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# Report On

RF Exposure Compliance Boundary Assessment of the  
Nokia Solutions and Networks  
Flexi Base Station Products (698-960 MHz and 1710-2690MHz)

Document 75925040 Report 06 Issue 1

September 2014



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29 September 2014



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## **SECTION 1**

### **REPORT SUMMARY**

RF Exposure Compliance Boundary Assessment of the  
Nokia Solutions and Networks  
Flexi Base Station Products (698-960 MHz and 1710-2690MHz)



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## 1.1 INTRODUCTION

The information contained in this report is intended to show verification of the RF Exposure Compliance Boundary Assessment of the Nokia Solutions and Networks Flexi Base Station Products (698-960 MHz and 1710-2690MHz) to the requirements of the applied test specifications.

|                               |                                                                                                                                                                                                                                                                                                                                             |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Objective                     | To perform RF Exposure Compliance Boundary Assessment to determine the Equipment Under Test's (EUT's) compliance of the applied rules.                                                                                                                                                                                                      |
| Applicant                     | Nokia Solutions and Networks                                                                                                                                                                                                                                                                                                                |
| Manufacturer                  | Nokia Solutions and Networks Oy                                                                                                                                                                                                                                                                                                             |
| Manufacturing Description     | Flexi Base Station Products                                                                                                                                                                                                                                                                                                                 |
| Model Number(s)               | Nokia Flexi Base Station Products (698-960 MHz and 1710-2690 MHz)<br><br>In this document Flexi Base Station Product is a common name for Flexi Lite BTS, Flexi WCDMA Base Station, Flexi Multiradio Base Station, Flexi Multiradio 10 Base Station, Flexi Compact BTS and Flexi Zone BTS, Flexi Multiradio BTS GSM/EDGE and Flexi EDGE BTS |
| Power Variants                | 2, 5, 10, 20, 30, 40, 50, 60, 70, 80 and 90W                                                                                                                                                                                                                                                                                                |
| Test Specification/Issue/Date | EN 62311:2008<br>FCC KDB 447498D01<br>RSS-102 Issue 4 March 2010<br>Radiocommunications (Electromagnetic Radiation – Human Exposure) Standard: 2003                                                                                                                                                                                         |
| Related Document(s)           | Council Recommendation 1999/519/EC:1999<br>FCC CFR 47 Part 1: 2013<br>FCC CFR 47 Part 2: 2013<br>Health Canada's Safety Code 6<br>ARPANSA<br>ICNIRP 1998<br>National Council on Radiation Protection and Measurements (NRP) - Report No. 86(1986)<br>50383:2010<br>IEEE Std C95.1-2005<br>Australian Standard 2772.2 – 1988                 |



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## 1.2 BRIEF SUMMARY OF RESULTS

### 1.2.1 Compliance Boundaries (cm) for General Public Levels

| Power (W) | Frequency Range (MHz) |           |
|-----------|-----------------------|-----------|
|           | 698-960               | 1710-2690 |
|           | Distance (cm)         |           |
| 2         | 150                   | 100       |
| 5         | 230                   | 150       |
| 10        | 320                   | 210       |
| 20        | 450                   | 290       |
| 30        | 550                   | 350       |
| 40        | 640                   | 410       |
| 50        | 710                   | 460       |
| 60        | 780                   | 500       |
| 70        | 840                   | 540       |
| 80        | 900                   | 580       |
| 90        | 950                   | 610       |

### 1.2.2 Compliance Boundaries (cm) for Occupational Levels

| Power (W) | Frequency Range (MHz) |           |
|-----------|-----------------------|-----------|
|           | 698-960               | 1710-2690 |
|           | Distance (cm)         |           |
| 2         | 70                    | 50        |
| 5         | 110                   | 70        |
| 10        | 150                   | 100       |
| 20        | 210                   | 140       |
| 30        | 260                   | 160       |
| 40        | 290                   | 190       |
| 50        | 330                   | 210       |
| 60        | 360                   | 230       |
| 70        | 390                   | 250       |
| 80        | 410                   | 270       |
| 90        | 440                   | 280       |

The distances are valid for antenna gain 16.4 dBi and RF power as indicated. For other antenna gains and/or RF-power, the compliance boundaries should be recalculated using the formulas in section 2.3 of this report.



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### 1.3 PRODUCT INFORMATION

#### 1.3.1 Attestation

The wireless device described within this report has been shown to be capable of compliance with the basic restrictions related to human exposure to electromagnetic fields for both General public and Occupational. The calculations shown in this report were made in accordance the procedures specified in the applied test specification(s).

#### 1.3.2 Technical Description

The Equipment under test was a Nokia Solutions and Networks Flexi Base Station Products (698-960 MHz and 1710-2690MHz). A full technical description can be found in the manufacturer's documentation.

All reported calculations were carried out on the relevant information supplied for the Nokia Flexi Base Station Products (698-960 MHz and 1710-2690MHz) to demonstrate compliance with the applied test specification(s) the sample assessed was found to comply with the requirements of the applied rules.

### 1.4 SUMMARY

The RF Exposure Compliance Boundary assessment is based upon the following criteria:

The Nokia Flexi Base Station Products (698-960 MHz and 1710-2690MHz) operate in the frequency range 698-960 MHz and 1710-2690MHz.

|            |                                              |
|------------|----------------------------------------------|
| Gain       | 16.4 dBi                                     |
| Power      | 2, 5, 10, 20, 30, 40, 50, 60, 70, 80 and 90W |
| Duty Cycle | 100%                                         |



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## **SECTION 2**

### **TEST DETAILS**





## 2.1 RATIONALE FOR ASSESSMENT OF THE RF EXPOSURE COMPLIANCE BOUNDARY

The aim of the assessment report is to evaluate the compliance boundary for a set of given input power(s) according to the basic restrictions (directly or indirectly via compliance with reference levels) related to human exposure to radio frequency electromagnetic fields.

The chosen assessment method to establish the compliance boundary in the far-field region is the reference method as defined in EN50383:2002 Clause 5.2; E-field or H-field calculation. The method of calculation used is defined in EN50383:2002; Clause 8.2.2, 8.2.3 and 8.2.4.

The calculated values have been compared with limits provided in the ICNIRP guidelines.

Calculations can be made in three separate regions, based on distance from the antenna. These are called:

- far-field region,
- radiating near-field region,
- reactive near-field region.

The theory that defines these regions is given in EN50383:2002 Annex A.

### Far-field region

As shown in EN50383 Annex A, the far-field calculations are accurate when the distance,  $r$ , from an antenna of length  $D$  to a point of investigation is greater than

$$r = \frac{2D^2}{\lambda}$$

Where,  $r$  is the distance from the antenna to the point of investigation.

### Radiating near-field region

The radiating near-field region of an antenna of length  $D$  as shown in EN50383 Annex A, this region is defined by

$$\frac{\lambda}{4} < r < \frac{2D^2}{\lambda}$$

### Reactive near-field region

The reactive near-field region of an antenna as shown in EN50383 Annex A, this region is defined by

$$r \leq \frac{\lambda}{4}$$

Where,  $r$  is the distance from the antenna to the point of investigation.

Recommend  $\lambda/4$  as the boundary between the radiated near-field and reactive near-field for RF Exposure Compliance Boundary compliance assessment.



## 2.2 DEFINED LIMITS

Normative Reference: ICNIRP Advice on Limiting Exposure to Electromagnetic Fields (0-300GHz). Table A4, Reference Levels for General Public Exposure to Time Varying Electric & Magnetic Fields. Vol 15 No.2. 2004. The defined limits are in accordance with 47 CFR § 1.1310 Radiofrequency radiation exposure limits.

Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values)

|                             |          |                                                          |
|-----------------------------|----------|----------------------------------------------------------|
| At 698 MHz                  |          |                                                          |
| Power density ( $W/m^2$ )   | = 3.490  | ICNIRP                                                   |
| Power density ( $mW/cm^2$ ) | = 0.465  | FCC 47 CFR § 1.1310                                      |
| Power density ( $W/m^2$ )   | = 4.653  | Canada's RF Safety Code 6                                |
| Power density ( $W/m^2$ )   | = 3.490  | Australian Radiation Protection Series Publication No. 3 |
| E-Field (Vm-1)              | = 36.327 | ICNIRP                                                   |
| E-Field (Vm-1)              | = N/A    | FCC 47 CFR § 1.1310                                      |
| E-Field (Vm-1)              | = 41.875 | Canada's RF Safety Code 6                                |
| E-Field (Vm-1)              | = 36.195 | Australian Radiation Protection Series Publication No. 3 |
| H-Field (Am-1)              | = 0.098  | ICNIRP                                                   |
| H-Field (Am-1)              | = N/A    | FCC 47 CFR § 1.1310                                      |
| H-Field (Am-1)              | = 0.111  | Canada's RF Safety Code 6                                |
| H-Field (Am-1)              | = 0.096  | Australian Radiation Protection Series Publication No. 3 |

|                             |          |                                                          |
|-----------------------------|----------|----------------------------------------------------------|
| At 1710 MHz                 |          |                                                          |
| Power density ( $W/m^2$ )   | = 8.550  | ICNIRP                                                   |
| Power density ( $mW/cm^2$ ) | = 1      | FCC 47 CFR § 1.1310                                      |
| Power density ( $W/m^2$ )   | = 10     | Canada's RF Safety Code 6                                |
| Power density ( $W/m^2$ )   | = 8.550  | Australian Radiation Protection Series Publication No. 3 |
| E-Field (Vm-1)              | = 56.859 | ICNIRP                                                   |
| E-Field (Vm-1)              | = N/A    | FCC 47 CFR § 1.1310                                      |
| E-Field (Vm-1)              | = 61.4   | Canada's RF Safety Code 6                                |
| E-Field (Vm-1)              | = 56.652 | Australian Radiation Protection Series Publication No. 3 |
| H-Field (Am-1)              | = 0.153  | ICNIRP                                                   |
| H-Field (Am-1)              | = N/A    | FCC 47 CFR § 1.1310                                      |
| H-Field (Am-1)              | = 0.163  | Canada's RF Safety Code 6                                |
| H-Field (Am-1)              | = 0.151  | Australian Radiation Protection Series Publication No. 3 |

Reference levels for occupational exposure to time-varying electric and magnetic fields (unperturbed rms values)

|                             |          |                                                          |
|-----------------------------|----------|----------------------------------------------------------|
| At 698 MHz                  |          |                                                          |
| Power density ( $W/m^2$ )   | = 17.450 | ICNIRP                                                   |
| Power density ( $mW/cm^2$ ) | = 2.327  | FCC 47 CFR § 1.1310                                      |
| Power density ( $W/m^2$ )   | = 23.267 | Canada's RF Safety Code 6                                |
| Power density ( $W/m^2$ )   | = 17.450 | Australian Radiation Protection Series Publication No. 3 |
| E-Field (Vm-1)              | = 79.259 | ICNIRP                                                   |
| E-Field (Vm-1)              | = N/A    | FCC 47 CFR § 1.1310                                      |
| E-Field (Vm-1)              | = 93.526 | Canada's RF Safety Code 6                                |
| E-Field (Vm-1)              | = 81.108 | Australian Radiation Protection Series Publication No. 3 |
| H-Field (Am-1)              | = 0.211  | ICNIRP                                                   |
| H-Field (Am-1)              | = N/A    | FCC 47 CFR § 1.1310                                      |
| H-Field (Am-1)              | = 0.248  | Canada's RF Safety Code 6                                |
| H-Field (Am-1)              | = 0.215  | Australian Radiation Protection Series Publication No. 3 |



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|                             |           |                                                          |
|-----------------------------|-----------|----------------------------------------------------------|
| At 1710 MHz                 |           |                                                          |
| Power density ( $W/m^2$ )   | = 42.750  | ICNIRP                                                   |
| Power density ( $mW/cm^2$ ) | = 5       | FCC 47 CFR § 1.1310                                      |
| Power density ( $W/m^2$ )   | = 50      | Canada's RF Safety Code 6                                |
| Power density ( $W/m^2$ )   | = 42.750  | Australian Radiation Protection Series Publication No. 3 |
| E-Field (Vm-1)              | = 124.056 | ICNIRP                                                   |
| E-Field (Vm-1)              | = N/A     | FCC 47 CFR § 1.1310                                      |
| E-Field (Vm-1)              | = 137     | Canada's RF Safety Code 6                                |
| E-Field (Vm-1)              | = 126.951 | Australian Radiation Protection Series Publication No. 3 |
| H-Field (Am-1)              | = 0.331   | ICNIRP                                                   |
| H-Field (Am-1)              | = N/A     | FCC 47 CFR § 1.1310                                      |
| H-Field (Am-1)              | = 0.364   | Canada's RF Safety Code 6                                |
| H-Field (Am-1)              | = 0.337   | Australian Radiation Protection Series Publication No. 3 |



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## 2.3 ESTABLISHING WAVELENGTH AND 1/4 WAVELENGTH

| Frequency<br>(MHz) | $\lambda = \frac{3 \times 10^8}{f}$ |                  | $\frac{\lambda}{4}$ |                  |
|--------------------|-------------------------------------|------------------|---------------------|------------------|
|                    | m                                   | cm               | m                   | cm               |
| 703                | 0.42674253200569                    | 42.674253200569  | 0.106685633001422   | 10.6685633001422 |
| 775.5              | 0.386847195357834                   | 38.6847195357834 | 0.0967117988394584  | 9.67117988394584 |
| 793                | 0.378310214375788                   | 37.8310214375788 | 0.094577553593947   | 9.4577553593947  |

| Frequency<br>(MHz) | $\lambda = \frac{3 \times 10^8}{f}$ |                  | $\frac{\lambda}{4}$ |                  |
|--------------------|-------------------------------------|------------------|---------------------|------------------|
|                    | m                                   | cm               | m                   | cm               |
| 1710               | 0.175438596491228                   | 17.5438596491228 | 0.043859649122807   | 4.3859649122807  |
| 2200               | 0.136363636363636                   | 13.6363636363636 | 0.0340909090909091  | 3.40909090909091 |
| 2690               | 0.111524163568773                   | 11.1524163568773 | 0.0278810408921933  | 2.78810408921933 |



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## 2.4 FAR FIELD CALCULATIONS

The following calculations are based on: 16.4 dBi gain antenna

### For 2W – 698 MHz

P = 2 Watts or 2000 milliwatts  
G = 43.652 Numeric Gain  
r = 150 centimetres or 1.5metres

The power flux:

$$S = \frac{PG_{(\theta, \phi)}}{4\pi r^2}$$

S = 3.09 W/m<sup>2</sup>  
S= 0.309 mW/cm<sup>2</sup>

The electric field strength:

$$E = \frac{\sqrt{30PG_{(\theta, \phi)}}}{r}$$

E = 34.12 V/m

The magnetic field strength:

$$H = \frac{E}{\eta_0}$$

H = 0.09 A/m

The following calculations are based on: 16.4 dBi gain antenna

### For 2W – 1710 MHz

P = 2 Watts or 2000 milliwatts  
G = 43.652 Numeric Gain  
r = 100 centimetres or 1metres

The power flux:

$$S = \frac{PG_{(\theta, \phi)}}{4\pi r^2}$$

S = 6.95 W/m<sup>2</sup>  
S= 0.695 mW/cm<sup>2</sup>

The electric field strength:

$$E = \frac{\sqrt{30PG_{(\theta, \phi)}}}{r}$$

E = 51.18 V/m

The magnetic field strength:

$$H = \frac{E}{\eta_0}$$

H = 0.14 A/m



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#### For 90 W – 698 MHz

P = 90 Watts or 90000 milliwatts  
G = 43.652 Numeric Gain  
r = 950 centimetres or 9.5metres

The power flux:

$$S = \frac{PG_{(\theta, \phi)}}{4\pi r^2} \quad S = 3.46 \text{ W/m}^2$$

$$S = 0.346 \text{ mW/cm}^2$$

The electric field strength:

$$E = \frac{\sqrt{30PG_{(\theta, \phi)}}}{r} \quad E = 36.14 \text{ V/m}$$

The magnetic field strength:

$$H = \frac{E}{\eta_0} \quad H = 0.0956 \text{ A/m}$$

#### For 90 W – 1710 MHz

P = 90 Watts or 90000 milliwatts  
G = 43.652 Numeric Gain  
r = 610 centimetres or 6.1metres

The power flux:

$$S = \frac{PG_{(\theta, \phi)}}{4\pi r^2} \quad S = 8.40 \text{ W/m}^2$$

$$S = 0.840 \text{ mW/cm}^2$$

The electric field strength:

$$E = \frac{\sqrt{30PG_{(\theta, \phi)}}}{r} \quad E = 56.28 \text{ V/m}$$

The magnetic field strength:

$$H = \frac{E}{\eta_0} \quad H = 0.15 \text{ A/m}$$

The calculations meet the General Public Exposure Levels described in the ICNIRP Guidelines.  
The calculations meet the General Public Exposure Levels described in the FCC 47CFR§1.1310.  
The calculations meet the General Public Exposure Levels described in the Canada's RF Safety Code 6.  
The calculations meet the General Public Exposure Levels described in the Australian Radiation Protection Series Publication No. 3  
The calculations meet the Occupational Exposure Levels described in the ICNIRP Guidelines.  
The calculations meet the Occupational Exposure Levels described in the FCC 47CFR§1.1310  
The calculations meet the Occupational Exposure Levels described in the Canada's RF Safety Code 6  
The calculations meet the Occupational Exposure Levels described in the Australian Radiation Protection Series Publication No. 3



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## **SECTION 3**

### **DISCLAIMERS AND COPYRIGHT**



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### **3.1      DISCLAIMERS AND COPYRIGHT**

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