

RF-EXPOSURE REPORT FCC 47 CFR Part 2.1093 RF-Exposure evaluation of portable equipment	
Report Reference No	G0M-2403-2497-TFC093PE01-V01
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Accreditation	 A2LA Accredited Testing Laboratory, Certificate No.: 1983.01 FCC Test Firm Designation Number: DE0008 ISED Testing Laboratory site: 3470A
Applicant	Jungheinrich AG
Address	Friedrich-Ebert-Damm 129 22047 Hamburg Germany
Test Specification	According to FCC rules
Standard	FCC 47 CFR 2.1093
Non-Standard Test Method	None
Equipment under Test (EUT):	
Product Description	UWB-Location-System is able to measure distances between the UWB components
Model(s)	52445055, Person Tag
Additional Model(s)	None
Brand Name(s)	zoneCONTROL
Hardware Version(s)	10616
Software Version(s)	0.0.30
FCC-ID	2AK6M-52445055
Test Result	PASSED

Possible test case verdicts:		
required by standard but not tested	N/T	
not required by standard	N/R	
test object does meet the requirement	P(PASS)	
test object does not meet the requirement	F(FAIL)	
Testing:		
Test Lab Temperature	20 °C - 30 °C	
Test Lab Humidity	25 % - 55 %	
Date of performance	2024-11-28	
Date of receipt of test item	See test sample identification table on page 7	
Report:		
Compiled by	Stephan Liebich	
Tested by (+ signature) (Responsible for Test)	Stephan Liebich	
Approved by (+ signature) (Senior Radio Expert)	Radwan Jaafar	
Date of Issue	2024-11-28	
Total number of pages	23	
General Remarks:		
The test results presented in this report relate only to the object tested. The results contained in this report reflect the results for this particular model and serial number. It is the responsibility of the manufacturer to ensure that all production models meet the intent of the requirements detailed within this report. This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory. The above equipment has been tested by Eurofins Product Service GmbH, and found compliance with the requirements of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's RF characteristics under the conditions specified in this report. Compliance of electromagnetic emission from electronic and electrical equipment with the basic restrictions usually is determined by measurements and, in some cases, calculation of the exposure level. If the electrical power used by or radiated by the equipment is sufficiently low, the electromagnetic fields emitted will be incapable of producing exposures that exceed the basic restrictions. Any relevant compliance assessment procedure which is consistent with the state of the art, reproducible and gives valid results can be used.		

For transmitters intended for use with more than one antenna configuration option, the combination of transmitter and antenna(s) which generates the highest available antenna power and/or average total radiated power shall be assessed.

Additional Comments:

RF-Exposure calculation is partly based on measurement results from reference documents.

VERSION HISTORY

Version History			
Version	Issue Date	Remarks	Revised By
01	2024-11-28	Initial Release	--

ABBREVIATIONS AND ACRONYMS

Acronyms	
Acronym	Description
EIRP	Equivalent Isotropic Radiated Power
ERP	Effective Radiated Power
EUT	Equipment Under Test
LPE	Low Power Exclusion

REPORT INDEX

1	Equipment (Test Item) Under Test.....	7
1.1	Photos – Equipment.....	8
1.2	Support Equipment.....	12
1.3	Test Modes	12
1.4	EUT Configuration.....	12
1.5	Sample emission level calculation.....	13
1.7	Reference Documents.....	15
1.8	Standalone radiation sources	16
1.9	Concurrent Sources	16
2	Result Summary.....	17
3	RF-Exposure classification	18
4	RF-Exposure limits and exclusion thresholds	19
4.1	SAR limits.....	19
4.2	SAR standalone test exclusion threshold	19
4.3	SAR concurrent test exclusion threshold.....	20
5	RF-Exposure Evaluation	21
6	Single Source Evaluation Results - FCC	22
7	Concurrent Evaluation Results - FCC.....	23

1 Equipment (Test Item) Under Test

Description	UWB-Location-System is able to measure distances between the UWB components			
Model	52445055, Person Tag			
Additional Model(s)	None			
Brand Name(s)	zoneCONTROL			
Sample Identification	EUT #	Sample-ID	Serial Number	Date of receipt
	EUT 1	48553	ID:17:B4:10:02:41:FA	2024-05-14
	EUT 2	See reference documents	See reference documents	See reference documents
Hardware Version(s)	10616			
Software Version(s)	0.0.30			
FCC ID	2AK6M-52445055			
Equipment type	End Product			
Number of antenna ports	2			
Number of radios	2			
Radio 1	Radio type	Transceiver		
	Operating frequency range	2400.0 MHz - 2483.5 MHz		
	Radio technology	IEEE 802.15.4		
	Modulation	O-QPSK		
	Port	IF1		
Antenna 1	Type	Integrated		
	Model	PCB		
	Manufacturer	Siemens		
	Gain	0.69 dBi (antenna pattern measurement)		
	Port	IF1		
Radio 2	Radio type	Transceiver		
	Operating frequency range	3.1 – 10.6 GHz		
	Radio technology	Ultra Wide-band		
	Modulation	BPSK with BPM		
	Port	IF2		
Antenna 2	Type	Integrated antenna		
	Model	PCB Antenna		
	Manufacturer	Siemens		
	Gain	4.15 dBi @ 4.0 GHz 8.38 dBi @ 6.5 GHz		
	Port	IF2		
Supply Voltage	V _{NOM}	5 V DC		
Dedicated AC/DC-Adaptor	None			
Environment	General public			
Use case	Body worn			

1.2 Support Equipment

Product Type	Device	Manufacturer	Model	Comment
AE	Laptop	HP	ProBook	For setting test modes
AE	USB-Serial-Adapter	Agilon	Not specified	--
CBL	Cable	Siemens	Not specified	From PCB with COM port to EUT
CBL	USB Cable	A-B Cable	Not specified	--
SFT	RadioMode Setup Tool v3.1.0	Siemens	Not specified	For setting test modes
AE	Charging station	Siemens	6GT2790-0DD20	--
AE	Power Adapter	Mean Well	GST60A05	For charging station
Description:				
AE	Auxiliary Equipment			
SIM	Simulator			
CBL	Connecting Cable			
SFT	Software			
Comment: --				

1.3 Test Modes

Mode	Description
Transmit	Mode = Transmit Modulation = BPSK with BPM Duty cycle = 100% Power setting = 0 dB (set by the software provided by customer)
Comment: --	

1.4 EUT Configuration

Configuration #	Description
1	EUT is powered by internal battery with a supply voltage of ~3.7 V DC. Ultra-wide band operates in 2 frequency bands (4 GHz and 6.5 GHz).

1.5 Sample emission level calculation

The following is a description of terms and a sample calculation, as appears in the radiated emissions data table. The numbers used in the calculation are for example only. There is no direct correlation to the specific data taken for the product described in this document:

Reading:

This is the reading obtained on the spectrum analyzer in dB μ V. Any external preamplifiers used are taken into account through internal analyzer settings.

A.F.:

This is the antenna factor for the receiving antenna. It is a conversion factor, which converts electric fields strengths to voltages, which can be measured directly on the spectrum analyzer. It is treated as a loss in dB. Cable losses have been included with the A.F. to simplify the calculations. The antenna factor is used in calculations as follows:

$$\text{Reading on Analyzer (dB}\mu\text{V)} + \text{A.F. (dB/m)} = \text{Net field strength (dB}\mu\text{V/m)}$$

Net:

This is the net field strength measurement (as shown above).

Margin:

This is the margin of compliance below the FCC limit. The units are given in dB. A negative margin indicates the emission was below the limit. A positive margin indicates that the emission exceeds the limit.

Field strength limit:

This is the FCC Class B radiated emission limit (in units of dB μ V/m). The FCC limits are given in units of μ V/m. The following formula is used to convert the units of μ V/m to dB μ V/m:

$$\text{Field strength limit (dB}\mu\text{V/m)} = 20 \cdot \log (\mu\text{V/m})$$

Example only for radiated field strength:

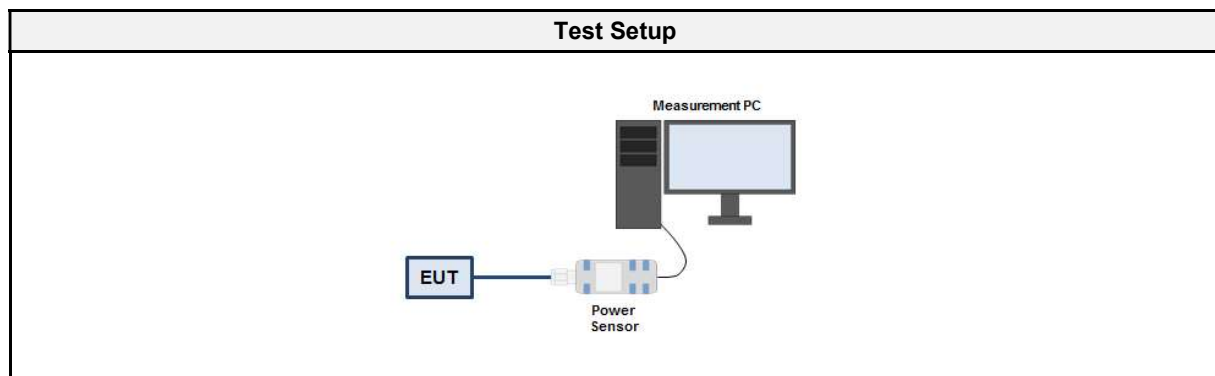
Reading + AF	= Net Reading	:	Net reading	- Field strength limit	= Margin
+21.5 dB μ V	+ 26 dB/m	:	47.5 dB μ V/m	- 57.0 dB μ V/m	= -9.5

1.6 Test Conditions and Results - Maximum RMS conducted output power

1.6.1 Information

Test Information	
Measurement Uncertainty	± 2.86 dB
Operator	Md Abu Bakar Siddique
Date	2024-11-25
EUT#	EUT 1

1.6.2 Setup



1.6.3 Equipment

Test Equipment					
Description	Manufacturer	Model	Identifier	Cal. Date	Cal. Due
Power meter	Rohde & Schwarz	NRVD	EF00157	2024-07	2026-07
Power sensor	Rohde & Schwarz	NRV-Z51	EF00172	2023-08	2026-08

1.6.4 Procedure

Test Procedure
1. EUT set to test mode 2. The EUT antenna port is connected to a wideband power sensor 3. The RMS power is measured with the power sensor

1.6.5 Results

Test Results		
Channel [GHz]	Power [dBm]	Power [W]
3.9935	-24.14	0.00385
6.4895	-31.36	0.00073

1.7 Reference Documents

Document Type	Document No.	Issued by	Date
RADIO REPORT	G0M-2403-2497-TFC247ZB-V01	Eurofins Product Service GmbH	2024-11-26
RADIO REPORT	G0M-2403-2497-TFC15FUW-V01	Eurofins Product Service GmbH	2024-11-26
ANTENNA UNDER TEST REPORT	G0M-2403-2497-TFCAUT-V01	Eurofins Product Service GmbH	2024-11-26

1.8 Standalone radiation sources

Standalone radiation sources					
Mode	Operating Frequency [MHz]	Maximum conducted power [dBm]	Maximum radiated power [dBm EIRP]	Maximum duty cycle [%]	Antenna distance to body [mm]
IEEE 802.15.4 (2.4 GHz)	2405	1.549	2.239	100	5
	2440	3.380	4.07	100	5
	2475	5.547	6.237	100	5
UWB (4 GHz)	3993.5	-24.14	-19.99	100	5
UWB (6.5 GHz)	6489.5	-31.36	-22.98	100	5
Comment: --					

1.9 Concurrent Sources

Concurrent operating conditions
IEEE 802.15.4 (2.4 GHz) + UWB (4 GHz) + UWB (6.5 GHz)
Comment: --

2 Result Summary

Standalone sources - FCC KDB 447498				
Product Standard Reference	Requirement	Reference Method	Mode	Verdict
KDB 447498	SAR Test Exclusion	KDB 447498 4.3.1	IEEE 802.15.4 (2.4 GHz)	PASS
KDB 447498	SAR Test Exclusion	KDB 447498 4.3.1	UWB (4 GHz)	PASS
KDB 447498	SAR Test Exclusion	KDB 447498 4.3.1	UWB (6.5 GHz)	PASS
Comment: SAR test exclusion power threshold acc. to FCC KDB 447498 D01 is max. $1.9 \leq 3.0$ 1g SAR				
Concurrent operational modes - FCC KDB 447498				
Product Standard Reference	Requirement	Reference Method	Mode	Verdict
KDB 447498	SAR Test Exclusion	KDB 447498 4.3.2	IEEE 802.15.4 (2.4 GHz) + UWB (4 GHz) + UWB (6.5 GHz)	PASS
Comment: --				

3 RF-Exposure classification

RF-Exposure Categories	
Fixed	A fixed device is defined as a device physically secured at one fixed location and cannot be easily re-located.
Mobile	A mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons.
Portable	A portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user.

RF-Exposure Categories	
Occupational / Controlled	Limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.
General population / Uncontrolled	Exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

4 RF-Exposure limits and exclusion thresholds

4.1 SAR limits

SAR Limits		
Type	Occupational SAR values [W / kg]	General population SAR values [W / kg]
Whole-body SAR averaging mass = entire body	0.4	0.08
Partial-body Localized Head, Neck and Trunk SAR averaging mass = 1g	8.0	1.6
Hands, Wrists, Feet and Ankles Localized Limbs SAR averaging mass = 10g	20.0	4

4.2 SAR standalone test exclusion threshold

SAR test exclusion power acc. to FCC KDB 447498 D01 – Standalone operation
Unless specifically required by the published RF exposure KDB procedures, standalone 1-g head or body and 10-g extremity SAR evaluation for general population exposure conditions, by measurement or numerical simulation, is not required when the corresponding SAR Exclusion Threshold condition, listed below, is satisfied. These test exclusion conditions are based on source-based time-averaged maximum conducted output power of the RF channel requiring evaluation, adjusted for tune-up tolerance, and the minimum test separation distance required for the exposure conditions. The minimum test separation distance is determined by the smallest distance from the antenna and radiating structures or outer surface of the device, according to the host form factor, exposure conditions and platform requirements, to any part of the body or extremity of a user or bystander The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by: a) For 100 MHz to 6 GHz and test separation distances ≤ 50 mm $\frac{\text{max. power of channel [mW]}}{\text{min. test separation distance [mm]}} \cdot \sqrt{f[\text{GHz}]} \leq \begin{cases} 3.0 & 1\text{g SAR} \\ 7.5 & 10\text{g SAR} \end{cases}$ b) For 100 MHz to 6 GHz and test separation distances > 50 mm 1) For 100 to 1500 MHz $\left\{ \text{Power allowed at numeric threshold for 50 mm in step a} + (\text{test separation distance} - 50\text{mm}) \cdot \frac{f(\text{MHz})}{150} \right\}, \text{mW}$ 2) for > 1500 MHz and ≤ 6 GHz $\{ \text{Power allowed at numeric threshold for 50 mm in step a} + (\text{test separation distance} - 50\text{mm}) \cdot 10 \}, \text{mW}$ c) for frequencies below 100 MHz: 1) test separation distances > 50 mm and < 200 mm: the power threshold at the corresponding test separation distance at 100 MHz in step b) is multiplied by $\left(1 + \log \left(\frac{100}{f(\text{MHz})} \right) \right)$ 2) test separation distances ≤ 50 mm: the power threshold determined by the equation in c) 1) for 50 mm and 100 MHz is multiplied by $\frac{1}{2}$

4.3 SAR concurrent test exclusion threshold

SAR test exclusion acc. to FCC KDB 447498 D01 – Concurrent operation	
When the sum of 1-g or 10-g SAR of all simultaneously transmitting antennas in an operating mode and exposure condition combination is within the SAR limit, SAR test exclusion applies to that simultaneous transmission configuration. For the test exclusion to apply, the maximum output power, duty factor, and other applicable parameters used in the standalone SAR tests, must be the same or more conservative than those required for simultaneous transmission. When an antenna qualifies for the standalone SAR test exclusion and also transmits simultaneously with other antennas, the standalone SAR value must be estimated according to the following to determine the simultaneous transmission SAR test exclusion criteria:	
1)	$\frac{\text{max.power of channel,including tune-up tolerance,mW}}{\text{min.test separation distance,mm}} \cdot \frac{\sqrt{f(\text{GHz})}}{x}, \text{ for test separation distances } \leq 50 \text{ mm}$ where x = 7.5 for 1-g SAR and x = 18.75 for 10-g SAR
2)	0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the test separation distance is > 50 mm

5 RF-Exposure Evaluation

Evaluation procedure acc. to FCC KDB 447498	
<u>Standalone operational modes</u>	
1)	For each standalone operational mode the associated frequencies, radiated output power values, duty cycles and antenna separation distances to the human body are specified
2)	From the radiated power and the duty cycle the source-based time averaged radiated output power is calculated
3)	The transmission frequency, average power and separation distance is used to determine the SAR test exclusion power threshold value acc. to FCC KDB 447498 D01
4)	If the time averaged output power of the transmission mode is lower than the SAR test exclusion power threshold value, the mode clarifies for SAR test exclusion and no further SAR evaluation is needed
<u>Concurrent operational modes</u>	
1)	For each operational mode that participates in the concurrent operational mode, the estimated SAR is calculated from the source-based time average conducted output power and the separation distance to the human body for each transmission frequency of the operation mode
2)	The maximum estimated SAR value for each operational is determined
3)	The sum of SAR values of the maximum estimated SAR values for each operational mode is calculated
4)	If the sum of SAR values is below the corresponding SAR limit, the concurrent operational mode clarifies for SAR test exclusion and no further evaluation is needed

6 Single Source Evaluation Results - FCC

Results – Standalone Operational Modes							
Mode	Frequency [MHz]	Power [mW]	Duty Cycle	Average Power [mW]	Distance [mm]	Power Limit [mW]	Verdict
IEEE 802.15.4 (2.4 GHz)	2405	1.43	1.00	1.43	5.0	10	PASS
	2440	2.18	1.00	2.18	5.0	10	PASS
	2475	3.59	1.00	3.59	5.0	10	PASS
UWB (4 GHz)	3993.5	0.00	1.00	0.00	5.0	8	PASS
UWB (6.5 GHz)	6489.5	0.00	1.00	0.00	5.0	N/A	PASS
Comment: --							

7 Concurrent Evaluation Results - FCC

IEEE 802.15.4 (2.4 GHz) + UWB (4 GHz) + UWB (6.5 GHz)				
Mode	Frequency [GHz]	Average Power [mW]	Distance [mm]	SAR Value [W/kg]
IEEE 802.15.4 (2.4 GHz)	2.475000	3.59	5	0.15
UWB (4 GHz)	3.993500	0.00	5	0.00
UWB (6.5 GHz)	6.489500	0.00	8	0.00
Sum SAR [W/kg]				0.15
SAR Limit [W/kg]				1.6
Compliance				PASS
Comment: --				

=== End of test report ===