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TECHNICAL REPORT

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Measurement procedure for the evaluation of power density related to human exposure to radio frequency fields from wireless communication devices operating between 6 GHz and 100 GHz

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MEASUREMENT PROCEDURE FOR THE EVALUATION OF POWER DENSITY RELATED TO HUMAN EXPOSURE TO RADIO FREQUENCY FIELDS FROM WIRELESS COMMUNICATION DEVICES OPERATING BETWEEN 6 GHz AND 100 GHz

FOREWORD

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IEC TR 63170, which is a Technical Report, has been prepared by IEC technical committee 106: Methods for the assessment of electric, magnetic and electromagnetic fields associated with human exposure.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
106/426/DTR	106/437/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This Technical Report describes methods and measurement techniques for the evaluation of power density related to human exposures due to electromagnetic field (EMF) transmitting devices operating in close proximity to the user at frequencies between 6 GHz and 100 GHz where basic restrictions can be expressed in terms of power density. The types of devices include but are not limited to mobile telephones, tablets, and laptops.

With the rapid development of new wireless technologies in the frequency range 6 GHz to 100 GHz for the fifth generation mobile technology (5G), there is a need to establish assessment procedures to ensure compliance of wireless devices with electromagnetic exposure limits.

For portable devices, the IEC 62209 series of SAR assessment standards for wireless devices used in close proximity to the users are valid up to 6 GHz. For base stations, IEC 62232 defines the methods to assess the compliance boundaries based on reference levels and basic restrictions. SAR tests are applicable when the compliance distance is in close proximity to the radiating sources in the frequency range 300 MHz to 6 GHz. Power density measurements above 6 GHz are also applicable in close proximity to the equipment, but no detailed protocol is available at this stage.

SAR is not considered as the relevant exposure metric above 10 GHz in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines which specify basic restrictions in terms of free-space incident power density. Similarly, IEEE C95.1-2005 [1][1] requires the assessment of incident power density above 6 GHz.

IEC TC 106 has previously noted the necessity to extend compliance assessment standards for portable devices beyond 6 GHz. However, with the 5G trials scheduled to commence in 2018, IEC TC 106 has decided on a two-step strategy to ensure that the fundamental assessment approaches are available by 2018.

1) IEC TC 106 (AHG10) focused in 2017 on the development of a Technical Report, specifying the state of the art of measurement techniques and test approaches for evaluating portable devices based on power density measurements from 6 GHz to 100 GHz.
2) IEC TC 106 submitted a new work item proposal in early 2018 to develop a new International Standard (IS) on the detailed measurement procedures to continue the work established in the Technical Report.

This informative document serves as the starting point for an International Standard. The methodologies and approaches described in this document can be useful for the assessment of early 5G products introduced for consumer trials. It also contains recommendations for future standardization work and highlights areas that may require additional investigation or consideration.

A few examples for measurements of a mock-up device characterized by an antenna array operating at about 28 GHz are given in Annex H.

1 Numbers in square brackets refer to the Bibliography.

MEASUREMENT PROCEDURE FOR THE EVALUATION OF POWER DENSITY RELATED TO HUMAN EXPOSURE TO RADIO FREQUENCY FIELDS FROM WIRELESS COMMUNICATION DEVICES OPERATING BETWEEN 6 GHz AND 100 GHz

1 Scope

This document describes the state of the art measurement techniques and test approaches for evaluating the local and spatial-average incident power density of wireless devices operating in close proximity to the users between 6 GHz and 100 GHz.

In particular, this document provides guidance for testing portable devices in applicable operating position(s) near the human body, such as mobile phones, tablets, wearable devices, etc. The methods described in this document may also apply to exposures in close proximity to base stations.

This document also gives guidance on how to assess exposure from multiple simultaneous transmitters operating below and above 6 GHz (including combined exposure of SAR and power density).

NOTE Compliance of devices with sufficiently low radiated power that is incapable of exceeding basic restrictions is addressed by IEC 62479 [2] and therefore not described in this document.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
averaging area
rectangular or circular area on the evaluation surface (3.9) over which the assessed power density is averaged

Note 1 to entry: Because of rotational symmetry a circular area might be preferable since the result of averaging will not depend on the rotation.

3.2
basic restriction
restriction on exposure to time-varying electric, magnetic and electromagnetic fields that is based on established biological effects

3.3
RF channel
specific sub-division of the available frequency range according to the operating parameters of a wireless technology

3.4
conducted power
power delivered by the power amplifier to a matched load

3.5
correlated signals
<in time> electromagnetic fields, associated to distinct signal waveforms, yielding non-zero time-domain correlation integral at some time instant

Note 1 to entry: For two power-limited field distributions $\mathbf{F}_1(\mathbf{r},t)$ and $\mathbf{F}_2(\mathbf{r},t)$, the time-domain correlation integral is defined as

$$(\mathbf{F}_1 \otimes \mathbf{F}_2)(\mathbf{r},t) = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} \mathbf{F}_1(\mathbf{r},\tau)^* \cdot \mathbf{F}_2(\mathbf{r},t+\tau)\,\mathrm{d}\tau \qquad (1)$$

where $\mathbf{r}$ is the location vector, the superscript * represents the complex conjugate operation and the symbol · represents the inner product operation

Note 2 to entry: Observe that two fields are uncorrelated at locations where they are geometrically orthogonal. This property does not generally hold at nearby points unless the respective waveforms are uncorrelated.

In case of scalar signals, correlated signal waveforms yield a non-zero time-domain correlation integral at some time instant. For two power-limited signals $s_1(t)$, $s_2(t)$, said integral is defined as:

$$(s_1 \otimes s_2)(t) = \lim_{T\to\infty} \frac{1}{2T} \int_{-T}^{T} s_1(\tau)^* \cdot s_2(t+\tau)\,\mathrm{d}\tau \qquad (2)$$

where the superscript * represents the complex conjugate operation.

Note 3 to entry: Two uncorrelated signals would feature a vanishing correlation integral, i.e. the above integral is equal to zero.

Note 4 to entry: Formulas (1) and (2) are originally specified in IEC TR 62630.

3.6
device holder
fixture constructed of low-loss dielectric material that is used to hold the DUT in the required test position during measurement

3.7
device under test
DUT
device that is tested according to the approaches described in this document to determine the power density

3.8
duty factor
ratio of the pulse duration to the pulse repetition period of a periodic pulse train

3.9
evaluation surface
surface, of a prescribed finite dimension, at a prescribed distance and orientation from the DUT where power density is assessed

Note 1 to entry: This is not necessarily the same as the measurement surface. Power density in the evaluation surface can be obtained, for instance, from measurement data in a different surface using reconstruction algorithms.

3.10
exposure ratio
ER
ratio of exposure metric and relevant exposure limit at a given operating frequency and location

EXAMPLE ER = S/S_{limit}

Note 1 to entry: Exposure ratio can also be expressed as a percentage, i.e. ER % = ER (dimensionless) × 100 %.

3.11
far-field region
region far from a source or aperture where the radiation pattern does not vary with distance from the source

3.12
frequency band
transmitting frequency range associated with a specific wireless operating mode

3.13
measurement surface
area, of a prescribed dimension, at a prescribed distance and orientation over which the electric and/or magnetic fields are measured using a probe sensitive to these quantities

Note 1 to entry: If the measurement surface and the evaluation surface are different, the data at the evaluation surface will then be derived from data taken at the measurement surface (measurements) by means of reconstruction algorithms.

Note 2 to entry: The dimension of the measurement surface is determined by the test equipment manufacturer based on the measurement methodology and test setup conditions necessary for evaluating the device under test.

3.14
near-field region
part of space between the antenna and the far-field region

3.15
operating mode
wireless protocol or standard used by a device to communicate in the wireless network

Note 1 to entry: Operating mode includes parameters such as modulation, source coding, channel bandwidth, etc.

3.16
plane wave equivalent power density
<of an electromagnetic wave> power density equal in magnitude to the power density of a plane wave

3.17
power density
local power density
S
energy per unit time and unit area crossing the infinitesimal surface dA characterized by the normal unit vector $\hat{\mathbf{n}}$

$$S = \frac{1}{T}\int (\mathbf{E}\times\mathbf{H})\cdot\hat{\mathbf{n}}\,\mathrm{d}T$$

where $\mathbf{E}$ and $\mathbf{H}$ are the electric and magnetic fields as function of time, respectively, and T is the period of the waveform.

Note 1 to entry: For time harmonic fields, $\mathbf{E} = \Re\left(\mathbf{E}e^{i\omega t}\right)$, $\mathbf{H} = \Re\left(\mathbf{H}e^{i\omega t}\right)$