

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices –
Part 1: Devices used next to the ear (Frequency range of 300 MHz to 6 GHz)**

**Procédure de mesure pour l'évaluation du débit d'absorption spécifique de l'exposition humaine aux champs radiofréquences produits par les dispositifs de communications sans fil tenus à la main ou portés près du corps –
Partie 1: Dispositifs utilisés à proximité de l'oreille (Plage de fréquences de 300 MHz à 6 GHz)**



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2016 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 15 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices –
Part 1: Devices used next to the ear (Frequency range of 300 MHz to 6 GHz)**

**Procédure de mesure pour l'évaluation du débit d'absorption spécifique de l'exposition humaine aux champs radiofréquences produits par les dispositifs de communications sans fil tenus à la main ou portés près du corps –
Partie 1: Dispositifs utilisés à proximité de l'oreille (Plage de fréquences de 300 MHz à 6 GHz)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 33.060.20

ISBN 978-2-8322-3500-3

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	11
INTRODUCTION.....	13
1 Scope.....	14
2 Normative references	14
3 Terms and definitions	14
4 Symbols and abbreviations	19
4.1 Physical quantities	19
4.2 Constants	20
4.3 Abbreviations	20
5 Measurement system specifications	20
5.1 General requirements.....	20
5.2 Phantom specifications (shell and liquid)	22
5.3 Hand and device holder considerations.....	23
5.4 Scanning system requirements	23
5.5 Device holder specifications	23
5.6 Characteristics of the readout electronics	24
6 Protocol for SAR assessment.....	24
6.1 General.....	24
6.2 Measurement preparation.....	24
6.2.1 Preparation of tissue-equivalent liquid and <i>system check</i>	24
6.2.2 Preparation of the wireless device under test (DUT).....	25
6.2.3 Operating modes	26
6.2.4 Positioning of the DUT in relation to the phantom	27
6.2.5 Test frequencies for DUT	34
6.3 Tests to be performed	34
6.4 Measurement procedure.....	36
6.4.1 General	36
6.4.2 General procedure	37
6.4.3 SAR measurements of handsets with multiple antennas or multiple transmitters.....	39
6.5 Post-processing of SAR measurement data	45
6.5.1 Interpolation.....	45
6.5.2 Extrapolation	46
6.5.3 Definition of the averaging volume.....	46
6.5.4 Searching for the maxima.....	46
6.6 Fast SAR testing.....	46
6.6.1 General	46
6.6.2 Fast SAR measurement procedure A.....	47
6.6.3 Fast SAR testing of required frequency bands	49
6.6.4 Fast SAR measurement procedure B.....	50
6.7 SAR test reduction	52
6.7.1 General requirements.....	52
6.7.2 Test reduction for different operating modes in the same frequency band using the same wireless technology	53
6.7.3 Test reduction based on characteristics of DUT design	54
6.7.4 Test reduction based on SAR level analysis.....	55

6.7.5	Test reduction based on simultaneous multi-band transmission considerations	57
7	Uncertainty estimation	58
7.1	General considerations.....	58
7.1.1	Concept of uncertainty estimation.....	58
7.1.2	Type A and Type B evaluation.....	59
7.1.3	Degrees of freedom and coverage factor	59
7.2	Components contributing to uncertainty	60
7.2.1	General	60
7.2.2	Calibration of the SAR probes	60
7.2.3	Contribution of mechanical constraints	65
7.2.4	Phantom shell.....	66
7.2.5	Device positioning and holder uncertainties	67
7.2.6	Tissue-equivalent liquid parameter uncertainty	69
7.2.7	Uncertainty in SAR correction for deviations in permittivity and conductivity.....	72
7.2.8	Measured SAR drift.....	74
7.2.9	RF ambient conditions.....	75
7.2.10	Contribution of post-processing	76
7.2.11	SAR scaling uncertainty	81
7.2.12	Deviation of experimental sources	82
7.2.13	Other uncertainty contributions when using <i>system validation</i> sources	82
7.3	Calculation of the uncertainty budget.....	83
7.3.1	Combined and expanded uncertainties	83
7.3.2	Maximum expanded uncertainty	83
7.4	Uncertainty of fast SAR methods based on specific measurement procedures and post-processing techniques	92
7.4.1	General	92
7.4.2	Measurement uncertainty evaluation.....	92
8	Measurement report	101
8.1	General.....	101
8.2	Items to be recorded in the measurement report	101
Annex A (normative)	Phantom specifications	104
A.1	Rationale for the SAM phantom shape.....	104
A.2	SAM phantom specifications.....	104
A.2.1	General	104
A.2.2	Phantom shell.....	108
A.3	Flat phantom specifications	110
A.4	Tissue-equivalent liquids	111
Annex B (normative)	Calibration and characterization of dosimetric probes	113
B.1	Introductory remarks	113
B.2	Linearity.....	114
B.3	Assessment of the sensitivity of the dipole sensors	114
B.3.1	General	114
B.3.2	Two-step calibration procedures.....	114
B.3.3	One step calibration procedures.....	120
B.3.4	Coaxial calorimeter method.....	124
B.4	Isotropy	126
B.4.1	Axial isotropy	126

B.4.2	Hemispherical isotropy	126
B.5	Lower detection limit	131
B.6	Boundary effects	131
B.7	Response time	131
Annex C	(normative) Post-processing techniques	132
C.1	Extrapolation and interpolation schemes	132
C.1.1	Introductory remarks	132
C.1.2	Interpolation schemes	132
C.1.3	Extrapolation schemes	132
C.2	Averaging scheme and maximum finding	132
C.2.1	Volume average schemes	132
C.2.2	Extrude method of averaging	132
C.2.3	Maximum peak SAR finding and uncertainty estimation	133
C.3	Example implementation of parameters for scanning and data evaluation	133
C.3.1	General	133
C.3.2	Area scan measurement requirements	133
C.3.3	Zoom scan	133
C.3.4	Extrapolation	134
C.3.5	Interpolation	134
C.3.6	Integration	134
Annex D	(normative) SAR measurement system verification	135
D.1	Overview	135
D.2	<i>System check</i>	135
D.2.1	Purpose	135
D.2.2	Phantom set-up	136
D.2.3	<i>System check</i> source	136
D.2.4	<i>System check</i> source input power measurement	137
D.2.5	<i>System check</i> procedure	138
D.3	<i>System validation</i>	139
D.3.1	Purpose	139
D.3.2	Phantom set-up	139
D.3.3	<i>System validation</i> sources	139
D.3.4	Reference dipole input power measurement	140
D.3.5	<i>System validation</i> procedure	140
D.3.6	Numerical target SAR values	141
D.4	Fast SAR method <i>system validation</i> and <i>system check</i>	144
D.4.1	General	144
D.4.2	Fast SAR method <i>system validation</i>	144
D.4.3	Fast SAR method <i>system check</i>	145
Annex E	(normative) Interlaboratory comparisons	146
E.1	Purpose	146
E.2	Phantom set-up	146
E.3	Reference wireless handsets	146
E.4	Power set-up	146
E.5	Interlaboratory comparison – Procedure	147
Annex F	(informative) Definition of a phantom coordinate system and a device under test coordinate system	148
Annex G	(informative) SAR <i>system validation</i> sources	150

G.1	Standard dipole source	150
G.2	Standard waveguide source	151
Annex H (informative)	Flat phantom	153
Annex I (informative)	Example recipes for phantom head tissue-equivalent liquids	156
I.1	Overview	156
I.2	Ingredients.....	156
I.3	Tissue-equivalent liquid formulas (permittivity/conductivity)	157
Annex J (informative)	Measurement of the dielectric properties of liquids and uncertainty estimation	160
J.1	Introductory remarks	160
J.2	Measurement techniques.....	160
J.2.1	General	160
J.2.2	Instrumentation	160
J.2.3	General principles	160
J.3	Slotted coaxial transmission line.....	161
J.3.1	General	161
J.3.2	Equipment set-up.....	161
J.3.3	Measurement procedure.....	161
J.4	Contact coaxial probe.....	162
J.4.1	General	162
J.4.2	Equipment set-up.....	162
J.4.3	Measurement procedure.....	164
J.5	TEM transmission line	164
J.5.1	General	164
J.5.2	Equipment set-up.....	164
J.5.3	Measurement procedure.....	165
J.6	Dielectric properties of reference liquids	166
Annex K (informative)	Measurement uncertainty of specific fast SAR methods and fast SAR examples	169
K.1	General.....	169
K.2	Measurement uncertainty evaluation.....	169
K.2.1	General	169
K.2.2	Probe calibration and system calibration drift.....	170
K.2.3	Isotropy	170
K.2.4	Sensor positioning uncertainty.....	171
K.2.5	Sensor location sensitivity	171
K.2.6	Mutual sensor coupling	172
K.2.7	Sensor coupling with the DUT	172
K.2.8	Measurement system immunity / secondary reception	172
K.2.9	Deviations in phantom shape.....	172
K.2.10	Spatial variation in dielectric parameters	173
K.3	Fast SAR examples.....	178
K.3.1	General	178
K.3.2	Example 1: Tests for one frequency band and mode	179
K.3.3	Example 2: Tests over multiple frequency bands and modes	183
K.3.4	Example 3: Tests for one frequency band and mode (Procedure B)	186
K.3.5	Example 4: Tests over multiple frequency bands and modes (Procedure B)	190
Annex L (informative)	SAR test reduction supporting information	194

L.1	General.....	194
L.2	Test reduction based on characteristics of DUT design	194
L.2.1	General	194
L.2.2	Statistical analysis overview.....	194
L.2.3	Analysis results.....	195
L.2.4	Conclusions	198
L.2.5	Expansion to multi transmission antennas	198
L.2.6	Test reduction based on analysis of SAR results on other signal modulations	198
L.3	Test reduction based on SAR level analysis.....	200
L.3.1	General	200
L.3.2	Statistical analysis	201
L.3.3	Test reduction applicability example	204
L.4	Other statistical approaches to search for the high SAR test conditions.....	205
L.4.1	General	205
L.4.2	Test reductions based on a design of experiments (DOE)	205
L.4.3	Analysis of unstructured data	206
Annex M (informative)	Applying the head SAR test procedures	207
Annex N (informative)	Studies for potential hand effects on head SAR	210
N.1	Overview	210
N.2	Background.....	210
N.2.1	General	210
N.2.2	Hand phantoms.....	211
N.3	Summary of experimental studies	211
N.3.1	General	211
N.3.2	Experimental studies using fully compliant SAR measurement systems	211
N.3.3	Experimental studies using non-compliant SAR measurement systems	211
N.4	Summary of computational studies	212
N.5	Conclusions	212
Annex O (informative)	Quick start guide	213
O.1	General.....	213
O.2	Quick start guide and level flow-chart	213
Bibliography	217

Figure 1 – Vertical and horizontal reference lines and reference Points A, B on two example device types: a full touch screen smart phone (top) and a keyboard handset (bottom)	29
Figure 2 – Cheek position of the wireless device on the left side of SAM where the device shall be maintained for the phantom test set-up.....	32
Figure 3 – Tilt position of the wireless device on the left side of SAM.....	32
Figure 4 – An alternative form factor DUT and standard coordinate and reference points applied	33
Figure 5 – Block diagram of the tests to be performed	36
Figure 6 – Orientation of the probe with respect to the line normal to the phantom surface, shown at two different locations	39
Figure 7 – Measurement procedure for different types of correlated signals	45
Figure 8 – The Fast SAR measurement procedure B.	52
Figure 9 – Modified chart of 6.4.2.....	57

Figure 10 – Orientation and surface of the averaging volume relative to the phantom surface	81
Figure A.1 – Illustration of dimensions in Table A.1 and Table A.2	105
Figure A.2 – Close-up side view of phantom showing the ear region	107
Figure A.3 – Side view of the phantom showing relevant markings	107
Figure A.4 – Sagittally bisected phantom with extended perimeter (shown placed on its side as used for device SAR tests)	109
Figure A.5 – Picture of the phantom showing the central strip	109
Figure A.6 – Cross-sectional view of SAM at the reference plane	110
Figure A.7 – Dimensions of the elliptical phantom	111
Figure B.1 – Experimental set-up for assessment of the sensitivity (conversion factor) using a vertically-oriented rectangular waveguide	118
Figure B.2 – Illustration of the antenna gain evaluation set-up	121
Figure B.3 – Schematic of the coaxial calorimeter system	125
Figure B.4 – Set-up to assess spherical isotropy deviation in tissue-equivalent liquid	127
Figure B.5 – Alternative set-up to assess spherical isotropy deviation in tissue-equivalent liquid	128
Figure B.6 – Experimental set-up for the hemispherical isotropy assessment	129
Figure B.7 – Conventions for dipole position (ξ) and polarization (θ)	129
Figure B.8 – Measurement of hemispherical isotropy with reference antenna	130
Figure C.1 – Extrude method of averaging	133
Figure C.2 – Extrapolation of SAR data to the inner surface of the phantom based on a fourth-order least-square polynomial fit of the measured data (squares)	134
Figure D.1 – Test set-up for the <i>system check</i>	137
Figure F.1 – Example reference coordinate system for the left ERP of the SAM phantom	148
Figure F.2 – Example coordinate system on the device under test	149
Figure G.1 – Mechanical details of the standard dipole	151
Figure G.2 – Standard waveguide source (dimensions are according to Table G.2)	152
Figure H.1 – Dimensions of the flat phantom set-up used for deriving the minimal phantom dimensions for V and L for a given phantom depth D	154
Figure H.2 – FDTD predicted uncertainty in the 10 g peak spatial-average SAR as a function of the dimensions of the flat phantom compared with an infinite flat phantom, at 800 MHz	154
Figure J.1 – Stripped line set-up	161
Figure J.2 – An open-ended coaxial probe with inner and outer radii a and b , respectively	163
Figure J.3 – TEM line dielectric test set-up [143]	165
Figure K.1 – SAR values for twelve hypothetical test configurations measured in the same frequency band and modulation (e.g. GSM 900 MHz) using a hypothetical full SAR (full SAR) and two fast SAR (fast SAR 1 and fast SAR 2) evaluations	178
Figure L.1 – Distribution of "Tilt/Cheek"	195
Figure L.2 – SAR relative to SAR in position with maximum SAR in GSM mode	200
Figure L.3 – Two points identifying the minimum distance between the position of the interpolated maximum SAR and the points at $0,6 \times SAR_{\max}$	201
Figure L.4 – Histogram for D_{\min} in the case of GSM 900 and iso-level at $0,6 \times SAR_{\max}$	202
Figure L.5 – Histogram for random variable <i>Factor</i> _{1g1800}	203

Figure O.1 – Quick guide flow-chart 214

Table 1 – Area scan parameters..... 38

Table 2 – Zoom scan parameters 38

Table 3 – Example method to determine the combined SAR value using Alternative 1 43

Table 4 – Threshold values $TH(f)$ used in this proposed test reduction protocol..... 56

Table 5 – Example uncertainty template and example numerical values for dielectric constant (ϵ_r') and conductivity (σ) measurement..... 71

Table 6 – Uncertainty of Formula (41) as a function of the maximum change in permittivity or conductivity..... 73

Table 7 – Parameters for the reference function f_1 in Formula (48) 77

Table 8 – Uncertainties relating to the deviations of the parameters of the standard waveguide source from theory..... 82

Table 9 – Other uncertainty contributions relating to the dipole sources described in Annex G..... 83

Table 10 – Other uncertainty contributions relating to the standard waveguide sources described in Annex G..... 83

Table 11 – Example of measurement uncertainty evaluation template for handset SAR test.. 85

Table 12 – Example of measurement uncertainty evaluation template for *system validation*..... 88

Table 13 – Example of measurement repeatability evaluation template for *system check* (applicable for one system). 90

Table 14 – Measurement uncertainty budget for relative fast SAR tests 97

Table 15 – Measurement uncertainty budget for *system check* using fast SAR methods 99

Table A.1 – Dimensions used in deriving SAM phantom from the ARMY 90th percentile male head data (Gordon et al. [56])..... 106

Table A.2 – Additional SAM dimensions compared with selected dimensions from the ARMY 90th-percentile male head data (Gordon et al. [56]) – specialist head measurement section..... 106

Table A.3 – Dielectric properties of the head tissue-equivalent liquid 112

Table B.1 – Uncertainty analysis for transfer calibration using temperature probes..... 116

Table B.2 – Guidelines for designing calibration waveguides 119

Table B.3 – Uncertainty analysis of the probe calibration in waveguide 120

Table B.4 – Uncertainty template for evaluation of reference antenna gain..... 122

Table B.5 – Uncertainty template for calibration using reference antenna..... 123

Table B.6 – Uncertainty components for probe calibration using thermal methods 126

Table D.1 – Numerical target SAR values (W/kg) for standard dipole and flat phantom..... 142

Table D.2 – Numerical target SAR values for waveguides specified in Clause G.2 placed in contact with flat phantom [94]..... 143

Table G.1 – Mechanical dimensions of the reference dipoles 150

Table G.2 – Mechanical dimensions of the standard waveguide 152

Table H.1 – Parameters used for calculation of reference SAR values in Table D.1 155

Table I.1 – Suggested recipes for achieving target dielectric parameters: 300 MHz to 900 MHz..... 157

Table I.2 – Suggested recipes for achieving target dielectric parameters: 1 450 MHz to 2 000 MHz..... 158

Table I.3 – Suggested recipes for achieving target dielectric parameters: 2 100 MHz to 5 800 MHz	159
Table J.1 – Parameters for calculating the dielectric properties of various reference liquids	167
Table J.2 – Dielectric properties of reference liquids at 20 °C	167
Table K.1 – Measurement uncertainty budget for relative fast SAR tests complying with Annex K requirements, for tests performed within one frequency band and modulation.....	174
Table K.2 – Measurement uncertainty budget for <i>system check</i> using fast SAR methods complying with Annex K requirements	176
Table K.3 – Measurements conducted according to Step a)	179
Table K.4 – Measurements conducted according to Step b)	180
Table K.5 – Measurements conducted according to Step c)	180
Table K.6 – Measurements conducted according to 6.4.2, Step 2).....	181
Table K.7 – Measurements conducted according to 6.4.2, Step 3).....	182
Table K.8 – Measurements conducted according to 6.4.2, Step 4).....	182
Table K.9 – Fast SAR measurements conducted according to Step a).....	183
Table K.10 – Fast SAR measurements showing highest SAR value according to Step b) ...	184
Table K.11 – Full SAR measurements conducted according to Step b).....	184
Table K.12 – Fast SAR measurements showing values according-to requirements in Step c)	185
Table K.13 – Full SAR measurements conducted according to Step c)	185
Table K.14 – Fast SAR measurements showing values according to requirements in Step e)	186
Table K.15 – Full SAR measurements conducted according to Step e).....	186
Table K.16 – Measurements conducted according to Step a)	187
Table K.17 – Measurements conducted according to Step b)	188
Table K.18 – Measurements conducted according to Step c)	188
Table K.19 – Measurements conducted according to Step e)	189
Table K.20 – Measurements conducted according to Step f)	190
Table K.21 – Fast SAR measurements conducted according to Step a).....	191
Table K.22 – Full SAR measurements conducted according to Step b).....	191
Table K.23 – Full SAR measurements conducted according to Step e).....	192
Table K.24 – Full SAR measurements conducted according to Step e).....	193
Table L.1 – The number of handsets used for the statistical study.....	195
Table L.2 – Statistical analysis results of $P(\text{Tilt/Cheek} > x)$ for various x values	196
Table L.3 – Statistical analysis results of $P(\text{Tilt/Cheek} > x)$ for 1 g and 10 g peak spatial-average SAR	196
Table L.4 – Statistical analysis results of $P(\text{Tilt/Cheek} > x)$ for various antenna locations.....	197
Table L.5 – Statistical analysis results of $P(\text{Tilt/Cheek} > x)$ for various frequency bands.....	197
Table L.6 – Statistical analysis results of $P(\text{Tilt/Cheek} > x)$ for various device types.....	198
Table L.7 – Distance D_{\min}^* for various iso-level values	202
Table L.8 – Experimental thresholds to have a 95 % probability that the maximum measured SAR value from the area scan will also have a peak spatial-average SAR	203
Table L.9 – SAR values from the area scan (GSM 900 band)	204
Table L.10 – SAR values from the area scan (GSM 900 band)	205

Table M.1 – SAR results tables for example test results – GSM 850.....	207
Table M.2 – SAR results table for example test results – GSM 900	208
Table M.3 – SAR results table for example test results – GSM 1800	208
Table M.4 – SAR results table for example test results – GSM 1900	209
Table O.1 – Quick start guide: SAR evaluation steps	215

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MEASUREMENT PROCEDURE FOR THE ASSESSMENT OF SPECIFIC
ABSORPTION RATE OF HUMAN EXPOSURE TO RADIO FREQUENCY
FIELDS FROM HAND-HELD AND BODY-MOUNTED WIRELESS
COMMUNICATION DEVICES –****Part 1: Devices used next to the ear
(Frequency range of 300 MHz to 6 GHz)**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62209-1 has been prepared by IEC technical committee 106: Methods for the assessment of electric, magnetic and electromagnetic fields associated with human exposure.

This second edition cancels and replaces the first edition published in 2005. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Extension of the frequency range to 300 MHz to 6 GHz.
- b) Fast SAR methods.

- c) Test reduction techniques.
- d) SAR measurements of terminals with multiple antennas and multiple transmitters.
- e) Deviation of dielectric characteristics of the tissue-equivalent liquids is relaxed up to 10 %.
- f) Uncertainty evaluation guidelines for temperature and dielectric parameter deviations of tissue-equivalent liquids.
- g) Addition of the following annexes:
 - Annex K (informative) Measurement uncertainty of specific fast SAR methods and fast SAR examples
 - Annex L (informative) SAR test reduction supporting information
 - Annex M (informative) Applying the head SAR test procedures
 - Annex N (informative) Studies for potential hand effects on head SAR
 - Annex O (informative) Quick start guide.

The text of this standard is based on the following documents:

FDIS	Report on voting
106/361/FDIS	106/365/RVD

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

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

In this standard, the following print types are used:

- specific test protocols: in *italic* type.

A list of all parts in the IEC 62209 series, published under the general title *Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

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

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

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. IEC TC 106 has developed this part of IEC 62209 to provide procedures to evaluate the specific absorption rate (SAR) of human exposures due to electromagnetic field (EMF) transmitting devices when held close to the ear. The types of devices include but are not limited to mobile telephones, cordless telephones, headphones, etc., which are used close to the ear. The IEC TC 106 standards do not deal with the exposure limits. Conformity assessment depends on the policy of national regulatory bodies. While basic restrictions on SAR in the ICNIRP Guidelines [64]¹ go up to 10 GHz, the frequency range for this part of IEC 62209 is limited to an upper end frequency of 6 GHz since current wireless handsets operate below this frequency.

IEC TC 106 and IEEE/ICES TC34² worked together formally through common membership to achieve the goal of harmonization, between IEC TC 106 Maintenance Team 1 for this part of IEC 62209 and IEEE/ICES TC34 for IEEE Std 1528 [66]. During the process a primary effort involved was to harmonize these two standards.

To aid the user of this part of IEC 62209, a quick start guide has been prepared and included as an informative annex (see Annex O). The quick start guide is not a substitute for following the detailed procedure of the standard.

¹ Numbers in square brackets refer to the Bibliography.

² The International Committee on Electromagnetic Safety of the IEEE.

MEASUREMENT PROCEDURE FOR THE ASSESSMENT OF SPECIFIC ABSORPTION RATE OF HUMAN EXPOSURE TO RADIO FREQUENCY FIELDS FROM HAND-HELD AND BODY-MOUNTED WIRELESS COMMUNICATION DEVICES –

Part 1: Devices used next to the ear (Frequency range of 300 MHz to 6 GHz)

1 Scope

This part of IEC 62209 specifies protocols and test procedures for measurement of the peak spatial-average SAR induced inside a simplified model of the head with defined reproducibility. It applies to certain electromagnetic field (EMF) transmitting devices that are positioned next to the ear, where the radiating structures of the device are in close proximity to the human head, such as mobile phones, cordless phones, certain headsets, etc. These protocols and test procedures provide a conservative estimate with limited uncertainty for the peak-spatial SAR that would occur in the head for a significant majority of people during normal use of these devices. The applicable frequency range is from 300 MHz to 6 GHz.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 17043:2010, *Conformity assessment – General requirements for proficiency testing*

ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

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

3.1

axial isotropy

maximum deviation of the SAR measured when rotating around the major axis of the probe while it is exposed to a wave impinging from a direction along its major axis

3.2

conducted power

power delivered by the power amplifier to a matched load

3.3

frequency band

transmitting frequency range associated with a specific wireless operating mode

Note 1 to entry: The frequency band is usually referred to using rounded figures; however the actual frequency allocation may be slightly different, e.g. GSM 850 MHz band actually uses 824 MHz to 849 MHz and 869 MHz to 894 MHz, GSM 900 MHz band actually uses 880 MHz to 915 MHz and 925 MHz to 960 MHz.