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EMF Test Report: Ericsson RBS 6401 LTE B2 B25




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Manufacturer and market name(s) of device:	Ericsson RBS 6401		
Testing has been performed in accordance with:	FCC CFR title 47, part 1.1310, FCC KDB447498 D01, Industry Canada RSS 102		
Test results:	The tested device complies with the requirements in respect of all parameters subject to the test.		
Additional information:			
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1 Summary of EMF Test Report¹

1.1 Equipment under test (EUT)

Product name	RBS 6401					
Product number	KRD 901 040/1/2/3/4/5/6, KRD 901 043/1/2/3/4					
Frequency Band [MHz]	1900	2412	5180	5260	5500	5745
Modes	LTE	Wi-Fi	Wi-Fi	Wi-Fi	Wi-Fi	Wi-Fi
Supported	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Covered by report	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Exposure environment	General public					

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 the internal cellular antenna (sector coverage) together with an assumed output power tolerance of 0.6 dB using procedures applicable for the US and Canadian markets [2], [3].

3GPP band	Standard	Nominal output power from the radio	Test position ²	Test separation distance ³	Exposure ratio ⁴	Combined exposure ratio ⁵	Result
B2, B25 (1900)	L (channels 8065, 8340, 8665)	2 x 1 W	Front	20 cm	0.58	NA	PASSED
B2, B25 ⁶ (1900)	L (channels 8065, 8340, 8665)	2 x 1 W	Front	20 cm	0.58	0.72	PASSED
	Wi-Fi 2.4 GHz (channel 1)	0.1 W			0.04		
	Wi-Fi 5 GHz (channels 36, 52, 100, 149)	≤ 0.25 W			0.10		

Expanded uncertainty (k=2) 95 % for field strength measurements using the DASY5 near field scanner.	< 30%
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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 For a test separation distance of 20 cm, the exposure was found to be well below applicable exposure limits in front of the antenna. Since this test position corresponds to the direction of maximum exposure [3] and the Pico RBS is classified as a mobile device with an intended separation distance to the user or nearby persons of at least 20 cm, other test positions were not considered.

³ The separation distance is measured from the EUT casing.

⁴ The exposure ratio is defined as the evaluated exposure parameter expressed as the power fraction of the related exposure limit. For Wi-Fi 5 GHz, the provided exposure ratio is the maximum value obtained for the four channels 36, 52, 100, and 149. For LTE, the provided exposure ratio is the maximum value obtained for the channels 8065, 8340 and 8665 (low, mid, and high).

⁵ The combined exposure ratio is the sum of the individual exposure ratios for each source.

⁶ The measurements were conducted for band 25 since band 2 constitutes a sub-band of band 25.

RF exposure assessment results for general public (uncontrolled) exposure as obtained for the Pico RBS with the external cellular antennas (omni-directional) together with an assumed output power tolerance of 0.6 dB using procedures applicable for the US and Canadian markets [2], [3].

3GPP band	Standard	Nominal output power from the radio	Test position ²	Test separation distance ³	Exposure ratio	Combined exposure ratio ⁵	Result
B2, B25 (1900)	L (channels 8065, 8340, 8665)	2 x 1 W	Front	20 cm	0.73	NA	PASSED
B2, B25 (1900)	L (channels 8065, 8340, 8665)	2 x 1 W	Front	20 cm	0.73	0.87	PASSED
	Wi-Fi 2.4 GHz (channel 1)	0.1 W			0.04		
	Wi-Fi 5 GHz (channels 36, 52, 100, 149)	≤ 0.25 W			0.10		
Expanded uncertainty (k=2) 95 % for field strength measurements using the DASY5 near field scanner.						< 30%	

2 General information

The test results reported in this document have been obtained by field strength measurements according to FCC procedures [3]. 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] - [4].

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 device can be installed in two different orientations, here denoted wall, for vertical installation on a wall, or shelf, for horizontal placement on a shelf with the radome facing up (see Figure 1). 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.

Table 1: Technical data for the EUT.

Product name	RBS 6401		
Product number	KRD 901 040/1/2/3/4/5/6 KRD 901 043/1/2/3/4		
Dimensions, H x W x D (mm)	420 x 260 x 85		
Configurations(s) covered by this report	LTE 1900 (B2, B25) LTE 1900 (B2, B25) + Wi-Fi 2400 (channel 1) + Wi-Fi 5000 (channels 36, 52, 100, 149)		
Antenna(s)	Internal sector coverage antennas (Cellular bands + WiFi)		
	External omni-directional antennas (Cellular bands)	Product number	Gain (dBi)
		KRE 101 2024/1	2
Transmitter frequency range (MHz)	LTE 1900 (B2): 1930 – 1990 LTE 1900 (B25): 1930 – 1995 Wi-Fi 2400: 2412 Wi-Fi 5000: 5180 – 5745		

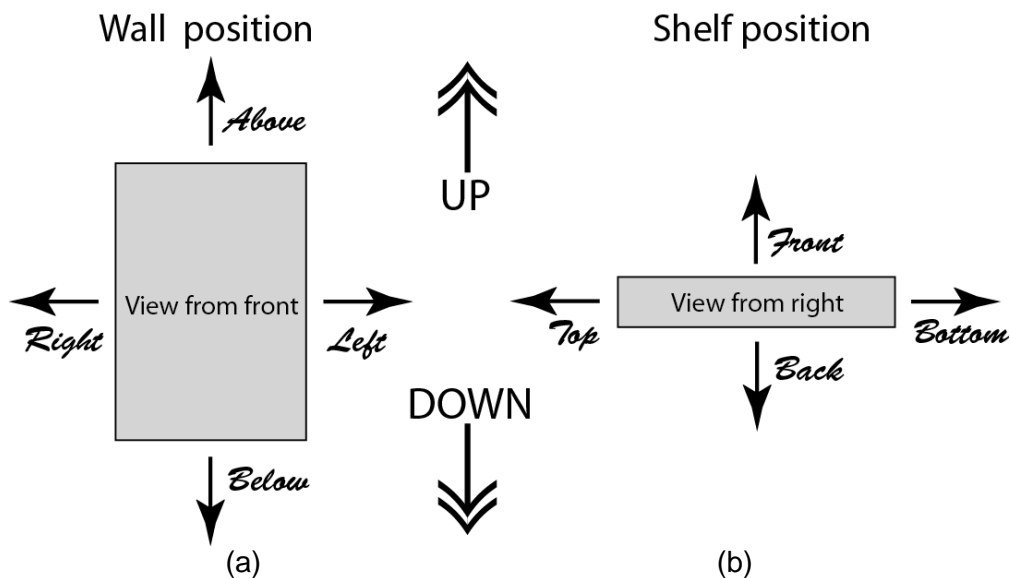


Figure 1: EUT installation positions and terminology used to denote the different sides of the EUT. (a) Wall installation position. (b) Shelf installation position.

In Table 2 the output power levels provided by the client are given for the different LTE bands.

Table 2: Nominal and measured output power levels for LTE.

Band / Mode	Nominal output power ⁷ (dBm)	Tolerance, upper limit (dB)	Maximum output power ⁸ (dBm)	Tested low, mid and high channels		Measured output power TX1 / TX2 (dBm)
				Channel number	Frequency (MHz)	
LTE B2, B25 (1900)	30.0	0.6	33.6	625, 8065	1932.5	30.1 / 30.0
				900, 8340	1960.0	30.1 / 29.9
				8665	1992.5	30.1 / 30.1

In Table 3 maximum Wi-Fi power levels are given that result in maximum allowed equivalent isotropically radiated power (EIRP) for different markets.

Table 3: Maximum power levels for the different Wi-Fi channels.

3GPP band	Wi-Fi module	Wi-Fi power level (dBm)				
		Channel 1 2412 MHz	Channel 36 5180 MHz	Channel 52 5260 MHz	Channel 100 5500 MHz	Channel 149 5745 MHz
B2 (1900)	FCC – US	20	14	18	18	24
	FCC – RoW	20	18	18	18	24
B25 (1900)	FCC – US	20	14	18	18	24

The EUT is equipped with an internal dual polarized patch antenna for mobile communications. Also the possibility to connect two external omni directional antennas (dipoles) exists for the cellular bands. For Wi-Fi at 2.4 GHz, one X-polarized plus one vertically⁹ polarized rectangular patch antenna are used. For Wi-Fi at 5 GHz, two circular patch antennas polarized $\pm 45^\circ$ are used. Pictures of the EUT and the internal antennas are shown in Appendix A.

The Wi-Fi module has been previously tested in the WCDMA version of the product [7] and measurement results from that test were re-used here. The Wi-Fi tests were conducted for the product configuration with the highest transmitted power (KRD 901 039/2).

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 4. In Appendix B calibration parameters for the used field strength test probe(s) are listed.

Table 4: Equipment list related to the DASY5 near-field scanner.

Description	Serial number	Calibration due date	Calibration interval
Probe electronics, DAE3	S/N 422	2014-04-16	12 months
H-field probe, H3DV6	S/N 6015	2014-04-18	12 months
E-field probe, ER3DV4R	S/N 2210	2014-04-19	12 months
E-field probe, EF3DV3	S/N 4033	2014-09-30	12 months
HAC dipole, CD1880V3	S/N 1053	NA	NA
HAC dipole, CD2450V3	S/N 1052	NA	NA

⁷ Nominal output power per port.

⁸ Conservative measure of the total maximum possible output power level delivered to the antenna, i.e. the nominal output power level per port plus the tolerance in production times the number of ports.

⁹ Vertically in this context corresponds to a vertically polarized electric field when the EUT is installed vertically.

4.2 Additional equipment

Additional equipment used during the measurements is listed in Table 5.

Table 5: List of additional equipment with calibration information.

Description	Serial number	Calibration due date	Calibration interval
Power meter, Agilent N1911A	S/N MY45100381	2013-12-12	12 months
Power sensor, Agilent N1921A	S/N MY45240486	2013-12-12	12 months
Power meter, Rhode & Schwartz NRVS	S/N 848888/052	2014-08-25	12 months
Power sensor, Rhode & Schwartz NRV-Z5	S/N 100609	2014-08-07	12 months

5 FCC EMF exposure assessments

FCC procedures [3] 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 for each frequency band 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 and the CD2450V3 hearing aid compatibility (HAC) dipoles. The electric field strength was measured in the far-field region and compared against theoretical results calculated using the far-field formula

$$E = \frac{\sqrt{\eta PG}}{2\sqrt{\pi R}}, \tag{4}$$

$$H = \frac{\sqrt{PG}}{2\sqrt{\pi\eta R}}, \tag{5}$$

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 6, are within ± 1 dB of the reference values.

Table 6: Field strength system performance check results

Frequency (MHz)	Transmitted power (W)	Antenna gain (dBi)	Separation distance (m)	E (V/m) / H (A/m)		Difference (dB)	Date
				Measured	Reference		
1880	0.25	1.46	0.4	7.56 / 0.0201	8.27 / 0.0219	-0.78 / -0.74	2013-09-30
2450	0.25	1.46	0.4	8.26 / 0.0225	8.27 / 0.0219	-0.01 / 0.24	2013-09-30

5.2 Field strength measurement description

The FCC KDB 447498 D01 [3] specifies that EMF exposure may be assessed for mobile conditions, i.e. when the minimum test separation distance is 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].

Here, however, an averaging length of 90 cm was assumed to make the results more conservative and applicable to all members of the general public¹⁰. The spatial resolution between the assessment points in the averaging plane was 10 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. The measurements were made for a wall installation exposure scenario with the line centred above the LTE antenna to correspond to a child standing in front of the EUT¹¹. This exposure scenario will result in a more conservative exposure assessment than any realistic exposure scenario for the shelf-mounted EUT. The obtained results were compared against the MPE limit [1] for general public/uncontrolled exposure.

First, the low, mid, and high LTE channels were measured and the plane-wave equivalent power density was determined via

$$S = \frac{E^2}{\eta}, \quad (8)$$

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

$$ER^{\text{cellular}} = \max_{f=\text{low,mid,high}} \left[\frac{S^{\text{cellular}}(f)}{S^{\text{lim}}(f)} \right], \quad (9)$$

where the maximum was taken with respect to the tested channels. For configurations where contributions from Wi-Fi are to be considered, field values for the different Wi-Fi channels were measured at the test separation distance and the total exposure ratio was calculated as

$$ER^{\text{total}} = ER^{\text{cellular}} + \frac{S^{\text{Wi-Fi}}(2.4 \text{ GHz})}{S^{\text{lim}}(2.4 \text{ GHz})} + \max_{f>5 \text{ GHz}} \left(\frac{S^{\text{Wi-Fi}}(f)}{S^{\text{lim}}(f)} \right), \quad (10)$$

where for the Wi-Fi bands above 5 GHz the maximum exposure was used. The exposure is below the exposure limits if the exposure ratio for the considered configuration is below 1.

Since the total exposure was found to be below the exposure limits right in front of the antennas at the 20 cm test separation distance (see Section 5.3), and the smallest possible distance of intended use is 20 cm in any direction from the equipment, measurements in other directions were not conducted.

5.3 Field strength measurement results

In Table 7, spatially averaged plane-wave equivalent power density values and the corresponding exposure ratios measured at the selected 20 cm test separation distance in front of the EUT are given.

¹⁰ In [16], a 96 cm long child phantom for whole-body SAR measurements were proposed based on body height statistics for 4-year old children.

¹¹ 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

Table 7: 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.

3GPP band	Standard / channel	Nominal output power from the radio (W)	Mounting/ Test position	Test separation distance (cm)	S (W/m ²)	S^{lim} (W/m ²)	ER^{max}	Total combined ER
B2, B25 (1900)	LTE – ch 25	2 x 1 W	Wall/Front	20	5.78	10	0.58	NA
	LTE – ch 300	2 x 1 W	Wall/Front	20	5.57	10	0.56	
	LTE – ch 575	2 x 1 W	Wall/Front	20	5.64	10	0.56	
B2, B25 (1900)	LTE (max)	2 x 1 W	Wall/Front	20	5.78	10	0.58	0.72
	Wi-Fi FCC-RoW 2.4 GHz ch 1	0.1 W	Wall/Front	20	0.45	10	0.04	
	Wi-Fi FCC-RoW 5 GHz ch 36	0.063 W	Wall/Front	20	0.36	10	0.03	
	Wi-Fi FCC-RoW 5 GHz ch 52	0.063 W	Wall/Front	20	0.38	10	0.03	
	Wi-Fi FCC-RoW 5 GHz ch 100	0.063 W	Wall/Front	20	0.33	10	0.03	
	Wi-Fi FCC-RoW 5 GHz ch 149	0.25 W	Wall/Front	20	0.95	10	0.10	

As shown above, the exposure ratios for both the individual LTE and Wi-Fi modes, as well as for the combined case, are below 1. Hence, the RF EMF exposure is below the relevant exposure limits [1] for the 20 cm test separation distance.

5.4 Field strength measurement uncertainty

An uncertainty budget for the field strength measurements using the DASY5 near-field scanner is given in Table 8.

Table 8: Uncertainty budget with the combined standard uncertainty and the extended (K=1.96) uncertainty for field strength measurements of base stations using the DASYS near-field scanner.

Influence quantities	Uncertainty (%)	Probability distribution	Divisor	Weighting factor, c_i (E)	Weighting factor, c_i (H)	Standard uncertainty (%) (E)	Standard uncertainty (%) (H)
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
Noise	± 3.8	Normal	1	1	1	± 3.8	± 3.8
Integration time	± 2.6	Rectangular	$\sqrt{3}$	1	1	± 1.5	± 1.5
Power chain	± 2.2	Normal	1	1	1	± 2.2	± 2.2
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							
Perturbation by the environment	± 12.0	Rectangular	$\sqrt{3}$	1	1	± 6.9	± 6.9
Combined standard Uncertainty						± 11.2	± 11.2
Expanded uncertainty (k=1.96)						± 22.4	± 22.4

5.5 Field strength calculations

The total effective radiated power for the omni-directional antennas used for the cellular bands is 2 W. As a consequence, the categorical exclusion provision of FCC CFR title 47, § 2.1091(c) applies [8] and the minimum test separation distance may be estimated by simple calculations according to plane-wave equivalent conditions [3].

The gain, G , of the omni-directional antennas used for the cellular bands is 2 dBi (1.6), see Table 1, and the corresponding exposure ratio, ER_{omni} , may be estimated as

$$ER_{\text{omni}} = \frac{S_{\text{est}}}{S_{\text{lim}}} = \frac{P_{\text{tot}}G}{4\pi r^2 S_{\text{lim}}},$$

where

P_{tot} = Total conducted power for the cellular bands (33.6 dBm).

r = Separation distance

S_{lim} = Power density exposure limit of 10 W/m².

For a 20 cm test separation distance, $ER_{\text{omni}} = 0.73$. From Table 7, the combined exposure ratio associated with the WiFi transmitters is $ER_{\text{WiFi}} = 0.14$. Thus, the total combined exposure ratio for the omni-directional configuration is $ER_{\text{omni,tot}} = ER_{\text{omni}} + ER_{\text{WiFi}} = 0.87$, see Table 9.

Table 9 RF exposure assessment results for general public (uncontrolled) exposure as obtained for the Pico RBS with the external cellular antennas (omni-directional) together with an assumed output power tolerance of 0.6 dB using procedures applicable for the US and Canadian markets [2], [3].

3GPP band	Standard	Nominal output power from the radio	Test position ¹²	Test separation distance ¹³	Exposure ratio ¹⁴	Combined exposure ratio ¹⁵	Result
B2, B25 (1900)	L (channels 8065, 8340, 8665)	2 x 1 W	Front	20 cm	0.73	NA	PASSED
B2, B25 (1900)	L (channels 8065, 8340, 8665)	2 x 1 W	Front	20 cm	0.73	0.87	PASSED
	Wi-Fi 2.4 GHz (channel 1)	0.1 W			0.04		
	Wi-Fi 5 GHz (channels 36, 52, 100, 149)	≤ 0.25 W			0.10		

Expanded uncertainty (k=2) 95 % for field strength measurements using the DASYS5 near field scanner.	< 30%
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As shown above, the exposure ratios for both the individual LTE and Wi-Fi modes, as well as for the combined case, are below 1. Hence, the RF EMF exposure is below the relevant exposure limits [1] for the 20 cm test separation distance.

6 Conclusion

The results in Section 5 show that the plane-wave equivalent power density, measured and estimated according to the requirements of FCC [3] and Industry Canada [2], is below the relevant MPE limits [1] for all specified configurations 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.

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), 2010.
- [3] FCC KDB447498 D01, “Mobile and Portable Devices RF exposure procedures and Equipment Authorization Policies”, October 2012.
- [4] IEEE Std C95.1-2005 (Revision of IEEE Std C95.1-1991), “Safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz”, The Institute of Electrical and Electronics Engineers Inc., New York, 2006.
- [5] Ericsson, EAB-13:016433 Uen, “Ericsson average field strength measurement specification for low power radio base stations”.
- [6] Thors et al., “Product Compliance Assessments of Low Power Radio Base Stations with Respect to Whole-Body Radiofrequency Exposure Limits”, in EuCAP, 2013.

¹² For a test separation distance of 20 cm, the exposure was found to be well below applicable exposure limits in front of the antenna. Since this test position corresponds to the direction of maximum exposure [3] and the Pico RBS is classified as a mobile device with an intended separation distance to the user or nearby persons of at least 20 cm, other test positions were not considered.

¹³ The separation distance is measured from the EUT casing.

¹⁴ The exposure ratio is defined as the evaluated exposure parameter expressed as the power fraction of the related exposure limit. For Wi-Fi 5 GHz, the provided exposure ratio is the maximum value obtained for the four channels 36, 52, 100, and 149. For LTE, the provided exposure ratio is the maximum value obtained for the channels 8065, 8340 and 8665 (low, mid, and high).

¹⁵ The combined exposure ratio is the sum of the individual exposure ratios for each source.

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- [7] Ericsson, EAB-13:04507, “ EMF Test Report: Ericsson-RBS 6401”
- [8] FCC, Code of Federal Regulations CFR title 47, part 2.1091, “ Radiofrequency radiation exposure evaluation: mobile devices”, Federal Communications Commission (FCC), November 2013.

8 Revision History

Rev.	Date	Description
A	2013-10-29	First revision
B	2013-11-15	Added results for omni-directional antennas

APPENDIX A: Photographs of the EUT



Figure A.1 Front view of the EUT and EUT with radome removed showing the LTE and Wi-Fi antennas.

APPENDIX B: Electric and magnetic field strength probe calibration parameters
H3DV6 S/N 6015; ER3DV4R S/N 2210
Diode compression:

Parameter	Value in mV
DCP X	98.4 (S/N 6015) / 97.6 (S/N 2210)
DCP Y	93.6 (S/N 6015) / 97 (S/N 2210)
DCP Z	91.6 (S/N 6015) / 97.7 (S/N 2210)

Sensitivity in free space (H3DV6 S/N 6015):

Parameter	Value in A/m / $\sqrt{\text{mV}}$		
	a0	a1	a2
Norm X	3.10E-003	-5.04E-004	1.27E-004
Norm Y	2.78E-003	-4.84E-004	1.38E-004
Norm Z	3.25E-003	-1.02E-003	4.03E-004

Sensitivity in free space (ER3DV4R S/N 2210):

Parameter	Value in $\mu\text{V}/(\text{V}/\text{m})^2$
Norm X	2.84
Norm Y	3.09
Norm Z	5.29

Probe tip to sensor center (S/N 6015): 3 mm

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

EF3DV3 S/N 2210 (5-6 GHz range)
Diode compression:

Parameter	Value in mV
DCP X	98.3
DCP Y	97.5
DCP Z	91.6

Sensitivity in free space:

Parameter	Value in $\mu\text{V}/(\text{V}/\text{m})^2$
Norm X	1.44
Norm Y	3.09
Norm Z	5.29

Probe tip to sensor center): 1.5 mm

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



Figure C.1 EUT positioned for field strength measurements in the front position using the DASYS5 near-field scanner.