PHOENIX TESTLAB

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Test Report

Report Number:

F240849E7

Equipment under Test (EUT):

Torque transducer stator T100 / rotor T110

Applicant:

Hottinger Brüel & Kjaer GmbH

Manufacturer:

Hottinger Brüel & Kjaer GmbH

ilac-MRA

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-17186-01-00

References

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

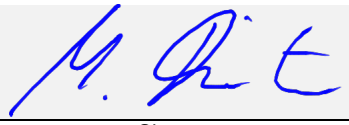
[2] **CFR 47 Rule part 2** Frequency Allocations and Radio Treaty Matters; General Rules and Regulations

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

[4] **KDB 680106 D01** Wireless Power Transfer v04

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. However, the measurement uncertainty is calculated and shown in this test report.

Tested and written by:		Michael DINTER 22.09.2025
	Signature	
Reviewed and approved by:		Mohamed Yassine Khalek 22.09.2025
	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:	Hottinger Brüel & Kjaer GmbH
Address:	Im Tiefen See 45, 64293 Darmstadt
Country:	Germany
Name for contact purposes:	Mr. Sebastian MUTINELLI
Phone:	+49 (0)6151-803-0
eMail address:	info.de@hbkworld.com
Applicant represented during the test by the following person:	None

1.2 Manufacturer

Name:	Hottinger Brüel & Kjaer GmbH
Address:	Im Tiefen See 45, 64293 Darmstadt
Country:	Germany
Name for contact purposes:	Mr. Sebastian MUTINELLI
Phone:	+49 (0)6151-803-0
eMail address:	info.de@hbkworld.com
Manufacturer represented during the test by the following person:	None

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. 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: *	Torque transducer stator	Torque transducer rotor
Model name: *	T100	T110
Model number: *	N/A	N/A
Order number: *	K-T100-STL-FAN-0-U	K-T110-500Q-S-0-0
FCC ID: *	2ADAT-DRQZ02B	2ADAT-DRQX02B

	EUT number T100		
	1	2	3
Serial number: *	281230132	-	-
PCB identifier: *	Mainboard: Rev. 02 Receiver: Rev. 02 Processor: Rev. 01 Power modul: Rev. 02	-	-

	EUT number T110		
	1	2	3
Serial number: *	264530007	-	-
PCB identifier: *	Rev. 02	-	-

* Declared by the applicant

One Torque transducer stator T100 / rotor T110 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: *	DC		
Supply voltage EUT: *	U_{nom} = 24 V_{DC}	U_{min} = 12 V_{DC}	U_{max} = 30 V_{DC}
Temperature range: *	-20 °C to +85 °C		
Lowest / highest internal frequency: *	120 kHz, 200 MHz		

* Declared by the applicant

Communication part T100 RX and T110 TX	
Operating frequency: *	15.36 MHz
Number of channels: *	1
Type of modulation: *	AM
Data rate: *	15.36 MBit
Duty cycle: *	50%
Antenna type: *	Coil
Antenna connector: *	Solder pad

* Declared by the applicant

WPT part T100 TX and T110 RX	
Operating frequency: *	120 kHz
Antenna type: *	Coil
Type of modulation: *	FSK
Antenna connector: *	Solder pad

Equipment used for testing	
Data cable termination box: *1	HBK test device
Laptop PC: *1	Dell Precision M4800

*1 Provided by the applicant

1.6 Dates

Date of receipt of test sample:	18.09.2024
Start of test:	13.02.2025
End of test:	13.02.2025

2 Operational States

Description of function of the EUT:

The EUT is a digital torque measurement system working with 15.36 MHz radio communication and 120 kHz wireless power transfer.

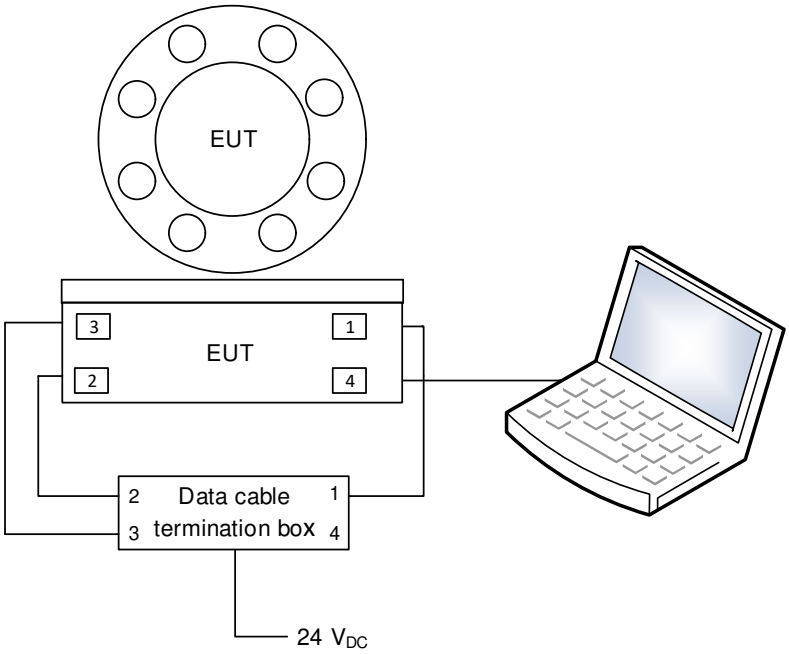
During all tests the EUT was powered with 24 V DC external power supply and internal via 120 kHz WPT.

The stator transmits WPT at 120 kHz and receives at 15.36 MHz.
The rotor receives WPT at 120 kHz and transmits at 15.36 MHz.

The following states were defined as the operating conditions:

During all tests, a continuously wireless power transfer via 120 kHz and a radio communication via 15.36 MHz was established.

The EUT was set up as follows:



3 Additional Information

As declared by the applicant the device is rotating in normal operation.

Therefore, a minimum safety distance of 20 cm for a normal person was declared by the applicant.

4 Evaluation Method

4.1 RF exposure test exemptions for single sources

4.1.1 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);

4.1.2 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	$P_{th}(mW) = ERP_{20cm}\left(\frac{d}{20}\right)^{x}$ $ERP_{20cm}\ (mW) = 3060$ $x = -log_{10}\left(\frac{60}{ERP_{20cm}\sqrt{f}}\right)$	$P_{th}(mW) = ERP_{20cm}$ $ERP_{20cm}\ (mW) = 3060$

4.1.3 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

4.1.4 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

4.2 RF exposure test exemptions for simultaneous transmission sources

4.2.1 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.

4.2.2 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.

4.2.3 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.

5 Results of evaluation

5.1 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)	4.1.1	-
☐	SAR Based Exemption acc. CFR 47 §1.1307(b)(3)(i)(B)	4.1.2	-
☐	MPE Based Exemption acc. CFR 47 §1.1307(b)(3)(i)(C)	4.1.3	-
☐	MPE Calculation	4.1.4	-
☒	MPE Evaluation	4.1.4	-

RF Exposure test exemptions for simultaneous transmission sources			
Used	Method	See sub-clause	Comment
☐	Not applicable		No simultaneous transmission possible
☐	1 mW test Exemption acc. 2.2.1 [3]	4.2.1	-
☐	SAR Based Exemption acc. 2.2.2 [3]	4.2.2	
☒	MPE Based Exemption acc. 2.2.2 [3]	4.2.2	
☐	SAR to Peak location separation ratio acc. 2.2.3 [3]	4.2.3	

5.2 Evaluation Distance

The device as declared by the applicant is a fixed installed device which is used at least at 20 cm separation distance between the device and the users.

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

Ambient temperature:	22 °C
Relative humidity:	21 %

Date:	14.02.2025
Tested by:	M. DINTER

The EUT operates in the frequency range 120 kHz and 15.36 MHz.

Before the measurement, the environmental fields must be considered, and the field probe has to be zeroed. Because the EUT is fixed installed the safety distance between the user and the EUT is defined by the applicant with 20 cm. Therefore, the field probe was moved with a distance of 20 cm in all directions around the EUT and Therefore, the field probe was moved with a distance of 20 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. The EUT was in operation mode without mechanical load and non-rotating.

Operating frequency power transfer 120 kHz stator T100.

Parameter	Measured result	Limit *	Test result
Electric field strength	0.9624 V/m at 20 cm distance (temporal peak field strengths)	614 V/m	Passed **

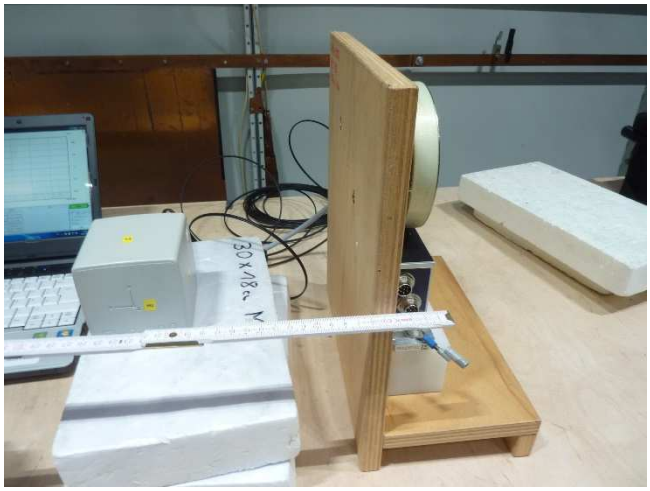
*: Limit for frequencies below 300 kHz according to clause 3.2 [4].

Operating frequency 15.36 MHz communication rotor T110.

Parameter	Measured result	Limit *	Test result
Electric field strength	0.1428 V/m at 20 cm distance (averaging time of 6 minutes)	53.6 V/m	Passed **

*: Limit for frequencies 3 – 30 MHz according to clause CFR 47 §1.1310(e)1 [1].

**: The Torque transducer stator T100 / rotor T110 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

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

Ambient temperature:	22 °C
Relative humidity:	21 %

Date:	14.02.2025
Tested by:	M. DINTER

The EUT operates in the frequency range 120 kHz and 15.36 MHz.

Before the measurement the environmental fields must be considered, and the field probe has to be zeroed. Because the EUT is fixed installed the safety distance between the user and the EUT is defined by the applicant with 20 cm. Therefore, the field probe was moved with a distance of 20 cm in all directions around the EUT and Therefore, the field probe was moved with a distance of 20 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. The EUT was in operation mode without mechanical load and non-rotating.

Operating frequency power transfer 120 kHz stator T100.

Parameter	Measured result	Limit *	Test result
Magnetic field strength	0.94 A/m at 20 cm distance (temporal peak field strengths)	1.63 A/m	Passed **

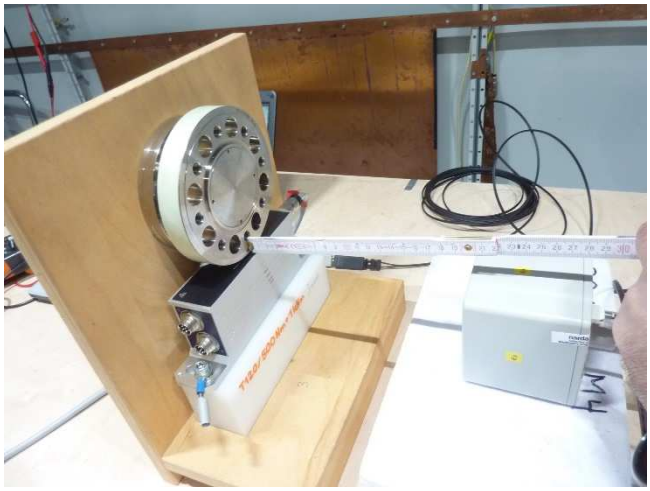
*: Limit for frequencies below 300 kHz according to clause 3.2 [4].

Operating frequency 15.36 MHz communication rotor T110.

Parameter	Measured result	Limit *	Test result
Magnetic field strength	0.0022 A/m at 20 cm distance (averaging time of 6 minutes)	0.1426 A/m	Passed **

*: Limit for frequencies 3 – 30 MHz according to clause CFR 47 §1.1310(e)1 [1].

**: The Torque transducer stator T100 / rotor T110 generates an 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

6 Simultaneous transmission

As declared by the applicant, the 15.36 MHz communication transmitter and the 120 kHz power transfer operate simultaneously.

Ratio assessment:

	Field strength [A/m]	Limit [A/m]	H-field / Limit Ratio
120 kHz Power transfer H-field	0.94	1.63	0.5767

	Field strength [A/m]	Limit [A/m]	H-field / Limit Ratio
15.36 MHz Communication H-field	0.0022	0.1426	0.0154

	Field strength [V/m]	Limit [V/m]	E-field / Limit Ratio
120 kHz Power transfer E-field	0.9624	614	0.0016

	Field strength [V/m]	Limit [V/m]	E-field / Limit Ratio
15.36 MHz Communication E-field	0.1428	53.6	0.0027

Limit	Sum Ratios
1	0.5963

Result
The sum of the ratios is below 1. Therefore, this device is also below the reference level while all transmitters operate simultaneously in a safety distance between the user and the EUT of 20 cm.

7 Conclusion

The EUTs stator T100 and rotor T110 comply in all operational modes to the limits given in CFR 47 §1.1310(e)1 at a distance of 20 cm.

8 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)

9 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	27.01.2025	01.2027

10 Report History

Report Number	Date	Comment
F240849E7	22.09.2025	Initial Test Report
-	-	-
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----- end of test report -----