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EMF Test Report Ericsson Pico RBS 6402 WCDMA B2 FCC and Industry Canada

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Testing labo	oratory:	Ericsson EMF Research Laboratory	Company/Client:		Mika Savilakso		
		Ericsson AB SE-164 80 Stockholm Sweden	csson AB -164 80 Stockholm /eden		Oy LM Ericsson AB Elektroniikkatie 10 FI - 905903 Oulu Finland		
Tests perfor	rmed by:	Jaroslav Kazejev	Dates of	f tests:	2015-11-09 to 2015-11-17		
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Additional in	nformation:						
Signature:		Test engineer			Quality Manager		
Janoslav Kazejer			-	Brom Thors			
	Ex jarosla T	Jaroslav Kazejev perienced Researcher iv.kazejev@ericsson.com el: +46 10 713 43 44		Senior S	Björn Thors Specialist RF Exposure Assessment bjorn.thors@ericsson.com Tel: +46 10 717 18 24		

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1 Summary of EMF Test Report¹

Product name RBS 6402 with internal or external antennas Product number KRD 901 060/1, KRD 901 060/2, KRD 901 060/7 Frequency Band [MHz] B2 [1900] Modes WCDMA Supported Image: Covered by report Exposure environment General public

1.1 Equipment under test (EUT)

1.2 Results

RF exposure assessment results for general public (uncontrolled) exposure applicable in USA and Canada [1] - [3] are given in the tables below. The equipment under test (EUT) conforms to the requirements of the relevant standards when the combined exposure ratio is less than one.

RF exposure assessment results for general public (uncontrolled) exposure as obtained for the Pico RBS with internal and external cellular antennas together with an assumed output power tolerance of 0.6 dB using procedures and exposure limits applicable for the US markets [3].

3GPP band and configuration	Standard	Nominal output power from the radio	Test position	Test separation distance ²	Exposure ratio ³	Result
B2, internal antenna	L	2 x 0.25 W	Front	20 cm	0.07	PASSED
B2, internal antenna	L	2 x 0.25 W	Side	20 cm	0.08	PASSED
B2, external antenna	L	2 x 0.25 W	Front	20 cm	0.04	PASSED
B2, external antenna	L	2 x 0.25 W	Side	20 cm	0.05	PASSED

Expanded uncertainty (k=2) 95 % for field strength measurements using the DASY5 each strength measurements usin

¹ This and the following page contain a summary of the test results. The full report provides a complete description of all test details and results.

² The separation distance is measured from the EUT casing.

³ The exposure ratio is defined as the evaluated exposure parameter expressed as the power fraction of the related exposure limit. Here, the maximum ER value among all different possible configurations is shown.

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RF exposure assessment results for general public (uncontrolled) exposure as obtained for the Pico RBS with the internal and external cellular antennas together with an assumed output power tolerance of 0.6 dB using procedures applicable for the Canadian markets [2].

3GPP band	Standard	Nominal output power from the radio	Test position	Test separation distance ²	Exposure ratio ³	Result
B2, internal antenna	L	2 x 0.25 W	Front	20 cm	0.15	PASSED
B2, internal antenna	L	2 x 0.25 W	Side	20 cm	0.17	PASSED
B2, external antenna	L	2 x 0.25 W	Front	20 cm	0.08	PASSED
B2, external antenna	L	2 x 0.25 W	Side	20 cm	0.10	PASSED

Expanded uncertainty (k=2) 95 % for field strength measurements using the DASY5 near field scanner.

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2 General information

The test results reported in this document have been obtained by field strength measurements according to FCC [3] and Industry Canada [2] procedures. The purpose of the tests was to verify that the equipment under test (EUT) is in compliance with the appropriate RF exposure standards, recommendations and limits [1] - [3].

3 Equipment under test

Table 1 summarizes the technical data for the EUT. Photographs of the device with the internal antennas are presented in Appendix A. The RBS 6402 can be installed in two different orientations, here denoted wall, for vertical installation on a wall, or ceiling, for horizontal mounting in a ceiling with the radome facing down (see Figure 1). The external antenna is intended for installations under a ceiling. Shown in Figure 1 is also the terminology used in this report to denote the different sides of the EUT. Note that this terminology is not dependent on the used mounting position.









In Table 2 the output power levels provided by the client are given for the tested band.⁶

⁴ Total height

⁵ Height protruding beneath the ceiling

⁶ The presented output power levels correspond to the maximum power configurations for which measurements were made.

	Nominal	Nominal Tolerance,		Cable Maximum output power ⁸		Tested low, cha	Measured	
Band / Mode	output power ⁷ (dBm)	upper limit (dB)	external antennas (dBm)	with internal antennas (dBm)	with external antennas (dBm)	Channel number	Frequency (MHz)	power TX1 / TX2 (dBm)
						9662	1932.4	22.9 / 22.1
WCDMA B2 (1900)	24.0	0.6	-1.7	24.6	22.9	9800	1960.0	22.9 / 22.2
						9938	1987.6	22.8 / 22.2

Table 2: Nominal and measured output power levels.

The EUT is equipped with one RF card having two internal PIFA antennas for mobile communications. Each antenna is positioned at the device extremities as shown in Appendix A. Separate measurements were conducted for both ports of the RF card. The two ports are denoted TX 1 and TX 2. 3GPP test model TM 1 was used for the assessment.

An external antenna can be connected to the RBS 6402. For this configuration the RBS 6402 is equipped with external connectors that are installed instead of the internal antennas. The external antenna is then connected with proprietary cables of length 2.6 m and an attenuation of 1.7 dB, see Table 2. In this case the external antenna becomes part of the EUT. The devices can be mounted arbitrarily within the range allowed by the cables.

4 Test equipment

4.1 Near-field scanner

The field strength measurements were conducted using the DASY5 professional near-field scanner by Schmid & Partner Engineering AG.

The equipment list related to the DASY5 near-field scanner is given in Table 3. In Appendix B calibration parameters for the used field strength test probe(s) are listed.

Description	Serial number	Calibration due date	Calibration interval
Probe electronics, DAE3	422	2016-06	12 months
E-field probe, ER3DV4R	2210	2016-06	12 months

Table 3: Equipment list related to the DASY5 near-field scanner.

4.2 Additional equipment

Additional equipment used for system validation is listed in Table 4.

⁷ Nominal output power per port.

⁸Conservative measure of the total maximum possible output power level delivered to the antennas, i.e. the nominal output power level per port plus the tolerance in production. For the external antennas the cable losses were also subtracted.

Description	Serial number	Calibration due date	Calibration interval
Power meter, Agilent N1911A	MY45100381	2016-12	24 months
Power sensor, Agilent N1921A	MY45240486	2016-04	12 months
Signal generator, Rohde & Schwartz SMB 100A	100166	2016-12	36 months
HAC dipole, 1880 MHz	1053	N/A	N/A
Amplifier, Milmega AS0204-2L	1003362	N/A	N/A

Table 4: List of additional equipment with calibration information.

5 EMF exposure assessments

FCC [3] and Industry Canada procedures [2] specify exposure assessment methods to verify compliance with EMF exposure limits [1] of mobile devices. A minimum test separation distance of at least 20 cm is required between the device and nearby persons to apply mobile device exposure limits. The test separation distance for which the equipment is shown to comply with the exposure limits must be clearly provided in the operating and installation instructions.

A system performance check was conducted to verify the system operations, see Section 5.1. A description of the field strength measurements is given in Section 5.2 and the results are given in Section 5.3. In Section 5.4, an uncertainty budget is provided.

5.1 Field strength system performance check

System performance checks of the DASY5 measurement system were conducted prior to the field strength measurements using the CD1880V3 hearing aid compatibility (HAC) dipole. The electric field strength was measured in the far-field region and compared against theoretical results calculated using the far-field formula

$$E = \frac{\sqrt{\eta PG}}{2\sqrt{\pi}R},$$

where P, G, η and R denote the transmitted power, the antenna gain, the free space wave impedance and the distance between the probe and the reference antenna, respectively. The results, provided in Table 5, are within ± 1 dB of the reference values.

Table 5: Field strength system performance check results

Frequency	Transmitted	Antenna	Separation	E	(V/m)	Difference	Date
(MHz)	(W)	(dBi)	(m)	Measured	Reference	(dB)	Date
1880	0.246	2.15	0.4	8.69	8.41	-0.29	2015-11-09

5.2 Field strength measurement description

The FCC KDB 447498 D01 [3] and RSS-102[2] specify that EMF exposure shall be assessed for mobile conditions, i.e. for a test separation distance of at least 20 cm, by conducting measurements of spatially averaged electric field strengths along vertical lines corresponding to the longest dimensions of the exposed person's body. For a typical standing adult, the height may be estimated as 180 cm [3].

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Here, however, an averaging length of 90 cm was assumed to make the results more conservative and applicable to all members of the general public9. The spatial resolution between the assessment points was 5 cm [3]. The electric field strength measurements were conducted using the DASY5 near field scanner.

The measurements were conducted in front of the EUT to confirm that the exposure is below the exposure limits at a test separation distance of 20 cm. The distance in this context corresponds to the shortest distance between the EUT casing and the line along which the measurements were taken. Prior to the measurements along line, area scans were conducted to check where the maxima occur when both ports are transmitting simultaneously. To maximize the measured front exposure, the corresponding measurement lines were defined to pass through the hot-spot locations, see Figure 2. An Ericsson internal tool, *Lowpower Compliance Analyzer* (LCA) [6], was used as a postprocessor to the measurement data to find the position of the line that has the maximum averaged field values (averaged over 90 cm) among the lines in the measurement area. Measurements were made for each port separately for a wall installation exposure scenario with the line placed along the position suggested by the LCA tool to correspond to a child standing in front of the EUT10. This exposure scenario will result in a more conservative exposure assessment than any realistic exposure scenario for the ceiling-installed EUT. The LCA tool was then used to scale the measurements data to the maximum output power values of the corresponding ports including tolerances.

Measurements were also conducted along one other radial to confirm that the exposure values were below the limits in this direction as well [3], see Figure 2. This radial was defined 900 from the radial along the front direction and to the right side of the EUT11. In this case, the measurement line was located 20 cm from the surface of the right side of the EUT. In the laboratory, the right side (the side with TX 1, see Appendix A) of the EUT was facing upwards and the measurement line was located 20 cm above the EUT surface, see Appendix C.

For the external antenna the measurements were conducted in front of and to the side of the EUT to confirm that the exposure is below the exposure limits at a test separation distance of 20 cm. In this scenario the antenna is mounted under the ceiling with the front facing down and the measurement lines extend along the vertical axis. The test separation distance in this context corresponds to the shortest distance between the EUT casing the starting points of the line along which the measurement lines extending vertically, see Appendix C. A similar approach to the one described above was used to find the location of the maximum exposure. Here, an area scan was conducted 20 cm from the center of the radiating elements. Another area scan was made, extending vertically 20 cm from the radome and in a plane passing through the local peaks. The LCA tool was then used as a postprocessor to the measurement data of the vertical area scan to find the position of the line that has the maximum averaged field values

Additional measurements of the external antenna were made starting 20 cm to the side from the casing, at the level of the back plane of the EUT. To find the position of the line that has the maximum averaged field values, several lines were measured in increments of 10 degrees to the directions of expected maxima (based on experience from the previous area scan). Around the directions with the highest averaged field values, additional lines were measured at 2 degree intervals. With the orientation as defined in Figure 3, the position of the side compliance measurement line was at 156 degrees.

The signals from the two ports are correlated. Therefore, the LCA tool was used to calculate ER with signal correlation of two ports taken into consideration. The electric field magnitudes from the two ports when transmitting separately were added point-by-point and root-mean-square averaged over the 90 cm long measurement line. The plane-wave equivalent power density was then determined via

$$S=\frac{E^2}{\eta},$$

where η is the free space wave impedance (approximately 377 Ω). The exposure ratio was then calculated as

$$ER = \max_{f=\text{low,mid,high}} \left[\frac{S(f)}{S^{\lim}(f)} \right],$$

 ⁹ In [5], a 96 cm long child phantom for whole-body SAR measurements were proposed based on body height statistics for 4-year old children.
 ¹⁰ In practice, the measurements were conducted in the laboratory with the EUT placed on a table using horizontal averaging planes. Therefore, effects of ground reflections are not included in these measurements. Since the EUT usually is mounted high above the ground this is a conservative estimate
 ¹¹ A measurement for one configuration was also conducted to the left side of the EUT. Since the ER to this side was lower than the ER for the right side,

the rest of the measurements were conducted to the right side and along a 45⁰ radial inclined to the right side.

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where the maximum was taken with respect to the tested low, mid and high WCDMA channels.

The obtained results were compared against the MPE limits [1] and RF field strength limits [2], corresponding to the limits for the products aimed for the US markets and Canadian markets, respectively, for general public/uncontrolled exposure. The exposure is below the exposure limits if the exposure ratio for the considered configuration is below 1.



Figure 2: Positions of measurement lines in the vicinity of the EUT (RBS 6402). The x-coordinate for the front exposure assessment was chosen to make the measurement line pass through the hot-spot location obtained via a surface (area) scan in the plane z = 20 cm with all ports transmitting simulataneously. Since the measurement line passing through the hot-spot will provide the maximum exposure in front of the EUT, no measurements were conducted along the 45 degree radial in this test.



Figure 3: Definitions of measurement lines in the vicinity of the EUT (external antenna). Blue: Measurements for front compliance, red: measurements for side compliance. The locations of the measurement lines in the horizontal plane are approximate and shown for illustrational purposes. The white rectangles over the EUT represent the approximate antenna radiator locations. (Top): View from below. (Bottom): View from the side.

5.3 Field strength measurement results

5.3.1 Field strength measurement results for internal antennas

In Table 6 - Table 7, spatially averaged plane-wave equivalent power density values and the corresponding exposure ratios, calculated based on the FCC limits specified in [1] are given.

In Table 8 - Table 9, spatially averaged plane-wave equivalent power density values and the corresponding exposure ratios, calculated based on the Industry Canada limits specified in [2] are given.

In all cases the highest ER was obtained for the *high* channel, typeset in bold in the tables.

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Table 6: Spatially averaged plane-wave equivalent power density values and corresponding exposure ratios measured at the selected 20 cm test separation distance in front of the EUT for general public (uncontrolled) exposure (applicable for products aimed for the US market).

Band	Frequency (MHz)	Nominal output power from the radio (W)	Mounting/ Test position	Test separation distance (cm)	<i>S</i> (W/m²)	S ^{lim} (W/m²)	ER
	1932.4	2 x 0.25 W	Wall/Front	20	0.66	10	0.07
B2	1960.0	2 x 0.25 W	Wall/Front	20	0.68	10	0.07
	1987.6	2 x 0.25 W	Wall/Front	20	0.70	10	0.07

Table 7: Spatially averaged plane-wave equivalent power density values and corresponding exposure ratios measured at the selected 20 cm test separation distance to the right side of the EUT for general public (uncontrolled) exposure (applicable for products aimed for the US market).

Band	Frequency (MHz)	Nominal output power from the radio (W)	Mounting/ Test position	Test separation distance (cm)	<i>S</i> (W/m²)	S ^{lim} (W/m²)	ER
B2	1932.4	2 x 0.25 W	Wall/Right	20	0.73	10	0.08
	1960.0	2 x 0.25 W	Wall/Right	20	0.71	10	0.08
	1987.6	2 x 0.25 W	Wall/Right	20	0.79	10	0.08

Table 8: Spatially averaged plane-wave equivalent power density values and corresponding exposure ratios measured at the selected 20 cm test separation distance in front of the EUT for general public (uncontrolled) exposure (applicable for products aimed for the Canadian market).

Band	Frequency (MHz)	Nominal output power from the radio (W)	Mounting/ Test position	Test separation distance (cm)	<i>S</i> (W/m²)	S ^{lim} (W/m²)	ER
B2	1932.4	2 x 0.25 W	Wall/Front	20	0.66	4.6	0.14
	1960.0	2 x 0.25 W	Wall/Front	20	0.68	4.7	0.15
	1987.6	2 x 0.25 W	Wall/Front	20	0.70	4.7	0.15

Table 9: Spatially averaged plane-wave equivalent power density values and corresponding exposure ratios measured at the selected 20 cm test separation distance to the right side of the EUT for general public (uncontrolled) exposure (applicable for products aimed for the Canadian market).

Band	Frequency (MHz)	Nominal output power from the radio (W)	Mounting/ Test position	Test separation distance (cm)	<i>S</i> (W/m²)	S ^{lim} (W/m²)	ER
	1932.4	2 x 0.25 W	Wall/Right	20	0.73	4.6	0.16
B2	1960.0	2 x 0.25 W	Wall/Right	20	0.71	4.7	0.15
	1987.6	2 x 0.25 W	Wall/Right	20	0.79	4.7	0.17

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5.3.2 Field strength measurement results for external antenna

In Table 10 - Table 11, spatially averaged plane-wave equivalent power density values and the corresponding exposure ratios, calculated based on the FCC limits specified in [1] are given.

In Table 12 - Table 13, spatially averaged plane-wave equivalent power density values and the corresponding exposure ratios, calculated based on the Industry Canada limits specified in [2] are given.

In all cases the highest ER was obtained for the low channel, typeset in bold in the tables.

Table 10: Spatially averaged plane-wave equivalent power density values and corresponding exposure ratios measured at the selected 20 cm test separation distance in front of the EUT for general public (uncontrolled) exposure (applicable for products aimed for the US markets).

Band	Frequency (MHz)	Nominal output power from the radio (W)	Mounting/ Test position	Test separation distance (cm)	<i>S</i> (W/m²)	S ^{lim} (W/m ²)	ER
	1932.4	2 x 0.25 W	Ceiling/Front	20	0.36	10	0.04
B2	1960.0	2 x 0.25 W	Ceiling/Front	20	0.34	10	0.04
	1987.6	2 x 0.25 W	Ceiling/Front	20	0.33	10	0.04

Table 11: Spatially averaged plane-wave equivalent power density values and corresponding exposure ratios measured at the selected 20 cm test separation distance to the right side of the EUT for general public (uncontrolled) exposure (applicable for products aimed for the US markets).

Band	Frequency (MHz)	Nominal output power from the radio (W)	Mounting/ Test position	Test separation distance (cm)	<i>S</i> (W/m²)	S ^{lim} (W/m²)	ER
	1932.4	2 x 0.25 W	Ceiling/Side	20	0.48	10	0.05
B2	1960.0	2 x 0.25 W	Ceiling/Side	20	0.46	10	0.05
	1987.6	2 x 0.25 W	Ceiling/Side	20	0.43	10	0.05

Table 12: Spatially averaged plane-wave equivalent power density values and corresponding exposure ratios measured at the selected 20 cm test separation distance in front of the EUT for general public (uncontrolled) exposure (applicable for products aimed for the Canadian markets).

Band	Frequency (MHz)	Nominal output power from the radio (W)	Mounting/ Test position	Test separation distance (cm)	<i>S</i> (W/m²)	S ^{lim} (W/m ²)	ER
	1932.4	2 x 0.25 W	Ceiling/Front	20	0.36	4.6	0.08
B2	1960.0	2 x 0.25 W	Ceiling/Front	20	0.34	4.7	0.08
	1987.6	2 x 0.25 W	Ceiling/Front	20	0.33	4.7	0.08

Table 13: Spatially averaged plane-wave equivalent power density values and corresponding exposure ratios measured at the selected 20 cm test separation distance to the right side of the EUT for general public (uncontrolled) exposure (applicable for products aimed for the Canadian markets).

Band	Frequency (MHz)	Nominal output power from the radio (W)	Mounting/ Test position	Test separation distance (cm)	<i>S</i> (W/m²)	S ^{lim} (W/m²)	ER
	1932.4	2 x 0.25 W	Ceiling/Side	20	0.48	4.6	0.10
B2	1960.0	2 x 0.25 W	Ceiling/Side	20	0.46	4.7	0.10
	1987.6	2 x 0.25 W	Ceiling/Side	20	0.43	4.7	0.10

5.4 Field strength measurement uncertainty

An uncertainty budget [4] for the field strength measurements using the DASY5 near-field scanner is given in Table 14.

Table 14: Uncertainty budget with the combined standard uncertainty and the extended (K=1.96) uncertainty for field strength
measurements of base stations using the DASY5 near-field scanner.

Influence quantities	Uncertainty (%)	Probability distribution	Divisor	Weighting factor, c _i €	Weighting factor, c _i (<i>H</i>)	Standard uncertainty (%) (<i>E</i>)	Standard uncertainty (%) (<i>H</i>)
Measurement equipment							
Calibration	± 5.1	Normal	1	1	1	± 5.1	± 5.1
Isotropy	± 4.7	Rectangular	$\sqrt{3}$	1	1	± 2.7	± 2.7
Linearity	± 4.7	Rectangular	$\sqrt{3}$	1	1	± 2.7	± 2.7
Fields out of measurement range	± 1.0	Rectangular	$\sqrt{3}$	1	1	± 0.6	± 0.6
Noise	± 0.0	Normal	1	1	1	± 0.0	±0.0
Integration time	\pm 2.6	Rectangular	$\sqrt{3}$	1	1	± 1.5	± 1.5
Power scaling	± 4.5	Rectangular	$\sqrt{3}$	1	1	± 2.6	±2.6
Mechanical constraints							
Positioning system	± 0.0	Rectangular	$\sqrt{3}$	1	1	± 0.0	±0.0
Matching between probe and EUT	± 4.7	Rectangular	$\sqrt{3}$	1	1	± 2.7	± 2.7
Physical Parameters							
Drifts in output power of the EUT, Probe, temperature and humidity	± 5.0	Rectangular	$\sqrt{3}$	1	1	± 2.9	± 2.9
Perturbation by the environment	± 12.0	Rectangular	$\sqrt{3}$	1	1	± 6.9	±6.9
Combined standard Uncertainty						±10.6	±10.6
Expanded uncertainty (k=1.96)						± 21.2	± 21.2

6 Conclusion

The results in Section 5 show that the plane-wave equivalent power density values, measured and estimated according to the requirements of FCC [3] and Industry Canada [2], are below the relevant MPE limits [1] and [2] at a separation distance of 20 cm between the equipment and any nearby person.

Consequently, the EUT is in compliance with the appropriate RF exposure standards and recommendations.

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7 References

- [1] FCC, Code of Federal Regulations CFR title 47, part 1.1310 "Radiofrequency radiation exposure limits", Federal Communications Commission (FCC), August 1997.
- [2] Industry Canada, Radio Standard Specification (RSS) 102, (Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands), 2015.
- [3] FCC KDB447498 D01, "Mobile and Portable Devices RF exposure procedures and Equipment Authorization Policies", February 2014.
- [4] Ericsson, EAB-13:071570, "Uncertainty budget for field strength measurements of radio base stations using the DASY5 system," Ericsson AB, Tech. Rep., 2013.
- [5] Thors et al., "Product Compliance Assessments of Low Power Radio Base Stations with Respect to Whole-Body Radiofrequency Exposure Limits", in EuCAP, 2013.
- [6] "Ericsson repository lowpower compliance (LCA) tool", available at https://eforge.ericsson.se/sf/wiki/do/viewPage/projects.postfeko/wiki/LowpowerTool," Ericsson, 2015.

8 **Revision History**

Rev.	Date	Description
А	2015-11-20	First version

APPENDIX A: Photographs of the EUT



Figure A.1 Front view of the RBS 6402.



Figure A.2 Front view of the RBS 6402 with radome removed showing the two antennas attached to the RF card at the top (indicated by arrows).



Figure A.3 Front view of the external antenna. (left) with radome (right) without radome.

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APPENDIX B: Electric and magnetic field strength probe calibration parameters

ER3DV4R S/N 2210

Diode compression:

Parameter	Value in mV
DCP X	100.5
DCP Y	100.0
DCP Z	100.9

Sensitivity in free space:

Parameter	Value in µV/(V/m) ²
Norm X	2.80
Norm Y	3.13
Norm Z	5.23

Probe tip to sensor center (S/N 2210): 2.5 mm

APPENDIX C: Photographs of the EUT when positioned for field strength measurements



Figure C.1 EUT (RBS 6402) positioned for field strength measurements in the front position using the DASY5 near-field scanner.



Figure C.2 EUT (RBS 6402) positioned for field strength measurements to the right side using the DASY5 near-field scanner.



Figure C.3 EUT (external antenna) positioned for field strength measurements using the DASY5 near-field scanner. The device is connected to the RBS 6402 (outside of picture frame).