PHOENIX TESTLAB

Königswinkel 10
32825 Blomberg, Germany
Phone: +49 (0) 52 35 / 95 00-0
Fax: +49 (0) 52 35 / 95 00-10
office@phoenix-testlab.de
www.phoenix-testlab.de

FCC RF Exposure Evaluation

Report Number:

F231143E3

Equipment under Test (EUT):

Liquiphant FTL43

Applicant:

Endress+Hauser SE+Co. KG

Manufacturer:

Endress+Hauser SE+Co. KG

ilac-MRA

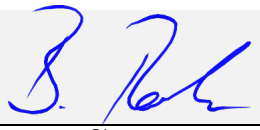
DAkkS
Deutsche
Akkreditierungsstelle
D-PL-17186-01-00

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**

Assessed and written by:		Bernward ROHDE 22.11.2024
	Signature	
Reviewed and approved by:		Manuel BASTERT 22.11.2024
	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 4
1.1 Applicant 4
1.2 Manufacturer 4
1.3 Test Laboratory 4
1.4 EUT (Equipment under Test) 5
1.5 Technical Data of Equipment 5
1.6 Additional Information 6
2 Evaluation Methods 7
2.1 RF exposure test exemptions for single sources 7
2.1.1 General Exemption CFR 47 §1.1307(b)(3)(i)(A) 7
2.1.2 SAR Based Exemption CFR 47 §1.1307(b)(3)(i)(B) 7
2.1.3 MPE Based Exemption CFR 47 §1.1307(b)(3)(i)(C) 7
2.1.4 Stand alone MPE evaluation limits 8
2.2 RF exposure test exemptions for simultaneous transmission sources 9
2.2.1 1 mW Test Exemption for simultaneous transmission sources 9
2.2.2 Simultaneous transmission SAR based and MPE based test exemptions 9
2.2.3 Test exemption based on the SAR to Peak Location Separation Ratio 10
3 Results of evaluation 11
3.1 Used evaluation methods 11
3.2 BLE 2.4 GHz Emissions 12
4 Conclusion 13
5 Report History 13

1 Identification

1.1 Applicant

Name:	Endress+Hauser SE+Co. KG
Address:	Hauptstr. 1, 79689 Maulburg
Country:	Germany
Name for contact purposes:	Mr. Ralf REIMELT
Phone:	+49 76 22 28 – 18 90
eMail address:	ralf.reimelt@endress.com
Applicant represented during the test by the following person:	---

1.2 Manufacturer

Name:	Endress+Hauser SE+Co. KG
Address:	Hauptstr. 1, 79689 Maulburg
Country:	Germany
Name for contact purposes:	Mr. Ralf REIMELT
Phone:	+49 76 22 28 – 18 90
eMail address:	ralf.reimelt@endress.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: *	Point level switch
Model name: *	Liquiphant FTL43
FCC ID: *	LCGFTL4X
IC certification number: *	2519A-FTL4X
PMN: *	FTL43, FTL60
HVIN: *	FTL43-2
FVIN: *	NA

	EUT number	
	1 (radiated)	2 (conducted PCB)
Serial number: *	FTL43_RED_EUT1	Engineering sample
PCB identifier: *	Sensor board: 71603955 Mainboard: 71439136 Terminal Board: 71439136 Visualisation Board: 71599584	Visualisation Board: 71599584
Hardware version: *	01.00.00	01.00.00
Software version: *	01.00.00	S140 V7.2.0 (Soft device)

* Declared by the applicant

1.5 Technical Data of Equipment

General EUT data			
Power supply EUT: *	DC		
Supply voltage EUT: *	U_{nom}= 24 V_{DC}	U_{min}= 12 V_{DC}	U_{max}= 30 V_{DC}
Temperature range: *	-40°C to +80°C		

Bluetooth® low energy frequencies			
Channel 00	2402 MHz	Channel 01	2404 MHz
Channel 02	2406 MHz	Channel 03	2408 MHz
…	…	…	…
…	…	…	…
Channel 18	2438 MHz	Channel 19	2440 MHz
…	…	…	…
…	…	…	…
Channel 36	2474 MHz	Channel 37	2476 MHz
Channel 38	2478 MHz	Channel 39	2480 MHz

Bluetooth® low energy radio mode		
Fulfils radio specification: *1	Bluetooth® low energy (BLE) 5.2	
Radio chip: *1	Nordic nRF52840 (SoC)	
Antenna type: *1	PCB IFA Antenna	
Antenna name: *1	n/a	
Antenna gain: *2	-0.3 dBi	
Antenna connector: *1	-	
Type of modulation: *1	BLE (1 Mbps PHY)	GFSK
	BLE (2 Mbps PHY)	GFSK
	BLE (500 kbps coded PHY)	GFSK
	BLE (125 kbps coded PHY)	GFSK
Operating frequency range: *1	BLE (1 Mbps PHY)	2402 – 2480 MHz
	BLE (2 Mbps PHY)	2402 – 2480 MHz
	BLE (500 kbps coded PHY)	2402 – 2480 MHz
	BLE (125 kbps coded PHY)	2402 – 2480 MHz
Number of channels: *1	BLE (1 Mbps PHY)	40 (2 MHz channel spacing)
	BLE (2 Mbps PHY)	40 (2 MHz channel spacing)
	BLE (500 kbps coded PHY)	40 (2 MHz channel spacing)
	BLE (125 kbps coded PHY)	40 (2 MHz channel spacing)

* Declared by the applicant
*2 based on the antenna test report F231143E4 by Phoenix TESTLAB GmbH

1.6 Additional Information

None

2 Evaluation Methods

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	-	No simultaneous possible
☐	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 BLE 2.4 GHz Emissions

MPE Based Exemption CFR 47 §1.1307(b)(3)(i)(C)

The following information are based on Test-Report F231143E2 of PHOENIX TESTLAB GmbH

P_{con} [dBm] incl. Tuneup	P_{con} [mW] incl. Tuneup	Ant. Gain [dBi]	Cable Antenuation [dB]	$P_{e.i.r.p}$ [dBm]	$P_{e.i.r.p}$ [mW]	$P_{e.r.p}$ [dBm]	$P_{e.r.p}$ [mW]
7.1	5.13	-0.3	0	6.8	4.79	4.65	2.92

Frequency [GHz]	Wavelength λ [cm]	λ/2π [cm]	d [cm]	d > λ/2π
2.48	12.0884056	1.9239295	20	**fulfilled**

Frequency [GHz]	d [cm]	Threshold ERP [mW]	$P_{e.r.p.}$ [mW]	Result
2.48	20	**768**	**2.92**	**exempted**

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

MPE Calculation

P_{con} [dBm] incl. Tuneup	P_{con} [mW] incl. Tuneup	Ant. Gain [dBi]	Cable Antenuation [dB]	$P_{e.i.r.p}$ [dBm]	$P_{e.i.r.p}$ [mW]	$P_{e.r.p}$ [dBm]	$P_{e.r.p}$ [mW]
7.1	5.13	-0.3	0	6.8	4.79	4.65	2.92

Frequency [MHz]	$P_{e.i.r.p}$ [mW]	Duty cycle D [%]	Distance d [cm]	S [mW/cm²]	S_{limit} [mW/cm²]	Result
2.48	4.79	98	20	**0.0009**	**1**	**exempted**

Due to the fact that for separation distances larger than d the Power Density S is below S_{limit} this emission is exempted from SAR Evaluation

4 Conclusion

The EUT complies in all operational modes to the limits given in CFR 47 §1.1310(e)1 in a separation distance of 20 cm.

5 Report History

Report Number	Date	Comment
F231143E3	22.11.2024	Initial Test Report
-	-	-
-	-	-

---end of test report ---