

# INTERNATIONAL STANDARD



Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure  
<https://standards.iteh.ai>

Document Preview

<https://standards.iteh.ai/color/cg/standard/iec/iec62232:2017>



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2017 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.

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

Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://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](http://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](http://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 It also gives information on projects, replaced and withdrawn publications.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](http://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](http://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 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC Glossary - [std.iec.ch/glossary](http://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](http://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](mailto:csc@iec.ch).

<https://standards.iteh.ae/iec62232/standard/iec/1c86622d-c600-439f-bc15-de1d631d1588/iec-62232-2017>



IEC 62232

Edition 2.0 2017-08

# INTERNATIONAL STANDARD



Determination of RF field strength, power density and SAR in the vicinity of  
radiocommunication base stations for the purpose of evaluating human  
exposure (<https://standards.iteh.ai>)

Document Preview

<https://standards.iteh.ai/cd/cg/standard/iec/iec62232:2017>

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 13.280; 17.240

ISBN 978-2-8322-4635-1

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD .....	12
INTRODUCTION .....	14
1 Scope .....	15
2 Normative references .....	15
3 Terms and definitions .....	16
4 Symbols and abbreviated terms .....	22
4.1 Physical quantities .....	22
4.2 Constants .....	23
4.3 Abbreviated terms .....	23
5 Quick start guide and how to use this document .....	24
5.1 Overview .....	24
5.2 Quick start guide .....	24
5.3 How to use this document .....	26
5.4 Worked case studies .....	27
6 Evaluation processes for product compliance, product installation compliance and in-situ RF exposure assessments .....	27
6.1 Evaluation process for product compliance .....	27
6.1.1 General .....	27
6.1.2 Establishing compliance boundaries .....	27
6.1.3 Iso-surface compliance boundary definition .....	28
6.1.4 Simple compliance boundaries .....	28
6.1.5 Methods for establishing the compliance boundary .....	30
6.1.6 Uncertainty .....	32
6.1.7 Reporting .....	32
6.2 Evaluation process used for product installation compliance .....	33
6.2.1 General .....	33
6.2.2 General evaluation procedure for product installations .....	33
6.2.3 Product installation data collection .....	34
6.2.4 Simplified product installation evaluation process .....	35
6.2.5 Assessment area selection .....	37
6.2.6 Measurements .....	39
6.2.7 Computations .....	40
6.2.8 Uncertainty .....	41
6.2.9 Reporting .....	41
6.3 Evaluation processes for in-situ RF exposure assessment .....	42
6.3.1 General requirements, source determination and site analysis .....	42
6.3.2 Measurement procedures .....	44
6.3.3 Uncertainty .....	45
6.3.4 Reporting .....	45
6.4 Averaging procedures .....	46
6.4.1 Spatial averaging .....	46
6.4.2 Time averaging .....	46
7 Determining the evaluation method .....	46
7.1 Overview .....	46
7.2 Process to determine the evaluation method .....	46
7.2.1 General .....	46

7.2.2	Establishing the evaluation points in relation to the source-environment plane .....	47
7.2.3	Exposure metric selection.....	49
8	Evaluation methods .....	49
8.1	Overview.....	49
8.2	Measurement methods.....	50
8.2.1	General .....	50
8.2.2	RF field strength measurements .....	50
8.2.3	<i>SAR</i> measurements .....	51
8.3	Computation methods .....	52
9	Uncertainty .....	53
10	Reporting.....	54
10.1	General requirements .....	54
10.2	Report format.....	54
10.3	Opinions and interpretations .....	55
Annex A (informative)	Source environment plane and guidance on the evaluation method selection.....	56
A.1	Guidance on the source-environment plane .....	56
A.1.1	General .....	56
A.1.2	Source-environment plane example .....	56
A.1.3	Source regions .....	57
A.2	Select between computation or measurement approaches .....	63
A.3	Select measurement method.....	64
A.3.1	Selection stages .....	64
A.3.2	Selecting between field strength and <i>SAR</i> measurement approaches .....	64
A.3.3	Selecting between broadband and frequency-selective measurement .....	65
A.3.4	Selecting RF field strength measurement procedures .....	66
A.4	Select computation method .....	66
A.5	Additional considerations .....	68
A.5.1	Simplicity .....	68
A.5.2	Evaluation method ranking .....	68
A.5.3	Applying multiple methods for RF exposure evaluation .....	68
Annex B (normative)	Evaluation methods .....	69
B.1	Overview.....	69
B.2	Evaluation parameters .....	69
B.2.1	Overview .....	69
B.2.2	Coordinate systems .....	69
B.2.3	Reference points .....	70
B.2.4	Variables .....	70
B.3	Measurement methods.....	73
B.3.1	RF field strength measurements .....	73
B.3.2	<i>SAR</i> measurements .....	104
B.4	Computation methods .....	114
B.4.1	Overview and general requirements.....	114
B.4.2	Formulas .....	115
B.4.3	Basic algorithms .....	123
B.4.4	Advanced computation methods .....	129
B.5	Extrapolation from the evaluated <i>SAR</i> / RF field strength to the required assessment condition.....	150

B.5.1	Extrapolation method .....	150
B.5.2	Extrapolation to maximum RF field strength using broadband measurements .....	151
B.5.3	Extrapolation to maximum RF field strength for frequency and code selective measurements .....	151
B.5.4	Influence of traffic in real operating network .....	152
B.6	Summation of multiple RF fields .....	152
B.6.1	Applicability .....	152
B.6.2	Uncorrelated fields .....	153
B.6.3	Correlated fields .....	153
B.6.4	Ambient fields .....	153
Annex C (informative)	Rationale supporting simplified product installation criteria .....	154
C.1	General .....	154
C.2	Class E2 .....	154
C.3	Class E10 .....	155
C.4	Class E100 .....	155
C.5	Class E+ .....	157
Annex D (informative)	Guidance on comparing evaluated parameters with a limit value .....	159
D.1	Overview .....	159
D.2	Information required to compare evaluated value against limit value .....	159
D.3	Performing a limit comparison at a given confidence level .....	159
D.4	Performing a limit comparison using a process based assessment scheme .....	160
Annex E (informative)	Uncertainty .....	161
E.1	Background .....	161
E.2	Requirement to estimate uncertainty .....	161
E.3	How to estimate uncertainty .....	162
E.4	Guidance on uncertainty and assessment schemes .....	162
E.4.1	General .....	162
E.4.2	Overview of assessment schemes .....	162
E.4.3	Examples of assessment schemes .....	163
E.4.4	Assessment schemes and compliance probabilities .....	166
E.5	Guidance on uncertainty .....	168
E.5.1	Overview .....	168
E.5.2	Measurement uncertainty and confidence levels .....	169
E.6	Applying uncertainty for compliance assessments .....	170
E.7	Example influence quantities for field measurements .....	170
E.7.1	General .....	170
E.7.2	Calibration uncertainty of measurement antenna or field probe .....	171
E.7.3	Frequency response of the measurement antenna or field probe .....	171
E.7.4	Isotropy of the measurement antenna or field probe .....	173
E.7.5	Frequency response of the spectrum analyser .....	173
E.7.6	Temperature response of a broadband field probe .....	173
E.7.7	Linearity deviation of a broadband field probe .....	173
E.7.8	Mismatch uncertainty .....	173
E.7.9	Deviation of the experimental source from numerical source .....	174
E.7.10	Meter fluctuation uncertainty for time varying signals .....	174
E.7.11	Uncertainty due to power variation in the RF source .....	174
E.7.12	Uncertainty due to field gradients .....	174

E.7.13	Mutual coupling between measurement antenna or isotropic probe and object .....	176
E.7.14	Uncertainty due to field scattering from the surveyor's body .....	177
E.7.15	Measurement device.....	178
E.7.16	Fields out of measurement range.....	178
E.7.17	Noise.....	179
E.7.18	Integration time .....	179
E.7.19	Power chain.....	179
E.7.20	Positioning system.....	179
E.7.21	Matching between probe and the EUT .....	179
E.7.22	Drifts in output power of the EUT, probe, temperature, and humidity.....	179
E.7.23	Perturbation by the environment .....	179
E.8	Example influence quantities for RF field strength computations by ray tracing or full wave methods .....	180
E.8.1	General .....	180
E.8.2	System .....	180
E.8.3	Technique uncertainties.....	181
E.8.4	Environmental uncertainties.....	181
E.9	Influence quantities for <i>SAR</i> measurements .....	182
E.9.1	General .....	182
E.9.2	Post-processing.....	182
E.9.3	Device holder .....	182
E.9.4	Test sample positioning.....	183
E.9.5	Phantom shell uncertainty.....	184
E.9.6	<i>SAR</i> correction / target liquid permittivity and conductivity .....	184
E.9.7	Liquid permittivity and conductivity measurements.....	184
E.9.8	Liquid temperature.....	185
E.10	Influence quantities for <i>SAR</i> calculations .....	185
E.11	Spatial averaging .....	185
E.11.1	General .....	185
E.11.2	Small-scale fading variations .....	186
E.11.3	Error on the estimation of local average power density .....	186
E.11.4	Error on the estimation of local average power density .....	187
E.11.5	Characterization of environment statistical properties .....	187
E.11.6	Characterization of different averaging schemes.....	188
E.12	Influence of human body on probe measurements of the electrical field strength .....	192
E.12.1	Simulations of the influence of human body on probe measurements based on the Method of Moments (Surface Equivalence Principle) .....	192
E.12.2	Comparison with measurements .....	194
E.12.3	Conclusions.....	194
Annex F (informative)	Technology-specific guidance.....	195
F.1	Overview to guidance on specific technologies .....	195
F.2	Summary of technology-specific information .....	195
F.3	Guidance on spectrum analyser settings .....	199
F.3.1	Overview of spectrum analyser settings .....	199
F.3.2	Detection algorithms.....	199
F.3.3	Resolution bandwidth and channel power processing .....	200
F.3.4	Integration per service .....	202
F.4	Constant power components .....	203

F.4.1	TDMA/FDMA technology .....	203
F.4.2	WCDMA/UMTS technology .....	203
F.4.3	OFDM technology .....	204
F.5	WCDMA measurement and calibration using a code domain analyser .....	204
F.5.1	WCDMA measurements – General .....	204
F.5.2	Requirements for the code domain analyser .....	204
F.5.3	Calibration .....	205
F.6	Wi-Fi measurements .....	207
F.6.1	General .....	207
F.6.2	Integration time for reproducible measurements .....	207
F.6.3	Channel occupation .....	208
F.6.4	Some considerations .....	208
F.6.5	Scalability by channel occupation .....	209
F.6.6	Influence of the application layers .....	209
F.7	LTE measurements for Frequency Division Duplexing (FDD) .....	209
F.7.1	Overview .....	209
F.7.2	Maximum LTE exposure evaluation .....	210
F.7.3	Instantaneous LTE exposure evaluation .....	213
F.7.4	MIMO multiplexing of LTE base station .....	213
F.8	LTE measurements for Time Division Duplexing (TDD) .....	214
F.8.1	General .....	214
F.8.2	Definitions and transmission modes .....	214
F.8.3	TDD frame structure .....	215
F.8.4	Maximum LTE exposure evaluation .....	217
F.9	Establishing compliance boundaries using numerical simulations of MIMO array antennas emitting correlated wave-forms .....	220
F.9.1	General .....	220
F.9.2	Field combining near radio base stations for correlated exposure with the purpose of establishing compliance boundaries .....	221
F.9.3	Numerical simulations of MIMO array antennas with densely packed columns .....	222
F.9.4	Numerical simulations of large MIMO array antennas .....	222
F.10	Smart antennas .....	223
F.10.1	Overview .....	223
F.10.2	Deterministic conservative approach .....	223
F.10.3	Statistical conservative approach .....	223
F.10.4	Example approaches .....	224
F.10.5	Smart antenna (TD-LTE) .....	233
F.11	Establishing compliance boundary for systems using dish antennas .....	233
F.11.1	General .....	233
F.11.2	Overview .....	234
F.11.3	Compliance boundary of a dish antenna .....	234
	Bibliography .....	236
	Figure 1 – Quick start guide to the evaluation process .....	25
	Figure 2 – Example of complex compliance boundary .....	28
	Figure 3 – Example of circular cylindrical compliance boundaries .....	28
	Figure 4 – Example of box shaped compliance boundary .....	29
	Figure 5 – Example of truncated box shaped compliance boundary .....	29

Figure 6 – Example of dish antenna compliance boundary (from [11]).....	30
Figure 7 – Example illustrating the linear scaling procedure.....	31
Figure 8 – Flowchart describing the product installation evaluation process .....	34
Figure 9 – Square-shaped assessment domain boundary (ADB) with size $D_{ad}$ .....	39
Figure 10 – Alternative routes to evaluate in-situ RF exposure.....	43
Figure 11 – Source-environment plane concept .....	48
Figure 12 – Flow chart of the measurement methods .....	50
Figure 13 – Flow chart of the relevant computation methods .....	52
Figure A.1 – Example source-environment plane regions near a radio base station antenna on a tower which has a narrow vertical (elevation plane) beamwidth (not to scale).....	56
Figure A.2 – Example source-environment plane regions near a roof-top antenna which has a narrow vertical (elevation plane) beamwidth (not to scale).....	57
Figure A.3 – Geometry of an antenna with largest linear dimension $L_{eff}$ and largest end dimension $L_{end}$ .....	58
Figure A.4 – Maximum path difference for an antenna with largest linear dimension $L$ .....	62
Figure B.1 – Cylindrical, cartesian and spherical coordinates relative to the RBS antenna .....	70
Figure B.2 – Evaluation locations .....	81
Figure B.3 – Relationship of separation of remote radio source and evaluation area to separation of evaluation points .....	82
Figure B.4 – Outline of the surface scanning methodology .....	84
Figure B.5 – Block diagram of the near-field antenna measurement system .....	85
Figure B.6 – Minimum radius constraint where $a$ denotes the minimum radius of a sphere, centred at the reference point, that will encompass the EUT .....	86
Figure B.7 – Maximum angular sampling spacing constraint .....	86
Figure B.8 – Outline of the volume/surface scanning methodology .....	90
Figure B.9 – Block diagram of typical near-field EUT measurement system .....	91
Figure B.10 – Spatial averaging schemes relative to foot support level and in the vertical plane oriented to offer maximum area in the direction of the source being evaluated .....	97
Figure B.11 – Spatial averaging relative to spatial-peak field strength point height .....	97
Figure B.12 – Positioning of the EUT relative to the relevant phantom .....	105
Figure B.13 – Phantom liquid volume and measurement volume used for whole-body SAR measurements with the box-shaped phantoms .....	111
Figure B.14 – Reflection due to the presence of a ground plane .....	116
Figure B.15 – Enclosed cylinder around collinear arrays, with and without electrical downtilt .....	116
Figure B.16 – Leaky feeder geometry .....	118
Figure B.17 – Directions for which SAR estimation expressions are given.....	119
Figure B.18 – Reference frame employed for cylindrical formulas for field strength computation at a point P (left), and on a line perpendicular to boresight (right) .....	124
Figure B.19 – Views illustrating the three valid zones for field strength computation around an antenna .....	125
Figure B.20 – Cylindrical formulas reference results .....	128
Figure B.21 – Spherical formulas reference results .....	129
Figure B.22 – Synthetic model and ray tracing algorithms geometry and parameters .....	131

Figure B.23 – Line 4 far-field positions for synthetic model and ray tracing validation example .....	134
Figure B.24 – Antenna parameters for synthetic model and ray tracing algorithms validation example .....	135
Figure B.25 – Generic 900 MHz RBS antenna with nine dipole radiators .....	142
Figure B.26 – Line 1, 2 and 3 near-field positions for full wave and ray tracing validation .....	142
Figure B.27 – Generic 1 800 MHz RBS antenna with five slot radiators .....	143
Figure B.28 – RBS antenna placed in front of a multi-layered lossy cylinder .....	149
Figure B.29 – Time variation over 24 h of the exposure induced by GSM 1800 MHz (left) and FM (right) both normalized to mean .....	152
Figure C.1 – Measured <i>ER</i> as a function of distance for a low power BS ( $\rho = 5 \text{ dBi}$ , $f = 2100 \text{ MHz}$ ) transmitting with an <i>EIRP</i> of 2 W (class E2) and 10 W (class E10) .....	154
Figure C.2 – Minimum installation height as a function of transmitting power corresponding to class E10 .....	155
Figure C.3 – Compliance distance in the main lobe as a function of <i>EIRP</i> established according to the far-field formula corresponding to class E100 .....	156
Figure C.4 – Minimum installation height as a function of transmitting power corresponding to class E100 .....	156
Figure C.5 – Averaged power density at ground level for various installation configurations of equipment with 100 W <i>EIRP</i> (class E100) .....	157
Figure C.6 – Compliance distance in the main lobe as a function of <i>EIRP</i> established according to the far-field formula corresponding to class E+ .....	158
Figure C.7 – Minimum installation height as a function of transmitting power corresponding to class E+ .....	158
Figure E.1 – Examples of general assessment schemes .....	164
Figure E.2 – Target uncertainty scheme overview .....	165
Figure E.3 – Probability of the true value being above (respectively below) the evaluated value depending on the confidence level assuming a normal distribution .....	169
Figure E.4 – Plot of the calibration factors for $E$ (not $E^2$ ) provided from an example calibration report for an electric field probe .....	172
Figure E.5 – Computational model used for the variational analysis of reflected RF fields from the front of a surveyor .....	177
Figure E.6 – Positioning device and different positioning errors .....	183
Figure E.7 – Physical model of Rayleigh (a) and Rice (b) small-scale fading variations .....	185
Figure E.8 – Example of $E$ field strength variations in line of sight of an antenna operating at 2,2 GHz .....	186
Figure E.9 – Error at 95% on average power estimation .....	187
Figure E.10 – 343 measurement positions building a cube (centre) and different templates consisting of a different number of positions .....	188
Figure E.11 – Moving a template (Line 3) through the CUBE .....	189
Figure E.12 – Standard deviations for GSM 900, DCS 1800 and UMTS .....	191
Figure E.13 – Simulation arrangement .....	193
Figure E.14 – Body influence .....	193
Figure E.15 – Simulation arrangement .....	194
Figure F.1 – Spectral occupancy for GMSK .....	200
Figure F.2 – Spectral occupancy for CDMA .....	201
Figure F.3 – Channel allocation for a WCDMA signal .....	204

Figure F.4 – Example of Wi-Fi frames .....	207
Figure F.5 – Channel occupation versus the integration time for IEEE 802.11b standard .....	208
Figure F.6 – Channel occupation versus nominal throughput rate for IEEE 802.11b/g standards.....	208
Figure F.7 – Wi-Fi spectrum trace snapshot.....	209
Figure F.8 – Frame structure of transmission signal for LTE downlink .....	210
Figure F.9 – Examples of received waves from LTE downlink signals using a spectrum analyser using zero span mode.....	213
Figure F.10 – Frame structure type 2 (for 5 ms switch-point periodicity).....	216
Figure F.11 – Frame structure of transmission signal for TDD LTE .....	216
Figure F.12 – PBCH measurement example.....	218
Figure F.13 – PBCH measurement example spectrum analyser using zero span mode .....	220
Figure F.14 – MIMO array antenna with densely packed columns .....	221
Figure F.15 – Plan view representation of statistical conservative model .....	224
Figure F.16 – Binomial cumulative probability function for $N = 24$ , $PR = 0,125$ .....	232
Figure F.17 – Binomial cumulative probability function for $N = 18$ , $PR = 2/7$ .....	233
Figure F.18 – Flowchart for the assessment of EMF compliance boundary in the line of sight of dish antennas (from [11]).....	235
 Table 1 – Quick start guide evaluation steps .....	26
Table 2 – Example of product installation classes where a simplified evaluation process is applicable (based on ICNIRP general public limits [13]) .....	36
Table 3 – Exposure metrics validity for evaluation points in each source region .....	49
Table 4 – Requirements for RF field strength measurements .....	51
Table 5 – Whole-body SAR exclusions based on RF power levels.....	51
Table 6 – Requirements for SAR measurements .....	51
Table 7 – Applicability of computation methods for source-environment regions of Figure 10 .....	53
Table 8 – Requirements for computation methods.....	53
Table A.1 – Definition of source regions .....	59
Table A.2 – Default source region boundaries .....	59
Table A.3 – Source region boundaries for antennas with maximum dimension less than $2,5 \lambda$ .....	60
Table A.4 – Source region boundaries for linear/planar antenna arrays with a maximum dimension greater than or equal to $2,5 \lambda$ .....	60
Table A.5 – Source region boundaries for equiphase radiation aperture (e.g. dish) antennas with maximum reflector dimension much greater than a wavelength .....	61
Table A.6 – Source region boundaries for leaky feeders .....	61
Table A.7 – Far-field distance $r$ measured in metres as a function of angle $\beta$ .....	63
Table A.8 – Guidance on selecting between computation and measurement approaches .....	64
Table A.9 – Guidance on selecting between broadband and frequency-selective measurement .....	65
Table A.10 – Guidance on selecting RF field strength measurement procedures.....	66
Table A.11 – Guidance on selecting computation methods.....	67

Table A.12 – Guidance on specific evaluation method ranking .....	68
Table B.1 – Dimension variables .....	70
Table B.2 – RF power variables .....	71
Table B.3 – Antenna variables .....	72
Table B.4 – Exposure metric variables .....	73
Table B.5 – Broadband measurement system requirements .....	75
Table B.6 – Frequency-selective measurement system requirements .....	76
Table B.7 – Sample template for estimating the expanded uncertainty of an in-situ RF field strength measurement that used a frequency-selective instrument .....	100
Table B.8 – Sample template for estimating the expanded uncertainty of an in-situ RF field strength measurement that used a broadband instrument .....	101
Table B.9 – Sample template for estimating the expanded uncertainty of a laboratory-based RF field strength measurement using the surface scanning method .....	102
Table B.10 – Sample template for estimating the expanded uncertainty of a laboratory-based RF field strength measurement using the volume scanning method .....	103
Table B.11 – Numerical reference <i>SAR</i> values for reference dipoles and flat phantom – All values are normalized to a forward power of 1 W .....	108
Table B.12 – Phantom liquid volume and measurement volume used for whole-body <i>SAR</i> measurements [35], [29] .....	111
Table B.13 – Correction factor to compensate for a possible bias in the obtained general public whole-body <i>SAR</i> when assessed using the large box-shaped phantom for child exposure configurations [36] .....	111
Table B.14 – Measurement uncertainty evaluation template for EUT whole-body <i>SAR</i> test .....	112
Table B.15 – Measurement uncertainty evaluation template for whole-body <i>SAR</i> system validation .....	113
Table B.16 – Applicability of <i>SAR</i> estimation formulas .....	120
Table B.17 – Definition of $C(f)$ .....	121
Table B.18 – Input parameters for <i>SAR</i> estimation formulas validation .....	123
Table B.19 – $SAR_{10g}$ and $SAR_{WB}$ estimation formula reference results for Table B.18 parameters and a body mass of 46 kg .....	123
Table B.20 – Definition of boundaries for selecting the zone of computation .....	126
Table B.21 – Input parameters for cylinder and spherical formulas validation .....	128
Table B.22 – Sample template for estimating the expanded uncertainty of a synthetic model and ray tracing RF field strength computation .....	133
Table B.23 – Synthetic model and ray tracing power density reference results .....	136
Table B.24 – Sample template for estimating the expanded uncertainty of a full wave RF field strength computation .....	140
Table B.25 – Validation 1 full wave field reference results .....	143
Table B.26 – Validation 2 full wave field reference results .....	144
Table B.27 – Sample template for estimating the expanded uncertainty of a full wave <i>SAR</i> computation .....	147
Table B.28 – Validation reference <i>SAR</i> results for computation method .....	149
Table E.1 – Determining target uncertainty .....	165
Table E.2 – Monte Carlo simulation of 10 000 trials, both surveyor and auditor using best estimate .....	167
Table E.3 – Monte Carlo simulation of 10 000 trials, both surveyor and auditor using target uncertainty of 4 dB .....	167

Table E.4 – Monte Carlo simulation of 10 000 trials surveyor uses upper 95 % CI vs. auditor uses lower 95 % CI .....	168
Table E.5 – Guidance on minimum separation distances for some dipole lengths to ensure that the uncertainty does not exceed 5 % or 10 % in a measurement of $E$ .....	175
Table E.6 – Guidance on minimum separation distances for some loop diameters to ensure that the uncertainty does not exceed 5 % or 10 % in a measurement of $H$ .....	176
Table E.7 – Example minimum separation conditions for selected dipole lengths for 10 % uncertainty in $E$ .....	176
Table E.8 – Standard estimates of dB variation for the perturbations in front of a surveyor due to body reflected fields as described in Figure E.5 .....	178
Table E.9 – Standard uncertainty ( $u$ ) estimates for $E$ and $H$ due to body reflections from the surveyor for common radio services derived from estimates provided in Table E.8.....	178
Table E.10 – Maximum sensitivity coefficients for liquid permittivity and conductivity over the frequency range 300 MHz to 6 GHz.....	185
Table E.11 – Uncertainty at 95 % for different fading models .....	188
Table E.12 – Correlation coefficients for GSM 900 and DCS 1800 .....	190
Table E.13 – Variations of the standard deviations for the GSM 900, DCS 1800 and UMTS frequency band .....	191
Table E.14 – Examples of total uncertainty calculation.....	192
Table E.15 – Maximum simulated error due to the influence of a human body on the measurement values of an omni-directional probe .....	194
Table E.16 – Measured influence of a human body on omni-directional probe measurements .....	194
Table F.1 – Technology specific information .....	196
Table F.2 – Example of spectrum analyser settings for an integration per service .....	202
Table F.3 – Example constant power components for specific TDMA/FDMA technologies .....	203
Table F.4 – WCDMA decoder requirements .....	205
Table F.5 – Signal configurations .....	205
Table F.6 – WCDMA generator setting for power linearity .....	206
Table F.7 – WCDMA generator setting for decoder calibration .....	206
Table F.8 – WCDMA generator setting for reflection coefficient measurement .....	207
Table F.9 – Theoretical extrapolation factor, $N_{RS}$ , based on frame structure given in 3GPP TS 36.104 [10] .....	212
Table F.10 – Configuration of special subframe (lengths of DwPTS/GP/UpPTS) .....	217
Table F.11 – Uplink-downlink configurations .....	217

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**DETERMINATION OF RF FIELD STRENGTH, POWER DENSITY AND *SAR*  
IN THE VICINITY OF RADIOTRANSMISSION BASE STATIONS FOR  
THE PURPOSE OF EVALUATING HUMAN EXPOSURE****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 62232 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 2011 and constitutes a technical revision.

The significant changes with respect to the previous edition are the following:

- a) Increased frequency range from 110 MHz to 100 GHz (including consideration of ambient sources 100 kHz to 300 GHz);
- b) product compliance – determination of compliance boundary information for an RBS product before it is placed on the market;
- c) product installation compliance – determination of the total RF exposure levels before the product is put into service;