International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

K.100

(06/2021)

SERIES K: PROTECTION AGAINST INTERFERENCE

Measurement of radio frequency electromagnetic fields to determine compliance with human exposure limits when a base station is put into service

Recommendation ITU-T K.100

Documents
Document Sharing Hub

Full document details: ITU-T K.100 2021

Documents
Document Sharing Hub

Full document details: ITU-T K.100 2021

Recommendation ITU-T K.100

Measurement of radio frequency electromagnetic fields to determine compliance with human exposure limits when a base station is put into service

Summary

Recommendation ITU-T K.100 provides information on measurement techniques and procedures for assessing compliance with the general public electromagnetic field (EMF) exposure limits when a new base station (BS) is put into service, taking into account effects of the environment and other relevant radio frequency sources present in its surroundings.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.100	2014-12-07	5	11.1002/1000/12290
2.0	ITU-T K.100	2017-07-29	5	11.1002/1000/13278
3.0	ITU-T K.100	2018-01-13	5	11.1002/1000/13450
4.0	ITU-T K.100	2019-07-14	5	11.1002/1000/13955
5.0	ITU-T K.100	2021-06-29	5	11.1002/1000/14725

Keywords

Base station, compliance, exposure assessment, put into service.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

Documents
Document Sharing Hub

Full document details: ITU-T K.100 2021

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents/software copyrights, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the appropriate ITU-T databases available via the ITU-T website at http://www.itu.int/ITU-T/ipr/.

© ITU 2021

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

Documents
Document Sharing Hub

Full document details: ITU-T K.100 2021

Table of Contents

		Page
1	Scope	1
2	References	1
3	Definitions	2
3.1	Terms defined elsewhere	2
3.2	Terms defined in this Recommendation	2
4	Abbreviations and acronyms	3
5	Conventions	4
6	Assessment procedure	5
6.1	General process	5
6.2	Method based on the actual maximum transmitted power or EIRP	6
7	Equipment under test data collection	8
8	Simplified assessment procedures	8
9	Measurement area selection	12
10	Measurement	14
10.1	Measurement equipment	14
10.2	Measured quantity	15
10.3	General exposure assessment	15
10.4	Comprehensive exposure assessment	16
10.5	Exposure contribution of ambient sources	17
10.6	Determination of the total exposure ratio	18
11	Uncertainty	18
Appendix I – Radio frequency field strength measurement equipment requirements		21
Appendix II – Guidance on comprehensive measurements for specific technologies		22
II.1	Time division multiple access/frequency division multiple access technology	22
II.2	Code division multiple access/wideband code division multiple access technology	22
II.3	ODFM technology	23
Appendix III – Maximum exposure location for a base station in the line of sight		25
Appendix IV – Exposure limits		26
IV.1	Introduction	26
IV.2	General description of exposure limits	26
IV.3	RF-EMF exposure limits RF-EMF exposure limits	26
Appendix V – Averaging time reduction		28
V.1	Introduction	28
V.2	Rationale and methodology	28
V.3	Results and discussion	28

Documents
Document Sharing Hub
Full document details: ITU-T K.100 2021

Page

Bibliography..... 30

Documents
Document Sharing Hub

Full document details: ITU-T K.100 2021

Recommendation ITU-T K.100

Measurement of radio frequency electromagnetic fields to determine compliance with human exposure limits when a base station is put into service

1 Scope

This Recommendation specifies the measurement procedure to assess compliance with general public electromagnetic field (EMF) exposure limits for a base station (BS) operating in the frequency range 100 MHz-100 GHz when it is put into service in its operational environment.

Simplified assessment procedures are provided to identify those installations that are known to be compliant with EMF exposure limits without measurements.

With its specific focus on measurements, this Recommendation complements the existing ITU-T K-series Recommendations.

Contact currents due to contact with conductive objects irradiated by EMFs, lie outside the scope of this Recommendation. For commercial market BS products, there could be other requirements specified by the manufacturer that might need to be fulfilled. For such types of product testing, this Recommendation also does not apply.

Where national laws, standards or guidelines on exposure limits to EMF exist and provide procedures that are at variance with this Recommendation, the pertinent national laws, standards or guidelines shall take precedence over the procedures provided in this Recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T K.52] Recommendation ITU-T K.52 (2018), *Guidance on complying with limits for human exposure to electromagnetic fields*.

[ITU-T K.61] Recommendation ITU-T K.61 (2018), *Guidance on measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations*.

[ITU-T K.70] Recommendation ITU-T K.70 (2018), *Mitigation techniques to limit human exposure to emfs in the vicinity of radiocommunication stations*.

[ITU-T K.91] Recommendation ITU-T K.91 (2020), *Guidance for assessment, evaluation and monitoring of human exposure to radio frequency electromagnetic fields*.

[IEC 62232] IEC 62232:2017, *Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure*.

[IEC 62479] IEC 62479:2010, *Assessment of the compliance of low power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields (10 MHz – 300 GHz)*.

Documents
Document Sharing Hub
Full document details: ITU-T K.100 2021

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 actual value: Time-averaged value of transmitted power or equivalent isotropically radiated power (EIRP) of the equipment under test (EUT) using the averaging time specified in the applicable radio frequency (RF) exposure limits, e.g., 6 minutes using [b-ICNIRP] or a conservative value close to it, e.g., 5 minutes using [b-IEC TR 62669].

3.2.2 actual maximum (max) value: Maximum value reached by the actual value when recorded by the EUT during a given period (e.g., week or month).

3.2.3 actual maximum (max) threshold: Threshold value of the actual transmitted power or EIRP configured by the EUT so that the actual maximum does not exceed this threshold during service, for example using transmitted power or EIRP control features and tools implemented in the EUT.

3.2.4 ambient source: A radio frequency (RF) source operating in the frequency range from 8.3 kHz to 300 GHz generating electromagnetic fields other than the emission from the equipment under test (EUT).

3.2.5 assessment domain boundary (ADB): Boundary surrounding an antenna of the equipment under test (EUT) outside of which measurements do not need to be conducted. The ADB defines the maximum possible measurement area where the source is considered to be relevant.

3.2.6 base station (BS): Fixed equipment for radio transmission used in cellular communication or wireless installation for local area networks. For the purpose of this Recommendation, the term base station includes all radio transmitter(s) and associated antenna(s).

3.2.7 compliance boundary (CB): Boundary defining a volume outside which the radio frequency (RF) exposure from the equipment under test (EUT) is below the exposure limit.

3.2.8 domain of investigation (DI): Sub-domain within the assessment domain boundary (ADB) to which the general public have access.

3.2.9 equipment under test (EUT): For the purpose of this Recommendation, the EUT is the base station that shall be put into service, including all transmitting antennas (operating in the frequency range 100 MHz to 100 GHz).

3.2.10 equivalent isotropically radiated power (EIRP): The product of the power accepted by the antenna and the maximum antenna gain relative to an isotropic antenna.

3.2.11 exposure ratio (ER): The assessed exposure parameter at a specified location for each operating frequency of a radio source, expressed as the fraction of the related limit.

For assessment against reference levels:

$$\mathrm{ER} = \max\left[(E/E_{\mathrm{lim}})^2, (H/H_{\mathrm{lim}})^2\right]$$

In the far-field:

$$\mathrm{ER} = (E/E_{\mathrm{lim}})^2 = (H/H_{\mathrm{lim}})^2 = S/S_{\mathrm{lim}}$$

where S, E, and H are the root mean square (r.m.s.) values, respectively, of power density, electric field strength and magnetic field strength measured at frequency f. S_{lim}, E_{lim} and H_{lim} are the corresponding limits at the same frequency.

Documents
Document Sharing Hub
Full document details: ITU-T K.100 2021

When exposure is evaluated for a certain frequency band (the total power density or the field strength within the frequency interval [f_{min},f_{max}] is assessed), S_{lim}, E_{lim} or H_{lim} are chosen as the most stringent limits within the band.

3.2.12 far-field formula: Formula that can be used in the far-field to evaluate the power density, S:

$$S = \frac{PG_{\theta,\varphi}}{4\pi d^2}$$

where P is the transmitted power, $G_{\theta,\varphi}$ is the gain of the antenna in the direction (θ,φ) and d is the distance from the antenna to the evaluation point. The associated electric field strength, E, and magnetic field strength, H, can be evaluated as follows:

$$E = \frac{\sqrt{30PG_{\theta,\varphi}}}{d},$$

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

where $\eta_0 \approx 377\ \Omega$.

If the power density is evaluated in the direction of maximum antenna gain:

$$S = \frac{EIRP}{4\pi d^2}.$$

3.2.13 isotropic antenna: A hypothetical, lossless antenna having equal radiation intensity in all directions.

3.2.14 main lobe: The radiation lobe containing the direction of maximum radiation. In certain antennas, such as multilobed or split-beam antennas, there may be more than one major lobe.

3.2.15 reactive near-field region: The reactive near field of an antenna with maximum extension D is in this context defined as max(λ, D, $D^2/4\lambda$) where λ denotes the free space wavelength.

3.2.16 relevant source: A radio source, in the frequency range 8.3 kHz to 300 GHz, which at a given point of investigation has an exposure ratio (ER) larger than 0.05.

3.2.17 side lobe: A radiation lobe in any direction other than the main lobe.

3.2.18 total exposure ratio (TER): The sum of exposure ratios (ERs) of the equipment under test (EUT) and other relevant sources.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ADB	Assessment Domain Boundary
AMPS	Advanced Mobile Phone System
BCCH	Broadcast Control Channel
BS	Base Station
CB	Compliance Boundary
CDF	Cumulative Distribution Function
CDMA	Code Division Multiple Access
CPICH	Common Pilot Channel

Documents
Document Sharing Hub
Full document details: ITU-T K.100 2021

DAB	Digital Audio Broadcasting
DI	Domain of Investigation
DVB-T	Digital Video Broadcasting-Terrestrial
EIRP	Equivalent Isotropically Radiated Power
EMF	Electromagnetic Field
ER	Exposure Ratio
EUT	Equipment Under Test
FDMA	Frequency Division Multiple Access
FM	Frequency Modulation
GSM	Global System for Mobile Communications
LOS	Line Of Site
LTE	Long-Term Evolution
MCCH	Multicast Control Channel
MIMO	Multiple Input Multiple Output
OFDM	Orthogonal Frequency-Division Multiplexing
PBCH	Physical Broadcast Channel
RBW	Resolution Bandwidth
RF	Radio Frequency
r.m.s.	root mean square
SAR	Specific Absorption Rate
SD	Standard Deviation
TACS	Total Access Communications System
TDMA	Time Division Multiple Access
TER	Total Exposure Ratio
TETRA	Terrestrial Trunked Radio
TETRAPOL	Terrestrial Trunked Radio for Police
UMTS	Universal Mobile Telecommunication System
WCDMA	Wideband Code Division Multiple Access
Wi-Fi	Wireless Fidelity

5 Conventions

None.

Documents
Document Sharing Hub
Full document details: ITU-T K.100 2021

6 Assessment procedure

6.1 General process

When in a base station (BS), the equipment under test (EUT), is installed and put into service at a site, the procedure described in Figure 6-1 shall be used to assess compliance with exposure limits. In order to allow for accurate and efficient assessments, different routes are possible depending on the characteristic of the EUT or on the installation type. The compliance assessment process can be implemented using the actual maximum equivalent isotropically radiated power (EIRP) threshold of the BS site or BS site sector sub-divisions and following the guidelines described in [b-IEC TR 62669]. The actual maximum EIRP threshold can be derived from the actual maximum transmitted power using the maximum gain of the antenna or individual antenna beams for massive multiple input multiple output (MIMO).

In some specific cases, compliance with relevant exposure limits can be assessed without the necessity to conduct measurements (e.g., because of the low power transmitted, or because of the position or orientation of the transmitters or antennas with respect to areas accessible to the general public, or because simpler calculation methods can be used [ITU-T K.52]). Both broadband and frequency-selective equipment can be used for the assessment (see clause 10.1). Measurements conducted with broadband equipment, however, might lead to overly conservative results. If the exposure level in areas accessible to the general public is found to be above the limits by means of broadband measurements, then compliance should be verified with frequency-selective equipment. Otherwise, the mitigation techniques described in [ITU-T K.70] shall be applied. The step-by-step procedure of Figure 6-1 is specified in clauses 7 to 11.

Documents
Document Sharing Hub
Full document details: ITU-T K.100 2021

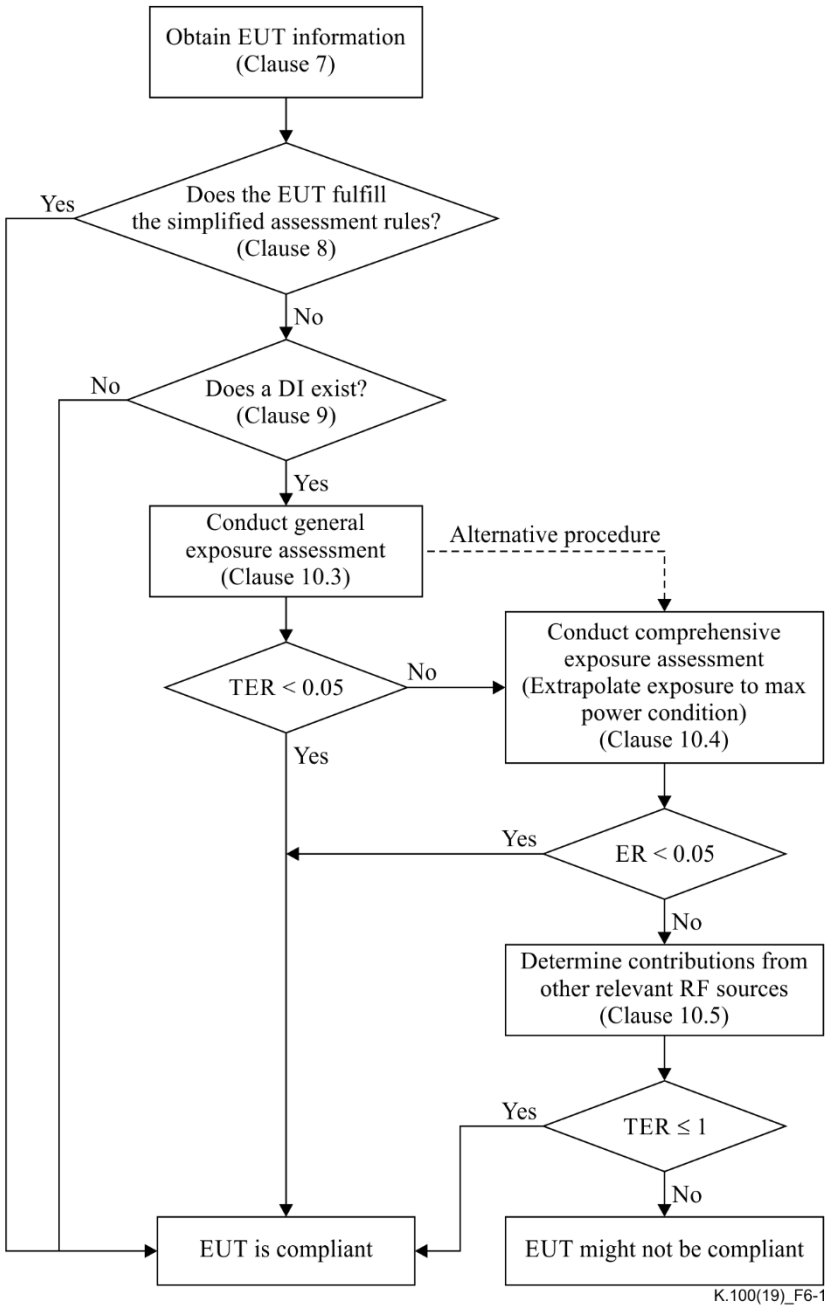

Figure 6-1 – Flowchart describing the measurement procedure specified in this Recommendation

6.2 Method based on the actual maximum transmitted power or EIRP

The method based on actual maximum transmitted power or EIRP provides for more accurate assessment of the real maximum exposure from a base station using the parameters of the site. It avoids the unrealistic over-estimation of other approaches.

[b-IEC TR 62669] provides measurement campaign and simulation results showing that the real time-averaged transmitted power by a base station (BS) during service, called actual transmitted power, is generally below the time-averaged maximum transmitted power.

[b-IEC TR 62669] makes the following recommendations:

1) As a conservative approach, the actual maximum EIRP (directly or derived from the actual maximum transmitted power) can be used to determine the RF compliance boundary

Documents
Document Sharing Hub
Full document details: ITU-T K.100 2021