

Test Report

Report Number:

F211971E2

Equipment under Test (EUT):

**Low Power Long Range LoRa Technology Transceiver Module
RN2903**

In dedicated host:

People Counter (IR Receiver)

Applicant:

IMBuildings B.V.

Manufacturer:

IMBuildings B.V.



Deutsche
Akkreditierungsstelle
D-PL-17186-01-00

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] **558074 D01 15.247 Meas Guidance v05r02 (April 2019)**, GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES
- [4] **RSS-247, Issue 2 (2017-02)** Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- [5] **RSS-Gen, Issue 5 Amendment 2 (2021-02)** 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

Name:	IMBuildings B.V.
Address:	Noordwijk 49, 7751 AH Dalen
Country:	Netherlands
Name for contact purposes:	-
Phone:	+31-524-551454
eMail address:	info@imbuildings.com
Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	IMBuildings B.V.
Address:	Noordwijk 49, 7751 AH Dalen
Country:	Netherlands
Name for contact purposes:	-
Phone:	+31-524-551454
eMail address:	info@imbuildings.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: *	Low Power Long Range LoRa Technology Transceiver Module
Model name: *	RN2903
Model number: *	IB010-102
Order number: *	Not available
FCC ID: *	2A6WLRN2903

	EUT number		
	1	2	3
Serial number: *	0004A30B00F6F7F6	-	-
PCB identifier: *	PRx20-LoRa	-	-
Hardware version: *	V1.1	-	-
Software version: *	Not available	-	-

* Declared by the applicant

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

1.5.1 EUT (LoRa module)

General EUT data			
Power supply EUT: *	DC		
Supply voltage EUT: *	$U_{nom} = 3.3 \text{ V}_{DC}$	$U_{min} = 2.1 \text{ V}_{DC}$	$U_{max} = 3.6 \text{ V}_{DC}$
Temperature range: *	-40°C to +85°C		
Lowest / highest internal clock frequency: *	32.768 kHz / 928 MHz		

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

Low power long range LoRa Technology transceiver			
Fulfil radio specification: *	LoRaWAN		
Antenna type: *	Integral meandered PCB monopole antenna		
Antenna name: *	Not available		
Antenna gain: * ²	Peak: -11 dBd (typical)		
Antenna connector: *	-		
Type of modulation: *	LoRa	FSK	
Operating frequency range: *	LoRa	902.3 – 927.5 MHz	
Number of channels: *	LoRa (DTS)	8	
	LoRa (FHSS)	64	

* As declared by the applicant

*² Based on test results, see 5.3.1

1.5.2 Dedicated host (People counter)

General Host data			
Power supply EUT: *	DC by 2 LR6 batteries		
Supply voltage EUT: *	$U_{nom} = 3.0 \text{ V}_{DC}$	$U_{min} = 2.3 \text{ V}_{DC}$	$U_{max} = 3.26 \text{ V}_{DC}$
Temperature range: *	0°C to +40°C		
Lowest / highest internal clock frequency: *	32.768 kHz / 928 MHz		

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

1.5.3 Ancillary Equipment / Equipment used for testing

Equipment used for testing	
Mobile Phone: *1	Samsung Galaxy S9; M/N: SM-G960F/DS, S/N:R58KB67DNEN

*1 provided by the laboratory

Ancillary Equipment	
-	-
-	-
-	-

1.6 Dates

Date of receipt of test sample:	14.12.2021
Start of test:	21.01.2022
End of test:	11.10.2022

2 Operational States

2.1 Description of function of the Dedicated host

The LoRaWAN People Counter is a battery powered sensor for counting people crossing a horizontal line. The counter consists of two parts, an infrared (ir) transmitter part and an infrared receiver part, which always work together.

The ir-transmitter creates an intermediate infrared signal in a fixed frequency.

The ir-receiver is the main part and holds the intelligence and communication with the outside world.

The created data is communicated from the internal algorithm microprocessor to the internal gateway microprocessor. The internal gateway processor communicates this information to the internal LoRaWAN module which takes care of the communication with the LoRaWAN network. Settings for the LoRaWAN interface are done via NFC memory.



2.1.1 Operation modes

Operation mode #	Radio technology	Frequency [MHz]	Channel / Band	Modulation / Mode	Power setting
1	LoRa WAN	903	-	FSK	-
2	LoRa WAN	914	-	FSK	-
3	LoRa WAN	927.5	-	FSK	-

The maximum output power of the Radio module is +20 dBm (typical)

The power was not settable by the test engineer

3 Additional Information

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

This test report incorporates only the results relevant for a C2P (new antenna and trace design) for the dedicated host for the LoRaWAN radio part.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-247 [4] RSS-Gen [5]	Tested EUT	Status
Maximum peak conducted output power	902 - 928	15.247 (b) (3), (4)	5.4 (d) [4]	-	Not performed
Maximum conducted output power	902 - 928	15.247 (b) (3), (4)	5.4 (d) [4]	-	Not performed
DTS Bandwidth / 99% Bandwidth	902 - 928	15.247 (a) (2)	5.2 (a) [4]	-	Not performed
Peak Power Spectral Density	902 - 928	15.247 (e)	5.2 (b) [4]	-	Not performed
Average Power Spectral Density	902 - 928	15.247 (e)	5.2 (b) [4]	-	Not performed
Band edge compliance	902 - 928	15.247 (d) 15.205 (a) 15.209 (a)	5.5 [4]	-	Not performed
Maximum unwanted emissions	30 – 10,000*	15.247 (d) 15.205 (a) 15.209 (a)	8.9 [5]	1	Passed*
Antenna Requirement	-	15.203 15.247 (b) (4)	6.8 [5]	1	Passed
Conducted emissions on supply line	0.15 – 30	15.207 (a)	8.8 [5]	-	_*2

- *: As declared by the applicant the highest radio clock frequency is 0.928 GHz. Therefore, the radiated emission measurement must be carried out up to 10th of the highest radio clock frequency in this case 10 GHz.
- *2 The EUT is battery powered and therefore not connectable to the mains network

5 Results

5.1 Test setups

5.1.1 Radiated: 30 MHz to 1 GHz

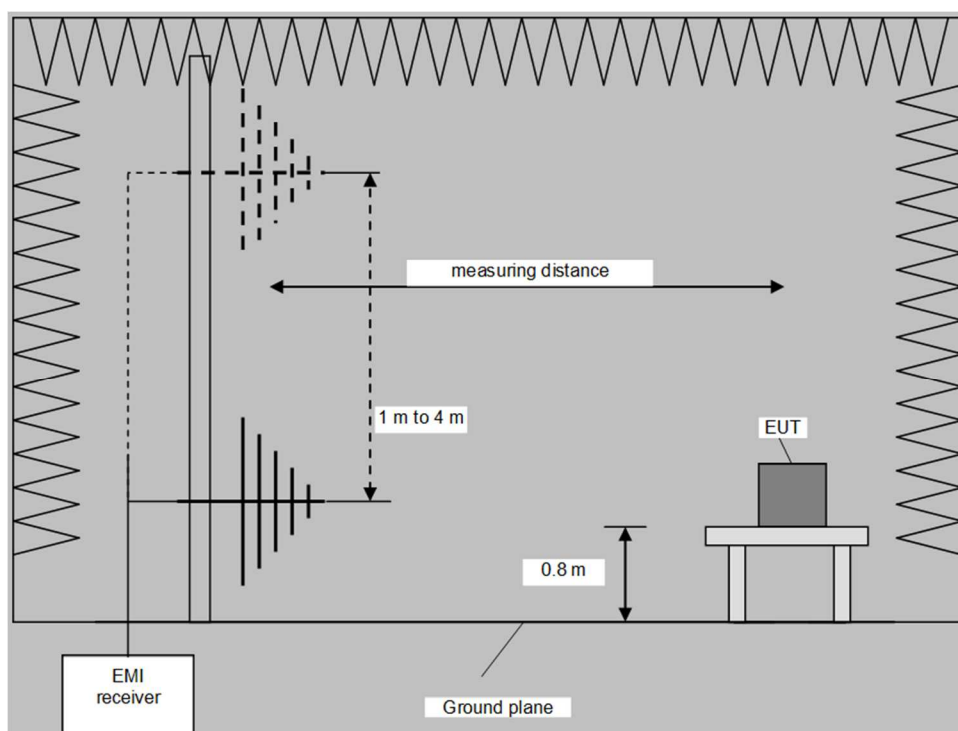
5.1.1.1 Preliminary and final measurement 30 MHz to 1 GHz

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.

5.1.2 Radiated: 1 GHz to 40 GHz

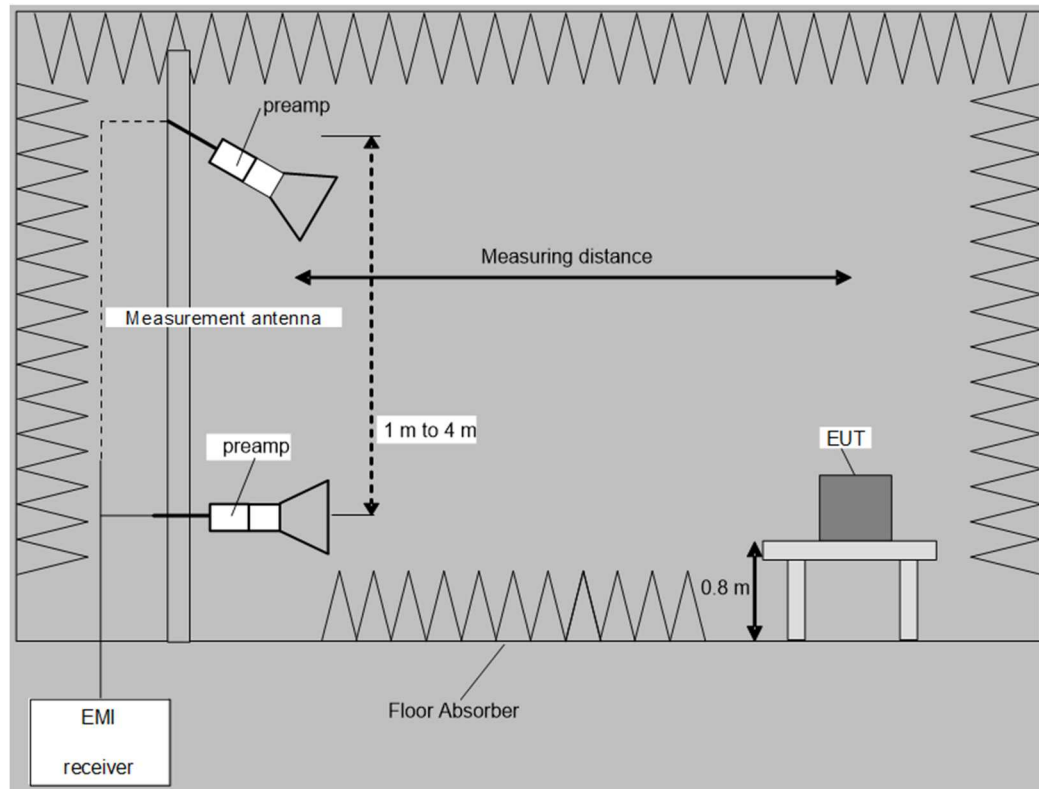
5.1.2.1 Preliminary and final measurement 1 GHz to 40 GHz

The preliminary and final measurements are performed in a semi-anechoic chamber at a measuring distance of 3 meters, with floor absorbers between EUT and measuring antenna. 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. While changing the height, the measuring antenna gets tilted so that it is always aiming at the EUT.

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	1 GHz - 40 GHz	250 kHz	1 MHz	-	Peak Average
Frequency peak search	+ / - 1 MHz	50 kHz	1 MHz	100 ms	Peak
Final measurement	1 GHz - 40 GHz	-	1 MHz	100 ms	Peak Average



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.

5.2 Duty cycle

As declared by the applicant the EUTs duty cycle is 100%, therefore no DCCF is applicable.

5.3 Transmit antenna performance considerations

Test setup (Transmit antenna performance considerations)		
Integral antenna	Antenna gain \leq 6dBi	Comment
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	No output power reduction necessary

5.3.1 Antenna calculation

Ambient temperature:	22 °C
Relative humidity:	44 %

Date:	11.10.2022
Tested by:	B. ROHDE

	903.0 [MHz]	914.3 [MHz]	927.5 [MHz]
Conducted output power [dBm]^{*1}	19.08	18.99	18.84
Radiated ERP [dBm ERP]^{*2}	7.63	6.80	7.66
Antenna Gain [dBd]	-11.45	-12.19	-11.18
Position of maximum gain	273° Vertical	270° Vertical	194° Vertical

*1 Results were taken from test report "HBCS Report # EMC_15009_2" from FCC ID T9JRN2903

*2 Results were measured at FAR at Phoenix TESTLAB GmbH

For details see Annex B

Test equipment (please refer to chapter 6 for details)
13 - 22

5.4 Radiated emissions

5.4.1 Test setup (Maximum unwanted emissions)

Test setup (Maximum unwanted emissions)			
Used	Setup	See sub-clause	Comment
<input checked="" type="checkbox"/>	Radiated: 30 MHz to 1 GHz	5.1.1	-
<input checked="" type="checkbox"/>	Radiated: 1 GHz to 10 GHz	5.1.2	-
<input type="checkbox"/>	Conducted: Antenna port	-	-

5.4.2 Test method (Maximum unwanted emissions)

Test method (radiated) see sub-clause 5.1.1 and 5.1.2 as described herein

5.4.3 Test results (Maximum unwanted emissions)

5.4.3.1 Test results (30 MHz – 1 GHz)

Ambient temperature:	22 °C
Relative humidity:	23 %

Date:	24.01.2022
Tested by:	B. ROHDE

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: Only one position was tested, see photos

Calculations:

Result [dBμV/m] = Reading [dBμV] + Correction [dBμV/m]

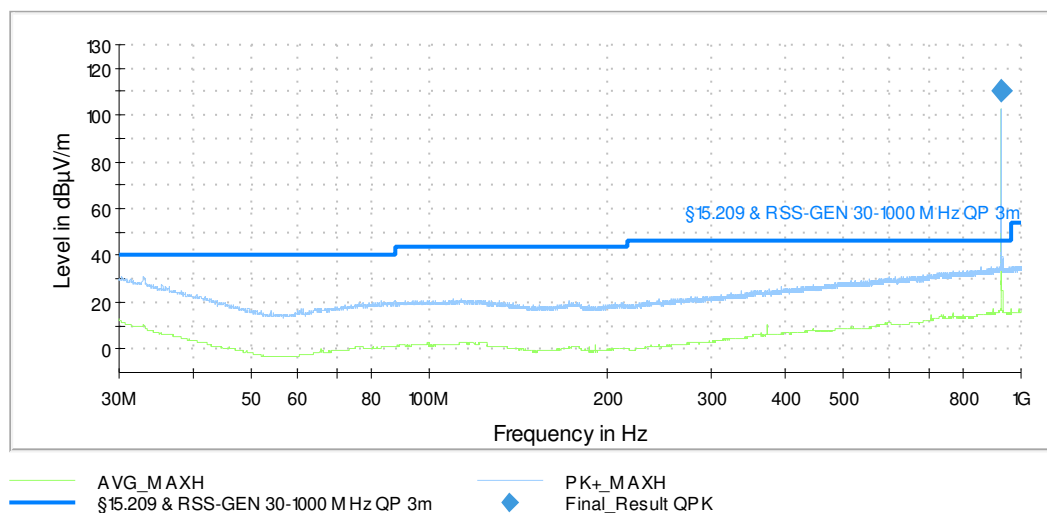
Correction [dBμV/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]

Margin [dB] = Limit [dBμV/m] - Result [dBμV/m]

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.

Worst case plot:

Spurious emissions from 30 MHz to 1 GHz (operation mode 3):



Result tables:

(Operation mode 1):

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Pol. (H/V)	Azimuth [deg]	Correction [dB/m]	Readings [dBµV]	Position #
903.000	107.3	---	---	189	V	200	30.0	77.3	1

(Operation mode 3):

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Pol. (H/V)	Azimuth [deg]	Correction [dB/m]	Readings [dBµV]	Position #
927.500	110.6	---	---	114	V	197	30.2	80.4	1

Test result: Passed

Test equipment (please refer to chapter 6 for details)
1 - 9

5.4.3.2 Test results (radiated 1 GHz to 10 GHz)

Ambient temperature:	22 °C
Relative humidity:	23 %

Date:	24.01.2022
Tested by:	B. ROHDE

Position of EUT: For tests for f between 1 GHz and the 10th harmonic, the EUT was set-up on a stand with a height of 150 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: Only one position was tested, see photos

Calculation:

Max Peak [dB μ V/m] = Reading [dB μ V] + Correction [dB μ V/m]

Average [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]+DCCF* [dB]
* (if applicable – only for Average values, that are fundamental related)

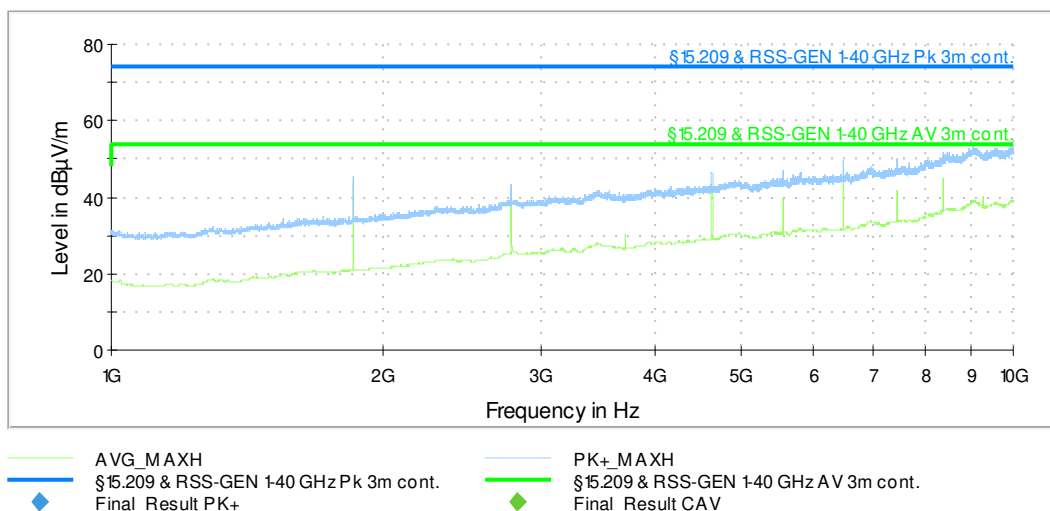
Margin [dB] = Limit [dB μ V/m] – Max Peak | Average [dB μ V/m]

The curves in the diagram only represent the maximum measured value for each frequency point of all preliminary measurements, which were carried out with various EUT and antenna positions.

The top measured curve represents the peak measurement. The measured points marked with "◆" are frequency points for the final peak detector measurement. These values are indicated in the following table. The bottom measured curve represents the average measurement. The measured points marked with "◆" are frequency points for the final average detector measurement.

Worst case plots:

Spurious emissions from 1 GHz to 10 GHz (operation mode 1):



Result tables:

Operation mode 1:

All emissions are below the average limit, no final measurement conducted, noise level (peak) ~53.5 dB μ V/m.

Test result: Passed

Test equipment (please refer to chapter 6 for details)
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1 - 7, 10 - 12

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 using a spectrum analyzer		
< 3.6 GHz	ETSI TR 100 028	2.3 dB
3.6 – 8 GHz	ETSI TR 100 028	2.8 dB
8 – 22 GHz	ETSI TR 100 028	3.2 dB
22 – 40 GHz	ETSI TR 100 028	3.6 dB
Power measurements		
Power meter	ETSI TR 100 028	0.9 dB
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	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
2	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
3	Antennasupport	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	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	Software	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
7	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	08.12.2021	12.2023
8	Attenuator 6 dB	WA2-6	Weinschel		482793	Calibration not necessary	
9	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	18.03.2021	03.2024
10	Low Noise Amplifier 100 MHz - 18 GHz	LNA-30-00101800-25-10P	Narda-Miteq	2110917	482967	18.02.2020	02.2022
11	Log.-Per. antenna	HL050	Rohde & Schwarz	100908	482977	13.08.2019	08.2022
12	High pass filter 1 GHz	WHKX12-935-1000-15000-40ST	Wainwright Instruments GmbH	12	482908	Calibration not necessary	
13	Antenna Log Per	HL223	Rohde & Schwarz	835556/014	480123	Calibration not necessary	
14	RF cable 36	SF106B/11N/11N/7000.0	Huber & Suhner	500219/6B	482416	Calibration not necessary	
15	Antenna support	AS620P	Deisel	620/375	480325	Calibration not necessary	
16	Fully anechoic chamber M20	B83117-E2439-T232	Albatross Projects	103	480303	Calibration not necessary	
17	Turntable	DS420 HE	Deisel	420/620/00	480315	Calibration not necessary	
18	Multiple Control Unit	MCU	Maturo GmbH	MCU/043/971107	480832	Calibration not necessary	
19	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101635	482467	22.02.2022	02.2024
20	Test software M20	EMC32 V10.60.15	Rohde & Schwarz	---	483261	Calibration not necessary	
21	Precision Dipole	HZ-13	Rohde & Schwarz	831782/02	480062	Calibration not necessary	
22	CW Generator Microwave	83650L	Agilent	3844A00554	480333	22.02.2022	02.2024

8 Test site Verification

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
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
Semi anechoic chamber M276	483227	1 -18 GHz	SVSWR	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	25.02.2021	24.02.2023

9 Report History

Report Number	Date	Comment
F211971E1	02.08.2023	Initial Test Report
-	-	-
-	-	-

10 List of Annexes

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Annex B	Transmit antenna performance considerations	2 pages