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Test Report

Report Number:

F221308E1 2nd version

Equipment under Test (EUT):

Captura 100 MIFARE

Applicant:

Martin Lehmann GmbH & Co. KG

Manufacturer:

Martin Lehmann GmbH & Co. KG



Deutsche
Akkreditierungsstelle
D-PL-17186-01-01
D-PL-17186-01-02
D-PL-17186-01-03

References

- [1] **ANSI C63.10: 2013** American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] **FCC CFR 47 Part 15** Radio Frequency Devices
- [3] **RSS-210 Issue 10 (December 2019)**
Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment
- [4] **RSS-Gen Issue 5 (March 2019) Amendment 1**
General Requirements for Compliance of Radio Apparatus

Test Result

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test. The complete test results are presented in the following.

“Passed” indicates that the equipment under test conforms with the relevant limits of the testing standard without taking any measurement uncertainty into account as stated in clause 1.3 of ANSI C63.10 (2013). However, the measurement uncertainty is calculated and shown in this test report.

Tested and written
by:

Signature

Reviewed and
approved by:

Signature

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The test results herein refer only to the tested sample. PHOENIX TESTLAB GmbH is not responsible for any generalisations or conclusions drawn from these test results concerning further samples. Any modification of the tested samples is prohibited and leads to the invalidity of this test report. Each page necessarily contains the PHOENIX TESTLAB Logo and the TEST REPORT NUMBER.

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1 Identification

1.1 Applicant

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Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	Martin Lehmann GmbH & Co. KG
Address:	Uphäuser Weg 82, 32429 Minden
Country:	Germany
Name for contact purposes:	Sönke SCHLÜTER
Phone:	+49 (0)571 5046-0
eMail address:	info@lehmann-locks.com
Manufacturer represented during the test by the following person:	-

1.3 Test Laboratory

The tests were carried out by:

PHOENIX TESTLAB GmbH
Königswinkel 10
32825 Blomberg
Germany

Accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-06 and D-PL-17186-01-05, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment under Test)

Test object: *	Furniture Lock „Captura“, Lock controller with integrated 13.56 MHz RFID reader
Model name: *	Captura 100 MIFARE
Model number: *	L3NF13C2
Order number: *	040160001 - 040160005
FCC ID: *	W2YL3NF13C2
IC certification number: *	8141A-L3NF13C2
PMN: *	Captura 100 MIFARE
HVIN: *	L3NF13C2
FVIN: *	0.1.97 **

	EUT number		
	1	2	3
Serial number: *	EMC Sample	-	-
PCB identifier: *	SA0013-11G	-	-
Hardware version: *	SA0013-22G	-	-
Software version: **	EMC software	-	-

* Declared by the applicant

** Remark: For this test a dedicated EMC software was used because the TAG is read once only in the original software 0.1.97.

One EUT was used for all tests.

Note: PHOENIX TESTLAB GmbH does not take samples. The samples used for tests are provided exclusively by the applicant.

1.5 Technical Data of Equipment

General					
Power supply EUT: *	DC via battery (CR123A, ES1 / PS1)				
Supply voltage EUT: *	$U_{\text{nom}} = 3.0 \text{ V}_{\text{DC}}$	$U_{\text{min}} = 2.3 \text{ V}_{\text{DC}}$	$U_{\text{max}} = 5.1 \text{ V}_{\text{DC}}$		
Temperature range: *	-5 °C to +60 °C				
Lowest / highest internal frequency: *	32.768 kHz / 80 MHz				

* Declared by the applicant

RFID part					
Operating frequency: *	13.56 MHz				
Number of channels: *	1				
Type of modulation: *	100 % ASK				
Data rate: *	106 kbit/s				
Duty cycle: *	100 %				
Antenna type: *	PCB coil				
Antenna connector: *	None				

* Declared by the applicant

Ports / Connectors					
Identification	Connector		Length during test	Shielding (Yes / No)	
	EUT	Ancillary			
-	-	-	--	-	-

Ancillary equipment					
TAG	MIFARE DESFire EV2 4 K 70 pF Supertag				
-	-				

*¹ Provided by the applicant

1.6 Dates

Date of receipt of test sample:	13.09.2022
Start of test:	14.09.2022
End of test:	19.10.2022

2 Operational States

Description of function of the EUT:

The Captura electronic lock serves as an access control system for furniture. It provides RFID functionality. The EUT is supplied via an internal primary battery. This lock opens or closes when a transponder authorized for access is recognized by the reader, via a RFID TAG.

In normal operation mode, the EUT detects when the RF field of the RFID transceiver is changed, e. g. when a TAG is placed in front of the EUT. The EUT then tries to read a TAG.

The following states were defined as the operating conditions:

The EUT was supplied by a 3.0 V_{DC} battery during the tests.

The tests were performed using test sample where the TAG is reading continuously.

The system was setup as follows:



3 Additional Information

The EUT was not labeled as required by FCC / IC.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-Gen, Issue 5 [4] and RSS-210, Issue 10 [3]	Tested EUT	Status
Conducted emissions on supply line	0.15 – 30	15.207 (a)	8.8 [4]	-	-
Radiated emissions	0.009 – 1000 **	15.205 (a) 15.209 (a)	8.9 and 8.10 [4] 7.1 and 7.3 [3]	1	Passed
99 % bandwidth	13.56	-	6.7 [4]	1	Passed
Antenna requirement	-	15.203 [2]	6.8 [4]	1	Passed *

* Integrated antenna only, requirement fulfilled.

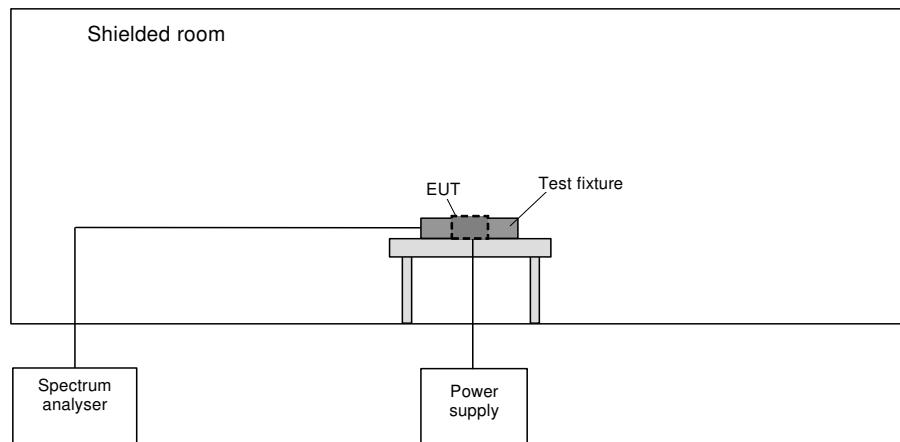
** As declared by the applicant the highest radio clock frequency is 13.56 MHz. Therefore, the radiated emission measurement must be carried out up to 10th of the highest radio clock frequency in this case 1 GHz.

5 Results

5.1 Test setups

5.1.1 Radiated: Test fixture

The test is carried out in a shielded chamber. Table-top devices are set up on a table and the spectrum analyser is connected to a test fixture / loop antenna, which is placed around / on top of the EUT.



5.1.2 Radiated: 9 kHz to 30 MHz

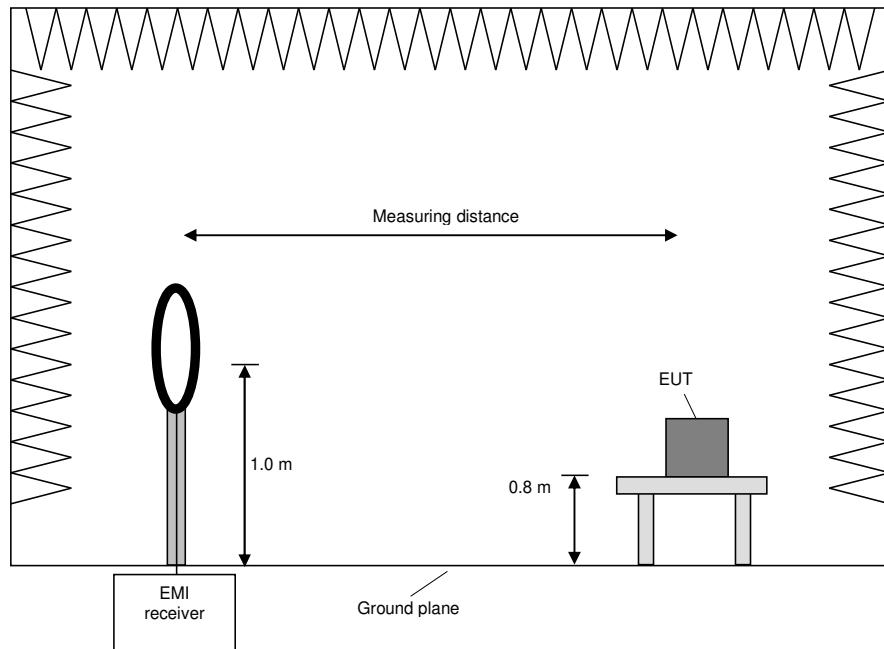
5.1.2.1 Preliminary measurement 9 kHz to 30 MHz

In the first stage a preliminary measurement is performed in a semi-anechoic chamber at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices are placed directly on the turntable / ground plane. The setup of the equipment under test is in accordance with [1].

The frequency range 9 kHz to 30 MHz is monitored with an EMI receiver while the system and its cables are manipulated to find out the configuration with the maximum emission levels if applicable. The EMI receiver is set to MAX hold mode. The EUT and the measuring antenna are rotated around their vertical axis to find the maximum emission levels.

The resolution bandwidth of the EMI receiver is set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz



Procedure preliminary measurement:

Pre-scans are performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

The following procedure is used:

- 1) Monitor the frequency range with the measuring antenna facing the EUT and an EUT / turntable azimuth of 0 °.
- 2) Manipulate the system cables to produce the maximum levels of emissions.
- 3) Rotate the EUT by 360 ° to maximize the detected signals.
- 4) Measure the frequencies of the highest detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency values.
- 5) If the EUT is portable or ceiling mounted, repeat steps 1 to 4 with other orientations (x, y, z) of the EUT.
- 6) Rotate the measuring antenna and repeat steps 1 to 5.

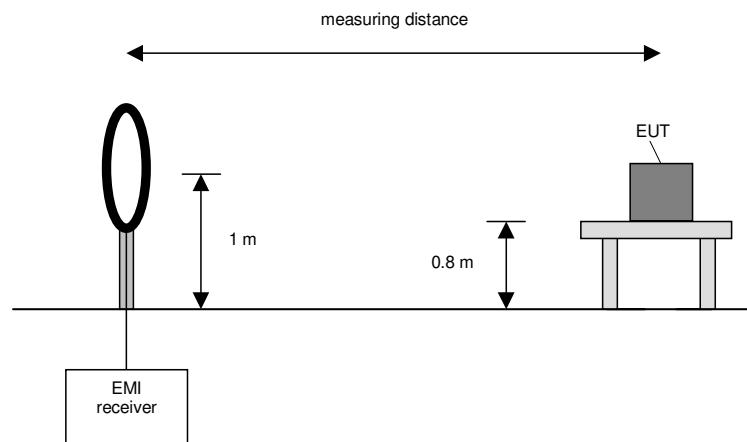
5.1.2.2 Final measurement 9 kHz to 30 MHz

In the second stage a final measurement is performed on an open area test site with no conducting ground plane at a measuring distance of 3 m, 10 m, or 30 m. If the standard requires larger measuring distances for a given frequency, the results are extrapolated according to section 15.31 (f) (2) [2]. The final measurement is performed with an EMI receiver set to Quasi-Peak detector, except for the frequency bands 9 kHz to 90 kHz and 110 kHz to 490 kHz where an Average detector is used according to section 15.209 (d) [2].

At the frequencies, which were detected during the preliminary measurements, the final measurement is performed while rotating the EUT and the measuring antenna in the range of 0 ° to 360 ° around their vertical axis until the maximum level value is found.

The resolution bandwidth of the EMI receiver is set to the following values:

Frequency range	Resolution bandwidth	Measuring time
9 kHz to 150 kHz	200 Hz	1 s
150 kHz to 30 MHz	9 kHz	1 s



Procedure final measurement:

The following procedure is used:

- 1) Monitor the selected frequencies from the preliminary measurement with the measuring antenna facing the EUT and an EUT azimuth of 0 °.
- 2) Rotate the EUT by 360 ° to maximize the detected signals.
- 3) Rotate the measuring antenna and repeat steps 1 to 2 until the maximum value is found and note it.
- 4) If the EUT is portable or ceiling mounted, repeat steps 1 to 3 with other orientations (x, y, z) of the EUT.

5.1.3 Radiated: 30 MHz to 1 GHz

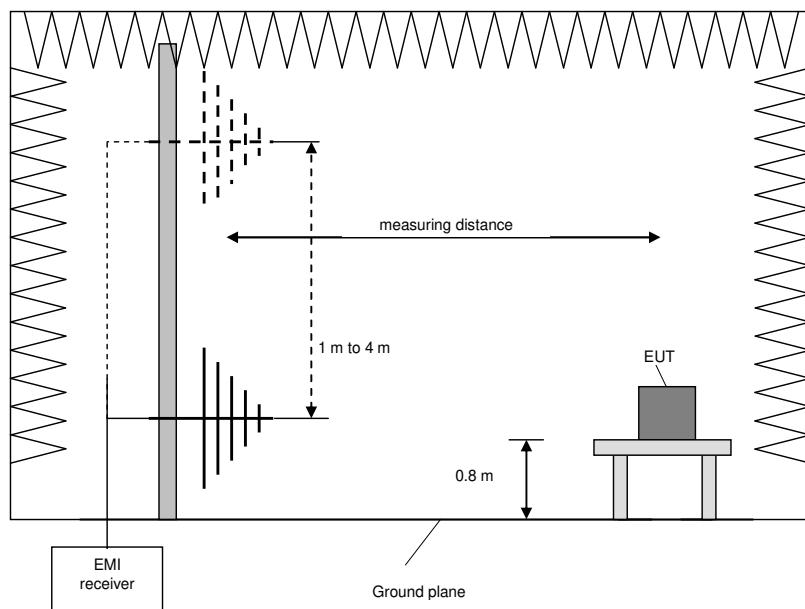
5.1.3.1 Preliminary and final measurement 30 MHz to 1 GHz

The preliminary and final measurements are performed in a semi-anechoic chamber with a metal ground plane at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices are placed directly on the turntable / ground plane. The setup of the equipment under test is in accordance with [1].

During the tests the EUT is rotated in the range of 0 ° to 360 °, the measuring antenna is set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

The resolution bandwidth of the EMI receiver is set to the following values:

Test	Frequency range	Step-size	Resolution bandwidth	Measuring time	Detector
Preliminary measurement	30 MHz to 1 GHz	30 kHz	120 kHz	-	Peak Average
Frequency peak search	± 120 kHz	10 kHz	120 kHz	1 s	Peak
Final measurement	30 MHz to 1 GHz	-	120 kHz	1 s	QuasiPeak



Procedure preliminary measurement:

The following procedure is used:

- 1) Set the measuring antenna to 1 m height.
- 2) Monitor the frequency range at horizontal polarization of the measuring antenna and an EUT / turntable azimuth of 0 °.
- 3) Rotate the EUT by 360° to maximize the detected signals.
- 4) Repeat steps 2 to 3 with the vertical polarization of the measuring antenna.
- 5) Increase the height of the measuring antenna for 0.5 m and repeat steps 2 to 4 until the final height of 4 m is reached.
- 6) The highest values for each frequency are saved by the software, including the measuring antenna height and polarization and the turntable azimuth for that value.

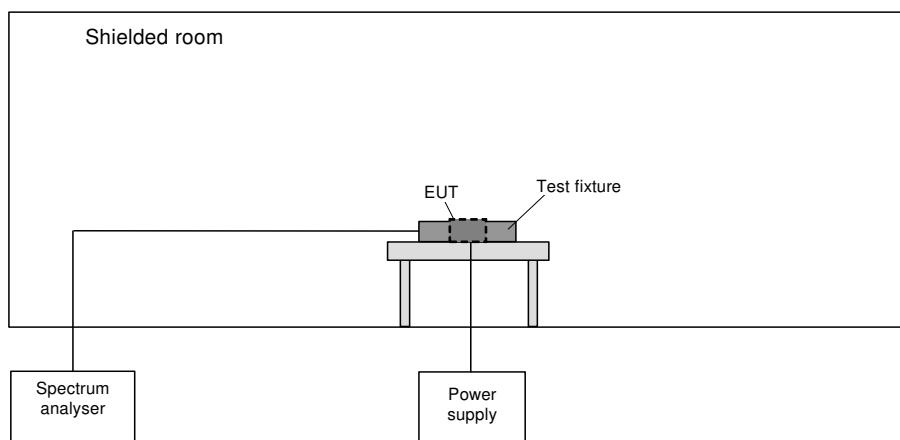
Procedure final measurement:

The following procedure is used:

- 1) Select the highest frequency peaks (lowest margin to the limit) for the final measurement.
- 2) The software determines the exact peak frequencies by doing a partial scan with reduced step size of the pre-scan of the selected peaks.
- 3) If the EUT is portable or ceiling mounted, find the worst-case EUT orientation (x, y, z) for the final test.
- 4) The worst-case measuring antenna height is found via varying the height by ± 0.5 m from the value obtained in the preliminary measurement while monitoring the emission level.
- 5) The worst-case turntable position is found via varying the turntable azimuth by ± 30 ° from the value obtained in the preliminary measurement while monitoring the emission level.
- 6) The final measurement is performed at the worst-case measuring antenna height and the worst-case turntable azimuth.
- 7) Steps 2 to 6 are repeated for each frequency peak selected in step 1.

5.1.4 Method 99% bandwidth

The test is carried out in a shielded chamber. Table-top devices are set up on a table and the spectrum analyser is connected to a test fixture / loop antenna, which is placed around / on top of the EUT.



The following procedure will be used for the occupied bandwidth measurement according to [1]:

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5 % of the total mean power of the given emission. The following procedure shall be used for measuring 99 % power bandwidth:

- a) The instrument centre frequency is set to the nominal EUT channel centre frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1 % to 5 % of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.
- c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.
- d) Step a) through step c) might require iteration to adjust within the specified range.

5.2 99 % bandwidth

5.2.1 Test setup (99 % bandwidth)

Test setup (99 % bandwidth)			
Used	Setup	See sub-clause	Comment
<input checked="" type="checkbox"/>	Radiated: Test fixture	5.1.4	-
<input type="checkbox"/>	Test setup (antenna port conducted)	-	-

5.2.2 Test method (99 % bandwidth)

Test method (99 % bandwidth)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	6.9.3	Occupied bandwidth – power bandwidth (99 %) measurement procedure	-	-

5.2.3 Test results (99 % bandwidth)

Ambient temperature:	22 °C
Relative humidity:	42 %

Date:	19.10.2022
Tested by:	M. Dinter



F _L	F _U	BW (F _U - F _L)
13.06045 MHz	14.07946 MHz	1019.01 kHz

Test result: Passed

Test equipment (please refer to chapter 7 for details)

1 - 2

5.3 Radiated emissions

5.3.1 Test setup (Maximum unwanted emissions)

Test setup (Maximum unwanted emissions)			
Used	Setup	See sub-clause	Comment
<input checked="" type="checkbox"/>	Radiated: 9 kHz to 30 MHz / 30 MHz to 1 GHz	5.1.2 / 5.1.3	-

5.3.2 Test method (Maximum unwanted emissions)

Test method (radiated) see sub-clause 5.1.2 / 5.1.3 as described herein

5.3.3 Test results (Maximum unwanted emissions)

5.3.3.1 Test results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	22 °C	Date:	14.09.2022
Relative humidity:	51 %	Tested by:	M. Dinter

Position of EUT: For tests for f between 9 kHz to 30 MHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Remark: The test was carried out in a normal build in position.

Calculations:

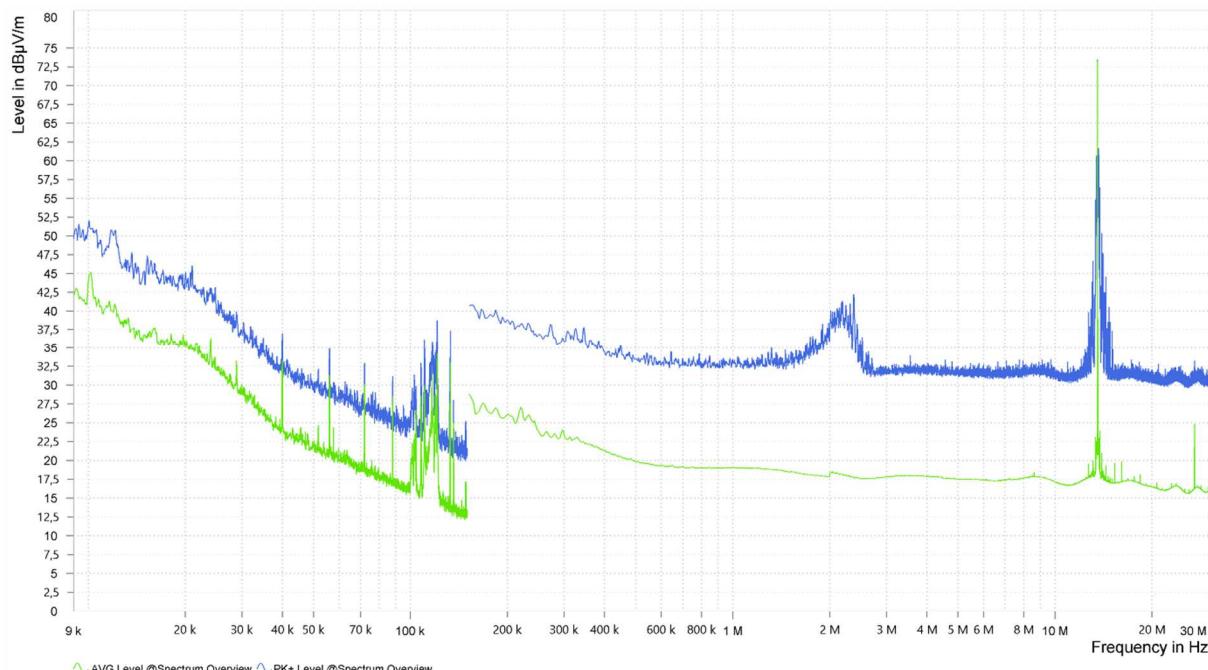
Result @ norm. dist. [dB μ V/m] = Reading [dB μ V] + AF [dB/m] + Distance corr. fact. [dB μ V/m]

Result @ norm. dist. [dB μ A/m] = Result @ norm. dist. [dB μ V/m] - 20 x log₁₀(377 Ω)

Margin [dB] = Limit [dB(μ V| μ A)/m] - Result [dB(μ V| μ A)/m]

Worst case plot:

Spurious emissions from 9 kHz to 30 MHz (operation mode reading TAG continuously):



Remark: Only the 13.56 MHz fundamental was found for the final measurement. All other emissions are below the noise floor of the outdoor test site and have more than 20 dB margin to the limit at 300 m or 30 m.

The following frequencies were found in the frequency range 9 kHz to 30 MHz:

13.56 MHz

This frequency has to be measured within a final measurement.

Test equipment (please refer to chapter 7 for details)
3 - 10

5.3.3.2 Test results final measurement 9 kHz to 30 MHz

Ambient temperature:	13 °C
Relative humidity:	58 %

Date:	19.10.2022
Tested by:	M. Dinter

The results of the standard subsequent measurement on the outdoor test site are indicated in the table below. The limits as well as the measured results (levels) refer to the above-mentioned standard while taking account of the specified requirements for a 30 m measuring distance.

Results 9 kHz - 30 MHz												
Frequency [MHz]	Reading @ measuring distance [dB(µV)]	Result @ norm. distance [dB(µV/m)]	Result @ norm. distance [dB(µA/m)]	Limit acc. 15.209 [dB(µV/m)]	Limit acc. RSS-Gen Table 6 [dB(µA/m)]	Margin	Detector	Antenna factor [dB/m]	Measuring distance [m]	Normative distance [m]	Distance correction factor [dB]	Position #
13.56	48.9	29.1 @ 30m	-22.4 @ 30m	29.5	-22.0	0.4	QP	20.2	3	30	40.0	normal

Remark:

The limits in CFR 47, Part 15, Subpart C, paragraph 15.209 (a), are identical to those in RSS-GEN Section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377Ω .

For example, the measurement frequency X kHz resulted in the level of Y dB μ V/m, which is equivalent to Y -51.5 = Z dB μ A/m, which was the same margin, W dB, to the corresponding RSS-GEN Table 6 as it has to the 15.209(a) limit.

Remark: At 3 m measuring distance the signal of the EUT was below the sensitivity of the measuring system.

Test result: Passed

Test equipment (please refer to chapter 7 for details)
11 - 13

5.3.3.3 Test results (30 MHz – 1 GHz)

Ambient temperature:	23 °C
Relative humidity:	53 %

Date:	29.09.2022
Tested by:	M. Dinter

Position of EUT: For tests for f between 30 MHz to 1 GHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

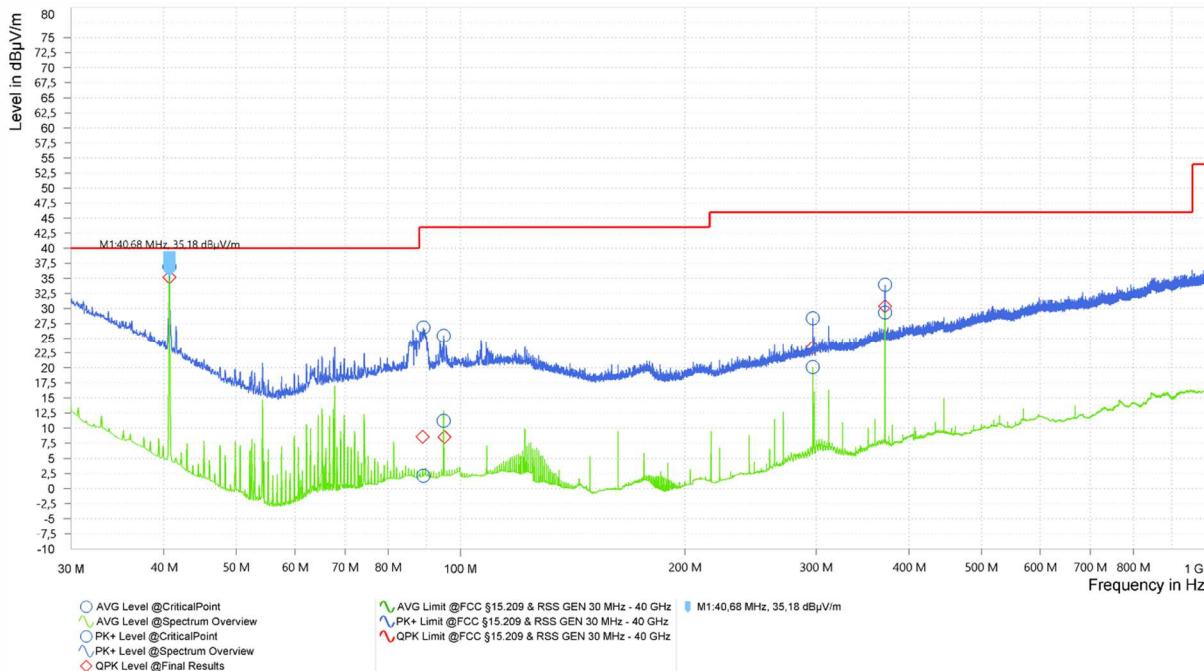
Test record: Plots for each frequency range are submitted below.

Remark: The test was carried out in a normal build in position.

Calculations:
 Result [dB μ V/m] = Reading [dB μ V] + Correction [dB μ V/m]
 Correction [dB μ V/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]
 Margin [dB] = Limit [dB μ V/m] - Result [dB μ V/m]

Worst case plot:

Spurious emissions from 30 MHz to 1 GHz (operation mode reading TAG continuously):



Result table (operation mode 1):

Frequency [MHz]	QPK Level [dB μ V/m]	QPK Limit [dB μ V/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Meas. Time [ms]
40.68	35.18	40.0	4.82	19.65	V	80.4	1	120	1000
88.98	8.55	43.5	34.95	17.01	V	185.45	2.77	120	1000
95.13	8.52	43.5	34.98	17.06	V	177.11	2.77	120	1000
297.03	23.42	46.0	22.58	18.95	V	50.51	2.75	120	1000
371.28	30.37	46.0	15.63	21.18	V	141	1	120	1000

Test result: Passed

Test equipment (please refer to chapter 7 for details)

4 - 10, 14 - 15

6 Measurement Uncertainties

Conducted measurements		
Measurement method	Standard used for calculating measurement uncertainty	Expanded measurement uncertainty (95 %) U_{lab}
Frequency error	ETSI TR 100 028	4.5×10^{-8}
Bandwidth measurements	-	9.0×10^{-8}
Conducted emissions from 150 kHz to 30 MHz with LISN	CISPR 16-4-2	2.8 dB

Radiated measurements		
Frequency error		
(Semi-) Anechoic chamber	ETSI TR 100 028	4.5×10^{-8}
OATS	ETSI TR 100 028	4.5×10^{-8}
Test fixture	ETSI TR 100 028	4.5×10^{-8}
Bandwidth measurements		
(Semi-) Anechoic chamber	-	9.0×10^{-8}
OATS	-	9.0×10^{-8}
Test fixture	-	9.1×10^{-8}
Radiated field strength M20		
CBL6112B @ 3 m 30 MHz – 1 GHz	CISPR 16-4-2	5.3 dB
R&S HL050 @ 3 m		
1 – 6 GHz	CISPR 16-4-2	5.1 dB
6 – 18 GHz	CISPR 16-4-2	5.4 dB
Flann Standard Gain Horns 18 – 40 GHz	-	5.9 dB
Radiated field strength M276		
R&S HL562E @ 3 m 30 MHz – 1 GHz	CISPR 16-4-2	4.8 dB
R&S HL050 @ 3 m	-	
1 – 6 GHz	CISPR 16-4-2	5.1 dB
6 – 18 GHz	CISPR 16-4-2	5.4 dB
Flann Standard Gain Horns 18 – 40 GHz	-	5.9 dB
OATS		
Field strength measurements below 30 MHz on OATS without ground plane	-	4.4 dB

7 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	EMI Receiver	ESW44	Rohde & Schwarz	101635	482467	22.02.2022	02.2024
2	Loop antenna	11 cm	PHOENIX TESTLAB	-	410084	Calibration not necessary	
3	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	22.02.2022	02.2024
4	Software	EMC32	Rohde & Schwarz	V11.30	482972	Calibration not necessary	
5	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
6	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
7	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
8	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
9	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
10	EMI Receiver	ESW44	Rohde & Schwarz	101828	482979	08.12.2021	12.2023
11	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	22.02.2022	02.2024
12	Outdoor test site	-	PHOENIX TESTLAB	-	480293	Calibration not necessary	
13	EMI Receiver / Spectrum Analyser	ESR7	Rohde & Schwarz	101733	482330	02.06.2022	02.2024
14	Attenuator 6 dB	WA2-6	Weinschel	8254	410119	Calibration not necessary	
15	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	18.03.2021	03.2024

8 Test site Verification

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
OATS Outdoor	480293	9 kHz – 30 MHz	-	ANSI C63.4-2014	-	-
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA/RSM	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	03.03.2021	02.03.2023

9 Report History

Report Number	Date	Comment
F221308E1	25.10.2022	Initial Test Report
F221308E1 2 nd version	23.11.2022	Change of HVIN and editorial changes
-	-	-

10 List of Annexes

Annex A	Test Setup Photos	5 pages
Annex B	EUT External Photos	6 pages
Annex C	EUT Internal Photos	5 pages