



BSI Standards Publication

**Case studies supporting IEC 62232 — Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure**

---

## National foreword

This Published Document is the UK implementation of IEC TR 62669:2019. It supersedes PD IEC/TR 62669:2011, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/106, Human exposure to low frequency and high frequency electromagnetic radiation.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2019  
Published by BSI Standards Limited 2019

ISBN 978 0 580 52316 8

ICS 13.280; 17.240

**Compliance with a British Standard cannot confer immunity from legal obligations.**

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 June 2019.

### Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

---



# TECHNICAL REPORT



---

**Case studies supporting IEC 62232 – Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 13.280; 17.240

ISBN 978-2-8322-6795-0

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

CONTENTS

FOREWORD..... 10

INTRODUCTION..... 12

1 Scope..... 13

2 Normative references ..... 13

3 Terms and definitions ..... 13

4 Symbols and abbreviations..... 17

    4.1 Physical quantities ..... 17

    4.2 Constants ..... 17

    4.3 Abbreviated terms..... 17

5 Overview of case studies..... 18

6 Indoor small cell product compliance assessment using SAR measurements..... 20

    6.1 General description..... 20

    6.2 Implementation of IEC 62232:2017 ..... 20

        6.2.1 Evaluation process ..... 20

        6.2.2 Methodology..... 21

        6.2.3 Reporting..... 22

    6.3 Technical outcome..... 22

    6.4 Lessons learned ..... 22

7 Outdoor small cell product compliance assessment using SAR measurements ..... 23

    7.1 General description..... 23

    7.2 Implementation of IEC 62232:2017 ..... 23

        7.2.1 Evaluation process ..... 23

        7.2.2 Methodology..... 24

        7.2.3 Reporting..... 24

    7.3 Technical outcome..... 24

    7.4 Lessons learned ..... 24

8 Small cell product installation compliance assessment using simplified installation criteria..... 24

    8.1 General description..... 24

    8.2 Implementation of IEC 62232:2017 ..... 25

        8.2.1 Evaluation process ..... 25

        8.2.2 Methodology..... 26

        8.2.3 Reporting..... 26

    8.3 Technical outcome..... 26

    8.4 Lessons learned ..... 27

9 Small cell site in-situ measurements..... 27

    9.1 General description..... 27

    9.2 Implementation of IEC 62232:2017 for measurement Campaign A ..... 27

        9.2.1 Evaluation process ..... 27

        9.2.2 Methodology..... 28

        9.2.3 Reporting..... 29

    9.3 Implementation of IEC 62232:2017 for measurement Campaign B ..... 29

        9.3.1 General description ..... 29

        9.3.2 Case B (comprehensive exposure evaluation) ..... 30

        9.3.3 Reporting..... 31

    9.4 Lessons learned ..... 31

10	Street cell product compliance assessment using SAR measurements and power density spatial averaging .....	31
10.1	General description.....	31
10.2	Implementation of IEC 62232:2017 .....	32
10.2.1	Evaluation process .....	32
10.2.2	Methodology.....	32
10.2.3	Reporting.....	33
10.3	Technical outcome.....	33
10.4	Validation study .....	33
10.4.1	Validation process .....	33
10.4.2	Comparison of spatial average field strength and whole-body SAR results .....	34
10.5	Lessons learned .....	34
11	Macro site in-situ measurements .....	34
11.1	General description.....	34
11.2	Implementation of IEC 62232:2017 .....	35
11.2.1	Evaluation process .....	35
11.2.2	Methodology.....	36
11.2.3	Reporting.....	36
11.3	Technical outcome.....	36
11.4	Lessons learned .....	36
12	Macro site in-situ measurements using drones .....	36
12.1	General description.....	36
12.2	Implementation .....	37
12.2.1	Evaluation system .....	37
12.2.2	Evaluation process and methodology.....	38
12.2.3	Reporting.....	38
12.3	Technical outcome.....	38
12.4	Lessons learned .....	39
13	RF exposure assessment based on actual maximum transmitted power or EIRP .....	39
13.1	General guidelines .....	39
13.1.1	Technical background and rationale .....	39
13.1.2	Guiding principles for conducting RF exposure assessment based on the actual maximum approach .....	42
13.1.3	EIRP evaluation assumptions .....	42
13.1.4	Technology duty cycle factor assumptions .....	43
13.1.5	Expected outcome of actual maximum approaches .....	45
13.2	Modelling studies for BS using mMIMO .....	45
13.2.1	Guiding principles .....	45
13.2.2	Simulation model parameters .....	45
13.2.3	Modelling case study A.....	47
13.2.4	Modelling case study B.....	49
13.2.5	Modelling case study C.....	51
13.2.6	Lessons learned .....	53
13.3	Measurement studies on operational sites with BS using mMIMO .....	54
13.3.1	Guiding principles .....	54
13.3.2	Measurement campaign parameters .....	54
13.3.3	Experiment process .....	55
13.3.4	Examples of RF exposure experiments .....	57

13.3.5	Lessons learned .....	61
13.4	Configurations with multiple transmitters .....	62
13.4.1	Guiding principles for configurations with multiple transmitters .....	62
13.4.2	Rationale .....	62
13.4.3	Power combination factors applicable to configurations with multiple transmitters .....	64
13.4.4	Lessons learned .....	65
14	Macro BS with massive MIMO product compliance assessment.....	65
14.1	General description.....	65
14.2	Implementation of IEC 62232:2017 .....	66
14.2.1	Evaluation process .....	66
14.2.2	Methodology.....	66
14.2.3	Reporting.....	67
14.3	Technical outcome.....	67
14.4	Lessons learned .....	68
15	Macro site with massive MIMO product installation compliance assessment .....	68
15.1	General description.....	68
15.2	Implementation of IEC 62232:2017 .....	69
15.2.1	Evaluation process .....	69
15.2.2	Methodology.....	69
15.2.3	Reporting.....	70
15.3	Technical outcome.....	70
15.4	Lessons learned .....	71
16	Small cell products at millimetre-wave frequency using massive MIMO.....	71
16.1	General description.....	71
16.2	Indoor product installation case study .....	72
16.2.1	Product configurations .....	72
16.2.2	Implementation of IEC 62232:2017 .....	72
16.2.3	Technical outcome.....	73
16.2.4	Lessons learned.....	73
16.3	In-situ measurement case study.....	73
16.3.1	Product configurations .....	73
16.3.2	Implementation of IEC 62232:2017 .....	74
16.3.3	Technical outcome.....	75
16.3.4	Lessons learned .....	77
17	Wireless link with parabolic dish antenna product compliance assessment .....	77
17.1	General description.....	77
17.2	Implementation of IEC 62232:2017 .....	78
17.2.1	Evaluation process .....	78
17.2.2	Methodology.....	79
17.2.3	Reporting.....	79
17.3	Technical outcome.....	79
17.4	Lessons learned .....	81
Annex A (informative) Technical information supporting the case study "Indoor small cell product compliance assessment using SAR measurements" (Clause 6).....		82
A.1	Technical details.....	82
A.2	Test report .....	82
Annex B (informative) Technical information supporting the case study "Outdoor small cell product compliance assessment using SAR measurements" (Clause 7).....		83

B.1	Physical parameters of the EUT antenna .....	83
B.2	Measurement set-up .....	83
B.3	Measurement results .....	84
B.4	Test report .....	84
Annex C (informative) Technical information supporting the case study "Small cell product installation compliance assessment using simplified installation criteria" (Clause 8) .....		85
C.1	3GPP categories of base stations .....	85
C.2	E0 installation class case study – Touch compliant .....	85
C.3	E2 installation class case study .....	86
C.4	E10 installation class case study .....	87
C.5	E100 installation class case .....	88
C.6	E+ installation class case study .....	90
Annex D (informative) Technical information supporting the case study "Small cell site in-situ measurements" (Clause 9) .....		93
D.1	General description and note .....	93
D.2	Technical information and results for measurement Campaign A .....	93
D.3	Technical information for measurement Campaign B .....	98
D.3.1	General description .....	98
D.3.2	Measurement process .....	98
D.3.3	Results .....	99
D.3.4	Measurement uncertainty .....	101
D.3.5	Test report for measurement Campaign B .....	101
Annex E (informative) Technical information supporting the case study "Street cell product compliance assessment using SAR measurements and power density spatial averaging" (Clause 10) .....		102
Annex F (informative) Technical information supporting the case study "Macro site in-situ measurements" (Clause 11) .....		103
F.1	Technical information used for performing the tests .....	103
F.2	Test report .....	103
Annex G (informative) Technical information supporting the case study "Macro site in-situ measurements using drones" (Clause 12) .....		104
G.1	Technical parameters of the measurement system .....	104
G.2	Technical parameters of the drone .....	104
G.3	Description of the BS measurement site .....	104
G.4	Technical details of the measurement process .....	105
G.5	Software interface of the drone-based measurement system .....	108
G.6	Considerations for performing RF exposure measurements using drones .....	108
Annex H (informative) Technical information supporting the case study "Macro BS with massive MIMO product compliance assessment" (Clause 14) .....		110
H.1	Technical details .....	110
H.2	Test report .....	111
Annex I (informative) Technical information supporting the case study "Macro site with massive MIMO product installation compliance assessment" (Clause 15) .....		112
I.1	Description of the site .....	112
I.2	Description of the EUT .....	113
I.3	Evaluation procedure .....	114
I.4	Calculations .....	114
I.5	Interpretation of the results .....	117
I.6	Test report .....	117

Annex J (informative) Technical information supporting the case study "Small cell products at millimetre-wave frequency using massive MIMO" (Clause 16)..... 118

Annex K (informative) Revised flow chart for the simplified RF exposure assessment of BS using parabolic dish antennas (Clause 17) ..... 119

Bibliography..... 121

  

Figure 1 – Tested local area BS product with two radios denoted RF1 and RF2..... 20

Figure 2 – Definition of cylindrical RF compliance boundary..... 21

Figure 3 – Small remote radio equipment at 3,5 GHz (EUT antenna) ..... 23

Figure 4 – Simplified process for product installation compliance applicable to small cells..... 25

Figure 5 – Overview of BS installation classes for simplified RF exposure assessment of small cells..... 26

Figure 6 – Illustration of small cells integration in street furniture ..... 28

Figure 7 – Photographs of typical examples of the three small cell site groups ..... 30

Figure 8 – Omni-directional antenna connected to the street cell product ..... 32

Figure 9 – Vertical scan lines for spatially averaged field strength measurements..... 33

Figure 10 – View from the measurement location to the BS ..... 35

Figure 11 – Drone used for field measurements around the BS site ..... 38

Figure 12 – Empirical CDFs of transmitted power (normalized) for different environments in 3G network in India [31] ..... 40

Figure 13 – Empirical CDFs of combined transmitted power (normalized) for a 2G/3G/4G network in Sweden [32] ..... 40

Figure 14 – Extrapolation factor of the power flux density  $S(t)$  of the different signals and the  $S_{total}(t)$  (all bands) with a sliding time averaging of 6 min applied to the measurements [27] ..... 41

Figure 15 – Generic structure of a base station transmitted RF signal frame ..... 44

Figure 16 – Fraction of the total power transmitted in the broadside beam direction for rural and urban scenarios ..... 48

Figure 17 – CDF of the power reduction factor for rural and urban installation scenarios ..... 49

Figure 18 – CDF of the normalized transmitted power for both UMa and UMi..... 51

Figure 19 – Relationship between additional power reduction factor and CDF as a function of number of beams (number of incoherent areas)..... 53

Figure 20 – CDF of measurement on 8-cell cluster (experiment #1) ..... 59

Figure 21 – CDF in high-traffic conditions (experiment #5)..... 60

Figure 22 – CDF of the reference Beta distribution used to assess power combination factors ..... 63

Figure 23 – CDF resulting from the combination of two independent transmitters having the reference Beta distribution ..... 63

Figure 24 – 5G BS product..... 65

Figure 25 – Box-shaped RF compliance boundary ..... 66

Figure 26 – Outline of the 5G site ..... 69

Figure 27 – Top view of the exclusion zones (red: occupational, yellow: general public) ..... 70

Figure 28 – Side view of the exclusion zones (red: occupational, yellow: general public) ..... 71

Figure 29 – Indoor site with 5G small cell product at millimetre-wave frequency..... 72

Figure 30 – Outdoor site with 5G small cell product at millimetre-wave frequency installed on a 44 m radio tower ..... 74

Figure 31 – Map of the outdoor measurement locations .....	76
Figure 32 – Outdoor measurement location 1.....	76
Figure 33 – Outdoor measurement location 2.....	76
Figure 34 – Typical radio transmitters using parabolic dish antennas.....	78
Figure 35 – Cylindrical shape RF compliance boundary .....	79
Figure B.1 – Views of the SAR measurement setup .....	84
Figure B.2 – Characteristics of SAR of EUT antennas as a function of separation distance at 3,5 GHz .....	84
Figure C.1 – Example of an E0 installation class configuration.....	86
Figure C.2 – Example of an E2 installation class configuration.....	87
Figure C.3 – Example of layout design for an E10 installation class configuration .....	88
Figure C.4 – Example of layout design for an E100 installation class configuration .....	90
Figure C.5 – Example of layout design for an E+ installation class configuration.....	92
Figure D.1 – Mean value of <i>E</i> -field measurements with broadband equipment at intermediate points for each site .....	94
Figure D.2 – Maximum global <i>E</i> -field values measured in close proximity of the sites .....	94
Figure D.3 – Consistency analysis between Case A and Case B (without extrapolation) results .....	95
Figure D.4 – Contribution of mobile services compared to Case B results .....	95
Figure D.5 – Routes used for walk-tests around each site in both trials.....	96
Figure D.6 – Cumulative distribution function of the upload throughput on Trial 1 normalized by the maximum value measured on each site when the small cells are off (left) and of the transmitted power by the handset (right) .....	96
Figure D.7 – Cumulative distribution function of the upload throughput on Trial 2 normalized by the maximum value measured on each site when the small cells are off (left) and of the transmitted power by the handset (right) .....	97
Figure D.8 – Cumulative distribution functions of the power transmitted by the handset during voice calls on Trial 2 when small cells are on and off .....	97
Figure D.9 – Results of the measurements around the selected sites.....	100
Figure D.10 – Comparison between Campaign B results and other countryside measurement campaigns.....	100
Figure G.1 – Photograph of test site .....	105
Figure G.2 – The measurement system.....	106
Figure G.3 – The route of the drone during the flight.....	106
Figure G.4 – The drone is hovering at measurement point 1 .....	107
Figure G.5 – The drone is hovering at measurement point 2 .....	107
Figure G.6 – Operating interface of the drone-based measurement system software .....	108
Figure I.1 – Rooftop scheme .....	112
Figure I.2 – Geometry of the rooftop installation.....	113
Figure I.3 – Compliance boundaries for general public (yellow).....	115
Figure I.4 – Compliance boundaries for occupational exposure (red) .....	116
Figure K.1 – Revised flow chart for the simplified assessment of RF compliance boundary in the line of sight of a parabolic dish antenna .....	120

Table 1 – Outline of RF exposure assessment case studies .....	19
Table 2 – ICNIRP RF exposure limits relevant for the product compliance assessment (from [8]).....	20
Table 3 – Dimensions of the cylindrical-shaped RF compliance boundary for general public (GP) and occupational (O) exposure.....	22
Table 4 – Typical examples of small cell configurations (from [18]) .....	25
Table 5 – General public compliance distances for the street cell BS with omnidirectional antenna .....	33
Table 6 – Street cell EMF compliance assessment comparison: general public (adult) compliance distances based on SAR and field strength .....	34
Table 7 – Operators and technologies present on the BS site .....	35
Table 8 – Measurement results for 1,5 m above relative ground level .....	36
Table 9 – The measurement results of the measurement points .....	38
Table 10 – Relevant parameters for conducting RF exposure modelling studies of a massive MIMO site or site cluster .....	46
Table 11 – Relevant parameters for conducting RF exposure assessment of massive MIMO site according to simulation method A (from [33]) .....	47
Table 12 – Relevant parameters for conducting RF exposure assessment of a massive MIMO site or site cluster according to simulation method B (from [35]).....	50
Table 13 – Summary of the percentiles of the normalized transmitted power and compliance distances for a UMa scenario from 3GPP TR 38.373 [6] and 3GPP TR 38.901 [7] .....	51
Table 14 – Relevant parameters for conducting RF exposure assessment of massive MIMO site according to simulation method C (from [36]) .....	52
Table 15 – Measurement campaign parameters for conducting RF exposure assessment of a massive MIMO site or site cluster .....	54
Table 16 – Measurement campaign parameters for RF exposure validation of several massive MIMO sites and site clusters .....	57
Table 17 – Actual maximum values for experiment #1.....	59
Table 18 – Actual maximum values for experiment #5.....	60
Table 19 – Summary of actual maximum power results based on measurements from different sites and clusters .....	61
Table 20 – Quantiles of the reference Beta distribution used to assess power combination factors .....	62
Table 21 – Percentiles resulting from the combination of 2 to 5 independent transmitters having the reference Beta distribution.....	64
Table 22 – Power combination factors applicable to the normalized transmitted power CDF in case of combination of multiple independent identical transmitters.....	64
Table 23 – Power combination factors applicable to two independent transmitters with a ratio $p_1$ amplitude .....	64
Table 24 – RF EMF exposure limits relevant for the product compliance assessment [8] .....	66
Table 25 – Dimensions of the box-shaped RF compliance boundary for general public (GP) and occupational (O) exposure for an actual maximum transmitted power configuration.....	67
Table 26 – RF EMF exposure limits relevant for the compliance assessment.....	69
Table 27 – Measurement results .....	75
Table 28 – RF EMF exposure limits relevant for the product compliance assessment (from [8]).....	78

Table 29 – Examples of radio relay configurations with parabolic dish antennas below 10 GHz .....	80
Table 30 – Examples of radio relay configurations with parabolic dish antennas above 10 GHz .....	80
Table A.1 – Technical data for the EUT.....	82
Table A.2 – EUT configuration with rated maximum transmitted power level and maximum transmitted power levels .....	82
Table B.1 – Physical parameters.....	83
Table C.1 – Range of transmitted power classes for 3G and 4G base stations (from 3GPP TS 25.104 [16] and 3GPP TS 36.104 [17]) .....	85
Table C.2 – Example of product parameters for an E0 installation class.....	85
Table C.3 – Example of product parameters for an E2 installation class.....	86
Table C.4 – Example of product parameters for an E10 installation class.....	87
Table C.5 – Example of product parameters for an E100 installation class.....	89
Table C.6 – Example of product parameters for an E+ installation class .....	91
Table D.1 – Main characteristics of the two trials of measurement Campaign A .....	93
Table D.2 – Country and site groups of the sites in measurement Campaign B .....	98
Table D.3 – The predefined services configured in the measurement equipment.....	99
Table G.1 – The information of the components in the measurement system .....	104
Table G.2 – The parameters of the drone.....	104
Table G.3 – The base station parameters .....	105
Table G.4 – The measurement steps .....	105
Table H.1 – Technical data for the EUT .....	110
Table H.2 – Properties of the antenna used .....	110
Table H.3 – EUT configuration with rated maximum transmitted power level and actual maximum transmitted power level including a power tolerance of 1 dB.....	111
Table I.1 – Properties of the installed base stations .....	113
Table I.2 – RF EMF exposure limits and product installation compliance assessment .....	117

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**CASE STUDIES SUPPORTING IEC 62232 – DETERMINATION OF RF FIELD STRENGTH, POWER DENSITY AND SAR IN THE VICINITY OF RADIOCOMMUNICATION 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.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a Technical Report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 62669, 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.

This second edition cancels and replaces the first edition published in 2011. This edition constitutes a technical revision.

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

Enquiry draft	Report on voting
106/473/DTR	106/482A/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.

When referring to subdivisions of IEC 62232:2017, the number of the subdivision is followed by "(IEC 62232:2017)" in order to differentiate from subdivisions of the current document. For example:

- "defined in 6.4 (IEC 62232:2017)" should be read as "defined in 6.4 of IEC 62232:2017";
- "see 8.2" should be read as "see 8.2 of IEC TR 62669:2019".

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

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

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

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

## INTRODUCTION

This document contains a series of case studies for the evaluation of electromagnetic (EM) sources transmitting in the frequency range 110 MHz to 100 GHz (including consideration of ambient sources from 100 kHz to 300 GHz) to support the methods specified in IEC 62232:2017.

Case studies presented in this document have been chosen to illustrate typical RF exposure assessments for the most common types of base stations (BS) deployed in mobile and wireless networks, such as small cells, street cells, macro base stations, and parabolic dish antennas used for wireless transmission or mobile backhaul.

The methodologies and approaches described in this document can be useful for the assessment of early 5G products and networks. Clause 13 is dedicated to the introduction, rationale and guiding principles for the implementation of RF exposure assessment using the actual maximum transmitted power or EIRP. While this approach is applicable to any type of BS, it is particularly important for BS using massive MIMO, which are intended to be introduced more predominantly in 5G networks. Multiple examples of case studies with BS using massive MIMO are provided in Clause 13 to Clause 16.

This document is informative. Each use case is described in the main body of the document and includes “lessons learned” and recommendations for improving IEC 62232:2017. More details, rationale and examples of reports are included in annexes.

# CASE STUDIES SUPPORTING IEC 62232 – DETERMINATION OF RF FIELD STRENGTH, POWER DENSITY AND SAR IN THE VICINITY OF RADIOCOMMUNICATION BASE STATIONS FOR THE PURPOSE OF EVALUATING HUMAN EXPOSURE

## 1 Scope

This document, which is a Technical Report, presents a series of case studies in which electromagnetic (EM) fields are evaluated in accordance with IEC 62232:2017. The case studies presented in this document involve intentionally radiating base stations (BS). The BS transmit on one or more antennas using one or more frequencies in the range 110 MHz to 100 GHz and RF exposure assessments take into account the contribution of ambient sources at least in the 100 kHz to 300 GHz frequency range.

Each case study has been chosen to illustrate a typical BS evaluation scenario and employs the methods detailed in IEC 62232:2017. The case studies are provided for guidance only and are not a substitute for a thorough understanding of the requirements of IEC 62232:2017. Based on the lessons learned from each case study, recommendations about RF assessment topics to be considered in the next revision of IEC 62232 are proposed. The methodologies and approaches described in this document are useful for the assessment of early 5G products introduced for consumer trials or deployments.

This document provides background and rationale for applying a compliance approach based on the actual maximum transmitted power or EIRP. Guidance for collecting and analysing information about the transmitted power of a base station and evaluating its actual maximum RF exposure based on modelling studies or measurement studies on operational sites (in networks, sub-networks or field trials) is also presented.

## 2 Normative references

IEC 62232:2017, *Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure*

IEC 62479, *Assessment of the compliance of low-power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields (10 MHz to 300 GHz)*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62232:2017 and the following apply.

NOTE The additional terms and definitions given below will be added in the next edition of IEC 62232.

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>