PHOENIX TESTLAB

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Test Report

Report Number:

F220996E2

Equipment under Test (EUT):

NEARFI PD 2A ETH R

Applicant:

PHOENIX CONTACT Electronics GmbH

Manufacturer:

PHOENIX CONTACT GmbH & Co.KG

ilac-MRA

DAkkS
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

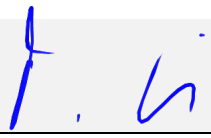
[2] **FCC CFR 47 Part 15** Radio Frequency Devices

[3] **RSS-210 Issue 11, June 2024**, Licence-Exempt Radio Apparatus: Category I Equipment

[4] **RSS-Gen Issue 5, February 2021 Amendment 2,** 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 1.4 of ANSI C63.10 (2020). However, the measurement uncertainty is calculated and shown in this test report.

Tested and written by:		Thomas Kühn 15.08.2024
	Signature	
Reviewed and approved by:		Bernd STEINER 15.08.2024
	Signature	

This test report is only valid in its original form.

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.

Contents: Page

1 Identification

1.1 Applicant

Name:	PHOENIX CONTACT Electronics GmbH
Address:	Dringenauer Straße 30, 31812 Bad Pyrmont
Country:	Germany
Name for contact purposes:	Maik STEMME
Phone:	+49 5281 946 3381
eMail address:	mstemme@phoenixcontact.com
Applicant represented during the test by the following person:	-

1.2 Manufacturer

Name:	PHOENIX CONTACT GmbH & Co.KG
Address:	Flachsmarktstr. 8, 32825 Blomberg
Country:	Germany
Name for contact purposes:	Maik STEMME
Phone:	+49 5281 946 3381
eMail address:	mstemme@phoenixcontact.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-17186-01-00, 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: *	Energy and data coupler
Model name / PMN: *	NEARFI PD 2A ETH R
PCB identifier: *	08-057908 REV E Z (60 GHz PCB), 1184502_03 (Data PCB), 30007751 (Interface PCB), 30007724 (Energy PCB)
Serial No.	2035672041
Hardware version / HVIN: *	1234225
Software version / FVIN: *	N/A
FCC ID: *	YG3PD2AETHR
IC:	4720B-PD2AETHR
Lowest / highest internal frequency: *	100 kHz / 63 GHz

*: 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

General			
Power supply EUT: *	Inductive from base by WPT		
Supply voltage EUT: *	U_{nom} = -	U_{min} = -	U_{max} = -
Temperature range: *	-20 °C to +65 °C		
Lowest / highest internal frequency: *	100 kHz / 10 MHz		

Energy communication part	
Carrier frequency: *	10 MHz
Frequency range: *	8.95 MHz to 11.05 MHz
Type of modulation: *	OOK
Rated H-field: *	-20 dBuA/m @ 3 m distance

* Declared by the applicant

Ports / Connectors				
Identification	Connector		Length during test	Shielding (Yes / No)
	EUT	Ancillary		
Power	5 pole M12 connector	4 mm laboratory plug	3.0 m	No
Ethernet	5 pole M12 connector	RJ45	3.0 m	No
-	-	-	-	-

Equipment used for testing	
-	-
-	-
-	-

*1 Provided by the applicant
*2 Provided by the laboratory

1.6 Dates

Date of receipt of test sample:	13.06.2022
Start of test:	30.06.2022
End of test:	29.08.2022

2 Operational States

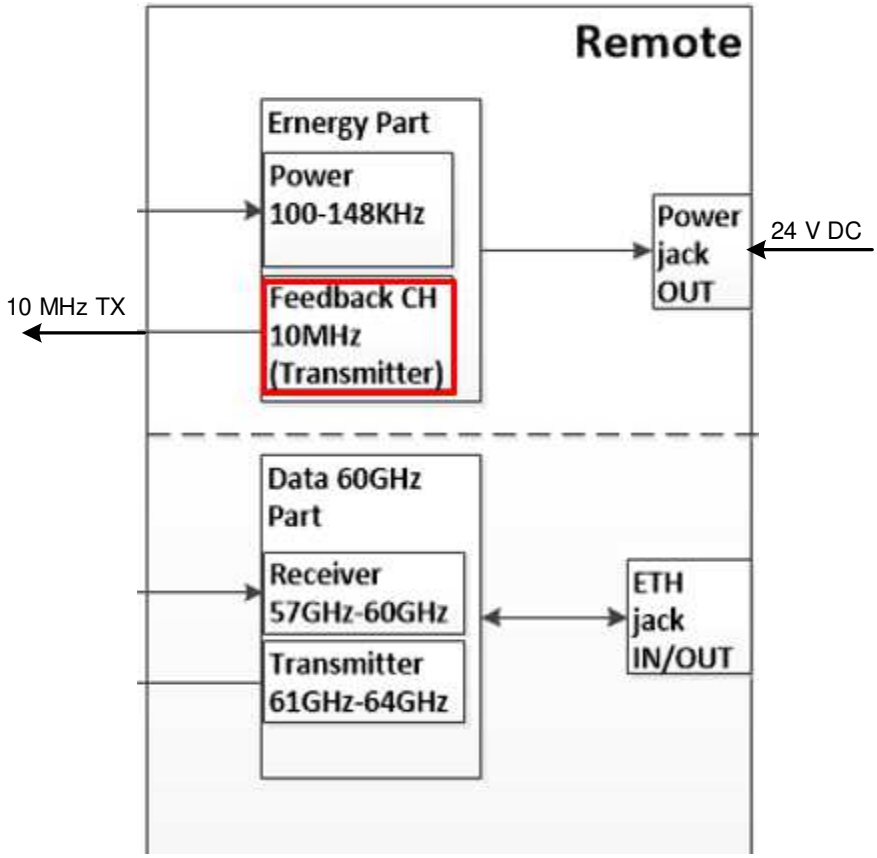
Description of function of the EUT:

The NearFi couplers transmit power and real time Ethernet data contact-free over an air gap of a few millimetres. For contactless transmission at least two devices are needed: a base coupler and one or more remote couplers. The base coupler transfers the energy inductively to the remote coupler. The Ethernet transmission is bidirectional between base and remote.

The following states were defined as the operating conditions:

The EUT is the remote coupler on a stand-alone basis.
Since no energy is transferred inductively, the EUT is supplied backwards from a laboratory power supply.
The operating voltage of 24 V is applied to the power output of the EUT.
The EUT is transmitting data at 10 MHz.

The system was setup as follows:



3 Additional Information

The EUT was not labeled as required by FCC / IC.
Data transmission part is subject of separate test reports.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-Gen [4] and RSS-210 [3]	Status
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] 8.2 and 8.3 [3]	Passed
99 % bandwidth	10	-	6.7 [4]	Passed
Antenna requirement	-	15.203 [2]	6.8 [4]	Passed *

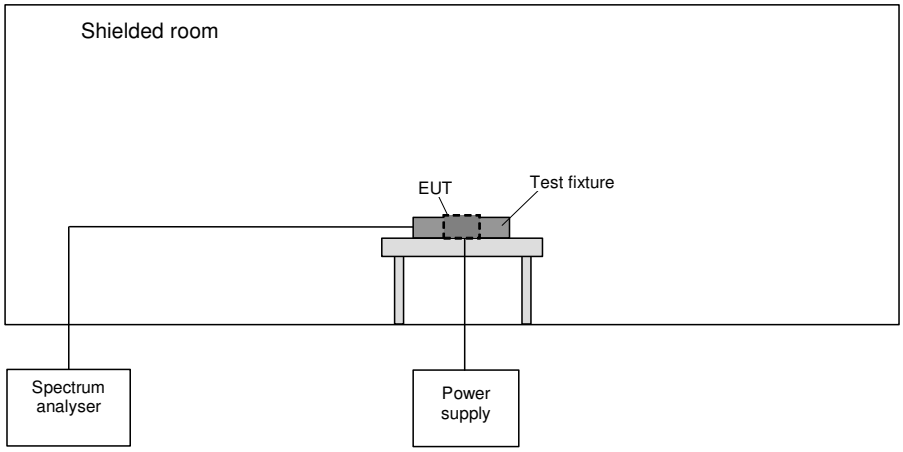
*: Integrated antenna only, requirement fulfilled.
**: As declared by the applicant the highest radio clock frequency is 0.01 GHz.
Therefore the radiated emission measurement must be carried out up to 10th of the highest radio clock frequency in this case 0.1 GHz.
***: Not applicable, because the EUT will be supplied via WPT.

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

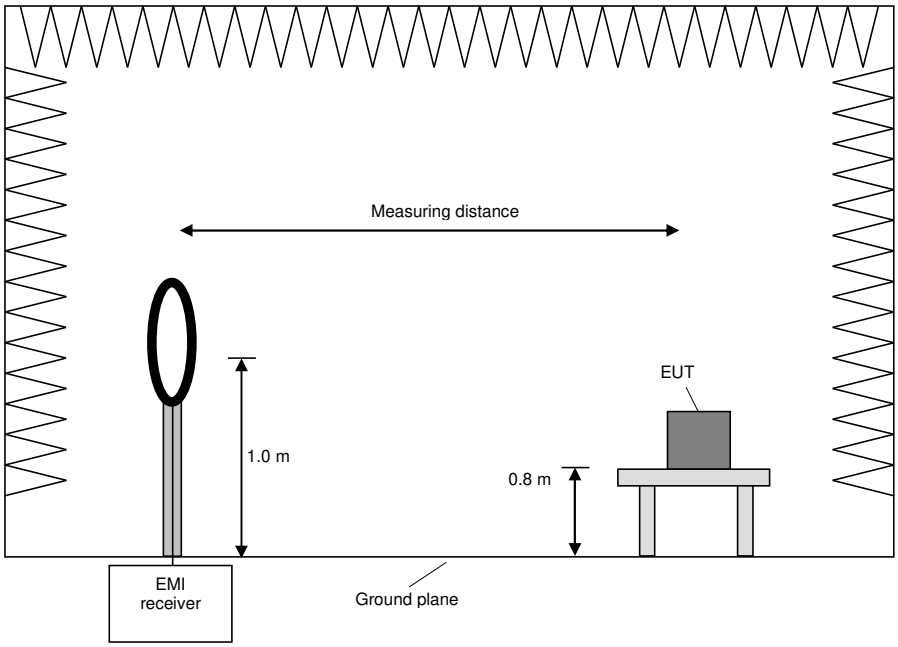
5.1.2.1 Preliminary measurement 9 kHz to 30 MHz

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.

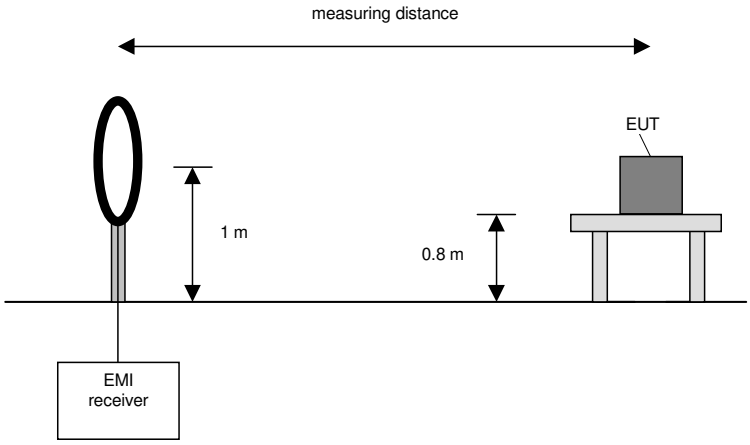
5.1.2.2 Final measurement 9 kHz to 30 MHz

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

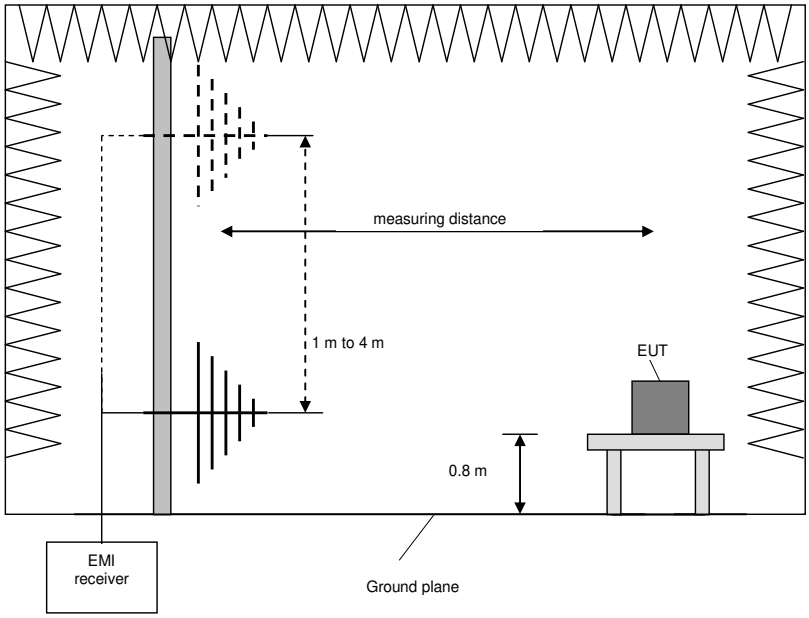
5.1.3.1 Preliminary and final measurement 30 MHz to 1 GHz

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.

5.2 99 % bandwidth

5.2.1 Test setup (99 % bandwidth)

Test setup (99 % bandwidth)			
Used	Setup	See sub-clause	Comment
☒	Radiated: Test fixture	5.1.1	-
☐	Test setup (antenna port conducted)	-	-

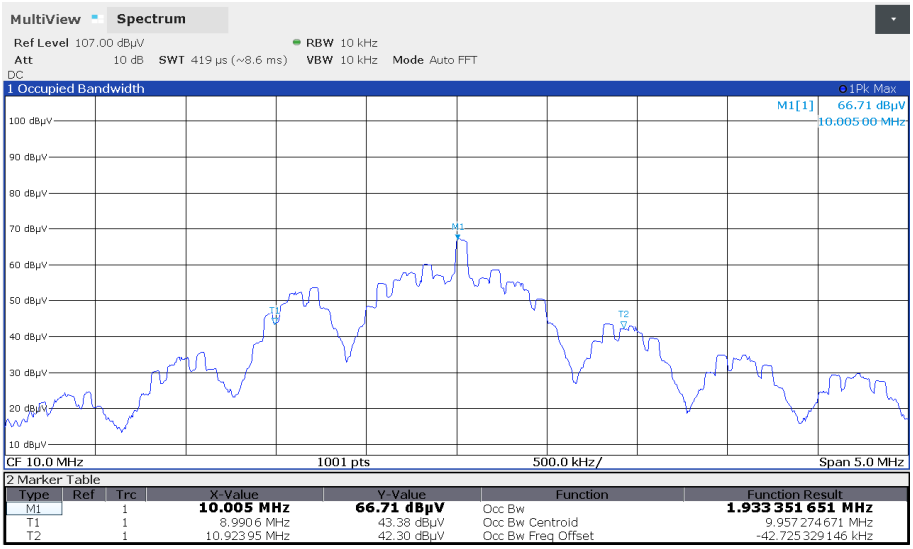
5.2.2 Test method (99 % bandwidth)

Test method (99 % bandwidth)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
☒	6.9.3	Occupied bandwidth – power bandwidth (99%) measurement procedure	-	-

5.2.3 Test results (99 % bandwidth)

Ambient temperature:	22 °C
Relative humidity:	55 %

Date:	24.08.2022
Tested by:	W. Kasalowsky



F_L	F_U	BW (F_U - F_L)
8.991 MHz	10.924 MHz	1.933 MHz

Test result: Passed

Test equipment (please refer to chapter 7 for details)
11, 13, 14

5.3 Radiated emissions

5.3.1 Test setup (Maximum unwanted emissions)

Test setup (Maximum unwanted emissions)			
Used	Setup	See sub-clause	Comment
☒	Radiated: 9 kHz to 30 MHz / 30 MHz to 1 GHz / 1 GHz to 40 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:	23 °C
Relative humidity:	51 %

Date:	07.07.2022
Tested by:	W. Kasalowsky

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.

Test record: The measurement value was already corrected by 40 dB/decade as described in 47 CFR 15.31(f)(2) regarding to the measurement distance as requested in 47 CFR 15.209(a)

Remark: All 3 orthogonal planes were tested separately

Calculations:

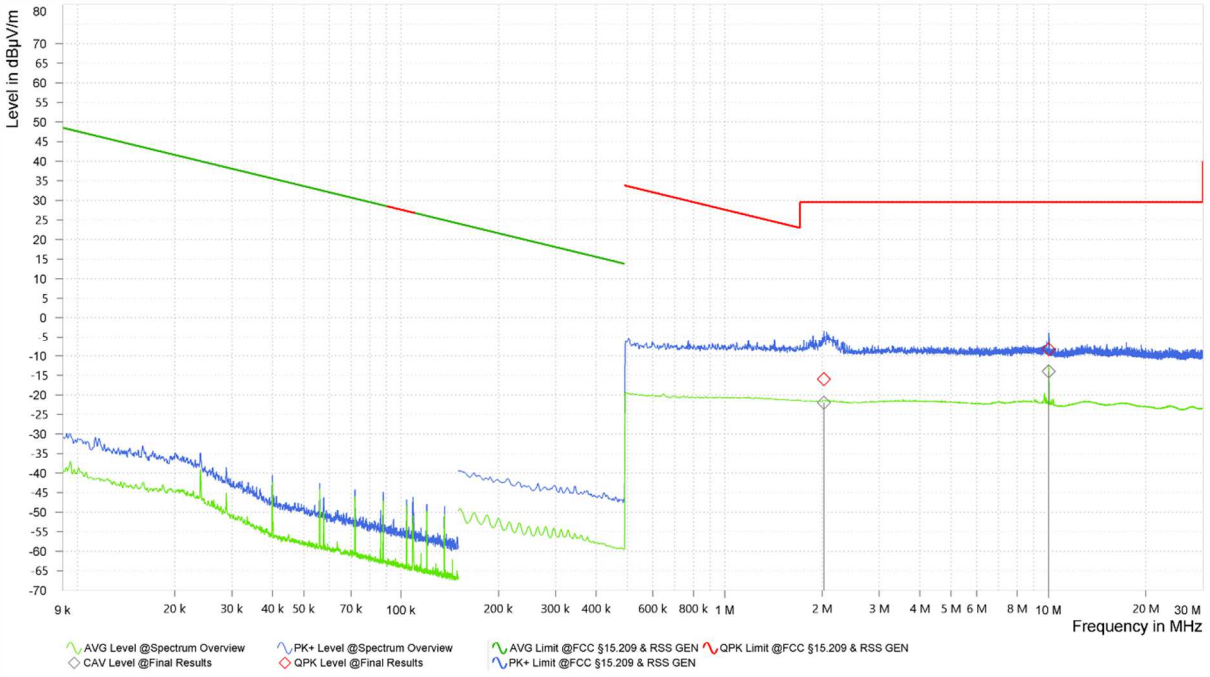
Result @ norm. dist. [dBµV/m] = Reading [dBµV] + AF [dB/m] + Distance corr. fact. [dBµV/m]

Result @ norm. dist. [dBµA/m] = Result @ norm. dist. [dBµV/m] – 20 x $\log_{10}$ (377 Ω)

Margin [dB] = Limit [dB(µV|µA)/m] - Result [dB(µV|µA)/m]

Worst case plot:

Spurious emissions from 9 kHz to 30 MHz:



During the preliminary measurement, the following emissions were found:

2.024 MHz and 10.023 MHz

On these frequencies a final measurement on an outdoor test site has to be carried out, the results of the final measurement are presented in the following.

Test equipment (please refer to chapter 7 for details)
3 – 5, 7, 8 – 11

5.3.3.2 Test results final measurement 9 kHz to 30 MHz

Ambient temperature:	20 °C
Relative humidity:	62 %

Date:	29.08.2022
Tested by:	W. Kasalowsky

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	Reading @ measuring distance	Result @ norm. distance	Result @ norm. distance	Limit acc. 15.209	Limit acc. RSS-Gen Table 6	Margin	Detector	Antenna factor	Measuring distance	Normative distance	Distance correction factor	Position
[MHz]	[dB(µV)]	[dB(µV/m)]	[dB(µA/m)]	[dB(µV/m)]	[dB(µA/m)]	[dB]		[dB/m]	[m]	[m]	[dB]	#
2.024	3.9	-15,9	-67.4	29.5	-21.9	45.4	QP	20.2	3	30	-40	1
10.023	11.4	-8.3	-59.8	29.5	-21.9	37.9	QP	20.3	3	30	-40	1

Test result: Passed

Test equipment (please refer to chapter 7 for details)
3, 11, 15, 16

5.3.3.3 Test results (30 MHz – 1 GHz)

Ambient temperature:	24 °C
Relative humidity:	61 %

Date:	30.06.2022
Tested by:	W. Kasalowsky

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: All 3 orthogonal planes were tested separately

Calculations:

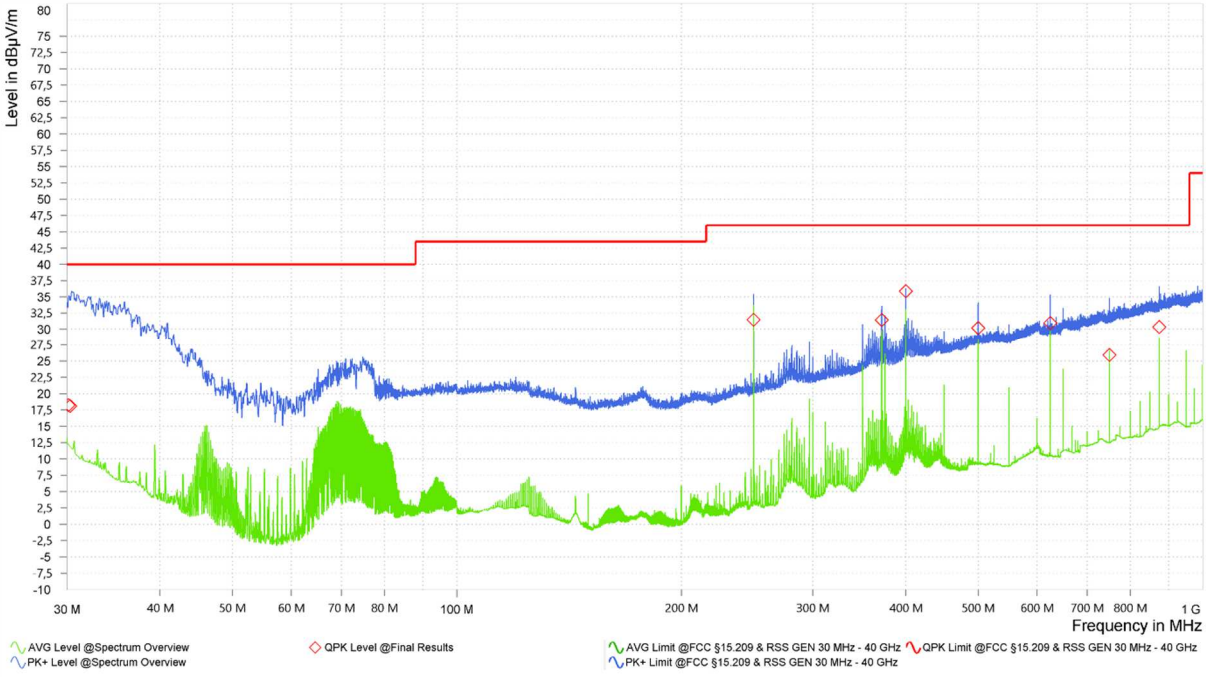
Result [dBµV/m] = Reading [dBµV] + Correction [dBµV/m]

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

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

Worst case plot:

Spurious emissions from 30 MHz to 1 GHz:



Result tables:

Frequency [MHz]	Result (QP) [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Readings [dBµV]	Correction [dB/m]	Height [m]	Azimuth [deg]	Pol. (H/V)	Position #
30.150	18.2	40.0	21.8	-7.7	25.9	4.25	148	V	1
30.300	18.1	40.0	21.9	-7.7	25.8	3.89	164	V	1
249.990	31.5	46.0	14.5	14.2	17.3	1.00	261	H	1
371.280	31.4	46.0	14.6	10.2	21.2	1.00	200	V	1
399.990	35.9	46.0	10.2	13.9	22.0	1.39	110	V	1
500.010	30.2	46.0	15.8	5.7	24.5	1.02	246	V	1
624.990	31.0	46.0	15.0	4.5	26.5	1.25	231	H	1
750.000	25.9	46.0	20.1	-2.1	28.0	1.89	157	H	1
874.980	30.4	46.0	15.6	0.8	29.6	1.53	297	H	1

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1, 2 ,4 – 11

6 Measurement Uncertainties

Conducted measurements		
Measurement method	Standard used for calculating measurement uncertainty	Expanded measurement uncertainty (95 %) U_{lab}
Bandwidth measurements	-	9.0×10^{-8}
Radiated measurements		
Radiated field strength M276		
R&S HL562E @ 3 m 30 MHz – 1 GHz	CISPR 16-4-2	4.8 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	Attenuator 6 dB	WA2-6	Weinschel	-	482793	Calibration not necessary	
2	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	18.03.2021	03.2024
3	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	22.02.2022	02.2024
4	RF Switch Matrix	OSP220	Rohde & Schwarz	-	482976	Calibration not necessary	
5	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
6	Antennasupport	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
7	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
8	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
9	Test software M276	Elektra V4.42	Rohde & Schwarz	101381	483755	Calibration not necessary	
10	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	08.12.2021	12.2023
11	Power Supply	TOE8852 (DC)	Toellner Electronic Inst.	51712	480233	Calibration not necessary	
13	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	19.11.2021	11.2022
14	Loop antenna	Loop antenna 22.5cm	PHOENIX TESTLAB GmbH	-	410085	Calibration not necessary	
15	EMI Receiver / Spectrum Analyser	ESR7	Rohde & Schwarz	101733	482330	02.06.2022	02.2024
16	Outdoor test site	-	PHOENIX TESTLAB GmbH	-	480293	Calibration not necessary	

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
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
F220998E1	15.08.2024	Initial Test Report
-	-	-
-	-	-

10 List of Annexes

Annex A Test Setup Photos 5 pages