

# INTERNATIONAL STANDARD



HORIZONTAL PUBLICATION

**Measurement of DC magnetic, AC magnetic and AC electric fields from 1 Hz to 100 kHz with regard to exposure of human beings –  
Part 1: Requirements for measuring instruments**



**THIS PUBLICATION IS COPYRIGHT PROTECTED**  
**Copyright © 2024 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 Secretariat  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[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 corrigendum or an amendment might have been published.

**IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)**

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 It also gives information on projects, replaced and withdrawn publications.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 once a month by email.

**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: [sales@iec.ch](mailto:sales@iec.ch).

**IEC Products & Services Portal - [products.iec.ch](http://products.iec.ch)**

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

**Electropedia - [www.electropedia.org](http://www.electropedia.org)**

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.



IEC 61786-1

Edition 1.1 2024-07  
CONSOLIDATED VERSION

# INTERNATIONAL STANDARD



HORIZONTAL PUBLICATION

**Measurement of DC magnetic, AC magnetic and AC electric fields from 1 Hz to 100 kHz with regard to exposure of human beings  
Part 1: Requirements for measuring instruments**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 17.220.20

ISBN 978-2-8322-9461-1

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

## CONTENTS

|  |    |
|--|----|
| FOREWORD   | 5  |
| 1 Scope  | 7  |
| 2 Normative references                               | 7  |
| 3 Terms and definitions                              | 8  |
| 3.1 Meters   | 8  |
| 3.2 Meter characteristics                            | 9  |
| 3.3 Field characteristics                            | 10 |
| 3.4 Measurements                                     | 11 |
| 4 Symbols  | 2  |
| 5 Instrumentation specifications                     | 13 |
| 5.1 General  | 13 |
| 5.2 Measurement uncertainty                          | 13 |
| 5.3 Magnitude range                                  | 14 |
| 5.4 Pass-band  | 14 |
| 5.5 Operating temperature and humidity ranges        | 14 |
| 5.6 Power supplies                                   | 14 |
| 5.7 Readability of scale                             | 15 |
| 5.8 Instrument dimensions and choice of probe        | 15 |
| 5.8.1 General <del>schema</del> schematic            | 15 |
| 5.8.2 Magnetic field meter                           | 15 |
| 5.8.3 Electric field meter                           | 16 |
| 5.8.4 Support for electric field meter               | 16 |
| 5.9 Electromagnetic compatibility                    | 16 |
| 5.9.1 Immunity                                       | 16 |
| 5.9.2 Emissions                                      | 17 |
| 5.10 Crest factor                                    | 18 |
| 5.11 Durability                                      | 18 |
| 5.12 Weight  | 19 |
| 5.13 Instrumentation choice                          | 19 |
| 6 Calibration  | 19 |
| 6.1 General  | 19 |
| 6.2 Calibration procedure                            | 19 |
| 6.2.1 General  | 19 |
| 6.2.2 Magnetic field calibration system              | 19 |
| 6.2.3 Electric field calibration system              | 20 |
| 6.2.4 Three-axis probes calibration                  | 20 |
| 6.2.5 Calibration values                             | 21 |
| 6.2.6 Calibration uncertainty                        | 21 |
| 6.3 Calibration documentation                        | 22 |
| 7 Verification                                       | 23 |
| Annex A (normative) Calibration methods              | 24 |
| A.1 Calibration of magnetic flux density meters      | 24 |
| A.1.1 Using magnetic field generation                | 24 |
| A.1.2 Voltage injection method                       | 28 |
| A.1.3 Comparison with reference magnetic field meter | 29 |
| A.2 Calibration of electric field strength meters    | 30 |

|   |   |    |
|---|---|----|
| A.2.1   | Electric field generation method.....                         | 30 |
| A.2.2   | Current injection method.....                                 | 34 |
| A.2.3   | Comparison with electric field reference .....                | 34 |
| Annex B (informative)   | Example of calibration uncertainty.....                       | 35 |
| Annex C (informative)   | General characteristics of magnetic and electric fields ..... | 37 |
| C.1   | General.....  | 37 |
| C.2   | Polarisation.....   | 37 |
| C.3   | Characteristics of magnetic field .....                       | 38 |
| C.4   | Characteristic of electric field.....                         | 39 |
| Annex D (informative)   | Magnetic flux density meters (magnetic field meters) .....    | 41 |
| D.1   | General characteristics of magnetic field meters .....        | 41 |
| D.2   | Theory of operation (coil probes) .....                       | 42 |
| D.3   | Static magnetic field-measuring instrumentation .....         | 44 |
| Annex E (informative)   | Electric field strength meters (electric field meters) .....  | 45 |
| E.1   | General characteristics of electric field meters .....        | 45 |
| E.2   | Theory of operation.....                                      | 45 |
| E.2.1   | Free-body meters .....  | 45 |
| E.2.2   | Ground reference meters.....                                  | 47 |
| Annex F (informative)   | Influence of humidity on electric field measurement.....      | 49 |
| F.1   | Measurement conditions .....                                  | 49 |
| F.2   | Results .....   | 49 |
| Annex G (informative)   | Units.....  | 51 |
| G.1   | Units .....   | 51 |
| G.2   | SI units and SI derived units .....                           | 51 |
| G.3   | Useful physical constants.....                                | 51 |
| Bibliography.....   |   | 52 |
| Figure 1 – <del>Schema</del> Schematic of a field meter.....  |   | 15 |
| Figure 2 – Insulating tripod and offset rod for an electric field probe (photograph RTE).....   |   | 16 |
| Figure 3 – Electric field measurement using a hand-held stick (photograph RTE).....   |   | 16 |
| Figure A.1 – Deviation in percentage departure of calculated axial field [7].....   |   | 24 |
| Figure A.2 – Coordinate system and geometry of rectangular loop of many turns of wire (see Equation (A.1)) .....  |   | 25 |
| Figure A.3 – Circular Helmholtz coils .....   |   | 26 |
| Figure A.4 – Deviation in percentage of calculated $B_z$ from centre value (see Equation (A.4)).....  |   | 27 |
| Figure A.5 – Schematic view of a circuit for calibration of magnetic field meter using a square loop to produce a known field.....                                      |   | 27 |
| Figure A.6 – Diagram for voltage injection technique .....  |   | 29 |
| Figure A.7 – Calculated normalized electric field at plate surfaces and midway between plates as a function of the normalized distance from the edge of the plate ..... |   | 30 |
| Figure A.8 – Parallel plates system for calibrating free-body electric field meters.....  |   | 32 |
| Figure A.9 – Arrangement with parallel plates orientated perpendicular to the floor.....  |   | 33 |
| Figure A.10 – Diagram for current injection technique.....  |   | 34 |
| Figure C.1 – Oscillating and rotating field quantities for cases of elliptical polarization, linear polarization, and circular polarization .....                       |   | 38 |
| Figure C.2 – Magnetic field from current in straight and circular conductors.....   |   | 39 |

|   |    |
|---|----|
| Figure C.3 – Perturbation of electric field distribution by a person (from IEC 62226-3-1).....                                  | 40 |
| Figure C.4 – Proximity effect with a 25 kV line and a building (from IEC 62110).....  | 40 |
| Figure D.1 – Schematic view of simple magnetic field meter with coil-type probe.....  | 41 |
| Figure D.2 – Approximate equivalent circuit of a coil probe when connected to the detector.....                                 | 43 |
| Figure E.1 – Single-axis free-body meter geometries.....  | 46 |
| Figure E.2 – Designs for flat plate probes used with ground-referenced electric field meters.....                               | 47 |
| Figure F.1 – Test in the climatic chamber with the normal tripod (left) and the offset tripod (right) (photograph EDF R&D)..... | 49 |
| Figure F.2 – E field measured as a function of the humidity with a normal tripod.....   | 50 |
| Figure F.3 – E field measured as a function of the humidity with an offset tripod.....  | 50 |
| Table 1 – Mains terminal disturbance voltage limits for class B group 1 equipment measured on a test site.....                  | 18 |
| Table A.1 – Calculated normalized electric field values midway between plates and at plate surfaces.....                        | 32 |
| Table B.1 – Example of uncertainty calculation.....   | 35 |

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

# MEASUREMENT OF DC MAGNETIC, AC MAGNETIC AND AC ELECTRIC FIELDS FROM 1 Hz TO 100 kHz WITH REGARD TO EXPOSURE OF HUMAN BEINGS –

## Part 1: Requirements for measuring instruments

### 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, accept 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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

**This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.**

**IEC 61786-1 edition 1.1 contains the fifth edition (2013-12) [documents 106/292/FDIS and 106/298/RVD] and its amendment 1 (2024-07) [documents 106/647/FDIS and 106/655/RVD].**

**In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.**

International Standard IEC 61786-1 has been prepared by IEC technical committee 106: Methods for the assessment of electric, magnetic and electromagnetic fields associated with human exposure.

The first editions of IEC 61786-1 and IEC 61786-2 replace IEC 61786:1998. Part 1 deals with measuring instruments, and Part 2 deals with measurement procedures. The content of the standard was revised in order to give up-to-date and practical information to the user.

It has the status of a horizontal standard in accordance with IEC Guide 108.

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

A list of all parts of the IEC 61786 series, published under the general title *Measurement of DC magnetic fields and AC magnetic and electric fields from 1 Hz to 100 kHz with regard to exposure of human beings*, can be found on the IEC website.

The committee has decided that the contents of this document and its amendment will remain unchanged until the stability date indicated on the IEC website under [www.iec.ch](http://www.iec.ch) in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

**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.**

# MEASUREMENT OF DC MAGNETIC, AC MAGNETIC AND AC ELECTRIC FIELDS FROM 1 Hz TO 100 kHz WITH REGARD TO EXPOSURE OF HUMAN BEINGS –

## Part 1: Requirements for measuring instruments

### 1 Scope

This part of IEC 61786 provides guidance for measuring instruments used to measure the field strength of quasi-static magnetic and electric fields that have a frequency content in the range 1 Hz to 100 kHz and with DC magnetic fields to evaluate the exposure levels of the human body to these fields.

Sources of fields include devices that operate at power frequencies and produce power frequency and power frequency harmonic fields, as well as devices that produce fields within the frequency range of this document, including devices that produce static fields, and the earth's static magnetic field. The magnitude ranges covered by this standard are 0,1  $\mu$ T to 200 mT in AC (1  $\mu$ T to 10 T in DC) and 1 V/m to 50 kV/m for magnetic fields and electric fields, respectively.

When measurements outside this range are performed, most of the provisions of this standard will still apply, but special attention should be paid to specified uncertainty and calibration procedures.

Specifically, this standard

- defines terminology;
- identifies requirements on field meter specifications;
- indicates methods of calibration;
- defines requirements on instrumentation uncertainty;
- describes general characteristics of fields;
- describes operational principles of instrumentation.

NOTE Measurement methods that achieve defined goals pertaining to assessment of human exposure are described in IEC 61786-2.

Sources of uncertainty during calibration are also identified. In regard to electric field measurement, this standard considers only the measurement of the unperturbed electric field strength at a point in free space (i.e. the electric field prior to the introduction of the field meter and operator) or above conducting surfaces.

This horizontal standard is primarily intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 108.

One of the responsibilities of a technical committee is, wherever applicable, to make use of horizontal standards in the preparation of its publications. The contents of this horizontal standard will not apply unless specifically referred to or included in the relevant publications.

### 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