

Test Report

Report Number:

F201474E1

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.

Tested and
written by:

Michael DINTER

Name



Signature

02.10.2020

Date

Reviewed
and approved
by:

Manuel BASTER

Name



Signature

02.10.2020

Date

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1 Identification

1.1 Applicant

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Country:	Germany
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Phone:	+49 (0)571 50531-31
eMail address:	info@lehmann-locks.com
Applicant represented during the test by the following person:	Mr. Guido JÄGER (some parts of the test)

1.2 Manufacturer

Name:	Martin Lehmann GmbH & Co. KG
Address:	Am Kohlgraben 6 - 10, 32429 Minden
Country:	Germany
Name for contact purposes:	Mr. Guido JÄGER
Phone:	+49 (0)571 50531-31
eMail address:	info@lehmann-locks.com
Manufacturer represented during the test by the following person:	Mr. Guido JÄGER (some parts of the test)

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 ISD# 3469A.

1.4 EUT (Equipment under Test)

Type of equipment: *	Furniture Lock „Captura“, Lock controller with integrated 13.56 MHz RFID reader
PMN: *	Captura 100 MIFARE
HVIN: *	L3NF13CX
Order number: *	040160001 - 040160005
Serial number: *	Engineering sample
FCC ID: *	W2YL3NF13CX
IC certification number: *	8141A-L3NF13CX
PCB identifier: *	1221237
Hardware version: *	2020-01-14 (Production)
Software version (FVIN): *	0.1.94 **

* 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 0.1.94.

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 (Type CR123A)					
Supply voltage EUT: *	U _{nom} =	3.0 V DC	U _{min} =	2.3 V DC	U _{max} =	5.1 V DC
Temperature range: *	-5 °C to +60 °C					
Lowest / highest internal clock frequency: *	32.768 kHz / 80 MHz					

* Declared by the applicant

RFID part:						
Operating frequency: *	13.56 MHz					
Antenna type: *	Integrated PCB antenna					
Data rate: *	106 kBit/s					
Antenna connector: *	None					
Type of modulation: *	100% ASK					
Number of channels: *	1					

* Declared by the applicant

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

Ancillary Equipment	
RFID TAG *1	MIFARE Desfire EV1 card

*1 Provided by the applicant

*2 Provided by the laboratory

1.6 Dates

Date of receipt of test sample:	28.09.2020
Start of test:	28.09.2020
End of test:	02.10.2020

2 Operational States

Description of function of the EUT:

The Captura electronic lock serves as an access control system for furniture. The EUT is supplied via an internal primary battery (Type CR123A). This lock opens or closes when an access authorized transponder is recognized by the reader.

The following states were defined as the operating conditions:

The EUT is designed to be installed into furniture made of different materials. Therefore, two setups were defined by the applicant.

Setup A:

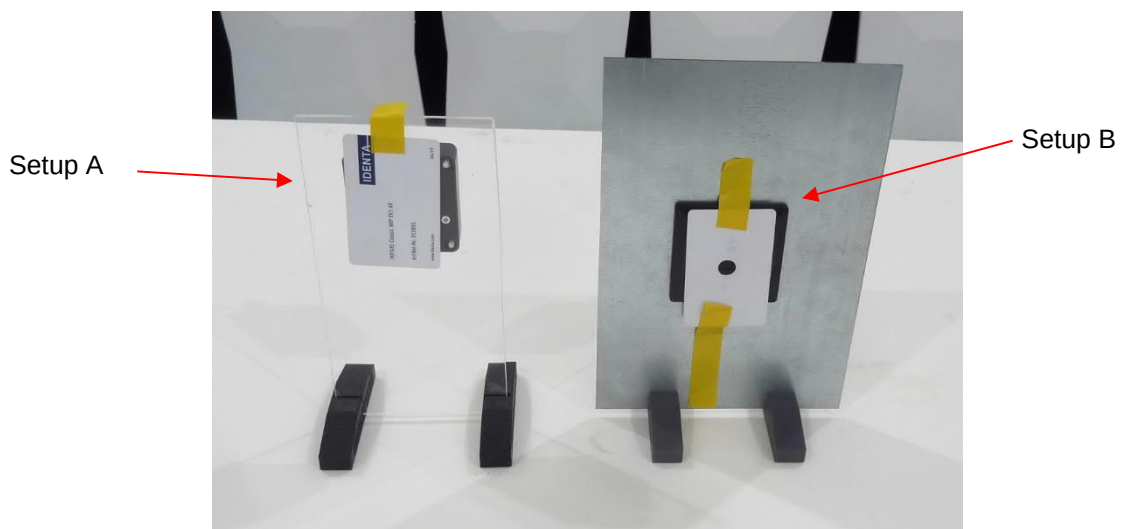
The EUT is installed behind a wooden or plastic furniture door. In this case a plastic plate was taken for the setup.

Setup B:

The EUT is installed into a metal furniture door.

During all tests a TAG was continuously read out by the EUT.

Both setups were tested together in one measurement run. The setup is shown in the picture below.



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]	Status	Refer page
Radiated emissions	0.009 – 1000**	15.205 (a) 15.209 (a)	8.9 and 8.10 [4] 7.1 and 7.3 [3]	Passed	10 et seq.
99 % bandwidth	13.56	-	6.7 [4]	Passed	19 et seq.
Antenna requirement	-	15.203 [2]	6.8 [4]	Passed *	-

*: Integrated antenna only, requirement fulfilled.

**:
As declared by the applicant the highest radio clock frequency is 80 MHz.
Therefore the radiated emission measurement must be carried out up to 10th of the highest radio clock frequency or in this case 1 GHz.

5 Results

5.1 Radiated emissions

5.1.1 Test method

The radiated emission measurement is subdivided into six stages.

- A preliminary measurement carried out in a fully or semi-anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 1 GHz.
- A final measurement carried out on an outdoor test site without reflecting ground plane and a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A preliminary and final measurement carried out in a semi anechoic chamber with a varying antenna height at a distance of 3 m to the EUT position in the frequency range 30 MHz to 1 GHz.
- A preliminary and final measurement carried out in a fully anechoic chamber with a various antenna height at a distance of 3 m to the EUT position in the frequency range 1 GHz to 40 GHz.

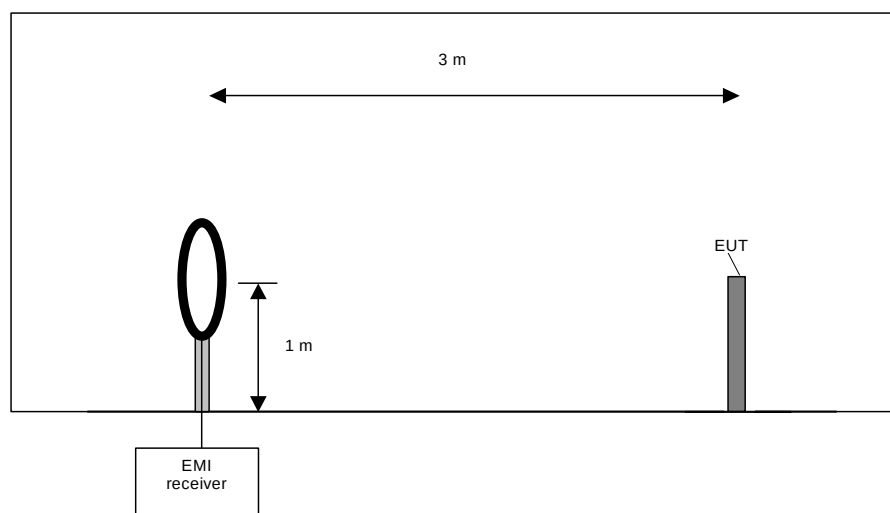
Preliminary measurement (9 kHz to 30 MHz):

In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of 3 meters. Table-top devices will 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 will be placed directly on the turntable/ground plane. The setup of the Equipment under test will be in accordance to [1].

The frequency range 9 kHz to 30 MHz will be monitored with a spectrum analyser while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable. The EMI Receiver will be set to MAX Hold mode. The EUT and the measuring antenna will be rotated around their vertical axis to find the maximum emissions.

The resolution bandwidth of the spectrum analyser will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	10 kHz



Preliminary measurement procedure:

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

The following procedure will be used:

- 1) Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
- 2) Manipulate the system cables within the range to produce the maximum level of emission.
- 3) Rotate the EUT by 360 ° to maximize the detected signals.
- 4) Make a hardcopy of the spectrum.
- 5) Measure the frequencies of highest detected emission with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
- 6) Repeat steps 1) to 5) with the other orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).
- 7) Rotate the measuring antenna and repeat steps 1) to 5).

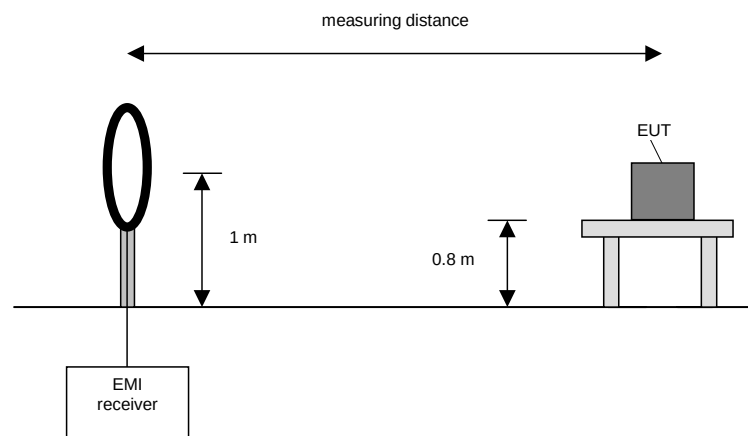
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distances of 3 m, 10 m and 30 m. In the case where larger measuring distances are required the results will be extrapolated based on the values measured on the closer distances according to Section 15.31 (f) (2) [2]. The final measurement will be performed with a 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 will be used according Section 15.209 (d) [2].

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

The resolution bandwidth of the EMI Receiver will be set to the following values:

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



Final measurement procedure:

The following procedure will be used:

- 1) Monitor the frequency range with the measuring antenna at vertical orientation parallel to the EUT at an azimuth of 0 °.
- 2) Rotate the EUT by 360 ° to maximize the detected signals and note the azimuth and orientation.
- 3) Rotate the measuring antenna to find the maximum and note the value.
- 4) Rotate the measuring antenna and repeat steps 1) to 3) until the maximum value is found.
- 5) Repeat steps 1) to 4) with the other orthogonal axes of the EUT (if the EUT is a module and might be used in a handheld equipment application).

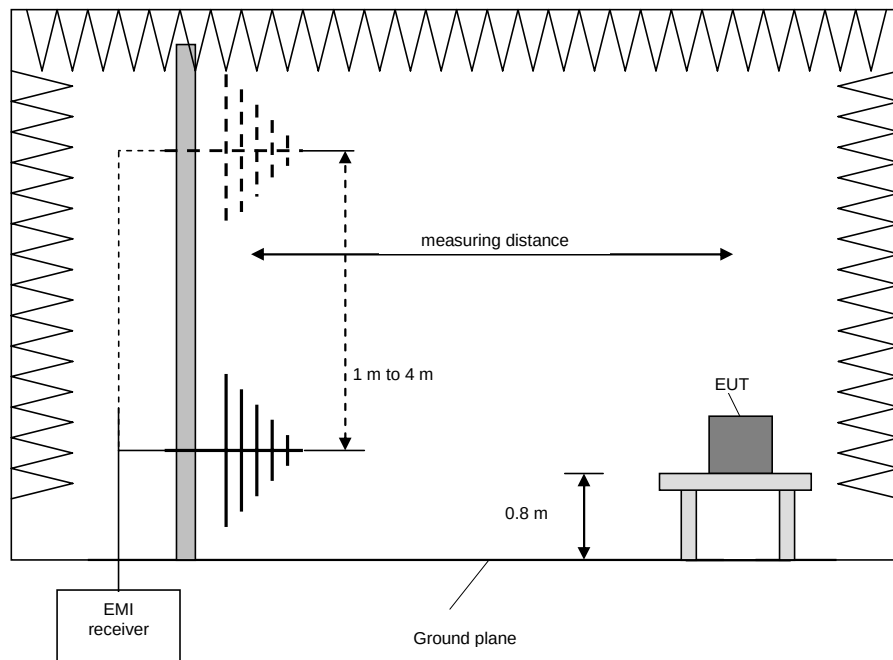
Preliminary and final measurement (30 MHz to 1 GHz)

The preliminary and final measurements were conducted in a semi-anechoic chamber with a metal ground plane in a 3 m distance.

During the test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be 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 will be set to the following values:

Test	Frequency range	Resolution bandwidth
Preliminary measurement	30 MHz to 1 GHz	100 kHz
Frequency peak search	+ / - 1 MHz	10 kHz
Final measurement	30 MHz to 1 GHz	120 kHz



Procedure preliminary measurement:

The following procedure is used:

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

Procedure final measurement:

The following procedure is used:

1. Select the highest frequency peaks to the limit for the final measurement.
2. The software will determine the exact peak frequencies by doing a partial scan with reduced RBW with +/- 10 times the RBW of the pre-scan of the selected peaks.
3. If the EUT is portable or ceiling mounted, find the worst case EUT position (x,y,z) for the final test.
4. The worst measurement antenna height is found by the measurement software by varying the measurement antenna height by +/- 0.5 m from the value obtained in the preliminary measurement, and to monitor the emission level.
5. The worst azimuth turntable position is found by varying the turntable azimuth by +/- 30° from the value obtained in the preliminary measurement, and to monitor the emission level.
6. The final measurement is performed at the worst-case antenna height and the worst case turntable azimuth
7. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.

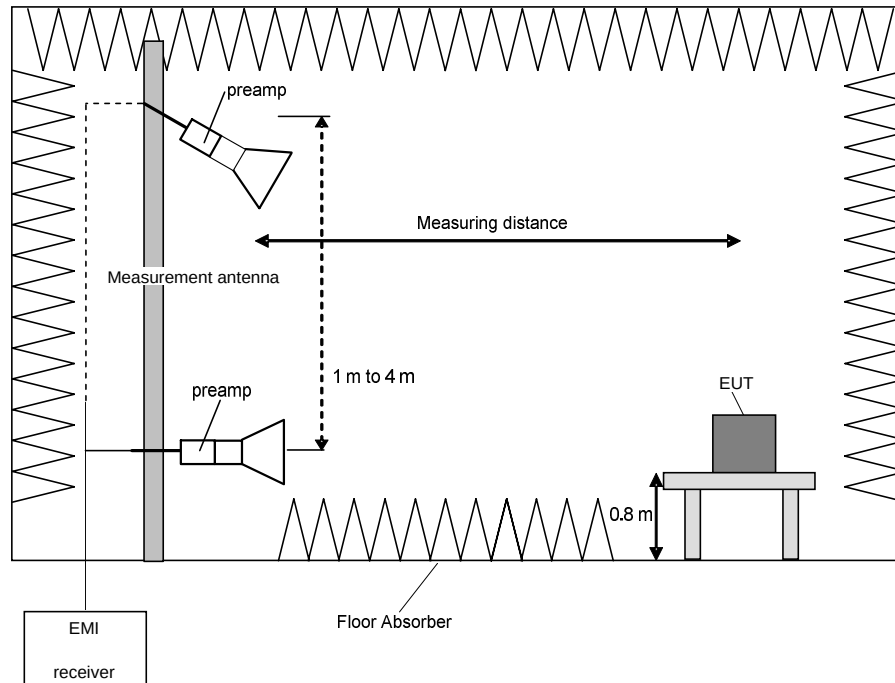
Preliminary and final measurement (1 – 40 GHz)

The preliminary and final measurements were conducted in a semi-anechoic chamber with floor absorbers between EUT and measurement antenna in a 3 m distance.

During the test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be 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. For each height the angle of the antenna will be tilted so that the measurement antenna is always aiming at the EUT.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Test	Frequency range	Resolution bandwidth
Preliminary measurement	1 - 40 GHz	1 MHz
Frequency peak search	+ / - 10 MHz	100 kHz
Final measurement	1 - 40 GHz	1 MHz



Procedure preliminary measurement:

The following procedure is used:

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

Procedure final measurement:

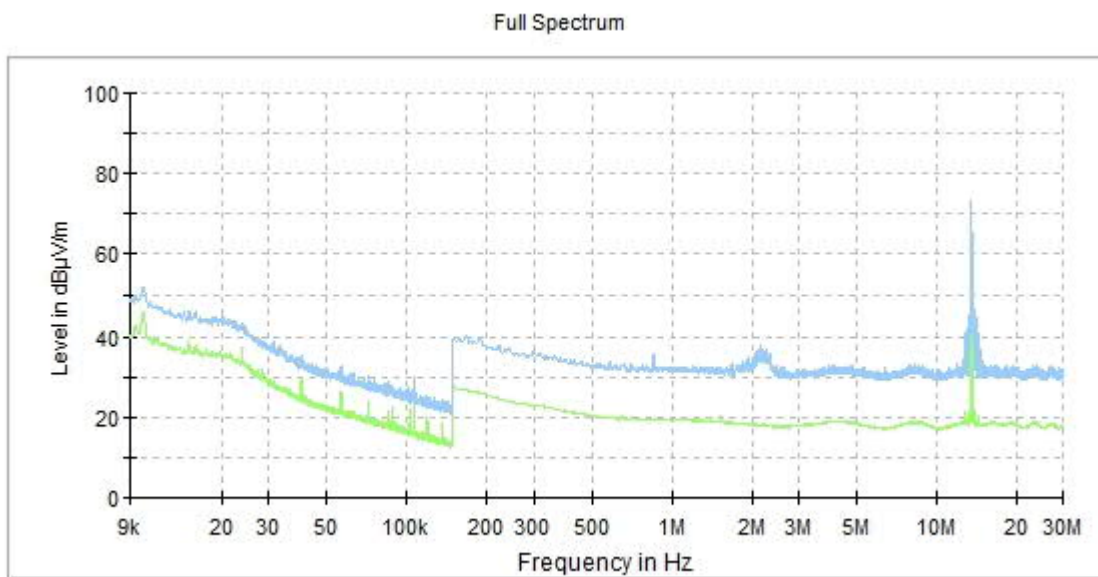
The following procedure is used:

1. Select the highest frequency peaks to the limit for the final measurement.
2. The software will determine the exact peak frequencies by doing a partial scan with reduced RBW with +/- 10 times the RBW 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 measurement antenna height is found by the measurement software by varying the measurement antenna height by +/- 0.5 m from the worst case value obtained in the preliminary measurement, and to monitor the emission level.
5. The worst azimuth turntable position is found by varying the turntable azimuth by +/- 30° from the worst case value obtained in the preliminary measurement, and to monitor the emission level.
6. The final measurement is performed at the worst case antenna height and the worst case turntable azimuth.
7. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.

5.1.2 Results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	21 °C
Relative humidity:	46 %

Date:	28.09.2020
Tested by:	M. Dinter



Except the fundamental of the EUT at no frequency was a value considerable above the noise of the system therefore only a final measurement for the fundamental on the open area test site was carried out. No spurious emissions caused by the equipment under test were found.

The following emission was found according to [2] and [3]. (fundamental of transmitter)

13.56 MHz.

Remark: No further emissions caused by the equipment under were found.

Test equipment (please refer to chapter 6 for details)
1 - 7

5.1.3 Result final measurement from 9 kHz to 30 MHz

Ambient temperature:	15 °C
Relative humidity:	65 %

Date:	28.09.2020
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.

Final result:

Frequency	Reading	Result*	Result*	Limit acc. 15.209	Limit acc. RSS-Gen Table 6	Margin**	Detector (acc. to §15.209 (d))	Antenna factor	Measuring Distance	Distance correction factor***
[MHz]	[dBμV]	[dBμV/m]	[dBμA/m]	[dBμV/m]	[dBμA/m]	[dB]		[dB/m]	[m]	[dB]
13.56	48.5	28.5 @ 30m	-23.0 @ 30m	29.5	-22.0	1.0	QP	20.0	3	40.0
Measurement uncertainty: ± 4.69 dB										

* Result @ norm dist = Reading + Antenna factor - Distance correction factor;

Result [dBμA/m] = Result [dBμV/m] - 20*log(377 Ω)

** Margin = Limit [dBμV|A]/m] - Result @ norm dist

*** 40 dB/decade according Part §15.31 (f) (2)

Remark: At 10 m measuring distance the signal of the EUT was below the sensitivity of the measuring system.

Test: Passed

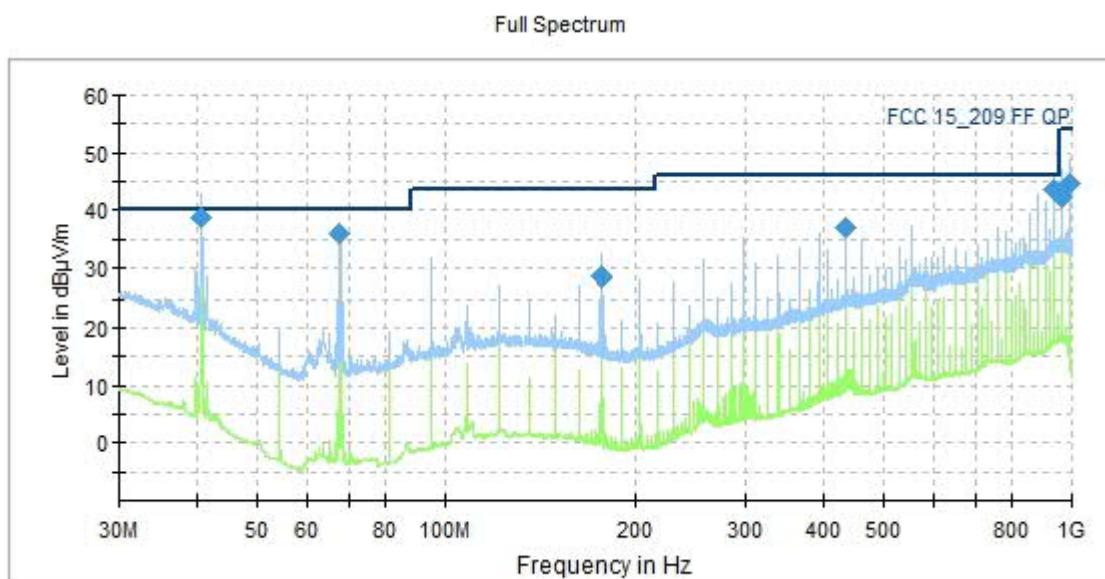
Test equipment (please refer to chapter 6 for details)
7 - 9

5.1.4 Result final measurement from 30 MHz to 1 GHz

Ambient temperature:	21 °C
Relative humidity:	46 %

Date:	28.09.2020
Tested by:	M.Dinter

The measured points and the limit line in the following diagram refer to the standard measurement of the emitted interference in compliance with the above-mentioned standard. The measured points marked with "♦" are the measured results of the standard subsequent measurement in a semi anechoic chamber.



The results of the standard subsequent measurement in a semi anechoic chamber 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 3 m measuring distance.

Final result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
40.69	38.93	40.0	1.07	1000.0	120.0	100.0	V	273.0	22.2
67.80	36.02	40.0	3.98	1000.0	120.0	143.0	V	94.0	13.0
176.27	28.54	43.5	14.96	1000.0	120.0	100.0	V	273.0	16.6
433.91	37.13	46.0	8.87	1000.0	120.0	116.0	V	196.0	24.7
935.63	43.56	46.0	2.44	1000.0	120.0	100.0	V	212.0	33.5
962.76	42.22	54.0	11.78	1000.0	120.0	100.0	V	192.0	34.0
989.88	44.66	54.0	9.34	1000.0	120.0	100.0	V	192.0	34.0
Measurement uncertainty: ± 4.8 dB									

Test: Passed

The correction factor was calculated as follows.

$\text{Corr. (dB)} = \text{cable attenuation (dB)} + 6 \text{ dB attenuator (dB)} + \text{antenna factor (dB)}$

Therefore, the reading can be calculated as follows:

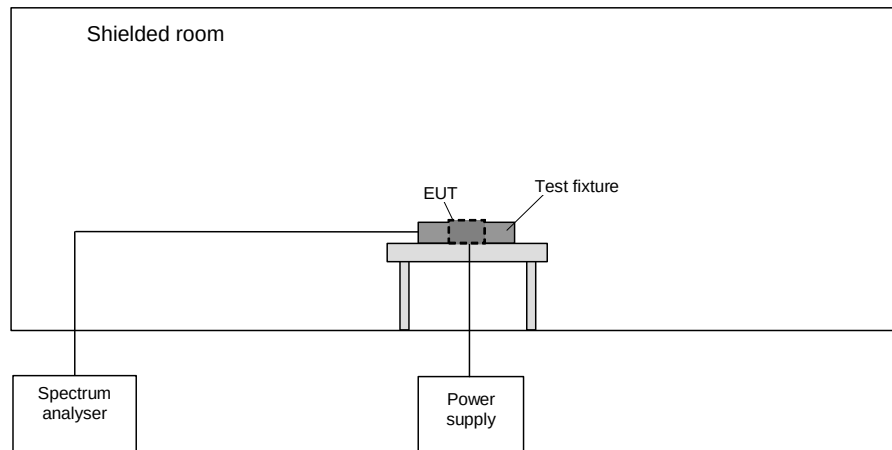
$\text{Reading (dB}\mu\text{V/m)} = \text{result QuasiPeak (dB}\mu\text{V/m)} - \text{Corr. (dB)}$

Test equipment (please refer to chapter 6 for details)
--

1 - 6, 10 - 12

5.2 99 % bandwidth

5.2.1 Test method



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:

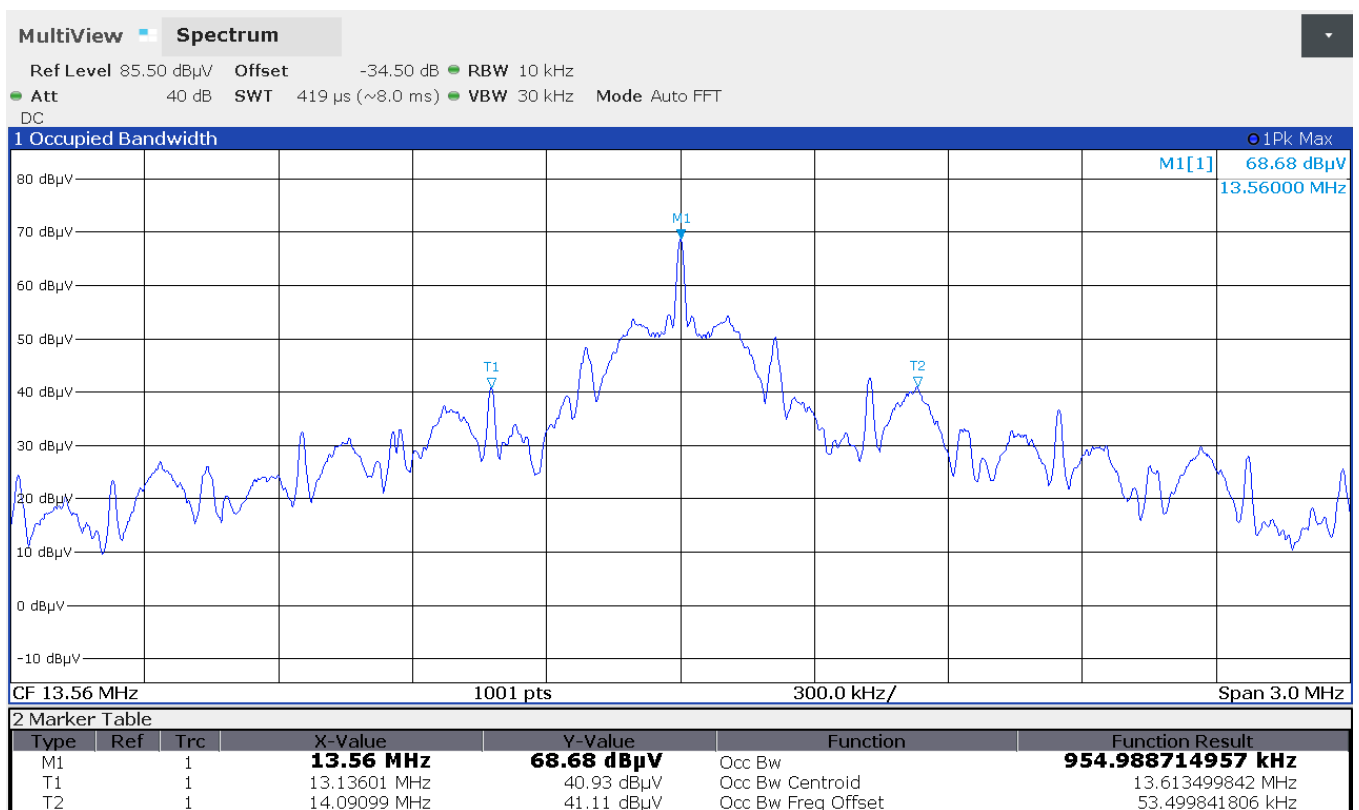
- The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.
- 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.
- Step a) through step c) might require iteration to adjust within the specified range.

5.2.2 Test results

Ambient temperature:	22 °C
Relative humidity:	52 %

Date:	02.10.2020
Tested by:	M. Dinter

99 % bandwidth:



F_L	F_U	BW ($F_U - F_L$)
13.136010 MHz	14.090998 MHz	954.988 kHz
Measurement uncertainty		$< 1 \cdot 10^{-7}$

Test: Passed

Test equipment (please refer to chapter 6 for details)
13 - 14

6 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Software	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
2	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
3	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
4	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
5	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
6	EMI Test Receiver	ESW44	Rohde & Schwarz	101828	482979	14.11.2019	11.2021
7	loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	05.02.2020	02.2021
8	Outdoor test site	-	PHOENIX TESTLAB	-	480293	Calibration not necessary	
9	EMI Receiver / Spectrum Analyser	ESI 40	Rohde & Schwarz	100064/040	480355	11.02.2020	02.2021
10	Attenuator 6 dB	WA2-6	Weinschel	8254	410119	Calibration not necessary	
11	Antenna (Bilog)	CBL6111D	Schaffner / Teseq	25761	480894	19.10.2017	10.2020
12	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
13	Loop antenna	Loop antenna 22.5cm	PHOENIX TESTLAB	-	410085	Calibration not necessary	
14	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	04.03.2020	03.2022

7 Test site Validation

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	ANSI C63.4a-2017	19.09.2019	18.09.2021

8 Report History

Report Number	Date	Comment
F201474E1	02.10.2020	Initial Test Report
-	-	-
-	-	-

9 List of Annexes

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Annex C	EUT Internal Photos	3 pages