RF-EXPOSURE REPORT

FCC 47 CFR Part 2.1093
FCC 47 CFR Part 1.1310
ISED RSS-102

RF-Exposure evaluation of portable equipment

Report Reference No	G0M-2006-9089-TFC093PEX-V01
Testing Laboratory	Eurofins Product Service GmbH
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Accreditation	 DAkkS - Registration number : D-PL-12092-01-03 (ISED) ISED Testing Laboratory site: 3470A-2 DAkkS - Registration number : D-PL-12092-01-04 (FCC) FCC Filed Test Laboratory, Reg.-No.: 96970
Applicant	In-Circuit GmbH
Address	Boltenhagener Str. 124 01109 Dresden GERMANY
Test Specification	According to FCC/ISED rules
Standard	FCC 47 CFR 2.1093 FCC 47 CFR 1.1013 ISED RSS-102 Issue 5
Non-Standard Test Method	None
Equipment under Test (EUT):	
Product Description	radio module with integrated microcontroller (nRF52840), BLE and UWB interface (DW1000)
Model(s)	radino40 DW1000
Additional Model(s)	None
Brand Name(s)	None
Hardware Version(s)	A
Software Version(s)	A
FCC-ID	2AWXURADINO40DW1000
IC	n/a
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 receipt of test item	2020-07-20 Test Sample ID 30163 Test Sample ID 30164

Report:		
Compiled by	Toralf Jahn	
Tested by (+ signature) (Responsible for Test)	Toralf Jahn	.....
Approved by (+ signature) (Head of Lab)	Christian Weber	.....
Date of Issue	2020-10-13	
Total number of pages	17	

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.

Additional Comments:

VERSION HISTORY

Version History			
Version	Issue Date	Remarks	Revised By
01	2020-10-13	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

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1 Equipment (Test Item) Under Test

Description	radio module with integrated microcontroller (nRF52840), BLE and UWB interface (DW1000)
Model	radino40 DW1000
Additional Model(s)	None
Brand Name(s)	None
Serial Number(s)	Not specified
Hardware Version(s)	A
Software Version(s)	A
PMN	n/a
HVIN	n/a
FVIN	n/a
HMN	n/a
FCCID	2AWXURADINO40DW1000
IC	n/a
Equipment type	End Product
Environment	General public
Use case	Body worn

1.1 Reference Documents

Document Type	Document No.	Issued by	Date
Test Report (FCC/ISED) – FCC 47 CFR § 15.247 + ISED RSS-247 Issue 2 (February 2017) – Bluetooth Low Energy	G0M-2006-9089-TFC247BL-V01	Eurofins Product Service GmbH	2020-08-03
Test Report (FCC/ISED) – FCC 47 CFR § 15.519 + ISED RSS-220 Issue 1, Amendment 1 (July 2018) – Ultra Wide Band	G0M-2006-9089-TFC15FUW-V01	Eurofins Product Service GmbH	2020-08-03

1.2 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]**
Bluetooth LE	2402	-1.7	-1.2	64	5.0
ULtra Wide Band	6489.6	-8.5	-6.3	100	5.0
Comment:					

1.3 Concurrent Sources

Concurrent operating conditions
Bluetooth LE + ULtra Wide Band
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	Bluetooth LE	PASS
47 CFR 1.1310	Maximum permissable exposure	KDB 447498	ULtra Wide Band	PASS
Comment:				

Standalone sources - ISED RSS-102				
Product Standard Reference	**Requirement**	**Reference Method**	**Mode**	**Verdict**
ISED RSS-102	SAR Test Exclusion	ISED RSS-102 2.5.1	Bluetooth LE	PASS
ISED RSS-102	Maximum permissable exposure	ISED RSS-102	ULtra Wide Band	PASS
Comment:				

Concurrent operational modes - FCC KDB 447498				
Product Standard Reference	**Requirement**	**Reference Method**	**Mode**	**Verdict**
KDB 447498	SAR Test Exclusion	KDB 447498 4.3.2	Bluetooth LE + ULtra Wide Band	PASS
Comment:				

Concurrent operational modes - ISED RSS-102				
Product Standard Reference	**Requirement**	**Reference Method**	**Mode**	**Verdict**
RSS-102	SAR Test Exclusion	KDB 447498 4.3.2	Bluetooth LE + ULtra Wide Band	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

$$\frac{max.\ power\ of\ channel\ [mW]}{min.\ test\ separation\ distance\ [mm]} \cdot \sqrt{f[GHz]} \leq \begin{cases} 3.0 & 1g\ SAR \\ 7.5 & 10g\ SAR \end{cases}$$

b) For 100 MHz to 6 GHz and test separation distances > 50 mm

1) For 100 to 1500 MHz

$$\left\{Power\ allowed\ at\ numeric\ threshold\ for\ 50\ mm\ in\ step\ a + (\text{test separation distance} - 50\text{mm}) \cdot \frac{f(MHz)}{150}\right\}, mW$$

2) for > 1500 MHz and ≤ 6 GHz

$$\{Power\ allowed\ at\ numeric\ threshold\ for\ 50\ mm\ in\ step\ a + (\text{test separation distance} - 50\text{mm}) \cdot 10\}, mW$$

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

$$\left(1 + \log\left(\frac{100}{f(MHz)}\right)\right)$$

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 ½

SAR test exclusion power acc. to ISED RSS-102 – Standalone Operation

SAR evaluation is required if the separation distance between the user and the radiating element of the device is less than or equal to 20 cm, except when the device operates at a power level below the following threshold limits:

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

For limb-worn devices where the 10 gram value applies, the exemption limits for routine evaluation are multiplied by a factor of 2.5.

For controlled use devices where the 8 W/kg for 1 gram of tissue applies, the exemption limits for routine evaluation in the Tables are multiplied by a factor of 5

4.3 SAR concurrent test exclusion threshold

SAR test exclusion acc. to ISED RSS-102 + 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 of 4.3.1 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) $\frac{\text{max.power of channel,including tune-up tolerance,mW}}{\text{min.test separation distance,mm}} \cdot \frac{\sqrt{f(GHz)}}{x}$, for test separation distances ≤ 50 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

4.4 RF-Exposure Limits

FCC Limits – General Population / Uncontrolled Exposure				
Frequency range [MHz]	**Electric field strength [V/M]**	**Magnetic field strength [A/M]**	**Power density [W/m²]**	**Averaging time [min]**
0.3 – 1.34	614	1.63	1000	30
1.34 – 30	824/f	2.19/f	$1800/f^2$	30
30 – 300	27.5	0.073	2	30
300 – 1500	-	-	f/150	30
1500 – 100000	-	-	10.0	30

FCC Limits – Occupational / Controlled Exposure				
Frequency range [MHz]	**Electric field strength [V/M]**	**Magnetic field strength [A/M]**	**Power density [W/m²]**	**Averaging time [min]**
0.3 – 3.0	614	1.63	1000	6
3.0 – 30	1842/f	4.89/f	$9000/f^2$	6
30 – 300	61.4	0.163	10.0	6
300 – 1500	-	-	f/30	6
1500 – 100000	-	-	50	6

ISED Limits – General Population / Uncontrolled Exposure				
Frequency range [MHz]	**Electric field strength [V/M]**	**Magnetic field strength [A/M]**	**Power density [W/m²]**	**Averaging time [min]**
0.003 – 10	83	90	-	Instantaneous
0.1 – 10	-	0.73/f	-	6
1.1 – 10	$87/f^{0.5}$	-	-	6
10 – 20	27.46	0.0728	2	6
20 – 48	$58.07/f^{05}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48 – 300	22.06	0.05852	1.291	6
300 – 6000	$3.142 \cdot f^{0.3417}$	$0.008335 \cdot f^{0.3417}$	$0.02619 \cdot f^{0.6834}$	6
6000 – 15000	61.4	0.163	10	6
15000 – 150000	61.4	0.163	10	$616000/f^{1.2}$
150000 – 300000	$0.158 \cdot f^{0.5}$	$4.21 \cdot 10^{-4} \cdot f^{0.5}$	$6.67 \cdot 10^{-5} \cdot f$	$616000/f^{1.2}$

ISED Limits – Occupational / Controlled Exposure				
Frequency range [MHz]	**Electric field strength [V/M]**	**Magnetic field strength [A/M]**	**Power density [W/m²]**	**Averaging time [min]**
0.003 – 10	170	180	-	Instantaneous
0.1 – 10	-	1.6/f	-	6
1.1 – 10	$193/f^{0.5}$	-	-	6
10 – 20	61.4	0.163	10	6
20 – 48	$129.8/f^{05}$	$0.3444/f^{0.25}$	$44.72/f^{0.5}$	6
48 – 300	49.33	0.1309	6.455	6
300 – 6000	$15.60 \cdot f^{0.25}$	$0.04138 \cdot f^{0.25}$	$0.6455 \cdot f^{0.5}$	6
6000 – 15000	137	0.364	50	6
15000 – 150000	137	0.364	50	$616000/f^{1.2}$
150000 – 300000	$0.354 \cdot f^{0.5}$	$9.40 \cdot 10^{-4} \cdot f^{0.5}$	$3.33 \cdot 10^{-4} \cdot f$	$616000/f^{1.2}$

5 RF-Exposure Evaluation

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

Evaluation procedure acc. to ISED RSS-102
Standalone operational modes 1) For each standalone operational mode the associated frequencies, conducted and radiated output power values, duty cycles and antenna separation distances to the human body are specified 2) From the higher of the conducted or radiated power and the duty cycle the source-based time averaged output power is calculated 3) The transmission frequency, average power and separation distance is used to determine the SAR test exclustion power threshold value acc. to ISED RSS-102 4) If the time averaged ouput power of the transmission mode is lower than the SAR test exclusion power threshold value, the mode califies for SAR test exclusion and no further SAR evaluation is needed Concurrent operational modes 1) For each operational mode that participates in the concurrent operational mode, the estimated SAR is calculated from the source-based time average conducted ouput 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 califies for SAR test exclusion and no further evaluation is needed

6 Single Source Evaluation Results – FCC Bluetooth LE

Results – Standalone Operational Modes							
Mode	Frequency [MHz]	Power [mW]	Duty Cycle	Average Power [mW]	Distance [mm]	Power Limit [mW]	Verdict
Bluetooth LE	2402	0.68	0.64	0.43	5.0	10	PASS
Comment:							

Results – Standalone Operational Modes							
Mode	Frequency [MHz]	Average Power [mW]	Distance [mm]	SAR value [W/kg]	SAR limit [W/kg]	SAR ratio	Verdict
Bluetooth LE	2402	0.43	5.0	0.028	1.6	0.02	PASS
Comment:							

7 Single Source Evaluation Results – ISED Bluetooth LE

Results – Standalone Operational Modes							
Mode	Frequency [MHz]	Power [mW]	Duty Cycle	Average Power [mW]	Distance [mm]	Power Limit [mW]	Verdict
Bluetooth LE	2402	0.76	0.64	0.49	5.0	4.3	PASS
Comment:							

Results – Standalone Operational Modes							
Mode	Frequency [MHz]	Average Power [mW]	Distance [mm]	SAR value [W/kg]	SAR limit [W/kg]	SAR ratio	Verdict
Bluetooth LE	2402	0.43	5.0	0.028	1.6	0.02	PASS
Comment:							

8 Single Source Evaluation Results – FCC Ultra Wide Band

A worst case estimation was used to justify the test exclusion for RF Exposure evaluation.
It is assumed that all power from the antenna will be directly radiated to the user by the complete antenna area at zero distance. Since this worst-case condition is far below the MPE limit, further near field testing not to be required.

Ultra Wide Band	
Transmission Mode	
Transmission Frequency (f) [MHz]	6489.6
Source average power	
Peak radiated power (PR) [dBm EIRP]	-6.3
Maximum transmission duty cycle (DC)	1.00
Duty cycle correction (DCC) [dB]	0.00
Average radiated power (PRAVG) [dBm EIRP]	-6.30
Average radiated power (PRAVG) [mW EIRP]	0.23
Power density	
Compliance power density limit [mW/cm^2]	1.000
1st antenna dimension [cm]	1.8
2nd antenna dimension [cm]	1.0
Antenna area [cm^2]	1.8
Power density (S) @ 0.000 m [mW/cm^2]	0.130
Power density ratio @ 0.000 m	0.130
Compliance	
Verdict	PASS
Comment: None.	

9 Single Source Evaluation Results – ISED Ultra Wide Band

A worst case estimation was used to justify the test exclusion for RF Exposure evaluation.
It is assumed that all power from the antenna will be directly radiated to the user by the complete antenna area at zero distance. Since this worst-case condition is far below the MPE limit, further near field testing not to be required.

Ultra Wide Band	
Transmission Mode	
Transmission Frequency (f) [MHz]	6489.6
Source average power	
Peak radiated power (PR) [dBm EIRP]	-6.3
Maximum transmission duty cycle (DC)	1.00
Duty cycle correction (DCC) [dB]	0.00
Average radiated power (PRAVG) [dBm EIRP]	-6.30
Average radiated power (PRAVG) [mW EIRP]	0.23
Power density	
Compliance power density limit [mW/cm^2]	1.000
1st antenna dimension [cm]	1.8
2nd antenna dimension [cm]	1.0
Antenna area [cm^2]	1.8
Power density (S) @ 0.000 m [mW/cm^2]	0.130
Power density ratio @ 0.000 m	0.130
Compliance	
Verdict	PASS
Comment: None.	

10 Concurrent Evaluation Results - FCC

Bluetooth Low Energy + Ultra Wide Band	
Information	
Number of concurrent modes	2
Maximum evaluation distance [m]	0.05
Maximum Ratios	
Bluetooth Low Energy	0.02
Ultra Wide Band	0.13
Sum of Ratios	
Sum	0.15
Compliance	
Verdict	PASS
Comment: None.	

11 Concurrent Evaluation Results - ISED

Bluetooth Low Energy + Ultra Wide Band	
Information	
Number of concurrent modes	2
Maximum evaluation distance [m]	0.05
Maximum Ratios	
Bluetooth Low Energy	0.02
Ultra Wide Band	0.13
Sum of Ratios	
Sum	0.15
Compliance	
Verdict	PASS
Comment: None.	