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EMF Test Report: Ericsson Radio 4490HP 44B5 44B12A C (FCC)

Document number:	GFTL-22:001675 Uen Rev A	**Date of report:**	2022-12-20
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Tests performed by:	Bo Xu	**Dates of tests:**	2022-12-20
Manufacturer and market name(s) of device:	Ericsson Radio 4490HP 44B5 44B12A C		
Testing has been performed in accordance with:	FCC OET Bulletin 65 IEC 62232:2017		
Test results:	RF exposure compliance boundaries (exclusion zones) in conformity with FCC 47 CFR 1.1310 to be included in the Customer Product Information (CPI) for Ericsson Radio 4490HP 44B5 44B12A C.		
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Summary of EMF Test Report[1]

Equipment under test (EUT)

Product name	Radio 4490HP 44B5 44B12A C		
Product number	KRC 161 981/3, KRC 161 981/31		
Supported bands, Tx frequency range (MHz) and standards[2]	B5 B12A	869 - 894 729 - 745	WCDMA/LTE/NR LTE/NR
Duplexing technology	FDD		

Antennas

Product number	80010901
Tested mode(s)	B5 + B12A (WCDMA/LTE/NR + LTE/NR)

Results

RF exposure compliance boundaries, outside of which the exposure is below the general public (GP) and occupational (O) exposure limits, are listed below.

Dimensions of the box-shaped compliance boundary for general public (GP) and occupational (O) exposure for Radio 4490HP 44B5 44B12A C applicable in the US and markets employing FCC exposure limits. The compliance boundaries are determined for maximum nominal output power with 0.5 dB transmission loss and 0.6 dB output power tolerance included.

Mode and output power for Radio 4490HP				**Dimensions of the box-shaped compliance boundary (m)**							
				Distance in front of antenna		**Width**		**Height**		**Distance behind antenna**	
Band	**Standard[2]**	**Maximum nominal output power from the radio**	**IEC 62232 installation class**	**GP**	**O**	**GP**	**O**	**GP**	**O**	**GP**	**O**
B5 + B12A	WCDMA/LTE/ NR + LTE/NR	4 × 60 W + 4 × 60 W	E+	22.3	9.9	17.3	7.8	4.8	2.4	0.5	0.2

For the power levels specified in the table with tolerances added, and the upward rounding of compliance boundary dimensions to the nearest decimeter, the specified results are conservative.

[1] This page contains a summary of the test results. The full report provides a complete description of all test details and results.
[2] If the radio supports NB-IoT, the distances are the same.

1 General information

The test results presented in this report define compliance boundaries for Radio 4490HP 44B5 44B12A C. Outside of these compliance boundaries, the radio frequency (RF) exposure levels are below the limits specified by the Federal Communications Commission (FCC) [1]. The tests were performed by calculations in accordance with the Ericsson RF exposure calculation procedure for base stations [2], which is in conformity with the FCC OET Bulletin 65 [3] and IEC 62232:2017 [4].

It should be noted that the test results presented in this test report are valid for the frequency range specified in Table 1, for the antenna properties specified in Table 2, and for the power level, power tolerance, and transmission loss specified in Table 3. These data as well as the applied antenna pattern files were supplied by the client and may affect the validity of the results.

Proposed EMF health and safety information for inclusion in the Customer Product Information (CPI) is provided in Appendices A, B and C.

2 Equipment under test

Table 1 and Table 2 below summarize the technical data for the equipment under test (EUT) and the properties of the antenna. Table 3 lists the maximum nominal output power from the radio unit (total peak power from all antenna branches) and the total time-averaged power delivered to the antenna for the specified configuration. The total time-averaged power delivered to the antenna includes transmission loss and output power tolerance.

The EUT related data in Tables 1-3 were supplied by the client.

Table 1 Technical data for the EUT.

Product name and product number	Radio 4490HP 44B5 44B12A C		KRC 161 981/3, KRC 161 981/31
Supported bands, Tx frequency range (MHz), and standards[2]	B5 B12A	869 - 894 729 - 745	WCDMA/LTE/NR LTE/NR
Duplexing technology	FDD		
Exposure environment	General public, Occupational		
IEC 62232 installation class[3]	E+		

Table 2 Properties of the antenna.

Product number	80010901	
Type	Macro cell, directional, 4 Tx (2 columns, X polarized)	
Tested band and frequency range (MHz)	B5 B12A	869 - 894 729 - 745
Gain (dBi)[4]	15.9	
Electrical tilt angle (degree)	2°	
Number of dual-polarized elements per column and element interspacing distance (mm)	7	250
Dimensions, $H \times W \times D$ (mm)	1999 × 508 × 175	

Table 3 Maximum nominal output power and total time-averaged power including transmission loss and output power tolerance for EUT.

Band	Standard	Maximum nominal output power from the radio	Transmission loss (dB)	Power tolerance (dB)	Total time-averaged power delivered to antenna (dBm/W)
B5 + B12A	WCDMA/LTE/NR + LTE/NR	4 × 60 W + 4 × 60 W	0.5	0.6	56.9 / 491.2

[3] The stated IEC 62232 installation class was determined based on the total EIRP without power tolerance included and considering the transmission loss. The total EIRP was obtained using the antenna patterns provided by the client.
[4] Maximum gain per antenna port obtained using the antenna patterns provided by the antenna manufacturers.

3 Exposure conditions

The EUT is intended to be used outdoor and installed on poles, walls, masts, towers, or similar structures making it possible to ensure that the general public has no access to the EMF compliance boundary. Other installation related exposure conditions are not reasonably foreseeable for the EUT.

The assessments were conducted for maximum power configurations, i.e., by assuming 100% utilization. Effects of real RBS utilization (time-averaged) is reasonably foreseeable and will significantly reduce the time-averaged power and the RF exposure. This factor was not considered in this assessment, which adds to the conservativeness of the obtained compliance boundaries.

4 EMF compliance boundary calculations

The RF exposure was evaluated using calculations performed according to the Ericsson RF Exposure Calculation Procedure for Base Stations [2], which conforms to FCC OET Bulletin 65 [3] and IEC 62232 [4]. The calculations were made using the Ericsson in-house MATLAB-based tool called MSI compliance analyzer (release 2022-02) [5]. The first step in calculating the compliance boundary was to use the spherical far-field formula to estimate power density:

$$S_{\mathrm{sph}}(\theta,\phi) = \frac{P_{\mathrm{a}} G(\theta,\phi)}{4\pi r^2},$$

where S,P_{a}, G, r, θ, and ϕ denote the power density, the power accepted by each antenna port, the antenna gain per port, the distance from the antenna, and the angular variables in a spherical coordinate system, respectively. Antenna far-field measurement data were provided by the client for five frequencies, specifically 869 MHz, 880 MHz, 882 MHz, and 894MHz (B5) and 737MHz (B12A). The procedure described in this section was applied to each of these, and the compliance boundaries were determined as the maximum values for the tested frequencies. Power density was evaluated for the lowest applicable electrical down tilt of the antenna (2°). The maximum gain values were found to 15.9 dBi (pol +45) and 15.8 dBi (pol -45), considering all the tested frequencies within B5 B12A.

The tested configurations are characterized by a total of 4 transmitters (4 TX per band), and the RF exposure was determined for both bands operating simultaneously (each antenna port serving both B5 and B12A).

The accepted power per port was taken as the total power delivered to the antenna, including tolerances, divided by the number of ports. In the frontal hemisphere ($\phi \in \left[-\frac{\pi}{2},\frac{\pi}{2}\right]$), the exposure from antenna ports with the same nominal polarizations (denoted ±45) were summed in a correlated way to consider beamforming while the exposure from antenna ports with different nominal polarizations were summed in an uncorrelated manner. Also, in the rear hemisphere ($\phi \notin [-\frac{\pi}{2},\frac{\pi}{2}]$), uncorrelated exposure was assumed [2]. With the two antenna columns denoted 1 and 2, the total power density as estimated by the spherical far-field formula is thus given by:

$$S_{\mathrm{total,sph,B5}} = \begin{cases} \left(\sqrt{S_{\mathrm{sph,1,+45,B5}}} + \sqrt{S_{\mathrm{sph,2,+45,B5}}}\right)^2 + \left(\sqrt{S_{\mathrm{sph,1,-45,B5}}} + \sqrt{S_{\mathrm{sph,2,-45,B5}}}\right)^2 & ,\phi \in \left[-\frac{\pi}{2},\frac{\pi}{2}\right] \\ S_{\mathrm{sph,1,+45,B5}} + S_{\mathrm{sph,2,+45,B5}} + S_{\mathrm{sph,1,-45,B5}} + S_{\mathrm{sph,2,-45,B5}} & ,\phi \notin [-\frac{\pi}{2},\frac{\pi}{2}] \end{cases}$$

$$S_{\mathrm{total,sph,B12A}} = \begin{cases} \left(\sqrt{S_{\mathrm{sph,1,+45,B12A}}} + \sqrt{S_{\mathrm{sph,2,+45,B12A}}}\right)^2 + \left(\sqrt{S_{\mathrm{sph,1,-45,B12A}}} + \sqrt{S_{\mathrm{sph,2,-45,B12A}}}\right)^2 & ,\phi \in \left[-\frac{\pi}{2},\frac{\pi}{2}\right] \\ S_{\mathrm{sph,1,+45,B12A}} + S_{\mathrm{sph,2,+45,B12A}} + S_{\mathrm{sph,1,-45,B12A}} + S_{\mathrm{sph,2,-45,B12A}} & ,\phi \notin [-\frac{\pi}{2},\frac{\pi}{2}] \end{cases}$$

The compliance distance for the spherical model, $CD_{\mathrm{sph}}(\theta,\phi)$ was obtained by solving the following equation for r:

$$\frac{S_{\mathrm{total,sph,B5}}(r,\theta,\phi)}{S^{\mathrm{lim}}_{\mathrm{gp,o,B5}}} + \frac{S_{\mathrm{total,sph,B12A}}(r,\theta,\phi)}{S^{\mathrm{lim}}_{\mathrm{gp,o,B12A}}} = 1$$

where $S_{\mathrm{gp,o}}^{\mathrm{lim}}$ denotes the FCC power density limits for general public and occupational exposure. The limits for the frequency bands of interest are given in Table 4.

Table 4 RF EMF exposure limits on power density for the frequency band used by the EUT.

Band	$S_{\mathrm{gp}}^{\mathrm{lim}}$ (W/m^2)	S_{o}^{lim} (W/m^2)
B5	5.8	29.0
B12A	4.9	24.3

If the spherical far-field formula is applied in the near-field, very conservative results may be obtained. Within the main beam direction, a better approximation of the spatial peak power density per antenna port is in this case obtained by using the cylindrical wave model[5] [6] given by

$$S_{\mathrm{cyl}}(r,\phi) = \frac{6.P_{\mathrm{t}}.2^{-\left(\frac{2\phi}{\Phi_{\mathrm{3dB}}}\right)^2}}{\pi\Phi_{\mathrm{3dB}}\cdot r\cdot L\cdot\cos^2(\gamma)\cdot\sqrt{1+\left(\frac{2r}{r_0}\right)^2}},\quad r_0=\frac{\Phi_{\mathrm{3dB}}}{12}D_{\mathrm{A}}\cdot L\cdot\cos^2(\gamma),$$

where $P_{\mathrm{t}}, L, D_{\mathrm{A}}, \Phi_{\mathrm{3dB}}$, and γ denote the transmitted power per antenna port[6] (W), the length over which the antenna elements are distributed (m), the peak directivity (unit-less), the horizontal half-power beam width (radians) and the electrical down tilt (radians), respectively. Here, D_{A} and Φ_{3dB} were obtained from the far-field measurement for each antenna port for the lowest applicable electrical tilt.

Similarly, as for the spherical formula, the total power density as estimated using the cylindrical wave model is given by

$$S_{\mathrm{total,cyl,B5}}(r,\phi) = \left(\sqrt{S_{\mathrm{cyl,1,+45,B5}}(r,\phi)}+\sqrt{S_{\mathrm{cyl,2,+45,B5}}(r,\phi)}\right)^2+\left(\sqrt{S_{\mathrm{cyl,1,-45,B5}}(r,\phi)}+\sqrt{S_{\mathrm{cyl,2,-45,B5}}(r,\phi)}\right)^2$$

$$S_{\mathrm{total,cyl,B12A}}(r,\phi) = \left(\sqrt{S_{\mathrm{cyl,1,+45,B12A}}(r,\phi)}+\sqrt{S_{\mathrm{cyl,2,+45,B12A}}(r,\phi)}\right)^2+\left(\sqrt{S_{\mathrm{cyl,1,-45,B12A}}(r,\phi)}+\sqrt{S_{\mathrm{cyl,2,-45,B12A}}(r,\phi)}\right)^2$$

The compliance distance for the cylindrical model, $\mathrm{CD}_{\mathrm{cyl}}(\phi)$ was obtained by solving the following equation for r:

$$\frac{S_{\mathrm{total,cyl,B5}}(r,\phi)}{S_{\mathrm{gp,o,B5}}^{\mathrm{lim}}}+\frac{S_{\mathrm{total,cyl,B12A}}(r,\phi)}{S_{\mathrm{gp,o,B12A}}^{\mathrm{lim}}}=1$$

The cylindrical wave model is applicable within the main beam for $-\pi/6\leq\phi\leq-\pi/6$ and $|z|\leq L/2$ (where z is the axis defined along the height of the antenna) and it is more accurate in the near-field regions where the spherical model is conservative. Therefore, within this angular range in the horizontal plane, the compliance distance is taken as the lesser of the values obtained by the two models [2]

$$CD(\theta,\phi)=\min\left(CD_{\mathrm{sph}}(\theta,\phi),CD_{\mathrm{cyl}}(\phi)\right).$$

Based on the calculated compliance distances, a box-shaped compliance boundary was determined. To comply with the FCC requirement of a minimum test separation distance for a non-portable device of 20 cm, the minimum distance from the antenna to the compliance boundary was set to 20 cm.

[5] In IEC 62232 **Error! Reference source not found.**, a slightly simplified cylindrical wave model is specified based on the approximation $\pi \approx 3$. Here, the expression in the original journal paper has been used which in the main beam direction $\phi = 0^{\circ}$ correctly converges to the spherical far field formula as $r \to \infty$.

[6] The transmitted power per antenna port were conservatively taken as the accepted power per antenna port.

5 Results

A box-shaped compliance boundary is used, characterized by its width, height, and the compliance distances behind and in front of the antenna, see Figure 1. Outside of this box, the RF exposure is below the exposure limits.

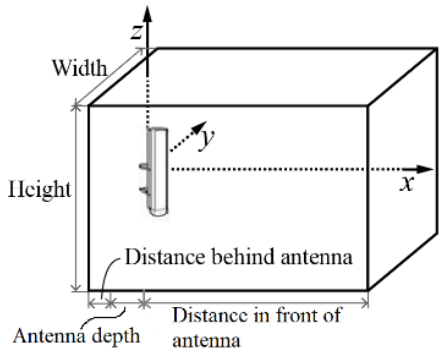

Figure 1 Box-shaped structure specifying the compliance boundary for the tested antenna.

When applied behind the antenna, the spherical far-field formula provides very conservative results. Therefore, the compliance distance in this direction should be interpreted as a large overestimate of the true value.

In Figure 2, the compliance distance results for general public (blue line) and occupational (red line) exposure are given for the tested configuration leading to the largest compliance boundary. The solid-colored lines represent the result obtained with the spherical model while the dash-dotted line represents the result obtained with the cylindrical wave model. Also shown are the resulting compliance boundaries (black lines, solid for general public, dashed for occupational exposure). The resulting compliance boundary dimensions are given in Table 5 rounded upwards to the nearest decimeter.

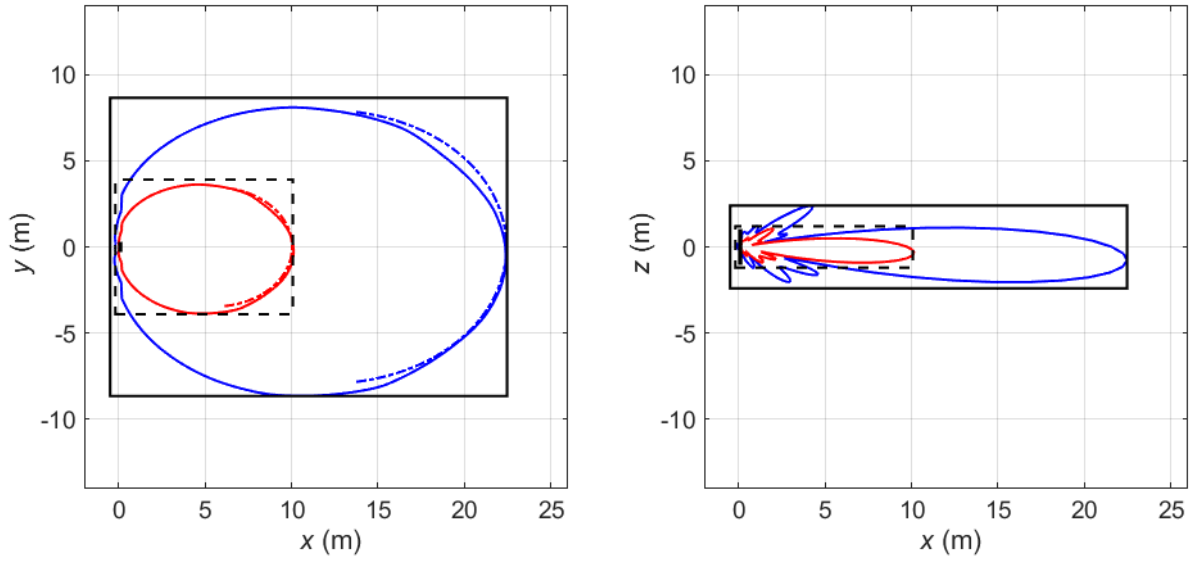

Figure 2 Compliance boundary for general public (black solid line) and occupational (black dashed line) exposure. The blue solid and dash-dotted lines correspond to compliance distance results for general public exposure obtained using the spherical and cylindrical models, respectively. The red solid and dash-dotted lines correspond to compliance distance results for occupational exposure obtained using the spherical and cylindrical models, respectively. The antenna is shown from the above (left) and from the side (right) with its back plane located at x = 0 m. Mode: B5 + B12A (WCDMA/LTE/NR + LTE/NR). Total time-averaged power delivered to the antenna: 491.2 W.

Table 5 Dimensions of the box-shaped compliance boundary for general public (GP) and occupational (O) exposure for Radio 4490HP 44B5 44B12A C applicable in the US and markets employing the FCC RF exposure limits. The compliance boundaries are determined for maximum nominal output power with 0.5 dB transmission loss and 0.6 dB output power tolerance included.

Mode and output power for Radio 4490HP				Dimensions of the box-shaped compliance boundary (m)							
				Distance in front of antenna		Width		Height		Distance behind antenna	
Band	**Standard[2]**	**Maximum nominal output power from the radio**	**IEC 62232 installation class**	**GP**	**O**	**GP**	**O**	**GP**	**O**	**GP**	**O**
B5 + B12A	WCDMA/LTE/NR + LTE/NR	4 × 60 W + 4 × 60 W	E+	22.3	9.9	17.3	7.8	4.8	2.4	0.5	0.2

For the power levels specified in the table with tolerances added, and the upward rounding of compliance boundary dimensions to the nearest decimeter, the specified results are conservative.

6 Uncertainty

For the input parameters defined in the test report, the calculated compliance boundary dimensions determined according to the approach described in Section 4 results in an exposure assessment which is conservative. The compliance boundary dimensions were determined by comparing the evaluated RF exposure directly with the limits.

7 Conclusion

The Ericsson Radio 4490HP 44B5 44B12A C has been tested using methods and procedures specified in FCC OET Bulletin 65 [3] and IEC 62232:2017 [4]. The results in Section 5 show the compliance boundary dimensions of the product to be included in the Customer Product Information (CPI). Outside of these compliance boundaries, the RF exposure is below the limits specified in [1].

8 References

[1] FCC, Code of Federal Regulations CFR title 47, part 1.1310 "Radiofrequency radiation exposure limits", Federal Communications Commission (FCC), August 1997.
[2] Ericsson, GFTE-16:001718 Uen, "Ericsson RF exposure calculation procedure for base stations".
[3] FCC, "Evaluating compliance with FCC guidelines for human exposure to radiofrequency electromagnetic fields. OET Bulletin 65. Edition 97-01." Federal Communications Commission (FCC), Office of Engineering and Technology, August 1997.
[4] IEC 62232:2017, "Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure", June 2017.
[5] Ericsson, GFTL-19:000424 Uen, "User manual of MSI compliance analyzer".
[6] R. Cicchetti and A. Faraone, “Estimation of the peak power density in the vicinity of cellular and radio base station antennas”, IEEE Trans. Electromagn. Compat., vol. 46, no. 2, pp. 275–290, 2004.
[7] Ericsson, LME-12:001904 Uen, "Exposure to radio frequency electromagnetic fields".

9 Revision history

Rev.	Date	Description
A	2022-12-20	First revision

Appendix A. Information to be included in the CPI

Table A.1 below lists the compliance boundaries (exclusion zones), outside of which the RF EMF exposure from Radio 4490HP 44B5 44B12A C is below the limits applicable in:

- USA (47 CFR 1.1310)

Table A.1 Dimensions of the box-shaped compliance boundary for general public (GP) and occupational (O) exposure for FCC applicable in the US and markets employing the FCC RF exposure limits. The compliance boundaries are determined for maximum output power with 0.5 dB transmission loss and 0.6 dB output power tolerance included.

Mode and output power				Dimensions of the box-shaped compliance boundary[1][2] (m)							
				Distance in front of antenna		Width		Height		Distance behind antenna	
Product	**Standard**	**Maximum nominal output power from the radio**	**IEC 62232 installation class**	**GP**	**O**	**GP**	**O**	**GP**	**O**	**GP**	**O**
Radio 4490HP 44B5 44B12A C	WCDMA/LTE/NR + LTE/NR	4 x 60 W + 4 x 60 W	E+	22.3	9.9	17.3	7.8	4.8	2.4	0.5	0.2

(1) The compliance boundaries are determined for maximum output power with transmission loss and power tolerance included using the antenna 80010901 for an electrical tilt of 2°.

(2) If the radio supports NB-IoT, the distances are the same.

Appendix B. Guidelines on how to install the product

The antenna connected to the Radio 4490HP 44B5 44B12A C product (KRC 161 981/3, KRC 161 981/31) shall be installed to make sure that the general public does not have access to the applicable RF EMF compliance boundary. The compliance boundary dimensions were determined for the product transmitting in free space.

Appendix C. Guidelines for workers during installation, maintenance, and repair of the product

For antenna connected to the Radio 4490HP 44B5 44B12A C product (KRC 161 981/3, KRC 161 981/31), if work needs to be performed within the compliance boundary applicable for workers, the radio equipment shall be powered off, or the power be reduced to a level ensuring that the RF EMF exposure is below the relevant exposure limit for workers.

If work is conducted on behalf of Ericsson, minimum EMF related requirements are provided in [7].

Appendix D. Photograph/Sketch of the EUT