

Test Report

Report Number:

F200997E4

Equipment under Test (EUT):

Transponderleser Plus

Applicant:

Jungheinrich AG

Manufacturer:

DATASCHALT engineering GmbH



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:	<u>Ruben BRAUN</u> Name	<u></u> Signature	<u>17.02.2021</u> Date
Reviewed and approved by:	<u>Michael DINTER</u> Name	<u></u> Signature	<u>17.02.2021</u> Date

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1 Identification

1.1 Applicant

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Country:	Germany
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eMail address:	peter.dibbern@jungheinrich.de
Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	DATASCHALT engineering GmbH
Address:	An der Hülshorst 7-9 23568 Lübeck
Country:	Germany
Name for contact purposes:	Mr. Jan-Ole HENKE
Phone:	+49 (0) 451 290 59 - 4024
eMail address:	janole.henke@dataschalt.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 ISSED# 3469A.

1.4 EUT (Equipment under Test)

Test object: *	125 kHz and 13.56 MHz RFID reader
Model name: *	Transponderleser Plus
Model number: *	N/A
Order number: *	51827289
FCC ID: *	2AK6M-CLRC6EM4TRP
IC Certification Number: *	22414-CLRC6EM4TRP
Serial number: *	035O6006
PCB identifier: *	LP1304/LP1305
HVIN (Hardware Version Identification Number): *	51827289
FVIN (Firmware Version Identification Number): *	V1
Hardware version: *	N/A
Software version: *	N/A

* Declared by the applicant

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					
Supply voltage EUT: *	U _{nom} =	24 V DC	U _{min} =	8.4 V DC	U _{max} =	62.4 V DC
Temperature range: *	-28 °C to +65 °C					
Lowest / highest internal frequency: *	115 kHz to 48 MHz					

* Declared by the applicant

RFID part:	
Operating frequency: *	125 kHz / 13.56 MHz
Number of channels: *	2 (1 for each operating frequency)
Type of modulation: *	ASK
Data rate: *	Up to 106 kbit/s
Duty cycle: *	125 kHz: 30.0 %; 13.56 MHz: 11.8 %; Total: 41.8 %
Antenna type: *	Printed PCB dual antenna
Antenna connector: *	None

* Declared by the applicant

Ports / Connectors				
Identification			Length during test	Shielding (Yes / No)
	EUT	Ancillary		
DC / CAN	Custom plug	Laboratory plug / D-Sub plug	1.8 m	No

Ancillary Equipment	
USB to CAN converter *1	PEAK System PCAN-USB Adapter RG 2015-16917
125 kHz TAG *1	EM4100
13.56 MHz TAG *1	ISO14443 Mifare
Laptop *2	Fujitsu LIFEBOOK S760, Serial No. DSBF062945

*1 Provided by the applicant

*2 Provided by the laboratory

1.6 Dates

Date of receipt of test sample:	19.11.2019
Start of test:	01.12.2020
End of test:	11.12.2020

2 Operational States

Description of function of the EUT:

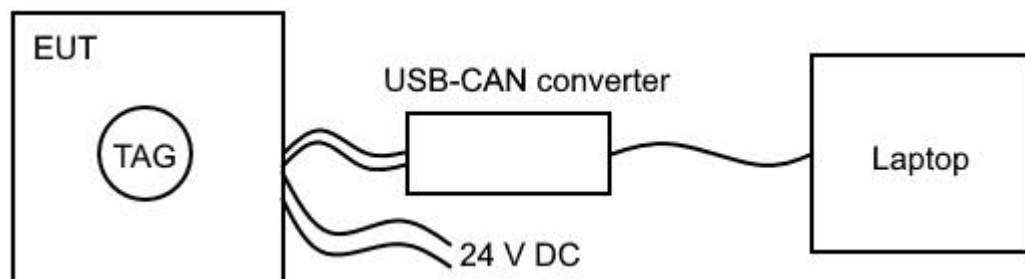
The EUT is a RFID reader to be installed into a forklift. The reader grants access to the forklift when the correct TAG is placed in front of the reader. The EUT is operating at 125 kHz and 13.56 MHz. Both operating frequencies get toggled cyclically but only one frequency is active at a time.

For each test case, two operation modes were tested. The EUT was reading either a 125 kHz or a 13.56 MHz TAG which was placed in front of the EUT. The radiated emissions from 30 MHz to 1 GHz were additionally measured without placing a TAG in front of the EUT.

The following states were defined as the operating conditions:

The EUT was supplied with 24 V DC via a battery.

The EUT was set up as follows:



3 Additional Information

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

As declared by the applicant, the EUT gets installed into a forklift (vehicular use) and is not operative when the forklift gets charged / is connected to a public power supply. Therefore, no conducted emissions tests on the supply line were carried out.

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
99 % bandwidth	0.125 13.56	-	6.7 [4]	Passed	9 et seq.
Conducted emissions on supply line	0.15 – 30	15.207 (a)	8.8 [4]	N/A*	-
Radiated emissions	0.009 – 1000	15.205 (a) 15.209 (a)	8.9 and 8.10 [4] 7.1 and 7.3 [3]	Passed	12 et seq.
Antenna requirement	-	15.203 [2]	6.8 [4]	Passed **	-

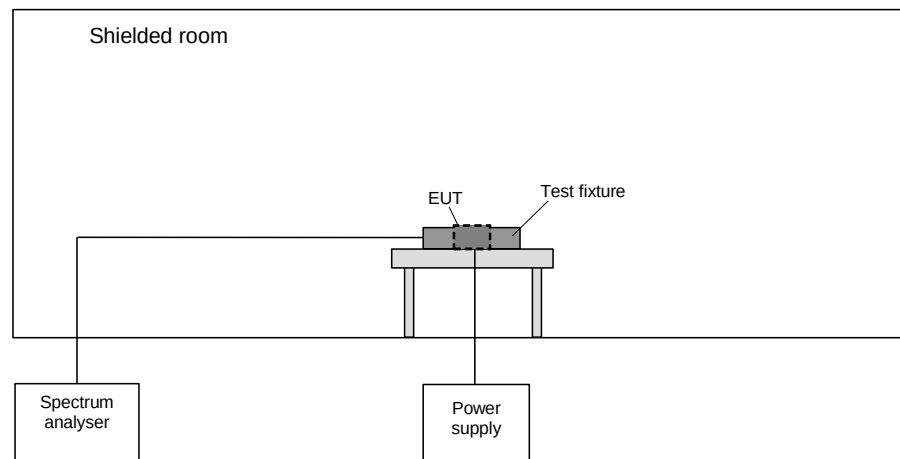
*: Refer chapter 3.

** : Integrated antenna only, requirement fulfilled.

5 Results

5.1 99 % bandwidth

5.1.1 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:

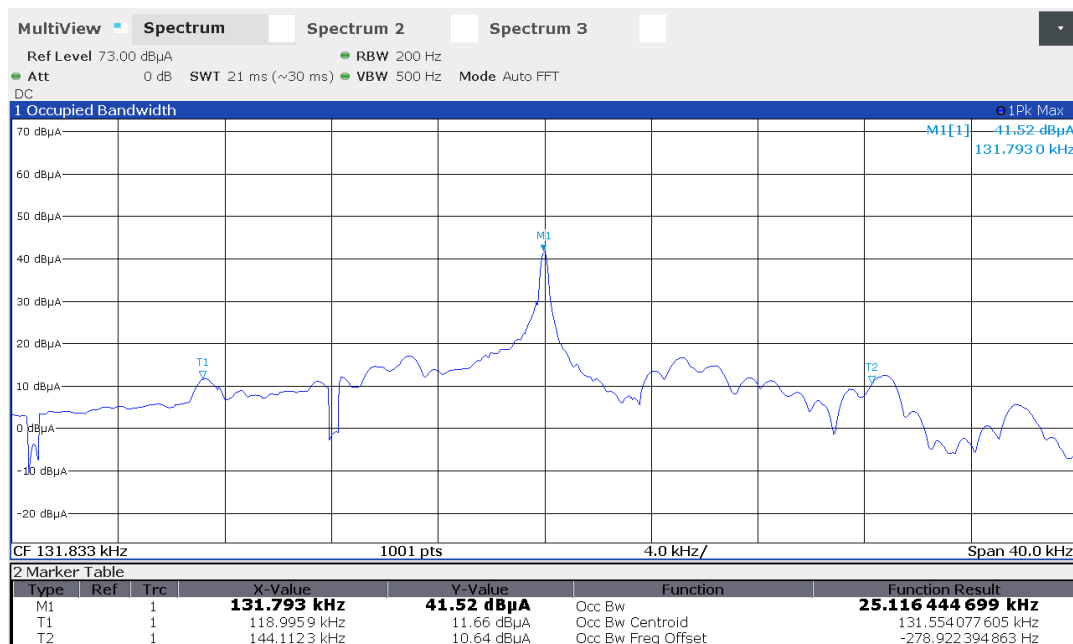
- The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW and the VBW shall be approximately 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.

5.1.2 Test results

5.1.2.1 125 kHz RFID

Ambient temperature:	20 °C	Relative humidity:	24 %
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Test description: 99 % bandwidth
 EUT: Transponderleser Plus
 Manufacturer: DATASCHALT engineering GmbH
 Operating conditions: 24 V DC, reading a 125 kHz TAG
 Test site: PHOENIX TESTLAB GmbH
 Operator: Ruben BRAUN
 Comment: -
 Date of test: 11.12.2020



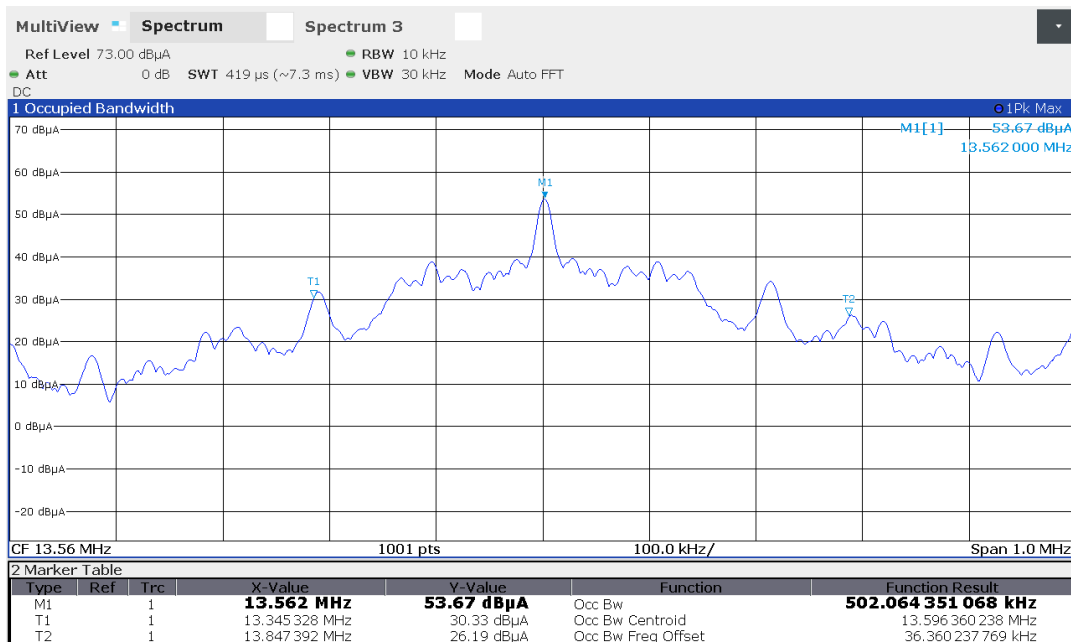
F_L	F_U	BW ($F_U - F_L$)
118.996 kHz	144.112 kHz	25.116 kHz
Measurement uncertainty		$< 1 \cdot 10^{-7}$

Test: Passed

5.1.2.2 13.56 MHz RFID

Ambient temperature:	20 °C	Relative humidity:	24 %
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Test description: 99 % bandwidth
 EUT: Transponderleser Plus
 Manufacturer: DATASCHALT engineering GmbH
 Operating conditions: 24 V DC, reading a 13.56 MHz TAG
 Test site: PHOENIX TESTLAB GmbH
 Operator: Ruben BRAUN
 Comment: -
 Date of test: 11.12.2020



F_L	F_U	BW ($F_U - F_L$)
13.345 MHz	13.847 MHz	502 kHz
Measurement uncertainty		$< 1 \cdot 10^{-7}$

Test: Passed

Test equipment (please refer to chapter 6 for details)
1, 2

5.2 Radiated emissions

5.2.1 Test method

The radiated emission measurement is subdivided into three stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- 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 in the frequency range 30 MHz to 1 GHz.

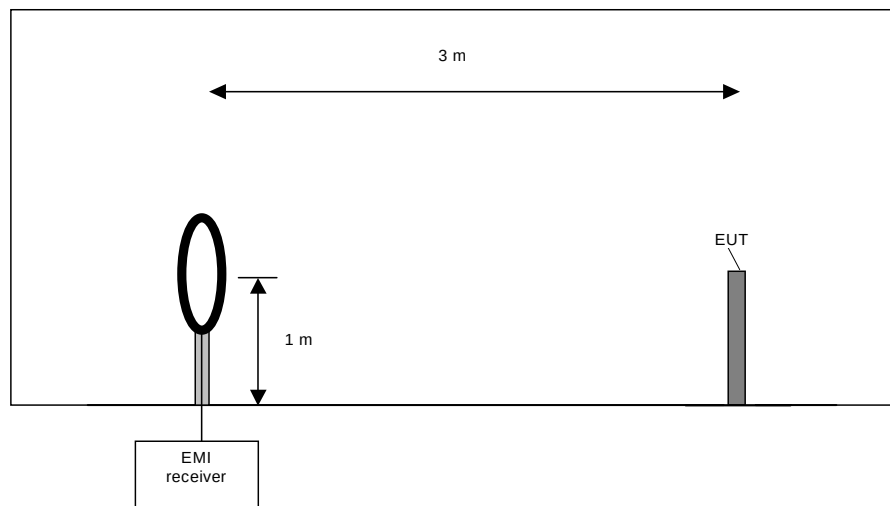
Preliminary measurement (9 kHz to 30 MHz):

In the first stage a preliminary measurement will be performed in a semi-anechoic chamber with 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 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 an EMI receiver 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 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



Preliminary measurement procedure (9 kHz to 30 MHz):

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) 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).
- 6) Rotate the measuring antenna and repeat steps 1) to 4).

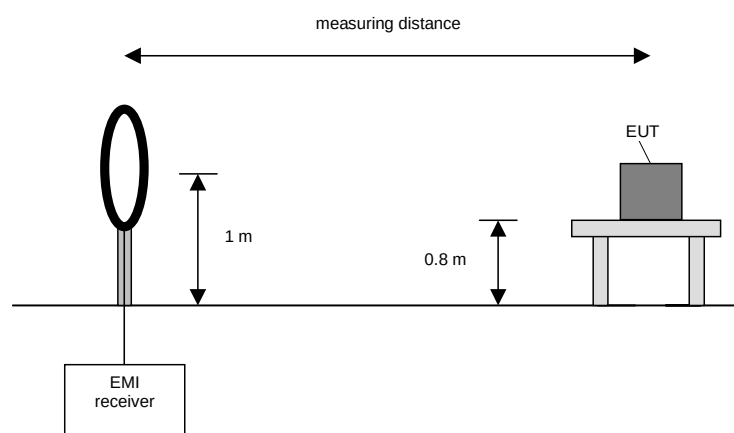
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distance of 3 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 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 will be used according to Section 15.209 (d) [2].

At 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 (9 kHz to 30 MHz):

The following procedure will be used:

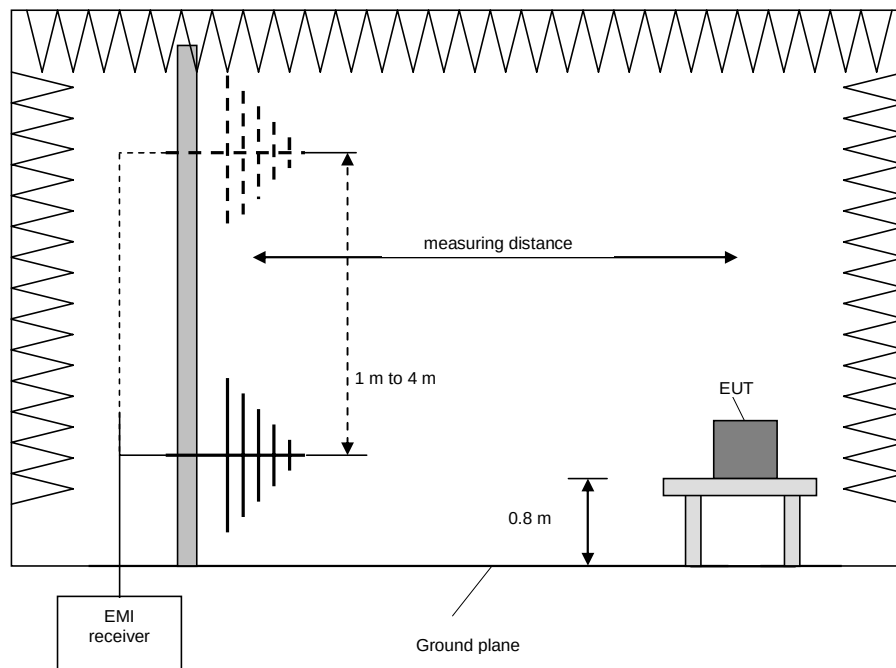
- 1) Monitor the frequencies with the measuring antenna at vertical orientation parallel to the EUT at an azimuth of 0 °.
- 2) Rotate the EUT by 360 ° to maximize the detected signals and note the azimuth and orientation.
- 3) Rotate the measuring antenna to find the maximum and note the value.
- 4) 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. 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



Preliminary measurement procedure (30 MHz to 1 GHz):

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 3) with the horizontal 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.

Final measurement procedure (30 MHz to 1 GHz):

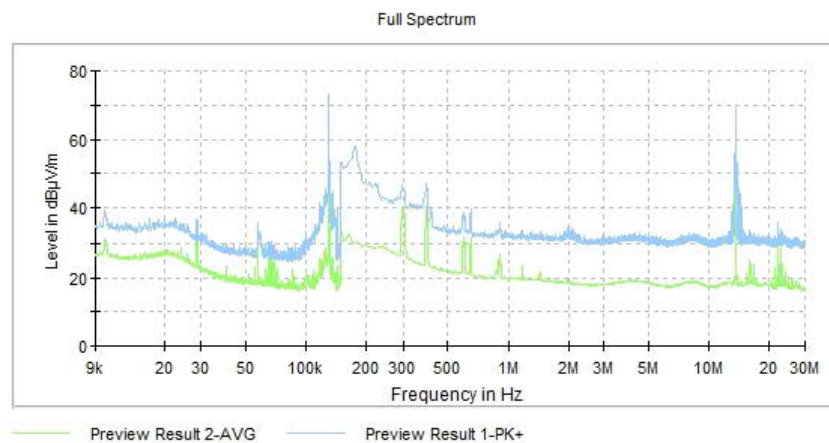
The following procedure is used:

1. Select the highest frequency peaks (smallest margin 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 measurement antenna height resulting in the highest emission level is found by the software by varying the measurement antenna height by +/- 0.5 m from the value obtained in the preliminary measurement.
5. The azimuth turntable position resulting in the highest emission level is found by varying the turntable azimuth by +/- 30° from the value obtained in the preliminary measurement.
6. The final measurement is performed at the worst-case antenna height and the worst-case turntable position.
7. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.

5.2.2 Results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	22 °C	Relative humidity:	23 %
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Test description: Preliminary measurement 9 kHz to 30 MHz
 EUT: Transponderleser Plus
 Manufacturer: DATASCHALT engineering GmbH
 Operating conditions: 24 V DC, reading a TAG
 Test site: PHOENIX TESTLAB GmbH; semi-anechoic chamber M276
 Operator: Ruben BRAUN
 Comment: -
 Date of test: 01.12.2020



Remark: The emissions were independent of the used TAG, therefore only one result is shown (reading 13.56 MHz TAG).

The following emission was found according to [2] and [3] (fundamental of transmitters): 131 kHz, 13.56 MHz.

The following frequencies were found outside and inside the restricted bands according to FCC 47 CFR Part 15 section 15.209.

These frequencies must be measured with in a final measurement.

Frequency in MHz	
0.010	0.392
0.029	0.654
0.058	15.947
0.299	21.880

Test equipment (please refer to chapter 6 for details)
3, 6 – 12

5.2.3 Result final measurement from 9 kHz to 30 MHz

Ambient temperature:	3 °C	Relative humidity:	90 %
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Test description: Final measurement 9 kHz to 30 MHz
 EUT: Transponderleser Plus
 Manufacturer: DATASCHALT engineering GmbH
 Operating conditions: 24 V DC, reading a TAG
 Test site: PHOENIX TESTLAB GmbH; OATS
 Operator: Ruben BRAUN
 Comment: -
 Date of test: 08.12.2020

Results 9kHz - 30 MHz										
Frequency [MHz]	Reading [dBμV]	Result* [dBμV/m]	Result* [dBμA/m]	Limit acc. 15.209 [dBμV/m]	Limit acc. RSS-Gen Table 6 [dBμA/m]	Margin** [dB]	Detector (acc. to §15.209 (d))	Antenna factor [dB/m]	Measuring Distance [m]	Distance correction factor*** [dB]
0.010* ¹	18.6	-40.5 @ 300m	-92.0 @ 300m	47.6	-3.9	88.1	AV	20.9	3	80.0
0.029* ¹	19.5	-40.0 @ 300m	-91.5 @ 300m	38.4	-13.2	78.4	AV	20.5	3	80.0
0.058* ¹	18.0	-41.6 @ 300m	-93.1 @ 300m	32.3	-19.2	73.9	AV	20.4	3	80.0
0.131	13.3	-25.5 @ 300m	-77.0 @ 300m	25.3	-26.3	50.7	AV	20.3	10	59.1
0.299* ¹	26.6	-33.1 @ 300m	-84.6 @ 300m	18.1	-33.4	51.2	AV	20.3	3	80.0
0.392	16.8	-42.9 @ 300m	-94.4 @ 300m	15.7	-35.8	58.6	AV	20.3	3	80.0
0.654* ¹	19.4	-0.3 @ 30m	-51.8 @ 30m	31.3	-20.2	31.6	QP	20.3	3	40.0
13.561	28.0	29.1 @ 30m	-22.4 @ 30m	29.5	-22.0	0.4	QP	20.2	10	19.1
15.947* ¹	14.1	-5.7 @ 30m	-57.2 @ 30m	29.5	-22.0	35.2	QP	20.2	3	40.0
21.880* ¹	16.0	-3.4 @ 30m	-54.9 @ 30m	29.5	-22.0	32.9	QP	20.6	3	40.0
Measurement uncertainty			+/- 4.69 dB							

Note: *Result @ norm dist. = Reading + Antenna factor - Distance correction factor; Result [dBμA/m] = Result [dBμV/m] - 20*log(377 Ω)

** Margin = Limit [dBμ{V|A}/m] - Result @ norm dist.

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

*¹ The emission could not be measured at the OATS due to environmental disturbances. Therefore, the maximum peak value determined in the preliminary measurement is taken as the final result.

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 377 Ohms.

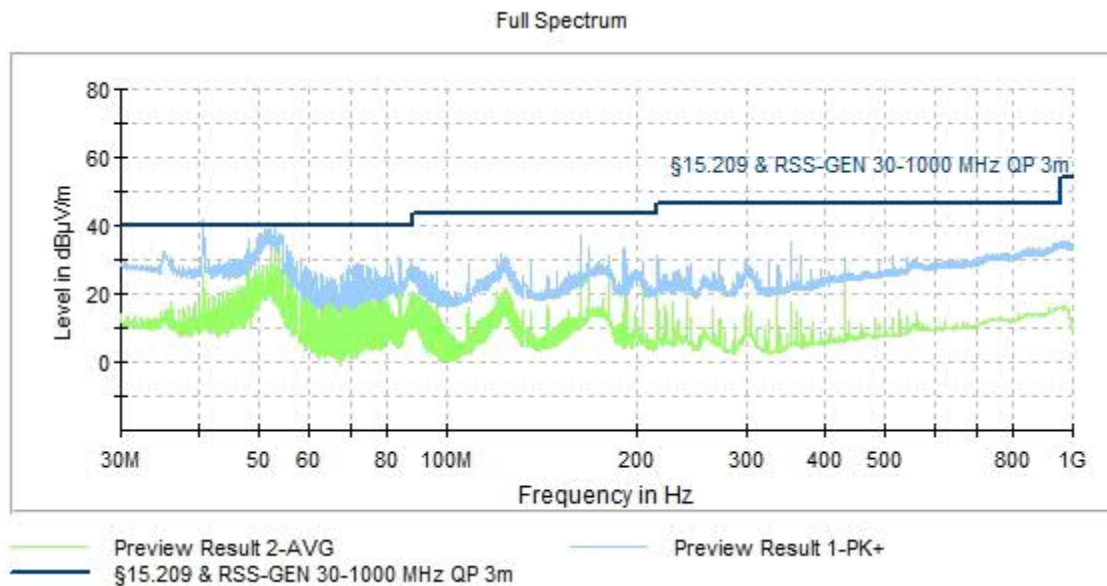
Test: Passed

Test equipment (please refer to chapter 6 for details)
3, 13, 14

5.2.4 Results preliminary and final measurement 30 MHz to 1 GHz

Ambient temperature:	22 °C	Relative humidity:	23 %
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Test description: Preliminary measurement 30 MHz to 1 GHz
 EUT: Transponderleser Plus
 Manufacturer: DATASCHALT engineering GmbH
 Operating conditions: 24 V DC, reading a TAG
 Test site: PHOENIX TESTLAB GmbH; Semi-anechoic chamber M276
 Operator: Ruben BRAUN
 Comment: -
 Date of test: 01.12.2020



Remark: Only the plot for the worst-case mode is shown (reading a 13.56 MHz TAG).

Remark: The EUT was only measured in one orientation, according to the usage position, as defined by the applicant.

Operation mode: Reading a 13.56 MHz TAG

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
40.680000	38.64	40.00	1.36	1000.0	120.000	102.0	V	62.0	23.4
53.030000	36.25	40.00	3.75	1000.0	120.000	102.0	V	160.0	15.5
84.000000	29.35	40.00	10.65	1000.0	120.000	123.0	V	222.0	16.0
162.740000	32.76	43.52	10.76	1000.0	120.000	243.0	H	274.0	18.2
352.600000	32.08	46.02	13.94	1000.0	120.000	102.0	H	238.0	22.5
Measurement uncertainty: ± 4.78 dB									

Operation mode: Reading a 125 kHz TAG

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
40.680000	36.83	40.00	3.17	1000.0	120.000	100.0	V	73.0	23.4
52.290000	35.49	40.00	4.51	1000.0	120.000	100.0	V	90.0	16.0
162.740000	32.07	43.52	11.45	1000.0	120.000	238.0	H	274.0	18.2
Measurement uncertainty: ± 4.78 dB									

Operation mode: Awaiting a TAG

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
40.690000	37.61	40.00	2.39	1000.0	120.000	100.0	V	74.0	23.4
48.000000	32.64	40.00	7.36	1000.0	120.000	100.0	V	-8.0	18.9
53.030000	36.68	40.00	3.32	1000.0	120.000	100.0	V	4.0	15.5
162.740000	32.48	43.52	11.04	1000.0	120.000	237.0	H	274.0	18.2
Measurement uncertainty: ± 4.78 dB									

The correction factor was calculated as follows.

Corr. (dB) = cable attenuation (dB) + 6 dB attenuator (dB) + antenna factor (dB)

Therefore, the reading can be calculated as follows:

Reading (dBμV/m) = result QuasiPeak (dBμV/m) - Corr. (dB)

Test: Passed

Test equipment (please refer to chapter 6 for details)
4 - 12

6 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	04.03.2020	03.2022
2	Loop antenna	Loop antenna 22.5cm	PHOENIX TESTLAB GmbH	-	410085	Calibration not necessary	
3	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	14.02.2020	02.2022
4	Attenuator 6 dB	WA2-6	Weinschel	8254	410119	Calibration not necessary	
5	Antenna (Bilog)	CBL6111D	Schaffner	25761	480894	09.10.2020	10.2023
6	Software	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
7	RF switch matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
8	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
9	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
10	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
11	Anechoic chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
12	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101828	482979	14.11.2019	11.2021
13	Outdoor test site	-	PHOENIX TESTLAB GmbH	-	480293	Calibration not necessary	
14	EMI Receiver / Spectrum Analyser	ESI 40	Rohde & Schwarz	100064/040	480355	11.02.2020	02.2021

7 Test site Validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
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
F200997E4	17.02.2021	Initial Test Report
-	-	-
-	-	-

9 List of Annexes

Annex A Test setup photos and ancillary devices

10 pages