PHOENIX TESTLAB

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Test Report

Report Number:

F220996E3

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

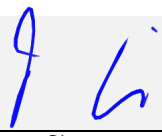
[1] **CFR 47 Rule part 1** Practice and Procedure

[2] **CFR 47 Rule part 2** Frequency Allocations and Radio Treaty Matters; General Rules and Regulations

[3] **KDB 447498 D04** Interim General RF Exposure Guidance v01

Test Result

The requirements of the tests performed as shown in the results (clause 3) 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. 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)* according to DIN EN ISO/IEC 17025:2018. The accreditation is only valid for the scope of accreditation listed in the annex of the certificate D-PL-17186-01-00.

1.4 EUT (Equipment under Test)

Test object: *	Energy and data coupler (Remote)
Model name: *	NEARFI PD 2A ETH R
Article number: *	1234225
Serial number: *	2035672017
FCC ID: *	YG3PD2AETHR

* Declared by the applicant

Only one EUT and one ancillary equipment was used for the 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:			
PCB identifier: *	08-057908 REV E Z (60 GHz PCB), 1184502_03 (Data PCB), 30007751 (Interface PCB), 30007724 (Energy PCB)		
Power supply EUT: *	Inductive from base by WPT		
Supply voltage EUT: *	U_{nom} = -	U_{nom} = -	U_{nom} =
Temperature range: *	-20 °C to +65 °C		
Distance between source and client: *	0 mm to 10 mm		
Max. output of the client: *	24 V_{DC} with 2 A_{DC} (with all distances between source and client)		
Safety distance in operation: *	30 cm		

* Declared by the applicant

Energy transfer part EUT (client):	
Receiver frequency: *	100 kHz - 148 kHz
Number of channels: *	-
Type of modulation: *	None, EUT is a receiver
Data rate: *	None
Duty cycle: *	100 %
Antenna type: *	Internal coil
Antenna connector: *	None

* Declared by the applicant

Energy communication part EUT (client)	
Carrier frequency: *	10 MHz
Frequency range: *	8.99 MHz to 10.92 MHz
Type of modulation: *	OOK

* Declared by the applicant

Ethernet communication part	
Operating frequency band: *	57,000 MHz to 71,000 MHz
Number of channels: *	1
Nominal channel bandwidth(s): *	N/A (one channel equipment)
Antenna type: *	Interna patch antenna
Antenna connector: *	None
Antenna gain:	12 dBi (refer antenna documentation)
Data rate: *	62.5 MBit
Type of modulation: *	OOK

*: Declared by the applicant.

Ports/Connectors			
Identification	Connector		Length
Port	NEARFI P 2A B (source)	Ancillary	
Power in	5 pole M12 connector	4 mm laboratory plug	3.0 m
Ethernet	5 pole M12 connector	RJ45	3.0 m

*: Length during the test

Ancillaries used for testing		
Ancillary	Description	
Laptop PC with measuring software *2	Fujitsu Lifebook S761 with Narda EHP200-TV Rel. 1.91	
Source *1	Client object: *	Energy and data coupler (Base)
	Model name: *	NEARFI PD 2A ETH B
	Article number: *	1234224
	Serial number: *	2035672017
	FCC ID: *	YG3PD2AETHB
	Connector:	Two 5 pole M12 connector
	Length during test:	3 m

*: Declared by the applicant
*1: Supplied by the applicant
*2: Supplied by the laboratory

1.6 Dates

Date of receipt of test sample:	13.06.2022
Start of test:	06.12.2023
End of test:	06.12.2023

2 Evaluation method

2.1 RF exposure test exemptions for single sources

2.1.1 General exemption CFR 47 §1.1307(b)(3)(i)(A)

The available maximum time-averaged power is no more than 1 mW, regardless of separation distance. This exemption may not be used in conjunction with other exemption criteria other than those in paragraph (b)(3)(ii)(A) of this section. Medical implant devices may only use this exemption and that in paragraph (b)(3)(ii)(A);

2.1.2 SAR based exemption CFR 47 §1.1307(b)(3)(i)(B)

The available maximum time-averaged power of effective radiated power (ERP), whichever is greater, is less than or equal to the threshold P_{th} (mW) described in the following formula. This method shall only be used at separation distances (cm) from 0.5 cm to 40 cm and at frequencies from 0.3 GHz to 6 GHz inclusive.

For the following separation distances [d] and frequency ranges P_{th} is given by the following formulas

	0.5 cm ≤ d ≤ 20cm	20 cm < d ≤ 40 cm
0.2 GHz ≤ f < 1.5 GHz	$P_{th}(mW) = ERP_{20cm}\left(\frac{d}{20}\right)^{x}$ $ERP_{20cm}\ (mW) = 2040f$ $x = -log_{10}\left(\frac{60}{ERP_{20cm}\sqrt{f}}\right)$	$P_{th}(mW) = ERP_{20cm}$ $ERP_{20cm}\ (mW) = 2040f$
1.5 GHz ≤ f ≤ 6 GHz	$P_{th}(mW) = ERP_{20cm}\left(\frac{d}{20}\right)^{x}$ $ERP_{20cm}\ (mW) = 3060$ $x = -log_{10}\left(\frac{60}{ERP_{20cm}\sqrt{f}}\right)$	$P_{th}(mW) = ERP_{20cm}$ $ERP_{20cm}\ (mW) = 3060$

2.1.3 MPE based exemption CFR 47 §1.1307(b)(3)(i)(C)

By using Table 1 and the minimum separation distance (d in meters) from the body of a nearby person for the frequency (f in MHz) at which the source operates, the ERP (watts) is no more than the calculated value prescribed for that frequency. For the exemption in Table 1 to apply, d must be at least λ/2π, where λ is the free-space operating wavelength in meters. If the ERP of a single RF source is not easily obtained, then the available maximum time-averaged power may be used in lieu of ERP if the physical dimensions of the radiating structure(s) do not exceed the electrical length of λ/4 or if the antenna gain is less than that of a half-wave dipole (1.64 linear value).

RF Source frequency [MHz]	Threshold ERP [W]
0.3 -1.34	1920 d^2
1.34 – 30	3450 d^2/f^2
30 – 300	3.83 d^2
300 – 1500	0.0128 d^2/f
1500 - 100000	19.2 d^2

d: Minimal separation distance from antenna to the user

2.1.4 Stand alone MPE evaluation limits

The human exposure to RF emissions from such devices could be evaluated based on the MPE limits adopted by the FCC for electric and magnetic field strength and / or power density. The limits for General Population / Uncontrolled Exposure are given in the following table from CFR 47 §1.1310(e)1:

Frequency range [MHz]	Electric field strength (E) [V/m]	Magnetic field strength (H) [A/m]	Power density (S) [mW/cm²]	Averaging time [min]
(i)Limits for Occupational/Controlled Exposure				
0.3 – 3.0	614	1.63	*(100)	≤6
3.0 – 30	1842/f	4.89/f	*(900/f²)	<6
30 – 300	61.4	0.163	1.0	<6
300 – 1,500			f/300	<6
1,500 – 100,000			5	<6
(ii)Limits for General Population / Uncontrolled Exposure				
0.3 – 1.34	614	1.63	*(100)	< 30
1.34 – 30	824/f	2.19/f	*(180/f²)	< 30
30 – 300	27.5	0.073	0.2	< 30
300 – 1500			f/1500	< 30
1500 – 100,000			1.0	< 30

Note: f = frequency in MHz; * Plane – wave equivalent power density

The power density is calculated as follows:

$$S = \frac{P \cdot G \cdot D}{4 \cdot \pi \cdot d^2}$$

Where:

P: conducted power

G: Antenna gain (linear)

D: Duty Cycle

d: Minimal separation distance from antenna to the user

2.2 RF exposure test exemptions for simultaneous transmission sources

2.2.1 1 mW test exemption for simultaneous transmission sources

As discussed in CFR 47 §1.1307(b)(3)(ii)(A) [1] the 1 mW exemption intended for single transmitters may be also applied to simultaneous transmission conditions, within the same host device, according one of the following criteria:

a. When the maximum available power each individual transmitting antenna with the same time averaging period is ≤1 mW, and the nearest parts of the antenna structures of the simultaneously operating transmitters are separated by at least 2 cm
b. When the aggregate maximum available power of all transmitting antennas is ≤1 mW in the same time-averaging period

This exemption may not be combined with any other exemption.

2.2.2 Simultaneous transmission SAR based and MPE based test exemptions

Although this is not a module integration in the sense of product approval, the procedure for simultaneous transmission specified in KDB 447498 D04 Interim General RF Exposure Guidance v01 [3] in chapter 2.2 was taken into account:

According to the RF exposure KDB 447498 D04 General RF Exposure Guidance v01 [3] in chapter 2.2.2:
This case is described in detail in CFR 47 §1.1307(b)(3)(ii)(B) and covers the situations where both SAR-based and MPE-based exemption may be considered for test exemption in fixed, mobile, or portable device exposure conditions. For these cases, a device with multiple RF sources transmitting simultaneously will be considered an RF exempt device if the condition of the following formular is satisfied.

$$\sum_{i=1}^{a} \frac{P_i}{P_{th,i}} + \sum_{i=1}^{b} \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^{c} \frac{Evaluated_k}{Exposure\ Limit_k} \leq 1$$

For these test exemptions to apply, the maximum output power, duty factor, and other applicable parameters used in the standalone ERP determination tests, must be the same, or corresponding to a more conservative choice, than those required for simultaneous transmission.

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤1.0, according to calculated/estimated, numerically modelled, or measured field strengths or power density. The MPE ratio of each antenna is determined at the minimum test separation distance required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to the MPE limit at the test frequency.

2.2.3 Test exemption based on the SAR to Peak Location Separation Ratio

When the ERP-based condition in the previous section does not apply, a test exemption may be still applicable based on the SAR to peak location separation ratio (SPLSR) procedure.
In this case, the simultaneously transmitting antennas in each operating mode and exposure condition combination must be considered one pair at a time to determine the SPLSR that qualifies for the additional test exemption.
This ratio is defined as:

$$SPLSR = (SAR_1 + SAR_2)^{\frac{1.5}{R_i}}$$

Where: SAR_1 and SAR_2 = highest reported SAR or estimated SAR values for the two sources in the pair i, and R_i is their distance in mm.
When SPLSR ≤ 0.0.4 (rounded to two decimal digits), for all antenna pairs in the configuration, then the device qualifies for 1 g SAR test exemption.
When 10 g SAR applies (e.g. for extremities) the corresponding test exemption condition is SPLSR ≤0.10.
If any antenna pair does not qualify for simultaneous transmission SAR test exemption, then the device must be tested for SAR compliance, according to the enlarged zoom scan and volume scan post-processing procedures in KDB Pub. 865664 D01.

3 Results of evaluation

3.1 Used evaluation methods

RF Exposure test exemptions for single sources			
Used	Method	See sub-clause	Comment
☐	General Exemption acc. CFR 47 §1.1307(b)(3)(i)(A)	2.1.1	-
☐	SAR Based Exemption acc. CFR 47 §1.1307(b)(3)(i)(B)	2.1.2	-
☐	MPE Based Exemption acc. CFR 47 §1.1307(b)(3)(i)(C)	2.1.3	-
☒	MPE Calculation	2.1.4	-

RF Exposure test exemptions for simultaneous transmission sources			
Used	Method	See sub-clause	Comment
☐	Not applicable	-	-
☐	1 mW test Exemption acc. 2.2.1 [3]	2.2.1	-
☐	SAR Based Exemption acc. 2.2.2 [3]	2.2.2	
☒	MPE Based Exemption acc. 2.2.2 [3]	2.2.2	
☐	SAR to Peak location separation ratio acc. 2.2.3 [3]	2.2.3	

3.2 Evaluation distance

According to the applicant's documentation, the device is a mobile device which is used at least with a separation distance of 30 cm.

3.3 Measurement of E field strength from the client without source

Ambient temperature:	22 °C
Relative humidity:	24 %

Date:	06.12.2023
Tested by:	Th. KÜHN

The EUT operates in the frequency range 8.99 MHz to 10.92 MHz.

Before the measurement the environmental fields must be considered, and the field probe has to be zeroed. Because the EUT is installed on movable machine parts the safety distance between the user and the EUT is defined by the applicant with 30 cm. Therefore, the field probe was moved with a distance of 30 cm in all directions around the EUT and peak level of the field strength was observed. At the position of the maximum level the measurement was carried out with an averaging time of 6 minutes. The position of the maximum field strength and the test setup are shown in the photograph below. For this test, the EUT was powered by an external power supply with 24 V_{DC} by an external power supply.

Parameter	Measured result	Limit	Difference to the 30 cm value	Test result
Electric field strength	0.0610 V/m at 30 cm distance	75.5 V/m	-	Passed *

*: The NEARFI PD 2A ETH R generates an electric field strength, which is below the level for MPE of persons in General Population / Uncontrolled Exposure [1].

Test equipment (please refer to chapter 5 for details)
1, 3, 4

3.4 Measurement of H field strength from the client without source

Ambient temperature:	22 °C
Relative humidity:	24 %

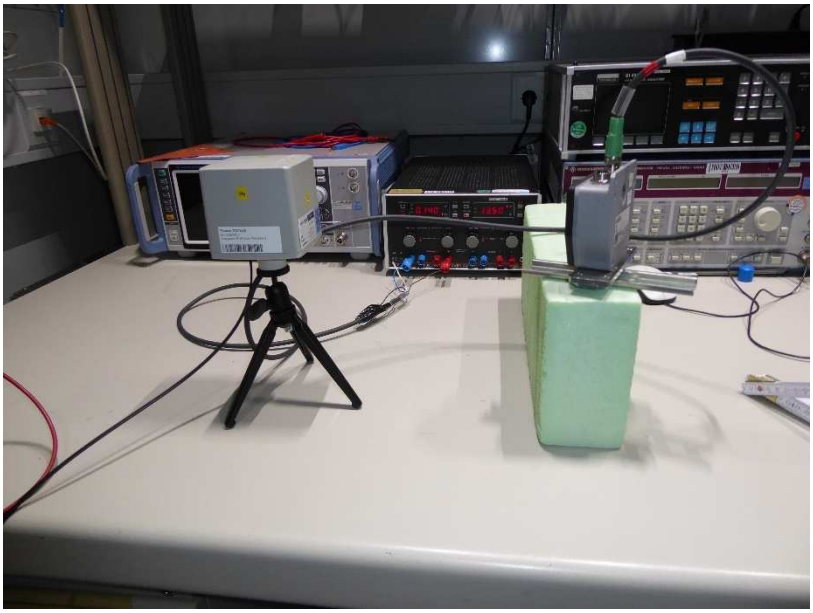
Date:	06.12.2023
Tested by:	Th. KÜHN

The EUT operates in the frequency range 8.99 MHz to 10.92 MHz.

Before the measurement the environmental fields must be considered, and the field probe has to be zeroed. Because the EUT is installed on movable machine parts the safety distance between the user and the EUT is defined by the applicant with 30 cm. Therefore, the field probe was moved with a distance of 30 cm in all directions around the EUT and peak level of the field strength was observed. At the position of the maximum level the measurement was carried out with an averaging time of 6 minutes. The position of the maximum field strength and the test setup are shown in the photograph below. For this test, the EUT was powered by an external power supply with 24 V_{DC} by an external power supply.

Parameter	Measured result	Limit*	Difference to the 30 cm value	Test result
Magnetic field strength	0.0009 A/m at 30 cm distance	0.201 A/m	-	Passed *

*: The NEARFI PD 2A ETH R generates a magnetic field strength, which is below the level for MPE of persons in General Population / Uncontrolled Exposure [1].



Test equipment (please refer to chapter 5 for details)
1, 3, 4

3.5 Measurement of E field strength from the client with source at minimum distance

Ambient temperature:	22 °C
Relative humidity:	24 %

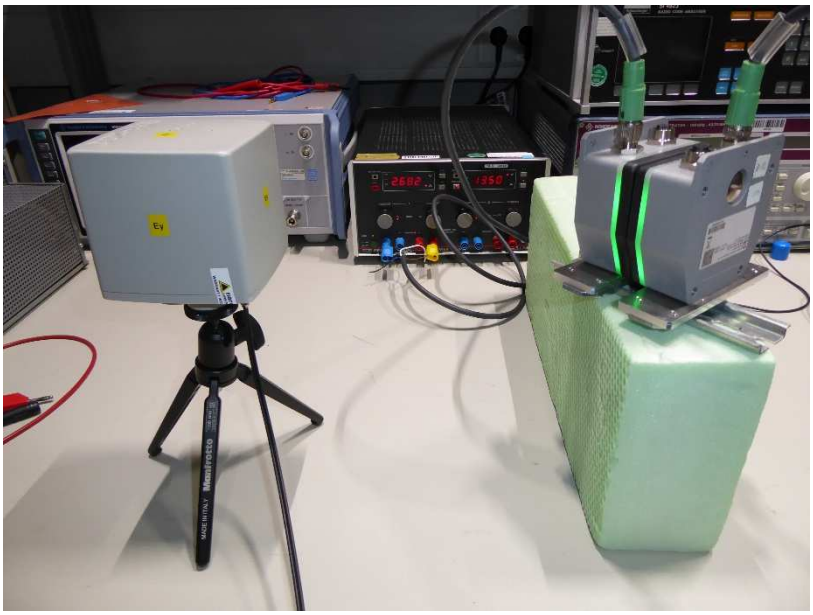
Date:	06.12.2023
Tested by:	Th. KÜHN

The EUT operates in the frequency range 8.99 MHz to 10.92 MHz.

Before the measurement the environmental fields must be considered, and the field probe has to be zeroed. Because the EUT is installed on movable machine parts the safety distance between the user and the EUT is defined by the applicant with 30 cm. Therefore, the field probe was moved with a distance of 30 cm in all directions around the EUT and peak level of the field strength was observed. At the position of the maximum level the measurement was carried out with an averaging time of 6 minutes. The position of the maximum field strength and the test setup are shown in the photograph below. The client was loaded with the maximum current of 2 A.

Parameter	Measured result	Limit *	Difference to the 30 cm value	Test result
Electric field strength	0.0599 V/m at 30 cm distance	75.5 V/m	-	Passed *

*: The NEARFI PD 2A ETH R generates an electric field strength, which is below the level for MPE of persons in General Population / Uncontrolled Exposure [1].



Test equipment (please refer to chapter 5 for details)
1 – 4

3.6 Measurement of H field strength from the client with source at minimum distance

Ambient temperature:	22 °C
Relative humidity:	24 %

Date:	06.12.2023
Tested by:	Th. KÜHN

The EUT operates in the frequency range 8.99 MHz to 10.92 MHz.

Before the measurement the environmental fields must be considered, and the field probe has to be zeroed. Because the EUT is installed on movable machine parts the safety distance between the user and the EUT is defined by the applicant with 30 cm. Therefore, the field probe was moved with a distance of 30 cm in all directions around the EUT and peak level of the field strength was observed. At the position of the maximum level the measurement was carried out with an averaging time of 6 minutes. The position of the maximum field strength and the test setup are shown in the photograph below. The client was loaded with the maximum current of 2 A.

Parameter	Measured result	Limit*	Difference to the 30 cm value	Test result
Magnetic field strength	0.0008 A/m at 30 cm distance	0.201 A/m	-	Passed *

*: The NEARFI PD 2A ETH R generates a magnetic field strength, which is below the level for MPE of persons in General Population / Uncontrolled Exposure [1].

Test equipment (please refer to chapter 5 for details)
1 – 4

3.7 Measurement of E field strength from the client with source at maximum distance

Ambient temperature:	22 °C
Relative humidity:	24 %

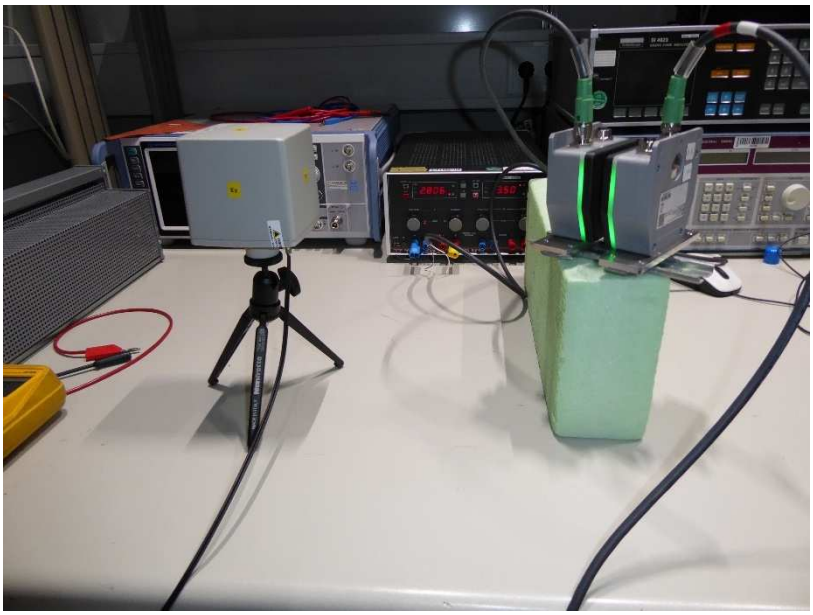
Date:	06.12.2023
Tested by:	Th. KÜHN

The EUT operates in the frequency range 8.99 MHz to 10.92 MHz.

Before the measurement the environmental fields must be considered, and the field probe has to be zeroed. Because the EUT is installed on movable machine parts the safety distance between the user and the EUT is defined by the applicant with 30 cm. Therefore, the field probe was moved with a distance of 30 cm in all directions around the EUT and peak level of the field strength was observed. At the position of the maximum level the measurement was carried out with an averaging time of 6 minutes. The position of the maximum field strength and the test setup are shown in the photograph below. The client was loaded with the maximum current of 2 A.

Parameter	Measured result	Limit *	Difference to the 30 cm value	Test result
Electric field strength	0.0597 V/m at 30 cm distance	75.5 V/m	-	Passed *

*: The NEARFI PD 2A ETH R generates an electric field strength, which is below the level for MPE of persons in General Population / Uncontrolled Exposure [1].



Test equipment (please refer to chapter 5 for details)
1 – 4

3.8 Measurement of H field strength from the client with source at maximum distance

Ambient temperature:	22 °C
Relative humidity:	24 %

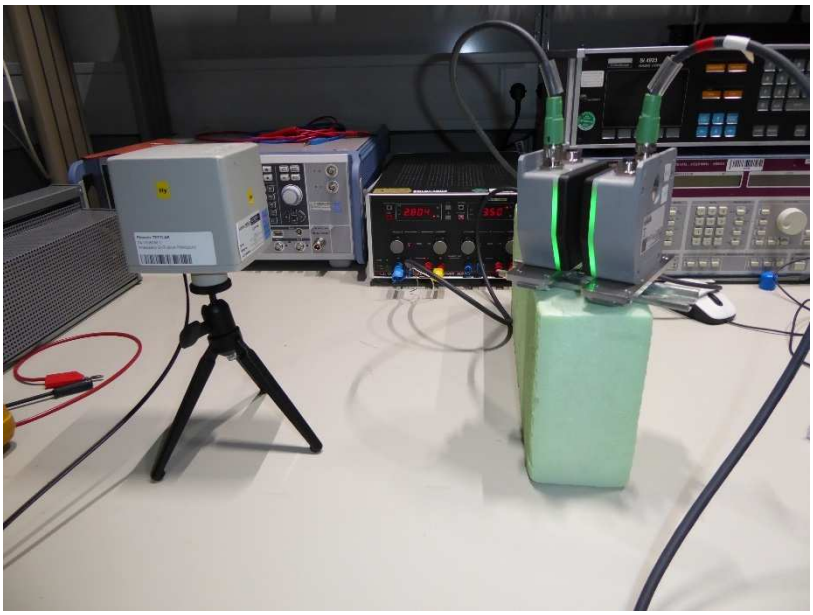
Date:	06.12.2023
Tested by:	Th. KÜHN

The EUT operates in the frequency range 8.99 MHz to 10.92 MHz.

Before the measurement the environmental fields must be considered, and the field probe has to be zeroed. Because the EUT is installed on movable machine parts the safety distance between the user and the EUT is defined by the applicant with 30 cm. Therefore, the field probe was moved with a distance of 30 cm in all directions around the EUT and peak level of the field strength was observed. At the position of the maximum level the measurement was carried out with an averaging time of 6 minutes. The position of the maximum field strength and the test setup are shown in the photograph below. The client was loaded with the maximum current of 2 A.

Parameter	Measured result	Limit*	Difference to the 30 cm value	Test result
Magnetic field strength	0.0008 A/m at 30 cm distance	0.201 A/m	-	Passed *

*: The NEARFI PD 2A ETH R generates a magnetic field strength, which is below the level for MPE of persons in General Population / Uncontrolled Exposure [1].



Test equipment (please refer to chapter 5 for details)
1 – 4

3.9 MPE base exemption for the data communication part

The following information are based on test report F220996E1 of PHOENIX TESTLAB GmbH

General exemption CFR 47 §1.1307(b)(3)(i)(C)

P_{EIRP} [dBm]	P_{EIRP} [mW]	P_{ERP} [dBm]	P_{ERP} [mW]
-12.3 (measured value)	0.059	-14.45	0.026
10 dBm (rated value)	10.0	7.85	6.10

Frequency [GHz]	Wavelength λ [cm]	λ / 2π [cm]	d [cm]	d > λ / 2π
58.02	0.517	0.0822	30	Fullfilled

Frequency [GHz]	d [cm]	Threshold ERP [mW]	P_{ERP} [mW]	Result
58.02	30	1728	0.026 (measured)	Exempted
			6.10 (rated)	

The separation distance d is larger than the wavelength divided by 2 π. Therefore, the MPE Exemption could be used.

Due to the fact that for separation distances larger than d the value for P_{ERP} is lower than the threshold ERP this emission is exempted from SAR evaluation.

3.10 Simultaneous MPE results

The worst case MPE ratios of the stand-alone modules are calculated in the following:

For the WPT part:

Test scenario	Measurement result	Limit	WPT limit ratio
Client (EUT) without source	0.0610 V/m (refer clause 3.3)	75.5 V/m	**0.000813**
	0.0009 A/m (refer clause 3.4)	0.201 A/m	**0.004478**
Client (EUT) with source at minimum distance	0.0599 V/m (refer clause 3.5)	75.5 V/m	0.000793
	0.0008 A/m (refer clause 3.6)	0.201 A/m	0.003980
Client (EUT) with source at maximum distance	0.0597 V/m (refer clause 3.7)	75.5 V/m	0.000791
	0.0008 A/m (refer clause 3.8)	0.201 A/m	0.003980

For the data transmission part:

$Data_{ratio}$ (measured) = $\frac{0.026\ \mathrm{mW}}{1728\ \mathrm{mW}}$ = 0.000015

$Data_{ratio}$ (rated) = $\frac{6.1\ \mathrm{mW}}{1728\ \mathrm{mW}}$ = 0.003530

The Sum of the MPE ratios for the simultaneous transmission with the measured results is:

Sum = 0.000015 + 0.000813 + 0.004478

Sum = 0.005306 < 1.0

The Sum of the MPE ratios for the simultaneous transmission with the rated / measured results is:

Sum = 0.003530 + 0.000813 + 0.004478

Sum = 0.008821 < 1.0

4 Conclusion

The NEARFI PD 2A ETH B complies in all operational modes to the limits for General Population / Uncontrolled Exposure given in CFR 47 §1.1310(e)1 in a separation distance of 30 cm.

5 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. Due
1	Isotropical E- and H-fieldanalyser	EHP-200A	Narda	170WX80314	482643	31.08.2023	08.2025
2	Resistor	SZZL600x65-27	Frizlen	36324	482420	Calibration not necessary	
3	Power supply	TOE8752-32	Toellner	31569	480009	Calibration not necessary	
4	Multimeter	971A	Hewlett Packard	JP39009358	480721	07.09.2023	09.2024

6 Measurement uncertainties

Measurement method	Standard used for calculating measurement uncertainty	Expanded measurement uncertainty (95 %) U_{lab}
Measurements of electric and magnetic fields	DIN EN 50413, Ch. C2 DIN EN 62233, Ch. 5.6	20.6 % (H-F) 24.8 % (E-F)

7 Report History

Report Number	Date	Comment
F220995E5	15.08.2024	Initial Test Report
-	-	-
-	-	-