RF exposure compliance assessment

Nokia AirScale Multiband Remote Radio Head Solution – AHFII

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Document Type	Final test report
Document ID	LPITPN2I4Q5L-1109616211-3286
Document location	https://nokia.sharepoint.com/:f:/r/sites/EMFProductManagement/Shared%20Documents/General/Products-RF-exposure-assessment/AHFII?csf=1&web=1&e=HqGaEV

Change History

Version	Status	Date	Author	Owner	Reviewed by	Reviewed date	Approver	Approval date	Description of changes
1.0	Final	09-02-2022	K. Bechta	C. Grangeat	C. Grangeat	09-02-2022	J. Kamdar	24-02-2022	
2.0	Final	17-05-2022	K. Bechta	C. Grangeat	C. Grangeat	09-02-2022	J. Kamdar	24-02-2022	Results for Canada (General population) corrected

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1 General content

This test report is addressing human exposure to radiofrequency electromagnetic fields (RF-EMF) transmitted by the following Nokia Multiband Remote Radio Head (RRH) product (see §4):

- Nokia AHFII AirScale Dual RRH 4T4R B25/66 480W

It provides the RF exposure compliance boundaries for this product when it is connected with a typical external antenna, such as Kathrein 80011867. The assessment is performed regarding both general population and occupational exposure. Outside of these compliance boundaries, human exposure to RF-EMF is below the limits defined by the US Federal Communications Commission (FCC), Canada Safety Code 6, Australia ARPANSA and European regulations (see §2.1 and [14]).

2 References

2.1 Applicable RF exposure standards and regulations

[1] EU 1999/519/EC, “Council Recommendation on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)”, July 1999

[2] EU 2013/35/EU, “Directive of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC”, June 2013

[3] EN 50385:2017, “Product standard to demonstrate the compliance of base station equipment with radiofrequency electromagnetic field exposure limits (110 MHz - 100 GHz), when placed on the market”, July 2017

[4] IEC 62232 ED3 CDV (106/550/CDV), “Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure”, 2021.

[5] AS/NZS 2772.2, "Radiofrequency fields Part 2: Principles and methods of measurement and computation-3 kHz to 300 GHz", 2016

[6] ARPANSA “Maximum Exposure Levels to Radiofrequency Fields — 3 kHz to 300 GHz”, Radiation Protection Series Publication No. 3, 2016

[7] Canada Safety Code 6, “Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz”, June 2015

[8] Canada RSS-102, “Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)”, Issue 5, March 2015,

[9] US FCC 47CFR 1.1310 “Radiofrequency radiation exposure limits”, August 1997.

[10] US FCC OET Bulletin 65, “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields and its supplements”, edition 97-01, August 1997.

2.2 Product and assessment method

[11] Microwave Vision Group (MVG), “EMF Visual User Manual”, SEWB/EMF-VISUAL-UM.1/v2021.2.

[12] Z. Altman, B. Begasse, C. Dale, A. Karwowski, J. Wiart, M. Wong and L. Gattoufi, “Efficient models for base station antennas for human exposure assessment”, IEEE Trans. Electromagnetic Compatibility, Nov 2002, vol.44, pp. 588-592.

[13] IEC TR62669, “Case studies supporting the implementation of IEC 62232”, (106/463/CD, July 2018).

[14] NGMN white paper, “Recommendation on Base Station Active Antenna System Standards v1.0”, July 2020, https://www.ngmn.org/wp-content/uploads/Publications/2020/NGMN_BASTA-AA_WP_1_0.pdf

[15] Kathrein 80011867, 8-Port Antenna 2LB/2HB 1.5m 65° | 698–862 14.5dBi | 880–960 15dBi | 1695–2690 18dBi | 1427–2690 18dBi

3 RF exposure limits

The applicable RF exposure limits are defined by [1] and [2] in Europe and ICNIRP countries, by [5] in Australia and New Zealand, by [7] in Canada and by [9] in the US and related countries such as Bolivia, Estonia, Mexico and Panama. The applicable power density limits are recalled in Table 1 for the frequency range applicable to the equipment under test.

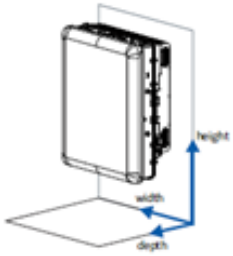
Table 1 – Applicable RF exposure levels in B25 and B66 bands expressed in power density

Region of application	General Population/Uncontrolled Exposures		Occupational/Controlled Exposures	
	B25	B66	B25	B66
US/related	10.0 W/m^2	10.0 W/m^2	50.0 W/m^2	50.0 W/m^2
EU/ICNIRP, Australia/NZ	9.6 W/m^2	10.0 W/m^2	48.2 W/m^2	50.0 W/m^2
Canada	4.6 W/m^2	4.9 W/m^2	28.3 W/m^2	29.6 W/m^2

4 Description of the equipment under test (EUT)

The main technical characteristics of AHFII product, when it is connected with a typical external antenna, such as Kathrein 80011867, are provided in Table 2.

Table 2 – AHFII and Kathrein 80011867 general technical characteristics

RRH Product name	**Nokia AHFII AirScale Dual RRH 4T4R B25/66 480W**	
Model number	475656A	
Rated max Tx power	480 W	
Number of TXRX	4TX4RX	
Beamforming	No	
SW supported techno.	3GPP compliant, FDD-LTE, NR, GSM, UMTS	
Frequency range	Band 25: RX 1850 MHz – 1915 MHz, TX 1930 MHz – 1995 MHz Band 66: RX 1710 MHz – 1780 MHz, TX 2110 MHz – 2200 MHz	
Antenna Product name	**Kathrein 80011867**	
Max Antenna Gain	Band 25: 17.9 dBi Band 66: 18.2 dBi	
Electrical Tilt range	+2.5° to +12°	
Dimensions 	Height: 1499 mm Width: 378 mm Depth: 164 mm	
Technology duty cycle factor	100 %	
Transmitted power tolerance	1.5 dB	

NOTE: This report presents compliance boundary only for bands B25 and B66. Additional transmitters in other bands can be connected to the same antenna. The combined compliance boundary should be assessed by the entity putting the base station site into service leveraging the transmitted power values for additional transmitters taking into account the information from antenna datasheet [15].

The EMF Visual model used for the RF exposure assessment is derived based on datasheet of Kathrein 80011867 antenna [15]. The EMF Visual model is validated with the product antenna model using the same pattern and gain. Table 4 to Table 6 presents EMF Visual models of beam

patterns in configurations used for the assessment of the compliance boundary. Selected patterns ensure that maximum compliance distance, applicable to evaluated product, is obtained.

Azimuth and elevation angles indicated in this report are provided according to the reference system used in product data sheets (see Table 3), unless otherwise stated.

Table 3 - Reference system used in this report (from NGMN white paper [14])

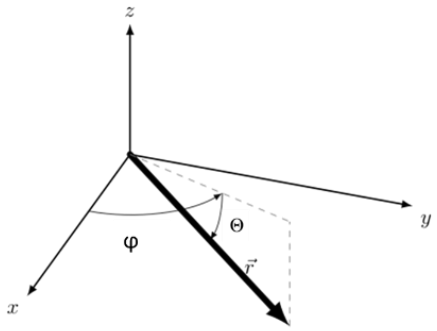
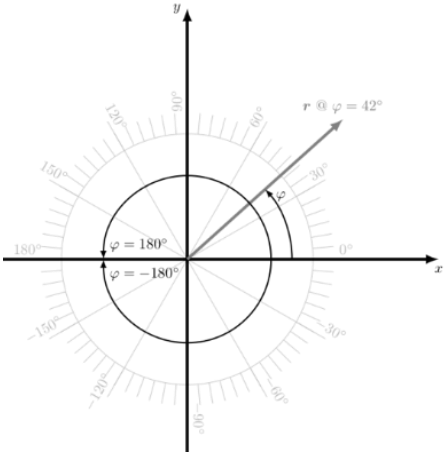
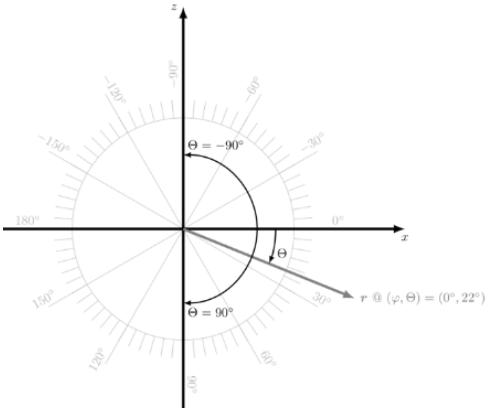
3D view Defintion of azimuth φ and elevation θ	
Top view (horizontal cut) Definition of azimuth φ	
Side view (vertical cut) Definition of elevation θ	

Table 4 – Antenna beam pattern models for band B25 used for EMF evaluation

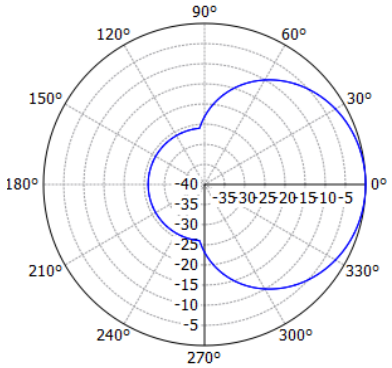
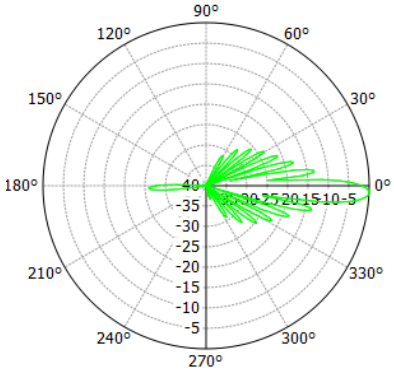
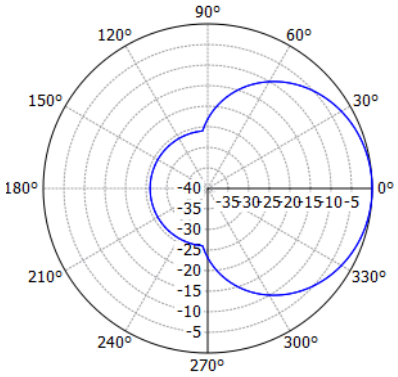
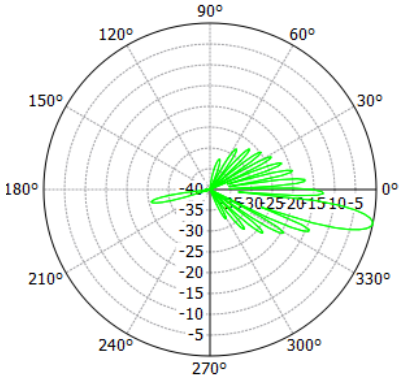
	Horizontal cut	Vertical cut
Boresight direction		
Max down-tilt		
NOTE: Angle references used in these graphs are derived from EMF Visual, which may differ from product data sheet (see Table 3)		

Table 5 – Antenna beam pattern models for band B66 used for EMF evaluation

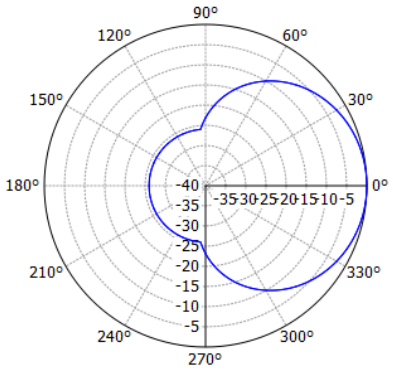
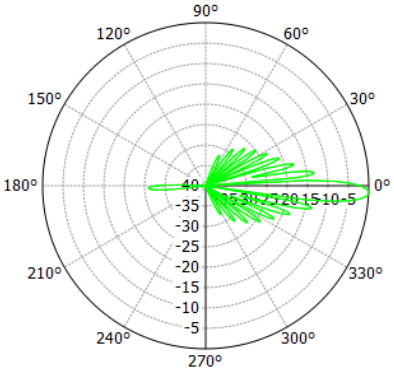
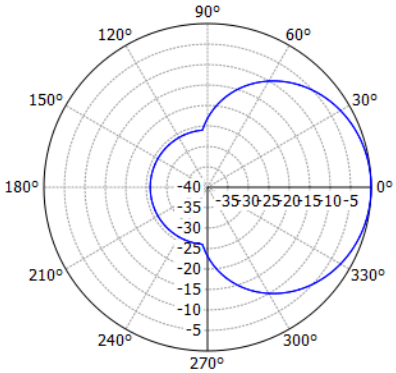
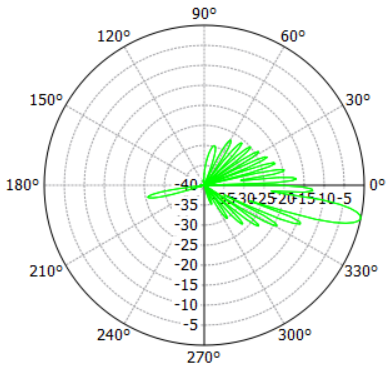
	Horizontal cut	Vertical cut
Boresight direction		
Max down-tilt		
NOTE: Angle references used in these graphs are derived from EMF Visual, which may differ from product data sheet (see Table 3)		

Table 6 – Antenna gain characteristics used during EMF evaluation

	Band	Azimuth pointing angle	Elevation pointing angle	Gain (dBi)
Boresight direction	B25	0°	+2.5°	17.9 dBi
	B66	0°	+2.5°	18.2 dBi
Max down-tilt	B25	0°	+12.0°	17.9 dBi
	B66	0°	+12.0°	18.2 dBi

The compliance boundary is defined by the box shape perimeter shown in Figure 4 of IEC 62232:2017 [4] and displayed in Figure 1. The distances D_f, $D_{s,a}$, $D_{u,a}$ and $D_{d,a}$ are taken from the nearest point of the antenna. For convenience, the distances $D_{s,c}$, $D_{u,c}$ and $D_{d,c}$ (respectively) taken from antenna center are also provided.

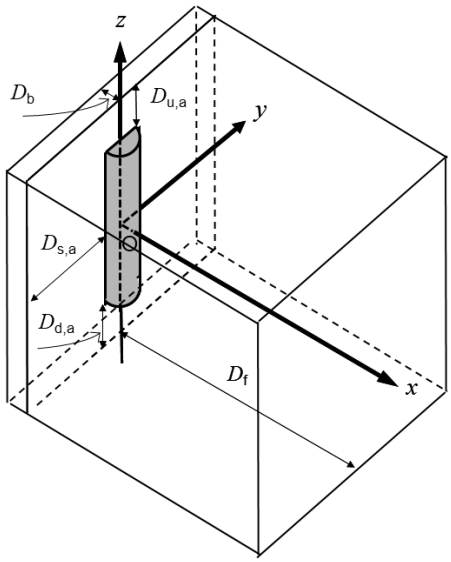


Figure 1 – Shape of the compliance boundary used for the RF exposure compliance assessment (from [4]).

5 RF exposure assessment method

RF exposure assessment is performed using the synthetic model computation method defined in B.4.4.1 of IEC 62232:2017. Calculations are performed with the "EMF Visual" software release OKTAL Version 4.0 2021.2 (see [11] and [12]).

The validation of the model is performed in the configuration with the beam in front (azimuth = 0° and elevation = +2.5°). The validation results are provided in Table 7.

Table 7 - Validation of the antenna model

	Band	Product	EMF Visual model	Deviation
Gain	B25	17.9 dBi	17.9 dBi	0.0 dB
	B66	18.2 dBi	18.2 dBi	0.0 dB
Horizontal half-power beamwidth	B25	66.0° ± 3.4°	66.5°	0.5°
	B66	66.0° ± 2.8°	65.0°	1.0°
Vertical half-power beamwidth	B25	6.7° ± 0.3°	7.0°	0.3°
	B66	6.3° ± 0.5°	6.5°	0.2°

The directivity pattern is derived from the simulation model and the antenna gain is adjusted to match exactly the simulated values for accurate scaling.

The RF compliance distances are provided for the time-averaged maximum transmitted power of 678 W, split into 226 W for band B25 (33%) and 452 W for band B66 (67%). This is corresponding to the time-averaged maximum EIRP of 76.42 dBm (71.45 dBm for band B25 and 74.75 dBm for band B66) in the boresight direction. The RF compliance distances are also provided for the actual EIRP threshold of 73.42 dBm, applying a power reduction factor of – 3 dB as defined in [4] and [13]. These values include a technology duty cycle factor of 100 % (see Table 2) for time averaging and a power tolerance of 1.5 dB due to electronic component dispersion and operational environmental conditions (temperature).

6 RF exposure computation results

6.1 Regions of application: US/related

The computed 3D distributions corresponding to a total exposure ratio (TER) of 1, for both general public and occupational exposure limits, are displayed in Figure 2 through Figure 5 for RF exposure limits defined in [9] for US/related countries.

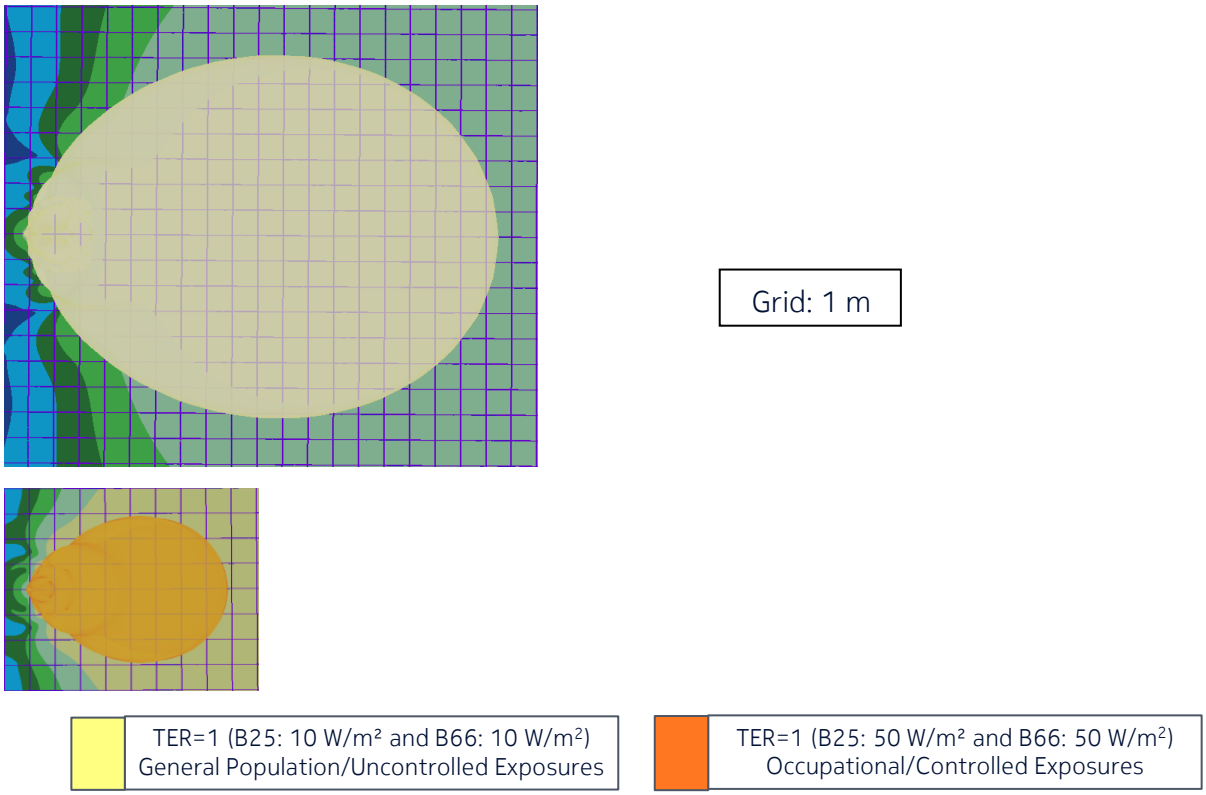


Figure 2 – Top view of the power density for the time-averaged maximum transmitted power of 678 W (corresponding to the time-averaged maximum EIRP of 76.42 dBm in the boresight direction) and the beam oriented in azimuth = 0° & elevation = +2.5° (US/related)

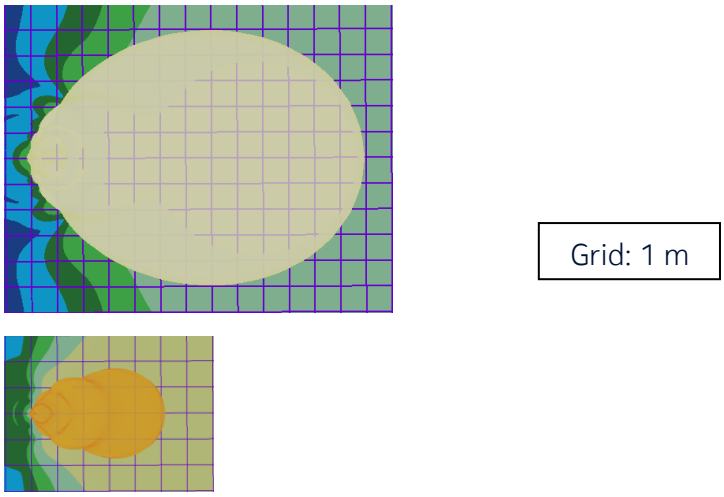


Figure 3 - Top view of the power density for the actual maximum transmitted power of 339 W (corresponding to the actual EIRP threshold of 73.42 dBm) and the beam oriented in azimuth = 0° & elevation = +2.5° (US/related)

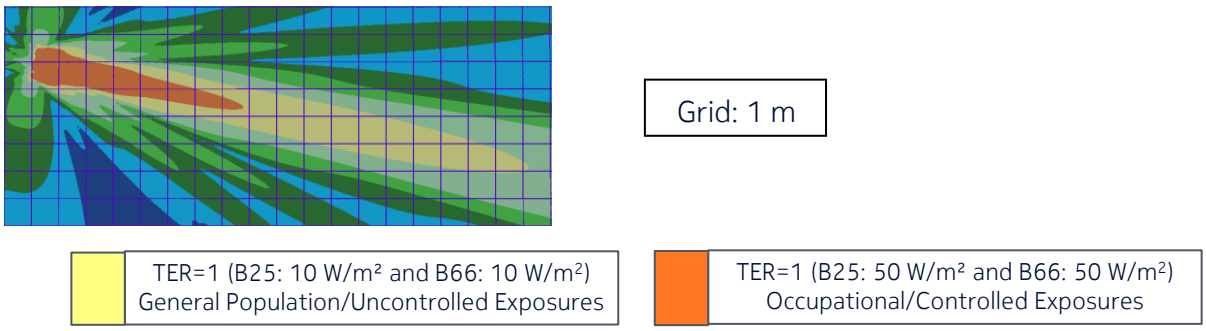


Figure 4 – Side view of the power density for the time-averaged maximum transmitted power of 678 W (corresponding to the time-averaged maximum EIRP of 76.42 dBm in the boresight direction) and the beam oriented in azimuth = 0° & elevation = +12° (US/related)

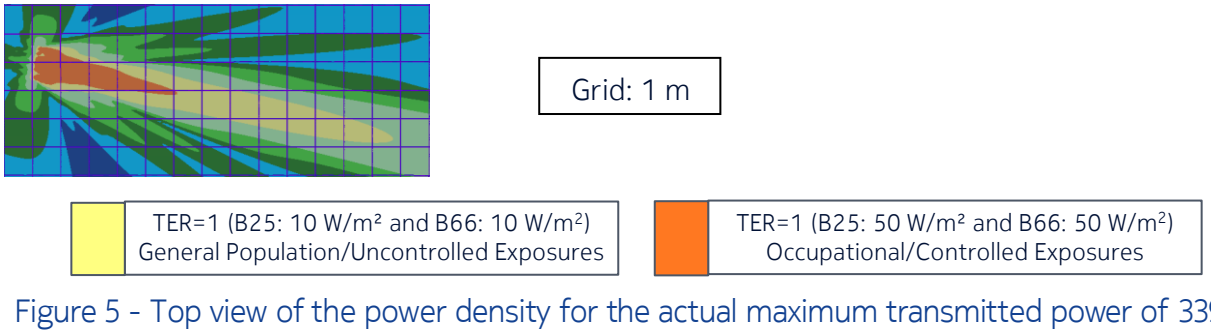


Figure 5 - Top view of the power density for the actual maximum transmitted power of 339 W (corresponding to the actual EIRP threshold of 73.42 dBm) and the beam oriented in azimuth = 0° & elevation = +12° (US/related)

6.2 Regions of application: EU/ICNIRP and Australia/NZ

The computed 3D distributions corresponding to a total exposure ratio (TER) of 1, for both general public and occupational exposure limits, are displayed in Figure 6 through Figure 9 for RF exposure limits defined in [1], [2] for EU/ICNIRP countries and [5] for Australia/NZ.

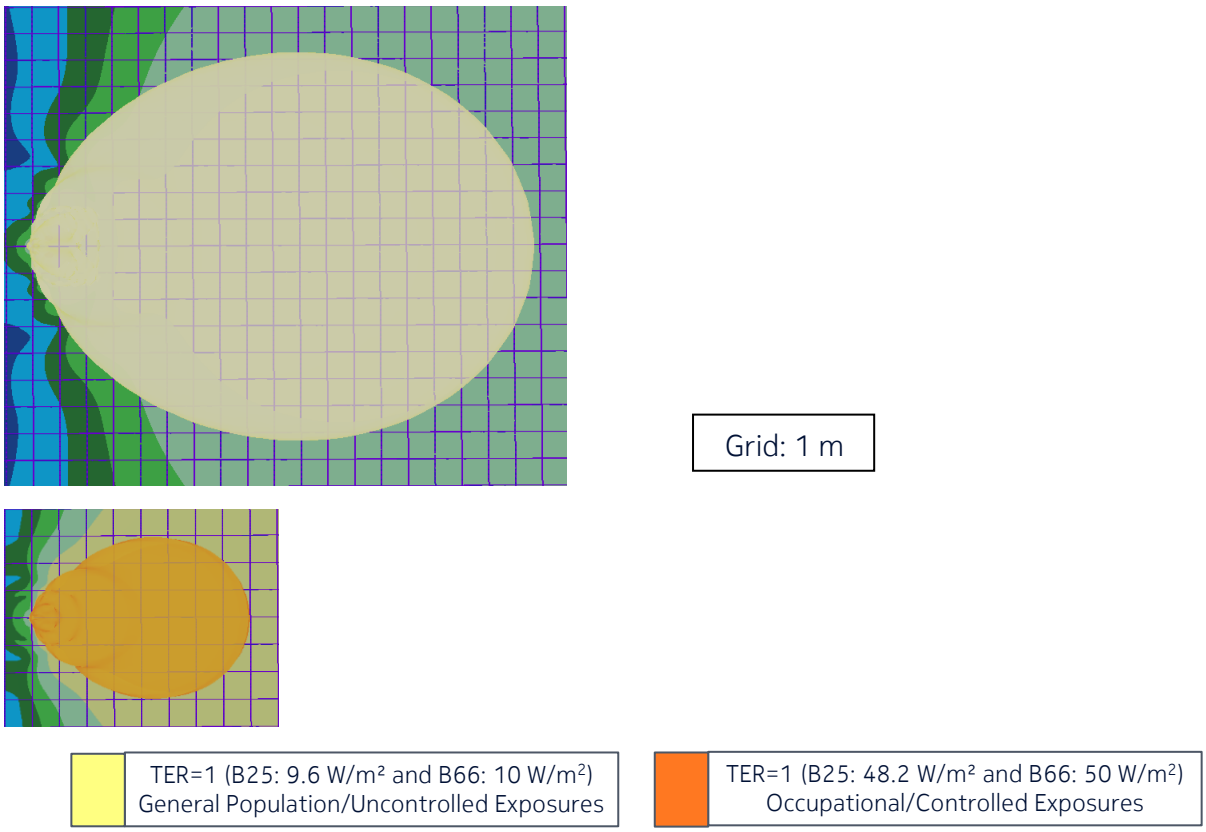


Figure 6 – Top view of the power density for the time-averaged maximum transmitted power of 678 W (corresponding to the time-averaged maximum EIRP of 76.42 dBm in the boresight direction) and the beam oriented in azimuth = 0° & elevation = +2.5° (EU/ICNIRP, Australia/NZ)

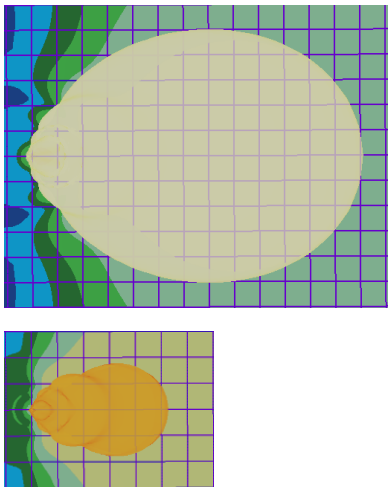


Figure 7 - Top view of the power density for the actual maximum transmitted power of 339 W (corresponding to the actual EIRP threshold of 73.42 dBm) and the beam oriented in azimuth = 0° & elevation = +2.5° (EU/ICNIRP, Australia/NZ)

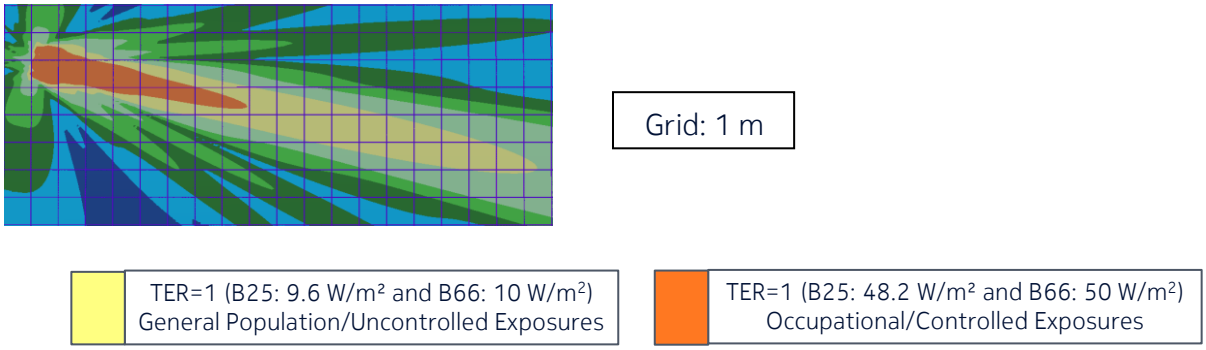


Figure 8 – Side view of the power density for the time-averaged maximum transmitted power of 678 W (corresponding to the time-averaged maximum EIRP of 76.42 dBm in the boresight direction) and the beam oriented in azimuth = 0° & elevation = +12° (EU/ICNIRP, Australia/NZ)

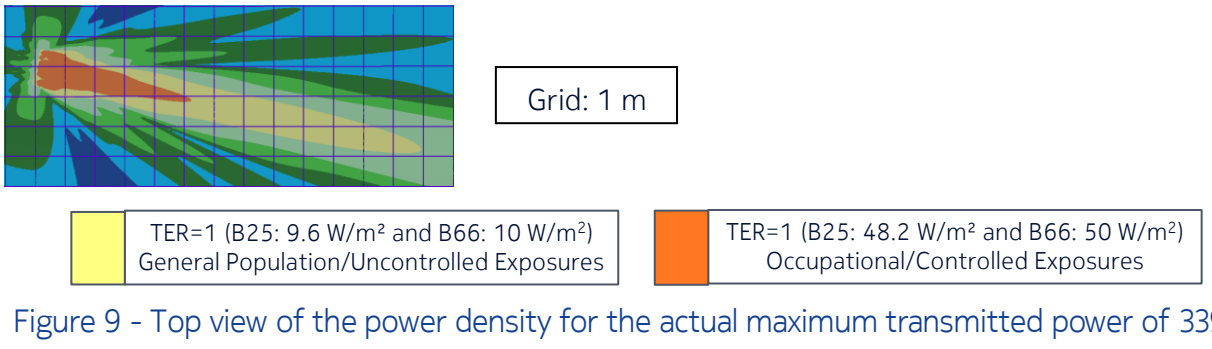


Figure 9 - Top view of the power density for the actual maximum transmitted power of 339 W (corresponding to the actual EIRP threshold of 73.42 dBm) and the beam oriented in azimuth = 0° & elevation = +12° (EU/ICNIRP, Australia/NZ)

6.3 Regions of application: Canada

The computed 3D distributions corresponding to a total exposure ratio (TER) of 1, for both general public and occupational exposure limits, are displayed in Figure 10 through Figure 13 for RF exposure limits defined in [7] for Canada.

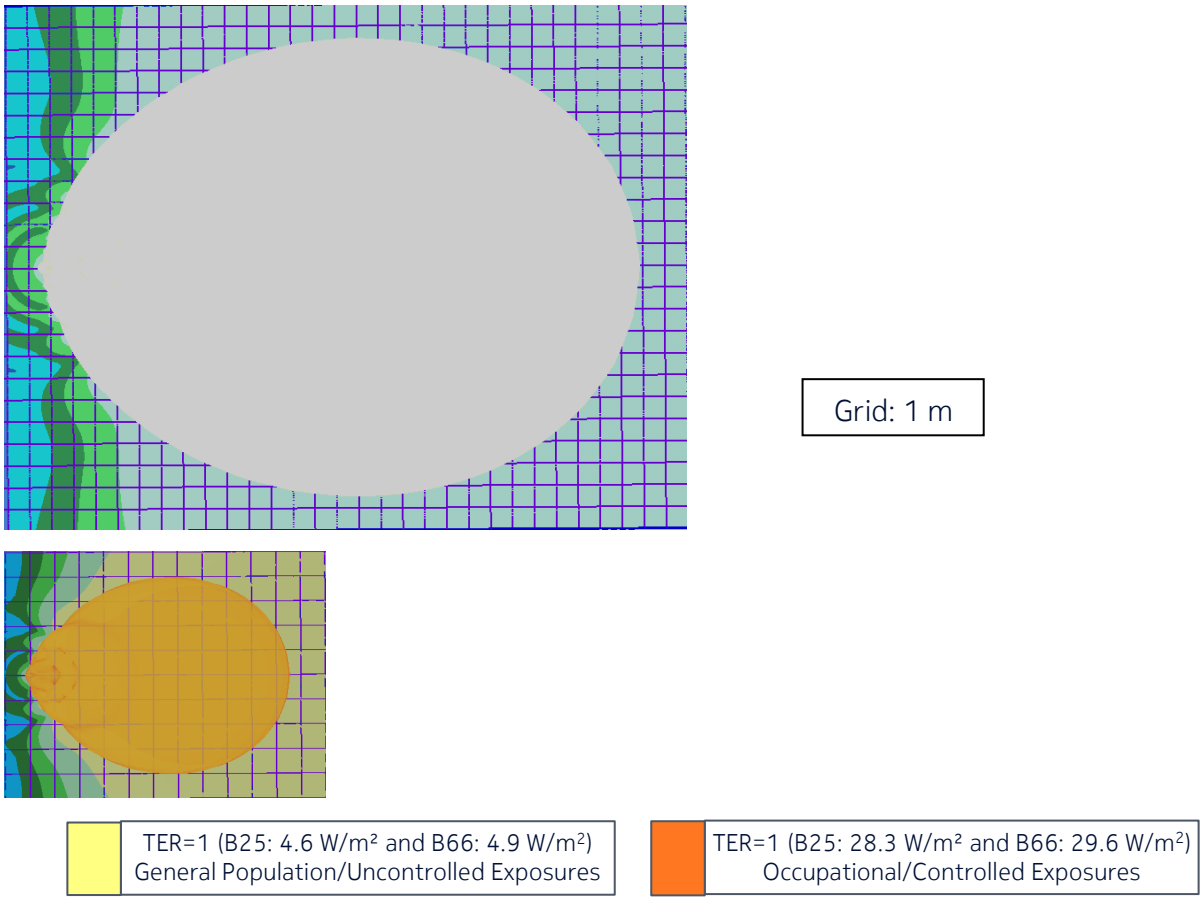


Figure 10 – Top view of the power density for the time-averaged maximum transmitted power of 678 W (corresponding to the time-averaged maximum EIRP of 76.42 dBm in the boresight direction) and the beam oriented in azimuth = 0° & elevation = +2.5 (Canada)

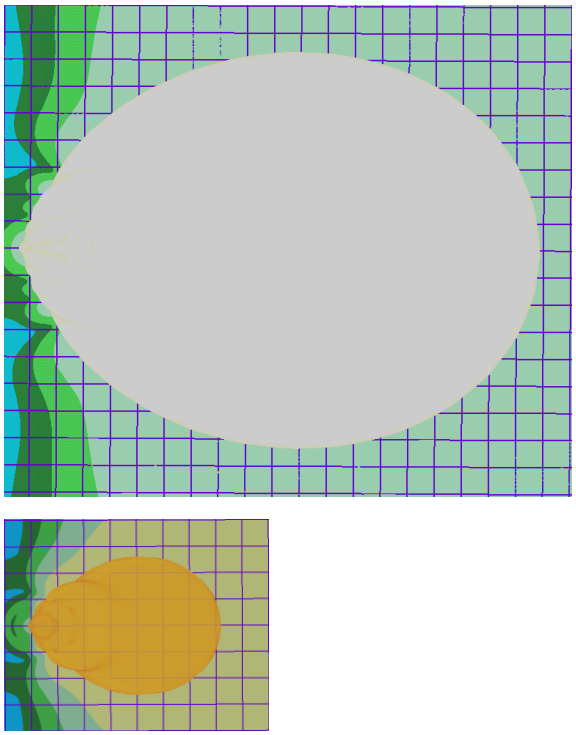


Figure 11 - Top view of the power density for the actual maximum transmitted power of 339 W (corresponding to the actual EIRP threshold of 73.42 dBm) and the beam oriented in azimuth = 0° & elevation = +2.5° (Canada)

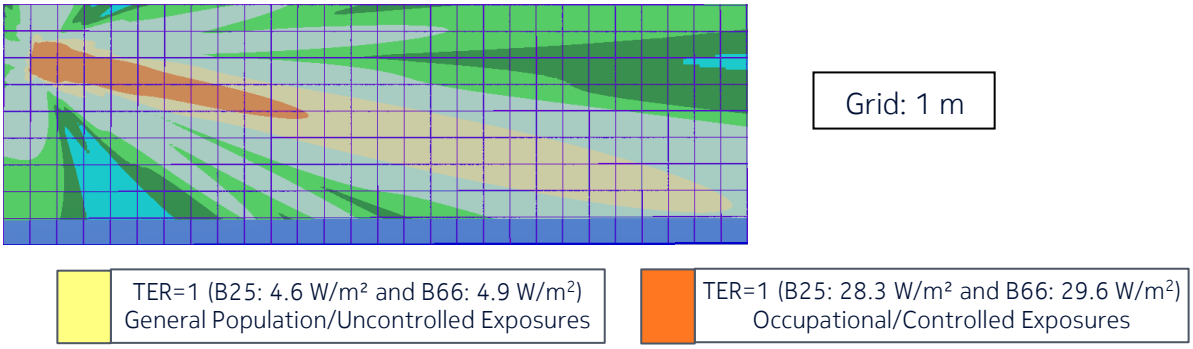


Figure 12 – Side view of the power density for the time-averaged maximum transmitted power of 678 W (corresponding to the time-averaged maximum EIRP of 76.42 dBm in the boresight direction) and the beam oriented in azimuth = 0° & elevation = +12 (Canada)

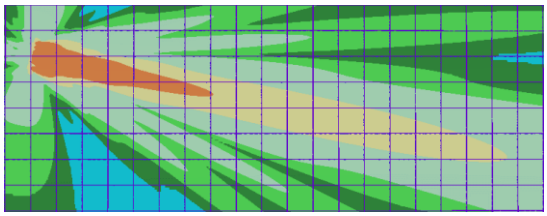


Figure 13 - Top view of the power density for the actual maximum transmitted power of 339 W (corresponding to the actual EIRP threshold of 73.42 dBm) and the beam oriented in azimuth = 0° & elevation = +12° (Canada)

7 Conclusion and installation recommendations

The RF exposure compliance distances for the Nokia AHFII AirScale Dual RRH 4T4R B25/66 480W product, when it is connected with a typical external antenna, such as Kathrein 80011867, are summarized in Table 8 for US/related [9] requirements, in Table 9 for EU/ICNIRP [1][2], Australia/NZ [5] and in Table 10 for Canada [7] requirements.

Table 8 – AHFII RF exposure compliance distances based on the time-averaged maximum transmitted power of 678 W for US/related

Region of application: US/related	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
RF-EMF power density exposure limits	TER=1 (B25: 10 W/m²; B66: 10 W/m²)	TER=1 (B25: 50 W/m²; B66: 50 W/m²)
Distance in front (D_f)	18.5 m	7.9 m
Distance to the side ($D_{s,a}$)	7.1 m	2.8 m
Distance below ($D_{d,a}$)	3.4 m	1.1 m
Distance above ($D_{u,a}$)	0.1 m	0.0 m
Distance to the side ($D_{s,c}$)	7.2 m	2.9 m
Distance below ($D_{d,c}$)	4.1 m	1.8 m
Distance above ($D_{u,c}$)	0.7 m	0.5 m

Table 9 – AHFII RF exposure compliance distances based on the time-averaged maximum transmitted power of 678 W for EU/ICNIRP and Australia/NZ

Region of application: EU/ICNIRP and Australia/NZ	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
RF-EMF power density exposure limits	TER=1 (B25: 9.6 W/m²; B66: 10 W/m²)	TER=1 (B25: 48.2 W/m²; B66: 50 W/m²)
Distance in front (D_f)	18.8 m	8.0 m
Distance to the side ($D_{s,a}$)	7.2 m	2.9 m
Distance below ($D_{d,a}$)	3.5 m	1.1 m
Distance above ($D_{u,a}$)	0.1 m	0.0 m
Distance to the side ($D_{s,c}$)	7.3 m	3.0 m
Distance below ($D_{d,c}$)	4.2 m	1.8 m
Distance above ($D_{u,c}$)	0.7 m	0.6 m

Table 10 - AHFII RF exposure compliance distances based on the time-averaged maximum transmitted power of 678 W for Canada

Region of application: Canada	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
RF-EMF power density exposure limits	TER=1 (B25: 4.6 W/m²; B66: 4.9 W/m²)	TER=1 (B25: 28.3 W/m²; B66: 29.6 W/m²)
Distance in front (D_f)	26.9 m	10.6 m
Distance to the side ($D_{s,a}$)	10.4 m	3.9 m
Distance below ($D_{d,a}$)	5.2 m	1.7 m
Distance above ($D_{u,a}$)	0.3 m	0.0 m
Distance to the side ($D_{s,c}$)	10.5 m	4.0 m
Distance below ($D_{d,c}$)	5.9 m	2.4 m
Distance above ($D_{u,c}$)	1.0 m	0.6 m

The RF exposure compliance distances based on the actual maximum transmitted power, applying a power reduction factor of – 3 dB, are summarized in Table 11 - Table 13. These values are provided for information about the RF exposure levels that may be reached in operational conditions considering a time-averaging window of 6 minutes according to [4] and [13].

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Table 11 – AHFII RF exposure compliance distances based on actual maximum transmitted power of 339 W for US/related

For information in US/related countries based on IEC/EN 62232:2017 [4] and IEC TR62669 [13]	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
RF-EMF power density exposure limits	TER=1 (B25: 10 W/m²; B66: 10 W/m²)	TER=1 (B25: 50 W/m²; B66: 50 W/m²)
Distance in front (D_f)	13.0 m	5.2 m
Distance to the side ($D_{s,a}$)	4.9 m	1.7 m
Distance below ($D_{d,a}$)	2.2 m	0.5 m
Distance above ($D_{u,a}$)	0.1 m	0.0 m
Distance to the side ($D_{s,c}$)	5.0 m	1.8 m
Distance below ($D_{d,c}$)	2.9 m	1.2 m
Distance above ($D_{u,c}$)	0.6 m	0.5 m

Table 12 – AHFII RF exposure compliance distances based on actual maximum transmitted power of 339 W for EU/ICNIRP and Australia/NZ

For information in EU/ICNIRP and Australia/NZ based on IEC/EN 62232:2017 [4] and IEC TR62669 [13]	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
RF-EMF power density exposure limits	TER=1 (B25: 9.6 W/m²; B66: 10 W/m²)	TER=1 (B25: 48.2 W/m²; B66: 50 W/m²)
Distance in front (D_f)	13.1 m	5.3 m
Distance to the side ($D_{s,a}$)	5.0 m	1.7 m
Distance below ($D_{d,a}$)	2.2 m	0.5 m
Distance above ($D_{u,a}$)	0.1 m	0.0 m
Distance to the side ($D_{s,c}$)	5.1 m	1.8 m
Distance below ($D_{d,c}$)	2.9 m	1.2 m
Distance above ($D_{u,c}$)	0.6 m	0.5 m

Table 13 - AHFII RF exposure compliance distances based on actual maximum transmitted power of 339 W for Canada

For information in Canada based on IEC/EN 62232:2017 [4] and IEC TR62669 [13]	General Population/Uncontrolled Exposures	Occupational/Controlled Exposures
RF-EMF power density exposure limits	TER=1 (B25: 4.6 W/m²; B66: 4.9 W/m²)	TER=1 (B25: 28.3 W/m²; B66: 29.6 W/m²)
Distance in front (D_f)	18.9 m	7.2 m
Distance to the side ($D_{s,a}$)	7.2 m	2.5 m
Distance below ($D_{d,a}$)	3.4 m	0.9 m
Distance above ($D_{u,a}$)	0.1 m	0.0 m
Distance to the side ($D_{s,c}$)	7.3 m	2.6 m
Distance below ($D_{d,c}$)	4.1 m	1.6 m
Distance above ($D_{u,c}$)	0.7 m	0.6 m

Installation of the Nokia AHFII AirScale Dual RRH 4T4R B25/66 480W product, when it is connected with a typical external antenna, such as Kathrein 80011867, shall be performed in accordance with all applicable manufacturer's recommendations and national laws and regulations related to human exposure to radiofrequency fields.

In particular:

- The operator or entity putting the equipment into service shall take the necessary measures to ensure that the general population cannot access the area within the general population/uncontrolled compliance boundary in the vicinity of the transmitting antennas (see Table 8 - Table 10)
- Depending on the site installation configuration, the operator or the entity putting the equipment into service determines the most suitable place to display the appropriate warning signs and any other necessary information or precautionary measures.
- Workers that are required to operate in the close proximity of the transmitting antennas connected to the equipment, for example installation and maintenance personnel, need to be informed about the potential risks of human exposure to RF fields and how to protect against them. They should strictly follow instructions provided by their employer. They should stand-off the occupational/controlled exposure compliance boundary defined in the vicinity of transmitting antennas (see Table 8 - Table 10). If it is necessary to operate within this compliance boundary, workers shall make sure that the transmitters contributing to exposure in this area are all switched off, or they must contact the relevant operator(s) to switch off emissions during operation period.

----- end of the test report ---------