

Appendix: EMF Exposure Estimation

1 About Electromagnetic Radiation Field Exposure

1.1 Introduction

Base Transceiver Station (BTS) emits RF radiation (Radiation Hazard). Although there is no scientific evidence of possible health risks to persons living near to base stations some recommendations are giving below for the installation and operation of base station transceivers. Operators of base station transceivers are required to obey the local regulation for erecting base station transceivers.

1.2 Limits and Guidelines on Exposure to Electromagnetic Fields

There are a number of international and national regulations, standards and guidelines for exposure to electromagnetic fields. Several European countries have adapted the recommendation of the council of the European Union published on 12. July 1999 on the limitation of exposure of the general public to electromagnetic fields (1999/519/EC), the recommendation is based on the guideline published by the International Commission on Non-Ionizing Radiation protection (ICNIRP). Below table shows a comparison between different regulations and applied reference levels of some countries.

Country	Limit 869-894 MHz E _{electric field strength}	Limit 869-894 MHz S _{power flux density}
ICNIRP International	61 V/m	10 W/m ²
Europe (1999/519/EC)	61 V/m	10 W/m²

Reference levels are provided for exposure assessment to determine whether the basic restrictions on exposure of humans to electromagnetic fields are exceeded. The basic restrictions on exposure to electromagnetic fields are based directly on established health effects and biological considerations.

1.3 Location of Base station antennas

Base stations antennas, the source of the radiation, are usually mounted on freestanding towers, with a height up to 30 m or on a tower on the top of buildings or in less cases to the

side of the building. Generally the height of the antenna position does not fall below 10 m. The power usually is focused into a horizontal main beam and slightly downward tilted. The remaining power goes into the weaker beams on both side of the main beam. The main beam however does not reach ground level until the distance from the antenna position is around 50 – 200 m.

The highest level of emission would be expected in close vicinity of the antenna and in line of sight to the antenna.

1.3.1 Exclusions Zones

1. Antenna location should be designed so that the public cannot access areas where the RF radiation exceeds the levels as described above and calculate in section 1.5 below.
2. If there are areas accessible to workers that exceed the levels as described above and calculated below, make sure that workers know where these areas are, and that they can (and do) power-down (or shut down) the transmitters when entering these areas. Such areas may not exist; but if they do, they will be confined to areas within 10 m of the antennas.
3. Each Exclusion zone should be defined by a physical barrier and by an easy recognizable sign warning the public or workers that inside the exclusion zone the RF radiation might exceed national limits.

1.3.2 Guidelines on Arranging Antenna Sites

1. For roof-mounted antennas, elevate the transmitting antennas above the height of people who may have to be on the roof.
2. For roof-mounted antennas, keep the transmitting antennas away from the areas where people are most likely to be (e.g., roof access points, telephone service points, HVAC equipment).
3. For roof-mounted directional antennas, place the antennas near the periphery and point them away from the building.
4. Consider the trade off between large aperture antennas (lower maximum RF) and small aperture antennas (lower visual impact).
5. Take special precautions to keep higher-power antennas away from accessible areas.
6. Keep antennas at a site as far apart as possible; although this may run contrary to local zoning requirements.
7. Take special precautions when designing "co-location" sites, where multiple antennas owned by different companies are on the same structure. This applies particularly to sites

that include high-power broadcast (FM/TV) antennas. Local zoning often favors co-location, but co-location can provide "challenging" RF safety problems.

8. Take special precautions for antenna sites near hospital and schools.
9. Obey the local regulation for erecting base station transceivers.

1.4 Location of Base Station Transceiver

The base station transceiver unit itself is shielded to minimize RF radiation hazards. The equipment has been tested to be in compliance with the radiated spurious emission requirements of EN 301 908 - 1. Those limits are far below the limits for RF radiation hazard. The base station transceiver should therefore not cause any danger to the public and workers under normal operation condition. However, it is still possible that because of imperfect antenna cables or other faults the limits set out above can be exceeded.

Sites of base station transceiver shall not be accessible by the public. Only authorized and trained workers shall access to sites or rooms.

Doors of the site or room shall be clearly marked with e.g. a sign warning the workers that inside the site or room the RF radiation might exceed national limits for radiation exposure.

Sites of base station transceivers should be regularly monitored and inspected after installation.

1.5 Calculation of Compliance Boundary for Base Transceiver Station according to EN 50385

Below method describes a theoretical approach to calculate the compliance boundary according to EN 50383:2002 based on a typical configuration of the base station. Compliance is declared with EN 50385:2002. Below method applies only to a site with the configurations described below, should the site include other transmitters namely from other CDMA network operators then those transmitters will affect the compliance boundaries for the antenna site. The method used for assessment is based on equations for far-field electromagnetic field calculation according to clause 8 of EN 50383. Those equations are accurate in the far-field of antennas but will over-predict in the near field, however it can be used for “worst case” or conservative prediction of electromagnetic fields or power densities radiated by antennas.

1.5.1 Typical Configuration of the Base Station Transceiver BTS

The base station transceivers are a solution to increase network capacity and blind spots of macro cells for example inside buildings, cities and remote areas. The series consist of 6 transceiver types with maximal 40 W(46dBm)output power. (See also description below).

1.5.2 Technical Description BTS3812

Technical Specification:

Output power:	40 W (46 dBm) / TRX
Transmitter frequency band	869- 894 MHz (WCDMA V Band)
Number of antenna ports:	6
Number of static power levels	10dB 1dB/Step
Number of TRX:	6
Antenna system and type (typical)	806 960 MHz, Kathrein 739624 Dual Polarization
Frequency range:	806 - 960 MHz
Gain:	18 dBi
Mechanical specification (Height)	2580 mm
Antenna cable: (length variable)	4dB/100m

For consideration of the compliance boundary the E-field and H-field calculation method according to clause 8 of EN 50383:2002 has been chosen.

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

Whereas:

P = input power of the antenna

G = antenna gain relative to an isotropic antenna

θ, ϕ = elevation and azimuth angles

r = distance from the antenna to the point of investigation

The wavelength for 869 MHz to 894 MHz is 0.336m to 0.345m. above calculations is accurate when the point of investigation is in the far-field region and over-estimates in the radiating near-field. The far-field region is determined by:

$$r = \frac{2D^2}{\lambda} = 39.6 \text{ m}$$

Whereas:

r = distance from the antenna to the point of investigation

D = length of antenna

λ = wavelength of transmitting frequency

The radiating near-field region is determined by:

$$\frac{\lambda}{4} < r \leq \frac{2D^2}{\lambda} = 0.084\text{m} < r \leq 39.6 \text{ m}$$

For the final determination of the compliance boundary the model for far-field calculation is used since this overestimates the field strength in the near-field region. Thus the calculated compliance boundary should be rather more conservative and on the safe side.

For above base station transceiver the following compliance boundary is calculated:

Power at antenna connector BTS: **46 dBm**

Antenna-cable attenuation: 4.0 dB per 100 m, actual length_{min} = 5 m = **0.2 dB**

Input power to antenna: **45.8 dBm (38W)**

Antenna gain: **18 dBi (63.1)**

Reference level for 869 MHz based on recommendation 1999/519/EC: **61 V/m**

Reference level for 894 MHz based on recommendation 1999/519/EC: **61 V/m**

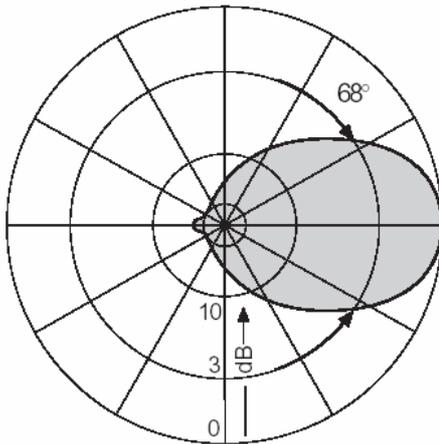
For any further assessment the value of 61 V/m is used.

Compliance boundary

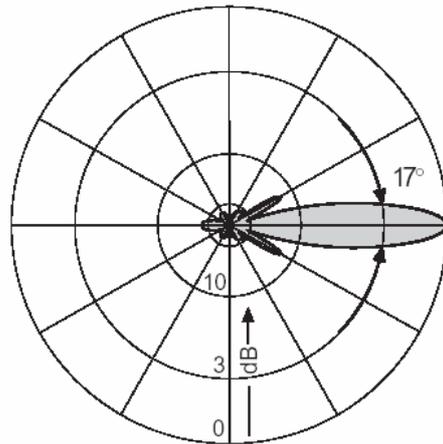
For 869-894MHz band:

$$r^2 = \frac{30 * P * G_{(\theta,\phi)}}{E^2} = r^2 = \frac{30 * 38 * 63.1}{61^2}$$

r = 4.4 m for 869 MHz 894 MHz



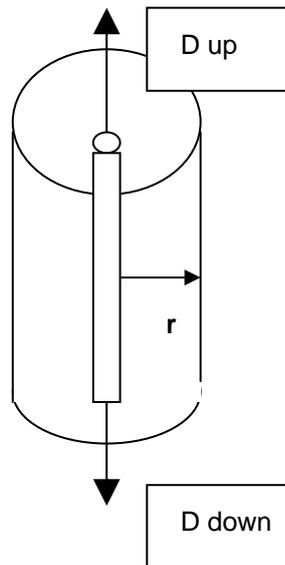
Horizontal Pattern



Vertical Pattern

For the beamed antenna, the mostly safe way is that the cylindrical boundary model is chosen for simple description of the compliance boundaries of the site.

In fact , the power usually is focused into a main beam and the remaining power goes into the weaker beams on both side of the main beam.For the up and down direction the antenna is considered to have no gain as derived from the vertical pattern of the antenna. Thus for the calculation of the compliance boundary the gain is skipped.



So for vertical direction, the antenna gain could be looked as 1 meaning no gain, and the distance D_{UP} , D_{DOWN} could be calculated as:

$$r^2 = \frac{30 * P * G_{(\theta,\phi)}}{E^2} = r^2 = \frac{30 * 38 * 1.0}{61^2}$$

$r = 0.55\text{m}$ for 869~894 MHz

1.5.3 1.5.4 Uncertainty of Calculation

Above calculations do not consider possible reflections from the ground, neighboring buildings or other obstacles. If the antenna is mounted on the rooftop of a building the field strength in D down direction is reduced by the building by around 10-20 dB. Furthermore above calculations are assuming that the transceiver is operating at full power.

1.5.4 Compliance with EN 50385

Based on above assessment compliance with EN 50385:2002 can be shown for any point of investigation outside the compliance boundary. However it must be mentioned again that in

case of co-locating other antennas the compliance boundary determined above is not anymore applicable. Furthermore it is suggested to conduct measurements according EN 50383 after the installation of the base station transceiver to confirm above calculated compliance boundaries.