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TECHNICAL REPORT

colour inside

Exposure assessment methods for wireless power transfer systems

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EXPOSURE ASSESSMENT METHODS FOR WIRELESS POWER TRANSFER SYSTEMS

FOREWORD

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IEC TR 62905, 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
106/416/DTR	106/424A/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- withdrawn,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

IEC TC 106 has the scope to prepare International Standards on measurement and calculation methods used to assess human exposure to electric, magnetic and electromagnetic fields. Wireless power transfer (WPT) systems have been developed and gradually become popular over the world. WPT basically utilize similar wireless technologies to provide power to mobile phones, tablet PCs, electric vehicles (EVs) and so on without cables; but the used frequency range, i.e., tens of kHz to tens of MHz, has not been often used and paid attention to. Both stimulation-based effects (< 10 MHz, for example) and heat-based effects (> 100 kHz, for example) should be considered in this frequency range. ITU-R published a report (ITU-R SM. 2303-1) related to WPT in June 2015 which also mentions RF exposure assessment methodologies. However, no concrete assessment method has been introduced. Only IEC TC 69 has addressed exposure assessment method of WPT for EV in IEC 61980-1:2015. There is no product standard related to WPT other than that standard. Considering that WPT products might be spread in the near future, IEC TC 106 needs to be aware of this issue and established a working group to address methods for assessment of WPT related to human exposures to electric, magnetic and electromagnetic fields.

Based on these backgrounds IEC TC 106 prepared this document consisting of an overview of WPT, basic exposure assessment methods for direct and indirect effects by WPT, case studies, and relevant research. Frequency up to 10 MHz is mainly focused on because both stimulation and heat effects need to be considered but have not been addressed so far. This document also mentions enhancement of internal fields by medical implant devices.

It is hoped that this document will be useful and helpful to develop International Standards for WPT exposure assessment.

EXPOSURE ASSESSMENT METHODS FOR WIRELESS POWER TRANSFER SYSTEMS

1 Scope

This document describes general exposure assessment methods for wireless power transfer (WPT) at frequency up to 10 MHz considering thermal and stimulus effects. Exposure assessment procedures and experimental results are shown as examples such as electric vehicles (EVs) and mobile devices.

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

3.2
contact current
current flowing into the body resulting from contact with a conductive object in an electromagnetic field

Note 1 to entry: This is the localized current flow into the body (usually the hand, for a light brushing contact).

3.3
current density
current per unit cross-sectional area flowing inside the human body as a result of exposure to electromagnetic fields

3.4
device under test
DUT
device that is tested according to the procedures specified in this document

3.5
dielectric constant
real part of the complex relative permittivity of the lossy material

3.6
direct effect
biological effect resulting from direct interaction of electromagnetic field with biological structures

3.7
electric field strength
magnitude of a field vector at a point that represents the force (F) on an infinitely small charge (q) divided by the charge

3.8
exposure
situation that occurs wherever a person is subjected to electric, magnetic or electromagnetic fields

3.9
incident field
electric and magnetic fields incident upon the human body

Note 1 to entry: This document focuses on the WPT operating close to the human body at frequency below 10 MHz. Electric and magnetic fields need to be separately evaluated in this region.

3.10
induced current
current induced inside the body as a result of exposure to electromagnetic fields

3.11
indirect effect
biological effect resulting from indirect interaction of electromagnetic field with biological structure

3.12
magnetic field strength
magnitude of vector quantity obtained at a given point by subtracting the magnetization M from the magnetic flux density B divided by the magnetic constant μ_0

3.13
peak spatial-average SAR
maximum average SAR within a local region based on a specific averaging volume or mass, e.g. any 1 g or 10 g of tissue in the shape of a cube

3.14
phantom
physical model similar in appearance to the human anatomy and comprised of material with electrical properties similar to the corresponding tissues

Note 1 to entry: A phantom representing the human head could be a simple spherical model or a more complex multi-tissue anthropomorphic model.

3.15
reference level
field level derived from the basic restrictions under worst case assumptions (e.g. exposure to homogeneous field)

3.16
specific absorption rate
SAR
SAR in the tissue-equivalent liquid can be determined by E-field or the rate of temperature increase, according to:

$$\text{SAR} = \frac{\sigma E^2}{\rho}$$

$$\text{SAR} = C_\text{h} \left. \frac{\text{d}T}{\text{d}t} \right|_{t=0}$$

where

SAR is the specific absorption rate in W/kg;

E is the rms value of the electric field strength in the tissue medium in V/m;

σ is the electrical conductivity of the tissue medium in S/m;

ρ is the mass density of the tissue medium in kg/m^3;

C_h is the specific heat capacity of the tissue medium in J/(kg K);

$\left. \frac{\text{d}T}{\text{d}t} \right|_{t=0}$ is the initial time derivative of temperature in the tissue medium in K/s.

4 Symbols and abbreviations

4.1 Physical quantities

The internationally accepted SI units are used throughout this document.

Symbol	Quantity	Unit	Dimensions
C_h	Specific heat capacity	joule per kilogram per kelvin	J/(kg K)
E	Electric field strength	volt per metre	V/m
f	Frequency	hertz	Hz
J	Current density	ampere per square metre	A/m^2
P	Average (temporal) absorbed power	watt	W
T	Temperature	kelvin	K
ε	Permittivity	farad per metre	F/m
λ	Wavelength	metre	m
σ	Electric conductivity	siemens per metre	S/m

NOTE In this document, temperature is quantified in degrees Celsius, as defined by: T (°C) = T (K) – 273,15.

4.2 Constants

Symbol	Physical constant	Magnitude
η_0	Intrinsic impedance of free space	120π Ω or 377 Ω
ε_0	Permittivity of free space	$8{,}854 \times 10^{-12}$ F/m
μ_0	Permeability of free space	$4\pi \times 10^{-7}$ H/m

4.3 Abbreviations

BR basic restriction

DUT device under test

RF radio frequency

rms root mean square

RSS root sum square

CW continuous wave

SAR specific absorption rate

psSAR peak spatial-average SAR

WPT wireless power transfer

EV electric vehicle

5 Overview of WPT systems

5.1 General

Clause 5 describes an overview of WPT systems, which include WPT technologies, applications and frequency ranges reported by ITU-R [1][1]. WPT systems using frequency range over 10 MHz are described in Annex A.

5.2 WPT systems whose frequency range is less than 100 kHz

a) Magnetic induction WPT systems for home appliances

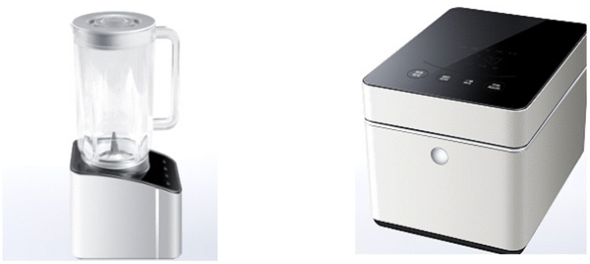
Inductive power sources (transmitters) may stand alone or be integrated into the kitchen counter tops or dining tables. These transmitters could combine the WPT to an appliance with conventional inductive heating.

For the home appliance application, the power level is usually up to several kilowatts, and the load may be motor-driven or heating type (Figure 1). Future products will support more than 2 kW power and some new design proposal for cordless kitchen appliances is being investigated.

Considering the high power usage in the home, frequencies in the order of tens of kHz are preferred to restrict electromagnetic exposure to human bodies. And high reliable devices such as Insulated Gate Bipolar Transistors (IGBTs) are usually used and these devices are working in the 10 kHz to 100 kHz frequency range.

The product applied in the kitchen needs to meet the safety and electromagnetic field (EMF) requirements and it is a key issue that transmitter should be the light and small size to fit the kitchen in addition to being low cost. The distance between the transmitter and the receiver is intended to be less than 10 cm.

The following pictures show examples of wireless power kitchen appliances that will come to the market soon.



Tightly coupled mixer   Tightly coupled rice cooker

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Figure 1 – Wireless power kitchen appliances [1]

WPT systems have already integrated into the product lines of semiconductor and LCD panel; the following pictures show examples (Figure 2).

[1] Numbers in square brackets refer to the Bibliography.