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TEST PROCEDURE
FOR MEASUREMENT OF
ELECTROMAGNETIC FIELDS
FROM
BASE STATION ANTENNA
No: TEC/TP/EMF/001/04.JUN 2018

(Supersedes document No: TEC/TP/EMF/001/02.OCT 2012 and other related addendums)

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TEST PROCEDURE FOR MEASUREMENT OF ELECTROMAGNETIC FIELDS FROM BASE STATION ANTENNA

1.0 Scope

This document provides the detailed procedure for the certificate of compliance of EMF exposure norms by the Telecom Service Providers (TSPs) and audit by the Licensed Service Area (LSA) Units of the Department of Telecommunications (DOT).

The objective of this Test Procedure is to confirm the EMF exposure from base station installations as per the exposure limits prescribed by the DOT.

The Telecom Service Providers will establish necessary facility for self-testing and offering them for auditing of EMF measurement to the concerned LSA Unit for complying with emission limits as per limits prescribed by the Department of Telecommunications vide Memo No. 800-15/2010-VAS (Pt), dated 30.12.2011

The latest current limits/reference levels 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 1

1.1 References

The following ITU-T Recommendations:

- ITU-T Recommendation K.52 (212/2016), 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.

  K.70 (2007): “Mitigation techniques to limit human exposure to EMFs in the vicinity of radiocommunication stations”
- K.100 (2014): “Measurement of radio frequency electromagnetic fields to determine compliance with human exposure limits when a base station is put into service”
- IEC 62232 (2011): Determination of RF field strength and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure.
- ICINRP Guidelines for limiting exposure to time- varying Electric, magnetic and electromagnetic fields (upto 300 GHz)
- EN 50492:2008 & A1 (2014): Basic standard for in-situ measurement of electromagnetic field strength related to human exposure in the vicinity of base stations.
- IEC TR/62669: Case studies supporting IEC 62232.

2.0 EMF exposure zones.

2.1 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.

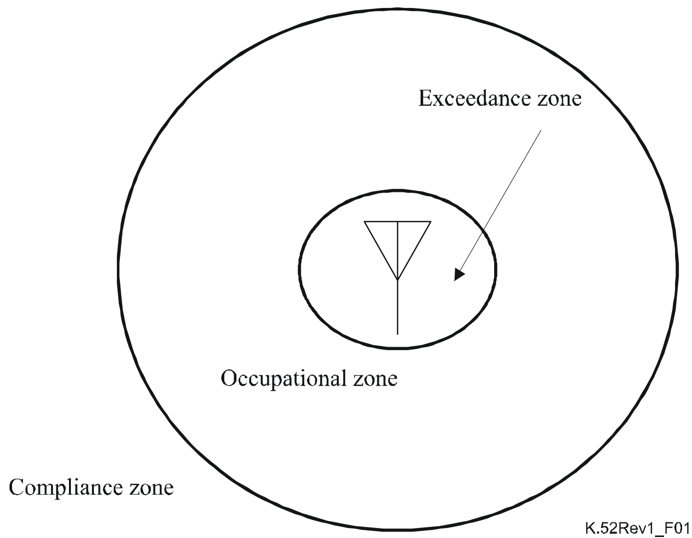


Figure 1 – Figurative illustration of exposure zones

3.0 Exposure level assessment

3.1 The assessment of the exposure level shall consider:

(i) the worst emission conditions;
(ii) the simultaneous presence of several EMF sources, even at different frequencies.

3.2 The following parameters should be considered:

(i) 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.

(ii) 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;

(iii) the frequency of operation; and

(iv) 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.

4.0 The installation classification scheme

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

(i) **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. All base stations with EIRP ≤ 2W are inherently compliant.

(ii) **Normally compliant**: Normally compliant installations contain sources that produce EMF that can exceed relevant exposure limits. All base stations with EIRP between > 2 and ≤ 100 watts as normally compliant and >100 Watt EIRP as provisionally compliant. 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 small cells with low transmit power (with EIRP ≤ 100 Watts) and antennas mounted on sufficiently tall towers. Precaution may need to be exercised by maintenance personnel who come into the close vicinity of emitters in certain normally compliant installations.

A format of the report to be filed for a normally compliant site is placed at **Appendix– F (1). Restriction on minimum height of lowest radiating part of Antenna and minimum distance to areas accessible to general public in the main lobe direction for Low Power Base Stations (EIRP <100 Watts) are as provided in Appendix-F (2).**

The LSA Units may conduct only physical audit of base stations covered under SAC for checking compliance to the requirement based on the EIRP declared by the TSP and no measurements need be conducted.

(iii) **Provisionally compliant**: These installations require requisite measures to achieve compliance.

Base Stations with EIRP > 100 Watts shall be subjected to LSA Units audit by measurement of EMF exposure levels using broadband / Frequency Selective measurement as laid down in this Test Procedure. Any violation of this requirement will be dealt as per the procedure prescribed by DoT/Licensor.

5.0 Procedure for determining installation class

5.1 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.

5.2 A useful procedure is as follows:

(1) 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.

(2) 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.

(3) 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.

(4) 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.

(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

6.1 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 exposure limits for RF electromagnetic fields from mobile radio base stations.

(a) ITU-T K.52 based Calculation Method for determination of $EIRP_{th}$

(b) ITU-T K.100 based simplified assessment procedure criteria of minimum distance and minimum height of radiating antenna.

(ii) Field Measurement Approach. -

(a) Broadband Measurement

(b) Frequency Selective Measurement.

(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.

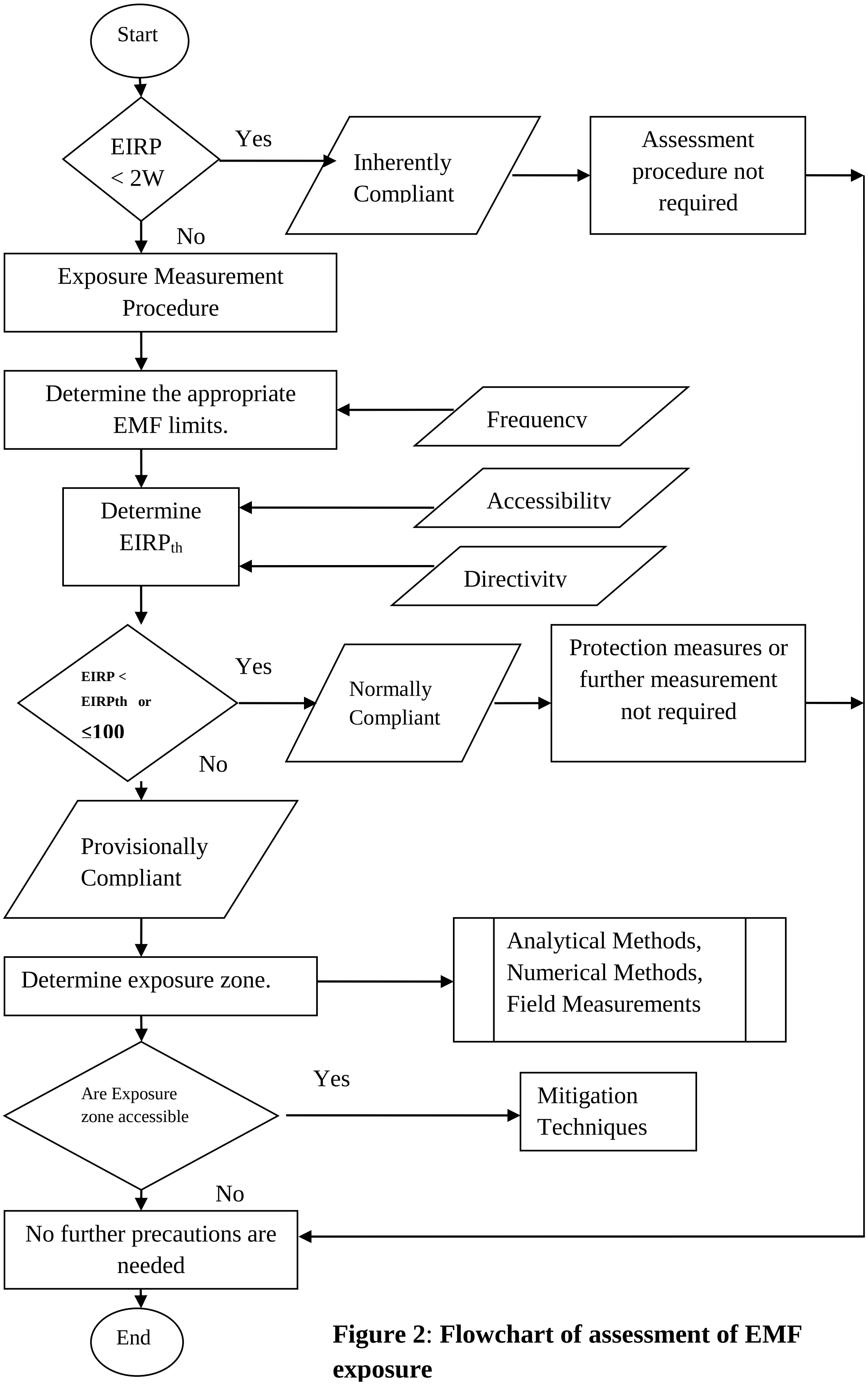


Figure 2: **Flowchart of assessment of EMF exposure**

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.

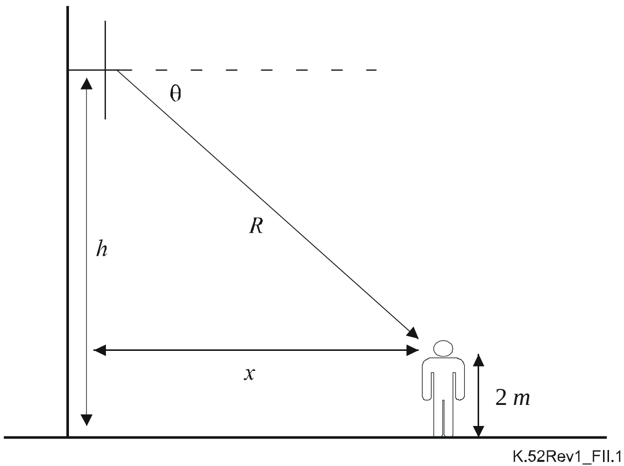


Figure 3: Sample configuration for calculating exposure at ground level

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

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

- **(i)** measurement of both the electric and magnetic components may be necessary in the non-radiating near field region;
- **(ii)** 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 wavelengthλ).

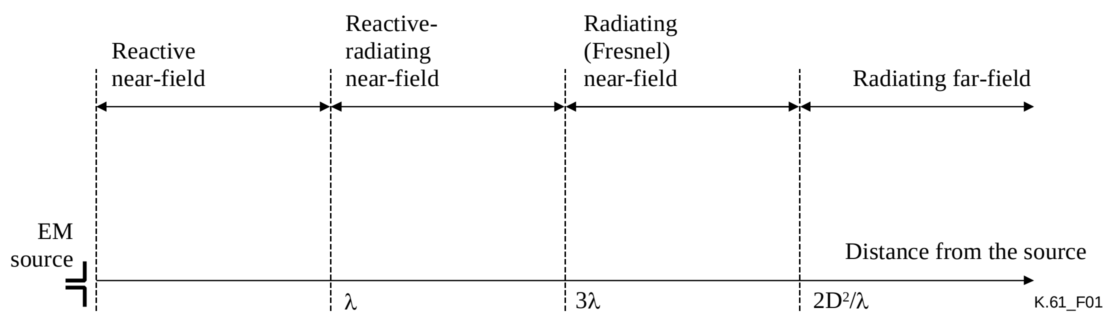


Figure 4 – Field regions around an EM source (the antenna maximum dimension D is supposed to be large compared with the wavelengthλ)

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

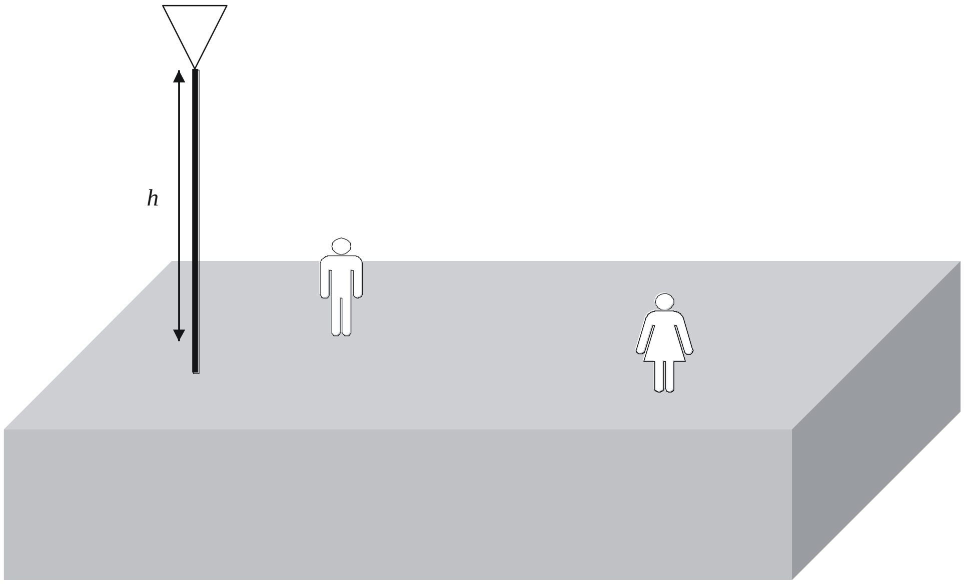


Figure 5 – Illustration of the accessibility category 1

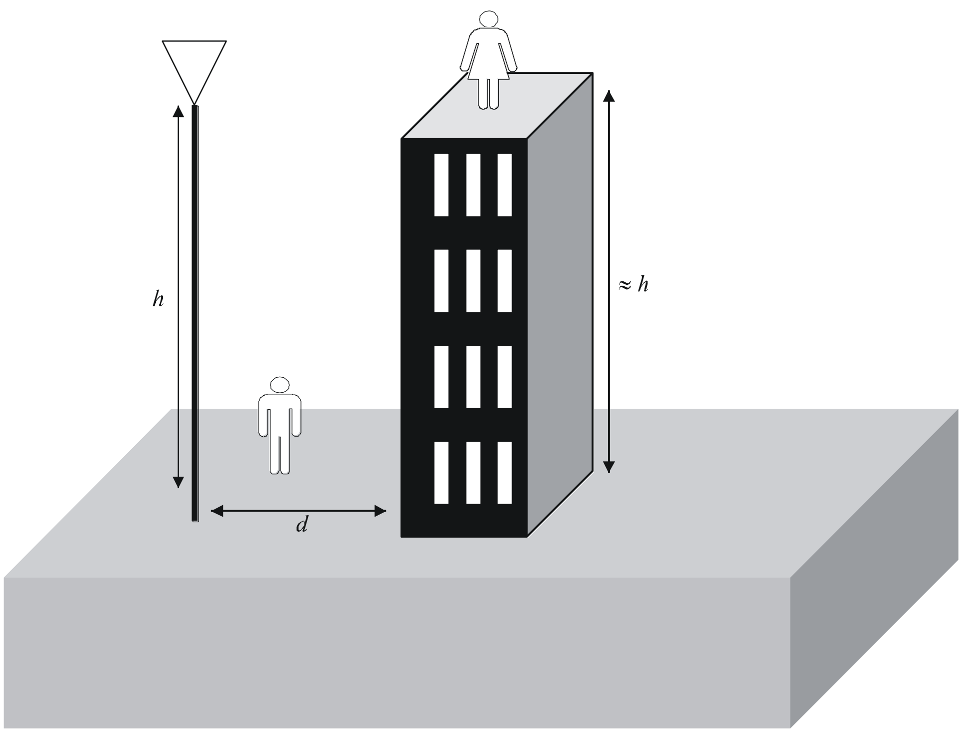


Figure 6 – Illustration of the accessibility category 2

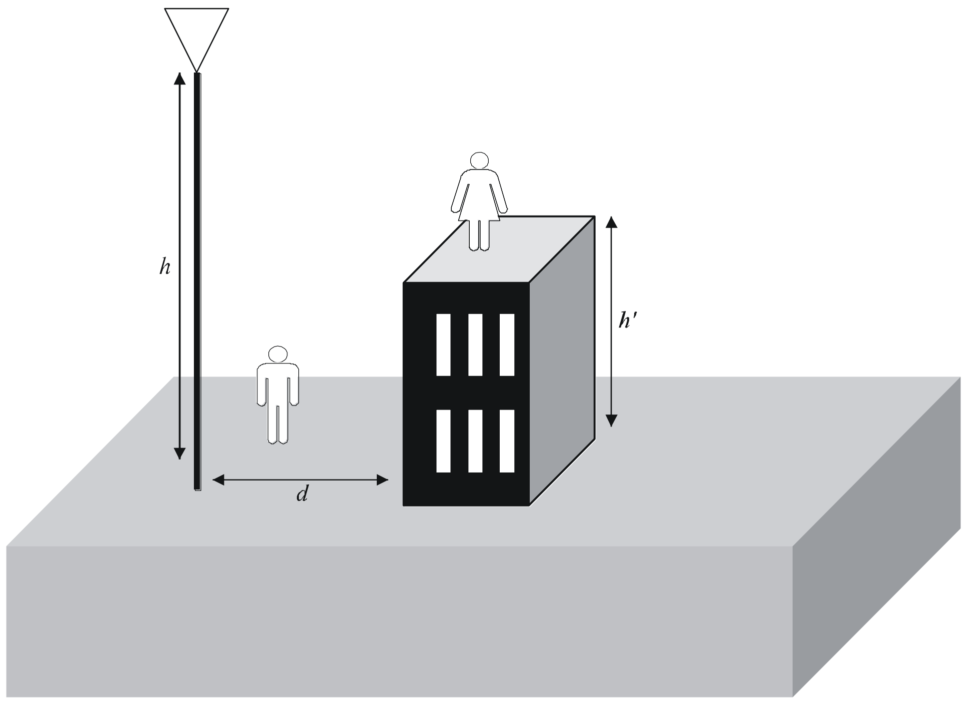


Figure 7 – Illustration of the accessibility category 3

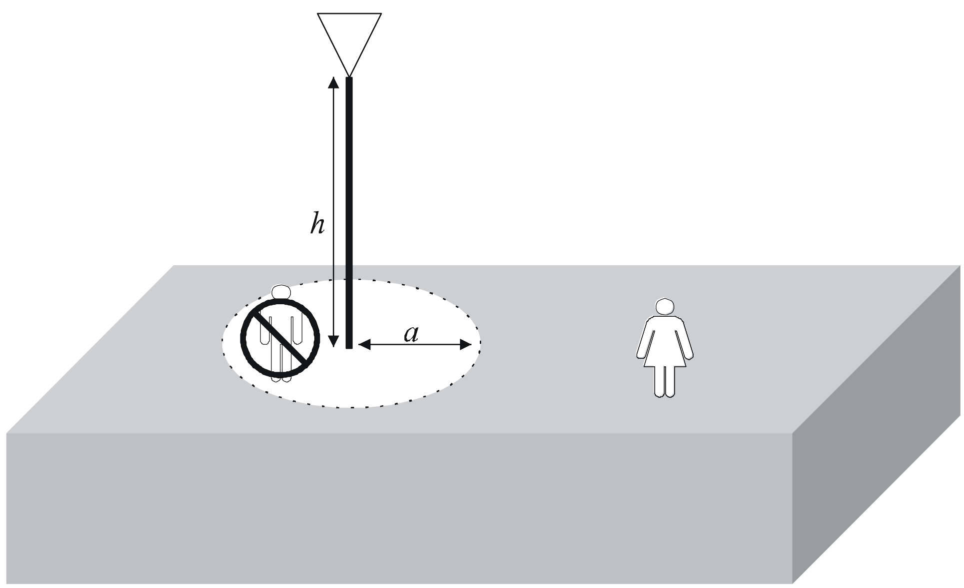


Figure 8 – Illustration of the accessibility category 4, circular exclusion area

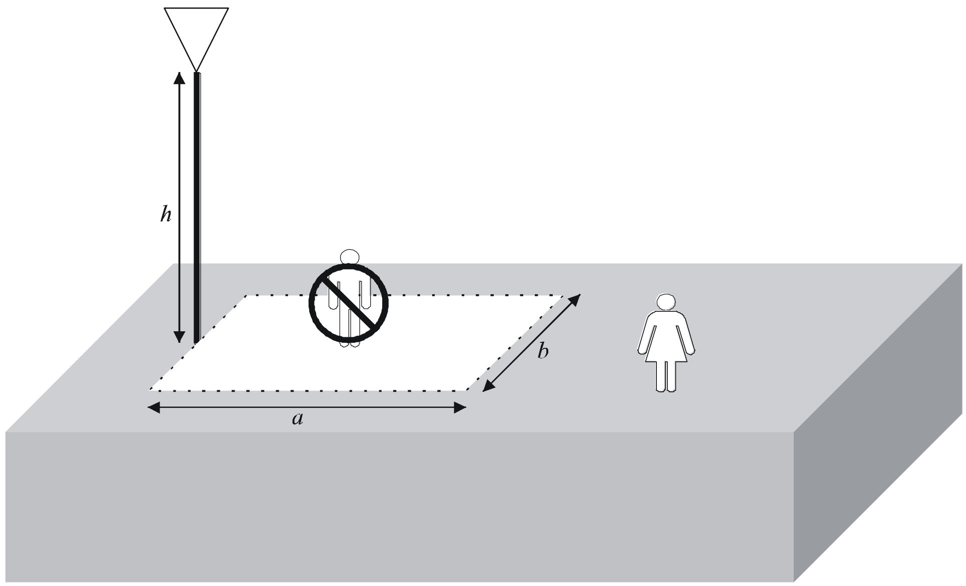


Figure 9 – Illustration of the accessibility category 4, rectangular exclusion area

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.

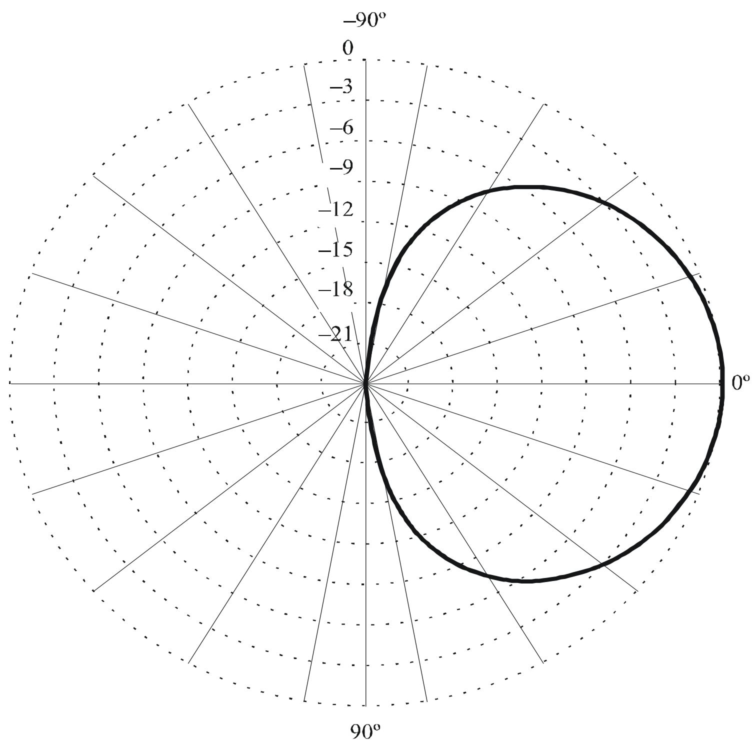


Figure 10 – Vertical pattern for a half-wave dipole in vertical polarization

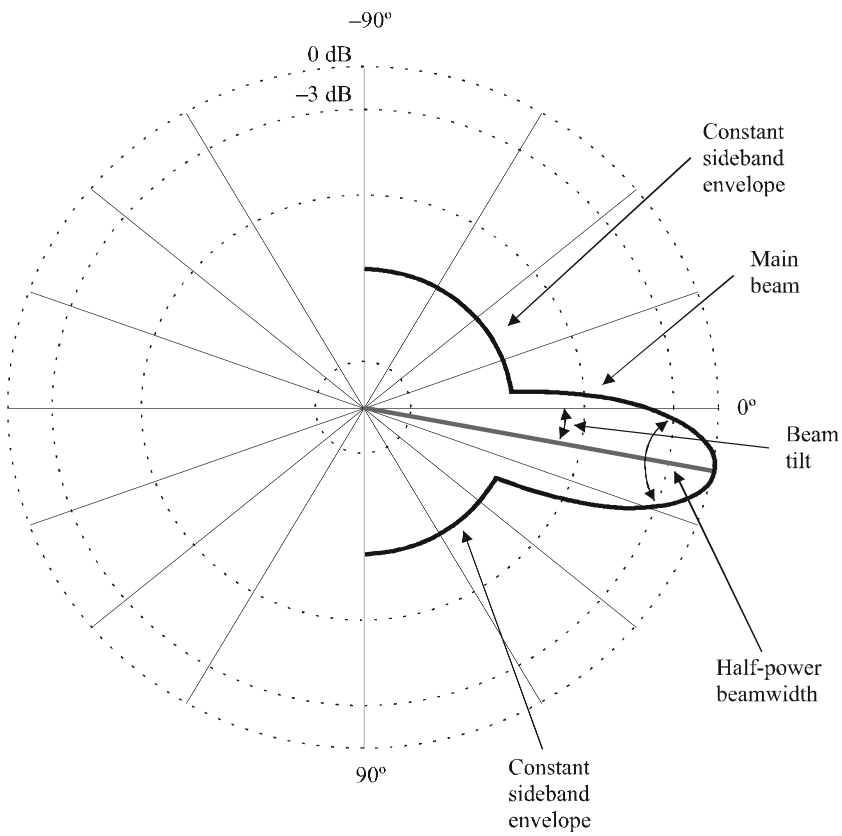


Figure 11 – Illustration of terms relating to antenna patterns

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.

9.0 Compliance options available to Service Providers for submission of Self Certification

Mobile Service Operator may self certify their base station for compliance of limits mentioned in Table-1, page 7 (or as may be prescribed from time to time) after assessment of estimated levels of EMR in the 60 meters radius of the base station based on appropriate methods from amongst the following:

(a) Calculations of $EIRP/EIRP_{th}$ based on ITU-T Recommendation K.52

Assessment of the value of ($EIRP/EIRP_{th}$) can be made at various publicly accessible points in the environment surrounding the base station 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 13.

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 taken as compliant. 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 base station site, Ground level and Roof Top of adjacent buildings in the vicinity of 60 meters from the base station under consideration.

The site can be self certified as compliant if the electromagnetic mapping by software simulation are within 50 % of the DoT prescribed limits in terms of power density value corresponding to the lowest frequency radiated at that site as mentioned in Table No. 1 on page 7 (may be revised time to time).

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

(c) <u>Broadband Measurements</u>

Broadband measurement facilitates overall exposure from all types of base stations of mobile services but it does not indicate the individual contributions made by individual sources such as GSM-900, GSM- 1800, WCDMA, LTE mobile phone services. The overall measured value of the 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 measurement to be conducted for the frequency range from 700 MHz to 3 GHz. Broadband measurement of power density (watt /sq. m) may be done with an isotropic field probe.

Broadband measurements will be done for first stage audit verification by LSA Unit to certify EMF compliance of a site subject to the condition that measured values do not exceed 50% of DoT prescribed limits in terms of power density value corresponding to the lowest frequency radiated at that site as mentioned in Table No. 1 on page 7 (may be revised time to time).

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

Mere exceedance of measured levels beyond 50% of the power density limits under broadband measurement does not amount to site being non-compliant. In these circumstances, Frequency Selective measurement should be conducted, as mentioned below.

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

Frequency Selective measurements with extrapolation for maximum traffic must be performed if the broadband measurement exceeds 50 % of limits prescribed by DoT.

For Frequency Selective Measurement Service Operator would be required to assess contribution of each base station for determination of compliance to limits prescribed for exposure to the general public before self certification of the base station. For such base station audit verification by LSA Unit would be carried out by selective measurement as described in Appendix E-III. Format of the report for Selective Measurement to be filed for a compliant site is placed at Appendix E-I and E-II. Please refer **Note** at the end of Appendix E-II for definition of a compliant site.

(e) Calculation of minimum height and minimum distance for Simplified Assessment Criteria based ITU-T Recommendation K.100

For base station not coming in the definition of shared site, compliance to EMF norms can be submitted with calculation of minimum height and minimum distance based on simplified assessment criteria given in ITU-T K.100 recommendation depending on the EIRP level, antenna installation characteristics such as mounting height, main lobe direction and distance to other ambient sources.

Format of the report for Simplified Assessment Criteria to be filed for a compliant site is placed at Appendix- F (1).

10.0 Field Measurement Approach.

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 the general public.

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

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

(v) 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. Measurements have to be carried out in publically accessible area which should be more than 1.3 m away from the antenna main lobe direction. 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.

(vi) 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.

(vii) 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 Frequency Selective instrumentation and a linear antenna are used, field intensities at three mutually orthogonal orientations of the antenna must be obtained at each measurement point.

10.1 Test Instruments Required

Instruments used for measuring radiofrequency fields must support broadband or Frequency Selective measurement. A typical broadband instrument responds essentially uniformly and instantaneously over a wide frequency range and requires no tuning. A Frequency Selective 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 isotropic antenna or probe to sample the field.
iii) Embedded software or Laptop to process the measured results.
iv) For Frequency Selective measurements in UMTS/LTE, dedicated decoder is required.

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.001/03. MAR2016** 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 a site, following devices or device(s) supporting the following features 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

10.2 Calibration of instruments

It is important that EMF Measuring Instruments should have valid calibration certificate. Calibration certificate issued by OEM or from an accredited lab (NABL or any international accreditation under ISO/IEC 17025) will be considered as valid.

11.0 Responsibility of Service Providers at Shared Sites

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

(a) Multiple base stations on a tower.

(b) Multiple towers with base stations on the same or different plots within 20 m radius.

(c) Multiple Roof Top Poles on with a base station on the same/ Adjacent Building within 20 m.

(2) Guidelines for capture of the lat/long of base station are as follows:

(a) Lat/long will be recorded in 5 decimal points.

(b) Lat/long to be captured of first clockwise northernmost leg of Tower in case of GBT/RTT

(c) Lat/long to be captured at the base in case of Monopole (GBMP/RTMP)

(d) A common reference point is specified in order to standardize the process of measuring the distance between two adjacent sites. In case multiple RTP/RTT/WM common reference point will be marked at the approximate geometrical center of the roof in the layout plan of the self certificate submitted.

(3) For self certification of shared sites,

(a) For new tenancy, only that TSP will submit self-certificate incorporating details of all constituent base stations on that shared site.

In case of upgradation, only the upgrading TSP will submit self-certificate incorporating details of all constituent base stations on that shared site. All TSPs shall submit a separate duly digitally signed self-certificate, in the form of consolidated monthly summary report (to be submitted by 10th day of the following month), for all the upgrades/additions on shared sites done by other TSPs, for each LSA. It will be deemed to be a self-certificate for all technical and legal purposes. The format of the summary report is at Appendix G.

(4) In case of non-compliance of shared site, penalty shall be imposed as per DoT instruction.

12.0 Numbering Scheme for Base Station and its Self-Certificates

Development of EMF Portal has necessitated for the standardization of numbering system for each base station and its associated certifications..

Coding for the numbering of base station will be based on aggregation of ten different parameters as follows:

SITE-ID
LSA / SSA /IP ID / IP Site No.
Base Station-ID
LSA/SSA/ IP ID/ IP Site No./ SP /RF Band / Technology / SP Base Station No.
Certificate Number
LSA /SSA /IP ID /IP Site No./ SP /RF Band /Technology /SP Base Station No. /ToS / DDMMYYYY

Complete Code for Unique Numbering Scheme

Details of different fields used in above nomenclature are as follows:

a. **LSA:** First classification of any site is based on broad geographical areas i.e. LSA, a very familiar term in telecom fraternity. Various licenses issued for provision of telecom services are based on LSA. In above coding LSA will be represented by two alphanumeric digits, for example- Andhra Pradesh as 'AP', Rajasthan as 'RJ', etc. Complete list of LSA coding is available in worksheet "LSA" in Appendix – A ("Nomenclature.xlsx")

b. **SSA:** As an LSA covers a huge area, there was a need to further go down to smaller geographical units to achieve a better administration and monitoring. Thus it is proposed to include "SSA" in this nomenclature. In above coding SSA will be represented by two numeric digit (LSA Madhya Pradesh consists of a maximum 40 nos. of SSAs, thus codes 01 to 99 are sufficient), for example- "Adilabad" SSA as "01", "Anantpur" SSA as "02", etc. Complete list of SSA coding is available in worksheet "SSA" in "Nomenclature.xlsx". (Also see Note-1).

c. **IP ID:** Further division for identification of site is based on different Infrastructure Providers in the LSA. Therefore, this code identifies the "Infrastructure Provider of the site". Infrastructure Provider can be anyone of the following:

   i. Existing TSP: Presently 206 in number.

   ii. Existing ISP: Presently 392 in number.

   iii. Existing IP-I: Presently 403 in number.

   iv. Any other SP, other than TSP and ISP

   IP ID will be represented by four numeric digit ranging from 0001 to 9999. It is further divided as follows:

   i. TSPs: 0001 to 2000

   ii. ISPs: 2001 to 5000

   iii. IP-Is: 5001 to 7000

   iv. Others: 7001 to 9999

   (Also see Note-2) These IP IDs are issued by DoT.

d. **IP Site No.:** This part of coding identifies a specific site of a specific Infrastructure provider in a particular LSA. Thus the first four part of the above coding together constitutes to form a nationally-unique-site-identifier and is called as "SITE-ID" (Figure-1). IP Site No. will be represented by four numeric digit ranging from 0001 to 9999 which will be decided by different IPs (TSPs/ISPs/IP-Is) LSA-wise.

e. **SP:** This segment of coding identifies a service provider who is responsible for setting up the radiating elements. An SP can be anyone of the following:

   i. Existing TSP of the LSA: Presently 206 in number.

   ii. Existing ISP: Presently 392 in number

   SP will be represented by four numeric digit ranging from 0001 to 9999. However, it is further proposed that SP may use the same code allotted to him as an IP ID in (c) above for better monitoring and administration of sites. (Also see Note-2)

f. **RF Band:** This is the sixth segment of proposed coding, which represents that RF Band on which the radiation is taking place by the radiating element installed by SP at a particular site. RF Band will be represented by two numeric digit ranging from 01 to 99. Based on the RF bands presently deployed for provision of services, coding has been proposed as follows:

SN	RF Band(MHz)	Code		SN	RF Band(MHz)	Code
1	**700**	**01**		**2**	**2300**	**06**
3	**800**	**02**		**4**	**2400**	**07**
5	**900**	**03**		**6**	**2500**	**08**
7	**1800**	**04**		**8**	**3400**	**09**
9	**2100**	**05**		**10**	**3800**	**10**
11	**Dual Band (900+1800)**	**34**		**12**	**Dual Band (900+2100)**	**35**
13	**Dual Band (800+1800)**	**24**		**14**	**Dual Band (2300+2500)**	**68**
15	**Dual Band (1800+2100)**	**45**		**16**	**Dual Band (900+2300)**	**36**
17	**Dual Band (900+2500)**	**38**				

Note: *Each Dual Band coding shall be unique for same mobile technology only, i.e. one among GSM, WCDMA, LTE-FDD or LTE-TDD.*

Coding for other RF bands may be done onwards on the basis of new RF bands deployed in service.

g. **Technology:** Seventh segment of coding is based on the technology deployed by SPs for provision of services. Technology will be represented by two numeric digit ranging from 01 to 99. Based on the technologies presently deployed for provision of services, coding has been proposed as follows:

SN	Technology	Code
1	**GSM**	**01**
2	**CDMA**	**02**
3	**WCDMA**	**03**
4	**LTE-FDD**	**04**
5	**LTE-TDD**	**05**

Coding for other technologies may be done onwards on the basis of new technologies deployed in services or any other existing wireless service providers being included in the EMF compliance domain.

h. **SP Base Station no.:** This eighth part of coding identifies a specific base station of a specific SP using a particular RF Band and technology. Thus the first eight part of the above coding together constitutes to form a nationally-unique-base station-identifier and is called as "Base Station-ID" (Figure-1). "Base Station-ID" will be represented by four numeric digit ranging from 0001 to 9999 which will be decided by different SPs (TSPs/ISPs etc.).

i. **ToS:** This is the ninth segment of above coding which has emerged to identify "Type of Submission" of a self-certificate by any TSP for a particular base station. Thus this segment will be a part of different certifications of that base station. Presently, on the basis of present regulations, the following Types of Submissions" are in-effect:

SN	ToS (Type of Submission)	Code
1	Self certificate submission for a new site	NS
2	Self certificate submission for a Self-Base Station upgrade	US
3	Self certificate submission on Bi-ennial basis	BE
4	Revised Self certificate	RS
5	Self revised Self certificate	SR

j. **DDMMYYYY:** This is the last segment in above coding which will be used to identify the date of self-certificate. Here DD represents date of submission, MM represents month, for example – 01 for January, 12 for December, etc. and YYYY represents year of submission, for example – 2013, 2014, etc. All the ten segments together constitute a nationally-unique-EMF-radiation-certificate-number.

Notes:

1. The option of "SSA" has been preferred over "District" as smaller geographical units. The reason behind this preference is that administrative boundaries of District are quite volatile in nature in comparison to SSA. Any change in District boundaries might result into ambiguities in coding/ recognition of the sites lying in affected areas. However, there is a least possibility of any change in the boundaries of SSAs. Further, the new license regime (ULs) has also started considering SSAs as sub telecom units.
2. Presently, coding has been done as per the list provided by different concerned units of DoT HQ in respect of TSPs, ISPs, and IP-Is. It is proposed to forward this list to concerned unit after finalization so that in future these codes may be issued by these units only. This is also in accordance to the "First report of the Committee for selection/ validation of EMF portal" duly approved by DoT HQ.
3. EMF guidelines issued by DoT HQ are not currently applicable for ISPs. The numbering scheme will take care of the situation when ISPs or any wireless service provider is included by DoT in the EMF compliance domain.
4. Base station numbering can undergo change due to changes in data fields like TSP Site ID, IP Site ID, SSA mapping and other related parameters. TSPs can inform the LSA Units about such changes through Tarang Sanchar.

5. However, a unique ID for each site will be created which shall remain unchanged and by which one should be able to track the history of changes made at a particular site

13.0 Compliance by Calculations of EIRP/$EIRP_{th}$ based on ITU-T Recommendation K.52

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 base station 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 base station. The data required for these calculations is enumerated below

13.1 Format of Report for Normal Compliance Calculation

A sample format of the report to be filed with LSA Unit 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:

13.1.1 Site Data

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

13.1.2 Adjacent Building Data

The surrounding high rise buildings (first highest building in each main lobe direction) within the range of 60m 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)

Lat/Long of the Tower (Deg)

Height of the buildings (m) AGL

13.1.3 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.

13.1.4 Technical Parameters

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

Base Station Technology	CDMA/UMTS/LTE
Frequency Band (MHz)	700, 850, 900, 1800, 2100, 2300, 2500, 2600
Base Ch. Freq	BCCH Freq (GSM) / Center Frequency (CDMA/UMTS/ LTE)
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	In built tilt+Electrical Tilt + Mechanical Tilt (Deg)
Antenna Tx Gain	Antenna Gain in dBi
Vertical BW	The Base Station 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)
Jumper & Connector Loss	Jumper & Connector Loss if any (dB)
RF Cable Length	Length of the RF Cable from Antenna to the Base Station (m)
RF Cable Unit Loss	Unit Loss of RF Cable (dB/100m)

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

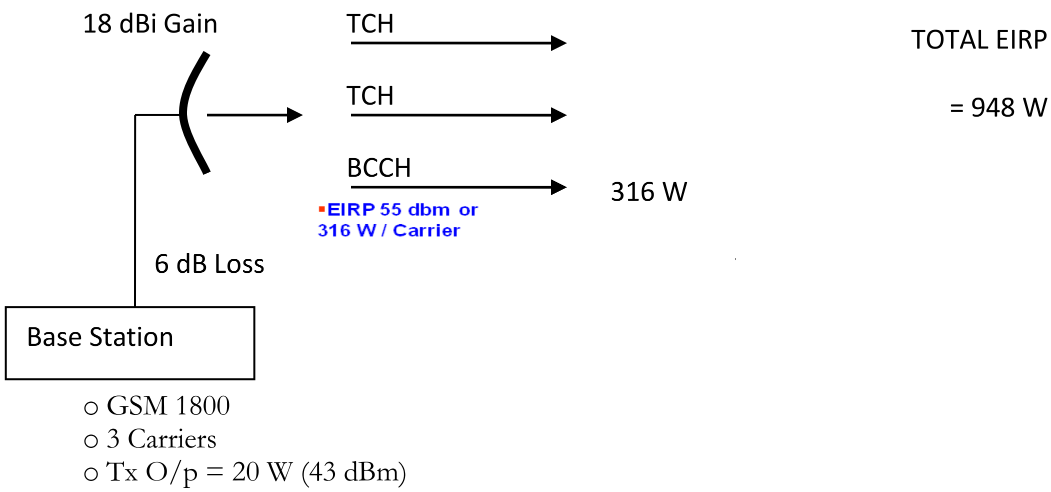
To calculate the total EIRP (EIRP [T]) for an operator, the EIRP of the BCCH Channel (Pilot Channel in case of CDMA) is worked out as follows:

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 x (Carriers / Sector)

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



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

As per, Appendix-. A, the case of calculation of EIRP$_{th}$ for ground points for Base Station 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)

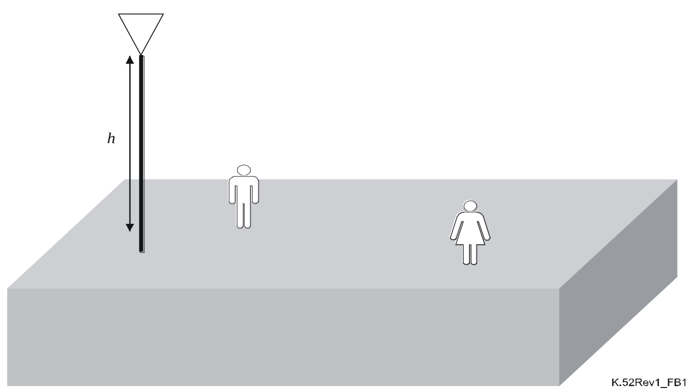


Figure12: Accessibility Category 1

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

Table 5

Note: 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]/$EIRP_{th}$)$_{Op3}$

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

As per Appendix- A, the case of calculation of $EIRP_{th}$ for adjacent roof tops for Base Station 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)

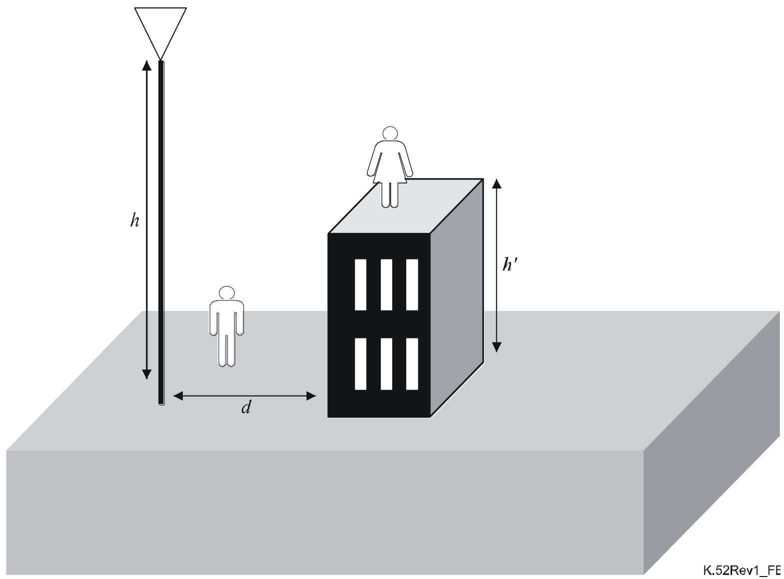


Figure 13: Accessibility Category 2

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 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 x 4 = 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] /$EIRP_{th}$)$_{Op3}$

13.1.8 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 1 for normal compliance.

(2) EIRP / EIRPth is also to be worked out for each operator, at the roof top level on the building (B0) on which the base station under observation is installed. The sum of (EIRP / $EIRP_{th}$) values for individual operators must be less than 1 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 1 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.

14.0 Compliance by Simplified Assessment Procedure Criteria based on ITU-T Recommendation K.100

14.1 Simplified assessment procedures to be used for single transmitter are provided to identify a base station which is known to be in compliance with relevant exposure limits without the necessity of following the general or comprehensive exposure assessment processes. This is relevant, for example because of the low power transmitted or because of the position of the antennas of base station with respect to the general public.

14.2. The simplified assessment procedures are based on knowledge of the equivalent isotropic radiated power (EIRP), and depending on the EIRP level, antenna installation characteristics such as mounting height, main lobe direction and distance to other ambient sources.

14.3. For low power base station (EIRP ≤ 100 Watts) the report is to be filed by TSP for such base station site as per the format given in **Appendix– F (1)**

The base station (EIRP ≤ 100 Watts) shall comply the restriction on minimum height of lowest radiating part of Antenna and minimum distance to areas accessible to general public in the main lobe direction as per the table given in Appendix-F (2)"

14.4 For EIRP larger than 100 W, minimum height H_m and minimum distance D_m (in meters) are to be computed for Cellular Radio Base Stations in for frequencies between 400 MHz and 2 000 MHz are given by the equations below:

$$H_m = \max\begin{cases} 2 + \sqrt{\dfrac{EIRP \cdot 2000\, A_{sl}}{f\pi}} \\ 2 + \sqrt{\dfrac{2000 \cdot EIRP}{f\pi}}\sin(\alpha + 1.129\theta_{\mathrm{bw}}) \end{cases}$$

$$D_m = \sqrt{\frac{EIRP \cdot 2000}{f\pi}}$$

14.5 To ensure compliance to the prescribed safety levels / limits for EMF for general public the Base Station should be installed so that:

(i) the lowest radiating part of the antenna(s) is at a minimum height of H_m metres above the general public walkway,

(ii) the minimum distance to areas accessible to the general public in the main lobe direction is D_m metres,

(iii)no other RF sources with EIRP above 100 W is located within a distance of 5Dm metres in the main lobe direction and within D_m metres in other directions.

A format of the report to be filed for base station site is placed at **Appendix– F(1)**

15.0 Compliance by Software Simulation

For more complex scattering environments as envisaged in a shared base station 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 base station 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)

15.1 Format of Report for Software Simulation

A sample format of the report to be filed with LSA Unit 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:

15.1.1 Site Data

Details of Site Under observation to be provided:

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

15.1.2 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.

15.1.3 Technical Parameters

Technical details of each operator need to be provided:

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

15.1.4 Adjacent Building Data

The 60 m by 60 m rectangular cross section with the site 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

15.1.5 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.

15.1.6 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.

15.1.7 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.

15.1.8 Compliance Distances/ Exclusion Zone

Sample pictures are enclosed at Appendix- C.

15.1.9 Site Photographs

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

16.0 Compliance by Measurements

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 power density levels prescribed by DOT for general public. Compliance by measurement would require calibrated instruments as defined in Section 10.2 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 power density limits prescribed by DOT as mentioned in Table No. 1 on page 7 (may be revised time to time). Following sections detail the measurement locations, time limits and other parameters.

16.1 Measurement Spots and Time

At any given base station location under test, the E Field Strength / Power Density measurements may be undertaken at:

(i) Various points & Corners on the roof top (which are publicly accessible) in case of RTT / RTP sites.

(ii) On roof top of adjacent buildings, and at various heights if required.

(iii) Representative Locations on Ground Level surrounding the site, if required.

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

16.2 DoT Limits for Compliance when using Broadband Instruments

The RMS value of power density as measured above will be compared with the DoT Limit of the lowest Frequency being used at the base station site.

17.0 Compliance by Broadband Measurements

A sample format of the report to be filed with LSA Unit 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:

17.1 Site Data

Site ID, Name, Date of Commissioning of base station, Address, Lat / Long up to 5 decimal places, RTT / GBT, Bldg Ht (in case of RTT), Lowest RF Ant. Ht AGL for each operator

17.2 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.

17.3 Technical Parameters

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

Base Station Technology	GSM/CDMA/UMTS/LTE
Frequency Band (MHz)	700, 850, 900, 1800, 2100, 2300, 2500, 2600
Base Ch. Freq	BCCH Freq (GSM) / Center Frequency (CDMA/UMTS/ LTE)
Carriers / Sector (Worst)	Max. No. of carriers / sector If two sectors are having 3 carriers, while the third one has 4 carriers, the value to be provided would be 4.

17.4 Site Photographs

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

18.0 Compliance by Frequency Selective Measurements

18.1 Report Format for Frequency Selective Measurement

A sample format of the report to be filed with LSA Unit 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:

18.2 Site Data

Measurement Location:

Nearest Base Station Site ID,

18.3 Technical Parameters:

Detail of all Base Stations falling within 60-meter radius around the location subjected to Frequency Selective Measurement of EMF

Operator (s)	Name of Mobile Service Operator
Base Station ID (s)	
Frequency Band (MHz)	700, 850, 900, 1800, 2100, 2300, 2500, 2600
Base Station Technology.	GSM/UMTS/LTE
Channel Bandwidth_TDD/ FDD_MIMO ports (If applicable)	CBW_XDD_N port MIMO
<u>Base Ch. Freq</u>	BCCH Freq (GSM) / Center Frequency (CDMA,UMTS and LTE)
<u>Carriers / Sector (Worst)</u>	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.

18.4: General comments on measurements

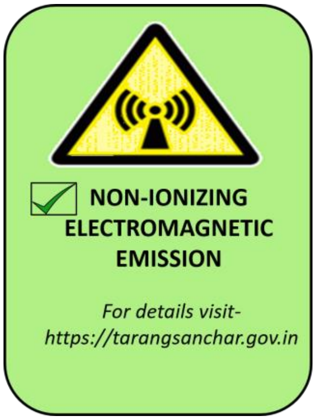
(i) Setting up Measurement Range (MR) has significant impact on readings. The MR must be set based on the presence of field strength. Start with minimum value of MR/attenuation and then increase the MR/Attenuation such that instrument just comes out of saturation mode. Alternatively set for automatic selection for MR, if feature exist in the instrument.

(ii) Screenshots of the measurement results should be recorded and included in the Measurement report for the EMF audit.

19.0 Safety Signage

The mobile service operator will ensure provision of proper signage warning for general public. The sign board should be clearly visible and identifiable and may contain the following text (as given in the sample below):

The sample of signboard is given below for reference



The rules for placement of signage are as follows:

(1) The signage is to be fixed at an appropriate point on the roof of the building of base station in case of RTT/RTP or on the tower structure in case of GBT.

(2) For base station installed on self supporting towers/GBM, the safety signage may be pasted around / install on the tower structure at 2 to 4 meters above the ground level.

Size of Signage: Signage shall be of 200mmX150mm.

20.0 LSA Unit Audit

During LSA Unit Audit, following points must be adhered to:

a) For the purpose of audit by LSA Units, only the latest self-certificate submitted by the TSPs for the site will be considered.

b) EMF Test Instruments for LSA Unit audit must be as per latest TEC GR.

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

21.0 EMF Portal:

A portal having database of all base stations and their emission compliance status (i.e. Compliant/Non-compliant) has been launched with the name 'Tarang-Sanchar' in May 2017 (tarangsanchar.gov.in).

The salient features and the objectives of the portal are as follows:

1. The Portal disseminates information to the public regarding Electro Magnetic Field (EMF) emissions for different telecom base stations in an area and to allay the misconceptions and apprehensions related to health issues of the same.

2. The Portal facilitates Department of Telecom field units and Telecom Operators to manage technical parameters of a base station for EMF compliance.

3. The portal provides facility to get EMF exposure assessment done at any location by requesting for the same through the portal on payment of a nominal fee.

22.0 Conclusion

This document is an attempt to cover many practical situations as conceivable. However, in any peculiar / un-foreseen case, the estimation of EMF exposure 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/m^2)**	
	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 $\frac{f\pi}{40}d^2$

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	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 $\frac{f\pi}{40}\left[\frac{d^2+(h-h')^2}{d}\right]^2$
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 $\frac{f\pi}{40}d^2$

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 (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 $\frac{f\pi}{40}\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$
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 $\frac{f\pi}{10A_{sl}}\left[\frac{d^2+(h-h')^2}{d}\right]^2$

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**
	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

Directivity category	Accessibility category	$EIRP_{th}$ (W)	
		General public	**Occupational**
1	1	$4\pi(h-2)^2$	$200\pi(h-2)^2$
	2	Lesser of: $4\pi(h-2)^2$ or πd^2	Lesser of: $200\pi(h-2)^2$ or $50\pi d^2$
	3	Lesser of: $4\pi(h-2)^2$ or $\pi\left[\frac{d^2+(h-h')^2}{d}\right]^2$	Lesser of: $200\pi(h-2)^2$ or $50\pi\left[\frac{d^2+(h-h')^2}{d}\right]^2$

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
1	4	Lesser of: $4\pi(h-2)^2$ {If a < (h – 2)} or $\pi\left[\frac{a^2+(h-2)^2}{a}\right]^2$	Lesser of: $200\pi(h-2)^2$ {If a < (h – 2)} or $50\pi\left[\frac{a^2+(h-2)^2}{a}\right]^2$
2	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 $50\pi\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$
	2 (determined by: h' > $h-d\tan(\alpha+1.129\theta_{bw})$)	Lesser of: $\frac{\pi}{A_{sl}}(h-2)^2$ or πd^2	Lesser of: $\frac{50\pi}{A_{sl}}(h-2)^2$ or $50\pi d^2$
	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 $\frac{50\pi}{A_{sl}}\left[\frac{d^2+(h-h')^2}{d}\right]^2$

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 $50\pi\left[\frac{h-2}{\sin(\alpha+1.129\theta_{bw})}\right]^2$
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 CERTIFICATION OF BASE STATION FOR COMPLIANCE OF THE EMF EXPOSURE LEVELS (CALCULATION OF EIRP/EIRP$_{th}$)

B-I: SITE DATA & TECHNICAL PARAMETERS

Name of the Base Station : **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)				
	Height of Lowest Antenna AGL	(m)				
TECHNICAL PARAMTERS	System Type (GSM/CDMA/UMTS/LTE)					
	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 of EIRP/EIRPth at Base Station Building	Building 0 (B0)		EIRPth at the Building Roof Top Level	Remarks
	Lat	Long		
	Operator 1			
	Operator 2			
	Operator 3			
	Overall EIRP/EIRPth			
	NORMALLY COMPLIANT (YES/ NO)			

Computation of of EIRP/EIRPth at adjacent buildings/ conspicuous locations within 60 meters radius.	Building 1 (B1)		EIRPth at various floors of the building around the Base Station site				
	Lat	Long	I	II	III	IV	Remarks
	Operator 1						
	Operator 2						
	Operator 3						
	Overall EIRP/EIRPth						
	NORMALLY COMPLIANT (YES/ NO)						
	Building 2 (B2)		EIRPth at various floors of the building around the Base Station site				
	Lat	Long	I	II	III	IV	Remarks
	Operator 1						
	Operator 2						
	Operator 3						
	Overall EIRP/EIRPth						
	NORMALLY COMPLIANT (YES/ NO)						

Computation of of EIRP/EIRPth at adjacent buildings/ conspicuous locations within 60 meters radius	**Building 3 (B3)**	EIRPth at various floors of the building around the Base Station site				
	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 around the Base Station site				
	Lat / **Long**	**I**	**II**	**III**	**IV**	**Remarks**
	Operator 1					
	Operator 2					
	Operator 3					
	Overall EIRP/EIRPth					
	NORMALLY COMPLIANT (YES/ NO)					
	EIRPth on the ground	**At representative location on road/ public walkway**				
		Lat		**Long**		**Remarks**
	Operator 1					
	Operator 2					
	Operator 3					
	Overall EIRP/EIRPth					
	NORMALLY COMPLIANT (YES/ NO)					

APPENDIX-C

FORMAT FOR CERTIFICATION OF BASE STATION FOR COMPLIANCE OF THE EMF EXPOSURE LEVELS

(BROADBAND MEASUREMENT)

C-I : SITE DATA & TECHNICAL PARAMETERS

Name of the Base Station : **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)				
	Height of lowest Antenna AGL	(m)				
	Make and model of Antenna					
	System Type (GSM/CDMA/UMTS/LTE)					
	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)				

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

Measured value of Power Density (W/Sqm) at adjacent buildings/ conspicuous locations within 20 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)						
Measured Value (W/Sqm)						
Exposure Ratio						
COMPLIANT (YES/ NO)						
Building 1 (B1)		**Measurement at various floors of the adjacent building**				
Azimuth	**Distance from Base Station**	**I**	**II**	**III**	**IV**	**Remarks**
Lat	**Long**					
Measured Value (W/Sqm)						
Exposure Ratio						
COMPLIANT (YES/ NO)						
Building 2 (B2)		**Measurement at various floors of the adjacent building**				
Azimuth	**Distance from Base Station**	**I**	**II**	**III**	**IV**	**Remarks**
Lat	**Long**					
Measured Value (W/Sqm)						
Exposure Ratio						
COMPLIANT (YES/ NO)						

Measured value of Power Density (W/Sqm) at adjacent buildings/ conspicuous locations within 20 meters radius.	**Building 3 (B3)**		**Measurement at various floors of the adjacent building**				
	Azimuth	**Distance from Base Station**	**I**	**II**	**III**	**IV**	**Remarks**
	Lat	**Long**					
	Measured Value (W/Sqm)						
	Exposure Ratio						
	COMPLIANT (YES/ NO)						
	OTHER REPRESENTATIVE LOCATIONS ON THE GROUND (if required)	**SPOT LANDMARK**	**Spot 1**	**Spot 2**	**Spot 3**	**Spot 4**	**Spot 5**
		Lat					
		Long					
		Azimuth					
		Distance from Base Station					
		Measured Value (W/Sqm)					
		Exposure Ratio					
	COMPLIANT (YES/ NO)						

NOTE: Reference levels/ limits for EMF exposure to be applied as per the frequency band of the system. This is 13.27 V/m for 900 MHz band (lowest frequency: 935 MHz) and 18.44 V/m for 1800 MHz band (lowest frequency: 1805 MHz).

APPENDIX –D

FORMAT FOR CERTIFICATION OF BASE STATION FOR COMPLIANCE OF THE EMF EXPOSURE LEVELS

(SOFTWARE SIMULATION)

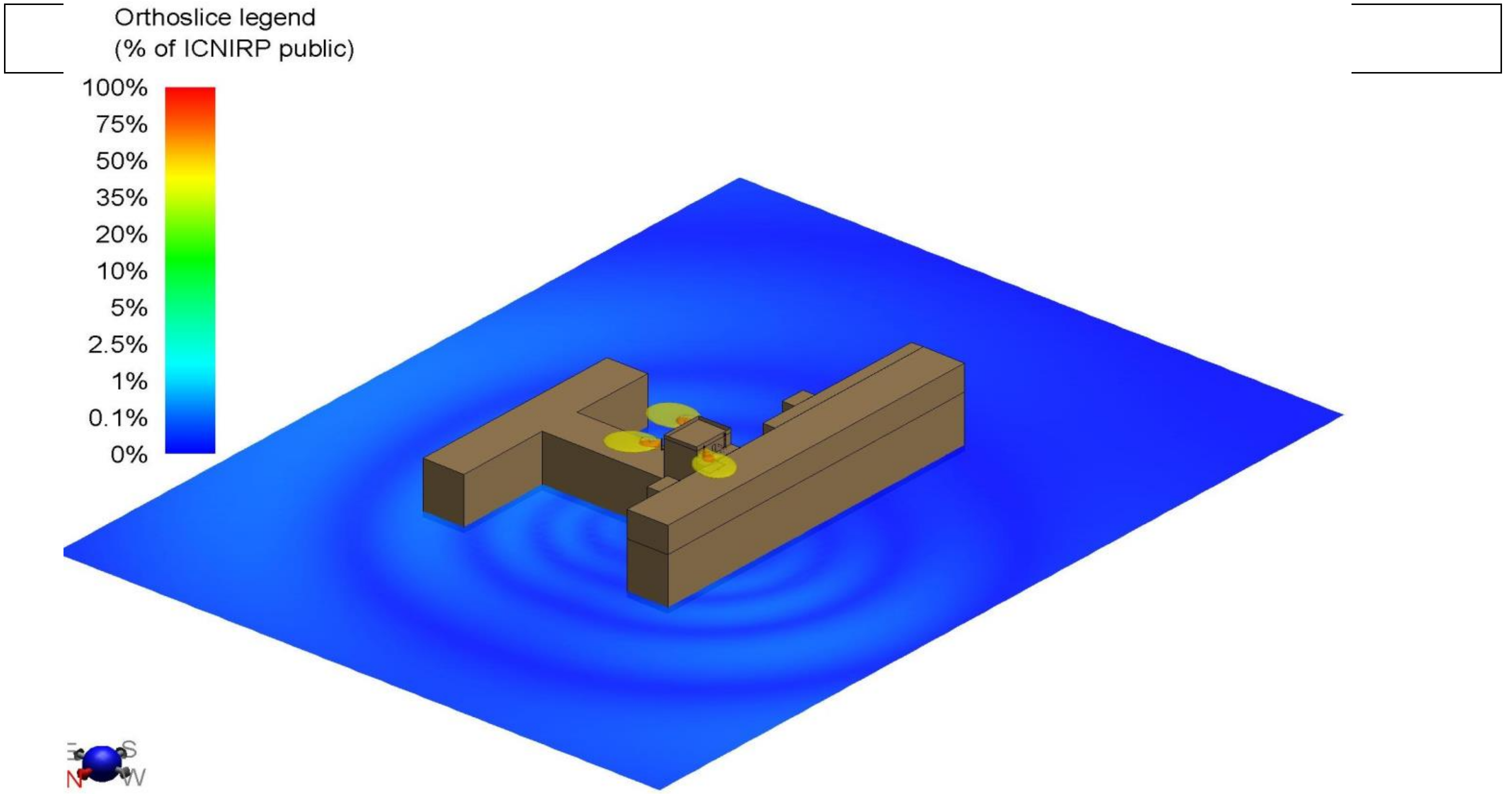
D-I : SITE DATA & TECHNICAL PARAMETERS

Name of the Base Station :

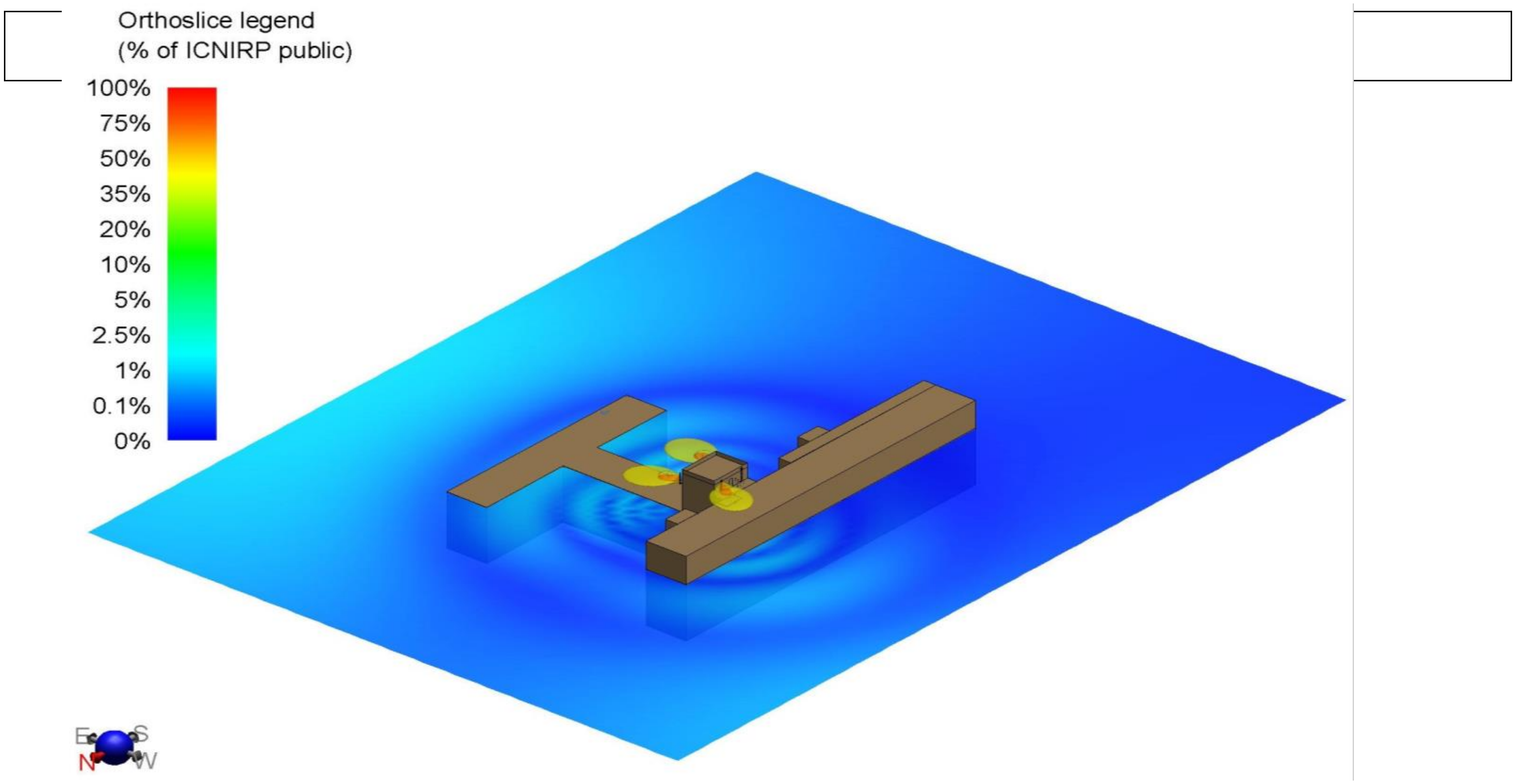
Date :

	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)			
	Height of Lowest Antenna 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)			

D-II :ORTHOSLICE AT GROUND LEVEL

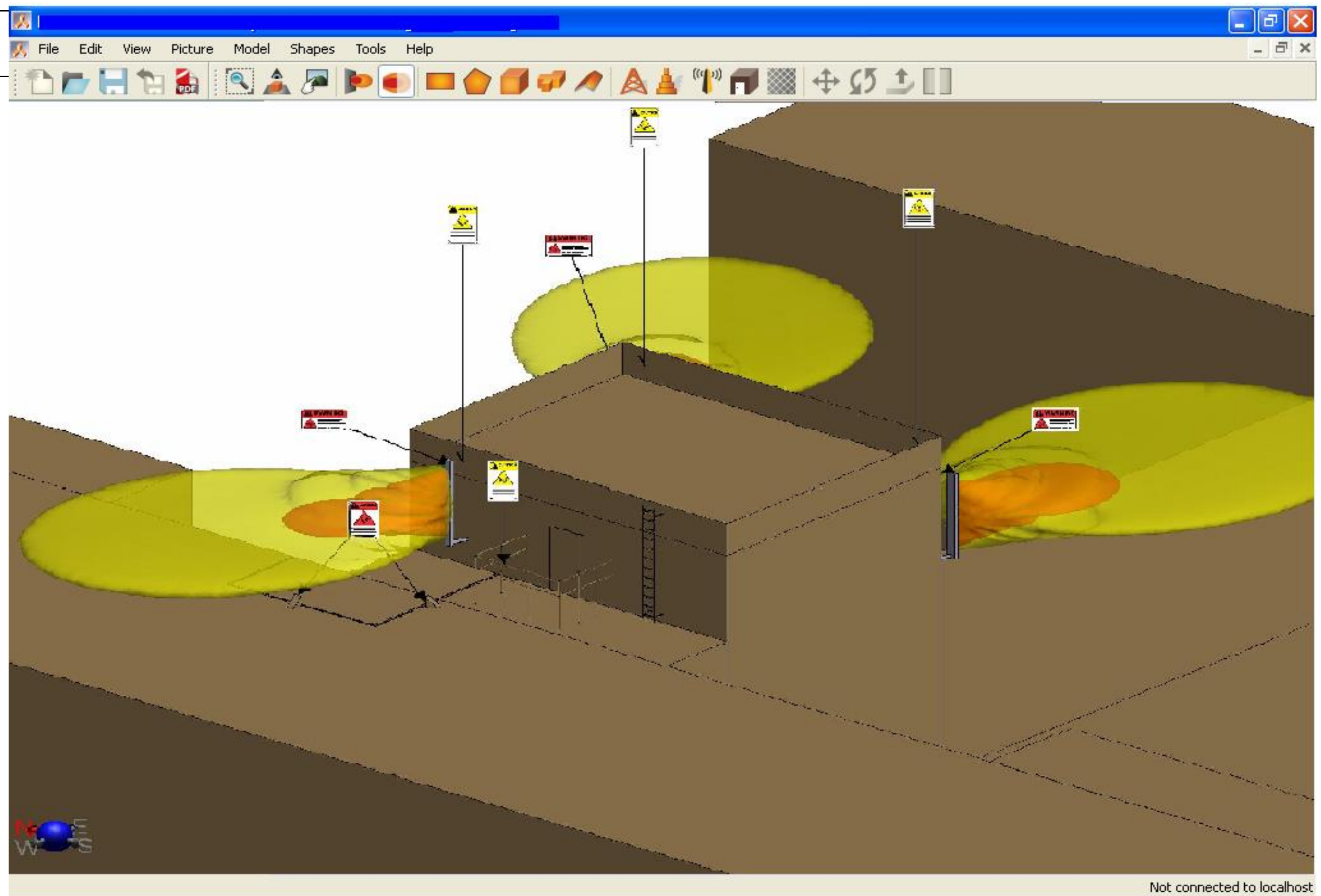
ORTHOSLICE AT GROUND LEVEL	POWER DENSITY AT 2 M ABOVE THE GROUND LEVEL
	

D-III :ORTHOSLICE AT ROOF TOP LEVEL

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

EXCLUSION DISTANCES

D-IV : EXCLUSION ZONES AND SAFETY SIGNAGE AT ROOFTOP



APPENDIX –E

FORMAT FOR FREQUENCY SELECTIVE MEASUREMENT FOR CERTIFICATION OF BASE STATIONS FOR COMPLIANCE WITH THE SAFE LIMITS FOR EMF EXPOSURE FROM CELLULAR RADIO BASE STATIONS

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E-I: TECHNICAL PARAMETERS FOR BASE STATIONS WITHIN 60 METER RADIUS OF THE LOCATION UNDER CONSIDERATION

	Operator 1	Operator 2	Operator 3	Operator n
BASE STATION ID (s)				
Frequency Band (700, 850, 900, 1800, 2100, 2300, 2500, 2600 MHz)				
Base Station Technology (GSM/UMTS/LTE)				
Channel Bandwidth_TDD/FDD_MIMO ports (If applicable)				
Base Ch. Freq [BCCH Freq (GSM) / Center Frequency (CDMA,UMTS and LTE)]				
Carriers / Sector (Worst)				

E-II : Measurements Records

Measurement Location :

Sr. No.	Operator	Base Station Technology (GSM-900/ GSM-1800/UMTS/ LTE-BAND_CBW_XDD_N port MIMO)	$BCCH_n$ / Scrambling Code/ (Cell_ID + RSi MIMO Antenna Path)	Frequency (MHz) [BCCH for GSM, Center Frequency of CDMA /UMTS/ LTE]	Measured Value corresponding to BCCH (GSM)/ CPICH for each Scrambling Code(UMTS)/ Reference Signal RS Cell specific or the CPICH signal (LTE) [d□□V/m]	Measurement Uncertainty	Extrapolation Factor [N_c for GSM / N_{CPICH} for CDMA/ UMTS/ Ki for LTE: Linear	Extrapolation Factor: dB	Correction Factor K2 for TDD only [dB]	Extrapolated Field Strength $E_{max,n}$ [d□□V/m]	$E_{max,n}$ [V/m]	Limit Value of Field Strength $E_{G,n}$ [V/m]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1		GSM-900	BCCH1	936.8	116.4		4	6		122.40	1.3183	13.02
2		GSM-900	BCCH2	946.6	105.3		2	3		108.30	0.2600	13.02
3		GSM-900	BCCH3	948.6	113.9		4	6		119.90	0.9886	13.02
4		GSM-1800	BCCH4	1860.0	109.8		4	6		115.80	0.6166	18.41
5		GSM-1800	BCCH5	1863.8	125.4		4	6		131.40	3.7154	18.41
6		GSM-1800	BCCH6	1864.6	116.4		4	6		122.40	1.3183	18.41
7		UMTS	178	2132.6	103.4			10		113.40	0.4677	19.29
8		UMTS	298	2132.6	117.3			10		127.30	2.3174	19.29
9		UMTS	155	2132.6	101			10		111.00	0.3548	19.29
10		LTE-1800_5_FDD_2-MIMO	280_0	1846.6	100.5		300	24.8		125.8	1.8408	18.41

11		LTE-1800_5_FDD_2-MIMO	280_1	1846.6	100		300	24.8		124.8	1.7378	18.41
12		LTE-800_10_TDD_2-MIMO	133_0	816.0	105.6		600	27.8	-1.5	131.9	3.9355	12.28
13		LTE-800_10_TDD_2-MIMO	133_1	816.0	105		600	27.8	-1.5	131.3	3.6728	12.28
14												

Exposure Index $I_E = \sqrt{\left(\frac{E_{\max,1}}{E_{G1}}\right)^2 + \left(\frac{E_{\max,2}}{E_{G2}}\right)^2 + ...+\left(\frac{E_{\max,n}}{E_{Gn}}\right)^2} \cdot 100\%$ = 53.83%*

Note: ***For a compliant site, the exposure index shall be within 100%**

E-III: Application Note on Frequency Selective Measurement of EMF from channelized mobile/wireless Base Transceiver Stations of various technologies.

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.

Depending upon the technology used for mobile wireless stations, Spectrum or Code Analyser performs the measurement of the time invariant signal and applies appropriate extrapolation to arrive at the power density of the EMF from mobile base stations under maximum output power condition.

For specific technology of the mobile base station, the time invariant component of the signal is transmitted at constant power level for specific frequencies within a certain band. The used time invariant signals for different technologies are:

(1) Broadcast Control Channel (BCCH) in GSM.
(2) Common Pilot Channel (CPICH) signal in UMTS and CDMA systems using dedicated Scrambling Code Decoder.
(3) Cell specific Reference Signal (RS) in LTE Systems.

(1)GSM Technology:

Time division multiple access (TDMA) mobile phone technology utilise a time invariant BS radio channel that operates at constant full power and can be used as a stable reference. In the GSM system this constant power channel is known as the BCCH.

If the Traffic Channels each operate at a maximum power equal to the constant power component, which is the case for GSM, then a conservative maximum transmit power (P_{max}) can be determined by multiplying the power of the constant power component (P_{const}) by the total number of carriers that are feed into the antenna, N_C (Example: N_C = 4, if BCCH carrier plus 3 additional Traffic Channels are feed into the antenna). Therefore, the power density corresponding to the maximum emitted power condition (S_{max}) can be obtained by measuring the power density in the BCCH (S_{BCCH}) of the EUT scaled by N_C:

$$S_{\max} = S_{BCCH} \cdot N_C$$

In terms of electric field intensity:

$$E_{\max} = E_{BCCH} \cdot \sqrt{Nc}$$

In logarithmic scale : E_{max} (dBμV/m) = E_{BCCH} (dBμV/m) + 10 $\log_{10}$ N_c

For frequency selective level measurement, the configuration parameters of the EMF measuring instrument for GSM signals is as follows:

- Perform a frequency selective measurement (Spectrum Analyser).
- Span: 935 - 960 MHz (GSM-900) and 1805 - 1880 MHz (GSM-1800) or only a part of the spectrum, if the signals are located in a smaller frequency range within the band.
- RBW = 200 kHz (smaller RBW would lead to an underestimation of the exposure, higher RBW, e.g. 300 kHz can be accepted, if influence of adjacent channels on the measurement results is negligible.
- Ensure RMS detection of the signal.
- Use "Max Hold" function of the instrument and move the measurement antenna slowly within the volume of investigation to get the spatial maximum. Watch the instrument display during the measurement and stop measurement, when no significant changing in the spectrum display appears any more. A measurement time of six minutes is not necessary.

Example: One operator with a 3 sector antenna system for GSM

Measure the electric field intensity corresponding to BCCH frequency of each sector antenna.

$$E_{\max,Sector\,1} = E_{BCCH\,1} \cdot \sqrt{N_{C1}}$$
$$E_{\max,Sector\,2} = E_{BCCH\,2} \cdot \sqrt{N_{C2}}$$
$$E_{\max,Sector\,3} = E_{BCCH\,3} \cdot \sqrt{N_{C3}}$$

E_{BCCHn} Value of the measured electric field for the BCCH of n^{th} sector.

N_{Cn} Total number of carriers in the n^{th} sector (Typical values: 2…6).

Each extrapolated Electric Field strength E_{max} value has to be compared with the corresponding limit E_G. E_G has to be applied as per the frequency band of the system. This is 13.27 V/m for 900 MHz band (lowest frequency: 935 MHz) and 18.44 V/m for 1800 MHz band (lowest frequency: 1805 MHz).

If more than one operator is present at the site, perform this extrapolation and limit consumption with all BCCH signals radiated from the antennas of the site.

$$I_E = \sqrt{\left(\frac{E_{\max,Sector1}}{E_{G1}}\right)^2 + \left(\frac{E_{\max,Sector\,2}}{E_{G2}}\right)^2 + \ldots\ldots + \left(\frac{E_{\max,Sectror\,n}}{E_{Gn}}\right)^2} \cdot 100\,\%$$

E_{Gn}: Limit value (electric field strength) for the band used by the antenna. (13.27 V/m for 900 MHz band and 18.44 V/m for 1800 MHz band)

(2) CDMA/WCDMA technology:

Code Division Multiple Access (CDMA) and Wideband Code Division Multiple Access (WCDMA) technology use spread spectrum technology employing a constant power control/pilot channel which has a fixed power relationship to the maximum allocated power.

Dedicated decoding instruments are available that enable the constant power reference channel (e.g. CPICH in UMTS/WCDMA) to be measured allowing calculation of maximum RF field strength. **In the absence of decoder for CDMA, spectral measurement method can be used.**

If the ratio of the maximum allocated power to the power in the control channel of the EUT is N_{CPICH} and the measured RF power density from the control channel is S_{CPICH} then the extrapolated value is:

$$S_{\max} = S_{CPICH} \cdot \frac{P_{\max}}{P_{CPICH}} = S_{CPICH} \cdot N_{CPICH}$$

The parameter N_{CPICH} is set by the telecommunications operator. A typical value is 10 (i.e., 10 % of total power allocated to CPICH).

For code selective level measurement, the configuration parameters of the EMF measuring instrument for UMTS/WCDMA signals is as follows:

- **Measuring Mode:** Code selective demodulation
- **Center frequency:** Centre frequency of the CDMA or UMTS signals; may be slightly different to the centre frequency of the channel (with steps of 100 kHz). Else the decoding does not work. Service providers often specify a number denoting the exact centre frequency of a UMTS frequency channel that they are using. This number is known as the UARFCN (UTRA Absolute Radio Frequency Channel Number). The corresponding frequency is determined using the following equation. f_{cent} = UARFCN/5.

  Example: UARFCN = 10836 then channel center frequency f_{cent} = 2167.2 MHz.

- **Measurement Range:** Dependent on the strength of signals to be measured (typically 20 dB higher than the strongest CPICH signal measured.

- Measure the field strength $E_{CPICH,i}$ of CPICH signals of each sector antenna which uses this frequency channel (The signal of each antenna is coded with an individual scrambling code). Many instruments automatically deliver a result table.
- Use "Max Hold" function of the instrument and move the measurement antenna slowly within the volume of investigation to get the spatial maximum. Watch the instrument display during the measurement and stop measurement, when no significant changing in the result table appears any more. A measurement time of six minutes is not necessary.
- Extrapolate the CPICH field strength values to maximal channel power (The ratio $N_{CPICH} = P_{max}/P_{CPICH}$ must be delivered by the network operator).

$$E_{\max,i} = E_{CPICH,i} \cdot \sqrt{\frac{P_{\max}}{P_{CPICH}}}$$

In logarithmic scale with dBµV/m:

$$E_{\max,i} = E_{CPICH,i} + 10 \cdot \log\left(\frac{P_{\max,i}}{P_{CPICH,i}}\right)$$

Finally calculate the sum exposure $\boldsymbol{I_E}$ of all antennas, which use this frequency channel.

$$I_E = \sqrt{\left(\frac{E_{\max,1}}{E_G}\right)^2 + \left(\frac{E_{\max,2}}{E_G}\right)^2 + \ldots\ldots + \left(\frac{E_{\max,n}}{E_G}\right)^2} \cdot 100\,\%$$

$E_{max,n}$: Extrapolated field strength for the signal with Code n

E_G: Limit value (electric field strength) to be applied to this frequency (e.g. 12.65 V/m for 850 MHz and 19.29 V/m for f > 2 GHz)

- If more than one CDMA / WCDMA frequency channel is radiated by antennas of the site (e.g. more than one operator): Repeat the code selective measurement for the other frequency channels.

(3) OFDM technology (LTE, Long Term Evolution):

LTE works in a single frequency network (similar to CDMA / WCDMA networks). Signals of different cells cannot be separated by spectral measurement and if one of the installed sector antennas or some MIMO channels do not radiate, this may not be noticed during the measurement. Therefore, the most reliable approach would be to measure stable Reference Signals (RS) using dedicated decoder.

METHOD USING A DEDICATED DECODER

By means of an LTE decoder the Reference Signals (RS), transmitted by the Base Station (e-NodeB) at a constant power level, are measured and extrapolated to the maximum power density according to the following expression:

$$S_{\max} = \frac{N_{RS}}{F_B} \cdot \left(S_{RS\_Port\,1} + S_{RS\_Port\,2} + \ldots + S_{RS\_Port\,n} \right)$$

S_{RS_PORT1}, S_{RS_PORT2}... S_{RS_PORTn} measured power density values of the Reference Signals RS transmitted by each antenna port.

F_B Power boosting factor. If RS are radiated with 3 dB (i.e. factor 2) higher level than the other carriers (this RS boosting is often done at MIMO systems), the extrapolation factor is reduced by factor 2. The information about F_B is to be ascertained from the Operator.

N_{RS} Ratio of the Base Station maximum total power to the power of the reference signal *RS* per resource element RE (i.e. per subcarrier) and therefore corresponds to the number of subcarriers of the LTE signal and is dependent by the LTE channel bandwidth. See Table-1

LTE Channel Bandwidth [MHz]	LTE Signal Bandwidth [MHz]	Number of Resource Blocks	N_{RS} (No of sub-carriers)	N_{RS} [dB]
1.4	1.08	6	72	18.6
3	2.7	15	180	22.6
5	4.5	25	300	24.8
10	9.0	50	600	27.8
15	13.5	75	900	29.5
20	18.0	100	1200	30.8

Table: H-1: Extrapolation factor for LTE (N_{RS})

For EMF exposure assessment, the field strength per resource element of RS signals cell specifically through averaging across a configurable frequency range (span) is to be measured. Where radiation takes place via multiple antenna ports (MIMO), the RS signals are to be recorded antenna-specifically.

At LTE base stations, the signals P-SS, S-SS and RS are coded (Cell ID) for specific cell (Sector Antenna). Cell Specific Reference Signal (RS) is transmitted at every sub-frame and span all across the operating bandwidth.

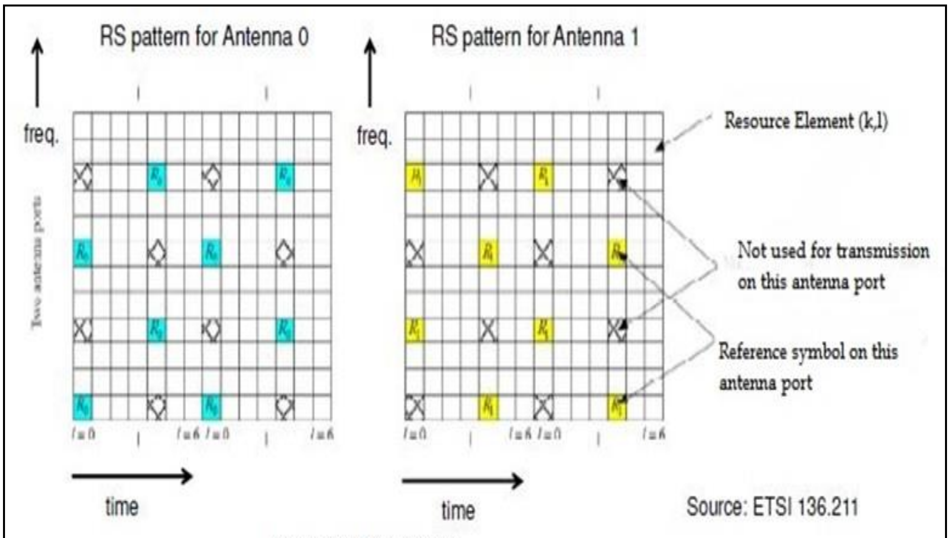

Fig. 2x 2 MIMO Antenna

Figure H-1: RS radiation scheme for 2 port MIMO

The RS signal can be separated relative to MIMO antenna ports. As displayed in figure 1, RS0 / RS1 signals are transmitted by the same carriers, but not at the same time (3 or 4 symbols shift). For 2 port MIMO the values of RS0 and RS1 have to be measured. Measurement values of RS0 and RS1 can differ due to antenna characteristic. If 4 antennae MIMO are used, RS2 and RS3 will also be required to be measured.

The RS field strength is measured as linear average over the field strength contributions of all resource elements that carry RS within the operating bandwidth. Thus the measured value corresponds to the average power transmitted for one subcarrier. If multiple antennas are used for transmission by the same cell (MIMO), the RS should be determined for each antenna (or antenna port).

In case of LTE-FDD, the maximum electric field strength E_{max} can also be expressed as

$$E_{\max} = \sqrt{\frac{N_{RS}}{F_B}} \, . \, E_{RS}$$

In case of LTE-FDD with smart antenna, the maximum electric field strength E_{max} can also be expressed as

$$E_{max} = \sqrt{\frac{N_{RS} \cdot D}{F_B}} . E_{RS}$$

Where E_{RS} is the field strength of RS per RE; N_{RS} is the extrapolation factor for RS, which is the ratio of the maximum transmission power to transmission power corresponding to the RS per RE; and F_B is the boosting factor for the RS; D is the beam forming gain of smart antenna.

The extrapolation factor K_i of antenna i therefore is:

$$K_i = \sqrt{\frac{N_{RSi} . D}{F_B}}.$$

In logarithmic scale: K_i (dB) = 10 $\log_{10} N_{RS}$ + 10 $\log_{10}$ D - 10 $\log_{10} F_B$

E_{max} (dBμV/m)= E_{RS} (dBμV/m) + K_i (dB)

Example: One operator with a 3 sector antenna system for LTE and 2 port MIMO

Measure the electric field intensity E_{RSn} corresponding to the RS signals for each MIMO port of each sector antenna.

Sector 1:

$$E_{max1,Port0} = E_{RS0} \cdot K_1$$
$$E_{max1,Port1} = E_{RS1} \cdot K_1$$

Sector 2:

$$E_{max2,Port0} = E_{RS0} \cdot K_2$$
$$E_{max2,Port1} = E_{RS1} \cdot K_2$$

Sector 3:

$$E_{max3,Port0} = E_{RS0} \cdot K_3$$
$$E_{max3,Port1} = E_{RS1} \cdot K_3$$

In most cases the extrapolation factors K_i are identical for antenna 1, 2 and 3.

Finally calculate the sum exposure I_E of all antennas and ports.

$$I_E = \sqrt{\left(\frac{E_{\max 1, Port0}}{E_{Gn}}\right)^2 + \left(\frac{E_{\max 1, Port1}}{E_{Gn}}\right)^2 + \left(\frac{E_{\max 2, Port0}}{E_{Gn}}\right)^2 + \left(\frac{E_{\max 2, Port1}}{E_{Gn}}\right)^2 + \left(\frac{E_{\max 3, Port0}}{E_{Gn}}\right)^2 + \left(\frac{E_{\max 3, Port1}}{E_{Gn}}\right)^2} \cdot 100\%$$

$E_{max,m,Portn}$: Extrapolated field strength for the signal with m^th Cell ID and n^th MIMO port.

E_{Gn}: Limit value (electric field strength) to be applied to this frequency (e.g. 18.44 V/m for 1800 MHz band and 19.29 V/m for f > 2 GHz)

Table View

Index	Cell ID	No. Ant	Max (PSS)	Max (SSS)	Max (RS 0)	Max (RS 1)
1	155	2	89.49 dBµV/m	89.12 dBµV/m	89.02 dBµV/m	89.16 dBµV/m
2	154	2	88.33 dBµV/m	88.05 dBµV/m	88.67 dBµV/m	87.86 dBµV/m
3	153	2	75.71 dBµV/m	72.21 dBµV/m	72.45 dBµV/m	73.96 dBµV/m
	Total		91.22 dBµV/m	90.85 dBµV/m	90.91 dBµV/m	91.27 dBµV/m
	Analog		105.47 dBµV/m			

Isotropic

Index: 986.4 • MR_NUM • Date: 12.12.14 17:32:33

Fcent:	816 MHz	CBW:	1.4 MHz	Sweep Time:	697 ms	Progress:	
MR:	125 dBµV/m	Extr. Fact.:	Off	Noise Suppr.:	Off	No. of Runs:	30
		Cell Sync.:	Sync.	CP Length:	Normal	AVG:	4

Figure H-2: Typical result of a RS measurement (3 sector antennas with 2 port MIMO)

For code selective level measurement of EMF exposure from LTE-FDD, the configuration parameters of the EMF Measuring Instrument is as follows:

- **Mode:** LTE Analyser / Code demodulation (Cell ID+ MIMO path)
- **Center frequency:** The centre frequency of the code analyser should be equal to the centre frequency of the LTE signal.
- **RBW** = Automatic selection.
- **Measurement Range:** Dependent on the strength of signals to be measured (typically 30 dB higher than the strongest RS signal measured.
- Use "Max Hold" function of the instrument and move the measurement antenna slowly within the volume of investigation to get the spatial maximum.

- Extrapolate the RS field strength values to maximal channel power (see description above).

- In case of LTE-TDD signal, additional correction factor K_2 (negative dB value) is required, because downlink signal is switched off during several sub frames. This TDD correction factor (ranging from -0.7 to -6.2 dB) depend upon the UL/DL configuration. $K_2 = t_{on}/10$ ms, where t_{on} is the total time within a 10 ms frame in which the antenna is radiating RF signals.

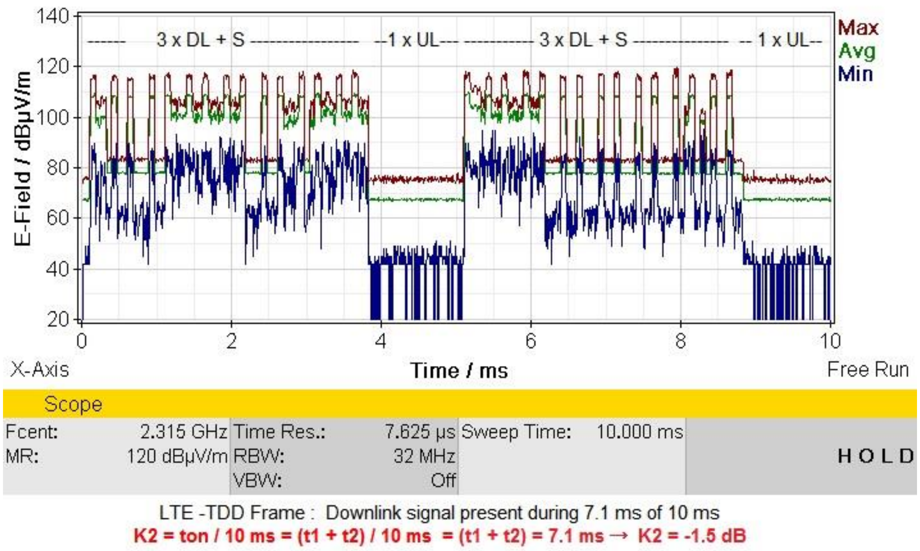

Figure H-3: Example for LTE-TDD with t_{on} = 7.1 ms (Check of t_{on} is possible with Zero Span (time domain) mode of a spectrum analyser).

ALTERNATIVE APPROACH: METHOD WITHOUT DECODING USING A STANDARD SPECTRUM ANALYSER

For LTE, which uses orthogonal frequency division multiplexing (OFDM) technology, basic spectrum analyser is less expensive is more commonly available. However, the power of the Reference Signal (RS) cannot be accurately detected since they are transmitted on single resource elements spread in frequency and time. To overcome this, the PBCH power can be measured.

Bit these kinds of measurements have some important disadvantages:

- Signals of different cells cannot be separated by this kind of spectrum analyser measurement and if one of the three sector antenna or some MIMO channels do not radiate, this may not (!) be noticed during the measurement.

- Exposure will be overestimated, if the PBCH signals have higher level than the other parts of the spectrum (at many sites the PBCH signals are boosted by 3 dB).
- Exposure will be underestimated by factor 3 dB, if the PBCH signals are not radiated synchronous but alternately via the MIMO ports.

The PBCH signals are transmitted with the same characteristics regardless of the configuration or signal bandwidth and span a bandwidth of approximately 1 MHz over the centre frequency of the LTE signal.

The extrapolation to maximum power is based on the measured field strength $E_{SYNCH/PBCH}$, the measurement bandwidth and the total signal bandwidth:

$$E_{\max} = E_{PBCH} \cdot \sqrt{\frac{B_{Signal}}{B_{Measurement}}}$$

E_{PBCH} : Measurement result

B_{Signal} : Signal bandwidth acc. Table 1

$B_{Measurement}$: Measurement bandwidth (depending on the used measurement instrument type, and the filter used, this value will slightly differ).

For a measurement of LTE signals with a simple spectrum analyser, the instrument should be adjusted as follows:

- Use Zero Span (time domain) or Receiver mode of the analyser.
- **Centre frequency:** The center frequency of the instrument should be equal to the center frequency of the LTE signal.
- Measurement Bandwidth (RBW): About 1 MHz

  (Smaller RBW can be used as long as all the contributions inside the occupied bandwidth of the PBCH signal are summed or the influence of the smaller bandwidth is included into the extrapolation factor.
- Detection mode: RMS.
- Use sufficient measurement time to catch the maximum signal power (Six-minute measurement time is not necessary).
- In case of LTE-TDD signal, additional correction factor K_2 (negative dB value) is required because downlink signal is switched off during several sub frames (Details: See code selective measurements of LTE above).

Appendix –F(1)

FORMAT FOR SIMPLIFIED ASSESSMENT PROCEDURE FOR SELF CERTIFICATION AS PER ITU-T RECOMMENDATION K.100

SITE DATA & TECHNICAL PARAMETERS

(Applicable only if no other Base Station within 5 * Dm)

Name of TSP :
Name of the Base Station :
Base Station ID :

Sr. No.	Item	Units	Site Data
1	Site ID		
2	Date of Commissioning		
3	Address		
4	Lat / Long (minimum 5 decimal places)	deg	
5	Make and model of Antenna/Base Station		
6	System Technology (GSM/CDMA/UMTS/LTE-FDD/TDD)		
7	Base Channel Frequencies (BCCH (GSM)/CPICH/PBCH and Centre Frequency (UMTS/LTE)	(MHz)	
8	Max No. of Carriers in the sector (For GSM) / MIMO configuration (For LTE)		
9	Antenna Tilt	deg	
10	Antenna Gain	dBi	
11	Tx Power	(dBm)	
12	EIRP	(dBm)	
13	Pole/wall Height	(m)	
14	Height of lowest part of radiating antenna(s) from public accessible area	(m)	
15	Computed value of H_m #	(m)	
16	Computed value of D_m #	(m)	

In case of EIRP > 2 Watts and ≤ 100 Watts, the H_m and D_m values as per Table in Appendix-F(2)

It is to certify that no other RF sources with EIRP above 100 W is located within a distance of 5$D_m$metres in the main lobe direction

Signature of authorized representative of TSP

Appendix-F (2)

Restriction on minimum height of lowest radiating part of Antenna and minimum distance to areas accessible to general public in the main lobe direction for Low Power Base Station (EIRP <100 Watts)

Sr. No.	EIRP (in Watts)	Minimum Height(in metres) as per different Antenna Tilts in degrees				Minimum Distance (in metres) for publically accessible area in the main lobe direction	Minimum Distance (in metres) for other Emitters ($\geq$ 10 Watts) in the main lobe direction
		0°	5°	10°	15°		
1	$\leq$ 2	No specific criteria. According to [ITU-T K.52] emitters with a maximum EIRP of 2 W or less are inherently compliant					
2	$\leq$ 10	2.5	2.7	2.8	3.0	1.9	9
3	$\leq$ 20	2.8	3.0	3.2	3.4	2.6	13
4	$\leq$ 30	2.9	3.2	3.5	3.7	3.2	16
5	$\leq$ 40	3.1	3.4	3.7	4.0	3.7	19
6	$\leq$ 50	3.2	3.5	3.9	4.2	4.2	21
7	$\leq$ 60	3.3	3.7	4.1	4.4	4.6	23
8	$\leq$ 70	3.4	3.8	4.2	4.6	4.9	25
9	$\leq$ 80	3.5	4.0	4.4	4.8	5.3	26
10	$\leq$ 90	3.6	4.1	4.5	4.9	5.6	28
11	$\leq$ 100	3.7	4.2	4.7	5.1	5.9	29

Appendix- G

Format for Monthly Summary Report of compliance for TSP XXX (LSA) sites – Due to upgrades/additions by other TSPs

Note: This Monthly Summary Report has to be submitted by all TSPs for all the upgrades/additions on shared sites done by other TSPs, for each LSA.

Jurisdiction - LSA, XXXX

Period - Month 1- 2018

1	2	3	4	5	6	7	8	9	10
S.No	**IP ID**	**TSPXXX Site ID**	**Other Tenant's Site ID**	**Date of Upgrade SC by other Tenant**	**Certificate Id submitted by other Tenant for each upgrade/ addition**	**Reason for Upgrade - Increase in TRX/ Electrical, Mechanical Tilt/ Antenna Change/ TX Power Increase/ Antenna Height/ Antenna Azimuth Change / New Site Addition**	**Compliance Methodology**	**EIRP Ratio Figure**	**Certificate of Compliance**
1									

2									
3									
4									
5									
6									
7									
8									

TSP XXX hereby certifies that the mentioned sites are EMF compliant to the laid down guidelines of DoT vide…….. and amendment to the said instructions from time to time. This Monthly Summary Report will be deemed to be a self-certificate for all technical and legal purposes.

Name:

Signature:

Date:

Place:

Appendix- H

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.

------------------------------End of Document--------------------------