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:

F231416E6

Equipment under Test (EUT):

Level Probing Radar

Micropilot FMR30B

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:	o. b. o.	Martin Eppinger 23.01.2025
	Signature	
Reviewed and approved by:		Bernward ROHDE 23.01.2025
	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.

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1 Identification

1.1 Applicant

Name:	Endress+Hauser SE+Co. KG
Address:	Hauptstr. 1, 79689 Maulburg
Country:	Germany
Name for contact purposes:	Mr. Florian SEIDLER, Mr. Ralf REIMELT
Phone:	+49 7622 28 1450
eMail address:	florian.seidler@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. Florian SEIDLER, Mr. Ralf REIMELT
Phone:	+49 7622 28 1450
eMail address:	florian.seidler@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) 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: *		Level Probing Radar
Model name: *		Micropilot
Model number: *		FMR30B
Order number: *		FMR30B-AABAKABNXQ0XR03
FCC ID: *	VU231C:	LCGVU231C
	Device:	LCGFMR30BL

* Declared by the applicant

Serial number: *	FMR30B_HA2W_0235		
PCB identifier: *	VU231C:		71599593
	Device:	Main:	71499710
		Terminal:	71581366
		Power:	71502179
		Sensor:	71574004
Hardware version: *	VU231C:		01.00.00
	Device:		01.00.00
Software version: *	VU231C:		S140 V7.2.0
	Device:		V01.00.00

* Declared by the applicant

1.5 Technical Data of Equipment

General EUT data			
Power supply EUT: *	DC		
Supply voltage EUT: *	U_{nom} = 24.0 V_{DC}	U_{min} = 12.0 V_{DC}	U_{max} = 30.0 V_{DC}
Temperature range: *	-40 °C to +80 °C		
Lowest / highest internal clock frequency: *	2.25 MHz / 84 GHz		

* Declared by the applicant

Radar part	
Type of equipment:	Level Probing Radar Micropilot FMR30B
Rated rf-output power: *	20 dBm/MHz
Antenna type: *	Encapsulated, PVDF, 40mm/1-1/2” Encapsulated, PVDF, 80mm/3”
Operating frequency band: *	75 GHz to 85 GHz
Nominal channel bandwidth(s): *	4 GHz
Type of modulation: *	FMCW
Antenna connector: *	None

* Declared by the applicant

Bluetooth® low energy part	
Fulfils Bluetooth specification: *	Bluetooth® Low Energy™ 5.1
Operating frequency range: *	2402 MHz – 2480 MHz
Number of channels: *	40
Type of modulation: *	GFSK
Antenna type / name: *	Integral PCB antenna

* Declared by the applicant

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 or 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 Standalone 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
☒	Not applicable	-	-
☐	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 CFR47 §2.1091 the device as declared by the applicant is a mobile device which is used at least with a separation distance of 20 cm between the device and the users.

3.3 Output power

The following information is based on the test-reports F231413E4 and F231416E1 by PHOENIX TESTLAB GmbH.

4 MPE evaluation

The power density is calculated as follows:

$$Power\ density = \frac{P \cdot D \cdot G}{4 \cdot \pi \cdot R^2}$$

Where:

P: conducted power [mW]

D: Duty cycle (linear)

G: Antenna gain (linear)

R: minimum separation distance from antenna to the user [cm]

4.1 Stand-alone MPE results

Band	Frequency [GHz]	Output power	Duty cycle [dB]	Antenna Gain [dBi]	Distance [cm]	Power Density [mW/cm²]	Limit of Power Density [mW/cm²]	Reference
Radar	77 to 81	32.8 dBm / 1.91 W	0.014	-*1	20	**0.005**	1.0	Test report F231416E1
Bluetooth® LE	2.402 to 2.480	8.0 dBm / 6.31 mW	1	1.1 *2	20	**0.0016**	1.0	Maximum output power *3

*1: No antenna gain is regarded because the documented value is a radiated (e.i.r.p.) value, the antenna gain is already included.
*2: The antenna gain was calculated according to antenna report F231413E5 by PHOENIX TESTLAB GmbH
*3: Maximum output power including tune up range as declared by the applicant

4.2 Simultaneous MPE results

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

For the Bluetooth part:

$BT_{ratio} = \frac{0.0016\ mW/cm^2}{1.0\ mW/cm^2} = 0.0016$

For the radar part:

$Radar_{ratio} = \frac{0.005\ mW/cm^2}{1.0\ mW/cm^2} = 0.005$

The sum of the MPE ratios for the simultaneous transmission is:

Sum = 0.0016 + 0.005

Sum = 0.0066 < 1.0

5 Conclusion

As the sum of the MPE ratios is less than 1.0, the device is excluded from the simultaneous transmission MPE test.

A safety statement concerning the minimum separation distance from enclosure of the device has to be integrated in the user´s manual to provide end-users with transmitter operating conditions for satisfying RF exposure compliance.

6 Report History

Report Number	Date	Comment
F231416E6	23.01.2025	Initial Test Report
-	-	-
-	-	-

--- end of test report ---