Division: Radio
Issue-SEP 2012

Test Procedure for
Measurement of Electromagnetic Fields from Base Station Antenna
(For Telecommunication Sector)

No: TEC/TP/EMF/001/02.SEP. 2012

TELECOMMUNICATION ENGINEERING CENTRE

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Test Procedure for Measurement of Electromagnetic Field Strength from Base station Antennas

1.0 Scope

This document provides the detailed procedure for the self certification by the service provider (TSPs) and audit by the Telecom Enforcement Resource and Monitoring (TERM) cell of the Department of Telecommunications in respect of compliance to the norms for exposure to electromagnetic fields from Base Transceivers Stations of GSM, CDMA, W-CDMA, 3 G and Wi-Max etc.

The main aim of the measurement is to confirm the compliance of base station installation as per the limits prescribed by the Department of Telecommunications.

The telecom service providers will establish necessary infrastructure for self- monitoring, self-testing and offering them for auditing of EMF measurement to the concerned TERM Cells for complying with emission limits as per limits prescribed by the department of telecommunication vide Memo No. 800-15/2010-VAS(Pt), dated 30.12. 2011.

The latest current limits/reference level are reproduced below:
(Unperturbed rms values)

Type of Exposure	Frequency range	Electric field strength (V/m)	Magnetic field Strength (A/m)	Equivalent Plane Wave Power Density S_{eq} (W/m^2)
General Public	400-2000 MHz	**$0.434f^{1/2}$**	**$0.0011f^{1/2}$**	**f/2000**
	2-300 GHz	**19.29**	**0.05**	**1**

f is the frequency of operation in MHz.

Table No: 1

The measuring instruments shall have the capability to average the measurements over any period of six minutes and also other conditions as per the International Commission for Non- ionizing Radiation Protection (ICNIRP) guidelines.

The test procedure will comply with ITU-T Recommendations K.52 (2004): "Guidance on complying with limits for human exposure to electromagnetic fields" and K.61 (2003), "Guidance to measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations".

1.1 References

The following ITU-T Recommendations:

- ITU-T Recommendation K.52 (2004), Guidance on complying with limits for human exposure to electromagnetic fields.
- ITU-T Recommendation K.61 (2003), Guidance to measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations.
- ICINRP Guidelines for limiting exposure to time- varying Electric, magnetic and electromagnetic fields (upto 300 GHz)

2.0 EMF exposure zones.

EMF exposure assessment is made if the intentional emitters are present, and conducted for all locations where people might be exposed to EMF in course of their normal activities. All such exposures to EMF pertain to one of these three zones (See Figure below):

1) **Compliance zone**: In the compliance zone, potential exposure to EMF is below the applicable limits for both controlled/occupational exposure and uncontrolled/general public exposure.
2) **Occupational zone**: In the occupational zone, potential exposure to EMF is below the applicable limits for controlled/occupational exposure but exceeds the applicable limits for uncontrolled/general public exposure.
3) **Exceedance zone**: In the exceedance zone, potential exposure to EMF exceeds the applicable limits for both controlled/occupational exposure and uncontrolled/general public exposure.

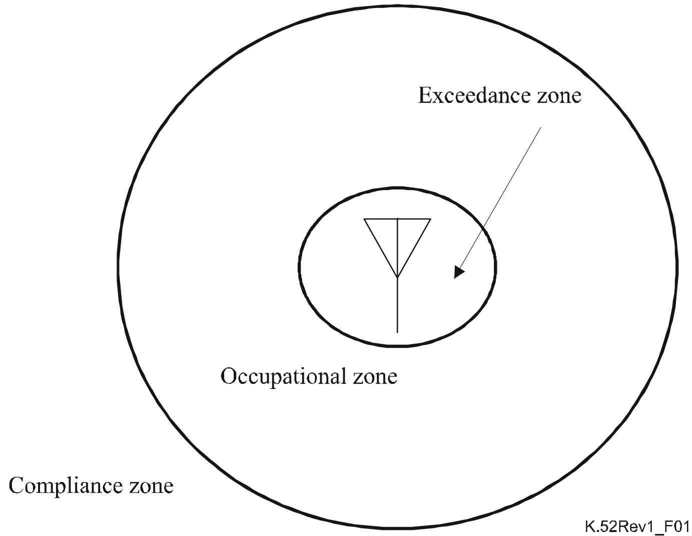

Figure 1 – Figurative illustration of exposure zones

3.0 Exposure level assessment

The assessment of the exposure level shall consider:

- the worst emission conditions;
- the simultaneous presence of several EMF sources, even at different frequencies.

The following parameters should be considered:

- the maximum EIRP of the antenna system (see definition: Equivalent Isotropic Radiated Power (EIRP));

  NOTE – Maximum EIRP should be calculated for mean transmitter power. For the majority of sources, the mean transmitter power is the nominal (rated) transmitter power.
- the antenna gain G (see definition: antenna gain) or the relative numeric gain F (see definition: relative numeric gain), including maximum gain and beam width;
- the frequency of operation; and
- various characteristics of the installation, such as the antenna location, antenna height, beam direction, beam tilt and the assessment of the probability that a person could be exposed to the EMF.

To manage the procedure and these parameters, the following classification scheme is introduced.

4.0 The installation classification scheme

Each emitter installation should be classified into the following three classes:

1) **Inherently compliant**: Inherently safe sources produce fields that comply with relevant exposure limits a few centimeters away from the source. Particular precautions are not necessary.

2) **Normally compliant**: Normally compliant installations contain sources that produce EMF that can exceed relevant exposure limits. However, as a result of normal installation practices and the typical use of these sources for communication purposes, the exceedance zone of these sources is not accessible to people under ordinary conditions. Examples include antennas mounted on sufficiently tall towers or narrow-beam earth stations pointed at the satellite. Precaution may need to be exercised by maintenance personnel who come into the close vicinity of emitters in certain normally compliant installations.

3) **Provisionally compliant**: These installations require special measures to achieve compliance.

5.0 Procedure for determining installation class

It is expected that operators providing a particular telecommunication service use a limited set of antennas and associated equipment with well-defined characteristics. Furthermore, installation and exposure conditions for many emitter sites are likely to be similar. Therefore, it is possible to define a set of reference configurations, reference exposure conditions and corresponding critical parameters that will enable convenient classification of sites.

A useful procedure is as follows:

1) Define a set of reference antenna parameters or antenna types. These categories can be customized to the types of emitters used for the particular application.
2) Define a set of accessibility conditions. These categories depend on the accessibility of various areas in the proximity of the emitter to people. These categories can be customized to the most commonly occurring installation environment for the particular service or application.
3) For each combination of reference antenna parameters and accessibility condition, determine the threshold EIRP. This threshold EIRP, which will be denoted as $EIRP_{th}$, is the value that corresponds to the exposure limit for the power density or field from the reference antenna for the accessibility condition. The determination may be performed by calculation or measurements.

4) An installation source belongs to the inherently compliant class if the emitter is inherently compliant (as defined above). There is no need to consider other installation aspects.

NOTE – An inherently compliant source for International Commission on Non – ionizing Radiation Protection (ICNIRP) limits has EIRP less than 2 W.

5) For each site, an installation belongs to the normally compliant class, if the following criterion is fulfilled:

$$\sum_i \frac{EIRP_i}{EIRP_{th,i}} \leq 1$$

where $EIRP_i$ is the temporal averaged radiated power of the antenna at a particular frequency i, and $EIRP_{th,i}$ is the EIRP threshold relevant to the particular antenna parameters and accessibility conditions. For a multiple-antenna installation, the following two conditions need to be distinguished:

- If the sources have overlapping radiation patterns as determined by considering the half-power beam width, the respective maximum time-averaged EIRP should satisfy the criterion.
- If there is no overlap of the multiple sources, they shall be considered independently.

6) Sites that do not meet the conditions for normally compliant classification are considered provisionally compliant.

For sites where the application of these categories is ambiguous, additional calculations or measurements will need to be performed.

6.0 EMF evaluation techniques

Evaluation of EMF for telecommunication installations can be done by following techniques:

(i) Calculation Method

Following two methods are being prescribed. Either of which could be used for predicting compliance to the radiation limits.

(a) Prediction of RF Fields.

(b) Calculation Method for determination of $EIRP_{th}$

(ii) Field Measurement Approach.

(iii) Electromagnetic mapping by software simulation method.

A flow chart of the exposure assessment for single EMF source of a telecommunication installation is given in Figure 2.

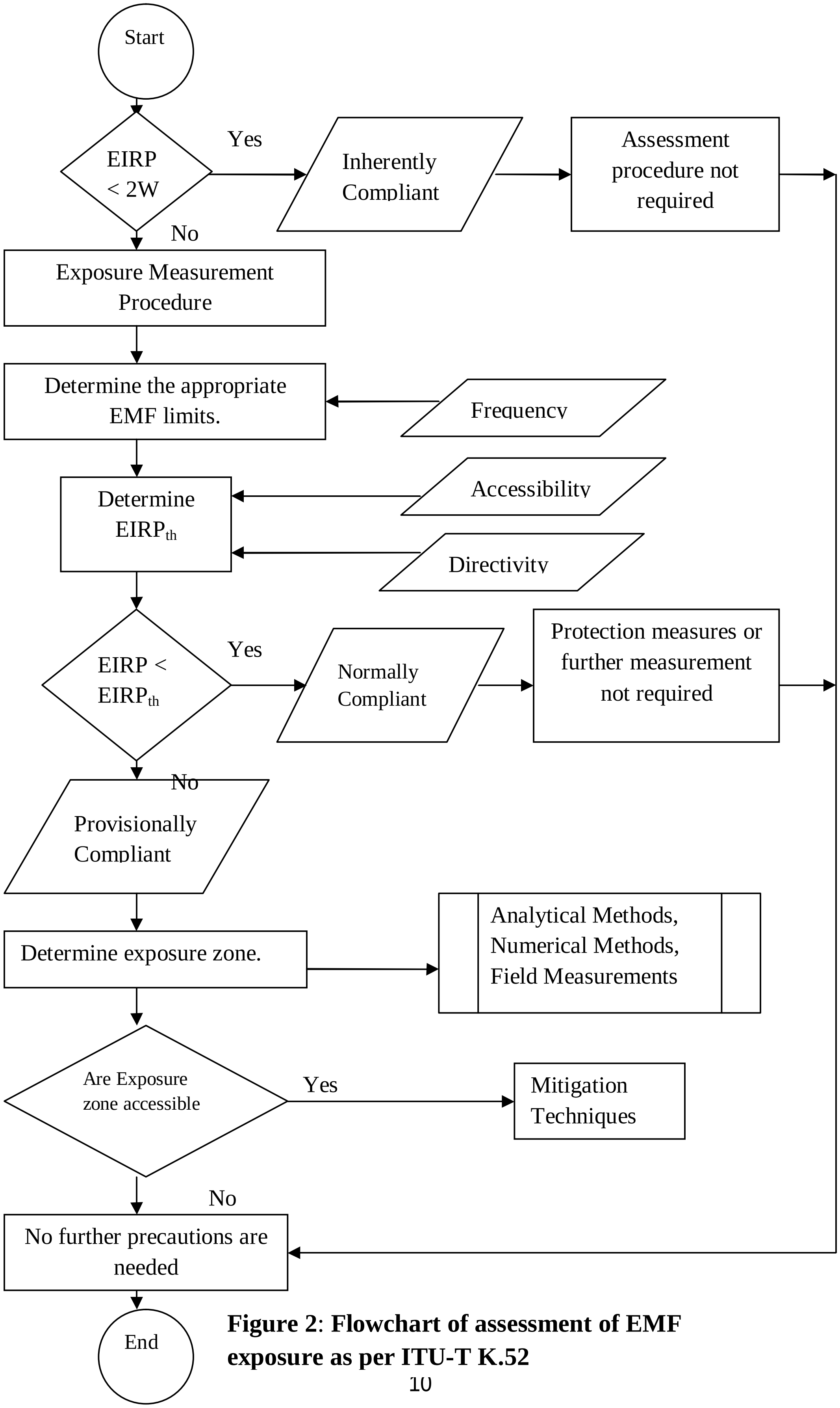

Figure 2: Flowchart of assessment of EMF exposure as per ITU-T K.52

7.0 Prediction of R.F. Fields

7.1 Equations for Predicting RF fields.

The geometry for calculating exposure at the ground level due to an elevated antenna is shown in Figure 3.

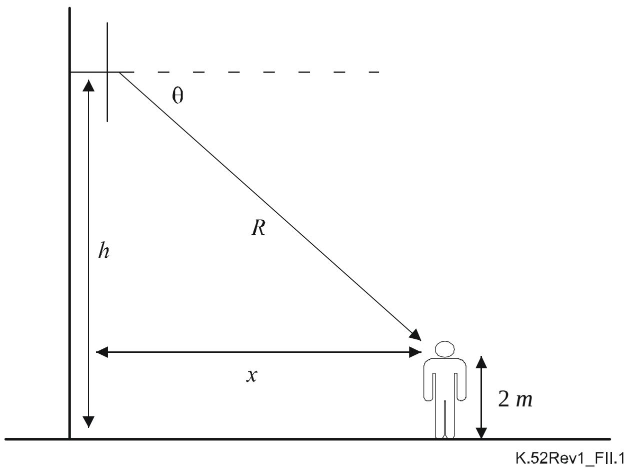

Figure 3: Sample configuration for calculating exposure at ground level

An antenna is installed so that the centre of radiation is at the height h above the ground. The goal of the calculation is to evaluate the power density at a point 2 m above the ground (approximate head level) at a distance x from the tower. In this example the main beam is parallel to the ground and the antenna gain is axially symmetrical (omnidirectional).

To simplify the foregoing, define h' = h – 2 [m]. Using trigonometry,

$$R^2 = h'^2 + x^2$$

$$\theta = \tan^{-1}\left(\frac{h'}{x}\right)$$

Taking into account reflections from the ground, the power density becomes:

$$S = \frac{2.56}{4\pi} F(\theta) \frac{EIRP}{x^2 + h'^2}$$

NOTE – The factor of 2.56 could be replaced by 4 (i.e., considering a reflection factor of 1) if a more severe approach is necessary.

7.2 Field regions

The properties of EM Fields need to be taken into consideration for their measurement and evaluation. For example:

- measurement of both the electric and magnetic components may be necessary in the non-radiating near field region;
- for numerical prediction: the far-field model usually leads to an overestimation of the field if applied in near field regions.

Therefore, it is important to be aware of the boundaries of each field region before starting a compliance procedure.

7.2.1 Near Field Region

i) Reactive near-field zone: It is immediately surrounding the antenna where reactive field predominates and typically extends to a distance of one wavelength from the antenna. For compliance with the safe exposure limits, measurement of both E & H components, or evaluation of SAR is required in this region.

ii) Reactive – radiating near-field region

The transitional region wherein the radiating field is beginning to be important compared with the reactive component. This outer region extends to a few (e.g., 3λ) wavelengths from the electromagnetic source. For compliance with the safe exposure limits, measurement of both E & H components or evaluation of SAR is required in this region.

iii) Radiating near-field (Fresnel) zone

The region of the field of an antenna between the reactive near-field and the far-field region and wherein the radiation field predominates. Here, the electric and magnetic components can be considered locally normal; moreover the ratio E/H can be assumed constant (and almost equal to Z_0, the intrinsic impedance of free space). This region exists only if the maximum dimension D of the antenna is large compared with the wavelengthλ. For compliance with the safe exposure limits, measurement of only E component is required in this region.

7.2.2 Far Field Zone-Radiating

The region of the field where the angular field distribution in essentially independent of the distance from the antenna and the radiated power density [W/m^2] is constant. The inner boundary of the radiating far-field region is defined by the larger between 3λ and $2D^2/\lambda$ in most of the technical literature (i.e., the limit is $2D^2/\lambda$ if the maximum dimension D of the antenna is large compared with the wavelengthλ). In the far-field region, the E and H field components are transverse and propagate as a plane wave.

For compliance with the safe exposure limits, measurement of E or Power (S) is required in this region.

The above regions are shown in Figure 4 given below (where D is supposed to be large compared with the wavelength λ).

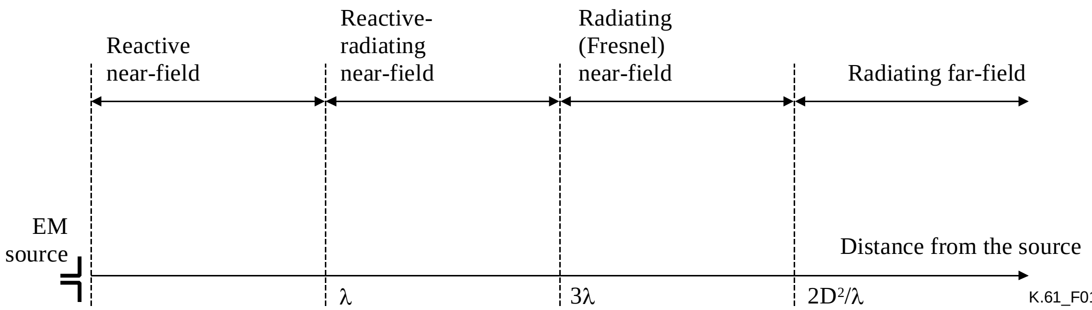

Figure 4 – Field regions around an EM source (the antenna maximum dimension D is supposed to be large compared with the wavelength λ)

In the case of EMF exposure assessment, however, a large phase difference and thus a shorter distance marking the beginning of the far-field zone is acceptable. A realistic practical distance from a large antenna, where the far-field begins is:

$$R_f = 0.5D^2/\lambda$$

Where R_f = distance which marks the beginning of the far-field region

D = the maximum dimension of the antenna

λ = wavelength, in metres (m)

8.0 Determination of $EIRP_{th}$

The procedure is the following:

1) Determine the field or the power density for each point O, where exposure can occur, for the particular antenna.
2) Find the maximum power density S_{max} within the exposure area from this set.
3) The condition $S_{max} = S_{lim}$ gives the $EIRP_{th}$ where S_{lim} is the relevant limit given by the EMF exposure standard at the relevant frequency.

This procedure may be performed by calculations methods or by measurements. If measurements are used, it is necessary to perform them at a number of representative locations for each accessibility configuration and antenna type.

8.1 Accessibility categories

These categories, which depend on the installation circumstances, assess the likelihood that a person can access the exceedance zone of the emitter are given in Table 2 below:

Table 2 – Accessibility categories

Accessibility category	Relevant installation circumstances	Figure reference
1	Antenna is installed on an inaccessible tower – the centre of radiation is at a height h above ground level. There is a constraint h > 3 m. Antenna is installed on a publicly accessible structure (such as a rooftop) – the centre of radiation is at a height h above the structure.	Figure 5
2	Antenna is installed at ground level – the centre of radiation is at a height h above ground level. There is an adjacent building or structure accessible to the general public and of approximately height h located a distance d from the antenna along the direction of propagation. There is a constraint h > 3 m.	Figure 6
3	Antenna is installed at ground level – the centre of radiation is at a height h (h > 3 m) above ground level. There is an adjacent building or structure accessible to the general public and of approximately height h' located at a distance d from the antenna along the direction of propagation.	Figure 7
4	Antenna is installed on a structure at a height h (h > 3 m). There is an exclusion area associated with the antenna. Two geometries for the exclusion area are defined: – A circular area with radius a surrounding the antenna; or – A rectangular area of size a × b in front of the antenna.	Figure 8 Figure 9

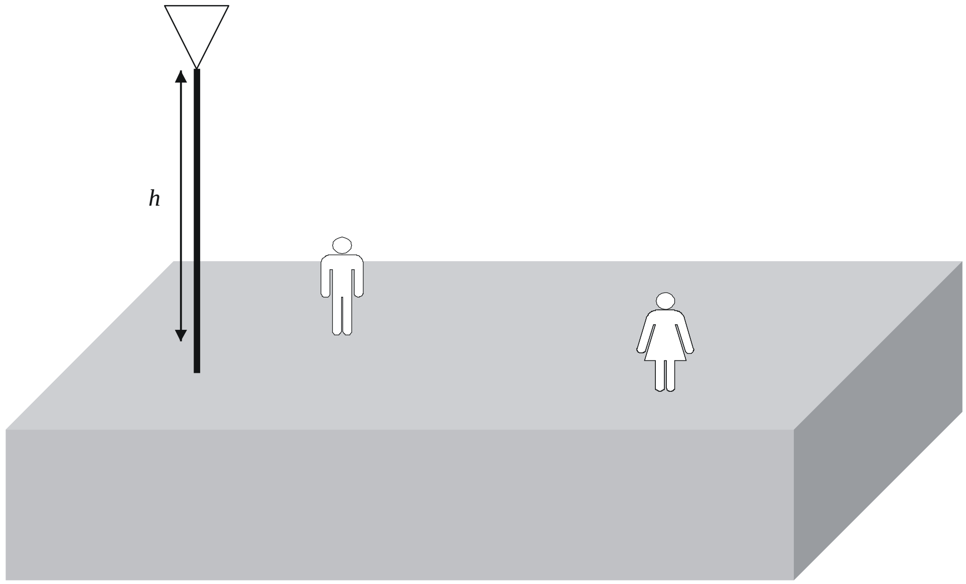

Figure 5 – Illustration of the accessibility category 1

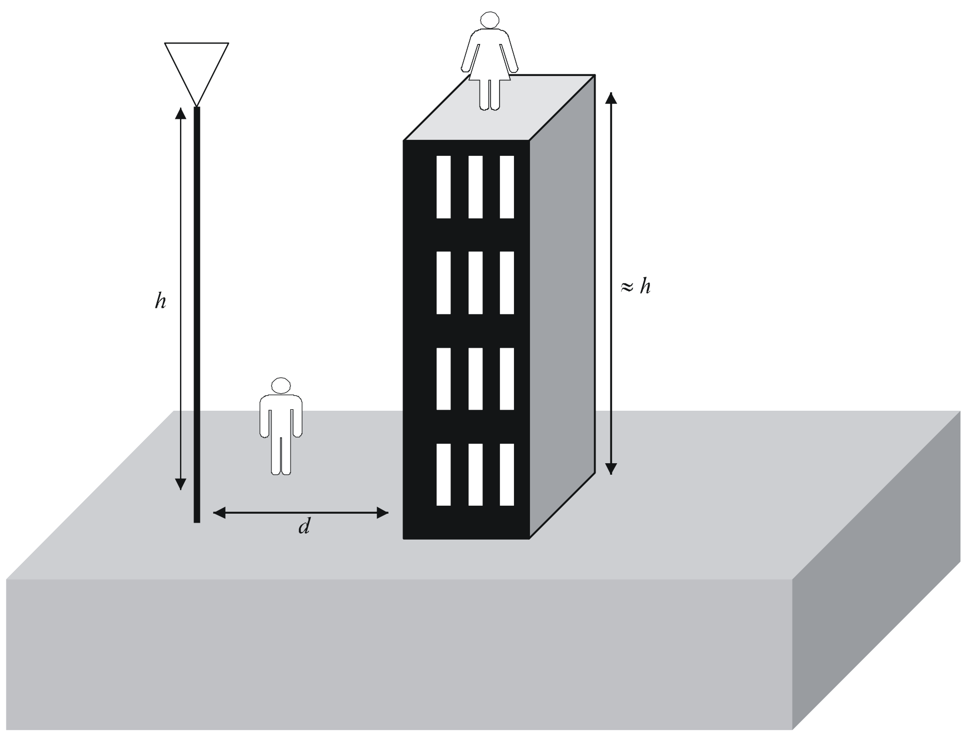

Figure 6 – Illustration of the accessibility category 2

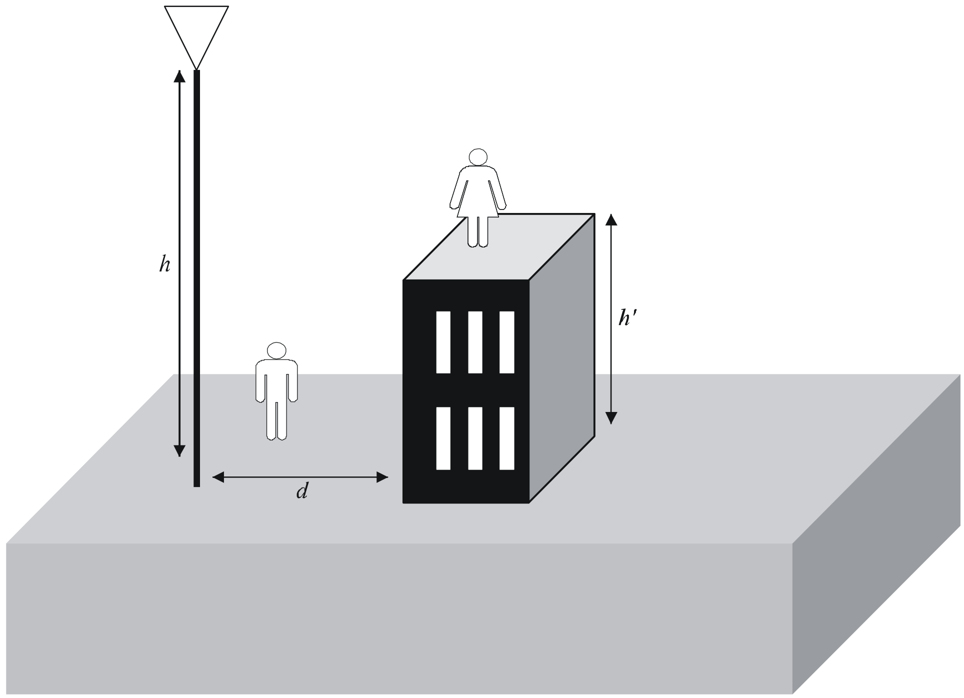

Figure 7 – Illustration of the accessibility category 3

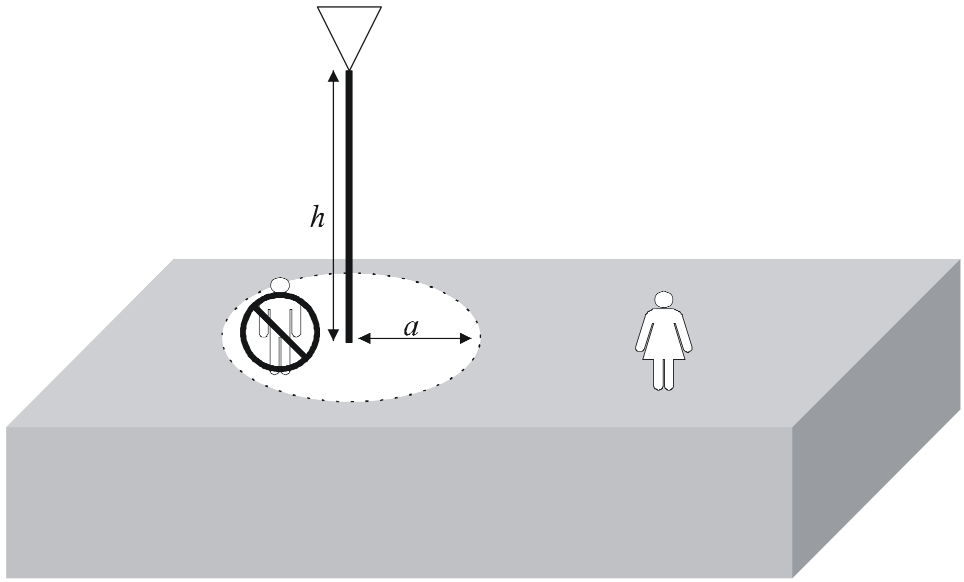

Figure 8 – Illustration of the accessibility category 4, circular exclusion area

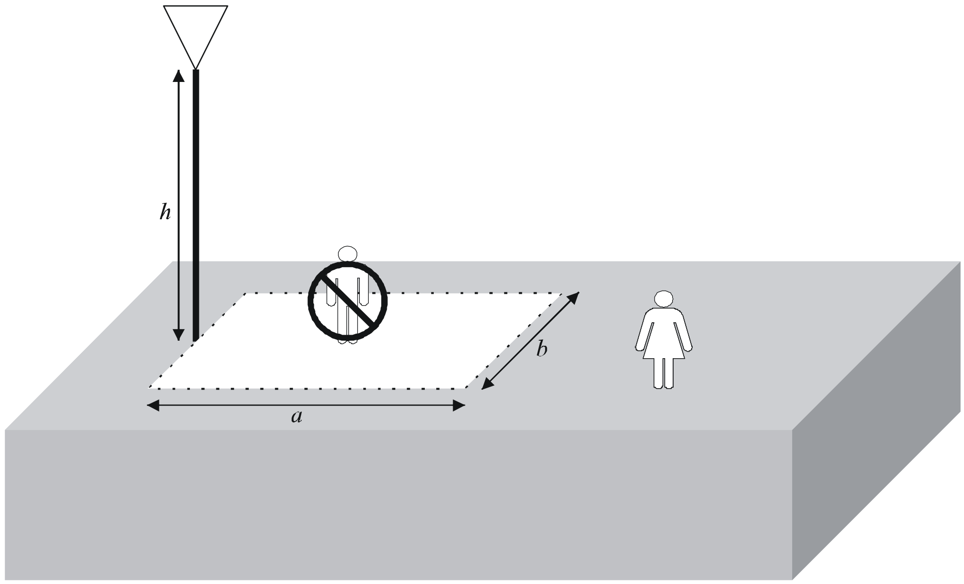

Figure 9 – Illustration of the accessibility category 4, rectangular exclusion area

8.2 Antenna directivity categories

Antenna directivity is important because it determines the pattern of potential exposure. High directivity means that most of the radiated power is concentrated in a narrow beam which may allow good control of the location of the exposure zones.

The antenna pattern is a major determinant and a frequently varying factor in determining the field. Table 3 presents a description to facilitate classification of antennas into generic categories. The most important parameter for determining the exposure due to elevated antennas is the vertical (elevation) antenna pattern. The horizontal (azimuth) pattern is not relevant because the exposure assessment assumes exposure along the direction of maximum radiation in the horizontal plane.

Note, however, that the vertical and horizontal patterns determine the antenna gain, and that horizontal pattern determines the exclusion area for accessibility category 4.

Table 3 – Antenna directivity categories

Directivity category	Antenna description	Relevant parameters
1	Half-wave dipole	None See Figure 10
2	Broad coverage antenna (omnidirectional or sectional), such as those used for wireless communication or broadcasting	• Vertical half-power beamwidth: θ_{bw} • Maximum side-lobe amplitude with respect to the maximum: A_{sl} • Beam tilt: α See Figure 11.
3	High-gain antenna producing a "pencil" (circularly symmetrical beam), such as those used for point-to-point communication or earth stations	• Vertical half-power beamwidth: θ_{bw} • Maximum side-lobe amplitude with respect to the maximum: A_{sl} • Beam tilt: α See Figure 11.

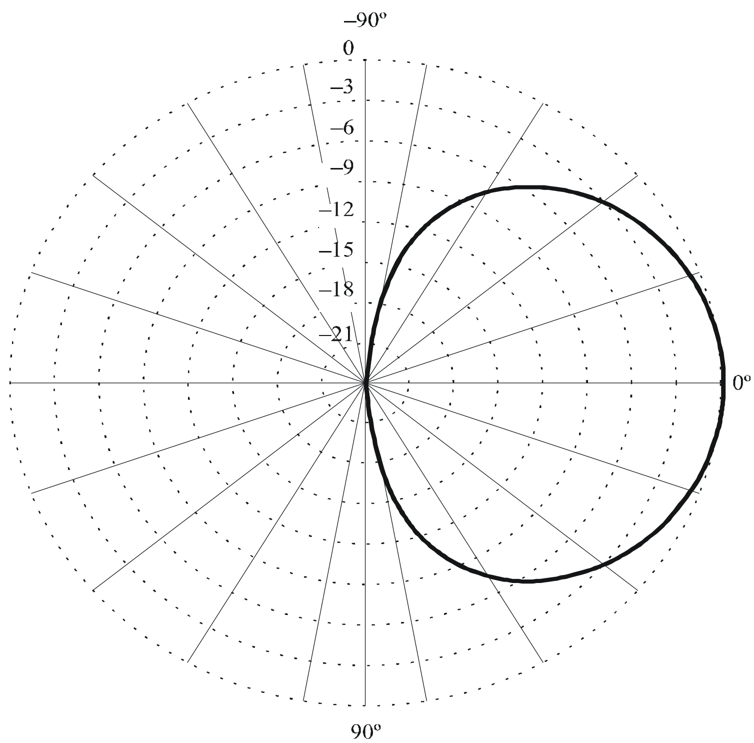

Figure 10 – Vertical pattern for a half-wave dipole in vertical polarization

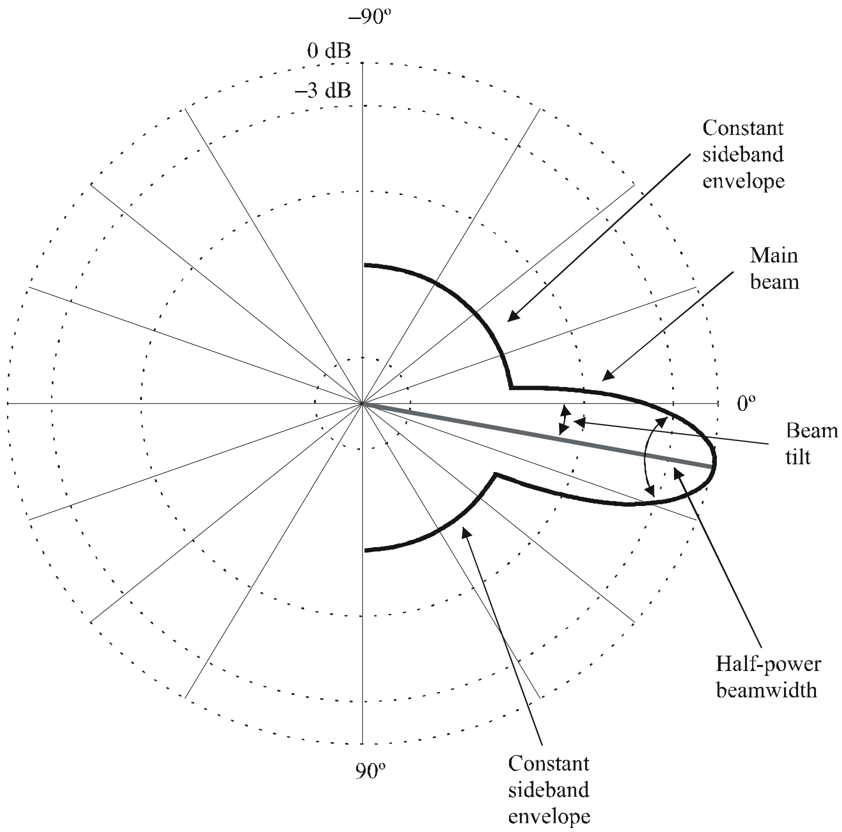

Figure 11 – Illustration of terms relating to antenna patterns

8.3 The exclusion area

This clause describes the exclusion areas for accessibility category 4. The exclusion area depends on the horizontal pattern of the antenna. The relevant parameter is the horizontal coverage of the antenna. Table 4 presents the exclusion areas for a few typical values of the horizontal coverage of omnidirectional, sectional or narrow-beam antennas.

Table 4 – Exclusion area as function of horizontal coverage

Horizontal coverage	Exclusion area	
Omnidirectional	Circular area (Figure 8)	
120º	Rectangular area (Figure 9)	b = 0.866a
90º	Rectangular area (Figure 9)	b = 0.707a
60º	Rectangular area (Figure 9)	b = 0.5a
30º	Rectangular area (Figure 9)	b = 0.259a
Less than 5º	Rectangular area (Figure 9)	b = 0.09a

The details of calculation of $EIRP_{th}$ and the relevant formats are covered subsequently in this document. (Ref. clause no: 12.0)

9.0 Field Measurement Approach.

As per ITU-T rec. K.52, a series of field-strength measurements shall be made throughout a height of 2.0 m, corresponding to the position of interest to be occupied by the body, but with the body absent. In the presentation of the results, the average value shall be stated together with the maximum value measured.

Before beginning a measurement it is important to characterize the exposure situation as much as possible. An attempt should be made to determine:

(i) The frequency and maximum power of the RF source(s) in question, as well as any nearby sources.

(ii) Areas those are accessible to either workers or the general public.

(iii) The location of any nearby reflecting surfaces or conductive objects that could produce regions of field intensification ("hot spots").

(iv) If appropriate, antenna gain and vertical and horizontal radiation patterns.

(v) Type of modulation of the source(s).

(vi) Polarization of the antenna(s).

(vii) Whether measurements are to be made in the near-field, in close proximity to a leakage source, or under plane-wave conditions. The type of measurement needed can influence the type of survey probe, calibration conditions and techniques used.

(viii) If possible, one should estimate the maximum expected field levels, in order to facilitate the selection of an appropriate survey instrument. For safety purposes, the electric field (or the far-field equivalent power density derived from the E-field) should be measured first because the body absorbs more energy from the electric field. In many cases it may be best to begin by using a broadband instrument capable of accurately measuring the total field from all sources in all directions. If the total field does not exceed the relevant exposure guideline in accessible areas, and if the measurement technique employed is sufficiently accurate, such a determination would constitute a showing of compliance with that particular guideline, and further measurements would be unnecessary.

(ix) When using a broadband measuring instrument, spatially-averaged exposure levels may be determined by slowly moving the probe while scanning over an area approximately equivalent to the vertical cross-section (projected area) of the human body. An average can be estimated by observing the meter reading during this scanning process or be read directly on those meters that provide spatial averaging.

(x) In many situations there may be several RF sources. For example, a broadcast antenna farm or multiple-use tower could have several types of RF sources including GSM, CDMA, W-CDMA, 3 G and Wi-Max etc and microwave antennas. Also, at rooftop sites many different types of cellular base station antennas are commonly present. In such situations it is generally useful to use both broadband and narrowband instrumentation to fully characterize the electromagnetic environment. Broadband instrumentation could be used to determine what the overall field levels appeared to be, while narrowband instrumentation would be required to determine the relative contributions of each signal to the total field.

(xi) In many situations a relatively large sampling of data will be necessary to spatially resolve areas of field intensification that may be caused by reflection and multipath interference. Areas that are normally occupied by personnel or are accessible to the public should be examined in detail to determine exposure potential. If narrowband instrumentation and a linear antenna are used, field intensities at three mutually orthogonal orientations of the antenna must be obtained at each measurement point. The values of E^2 or H^2 will then be equal to the sum of the squares of the corresponding, orthogonal field components. If an aperture antenna is used, unless the test antenna responds uniformly to all polarizations in a plane, e.g., a conical log-spiral antenna, it should be rotated in both azimuth and elevation until a maximum is obtained. The antenna should then be rotated about its longitudinal axis and the measurement repeated so that both horizontally and vertically polarized field components are measured. It should be noted that when using aperture antennas in reflective or near-field environments, significant negative errors may be obtained.

9.1 Test Instruments Required

Instruments used for measuring radiofrequency fields may be either broadband or narrowband devices. A typical broadband instrument responds essentially uniformly and instantaneously over a wide frequency range and requires no tuning. A narrowband instrument may also operate over a wide frequency range, but the instantaneous bandwidth may be limited to only a few kilohertz, and the device must be tuned to the frequency of interest. The choice of instrument depends on the situation where measurements are being made.

All instruments used for measuring RF fields have the following basic components covering the frequency range of interest.

i) Field Strength Meter or Spectrum Analyzer
ii) an antenna or probe to sample the field. Isotropic, shaped isotropic and directional both.
iii) Laptop to process the measured results.

The antennas most commonly used with broadband instruments are either dipoles that respond to the electric field (E) or loops that respond to the magnetic field (H). Surface area or displacement-current sensors that respond to the E-field are also used. In order to achieve a uniform response over the indicated frequency range, the size of the dipole or loop must be small compared to the wavelength of the highest frequency to be measured. Isotropic broadband probes contain three mutually orthogonal dipoles or loops whose outputs are summed so that the response is independent of orientation of the probe.

All measuring instruments as required to be available for the measurements and display of results. The instruments and accessories shall have the capability to measure in the frequency range of interest.

Field Strength Meter of required capabilities to measure

- E-field
- Power density

in the specified frequency range in V/M, W/square meter as per DoT limits. The instrument should preferably be portable and battery operated for carrying to roof-top and various accessible places easily.

Field strength measuring instruments shall have facility to display spectrum and present results in any one unit**. The components of measurement solution are as under:**

(i) **Field Strength Meter** of specified frequencies.

(ii) **Isotropic Probe** for E-field measurement with facility for direct connecting to the meter**.** Shaped probe weighted as per ICNIRP guidelines limits shall also be available.

(iii) **Directional Antennas** of various frequencies to identify the source of emission. The directional may be of various types.

(iv) **Connecting cable (Coaxial or Optical)**.

(v) **Lap-top PC** to perform necessary measurements and display results in case field strength meter is not integrated with calculating the results and displaying in desired units.

Generic Requirements on “EMF Strength Measuring Instrument in the frequency range of 30 MHz to 3/6 GHz” published by TEC vide document No. **TEC/TX/GR/EMI.001/02.SEP. 2011** may be referred for technical specifications etc. Instruments used for measuring radio frequency fields may be either broadband or frequency selective.

For EMF Compliance check of BTS, following devices may also be required:

(a) Built in or plug in GPS Receiver for Longitude-Latitude logging.

(b) Laser Distance Meter.

(c) Digital Camera

(d) Magnetic Compass for azimuth measurement.

(e) Measuring Tape

9.2 Calibration of instruments

It is outside the scope of this standard to detail methods of calibration for the various measuring instruments described above but, for safety reasons, it is important that they be recalibrated at regular intervals by an accredited calibration laboratory.

A list of simple routine functional checks to be carried out before and after undertaking a measurement survey.

9.3 Check points before Measurement

Before making a survey of potentially hazardous electromagnetic fields, it is important to determine as many characteristics of the source of these fields as possible and their likely propagation characteristics.

This knowledge will facilitate better estimation of expected field strengths and a more appropriate selection of test instruments and test procedures.

(a) A check-list of source and characteristics may include the following:

- (i) type of generator and generated power;
- (ii) carrier frequency or frequencies;
- (iii) modulation characteristics;
- (iv) polarization;
- (v) duty factor, pulse width and repetition frequency, if relevant;
- (vi) type of antenna (unless a leakage source) and such properties as gain, physical dimensions and radiation pattern, etc.
- (vii) number of sources, including any out-of-band signals that might affect the measurements.

(b) A check-list on propagation characteristics may include:

- (i) distance from source to test site or measuring point;
- (ii) existence of absorbing , scattering or reflecting objects likely to influence the strength at the measuring point.

Measurement procedures may differ, depending on the source and propagation information that is available. If the information is well-defined, then the surveyor, after making estimates of expected field strengths and selecting a suitable instrument, may proceed with the survey using a high-power probe, to avoid inadvertent burnout.

On the other hand, if the information is not well-defined, then it may be necessary to make a number of exploratory measurements around the test site, scanning a broad frequency spectrum until some positive response is found.

The test procedures will differ depending on whether the radiation source is an intentional radiator or a leakage source. If an intentional radiator, the surveyor can proceed progressively and knowingly toward the main beam and the antenna. In the case of a leakage source , the surveyor shall start first with low-level probe and range settings as the approach is made cautiously towards the likely sources of leakage, i.e. , first at a distance along the exterior surface of the equipment. The instrument is then switched to higher range settings after the location of the leakage is confirmed and a closer approach made. For leakage measurements, a non-directional and non-polarized sensor is desirable because of its ability to respond to signals of arbitrary direction and polarization. However, in cases of strong fields where the source of leakage is uncertain, initially a directional probe may be found helpful in locating the actual source.

9.4 Functional tests for measuring instruments

Before commencing a measurement survey it is strongly recommended that some simple functional tests be made on the measuring instruments to confirm that they function correctly.

Such a check-list could include the following:

a) Take a suitable far-field reading on a known radiation source.
b) If the probe is isotropic, check that the reading is largely independent of probe orientation.
c) Change the direction of the sensor leads whilst keeping the probe stationery to check for undue pickup on the leads.
d) If a second instrument is available, compare their readings.
e) If possible, compare the reading with the expected (or calculated) field strength.

Repeat the above tests after the survey has been completed, in order to check there has been no inadvertent damage to the measuring instrument during use.

10.0 SELF CERTIFICATION BY SERVICE OPERATORS

Mobile Service Operator may self certify their BTS for compliance of limits mentioned in table-1, page 5 (or as may be prescribed from time to time) after assessment estimated levels of EMR in the up to 60 meters radius of the BTS based on appropriate methods from amongst the following:

(a): Calculations of EIRP/EIRP$_{th}$

Assessment of the value of (EIRP/EIRP$_{th}$) can be made at various publicly accessible points in the environment surrounding the BTS Site under study (On rooftop, On Ground, at adjacent buildings etc…). The assessment is based on the formulae given in the, Appendix -A. The calculation procedure is detailed with the help of an example in this document at Section 12.0.

If the value of (EIRP/EIRP$_{th}$) is found to be less than unity at all points outside the exclusion zone, the site will be theoretically compliant but for the purpose of self certification **TEC** allows (EIRP/EIRP$_{th}$) ratio to be less than 0.5 i.e. to the extent of 50% of revised DoT limits. A format of the report to be filed for a normally compliant site is placed at Appendix – B.

(b): Electromagnetic Mapping by Software Simulation.

Electromagnetic mapping can be done by software simulation based on any of the methods mentioned in ITU-T Recommendation K-70 / 61, which include the following:

a. Ray tracing model, as per ITU-T rec. K.61.
b. Point Source Model, as per ITU-T rec. K.70 Annex -B

The test results of software simulation are to be presented in the form of power density in percentage of reference levels prescribed as above for general public for various positions 2 meters above the Roof Top Level of the BTS site, Ground level and Roof Top of adjacent buildings in the vicinity of 60 meters from the BTS under consideration.

The site can be self certified as compliant if the electromagnetic mapping by software simulation and / or calculation are within 50 % of the limits prescribed by DOT as mentioned in Table No. 1 on page 5 (may be revised time to time).

Details of software simulation are described in section 13.0. Sample pictures of the reports are enclosed at Appendix-C.

(c) Broadband Measurements

Broadband measurement facilitates overall picture but it does not indicate the difference between contributions to overall radiation level made by individual sources such as GSM-900, 3G and GSM- 1800 mobile phone services. The overall measured value of the Electric Field or Power Density with broadband measurement test set, if found within the reference levels prescribed by DoT for general public, the service provider may choose to certify the site as normally compliant.

Broadband measurements will be done for first stage audit verification by TERM Cell to certify EMF compliance of BTS subject to the condition that measured values do not exceed 50% of levels/ limits prescribed by DOT for general public as mentioned in Table No. 1 on page 5 (may be revised time to time).

Broadband measurement of Electric Field Strength (V/m) or power density (watt/sq. m) may be done with an isotropic field probe.

A format of the report for a compliant site (cleared by measurement using Broad band instruments) is placed at **Appendix- D**

(d) <u>Frequency Selective Measurements</u>

Frequency selective measurements with extrapolation for maximum traffic must be performed if the broadband measurements exceeds 50 % of limits prescribed by DOT as mentioned in Table No. 1 on page 5 (may be revised time to time).

indicates the site as non- compliant due to higher levels of emission, i.e. exceeding the current prescribed levels stated in section 1.0 Most of the broadband test sets are not sensitive enough to measure the – usually low level - individual sources. So it would be next to impossible to detect the source responsible for overall non-compliance. High sensitivity, frequency selective measuring instrument is therefore essential. Under these circumstances, Service Operator would be required to assess contribution of each BTS for determination of compliance to limits prescribed for exposure to the general public before self certification of the BTS.

For such BTS audit verification by TERM Cell would be carried out by selective measurement as described herein. A format of the report to be filed for a compliant site is placed at Appendix- E.

11.0 RESPONSIBILITY OF SERVICE PROVIDERS AT SHARED SITES

(1) A shared site may be defined as having:

  (a) Multiple towers on the same or different plots within 60 m radius.

  (b) Multiple Roof Top Poles on a BTS Site/ Adjacent Building within 60 m radius.

(2) Responsibility for EMF compliance of shared site shall lie with all the participating operators.

(3) Placement of signage at shared site will also be joint responsibility of all the participating operators.

(4) For self certification of shared sites, participating operators will also separately issue self certification of their individual BTS.

(5) In case of overall non-compliance of shared site, penalty shall be imposed on all participating operators.

12.0 COMPLIANCE BY CALCULATIONS OF EIRP/EIRPth

As mentioned above in section 10.0 an assessment of the value of (EIRP / $EIRP_{th}$), is made at various publicly accessible points in the environment surrounding the BTS Site under study (On rooftop, On Ground, and at adjacent buildings). The assessment is based on the formulae given in the Appendix-A of this document for measurement of EMF from BTS.

The data required for these calculations is enumerated below

12.1 Format of Report for Normal Compliance Calculation

A sample format of the report to be filed with TERM Cell for a site, cleared by calculations is place at **Appendix-B**. An explanation of the various terms / data required in this report is place below:

12.1.1 SITE DATA

Site ID, Date of Commissioning of BTS, Name, Address, Lat / Long (WGS 84), RTT / GBT, Bldg Ht (in case of RTT), Lowest RF Ant. Ht AGL for each operator.

12.1.2 ADJACENT BUILDING DATA

The surrounding 60 m radius of the Site are to be surveyed and high rise buildings, which are likely to experience EMF exposure to be marked as B1, B2, B3 etc… . Following data to be provided for each of these buildings:

Horizontal Distance from the Tower base (m)

Azimuth from the Tower (Deg)

Height of the buildings (m) AGL

12.1.3 SITE LAYOUT

A Site / Roof layout is to be submitted, having marking for North Direction, location of the Tower / Poles / GBT, marking for corners / points (C1, C2 C3 and C4). The layout is also to be marked with the location of Safety Signs installed at Site.

12.1.4 TECHNICAL PARAMETERS

Technical details of each operator on the Tower need to be provided:

Base Ch. Freq	BCCH Freq (GSM) / C-PICH Common Pilot Channel Freq. (CDMA and UMTS) of any sector to be provided.
Carriers / Sector (Worst)	Max. No. of carriers / sector eg.. if two sectors are having three carriers, while the third one has four carriers, the value to be provided would be four.
Total Tilt	Electrical Tilt + Mechanical Tilt (Deg)
Antenna Tx Gain	Antenna Gain in dBi
Vertical BW	The BTS Antenna vertical 3 db beam-width (Deg)
Side Lobe Atten	The db down value of the largest side lobe, w.r.t to the main lobe, in the vertical radiation pattern of the antenna.
Tx Power	Transmitter Output power (dBm)
Combiner Loss	Combiner Loss if any (dB)
RF Cable Length	Length of the RF Cable from Antenna to the BTS (m)
RF Cable Unit Loss	Unit Loss of RF Cable (dB/100m)

12.1.5 Estimation of Total EIRP (EIRP [T]) for each Operator

To calculate the total EIRP (EIRP [T]) for an operator, the EIRP of the BCCH Channel (Pilot Channel in case of CDMA) is worked out as follows:

EIRP (BCCH) = Tx Power – Combiner Loss – (Cable Length x Unit Loss) + Antenna Gain (dBm)

The EIRP [T] is then given by:

EIRP [T] =EIRP (BCCH) watts +EIRP (BCCH) watts x 0.9 x 0.9 x (Carriers / Sector – 1)

An example of the calculation of EIRP [T] is given below:

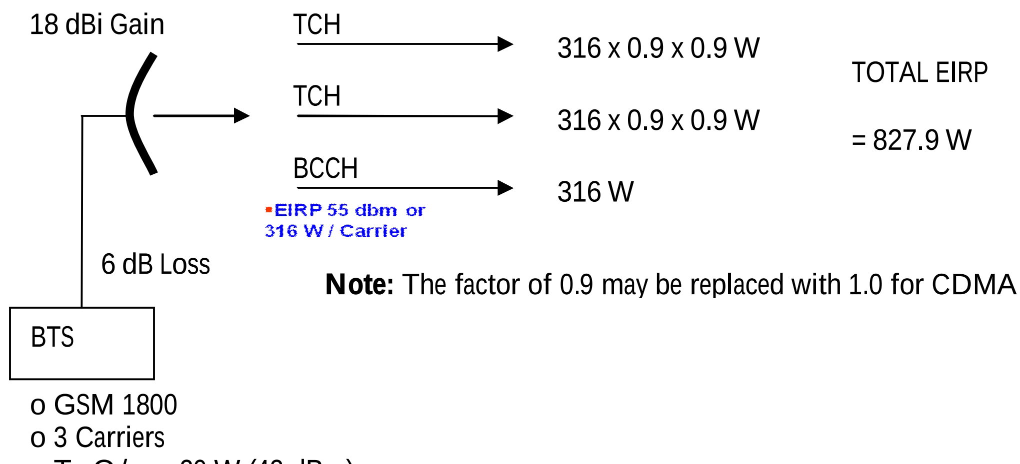

Figure: 1

12.1.6 Estimation of EIRP [T] /EIRP$_{th}$ at Ground

As per, Appendix-.A, the case of calculation of EIRP$_{th}$ for ground points for BTS sites falls under Accessibility category 1 and Directivity Category 2. Appropriate Formulae may be used from Table A.1 (400 – 2000 MHz) or Table A.2 (above 2000 MHz) depending upon Freq Band of Operation.

CALCULATION OF EIRP$_{th}$ FOR ACCESSIBILITY CATEFORY 1

(ON ROADS AT THE GROUND LEVEL)

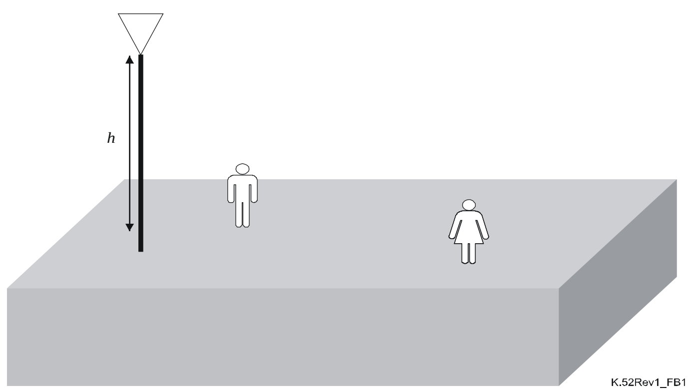

Figure12: Accessibility Category 1

(Refer Page No. 13)

An example of the calculation for a GSM operator at 1800 MHz is given below:

For a GSM-1800 Operator with below given site data:

OPERATOR	f	H	α	θ_{bw}	A_{sl}
Operator 1	1836.6	26	0.052	0.138	0.04786

<u>TableNo: 5</u>

<u>Note:</u> A_{sl} is the Attenuation of the largest side lobe of the antenna in Vertical Pattern w.r.t. main lobe, converted to decimal.

The $EIRP_{th}$ would be

Lesser of: $\frac{f\pi}{2000A_{sl}}(h-2)^2$ or $\frac{f\pi}{2000}\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$

$EIRP_{th}$ For Operator 1 works out = 34718.18 W

The EIRP [T] / $EIRP_{th}$ therefore works out to 827.9/34718.18W = 0.0238

If it is a shared site, similar calculation are made for the other operators and total ratio calculated as under:

Σ (EIRP/$EIRP_{th}$) = (EIRP [T]/$EIRP_{th}$)$_{Op1}$ + (EIRP [T]/$EIRP_{th}$)$_{Op2}$ + (EIRP [T]/$EIRP_{th}$)$_{Op3}$

12.1.7 Estimation of EIRP [T]/EIRPth at Adjacent Building

As per Appendix- A, the case of calculation of $EIRP_{th}$ for adjacent roof tops for BTS sites falls under Accessibility category 2 or 3 and Directivity Category 2. Appropriate Formulae may be used from Table A.1 (400 – 2000 MHz) or Table A.2 (above 2000 MHz) depending upon Freq Band of Operation.

CALCULATION OF EIRP$_{th}$ FOR ACCESSIBILITY CATEFORY 2/3

(ON ADJACENT BUILDING ROOF TOP)

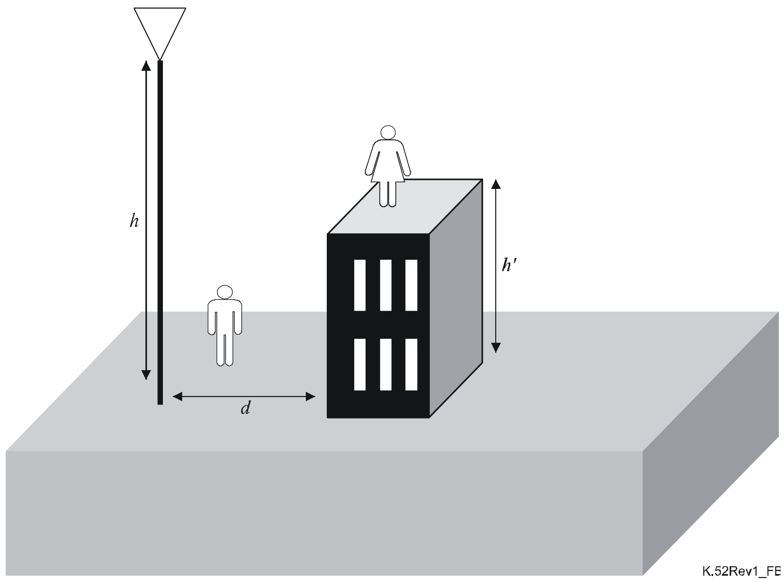

Figure 13: Accessibility Category 2

(Refer Page No. 14)

For a CDMA operator at 800 MHz with site data given below:

OPERATOR	F	A_{sl}	H	H	D
Operator 2	836.6	0.0724436	34.5	33	10

Table No: 6

The EIRP$_{th}$ would be

Lesser of: $\frac{f\pi}{2000A_{sl}}(h-2)^2$ or $\frac{f\pi}{2000A_{sl}}\left[\frac{d^2+(h-h')^2}{d}\right]^2$

Thus the EIRP$_{th}$ for the Operator 2 works out to be 1304.62 W

Considering 4 carriers / sector, 20W output, 3dB Combiner Loss and 45m Cable (3.69 db / 100m Unit Loss) and Antenna gain of 15.8 dbi, the EIRP [T] works out to:

EIRP (Pilot) = 43 – 3 – (45x3.69) + 15.8 = 54.13 dBm = 258W

EIRP [T] = 258 + 258 x 3 = 1032W

The Ratio EIRP [T] / $EIRP_{th}$ = 1032 / 1304.62 = 0.79

Similar calculations are made for the other operators and total ratio calculated as under:

Σ (EIRP/$EIRP_{th}$) = (EIRP [T]/$EIRP_{th}$)$_{Op1}$ + (EIRP [T]/$EIRP_{th}$)$_{Op2}$ + (EIRP [T]/$EIRP_{th}$)$_{Op3}$

12.1.8 Other guidelines for Compliance Calculation
Following points may be taken into consideration for calculations:

(1) EIRP / EIRPth has to be worked out for each operator, at the buildings B1, B2, B3… defined above at various floors. The calculation has to be made based on the data defined above and using the formulae given in Appendix A. The sum of the EIRP / EIRPth at each building should be less than 0.5 for normal compliance.

(2) EIRP / EIRPth is also to be worked out for each operator, at the Corners / Points on the building (B0) on which the BTS under observation is installed (in case of RTT only.). These corners / points are to be designated as C1, C2, C3, C4 etc and clearly defined / marked on the roof layout of the site to be attached with the compliance report. The sum of (EIRP / $EIRP_{th}$) values for individual operators at each of these corners / points must be less than 0.5 for normal compliance.

(3) EIRP / $EIRP_{th}$ has to be worked out for General Public Exposure on Ground (for both GBT as well as RTT / RTP case) based on the formulae given in Appendix A. The sum of values for EIRP / $EIRP_{th}$ should be less than 0.5 for normal compliance.

(4) Photographs are required for the site, as well as the Buildings B1, B2, B3… etc. at which the evaluation of EIRP / $EIRP_{th}$ has been done in the report.

13.0 COMPLIANCE BY SOFTWARE SIMULATION

For more complex scattering environments as envisaged in a shared BTS site having multiple towers or multiple antennae mounted on a single tower or multiple antennas on a roof top in urban area that involve reflections from building, fluctuations in earth elevations, etc., numerical ray-tracing / point source algorithms are recommended. It would require detailed Electromagnetic mapping of the area around the BTS using appropriate software based on ray tracing / point source method. (Refer to section I.2.3: Ray Tracing Method of calculation, Appendix-I of ITU-T Rec. K.61, Annex B of ITU-T K 70 for Point Source Model)

13.1 Format of Report for Software Simulation

A sample format of the report to be filed with TERM Cell for a site, cleared by software simulation is place at **Appendix-C**. An explanation of the various terms / data required in this report is place below:

13.1.1 SITE DATA

Details of Site Under observation to be provided:

Site ID, Name, Date of Commissioning of BTS, Address, Lat / Long (WGS84) , RTT / GBT , Tower height and Antenna Height (in case of GBT), Bldg Ht and pole height (in case of RTT),

13.1.2 SITE OVERVIEW AND LAYOUT

A Site / Roof layout is to be submitted, having marking for North Direction, location of the Tower / Poles / GBT, marking for corners / points (C1, C2 C3 and C4). In case of roof top details of lift shafts, water tanks etc which are publicly accessible are also to be submitted. The layout is also to be marked with the location of Safety Signs installed at Site. A Google picture (sketchup) of 60 m radius area around the site with high buildings (comparable to the lowest antenna AGL on site) marked on the picture. This should be verifiable on Google. .

13.1.3 TECHNICAL PARAMETERS

Technical details of each operator need to be provided:

<u>Antenna Make and Model</u>:	Antenna type, Manufacturer and model of Antenna
<u>Azimuth</u>:	Azimuth of the antenna
<u>Frequency of operation</u>:	All radiating frequencies used
<u>Power</u>:	Transmitted Power at each port
<u>Tilt:</u>	Electrical and Mechanical Tilt

13.1.4 ADJACENT BUILDING DATA

The 60 m by 60 m rectangular cross section with the BTS at the centre of rectangle (in case of RTT/RTP, centre of rectangular area will be assumed at the notional centre of such site) are to be surveyed and high rise buildings, which are likely to experience EMF exposure to be marked as B1, B2, B3 etc… . Following data to be provided for each of these buildings:

Horizontal Distance from the Tower base (m) or building base (if RTT)
Azimuth from the Tower (Deg)
Height of the adjacent buildings (m) AGL

13.1.5 ORTHOSLICE AT GROUND LEVEL

Orthoslice (in horizontal plane) at 2 m above ground level of power density in percentage of current prescribed limits as in section 1.0 for general public is to be submitted with legend in logarithmic scale and north direction marked. Sample pictures are enclosed at Appendix- C.

13.1.6 ORTHOSLICE AT ROOF TOP LEVEL

Orthoslice at 2m above rooftop level of power density in percentage of restriction levels prescribed by DoT for general public is to be submitted with legend in logarithmic scale and north direction marked. Sample pictures are enclosed at Appendix- C.

13.1.7 ORTHOSLICE FOR ADJACENT BUILDINGS

Orthoslice at the antenna height (to analyze the crossover of exclusion zones with adjacent nearby buildings in close vicinity, if any) power density in percentage of restriction levels prescribed in section1.0 for general public is to be submitted with legend in logarithmic scale and north direction marked.

13.1.8 COMPLIANCE DISTANCES/ EXCLUSION ZONE

Refer détails in Section 17.2 for exclusion zone distances.

Sample pictures are enclosed at Appendix- C.

13.1.9 SITE PHOTOGRAPHS

Photographs are required for the site, as well as the adjacent buildings B1, B2, B3 etc.

14.0 COMPLIANCE BY MEASUREMENTS

As indicated at section10.0 above, measurements can be undertaken for compliance of a site if $EIRP_{th}$ calculations and electromagnetic mapping by software simulation with Power Density exceeding 50 % of levels prescribed by DOT for general public. Compliance by measurement would require calibrated instruments as defined in Section 9.2 of this document. The measurements can first be made using a broadband Meter and would be accepted for compliance if the broadband measurements are within 50% of limits prescribed by DOT as mentioned in Table No. 1 on page 5 (may be revised time to time).Following sections detail the measurement locations, time limits and other parameters.

14.1 Measurement Spots and Time

At any given BTS Location under test, the E Field Strength / Power Density measurements have to be undertaken at:

- Various points & Corners on the roof top (which are publicly accessible) in case of RTT / RTP sites
- On roof top of adjacent buildings, and at various heights if required.
- Representative Locations on Ground Level surrounding the site.

At each location, the measurement will be done for a period not less than 6 minutes, and Peak value of Electric Field/ Power will be measured during the above period of 6 minutes using the Broad Band Field Meter.

14.2 DoT Limits for Compliance when using Broadband Instruments

The Peak value of Electric Field/ Power as measured above will be compared with the DoT Limit of the lowest Frequency being used at the BTS Site under test.

15.0 COMPLIANCE BY BROADBAND MEASUREMENTS

A sample format of the report to be filed with TERM CELL for a site, cleared by measurements is placed at Appendix D. An explanation of the various terms / data required in this report is place below:

15.1 SITE DATA

Site ID, Name, Date of Commissioning of BTS, Address, Lat / Long (WGS84) , RTT / GBT, Bldg Ht (in case of RTT), Lowest RF Ant. Ht AGL for each operator

15.2 SITE LAYOUT

A Site / Roof layout is to be submitted, having marking for North Direction, location of the Tower / Poles / GBT, marking for corners / points (C1, C2 C3 and C4 etc) where measurements have been undertaken. The layout is also to be marked with the location of Safety Signs installed at Site.

15.3 TECHNICAL PARAMETERS

Technical details of each operator on the Tower need to be provided:

Operating Freq: BCCH Freq (GSM) / Pilot Channel Freq. (CDMA) of all sectors to be provided.

Carriers / Sector: No of carriers in each sector to be provided for each operator.

15.4 SITE PHOTOGRAPHS

Photographs are required for the site, as well as the Buildings B1, B2, B3 where measurement of Field Strengths have been undertaken

16.0 COMPLIANCE BY FREQUENCY SELECTIVE MEASUREMENTS.

As indicated at Section 10.0 above, compliance by selective measurements is to be undertaken, in case calculations or by broadband instruments indicates the emission levels in excess of 50 % of prescribed DOT limits as mentioned in Table No. 1 on page 5 (may be revised time to time) . Compliance by selective measurement would require calibrated instruments as defined in this document. Further, the measurements will have to be performed for all operators together, as, the compliance to limit is for the overall site.

Following sections detail the measurement frequencies and overall field value for an operator, determination of compliance, measurement report format and other parameters.

16.1 Measurement Frequencies and Overall Field Value for an Operator.

Many operators make use of common tower or use the same site to provide mobile services. If there is any dispute each one will want to show how much their transmitter is contributing to the overall exposure. That is impossible with a simple, broadband measurement. For that to work, the operator would need to be the only one present, or the effects of other services would have to be negligible. And, the transmitter would have to output full power on all channels to generate the maximum level of electromagnetic radiation. The answer here is a selective measurement that detects every output frequency used, and every occupied channel separately, and displays the corresponding field strengths. Intelligent instruments can also integrate over the frequency range of a particular service and display the result, either as an absolute value or as a percentage of the permitted limit value.

There’s another, clever way to check out GSM: you can selectively measure one or all of the control channels, which always transmit at full power, and calculate the field strength that would occur if all voice channels were running at full load too. A similar method can be used for UMTS. At off-peak times, you can measure a frequency block and calculate the overall exposure on the assumption that only the pilot channel was operating. Whatever the method, the test equipment must have the matching bandwidths, adjustable to individual channels, channel groups, or entire frequency blocks.

In case of a GSM System, the measurements will need to be done at all the BCCH Frequencies (for all operators) being used at the site. The contribution of each BTS shall be combined for determination of compliance to limits prescribed for exposure to the general public. Appropriate mitigation techniques shall be deployed for safety of general public.

The value of resultant Electric Field for an operator will be determined as follows:

$$E\ (\text{Sector } 1) = EBCCH1 \times \sqrt{[\,1 + (Nc1 - 1) \times 0.9 * 0.9\,]}$$

$$E\ (\text{Sector } 2) = EBCCH2 \times \sqrt{[\,1 + (Nc2 - 1) \times 0.9} * 0.9\,]$$

$$E\ (\text{Sector } 3) = EBCCH3 \times \sqrt{[\,1 + (Nc3 - 1) \times 0.9 * 0.9\,]}$$

$$E_{operator} = \sqrt{[E(\text{Sector } 1)2 + E(\text{Sector } 2)2 + E(\text{Sector } 3)2\,]} \qquad \text{(RMS Sum)}$$

Where

EBCCHn is the value of the measured peak electric field at a location for the BCCH of nth sector.

Ncn is the number of carriers in the nth sector

For the CDMA System, similar procedure can be used, but the factors of 0.9 can be replaced with 1.0.

As an example, of this calculation with actual values is shown below:

Sector No	No of Carriers	Frequency $BCCH_n$	Field Strength E_{BCCHn}	$E_{(Sector)}$	$E_{Operator}$
		[MHz]	[V/m]	V/m	(V/m)
1	3	951.60	9.04	14.64	
2	4	951.80	13.11	24.29	42.34
3	3	956.80	19.43	31.45	

Table No: 7

- The values of Electric Field Strength as defined above have to be mentioned separately for each measurement location, in the format given in Appendix-E.

- **16.2 Determining Compliance at an individual location**
- After the Peak Electric Field levels are available for all the operators as defined above, their ratios are calculated with respect to the individual limits as defined at section 1.0 above. The RMS of these ratios should be less than 1 for compliance.

For example: At a given location the Peak Electric Field measured are:

5 V/m	for	GSM 900
4 V/m	for	CDMA 800
8 V/m	for	GSM 1800

The corresponding limits are:

<u>**13.05 at 900 MHz**</u>

<u>**12.30 at 800 MHz**</u>

<u>**19.29 at 1800 MHz**</u>

The RMS overall ratio would be:

$\sqrt{[(5/13.05)^2 + (4/12.3)^2 + (08/19.3)^2]}$ = 0.6514, hence compliance is assumed at this location.

If a site is thus compliant at all publicly accessible locations as defined at Section 9.0, it can be declared compliant.

16.3 Report Format for frequency selective Measurement

A sample format of the report to be filed with TERM CELL for a site, cleared by measurements is placed at **Appendix-E**. An explanation of the various terms / data required in this report is place below:

16.3.1 SITE DATA

Site ID, Name, Date of Commissioning of BTS, Address, Lat / Long (WGS 84), RTT / GBT, Bldg Ht (in case of RTT), Lowest RF Ant. Ht AGL <u>for each operator</u>

16.3.2 TECHNICAL PARAMETERS

Technical details of <u>each operator</u> on the Tower need to be provided:

<u>Operating Freq</u> : BCCH Freq (GSM) / Pilot Channel Freq. (CDMA) of all sectors to be provided.

Carriers / Sector: No of carriers in each sector to be provided for each operator.

16.3.3 SITE PHOTOGRAPHS

Photographs are required for the site, as well as the Buildings B1, B2, B3 where measurement of Field Strengths have been undertaken

16.3.4 SITE LAYOUT

A Site / Roof layout is to be submitted, having marking for North Direction, location of the Tower / Poles / GBT, marking for corners / points (C1, C2 C3 and C4 etc) where measurements have been undertaken. The layout is also to be marked with the location of Safety Signs installed at Site.

17.0 COMPLIANCE DISTANCES

(Reffered from ITU-T Recommandation K.70, Appendix-C)

Radio frequency range	**General public exposure**	
1 to 10 MHz	$r = 0.316\sqrt{eirp \times f}$	$r = 0.408\sqrt{erp \times f}$
10 to 400 MHz	$r = 1.01\sqrt{eirp}$	$r = 0.409\sqrt{erp}$
400 to 2000 MHz	$r = 20.16\sqrt{eirp / f}$	$r = 8.16\sqrt{erp / f}$
2000 to 300000 MHz	$r = 0.452\sqrt{eirp}$	$r = 0.581\sqrt{erp}$
r is the minimum antenna distance, in meters f is the frequency, in MHz erp is the effective radiated power in the direction of the largest antenna gain, in Watts eirp is the equivalent isotropic radiated power in the direction of the largest antenna gain, in Watts		

Table: 8

Where: r is the minimum antenna distance, in meters.

f is the frequency in MHz

erp is the effective radiated power in the direction of the largest antenna gain, in Watts.

eirp is the equivalent isotropic radiated power in the direction of the largest antenna gain, in Watts.

17.1 Calculation of Compliance Distance/ Exclusion Zone for Single Transmitter

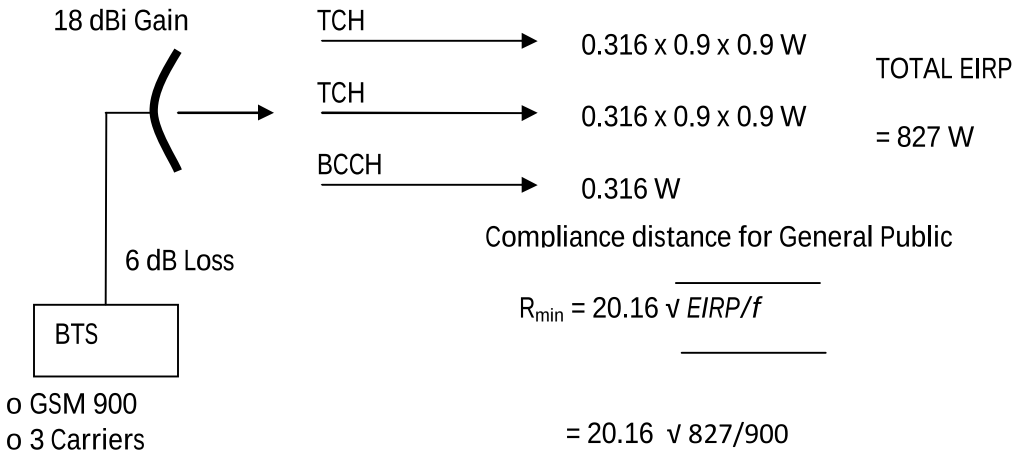

Figure 15

17.2 Calculation of Compliance Distance / Exclusion Zone for BTS sites shared by multiple operators

Analytical formulas are sufficient for calculations of exclusion zone parameters for single antennas or multiple antennas at single location. However, on many sites numerous antennas are installed in close proximity to each other and the calculation of exclusion zones through analytical formulas become impractically conservative or difficult to interpret due to the complexity of the environment. For complex scattering environments, exclusion zones/compliance distances for multiple antennas in close proximity are drawn by software simulation based on Ray tracing / Point Source Model or by aggregation of discrete exclusion zones.

The 3D exclusion zones results after electromagnetic mapping is used for prediction of exact exclusion zones distances. Sample pictures are enclosed in Appendix C.

17.3 Safety Signage

The mobile service operator will ensure provision of proper signage warning entry of general public of the exclusion zones. The sign board should be clearly visible and identifiable and may contain the following text in black over white background:

- **Danger!** RF Radiation! Do not touch tower ! Access to Authorised Personnel Only.
- **Warning!** Non-ionizing Radiation! Beyond this point RF fields exist that exceed the rules for human exposure. Authorised Personnel Only.
- **Caution!** Non-ionizing Radiation!.

The colour code for Danger, Warning and Caution are Red, Orange and Yellow respectively as shown below:

(Red Colour)

(Orange Colour)

(Yellow Colour).

The samples of signboards are given below for reference

The rules for placement of signage are as follow:

(1) **<u>DANGER</u>**<u>: On the tower structure at a height of 2 to 4 meters.</u>

(2) **<u>WARNING</u>**<u>: To be provided only where exclusion zone is formed in any area accessible to public.</u>

(3) **<u>CAUTION</u>**<u>: at the entry point of roof of the building of BTS in case of RTT or at the entrance of BTS compound in case of GBT.</u>

<u>Size of Signage :</u> <u>All signages shall be of 2 feet in width and 3 feet in height.</u>

18.0 TERM CELL AUDIT

During TERM Cell Audit, following points must be adhered to:

a) A copy of the EMF Self Certification Report (By calculation / measurement) submitted by the operator for the site, should be made available to the TERM Cell team for verification and endorsement of parameters by TERM Cells.
Before undertaking measurement, the Tx Power of the Carriers (BCCH's for GSM and Total Channel Power RMS & Pilot Power for CDMA / 3G) will be verified using a BTS Site Master / Spectrum Analyzer (with option for Power measurement) with appropriate couplers / Attenuators , if feasible.

b) EMF Test Instruments for TERM Cell audit must be as per **TEC/TX/GR/EMI-001/02.SEP. 2011.**

c) TERM Cell is required to formally certify the site to be compliant / non compliant on the Audit Report, after completion of Audit.

19.0 CONCLUSION

This document has attempted to cove**r** many practical situations as conceivable. However, in any peculiar / un-foreseen case, the estimation of EMF should be on a conservative note and for public good.

Appendix –'A'
Example of $EIRP_{th}$ calculation

The $EIRP_{th}$ values

Tables A.1 to A.2 show the expressions for $EIRP_{th}$ values based on the DoT limits for various frequency ranges, accessibility conditions and antenna directivity categories.

It is necessary to point out that the radiated density power can be used only in far-field conditions, when it is representative of the electric and magnetic fields. This represents the limit of validity of the proposed assessment procedure for normally compliant installations. Where the procedure is not applicable (e.g., low frequencies or exposure in near-field conditions), then the installation shall be considered provisionally compliant.

The following table shall be applicable:

f (MHz)	**$S_{lim}(f)$ (W/m²)**	
	General public	**Occupational**
400-2 000	**f /2000**	f /40
$2 \cdot 10^3$-$300 \cdot 10^3$	**1**	50

The $EIRP_{th}$ values are given as functions of antenna height and other relevant parameters such as accessibility, directivity and frequency.

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NOTE – In the following Tables a, d, h and h' are in metres.

Table A.1 – Conditions for normal compliance of installations based on ICNIRP limits for frequency range 400-2000 MHz

Directivity category	**Accessibility category**	**$EIRP_{th}$ (W)**	
		General public	**Occupational**
1	1	$\frac{f\pi}{500}(h-2)^2$	$\frac{f\pi}{10}(h-2)^2$
	2	Lesser of: $\frac{f\pi}{500}(h-2)^2$ or $\frac{f\pi}{2000}d^2$	Lesser of: $\frac{f\pi}{10}(h-2)^2$ or $\frac{f\pi}{40}d^2$
	3	Lesser of: $\frac{f\pi}{500}(h-2)^2$ or $\frac{f\pi}{2000}\left[\frac{d^2+(h-h')^2}{d}\right]^2$	Lesser of: $\frac{f\pi}{10}(h-2)^2$ or $\frac{f\pi}{40}\left[\frac{d^2+(h-h')^2}{d}\right]^2$

Table A.1 – Conditions for normal compliance of installations based on ICNIRP limits for frequency range 400-2000 MHz

Directivity category	Accessibility category	$EIRP_{th}$ (W)	
		General public	**Occupational**
1	4	Lesser of: $\frac{f\pi}{500}(h-2)^2$ {If a < (h – 2)} or $\frac{f\pi}{2000}\left[\frac{a^2+(h-2)^2}{a}\right]^2$	Lesser of: $\frac{f\pi}{10}(h-2)^2$ {If a < (h – 2)} or $\frac{f\pi}{40}\left[\frac{a^2+(h-2)^2}{a}\right]^2$
2	1	Lesser of: $\frac{f\pi}{2000A_{sl}}(h-2)^2$ or $\frac{f\pi}{2000}\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$	Lesser of: $\frac{f\pi}{40A_{sl}}(h-2)^2$ or $\frac{f\pi}{40}\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$
	2 (determined by: h' > $h-d\ \tan(\alpha+1.129\theta_{bw})$)	Lesser of: $\frac{f\pi}{2000A_{sl}}(h-2)^2$ or $\frac{f\pi}{2000}d^2$	Lesser of: $\frac{f\pi}{40A_{sl}}(h-2)^2$ or $\frac{f\pi}{40}d^2$
	3 (determined by: h' < $h-d\ \tan(\alpha+1.129\theta_{bw})$)	Lesser of: $\frac{f\pi}{2000A_{sl}}(h-2)^2$ or $\frac{f\pi}{2000A_{sl}}\left[\frac{d^2+(h-h')^2}{d}\right]^2$	Lesser of: $\frac{f\pi}{40A_{sl}}(h-2)^2$ or $\frac{f\pi}{40A_{sl}}\left[\frac{d^2+(h-h')^2}{d}\right]^2$
	4	Lesser of: $\frac{f\pi}{2000A_{sl}}\left[\frac{a^2+(h-2)^2}{a}\right]^2$ or $\frac{f\pi}{2000}\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$	Lesser of: $\frac{f\pi}{40A_{sl}}\left[\frac{a^2+(h-2)^2}{a}\right]^2$ or $\frac{f\pi}{40}\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$

Table A.1 – Conditions for normal compliance of installations based on ICNIRP limits for frequency range 400-2000 MHz

Directivity category	Accessibility category	$EIRP_{th}$ (W)	
		General public	**Occupational**
3	1	Lesser of: $\frac{f\pi}{2000A_{sl}}(h-2)^2$ or $\frac{f\pi}{2000}\left[\frac{h}{\sin(\alpha+1.129\theta_{bw})}\right]^2$	Lesser of: $\frac{f\pi}{40A_{sl}}(h-2)^2$ or $\frac{f\pi}{40}\left[\frac{h}{\sin(\alpha+1.129\theta_{bw})}\right]^2$
3	2	N/A (Line of sight is usually required)	N/A (Line of sight is usually required)
	3 (determined by: $h' < h-d\tan(\alpha+1.129\theta_{bw})$)	Lesser of: $\frac{f\pi}{2000A_{sl}}(h-2)^2$ or $\frac{f\pi}{500A_{sl}}\left[\frac{d^2+(h-h')^2}{d}\right]^2$	Lesser of: $\frac{f\pi}{40A_{sl}}(h-2)^2$ or $\frac{f\pi}{10A_{sl}}\left[\frac{d^2+(h-h')^2}{d}\right]^2$
	4	Lesser of: $\frac{f\pi}{2000A_{sl}}\left[\frac{a^2+(h-2)^2}{a}\right]^2$ or $\frac{f\pi}{2000}\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$	Lesser of: $\frac{f\pi}{40A_{sl}}\left[\frac{a^2+(h-2)^2}{a}\right]^2$ or $\frac{f\pi}{40}\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$

Table A.2 – Conditions for normal compliance of installations based on ICNIRP limits for frequency range 2000-300 000 MHz

<table>
<tr><th rowspan="2">Directivity category</th><th rowspan="2">Accessibility category</th><th colspan="2">$EIRP_{th}$ (W)</th></tr>
<tr><th>General public</th><th>Occupational</th></tr>
<tr><td rowspan="3">1</td><td>1</td><td>$4\pi(h-2)^2$</td><td>$200\pi(h-2)^2$</td></tr>
<tr><td>2</td><td>Lesser of:
$4\pi(h-2)^2$
or
πd^2</td><td>Lesser of:
$200\pi(h-2)^2$
or
$50\pi d^2$</td></tr>
<tr><td>3</td><td>Lesser of:
$4\pi(h-2)^2$
or
$\pi\left[\frac{d^2+(h-h')^2}{d}\right]^2$</td><td>Lesser of:
$200\pi(h-2)^2$
or
$50\pi\left[\frac{d^2+(h-h')^2}{d}\right]^2$</td></tr>
<tr><td>1</td><td>4</td><td>Lesser of:
$4\pi(h-2)^2$ {If a < (h – 2)}
or
$\pi\left[\frac{a^2+(h-2)^2}{a}\right]^2$</td><td>Lesser of:
$200\pi(h-2)^2$ {If a < (h – 2)}
or
$50\pi\left[\frac{a^2+(h-2)^2}{a}\right]^2$</td></tr>
<tr><td rowspan="2">2</td><td>1</td><td>Lesser of:
$\frac{\pi}{A_{sl}}(h-2)^2$
or
$\pi\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$</td><td>Lesser of:
$\frac{50\pi}{A_{sl}}(h-2)^2$
or
$50\pi\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$</td></tr>
<tr><td>2
(determined by: h' > $h-d\ \tan(\alpha+1.129\theta_{bw})$)</td><td>Lesser of:
$\frac{\pi}{A_{sl}}(h-2)^2$
or
πd^2</td><td>Lesser of:
$\frac{50\pi}{A_{sl}}(h-2)^2$
or
$50\pi d^2$</td></tr>
</table>

Table A.2 – Conditions for normal compliance of installations based on ICNIRP limits for frequency range 2000-300 000 MHz

Directivity category	**Accessibility category**	**EIRP$_{th}$ (W)**	
		General public	**Occupational**
	3 (determined by: h' < $h-d\ \tan(\alpha+1.129\theta_{bw})$)	Lesser of: $\frac{\pi}{A_{sl}}(h-2)^2$ or $\frac{\pi}{A_{sl}}\left[\frac{d^2+(h-h')^2}{d}\right]^2$	Lesser of: $\frac{50\pi}{A_{sl}}(h-2)^2$ or $\frac{50\pi}{A_{sl}}\left[\frac{d^2+(h-h')^2}{d}\right]^2$
	4	Lesser of: $\frac{\pi}{A_{sl}}\left[\frac{a^2+(h-2)^2}{a}\right]^2$ or $\pi\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$	Lesser of: $\frac{50\pi}{A_{sl}}\left[\frac{a^2+(h-2)^2}{a}\right]^2$ or $50\pi\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$
3	1	Lesser of: $\frac{\pi}{A_{sl}}(h-2)^2$ or $\pi\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$	Lesser of: $\frac{50\pi}{A_{sl}}(h-2)^2$ or $50\pi\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$
3	2	N/A (Line of sight is usually required)	N/A (Line of sight is usually required)
	3 (determined by: h' < $h-d\ \tan(\alpha+1.129\theta_{bw})$)	Lesser of: $\frac{\pi}{A_{sl}}(h-2)^2$ or $\frac{0.25\pi}{A_{sl}}\left[\frac{d^2+(h-h')^2}{d}\right]^2$	Lesser of: $\frac{50\pi}{A_{sl}}(h-2)^2$ or $\frac{12.5\pi}{A_{sl}}\left[\frac{d^2+(h-h')^2}{d}\right]^2$

Table A.2 – Conditions for normal compliance of installations based on ICNIRP limits for frequency range 2000-300 000 MHz

Directivity category	Accessibility category	$EIRP_{th}$ (W)	
		General public	**Occupational**
	4	Lesser of: $$\frac{\pi}{A_{sl}}\left[\frac{a^2+(h-2)^2}{a}\right]^2$$ or $$\pi\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$$	Lesser of: $$\frac{50\pi}{A_{sl}}\left[\frac{a^2+(h-2)^2}{a}\right]^2$$ or $$50\pi\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$$

NOTE 1 – f is in MHz.
NOTE 2 – All angles should be expressed in radians.
NOTE 3 – A_{sl} should be expressed as a numerical factor. However, usually, it is given in dB with respect to the maximum. To convert: $A_{sl}=10^{A_{sl}[dB]/10}$.

APPENDIX – B

Format for Compliance by determination of EIRP/ $EIRP_{th}$

Appendix-B

FORMAT FOR CERTIFICATION OF BTS FOR COMPLIANCE OF THE EMF EXPOSURE LEVELS (CALCULATION OF EIRP/EIRPth)

B-I : SITE DATA & TECHNICAL PARAMETERS

Name of the BTS : **Date :**

	Item	Units	Operator 1	Operator 2	Operator n	REMARKS
SITE DATA	Site ID					
	Name					
	Date of Commissioning					
	Address					
	Lat / Long					
	RTT / GBT					
	Building Height AGL	(m)				
	Antenna Height AGL	(m)				
TECHNICAL PARAMTERS	System Type (GSM/CDMA/UMTS)					
	Base Channel Frequency	(MHz)				
	Carriers / Sector (Worst)					
	Make and Model of Antenna					
	Antenna Gain	(dBi)				
	Total Tilt	(Deg)				
	Vertical Beamwidth	(Deg)				
	Side Lobe Attenuation	(db)				
	Tx Power	(dBm)				
	Combiner Loss	(db)				
	RF Cable Length	(m)				

	Unit Loss	(dB/100m)				
	EIRP (Base Channel)	(W)				
	DTX factor					
	ATPC factor					
	EIRP (TCH) incl DTX , ATPC	(W)				
	EIRP (Total)	(W)				

B-II : EIRP/EIRPth CALCULATION

Computation of EIRP/EIRPth at adjacent buildings/conspicuous locations within 50 metres radius.

Building 0 (B0)		EIRPth at the Building Roof Top Corners and other points on the periphery of exclusion zone				
Lat	Long	Building Top Corners				
Azimuth	Distance from BTS	C1	C2	C3	C4	Remarks
Operator 1						
Operator 2						
Operator 3						
Overall EIRP/EIRPth						
NORMALLY COMPLIANT (YES/ NO)						
Building 1 (B1)						
Azimuth	Distance from BTS					
Building 2 (B2)						
Azimuth	Distance from BTS					

Building 3 (B3)		EIRPth at various floors of the building				
Lat	Long	I	II	III	IV	Remarks
Operator 1						
Operator 2						
Operator 3						
Overall EIRP/EIRPth						
NORMALLY COMPLIANT (YES/ NO)						

Building 4 (B4)		EIRPth at various floors of the building				
Azimuth	Distance from BTS					
Lat	Long	I	II	III	IV	Remarks
Operator 1						
Operator 2						
Operator 3						
Overall EIRP/EIRPth						
NORMALLY COMPLIANT (YES/ NO)						

EIRPth on the ground					
Operator 1					
Operator 2					
Operator 3					
Overall EIRP/EIRPth					
NORMALLY COMPLIANT (YES/ NO)					

APPENDIX – C

Format for Compliance by Software Simulation

APPENDIX – C

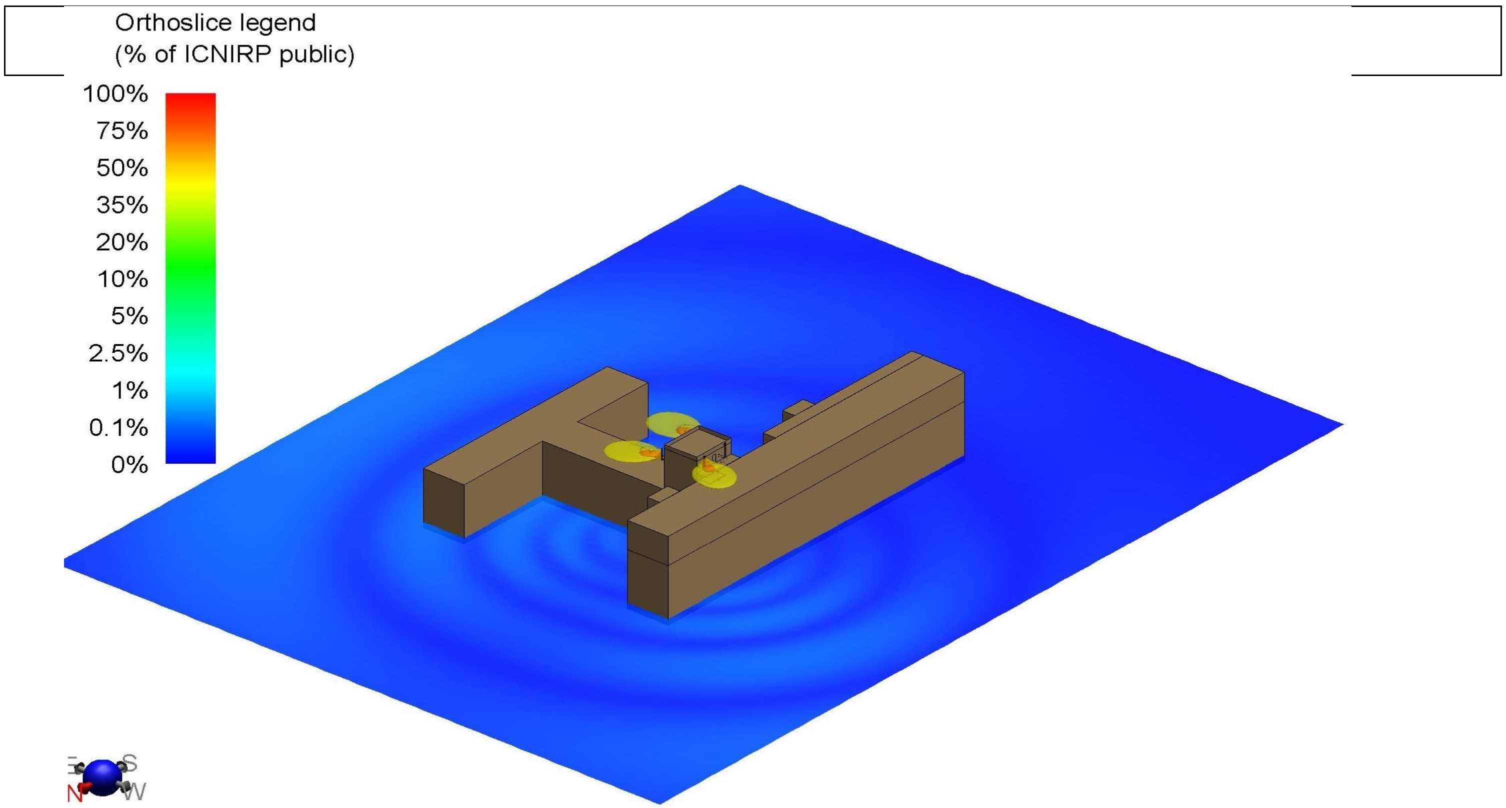
FORMAT FOR CERTIFICATION OF BTS FOR COMPLIANCE OF THE EMF EXPOSURE LEVELS (SOFTWARE SIMULATION)

C-I : SITE DATA & TECHNICAL PARAMETERS

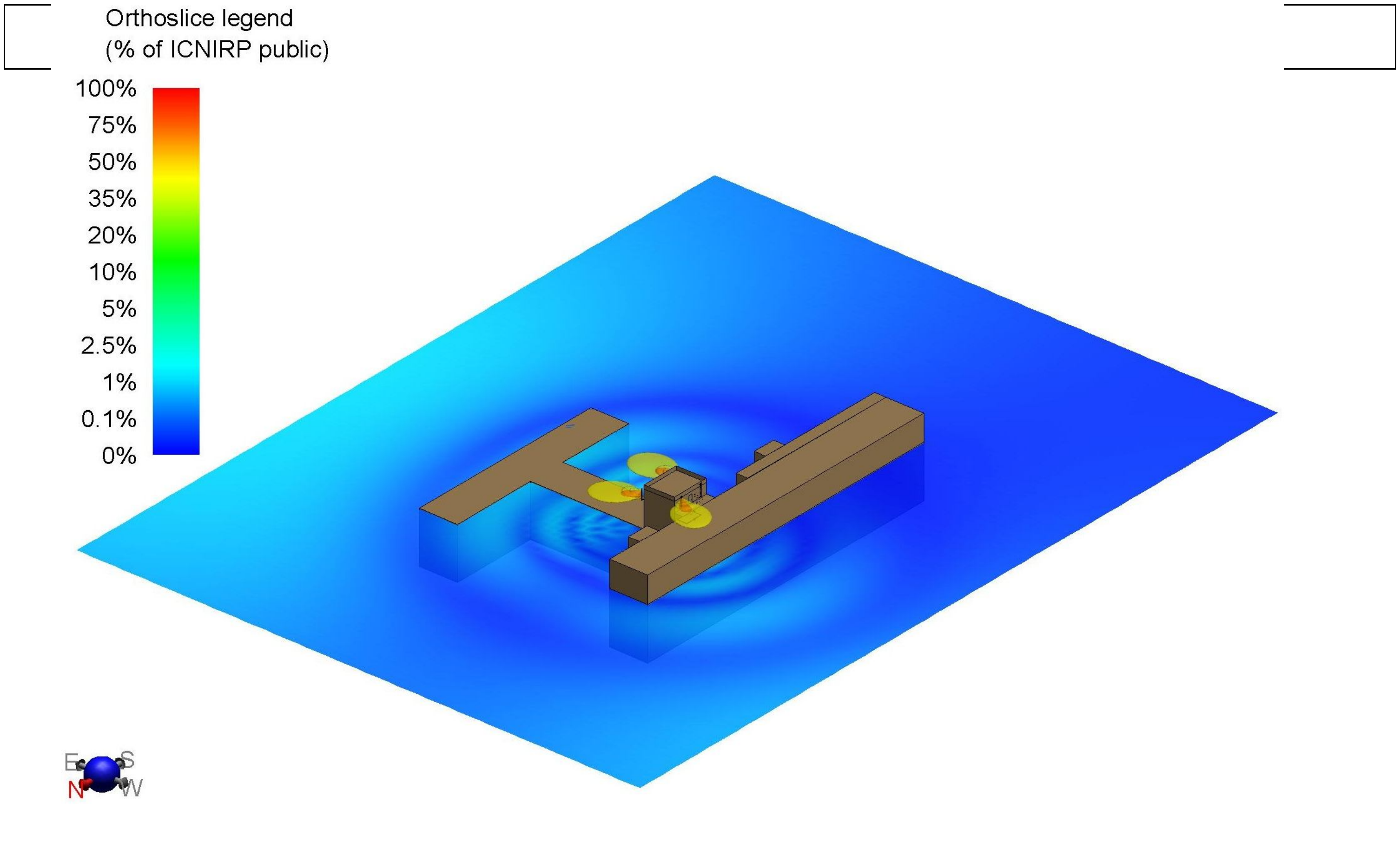
Name of the BTS : **Date :**

	Item	Units	Operator 1	Operator 2	Operator n
SITE DATA	Site ID				
	Name				
	Date of Commissioning				
	Address				
	Lat / Long				
	RTT / GBT				
	Building Height AGL	(m)			
	Antenna Height AGL	(m)			
TECHNICAL PARAMTERS	System Type (GSM/CDMA/UMTS)				
	Frequency of operation	(MHz)			
	Make and Model of Antenna				
	Antenna Gain	(dBi)			
	Electrical Tilt	(Deg)			
	Mechanical Tilt	(Deg)			
	Tx Power	(dBm)			

C-II :ORTHOSLICE AT GROUND LEVEL

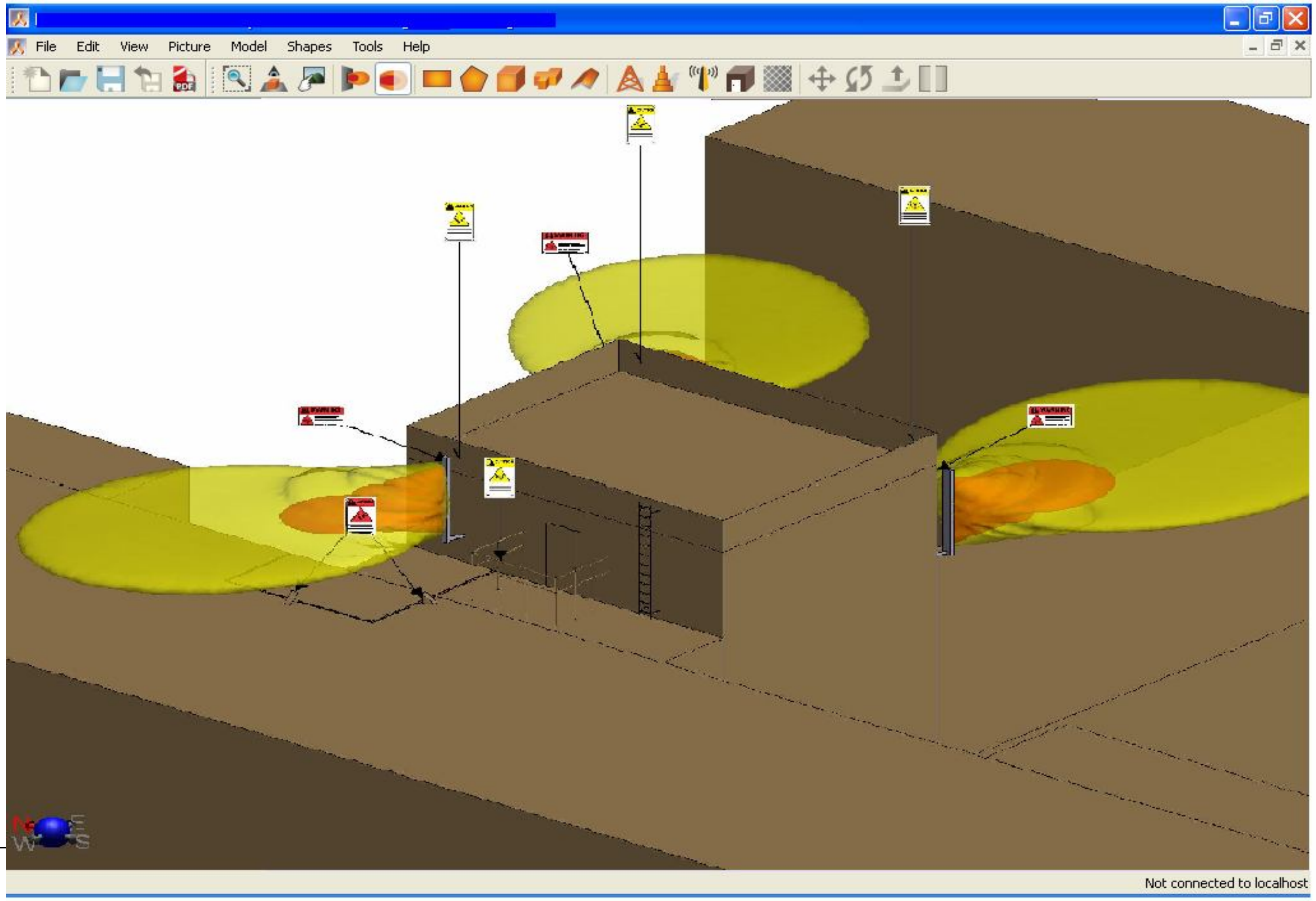
ORTHOSLICE AT GROUND LEVEL	POWER DENSITY AT 2 M ABOVE THE GROUND LEVEL
	

C-III :ORTHOSLICE AT ROOF TOP LEVEL

ORTHOSLICE AT ROOF TOP LEVEL	POWER DENSITY AT 2 M ABOVE THE ROOF TOP LEVEL
	

C-IV :EXCLUSION ZONES

EXCLUSION DISTANCES	EXCLUSION ZONES AND SAFETY SIGNAGE AT ROOFTOP



APPENDIX – D

Format for Compliance by Broadband Measurement

Appendix-D

FORMAT FOR CERTIFICATION OF BTS FOR COMPLIANCE OF THE EMF EXPOSURE LEVELS (BROADBAND MEASUREMENT)

D-I : SITE DATA & TECHNICAL PARAMETERS

Name of the BTS : System Type:

	Item	Units	Operator 1	Operator 2	Operator n	REMARKS
SITE DATA	Site ID					
	Name					
	Date of Commissioning					
	Address					
	Lat / Long					
	RTT / GBT					
	Building Height AGL	(m)				
	Antenna Height AGL	(m)				
	Make and model of Antenna					
	System Type (GSM/CDMA/UMTS)					
	Base Channel Frequencies	(MHz)	Sec 1, Sec2, Sec 3	Sec 1, Sec2, Sec 3	Sec 1, Sec2, Sec 3	
	Carriers / Sector		Sec1, Sec 2, Sec 3	Sec1, Sec 2, Sec 3	Sec1, Sec 2, Sec 3	
	Tx Power	(dBm)				

D-II : BROADBAND MEASUREMENT OF POWER DENSITY (W/Sqm)

Measured value of Power Density (W/Sqm) at adjacent buildings/ conspicuous locations within 60 meters radius.

Building 0 (B0)		Own Building Top Corners and other points on the periphery of exclusion zone				
Lat	Long	C1	C2	C3	C4	Remarks
Dis. From Tower Base (m)						
DOT Limit (W/Sqm) *						
Measured Value (W/Sqm)						
Ratio (Measured / DOT limit)						
COMPLIANT (YES/ NO)						
Building 1 (B1)		Measurement at various floors of the adjacent building				
Azimuth	Distance from BTS	I	II	III	IV	Remarks
Lat	Long					
DOT Limit (W/Sqm) *						
Measured Value (W/Sqm)						
Ratio (Measured / DOT limit)						
COMPLIANT (YES/ NO)						
Building 2 (B2)		Measurement at various floors of the adjacent building				
Azimuth	Distance from BTS	I	II	III	IV	Remarks
Lat	Long					
DOT Limit (W/Sqm) *						
Measured Value (W/Sqm)						

	Ratio (Measured / DOT limit)						
	COMPLIANT (YES/ NO)						
Measured value of Power Density (W/Sqm) at adjacent buildings/ conspicuous locations within 60 meters radius.	Building 3 (B3)		Measurement at various floors of the adjacent building				
	Azimuth	Distance from BTS	I	II	III	IV	Remarks
	Lat	Long					
	DOT Limit (W/Sqm) *						
	Measured Value (W/Sqm)						
	Ratio (Measured / DOT limit)						
	COMPLIANT (YES/ NO)						
	OTHER CONSPICUOUS LOCATIONS ON THE GROUND	SPOT LANDMARK	Spot 1	Spot 2	Spot 3	Spot 4	Spot 5
		Lat					
		Long					
		Azimuth					
		Distance from BTS					
		DOT Limit (W/Sqm) *					
		Measured Value (W/Sqm)					
		Ratio (Measured / DOT Limit)					
RESULT	COMPLIANT (YES/ NO)						

APPENDIX – E

Format for Compliance by Frequency Selective Measurement

Appendix-E

FORMAT FOR CERTIFICATION OF BTS FOR COMPLIANCE OF THE EMF EXPOSURE LEVELS (FREQUENCY SELECTIVE MEASUREMENT)

E-I : SITE DATA & TECHNICAL PARAMETERS

Name of the BTS : **Date:**

	Item	Units	Operator 1	Operator 2	Operator n	REMARKS
SITE DATA	Site ID					
	Name					
	Date of Commissioning					
	Address					
	Lat / Long					
	RTT / GBT					
	Building Height AGL	(m)				
	Antenna Height AGL	(m)				
	Make and model of Antenna					
	System Type (GSM/CDMA/UMTS)					
	Base Channel Frequencies	(MHz)	Sec 1, Sec2, Sec 3	Sec 1, Sec2, Sec 3	Sec 1, Sec2, Sec 3	
	Carriers / Sector		Sec1, Sec 2, Sec 3	Sec1, Sec 2, Sec 3	Sec1, Sec 2, Sec 3	
	Tx Power	(dBm)				

E-II : FREQUENCY SELECTIVE MEASUREMENT OF ELECTRIC FILED / POWER DENSITY

Measured value of Electric field (V/m) or Power Density (W/m2) at adjacent buildings / conspicuous locations within 60 meters radius.	Building 0 (B0)			Own Building Top Corners and other points on the periphery of exclusion zone				
	Lat	Long		C1	C2	C3	C4	Remarks
	Measured Value	Op 1	EBCCH1					
			EBCCH2					
			EBCCH3					
		Op 2	EBCCH1					
			EBCCH2					
			EBCCH3					
		Op 3	EBCCH1					
			EBCCH2					
			EBCCH3					
	Exposure Index		Operator 1					
			Operator 2					
			Operator 3					
	Aggregate of Exposure Index							

	COMPLIANT (YES/ NO)				

Measured value of Electric field (V/m) or Power Density (W/m2) at adjacent buildings/ conspicuous locations within 60 meters radius	Building 1 (B1)			Measurement at various floors of the adjacent building				
	Azimuth	Distance from BTS		I	II	III	IV	Remarks
	Lat	Long						
	Measured Value	Op 1	BCCH1					
			BCCH2					
			BCCH3					
		Op 2	BCCH1					
			BCCH2					
			BCCH3					
		Op 3	BCCH1					
			BCCH2					
			BCCH3					
	Exposure Index		Operator 1					
			Operator 2					
			Operator 3					
	Aggregate of Exposure Index							
	COMPLIANT (YES/ NO)							

Measured value of Electric field (V/m) or Power Density (W/m2) at adjacent buildings/ conspicuous locations within 60 meters radius

Building 2 (B2)			Measurement at various floors of the adjacent building				
Azimuth	Distance from BTS		I	II	III	IV	Remarks
Lat	Long						
Measured Value	Op 1	BCCH1					
		BCCH2					
		BCCH3					
	Op 2	BCCH1					
		BCCH2					
		BCCH3					
	Op 3	BCCH1					
		BCCH2					
		BCCH3					
Exposure Index		Operator 1					
		Operator 2					
		Operator 3					
Aggregate of Exposure Index							
COMPLIANT (YES/ NO)							

				Spot 1	Spot 2	Spot 3	Spot 4	Spot 5
Measured value of Electric field (V/m) OR Power density (W/m2) at adjacent buildings/ conspicuous locations within 60 meters radius	OTHER LOCATIONS ON THE GROUND		SPOT LANDMARK					
			Azimuth					
			Distance from BTS					
			Lat					
			Long					
	Measured Value	Op 1	BCCH1					
			BCCH2					
			BCCH3					
		Op 2	BCCH1					
			BCCH2					
			BCCH3					
		Op 3	BCCH1					
			BCCH2					
			BCCH3					
	Exposure Index		Operator 1					
			Operator 2					
			Operator 3					

	Aggregate of Exposure Index				
	COMPLIANT (YES/ NO)				

Appendix-'F'

TERMS AND DEFINITIONS

1. antenna gain: The antenna gain G (θ, ϕ) is the ratio of power radiated per unit solid angle multiplied by 4π to the total input power. Gain is frequently expressed in decibels with respect to an isotropic antenna (dBi). The equation defining gain is:

$$G(\theta,\varphi) = \frac{4\pi}{P_{in}}\frac{dP_r}{d_\Omega}$$

where:

- θ, ϕ are the angles in a polar coordinate system
- P_r is the radiated power along the (θ, ϕ) direction
- P_{in} is the total input power
- Ω elementary solid angle along the direction of observation

2. average (temporal) power (P_{avg}): The time-averaged rate of energy transfer defined by:

$$P_{avg} = \frac{1}{t_2 - t_1}\int_{t_1}^{t_2} P(t)dt$$

where t_1 and t_2 are the start and stop time of the exposure. The period $t_1 - t_2$ is the exposure duration time.

3. averaging time (T_{avg}): The averaging time is the appropriate time period over which exposure is averaged for purposes of determining compliance with the limits.

4. continuous exposure: Continuous exposure is defined as exposure for duration exceeding the corresponding averaging time. Exposure for less than the averaging time is called short-term exposure.

5. contact current: Contact current is the current flowing into the body by touching a conductive object in an electromagnetic field.

6. controlled/occupational exposure: Controlled/occupational exposure applies to situations where persons are exposed as a consequence of their employment and in which those persons who are exposed have been made fully aware of the potential for exposure and can exercise control over their exposure. Occupational/controlled exposure also applies where the exposure is of transient nature as a result of incidental passage through a location where the exposure limits may be above the general population/uncontrolled limits, as long as the exposed person has been made fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

7. **directivity**: Directivity is the ratio of the power radiated per unit solid angle over the average power radiated per unit solid angle.

8. **Equivalent Isotropically Radiated Power (EIRP)**: The EIRP is the product of the power supplied to the antenna and the maximum antenna gain relative to an isotropic antenna.

9. **exposure**: Exposure occurs wherever a person is subjected to electric, magnetic or electromagnetic fields, or to contact currents other than those originating from physiological processes in the body or other natural phenomena.

10. **exposure level**: Exposure level is the value of the quantity used when a person is exposed to electromagnetic fields or contact currents.

11. **exposure, non-uniform/partial body**: Non-uniform or partial-body exposure levels result when fields are non-uniform over volumes comparable to the whole human body. This may occur due to highly directional sources, standing waves, scattered radiation or in the near field.

12. **far-field region**: That region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna. In the far-field region, the field has a predominantly plane-wave character, i.e., locally uniform distribution of electric field strength and magnetic field strength in planes transverse to the direction of propagation.

13. **general public**: All non-workers (see definition of workers in 3.27) are defined as the general public.

14. **induced current**: Induced current is the current induced inside the body as a result of direct exposure to electric, magnetic or electromagnetic fields.

15. **intentional emitter**: Intentional emitter is a device that intentionally generates and emits electromagnetic energy by radiation or induction.

16. **near-field region**: The near-field region exists in proximity to an antenna or other radiating structure in which the electric and magnetic fields do not have a substantially plane-wave character but vary considerably from point-to-point. The near-field region is further subdivided into the reactive near-field region, which is closest to the radiating structure and that contains most or nearly all of the stored energy, and the radiating near-field region where the radiation field predominates over the reactive field, but lacks substantial plane-wave character and is complicated in structure.

NOTE – For many antennas, the outer boundary of the reactive near-field is taken to exist at a distance of one-half wavelength from the antenna surface.

17. power density (S): Power flux-density is the power per unit area normal to the direction of electromagnetic wave propagation, usually expressed in units of Watts per square metre (W/m^2).

NOTE – For plane waves, power flux-density, electric field strength (E), and magnetic field strength (H) are related by the intrinsic impedance of free space, $\eta_0 = 377\ \Omega$. In particular,

$$S = \frac{E^2}{\eta_0} = \eta_0 H^2 = EH$$

where E and H are expressed in units of V/m and A/m, respectively, and S in units of W/m^2. Although many survey instruments indicate power density units, the actual quantities measured are E or H.

18. general population/uncontrolled exposure: General population/uncontrolled exposure applies to situations in which the general public may be exposed, or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure, or cannot exercise control over their exposure.

19. workers: Employed and self-employed persons are termed workers, whilst following their employment.

20. unintentional emitter: An unintentional emitter is a device that intentionally generates electromagnetic energy for use within the device, or that sends electromagnetic energy by conduction to other equipment, but which is not intended to emit or radiate electromagnetic energy by radiation or induction.