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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Assessment of power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body (frequency range of 6 GHz to 300 GHz) –
Part 2: Computational procedure

Évaluation de la densité de puissance de l'exposition humaine aux champs radiofréquences provenant de dispositifs sans fil à proximité immédiate de la tête et du corps (plage de fréquences de 6 GHz à 300 GHz) –
Partie 2: Procédure de calcul

IEC/IEEE 63195-2:2022-05(en-fr)

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ASSESSMENT OF POWER DENSITY OF HUMAN EXPOSURE TO RADIO FREQUENCY FIELDS FROM WIRELESS DEVICES IN CLOSE PROXIMITY TO THE HEAD AND BODY (FREQUENCY RANGE OF 6 GHz TO 300 GHz) –

Part 2: Computational procedure

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This document is published as an IEC/IEEE Dual Logo standard.

This publication contains supplemental files that are required for the code verification according to Annex A. Download links and checksums for these files can be found in Annex I.

The text of this International Standard is based on the following IEC documents:

Draft	Report on voting
106/564/FDIS	106/569/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with the rules given in the ISO/IEC Directives, Part 2, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC/IEEE 63195 series, published under the general title *Assessment of power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body*, can be found on the IEC website.

The IEC Technical Committee and IEEE Technical Committee have decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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- withdrawn,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.

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INTRODUCTION

This document provides a method to evaluate the human exposure from wireless devices using computational methods. This document was developed to provide procedures for the numerical modelling and evaluation of such wireless devices operating close to the head, held in the hand or in front of the face, mounted on the body or embedded in garments. It applies to individual transmitters as well as to transmitters operating simultaneously with other transmitters within a product. The choice of technique, i.e. FDTD or FEM, is optional but can be influenced by the application. The advantages of computational procedures include the capability to provide repeatable, non-intrusive methods for determining exposure in or near an object and without the need for expensive hardware equipment. Device categories covered include but are not limited to mobile telephones, radio transmitters in personal computers, desktop and laptop devices, and multi-band and multi-antenna devices. This document specifies:

- requirements on the numerical software (Clause 5);
- model development and validation (Clause 7);
- power density computation and averaging (Clause 8);
- uncertainty evaluation (Clause 9);
- reporting requirements (Clause 10).

To develop this document, IEC Technical Committee 106 (TC 106) and IEEE International Committee on Electromagnetic Safety (ICES), Technical Committee 34 (TC 34) Subcommittee 1 (SC 1) formed Joint Working Group 11 (JWG 11) on computational methods to assess the power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body.

ASSESSMENT OF POWER DENSITY OF HUMAN EXPOSURE TO RADIO FREQUENCY FIELDS FROM WIRELESS DEVICES IN CLOSE PROXIMITY TO THE HEAD AND BODY (FREQUENCY RANGE OF 6 GHz TO 300 GHz) –

Part 2: Computational procedure

1 Scope

This document specifies computational procedures for conservative and reproducible computations of power density (PD) incident to a human head or body due to radio-frequency (RF) electromagnetic field (EMF) transmitting devices. The computational procedures described are finite-difference time-domain (FDTD) and finite element methods (FEM), which are computational techniques that can be used to determine electromagnetic quantities by solving Maxwell's equations within a specified computational uncertainty. The procedures specified here apply to exposure evaluations for a significant majority of the population during the use of hand-held and body-worn RF transmitting devices. The methods apply to devices that can feature single or multiple transmitters or antennas, and that can be operated with their radiating part or parts at distances up to 200 mm from a human head or body.

This document can be employed to determine conformity with any applicable maximum PD requirements of different types of RF transmitting devices used in close proximity to the head and body, including those combined with other RF transmitting or non-transmitting devices or accessories (e.g. belt-clip), or embedded in garments. The overall applicable frequency range of these protocols and procedures is from 6 GHz to 300 GHz.

The RF transmitting device categories covered in this document include but are not limited to mobile telephones, radio transmitters in personal computers, desktop and laptop devices, and multi-band and multi-antenna devices.

The procedures of this document do not apply to PD evaluation of electromagnetic fields emitted or altered by devices or objects intended to be implanted in the body.

NOTE For the evaluation of the combined exposure from simultaneous transmitters operating on frequencies below 6 GHz, the relevant standards for SAR computation are IEC/IEEE 62704-1:2017 and IEC/IEEE 62704-4:2020.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC/IEEE 62704-1:2017, *Determining the peak spatial-average specific absorption rate (SAR) in the human body from wireless communications devices, 30 MHz to 6 GHz – Part 1: General requirements for using the finite difference time-domain (FDTD) method for SAR calculations*

IEC/IEEE 62704-4:2020, *Determining the peak spatial-average specific absorption rate (SAR) in the human body from wireless communications devices, 30 MHz to 6 GHz – Part 4: General requirements for using the finite element method for SAR calculations*

IEC/IEEE 63195-1:2021[1], *Assessment of power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body (frequency range of 6 GHz to 300 GHz) – Part 1: Measurement procedure*

IEEE Std 145, *IEEE Standard for Definitions of Terms for Antennas*

3 Terms and definitions

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

ISO, IEC, and IEEE 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
- IEEE Dictionary Online: available at http://dictionary.ieee.org

3.1 Exposure metrics and parameters

3.1.1
power density
PD
local power density
function of the complex Poynting vector $\boldsymbol{S}$ at the location $\boldsymbol{r}$ that is integrated over a surface to compute the sPD

Note 1 to entry: Specifications of power density in terms of the integrands of Formula (4), Formula (5), and Formula (8) are provided in 8.5. See also rationales provided in Annex F for the PD specifications of 8.5.

Note 2 to entry: The formula used to compute PD can depend on the applicable exposure guidelines or national regulations.

Note 3 to entry: Power density is also referred to as power flux density.

Note 4 to entry: The associated term incident power density refers to quantity of power per unit area that impinges on the body surface. The incident power density just outside the body surface is used to establish local exposure reference levels, which apply at frequencies above 6 GHz in some jurisdictions.

3.1.2
spatial-average power density
sPD
PD (3.1.1) averaged over a surface of area A_{av}

Note 1 to entry: sPD is a function of the location vector $\boldsymbol{r}$. It is determined on the evaluation surface, except for the edges where no averaging area can be constructed.

Note 2 to entry: Example averaging area sizes specified in exposure limits are 1 cm^2 and/or 4 cm^2.

[1] To be published.

3.1.3
peak spatial-average power density
psPD
global maximum value of all the *sPD* (3.1.2) values on the evaluation surface (3.2.2)

Note 1 to entry: *psPD* is given by Formula (1)

$$psPD = \max_{\boldsymbol{r}} \left\{ sPD(\boldsymbol{r}) \right\} \tag{1}$$

where $\boldsymbol{r}$ is a point on the evaluation surface.

Note 2 to entry: Other local maxima (i.e. secondary peak spatial-average power density values) can exist.

3.1.4
maximized peak spatial-average power density
mpsPD
psPD (3.1.3) of the excitation vector (3.3.5) that maximizes its value

3.1.5
Poynting vector
$\boldsymbol{S}$
vector product of the electric field strength $\boldsymbol{E}$ and the magnetic field strength $\boldsymbol{H}$ of the electromagnetic field at a given point

Note 1 to entry: The flux of the Poynting vector through a closed surface is equal to the electromagnetic power passing through this surface.

Note 2 to entry: For a periodic electromagnetic field, the time average of the Poynting vector is a vector the direction of which, with certain reservations, can be considered as being the direction of propagation of electromagnetic energy and the magnitude of which can be considered as being the average power flux density.

Note 3 to entry: For a sinusoidal wave of angular frequency ω, the complex Poynting vector is expressed by Formula (2)

$$\boldsymbol{S} = \frac{1}{2} \boldsymbol{E} \times \boldsymbol{H}^{*} \tag{2}$$

where $\boldsymbol{E}$ and $\boldsymbol{H}$ are phasors and the asterisk denotes the complex conjugate.

Note 4 to entry: The Poynting vector has units of watt per square metre (W/m^2).

[SOURCE: IEC 60050-121:2019, 121-11-66 and IEC 60050-705:1995, 705-02-10, modified – The entries have been combined and rearranged; Note 4 has been added.]

3.1.6
conservative estimate
<of exposure> estimate of the exposure, including uncertainties as specified in this document, representative of and slightly higher than that expected to occur in the head or body of a significant majority of the human population during intended use of a wireless transmitting device

3.2 Spatial, physical, and geometrical parameters associated with exposure metrics

3.2.1
averaging area
A_{av}
nominal size of the area used for computing *sPD* (3.1.2)

Note 1 to entry: On a planar evaluation surface, *sPD* is computed as the ratio of power density (3.1.1) integrated over the averaging area A_{av}. On a non-planar evaluation surface, the averaging area indicates the dimensions of the projection of the integration area of the power density on a planar surface.

Note 2 to entry: See details on averaging in 8.4.

3.2.2
evaluation surface
virtual surface for the evaluation of the spatial-average power density (sPD) emitted by a DUT

Note 1 to entry: Typical evaluation surfaces that can be applied in this document are the inner shell of the SAM phantom with an added pinna, or a planar surface with finite or infinite extension.

Note 2 to entry: The evaluation of the $psPD$ (3.1.3) on the evaluation surface should yield a conservative estimate (3.1.6) of the exposure.

Note 3 to entry: In practice, an evaluation surface can be different from a measurement surface or area.

3.2.3
near-field
region encompassed by the reactive near-field and the radiative near-field

Note 1 to entry: See also 3.2.5 and 3.2.4 for definitions of reactive near-field and radiative near-field, respectively.

3.2.4
radiative near-field
region of space between the reactive near-field and the far-field, wherein the predominant components of the electromagnetic field are those that represent a propagation of energy, and wherein the angular field distribution is dependent upon the distance from the antenna

Note 1 to entry: In the radiative near-field, the out-of-phase (i.e. evanescent) component of the electromagnetic field decays, and the in-phase (i.e. propagating) component of the electromagnetic field emerges.

3.2.5
reactive near-field
region of space immediately surrounding an antenna, where the predominant components of the electric field and magnetic field are those that represent an exchange of reactive energy between the antenna and the surrounding medium, and where electric field and magnetic field components are 90° out of phase

[SOURCE: IEC 60050-712:1992, 712-02-01, modified – In the definition, the electric field and magnetic field component phase difference has been added.]

3.2.6
far-field
region of the electromagnetic field of an antenna where the predominant components of the field are those that represent energy propagation, the angular field distribution is essentially independent of the distance from the geometrical centre of the antenna, and the ratio of predominant electric field and magnetic field components is constant and equal to the wave impedance of 377 Ω

[SOURCE: IEC 60050-712:1992, 712-02-02, modified – In the definition, the distance to geometrical centre of the antenna has been clarified, and a phrase on the ratio of the electric and magnetic components has been added.]

3.3 Test device technical operating and antenna parameters

3.3.1
channel
RF channel
part of the frequency spectrum intended to be used for the transmission of signals and which may be defined by two specified limits, or by its centre frequency and the associated bandwidth, or by any equivalent indication

Note 1 to entry: The number of RF channels and the corresponding channel bandwidth can vary among individual wireless technologies and is subject to national frequency allocations. For the purposes of this document, PD computations are performed at specific channels; for example, the high, middle, and low channels of the transmission band.

3.3.2
antenna sub-array
subset of radiating elements in an array that operate collectively

Note 1 to entry: Antenna elements can be used separately by two or more sub-arrays.

3.3.3
array
<of antennas> antenna comprised of a number of generally identical radiating elements, arranged, oriented and excited to obtain a prescribed radiation pattern

3.3.4
codebook
set of all possible excitation vectors

3.3.5
excitation vector
vector of all phasors that represent the input signal to an antenna array or sub-array

Note 1 to entry: The entries of a codebook are excitation vectors.

3.3.6
module
sub-assembly
self-contained RF transceiver that only needs power and communication to its host through a connector, ball grid arrays or pins and is designed to be incorporated into a final product

3.4 Computational parameters

3.4.1
computational domain
set of all spatial locations at which the electric field or magnetic field is computed by a mathematical equation or a computational algorithm

3.4.2
lumped source
source with an inner impedance which is applied to an electric field component on an edge of the computational mesh

3.4.3
perfect electric conductor
PEC
material with infinite electrical conductivity which does not dissipate any energy