)		
Supply voltage:	5 V	Frequ	iency under nor	ninal conditions:	13,	560633 M
eapply reliage.						000000 11
Temperature	Frequency	Frequency	/ Tolerance	Upper Limit	Lower Limit	Margin
Temperature (°C)	Frequency (MHz)	Frequency (Hz)	/ Tolerance (ppm)	Upper Limit (ppm)	Lower Limit (ppm)	Margin (ppm)
Temperature (°C) -20	Frequency (MHz) 13,560730	Frequency (Hz) 97	/ Tolerance (ppm) 7,2	Upper Limit (ppm) +100,0	Lower Limit (ppm) -100,0	Margin (ppm) 92,8
Temperature (°C) -20 -10	Frequency (MHz) 13,560730 13,560695	Frequency (Hz) 97 62	7 Tolerance (ppm) 7,2 4,6	Upper Limit (ppm) +100,0 +100,0	Lower Limit (ppm) -100,0 -100,0	Margin (ppm) 92,8 95,4
Temperature (°C) -20 -10 ±0	Frequency (MHz) 13,560730 13,560695 13,560676	Frequency (Hz) 97 62 43	/ Tolerance (ppm) 7,2 4,6 3,2	Upper Limit (ppm) +100,0 +100,0 +100,0	Lower Limit (ppm) -100,0 -100,0 -100,0	Margin (ppm) 92,8 95,4 96,8
Temperature (°C) -20 -10 ±0 +10	Frequency (MHz) 13,560730 13,560695 13,560676 13,560653	Frequency (Hz) 97 62 43 20	/ Tolerance (ppm) 7,2 4,6 3,2 1,5	Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0	Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0	Margin (ppm) 92,8 95,4 96,8 98,5
Temperature (°C) -20 -10 ±0 +10 +20	Frequency (MHz) 13,560730 13,560695 13,560676 13,560653 13,560633	Frequency (Hz) 97 62 43 20 0	/ Tolerance (ppm) 7,2 4,6 3,2 1,5 0,0	Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0	Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0	Margin (ppm) 92,8 95,4 96,8 98,5 100,0
Temperature (°C) -20 -10 ±0 +10 +20 +30	Frequency (MHz) 13,560730 13,560695 13,560676 13,560653 13,560633 13,560642	Frequency (Hz) 97 62 43 20 0 9	/ Tolerance (ppm) 7,2 4,6 3,2 1,5 0,0 0,7	Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0	Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0	Margin (ppm) 92,8 95,4 96,8 98,5 100,0 99,3
Temperature (°C) -20 -10 ±0 +10 +20 +30 +40	Frequency (MHz) 13,560730 13,560695 13,560676 13,560653 13,560643 13,560642 13,560646	Frequency (Hz) 97 62 43 20 0 9 13	/ Tolerance (ppm) 7,2 4,6 3,2 1,5 0,0 0,7 1,0	Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0 +100,0	Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0 -100,0	Margin (ppm) 92,8 95,4 96,8 98,5 100,0 99,3 99,0
Temperature (°C) -20 -10 ±0 +10 +20 +30 +40 +50	Frequency (MHz) 13,560730 13,560695 13,560653 13,560633 13,560642 13,560642 13,560646 13,560657	Frequency (Hz) 97 62 43 20 0 9 13 24	/ Tolerance (ppm) 7,2 4,6 3,2 1,5 0,0 0,7 1,0 1,8	Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0	Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0	Margin (ppm) 92,8 95,4 96,8 98,5 100,0 99,3 99,0 98,2
Temperature (°C) -20 -10 ±0 +10 +20 +30 +40 +50 +60	Frequency (MHz) 13,560730 13,560695 13,560676 13,560653 13,560633 13,560642 13,560646 13,560657 13,560634	Frequency (Hz) 97 62 43 20 0 9 13 24 1 1	/ Tolerance (ppm) 7,2 4,6 3,2 1,5 0,0 0,7 1,0 1,8 0,1	Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0	Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0	Margin (ppm) 92,8 95,4 96,8 98,5 100,0 99,3 99,0 98,2 99,9
Temperature (°C) -20 -10 ±0 +10 +20 +30 +40 +50 +60 +70	Frequency (MHz) 13,560730 13,560695 13,560676 13,560653 13,560633 13,560642 13,560646 13,560657 13,560634 13,560613	Frequency (Hz) 97 62 43 20 0 9 13 24 1 -20	/ Tolerance (ppm) 7,2 4,6 3,2 1,5 0,0 0,7 1,0 1,0 1,8 0,1 -1,5	Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0	Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0	Margin (ppm) 92,8 95,4 96,8 98,5 100,0 99,3 99,0 98,2 99,9 98,5
Temperature (°C) -20 -10 ±0 +10 +20 +30 +40 +50 +60 +70 +80	Frequency (MHz) 13,560730 13,560695 13,560676 13,560653 13,560642 13,560642 13,560646 13,560657 13,560634 13,560613 13,560659	Frequency (Hz) 97 62 43 20 0 9 13 24 1 -20 26	/ Tolerance (ppm) 7,2 4,6 3,2 1,5 0,0 0,7 1,0 1,8 0,1 -1,5 1,9	Upper Limit (ppm) +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0 +100,0	Lower Limit (ppm) -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0 -100,0	Margin (ppm) 92,8 95,4 96,8 98,5 100,0 99,3 99,0 98,2 99,9 98,5 98,5 98,5

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8 Bandwidths

according to CFR 47 Part 2, section 2.202(a), and RSS-Gen, section 6.6

8.1 Test Location

See clause 5.1 on page 22.

8.2 Test instruments

See clause 5.2 on page 22.

8.3 Limits

The bandwidths are recorded only. There are no limits specified in CFR 47 Part 15, section 15.225, and RSS-210, Annex B6

8.4 Test procedure "occupied bandwidth (99%)"

When an occupied bandwidth value is not specified in the applicable RSS, the transmitted signal bandwidth to be reported is to be its 99% emission bandwidth, as calculated or measured. The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts. The resolution bandwidth shall be set to as close to 1% of the selected span as is possible without being below 1%. The video bandwidth shall be set to 3 times the resolution bandwidth. Video averaging is not permitted. Where practical, a sampling detector shall be used given that a peak or peak hold may produce a wider bandwidth than actual.

The trace data points are recovered and directly summed in linear terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points. This frequency is recorded. The span between the two recorded frequencies is the occupied bandwidth. For this purpose the appropriate measurement function of the spectrum analyzer is used.



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8.5 Test procedure "-20 dB emission bandwidth"

When an occupied bandwidth value is not specified in the applicable RSS, the transmitted signal bandwidth to be reported is to be its 99% emission bandwidth, as calculated or measured. The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts. The resolution bandwidth shall be set to as close to 1% of the selected span as is possible without being below 1%. The video bandwidth shall be set to 3 times the resolution bandwidth. Video averaging is not permitted. Where practical, a sampling detector shall be used given that a peak or peak hold may produce a wider bandwidth than actual.

The trace data points are recovered and directly summed in linear terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points. This frequency is recorded. The span between the two recorded frequencies is the occupied bandwidth. For this purpose the appropriate measurement function of the spectrum analyzer is used.

8.6 Test setup

See clause 0 on page 24.

8.7 Test deviation

There is no deviation from the standards referred to.



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8.8 Test results "antenna 2010"

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-24

Occupied bandwidth (99 %)



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13 560000	Index	f _{-20dB} (MHz)	Δf _T (kHz)	∆f _∪ (kHz)	f _{-20dB(T, U)} (MHz)	Limit (MHz)	Margin (kHz)	Result
13 560000	low	13.556700	0.000	0.081	13.556619	13.110000	446.619	Passed
10.000000	high	13.564080	0.084	0.076	13.564164	14.010000	445.836	Passed
	Bandwidth	7.380 kHz			7.545 kHz			
vith: f_{-20dk} f_{-20dk} f_{assig} $\Delta f_{T(k}$ $\Delta f_{U(k)}$ $\Delta f_{U(k)}$ $\Delta f_{U(k)}$ $\Delta f_{U(k)}$ f_{-20dk} Measured - At nominal - ncluding va	3(low) = le $3(high) = u$ $ned = a$ $20w) = r$ r r r r r r r r r	ower frequen upper frequer assigned freq naximum abs nominal cond naximum abs nominal cond naximum abs conditions ca naximum abs conditions ca naximum abs conditions ca requency in I ncluding offs recorded in cl sion bandwic semperature a	cy in M ncy in N uency i solute v solute v itions ca solute v used by solute v used by MHz wh et cause ause 7.	Hz when Hz when Hz when alue of alue of alue of alue of alue of voltage alue of voltage voltag	ere emission negative fre by temperat negative fre oy voltage v positive fre e variation i positive fre e variation i ssion is at ariations of 7.3 age: 7.5	n is at least n is at least equency offs ariation in k quency offs ariation in kHz quency offs n kHz least 20 dB temperature 80 kHz 45 kHz	20 dB belo 30 dB belo set to frequent set to frequent et to frequent to frequent below the e and supp	ow the carrie ow the carrie uency at uency at ency at nom ency at nom ency at nom carrier, oly voltage a
						G	MMC GmbH	
TESTHA	U S	EMV TESTHA	US Gmb			G 13.56 MHz Mu F	MMC GmbH Iti Standard Reader/Write	H - Multi Antenna
		EMV TESTHA	US Gmb	н		G 13.56 MHz Mu	MMC GmbH Iti Standard	H - Multi Antenna

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8.9 Test results "antenna Jay"

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-24

Occupied bandwidth (99 %)



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f _{assigned} (MHz)	Index	т _{-20dB} (MHz)	Δt _T (kHz)	Δt _U (kHz)	Т _{-20d} B(T, U) (MHz)	(MHz)	Margin (kHz)	Result
	low	13.557480	0.032	0.073	13.557407	13.110000	447.407	Passed
13.560000	high	13.563780	0.066	0.085	13.563865	14.010000	446.135	Passed
	Bandwidth	6.300 kHz			6.458 kHz			
with: f_{-20} f_{-20} f_{ass} Δf_T Δf_L Δf_L Δf_L Δf_V f_{-20}	dB(low) = H $dB(high) = U$ $dB(high) = U$ $(low) = r$ r $(low) = r$ r $(high) = r$ $dB(high) = r$ $dB(T, U) = f$	ower frequer upper frequer assigned freq naximum absorted naximum absorted naximum absorted naximum absorted conditions ca naximum absorted conditions ca	icy in M ncy in N juency i solute v itions c solute v used by solute v used by solute v used by MHz wh et cause lause 7.	HZ Whe IHZ whe alue of aused k alue of aused k alue of tempe alue of voltag alue of voltag alue of voltag bere em ed by v	re emission ere emission negative fre by temperat negative fre oy voltage v positive fre evariation i positive fre e variation i positive fre e variation i ariations of	n is at least n is at least equency offs ariation in k quency offs ariation in kHz quency offs n kHz quency offs n kHz least 20 dB temperature	20 dB bel 30 dB bel set to freq in kHz set to frequent et to frequent to frequent below the e and sup	ow the carrie low the carrie uency at uency at nom uency at nom uency at nom e carrier, ply voltage a
Aeasured At nominal ncluding v	-20 dB emis conditions: ariations in t	sion bandwic	Ith: and sup	ply volt	6.3 tage: 6.4	00 kHz 58 kHz		

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8.10 Test results "antenna 4040"

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-24

Occupied bandwidth (99 %)





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13.560000 with: f_{-20dB}	$\frac{1}{100}$ $\frac{1}$	13.557600 13.563720 6.120 kHz ower frequer assigned freq naximum abs nominal cond naximum abs nominal cond naximum abs nominal cond naximum abs nominal cond naximum abs	0.047 0.107 0.107 0.107 0.107 0.107 0.107 0.107 0.107 0.107 0.107 0.107 0.107 0.107 0.107 0.107 0.107	0.107 0.061 Hz whe IHz whe n kHz alue of aused b alue of	13.557493 13.563827 6.334 kHz ere emission ere emission negative fre by temperat	13.110000 14.010000 n is at least n is at least equency offs ure variation	447.493 446.173 20 dB belo 30 dB belo set to frequ	Passed Passed ow the carrie ow the carrie uency at
13.560000 vith: f_{-20dB_i}	$\begin{array}{rcl} high\\ \hline Bandwidth\\ \hline B(low) &= le\\ B(high) &= u\\ hed &= a\\ hw) &= r\\ hw) &= r\\ hw) &= r\\ hy) &= r$	13.563720 6.120 kHz ower frequen upper frequen assigned freq naximum abs nominal cond naximum abs nominal cond naximum abs conditions ca naximum abs	0.107 acy in M acy in M juency in solute v itions ca solute v itions ca solute v	0.061 Hz whe IHz whe n kHz alue of aused b alue of	13.563827 6.334 kHz ere emission ere emission negative fre by temperat	n is at least n is at least n is at least equency offs ure variation	446.173 20 dB belo 30 dB belo set to frequ	Passed
vith: f_{-20dB_i} f_{-20dB_i} f_{assign} $\Delta f_{T(lot)}$ $\Delta f_{U(lot)}$ $\Delta f_{U(lot)}$ $\Delta f_{U(lot)}$ $\Delta f_{U(hit)}$ $\Delta f_{Volt(lot)}$	Bandwidth $g(low)$ = $g(high)$ = hed =	6.120 kHz ower frequen assigned freq naximum abs nominal cond naximum abs nominal cond naximum abs conditions ca naximum abs	ncy in M ncy in M juency i solute v itions c solute v itions c solute v	Hz whe Hz whe n kHz alue of aused b alue of	6.334 kHz ere emissior ere emissio negative fre by temperat	n is at least n is at least equency offs ure variation	20 dB belo 30 dB bel set to frequ	ow the carrie ow the carrie uency at
vith: f_{-20dB_i} f_{-20dB_i} f_{assign} $\Delta f_{T(loi)}$ $\Delta f_{U(loi)}$ $\Delta f_{U(loi)}$ $\Delta f_{U(loi)}$ $\Delta f_{U(hi)}$ $\Delta f_{U(hi)}$ $\Delta f_{volt(i)}$	$\begin{array}{llllllllllllllllllllllllllllllllllll$	ower frequen apper frequer assigned freq naximum abs nominal cond naximum abs cominal cond naximum abs conditions ca	ncy in M ncy in M juency i solute v itions c solute v itions c solute v	Hz whe Hz whe n kHz alue of aused b alue of	ere emission ere emission negative fre by temperat	n is at least n is at least equency offs ure variation	20 dB belo 30 dB bel set to frequ	ow the carrie ow the carrie uency at
Aeasured -2 At nominal of noluding va	(high) = r (T, U) = f in 20 dB emiss conditions: riations in t	conditions ca naximum abs conditions ca requency in I ncluding offs ecorded in cl sion bandwic emperature a	used by solute v used by solute v used by MHz wh et caus lause 7. Ith: and sup	auseu (alue of / tempe alue of / voltag alue of / voltag here em ed by va .9	negative fre- by voltage v positive fre- e variation i positive fre- e variation i ission is at ariations of 6.1 tage: 6.3	20 kHz 20 kHz 34 kHz	MMC GmbH	uency at ency at nom ency at nom ency at nom carrier, oly voltage as

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8.11 Test results "antenna 7248"

Temperature:	20°C	Humidity:	41%
Tested by:	Martin Müller	Test date:	2017-03-24

Occupied bandwidth (99 %)





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	Index	(MHz)	(kHz)	Δι _υ (kHz)	^т -20dB(T, U) (MHz)	(MHz)	(kHz)	Result
	low	13.557540	0.020	0.092	13.557448	13.110000	447.448	Passed
13.560000	high	13.563720	0.097	0.082	13.563817	14.010000	446.183	Passed
	Bandwidth	6.180 kHz			6.369 kHz			
vith: f_{-2C} f_{-2C} f_{ass} Δf_{1} Δf_{1} Δf_{1} Δf_{2} Δf_{2} Δf_{2}	dB(low) = 1 $dB(high) = 1$ $iigned = 3$ $i(low) = 1$ $l(low) = 1$ $l(low) = 1$ $l(high) = 1$ $u(high) = 1$ $dB(T, U) = 1$	ower frequer upper frequer assigned freq maximum abs nominal cond maximum abs conditions ca maximum abs conditions ca maximum abs conditions ca maximum abs conditions ca frequency in l ncluding offs recorded in cl	ncy in M ncy in M juency i solute v litions c solute v used by solute v used by solute v used by MHz wh et cause lause 7.	Hz when Hz when n kHz value of aused to value of value of voltag voltag voltag alue of voltag voltag here em ed by voltag	ere emission negative fre by temperat negative fre by voltage v positive fre positive fre e variation i positive fre e variation i positive fre e variation i positive fre a variation i positive fre e variation i positive fre a variation i positive fre	n is at least n is at least equency offs ure variation equency offs ariation in kHz quency offs in kHz quency offs n kHz least 20 dB temperature	20 dB bel 30 dB bel set to freq in kHz set to freque et to freque et to freque below the e and sup	ow the carrie low the carrie uency at uency at nom uency at nom uency at nom e carrier, ply voltage a
Measured At nomina ncluding v	-20 dB emis I conditions: variations in	sion bandwic	dth: and sup	oply volt	6.1 tage: 6.3	80 kHz 69 kHz		

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9 Equipment calibration status

Description	Modell number	Serial number	Inventory number(s)	Last calibration	Next calibration
Test receiver	ESCI 3	100013	E00001	2016-02	2018-02
Test receiver	ESCI 3	100328	E00552	2016-09	2018-09
Test receiver	ESCS 30	825442/0002	E00003	2016-04	2018-04
LISN	ESH2-Z5	893406/009	E00005	2016-02	2018-02
Loop antenna	HFH2-Z2	871398/0050	E00060	2016-09	2018-09
Broadband antenna	VULB 9160	9160-3050	E00011	2015-09	2017-09
Broadband antenna	VULB 9163	9163-114	E00013	2015-09	2017-09
Magnetic field probe	RF-R 400-1	02-2030	E00270	N/A (see	e note 1)
Shielded room	P92007	B83117C1109T211	E00107	N	/A
Compact diagnostic chamber (CDC)	VK041.0174	D62128-A502-A69- 2-0006	E00026	N/A	
Open area test site (OATS)			E00354	2015-10	2017-10
Climatic chamber 340 I	VC ³ 4034	58566123250010	C00015	2016-10	2018-10
Cable set shielded room	Cable no. 30		E00424	2016-07	2018-07
Cable set CDC	Cables no. 37 and 38		E00459 E00460	2015-05	2017-05
Cable set OATS 3 m	Cables no. 19, 34 and 36		E00453 E00456 E00458	2015-11	2017-11

Table 1: Equipment calibration status

Note 1:Used for relative measurements only (see test instruments for "Carrier frequency
stability", clause 7.2)Note 2:Expiration date of measurement facility registration (OATS) by
- FCC (registration number 221458):2017-04

- Industry Canada (test sites number 3472A-1 and 3472A-2): 2018-11 Note 3: Expiration date of test firm accreditation for OATS and SAC:

FCC test firm type "accredited": 2017-06



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10 Measurement uncertainty

Description	Max. deviation	k=
Conducted emission AMN (9kHz to 30 MHz)	± 3.8 dB	2
Radiated emission open field (3 m) (30 MHz to 300 MHz) (300MHz to 1 GHz)	± 5.4 dB ± 5.9 dB	2
Radiated emission absorber chamber (> 1000 MHz)	± 4.5 dB	2

Table 2: Measurement uncertainty

The uncertainty stated is the expanded uncertainty obtained by multiplying the standard uncertainty by the coverage factor k. For a confidence level of 95 % the coverage factor k is 2.



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11 Revision History

Date	Description	Person	Revision
2017-03-31	First edition	M. Müller	0



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