BS EN 60118-4:2015

BSI Standards Publication

Electroacoustics — Hearing aids

Part 4: Induction-loop systems for hearing aid purposes — System performance requirements

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National foreword

This British Standard is the UK implementation of EN 60118-4:2015. It is identical to IEC 60118-4:2014. It supersedes BS EN 60118-4:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/29, Electroacoustics.

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.

Published by BSI Standards Limited 2014

ISBN 978 0 580 79122 2
ICS 17.140.50

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

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 28 February 2015.

Amendments issued since publication

Amd. No.	Date	Text affected

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 60118-4

February 2015

ICS 17.140.50

Supersedes EN 60118-4:2006

English Version

Electroacoustics - Hearing aids - Part 4: Induction-loop systems for hearing aid purposes - System performance requirements (IEC 60118-4:2014)

Électroacoustique - Appareils de correction auditive - Partie 4: Systèmes de boucles d'induction utilisées à des fins de correction auditive - Exigences de performances système (IEC 60118-4:2014)

Akustik - Hörgeräte - Teil 4: Induktionsschleifen für Hörgeräte - Leistungsanforderungen (IEC 60118-4:2014)

This European Standard was approved by CENELEC on 2015-01-15. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 60118-4:2015 E

Foreword

The text of document 29/855/FDIS, future edition 3 of IEC 60118-4, prepared by IEC TC 29, Electroacoustics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60118-4:2015.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-10-15
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2018-01-15

This document supersedes EN 60118-4:2006.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 60118-4:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61938	NOTE	Harmonised as EN 61938.
IEC 61260-1	NOTE	Harmonised as EN 61260-1.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60268-3	2013	Sound system equipment -- Part 3: Amplifiers	EN 60268-3	2013
IEC 60268-10	1991	Sound system equipment -- Part 10: Peak programme level meters	HD 483.10 S1	1993
IEC 61672-1	2013	Electroacoustics - Sound level meters -- Part 1: Specifications	EN 61672-1	2013
IEC 62489-1	2010	Electroacoustics - Audio frequency induction loop systems for assisted hearing -- Part 1: Methods of measuring and specifying the performance of system components	EN 62489-1	2010

CONTENTS

INTRODUCTION

Audio-frequency induction-loop systems are widely used to provide a means for hearing aid users, whose hearing aids are fitted with induction pick-up coils, generally known as 'telecoils', to minimise the problems of listening when at a distance from a source of sound, shielded from the person speaking by a protective window, and/or in a background noise. Background noise and distance are two of the main causes of hearing aid users being unable to hear satisfactorily in other than face-to-face quiet conditions. Induction-loop systems have been widely installed in churches, theatres and cinemas, for the benefit of hearing-impaired people. The use of induction-loop systems has been extended to many transient communication situations such as ticket offices, bank counters, drive-in/drive-through service locations, lifts/elevators etc. The widespread provision of telephone handsets that provide inductive coupling to hearing aids is another significant application, where ITU-T Recommendation P370 [1][1] applies.

Transmission of an audio-frequency signal via an induction-loop system can often establish an acceptable signal-to-noise ratio in conditions where a purely acoustical transmission would be significantly degraded by reverberation and background noise.

One form of audio frequency induction-loop system comprises a cable installed in the form of a loop usually around the perimeter of a room or area in which a group of hearing impaired persons wish to listen. The cable is connected via an amplifier to a microphone system or other source of audio signal, such as a radio receiver, CD player etc. The amplifier produces an audio-frequency electric current in the induction loop cable, causing a magnetic field to be produced inside the loop. The design and implementation of the induction loop is determined by the construction of the building in which it is installed, particularly by the presence of large amounts of iron, steel or aluminium in the structure. In addition the layout and position of electrical cables and equipment may generate high levels of background audio frequency magnetic fields that may interfere with the reception of the loop signal.

Another form of induction-loop system employs a small loop, intended for communication with a hearing-aid user in its immediate vicinity. Examples are: neck loops, ticket-counter systems, self-contained 'portable' systems and chairs incorporating induction loops. (See Annex A)

The pick-up device for an audio-frequency induction-loop system is usually a personal hearing aid, of a type fitted with a pick-up coil (telecoil); however, special induction loop receivers may be used in certain applications.

1 Numbers in square brackets refer to the Bibliography.

ELECTROACOUSTICS – HEARING AIDS –

Part 4: Induction-loop systems for hearing aid purposes – System performance requirements

1 Scope

This part of IEC 60118 is applicable to audio-frequency induction-loop systems producing an alternating magnetic field at audio frequencies and intended to provide an input signal for hearing aids operating with an induction pick-up coil (telecoil). Throughout this standard, it is assumed that the hearing aids used with it conform to all relevant parts of IEC 60118.

This standard specifies requirements for the field strength in audio-frequency induction loops for hearing aid purposes, which will give adequate signal-to-noise ratio without overloading the hearing aid. The standard also specifies the minimum frequency response requirements for acceptable intelligibility.

Methods for measuring the magnetic field strength are specified, and information is given on appropriate measuring equipment (see Annex B), information that should be provided to the operator and users of the system (see Annex C), and other important considerations.

This standard does not specify requirements for loop driver amplifiers or associated microphone or audio signal sources, which are dealt with in IEC 62489-1, or for the field strength produced by equipment, such as telephone handsets, within the scope of ITU-T P.370.

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.

IEC 60268-3:2013, *Sound system equipment – Part 3: Amplifiers*

IEC 60268-10:1991, *Sound system equipment – Part 10: Peak programme level meters*

IEC 61672-1:2013, *Electroacoustics – Sound level meters – Part 1: Specifications*

IEC 62489-1:2010, *Electroacoustics – Audio-frequency induction-loop systems for assisted hearing – Part 1: Methods of measuring and specifying the performance of system components*

3 Terms and definitions

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

3.1
reference magnetic field strength level
level of 0 dB referred to a magnetic field strength of 400 mA/m

Note 1 to entry: This is measured as specified in 8.2.

3.2
useful magnetic field volume
volume (of 3-dimensional space) within which the system provides hearing-aid users with a signal of acceptable quality (see 8.4)

Note 1 to entry: In the first edition of this standard, the concept of 'specified magnetic field area' was defined, because that edition did not consider the very important 'height' dimension (the perpendicular distance between the hearing aid pick-up coil and the plane of the loop). See Annex E.

Note 2 to entry: The base area of the useful magnetic field volume is often different from the plan area of the induction loop.

3.3
telecoil
inductor with an open magnetic circuit, intended for detecting the magnetic fields of audio-frequency induction-loop systems

4 General

4.1 Procedure for setting up and commissioning an audio-frequency induction loop system

The flow chart in Figure 1 shows the sequence of operations detailed in this standard.

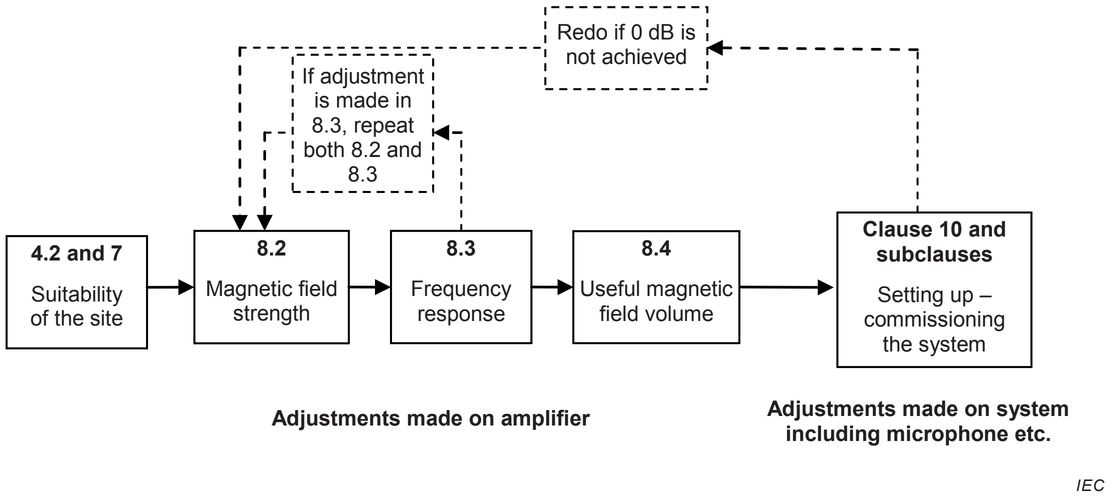


Figure 1 – Flow chart for the operations in this standard

4.2 Suitability of the site for the installation of an audio-frequency induction-loop system

It may not be possible to obtain acceptable conditions for an induction-loop system in all places where it is desirable. It is therefore essential, ***in the planning stage***, to examine a proposed location with respect to the following conditions:

- the magnetic noise level from electric installations, e.g. heating systems in the floor or roof, the electrical control of lighting systems (especially in theatres), (see Clause 7);
- the influence of magnetizable and electrically-conducting materials in the structure in which the loop is intended to be installed;
- the presence of other induction-loop systems in the neighbourhood, the signals of which may interfere with that of the planned loop system.

NOTE Techniques exist to reduce the magnetic field strength outside an induction loop, but previously-installed systems may not be so designed.

4.3 Relation of the magnetic field strength level at the telecoil to the sound pressure level at the microphone.

An acoustic input sound pressure level of 70 dB and a long-term average magnetic field strength level ($L_{eq,60\ s}$) of −12 dB ref. 400 mA/m, i.e. 100 mA/m, at the telecoil in a hearing aid are assumed to give the same acoustic output level.

5 Using components of a sound system in an induction-loop system

5.1 General

It may seem economically attractive to derive signals for an induction-loop system from a sound system serving the same space, but it may not be technically straightforward.

5.2 Microphones

Microphones for a sound system may not be positioned at the optimum places to obtain a signal as free as possible from ambient acoustic noise and reverberation. It is essential to listen to the signal, preferably with high-quality headphones, to assess its suitability. This should be done for all microphone signals that the sound system can produce in different modes or configurations.

5.3 Mixer

The signal for the induction-loop system shall be taken from the mixer at a point where the level of that signal is controlled independently from the signal level in the chain leading to the loudspeakers of the sound system.

5.4 Power amplifier

It is possible that a suitable signal can be obtained from the output of a power amplifier, but such a signal can be satisfactory only if it is applied to an induction-loop amplifier provided with an input of appropriate sensitivity and impedance, and with automatic gain control of a range sufficient to accommodate changes in the signal level in the sound system.

In general, it is not advisable to attempt to derive from a sound system a signal suitable for connection directly to an induction loop. Such an interconnection must be individually designed to suit the electrical characteristics of the sound system and the loop system.

6 Meters and test signals

6.1 Meters

6.1.1 Meters in general

For historical reasons, two types of magnetic field strength meter are in use, and it is not practicable to disallow the use of either of them. The results of measurements with the two types of meters are exactly equal only for sinusoidal signals but in most cases the differences are not so large as to cause serious problems. Indications are given in this standard of differences that may be expected in some cases. In case of doubt, the result of measurement with the meter specified in 6.1.3 shall be definitive.

6.1.2 Requirements common to both types

The meter shall have a frequency response flat within ± 1 dB from 50 Hz to 10 kHz, falling at an ultimate rate of at least 6 dB/octave outside this range. A-weighting shall also be provided. The frequency response in A-weighted mode shall conform, within the frequency band 100 Hz to 5 kHz, to those for a Class 2 meter specified in IEC 61672-1. Other features can also be provided, such as other weighting characteristics.

6.1.3 True-r.m.s. meter

This meter was derived from the IEC sound level meter specified in IEC 61672-1 by replacing the microphone by a magnetic pick-up coil and an amplifier with frequency response correction. This meter has a true-r.m.s. detector and a 125 ms averaging time constant in 'F' mode.

A useful additional feature is a peak-hold indication.

6.1.4 Peak programme meter (PPM)

This meter was derived from the PPM Type II specified in IEC 60268-10 by adding a magnetic pick-up coil, usually together with a modern display (preferably a 'bar' type) in place of the original moving-coil pointer instrument.

It shall have dynamic responses conforming to the relevant requirements of IEC 60268-10, i.e. an attack time-constant of approximately 5 ms and a release time-constant of approximately 1,0 s.

6.2 Test signals in general

It is possible to use several different types of test signal for the setting-up and measurement of the frequency mid-band value (in case of doubt, the average value over the octave band centred on 1 kHz) and the frequency response of the magnetic field strength. However, some signals are not suitable for some purposes, and the suitability depends on the amplitude characteristic of the amplifier in the system (see IEC 62489-1). Table 1 shows the range of applications of the specified test signals. The test signal specified by the amplifier manufacturer shall be used, unless the use of a different signal can be justified.

Table 1 – Application of signals

Clause number and measurement in this standard (unless otherwise specified)	Sine wave	Pink noise	Simulated speech	Reference speech	Combi	Other
IEC 62489-1 Amplitude characteristic	Y	N	N	N	Y	N
7.1 Magnetic noise level	N	N	N	N	N	Y (no signal)
8.2 Magnetic field strength	Y	Y	Y	Y	Y	N
8.3 Frequency response	Y	Y	See Note to 8.3.2	N	Y	N
10.1 Commissioning the system	N	N	N	Y	N	Y (real signals)

The use of a wideband signal and wideband meter to determine the achievement of the reference magnetic field strength requires a special procedure to prevent serious errors. First the magnetic background noise level shall be measured, to ensure sufficient signal to noise ratio, followed by the frequency response of the wanted magnetic field, after making any adjustments to the amplifier controls so as to achieve the flattest possible response. The achievement of the reference magnetic field strength can then be determined.

The frequency-response controls are set to achieve the flattest possible response, otherwise it is possible that the reference magnetic field strength is not achieved at 1 kHz. Particularly in rooms with metal reinforcement, this may cause considerable errors. Also, if the signal-to-noise ratio is not sufficient, particularly if there are strong components in the noise, this method may not be accurate.

6.3 Speech signals

6.3.1 Live speech signals

Live speech is suitable only for use as a test signal for the final verification (commissioning) of the operation of an induction-loop system. However, live speech is an essential element in the subjective assessment of loop systems.

6.3.2 Recorded speech material

Speech that has been recorded under controlled conditions and evaluated both subjectively and objectively may be used for test purposes. See also B.2.1.

6.3.3 Simulated speech material

6.3.3.1 General

Simulated or synthetic speech material contains the features of speech in terms of its amplitude, frequency components and temporal characteristics, but has no recognizable intelligibility.

6.3.3.2 ITU-T P.50

ITU-T P.50 [2] is accompanied by a CD containing a standardized form of synthetic speech. See also B.2.2.

6.3.3.3 Reference speech signal

The ISTS (International Speech Test Signal) [3] is recommended for making objective measurements. It was developed by EHIMA (European Hearing Instrument Manufacturers' Association) is derived from 21 female speakers in six different mother tongues (American English, Arabic, Chinese, French, German and Spanish) and is based on natural recordings but is largely non-intelligible because of segmentation and remixing. This was then analysed and compared to the original recordings in respect of different criteria (involving many time, frequency and amplitude distributions) and found to be entirely representative.

6.4 Pink noise signal

The signal shall be bandwidth limited, with a peak-to-peak voltage (as measured with an oscilloscope) to true r.m.s. voltage ratio of at least 18 dB (crest factor = 4), with a third-octave-band spectrum flat within ±1 dB from 100 Hz to 5 kHz.

Bandwidth limitation shall be carried out by means of at least one-third-order Butterworth high pass and low pass filters giving −3 dB responses at 75 Hz and 6,5 kHz. See also B.2.3.

NOTE 1 This specification is given to ensure that the test signal stimulates the system in a manner similar to normal speech.

NOTE 2 The tolerance of ±1 dB is necessary because the theoretical responses of the specified 3rd order Butterworth filters are –0,8 dB at 100 Hz and –0,7 dB at 5 kHz, and component tolerances affect the exact values. This effect is taken into account in the method of measuring frequency response using the pink noise signal.

6.5 Sinusoidal signal

The signal source should provide at least the three frequencies 100 Hz, 1 kHz and 5 kHz (one at a time or simultaneously, or both), with less than 2 % total harmonic distortion in a 20 kHz bandwidth. The output voltage should be capable of being set to the ranges 0 mV to 10 mV and 0 V to 1 V (so as to be suitable for microphone and line-level tests). The output source impedance should be 600 Ω or less.

A sinusoidal signal can be used for the tests specified in 8.2 and 8.3 if the amplitude characteristic of the amplifier (see IEC 62489-1) includes a range of input signal voltages for which the output current is proportional to the input voltage. Amplifiers with automatic gain control normally exhibit such a range. Amplifiers with expansion or more complex signal-processing cannot usually be measured satisfactorily, other than for the amplitude characteristic and the field strength produced at 1 kHz, with sinusoidal signals. See also 6.2.

6.6 Combi signal

This is a signal consisting of shaped tone-bursts of 1 kHz sine wave interleaved with pink noise, and as such is suitable for any measurements specified in this standard that the 1 kHz sine wave or pink noise signal is suitable for.

The level of the 1 kHz sine wave can be measured, and with an amplifier employing a peak detecting AGC (automatic gain control), the lower r.m.s levels of the pink noise segments mean that overall it produces considerably less heating in the amplifier, which is an advantage when test times are long.

The length of the 1 kHz sine wave is limited to a minimum of 1 s to allow either meter specified in 5.1 to reach the correct measurement level and become stable enough for accurate reading before the transition.

The duration of the pink noise signal shall be long enough in relation to that of the sine wave signal (ratio ≥ 4:1) in order to lower the overall amplifier heating, while providing reasonably frequent bursts of the sine wave signal for measurement purposes.

The specification of the combi signal is summarized in Table 2.

Table 2 – Specification of the combi signal

Characteristic	Sinusoidal part	Pink noise part	Notes
Frequency, kHz	1	Not applicable	
3 dB bandwidth, Hz	Not applicable	See 6.4 and B.2.3	
Rise and fall times, ms	5	Not applicable	All transitions between signals shall be at zero-crossings.
Relative (r.m.s.) levels, dB	0	–6	The peaks of the sine wave signal are 3 dB below the maximum peak of pink noise having a crest factor of 4.
Duration, s	≥1	≥4	These minimum values may be increased but not decreased, and the ratio of 4:1 shall not be reduced.

7 Magnetic background noise level of the installation site

7.1 Method of measurement

Measurements of magnetic noise levels shall be performed by using an A-weighting network in the measuring instrument. The measured values of the magnetic field strength, measured with a meter as specified in 6.1, with a pick-up coil whose magnetic axis is vertical (unless otherwise specified, see 8.1), shall be expressed as levels referred to the reference magnetic field strength level (see 3.1) in dB.

The induction-loop system, if already installed, shall be switched off, but all other equipment normally operated at the site shall be switched on and dimmable lighting shall be set to half-dimmed. The magnetic background noise level shall be measured at a sufficient number of points in the required useful magnetic field volume. The selection of points may be randomly distributed, but should be influenced by the height range of the users (normally 1,2 m for seated listeners and 1,7 m for standing listeners should be used), specific seating requirements, physical layout of the location and potential influence from metal and interfering signals.

NOTE It is useful to listen to the noise, to form a subjective impression of its spectrum, and thus the likely disturbing effect on listeners.

7.2 Recommended maximum magnetic noise levels

Ideally, the difference between the reference magnetic field strength level and the A-weighted magnetic background noise level, which for clarity is referred to as 'reference signal-to-noise ratio' in this standard, should be greater than 47 dB. This value is appropriate in situations where the aesthetic value of the speech is important and the background acoustic noise level is very low, i.e. in theatres and similar locations. Such low levels of magnetic (and acoustic – see Note 1) noise may not always be present.

NOTE 1 Hearing-aid users are exposed to acoustic noise at the site, as well as magnetic noise. There is normally no point in requiring a magnetic noise level far lower than the acoustic noise level as perceived by hearing-aid users, taking into account the effect of hearing loss on the audibility of the acoustic noise. However, this does not apply if the users wear ear-defenders.

In cases where communication takes priority over aesthetic considerations, a higher magnetic noise level may be tolerable. It should also be considered that high levels of magnetic background noise can be tiring and thus should only be tolerated where the communication is of a short and essential nature. For this reason, a signal-to-noise ratio of 32 dB is recommended as a minimum. If the actual ratio is less than 32 dB, this shall be reported and agreed with the system operator, so that consideration can be given to remedial measures.

Under some circumstances, a signal-to-noise ratio of 32 dB might be unacceptable.

However, if the magnetic noise has no significant undesirable tonal quality or is mostly at low frequencies, then a higher level of interfering signal may be acceptable. For example, a reference signal-to-noise ratio as low as 22 dB may be tolerable for short periods only. The actual audible impact of the interfering signal should then be considered in assessing whether the overall benefit of the system to hearing-aid users is preferable to the absence of a loop system or the use of an alternative technique requiring a special receiver (i.e. infra-red or radio).

NOTE 2 Such a system can be used only with headphones suitable for hearing aid wearers, or accessories, such as wireless modules, giving a direct electrical input to the hearing aid, because, if a neck loop were used, the magnetic background noise would be picked up by a hearing aid switched to ‘T’.

8 Characteristics to be specified, methods of measurement and requirements

8.1 General

The manufacturer of the system (and in some cases, the amplifier alone) should specify values for those characteristics that are independent of the particular installation. The installer should measure the values of those characteristics that are specific to the installation, and provide the results to the system operator for future reference.

Measurements shall be made with a receiver having the pick-up coil axis vertical, unless specifically requested due to a special situation. These may be encountered in places of worship, hospitals and recovery areas, where people may be kneeling, prone or supine.

Where these situations exist, all measurements shall be made with the measuring receiver positioned at the appropriate orientation. The recommendations for background interfering signal levels and the requirements for field strength and frequency response remain unchanged from the requirements for a normal system.

The levels of speech signals, and ambient magnetic noise levels, may vary over periods of several seconds or even minutes. It is important to observe the signal levels for a sufficient time so that such variations can be observed and taken into account.

During the measurements, the induction-loop system shall be operated under the conditions deemed to be normal during use. Other power installations such as lighting shall be adjusted to the conditions deemed to be normal during the use of the induction-loop system.

A warm up time of at least 10 min shall be allowed before any measurements take place. When changing the input levels to the system, consideration shall be given to the release time of the AGC circuit, if any, which may be several tens of seconds.

The characteristics of AGC circuits vary, and this may affect the results of measurements on the installed loop system. If the AGC characteristics of the amplifier are not known, the relevant measurements specified in IEC 62489-1 should be carried out first.

AGC does not create short-term non-linear distortion, and it is necessary to distinguish between gain changes which are needed to keep the average signal level fairly constant while maintaining linear short-term amplification and actual transfer characteristic non-linearities introduced by some specialized signal processing, which change the peak-to-average ratio. A correctly-performing AGC system is not non-linear over short time intervals (milliseconds) in common understanding.

The methods of measurement using different signals are alternatives: it is required to use one method only, but results for different methods may be presented if desired. If such results differ, the results of measurements using the methods specified in this standard, or used or recommended by the manufacturer, are definitive.

8.2 Magnetic field strength

8.2.1 Characteristic to be specified

The maximum value of the magnetic field strength, measured with a meter as specified in 5.1 and a pick-up coil whose magnetic axis is vertical (unless otherwise specified – see 6.1), produced by the system at one point, at least, within the useful magnetic field volume (see 8.4).

The methods of measurement given in 8.2.2 to 8.2.5 are based on the use of an amplifier which has a 'loop drive' gain control following an AGC stage, and are intended ONLY to show that the amplifier is capable of producing the required magnetic field strength. If such a control is not provided, the manufacturer's instructions shall nevertheless be followed. In order to determine that the whole system is capable of producing the required magnetic field strength from the microphone(s) and any other signal source(s), the procedure described in Clause 10 is necessary.

8.2.2 Method of measurement with a simulated speech signal

Apply the simulated speech signal specified in 6.3.3 to the amplifier and adjust its controls in accordance with the manufacturer's instructions so that the requirements specified in 8.4 are satisfied.

8.2.3 Method of measurement with pink noise

Apply the pink noise signal specified in 6.4 to the amplifier and adjust its controls in accordance with the manufacturer's instructions until the requirements specified in 8.4 are satisfied.

8.2.4 Method of measurement with a sinusoidal signal

Apply a 1 kHz sinusoidal signal to the amplifier and adjust its controls in accordance with the manufacturer's instructions until the requirements specified in 8.4.3 are satisfied.

NOTE The manufacturer is free to specify a maximum duration of the test, which is long enough to perform the measurement but does not result in excessive temperature rise in the amplifier.

8.2.5 Method of measurement with a combi signal

Apply the combi signal specified in 6.6 to the amplifier and adjust its controls in accordance with the manufacturer's instructions until the requirements specified in 8.4 are satisfied. For an instrument with the 0,125 s averaging time, a peak hold feature is particularly useful for this measurement.

8.2.6 Method of measurement – Other

Not applicable.

8.2.7 Requirements

The maximum value of the magnetic field shall be 400 mA/m, measured with a meter as specified in 6.1, and a sinusoidal test signal (or equivalent combi signal, see 6.6). Because of the peak-detecting AGC used in most amplifiers, other signals are likely to give different measured values, depending on which type of meter is used.

If the manufacturer recommends the use of a peak programme meter and a non-sinusoidal test signal, the measured value of magnetic field strength obtained with the specified test signal, fully activating the AGC circuit, shall be specified, when the amplifier is set up to produce, from a sinusoidal test signal also fully activating the AGC circuit, a field strength of 400 mA/m, measured with a meter as specified in 6.1.

Typical values for the field strengths to be produced by the different test signals, when an amplifier with peak-detecting AGC is set up to produce 400 mA/m with a sinusoidal signal, are given in Table 3. For an amplifier with AGC which is not peak-detecting, the differences are often much smaller and may be negligible.

Table 3 – Magnetic field strengths typically produced by different test signals, with an amplifier having peak-detecting AGC

Test signal	Level referred to 400 mA/m dB	
	RMS (using meter specified in 6.1.3)	PPM (using meter specified in 6.1.4)
Sinusoidal (1 kHz)	0	0
Pink noise (see 6.4)	–6	0
EHIMA ISTS reference speech	0	0
Combi	As sinusoidal and noise components	0

Because of the short averaging time, the meter reading produced by pink noise or simulated (or real) speech fluctuates. The measurement should be taken over approximately 60 s and the maximum indication read (see also B.3.1.2). If the meter offers a peak hold facility, with the 0,125 s averaging time, this should be used in preference.

NOTE It is inherent in the nature of noise and speech signals that short-duration peaks occur which considerably exceed the 0,125 s r.m.s. value and can cause clipping of the signal current. It has been shown that, unless very severe, such clipping has no significant effect on speech intelligibility. See [4].

8.3 Frequency response of the magnetic field

8.3.1 Characteristic to be specified

The frequency response of the magnetic field strength, measured with a pick-up coil whose magnetic axis is vertical (unless otherwise specified, see 8.1).

8.3.2 Method of measurement with a simulated speech signal

Proceed as follows.

a) Apply the simulated speech signal specified in 6.3.3.3 to the amplifier and adjust its controls in accordance with the manufacturer's instructions on the conditions under which the frequency response shall be measured (see IEC 62489-1).
b) Measure the one-third-octave band spectrum of the signal source.
c) Measure the one-third-octave band spectrum of the magnetic field at a sufficient number of points within the usable magnetic field volume.
d) Subtract the results of b) from the results of c), so as to make the final results independent of the spectrum of the source.

NOTE The use of simulated speech or other signals of similar complexity for measuring frequency response is rather difficult to carry out accurately, and is more suited to research and development applications than for commissioning.

8.3.3 Method of measurement with pink noise

Proceed as follows.

a) Apply the pink noise signal specified in 6.4 to the amplifier and adjust its controls in accordance with the manufacturer's instructions on the conditions under which the frequency response shall be measured (see Clause C.4).
b) Measure the one-third-octave spectrum of the signal source.
c) Measure the one-third-octave spectrum of the magnetic field at a sufficient number of points within the usable magnetic field volume.
d) Subtract the results of b) from the results of c), so as to make the final results independent of the spectrum of the source.

Measurements shall be made at least in the one-third-octave bands centred on 100 Hz, 1 kHz and 5 kHz, at a sufficient number of points within the useful magnetic field volume (see 8.4). Preferably, an analysis should be made of the variation of frequency response within the volume, and the one-third-octave band centred on 5 kHz is recommended for the initial test. This is to ensure that any spurious losses due to conductive metal structures are identified.

8.3.4 Method of measurement with a sinusoidal signal

Proceed as follows.

a) Apply the sinusoidal signal specified in 6.5 to the amplifier and adjust its controls in accordance with the manufacturer's instructions on the conditions under which the frequency response shall be measured (see Clause C.4), so that the amplifier is operating below the threshold of AGC, as specified by the manufacturer or determined according to IEC 62489-1.

   NOTE 1 The manufacturer is free to specify the magnetic field strength at 1 kHz at which the measurement is made.

   NOTE 2 This method is not suitable for use with amplifiers that do not have a linear relationship between output current and input voltage at any input signal level. See Clause C.4.

b) Measure the magnetic field strength produced.

c) Measurements shall be made at least at 100 Hz, 1 kHz and 5 kHz, at a sufficient number of points within the useful magnetic field volume (see 8.4). Preferably, an analysis should be made of the variation of frequency response within the volume, and a frequency of 5 kHz is recommended as a primary test frequency. This is to ensure that any spurious losses due to conductive metal structures are identified.

8.3.5 Method of measurement with combi signal

Proceed as follows.

a) Apply the combi signal as specified in 6.6 to the amplifier and adjust its controls in accordance with the manufacturer's instructions on the conditions under which the frequency response shall be measured (see Clause C.4).

b) Using the meter specified in B.3.3, with no additional long-term averaging, measure the one-third-octave spectrum of the signal source and magnetic field as specified in 8.3.3 b) to d), but ignore the results obtained during the sine wave burst part of the combi signal.

8.3.6 Method of measurement – Other

Not applicable.

8.3.7 Requirements

The frequency response shall be within the range ±3 dB with reference to the response at 1 kHz, from 100 Hz to 5 000 Hz.

8.4 Useful magnetic field volume

8.4.1 Characteristic to be specified

The volume within which the requirements recommended or specified in Clause 7, 8.2.7, 8.3.7 and 10.2.7 are met.

8.4.2 Methods of measurement

See Clause 7, 8.2, 8.3 and 10.2. The measurements shall be made at a sufficient number of points in the predicted or required useful magnetic field volume. The selection of points should be influenced by where the users are likely to be, their range of heights, specific seating requirements, the physical layout of the location and potential influence from metal and interfering signals. Normally, measurement heights of 1,2 m for seated listeners and 1,7 m for standing listeners should be used.

8.4.3 Requirements

The measured levels of magnetic field strength at the selected points shall be within ± 3dB of the level specified according to 8.2.7. This does not apply to small volume systems, for which a wider range is acceptable. See Clause 9 and Annex A. For the other characteristics, the recommendations in Clause 7, and the requirements in 8.3.7 and 10.2.7 apply.

9 Small-volume systems

9.1 Inapplicability of the 'useful magnetic field volume' concept

For these systems it is possible and necessary to specify in the standard the positions of the measurement points and not to use the 'useful magnetic field volume' concept, whereas for other systems it is not possible, so for the latter the 'useful magnetic field volume' approach taken in Clause 8 is appropriate.

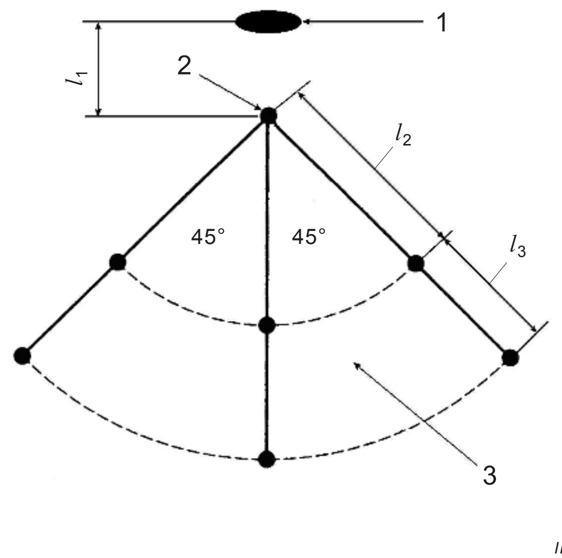
9.2 Disabled refuge and similar call-points

Unless specifically replaced by contractual requirements, measurements shall be made at the six points specified in Figure 2. The reference point (or line) is the face or surface of the call-point, intercom, or help point closest to the user, and is not necessarily the location of the magnetic field source.

The semi-circular layout is more suitable for small magnetic field sources and the rectangular layout is more suitable for vertical or floor loop sources. Only one of the diagrams shall be used for a given system.

NOTE An offset between the reference point (or line) and the position of the magnetic field source promotes evenness of field pattern over the area where people are expected to stand.

Dimensions in millimetres



Key

1 magnetic field source

2 reference point

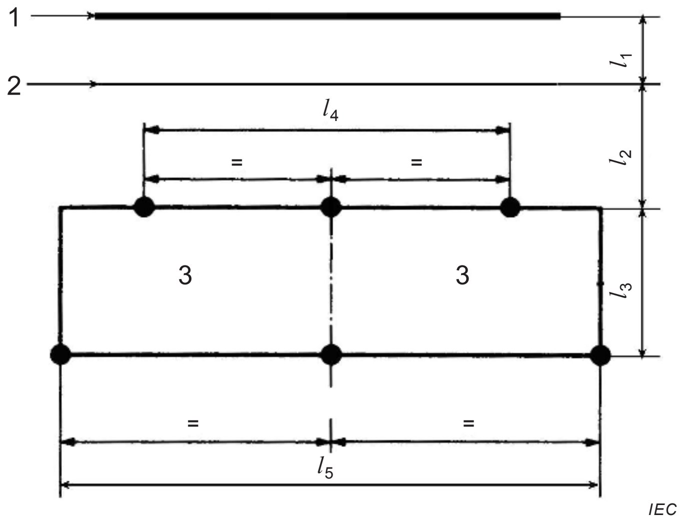
3 area where people are expected to stand

l_1 offset

l_2 inner radius 300

l_3 outer radius 200

a) Magnetic field source of small dimensions



Key

1 magnetic field source (vertical loop)

2 reference line

3 area where people are expected to stand

l_1 offset l_3 200 l_5 700

l_2 300 l_4 424

b) Larger magnetic field source

Figure 2 – Measurement points for disabled refuge and similar call-points

The six measurement points are required at both 1,2 m and 1,7 m. See Figure 3 b), but there is no requirement to measure at a height of 1,45 m.

9.3 Requirements for disabled refuge and similar call-points

Unless specifically replaced by contractual requirements, the system shall comply with the requirements specified in 9.3 and 8.3.7 at all measurement points specified in Figure 2, across both vertical and horizontal ranges. The magnetic field strength level at these points shall be ±6 dB ref. 400 mA/m, measured according to 8.2. At one point at least, it shall be ≥0 dB ref. 400 mA/m.

The magnetic field strength level shall not be above +8 dB ref. 400 mA/m in the area where people are expected to stand.

NOTE 1 This high field strength is inevitable for a simple vertical loop of practicable dimensions. If the signal is too loud or distorted, the user can just move a short distance further away from the source of the magnetic field.

NOTE 2 Clauses 4 and 7 deal with the subject of magnetic background noise level. It is not practicable to specify a requirement, as this might rule out the provision of a system that would be at least helpful to users.

9.4 Counter systems

Unless specifically replaced by contractual requirements, measurements shall be made at the points specified in Figure 3. The reference point is the face or surface of the counter closest to the user, and is not necessarily the position of the magnetic field source.

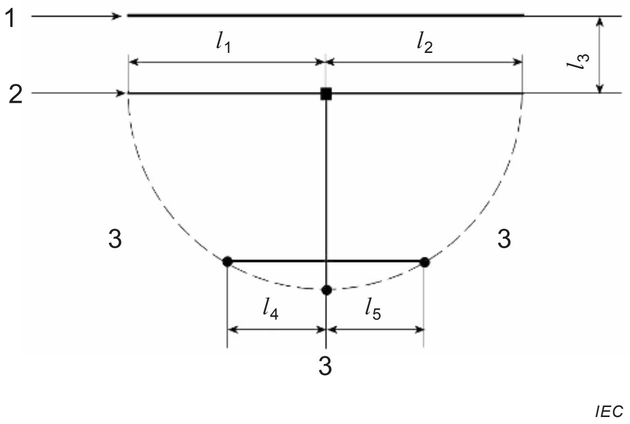
For counter systems there is often a requirement to control overspill to an adjacent counter position. Controlling this overspill is likely to be a significant factor in design, and as such may result in a compromise of evenness of field over the area where people are expected to stand.

NOTE 1 It is not necessary to reduce the magnetic spill between counter positions below a level comparable with the acoustic spill. A difference greater than 20 dB between equivalent positions at the two counters could be enough.

NOTE 2 The boundaries of the area where people are expected to stand cannot be standardized as they depend on the building layout and other factors.

NOTE 3 For vertical loops, an offset between the reference point and the position of the loop promotes evenness of field pattern over the area where people are expected to stand, but reduces the effectiveness of spill control to the next counter position.

Dimensions in millimetres



Key

1 magnetic field source

2 reference line

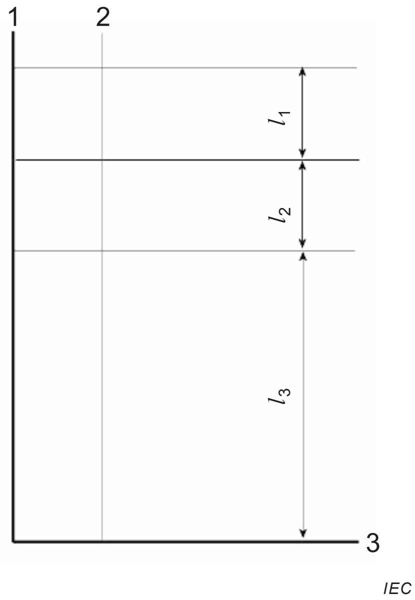
3 area where people are expected to stand

l_1 300 l_4 150

l_2 300 l_5 150

l_3 offset

a) Plan view



Key

1 magnetic field source

2 reference line

3 floor level

l_1 250 l_3 1 200

l_2 250

b) Side elevation

Figure 3 – Measurement points for a counter system

Measurements at the three points shown in the plan view are required at 1,2 m, 1,45 m and 1,7 m.

9.5 Requirements for counter systems

Unless specifically replaced by contractual requirements, the system shall comply with the requirements specified in 9.3 and 8.3.7 at all measurement points specified in Figure 3, across both vertical and horizontal ranges. The magnetic field strength level at these points shall be ±6 dB ref. 400 mA/m, measured according to 8.2. At one point at least, it shall be ≥0 dB ref. 400 mA/m.

The field strength shall not be above +8 dB ref. 400 mA/m in the area where people are expected to stand.

NOTE 1 This high field strength is inevitable for a simple vertical loop of practicable dimensions. If the signal is too loud or distorted, the user can just move a short distance further away from the source of the magnetic field.

NOTE 2 Clauses 4 and 7 deal with the subject of magnetic background noise level. It is not practicable to specify a requirement, as this might rule out the provision of a system that would be at least helpful to users.

10 Setting up (commissioning) the system

10.1 Procedure

The commissioning procedure shall include a test with the sound sources (talker, etc.) in their normal positions with respect to the system microphone(s), and with any other sources, such as a CD player. Measurements shall be made to check that the controls of the amplifier, etc., are set so that the magnetic field strength specified in 8.2.7 is achieved. If the amplifier has a gain control preceding the AGC stage, and an indicator that the AGC is operating, it is normally sufficient to set the control so that the indication specified by the manufacturer is achieved. The reference speech signal as defined in 6.3.3.3 can also be used for a more objective test, but as in all cases it should not be necessary to adjust the 'loop drive' control (gain control after the AGC stage) of the amplifier.

It is desirable that a small number of hearing-aid users should be present when a system is being set up for the first time or after extensive changes, to check that the subjective results are consistent with the measurements. It is important to check these hearing aid users for correct operation of their aids, and to ensure that they actually understand what they are supposed to be listening to.

It is essential that the trained persons(s) specified in Clause E.5 are present, with the receivers they will use for normal system checking.

NOTE Some hearing aid users set their volume controls much too high, and some older hearing aids tended to overload at a rather low field strength. Where significant variations of opinion are experienced between hearing aid users, on the performance of a system, it could be necessary to check the setting of the aids.

10.2 Magnetic noise level due to the system

10.2.1 Explanation of term

The magnetic field strength, measured with a pick-up coil whose magnetic axis is vertical (unless otherwise specified, see 8.1), due to the combination of background fields and the field due to amplifier noise, with all the signal inputs muted.

NOTE This value cannot be measured correctly until the commissioning procedure has been carried out.

10.2.2 Method of measurement with a speech signal

Not applicable.

10.2.3 Method of measurement with pink noise

Not applicable.

10.2.4 Method of measurement with a sinusoidal signal

Not applicable.

10.2.5 Method of measurement with a combi signal

Not applicable.

10.2.6 Method of measurement – Other (no input signal)

The magnetic field strength shall be measured as specified in Clause 7, with A-weighting, at a sufficient number of points within the useful volume, with the system switched on but with all the signal inputs muted.

NOTE If the signal is derived from sound system equipment, the muting is applied at the inputs of that equipment.

10.2.7 Requirements

If the reference signal-to-noise ratio as measured in 7.2 is greater than 47 dB, the magnetic field strength level at any point with the system switched on shall not exceed –47 dB. If the reference signal-to-noise ratio is less than 47 dB then the magnetic field strength level at any point with the system switched on shall not exceed that with the system switched off by more than 1 dB.

10.3 Amplifier overload at 1,6 kHz

10.3.1 Explanation of term

If frequency response correction is applied to the amplifier in order to compensate for metal loss, the amplifier may be capable of producing the required maximum magnetic field strength at 1 kHz but may be overloaded at a higher frequency. A test using a signal at 1,6 kHz is considered sufficient.

10.3.2 Methods of test

Apply a sine wave signal at 1 kHz and adjust its level so that a magnetic field strength 1 dB less than the required value is obtained at a given point. Apply this signal only for the shortest practicable time, in order to prevent overheating of the amplifier. Change the frequency to 1,6 kHz without changing its level.

NOTE 1 The magnetic field strength is intentionally increased by the frequency-response compensation.

To determine whether the amplifier is overloaded, apply one of the following tests:

- observe the 'clip indicator' on the amplifier, if one is provided;
- compare the measured output voltage with the manufacturer's specified value;
- examine the output ***current*** waveform with an oscilloscope.

NOTE 2 The current can be checked by including a low-value resistor, such as 0,22 Ω, in series with the loop, but neither end of the resistor is likely to be at earth potential. For many amplifiers, a measurement can be made between the 'cold' loop output terminal and the amplifier signal earth.

10.4 Requirements

The maximum value of the magnetic field strength obtained from the reference speech signal (see 6.3.3.3) shall normally be 400 mA/m, measured with a meter as specified in 6.1.

For the reference signal and all real sound sources, the measured value depends on the characteristics of the AGC circuit as well as the signal source itself, and as a result the measured r.m.s levels are likely to deviate from the target value. Provided the measurement time is long enough to observe true maximum levels, the system should usually achieve ±3 dB ref 400 mA/m (283 mA/m to 566 mA/m).

No change from 400 mA/m shall be made if the general public has access to, and uses, the system. The field strength may be adjusted only if the system is solely used by a closed group of hearing-aid users who indicate that, unless adjusted, the signal level is unsatisfactory (the system designer has no control over where system users set the gain controls of their hearing aids). As explained in the Note below, there are conditions in which a close community of users may find a field strength of 400 mA/m unsatisfactory.

If a field strength of 400 mA/m ± 3 dB is not achieved with real signals, the measurement shall be repeated using the signal specified in 6.3.3.3. If the requirement is still not achieved, the system specification and the set-up procedure given in 4.1 shall be reviewed, to determine whether the system as a whole, and the amplifier, have been correctly specified.

NOTE Because the field strength varies from place to place, it is bound to be equal to the value determined according to 8.2 at some places, more at others and less elsewhere. The subjective loudness also depends on the volume control settings of the hearing aids, which are not under the manufacturer's or installer's control. It is therefore inappropriate to make a specific value of field strength mandatory, when there is a consensus that a change of the field strength can be made.

Annex A
(informative)

Systems for small useful magnetic field volumes

A.1 Overview

There is often a requirement to supply an induction loop signal to a hearing aid user in specialised circumstances. These can normally be divided into three major categories.

A.2 Body-worn audio systems

Body worn systems generally use a neck loop, which is essentially a small loop worn round the neck like a necklace. These loops are generally driven from an output on normal audio equipment designed to drive standard headphones, or to be connected to cell phones or mobile phones. The position of the pick-up coil in the hearing aid can normally be controlled easily, and therefore the location of the listening space where the performance can be measured is easily defined. Performance as defined in this document should normally be expected. See also IEC 62489-1.

A.3 Small volume, defined seating, mainly in households

A small volume system, often in a household environment, may be either a neck loop, a specialised cushion which the listener sits on or a loop embedded in the chair of the user. In such situations, the loop is normally driven by a small dedicated amplifier. For cushions or chair loops, allowance should be made for the listener's head position, which may be significantly affected by the height of the actual person. Performance as specified in this standard should normally be expected. Sometimes, towards the limits of the space likely to be occupied by a user's hearing aid, the field strength requirements may not be met.

A.4 Specific locations such as help and information points, ticket and bank counters, etc.

Information points and similar are often used in many fixed locations. The listening space is often difficult to define easily, as it is necessary for the installation to allow for the potential head height of the listener, which may be 1 m for a child, 1,2 m for a wheelchair user, and 1,7 m for a tall person. Horizontally, there are likely to be significant displacements from the optimal position. Also in this situation, it may easily occur that significant amounts of metal are present. This creates difficulties with achieving good performance of the system, and the requirements for background noise (often computer-generated), signal strength and frequency response should be applied with insight, taking into account that a system that is a good as it can be, given the restraints under which it has to operate, is usually better than no system at all.

Loops for counter systems vary in size and configuration, and loops that extend into three dimensions are not easy to treat analytically. A vertical loop is usually easy to install, but arranged conventionally, its field pattern is far from ideal, having a large volume of low field strength centred on the horizontal axis, as shown, for a typical loop 70 cm square, in Figure A.1.

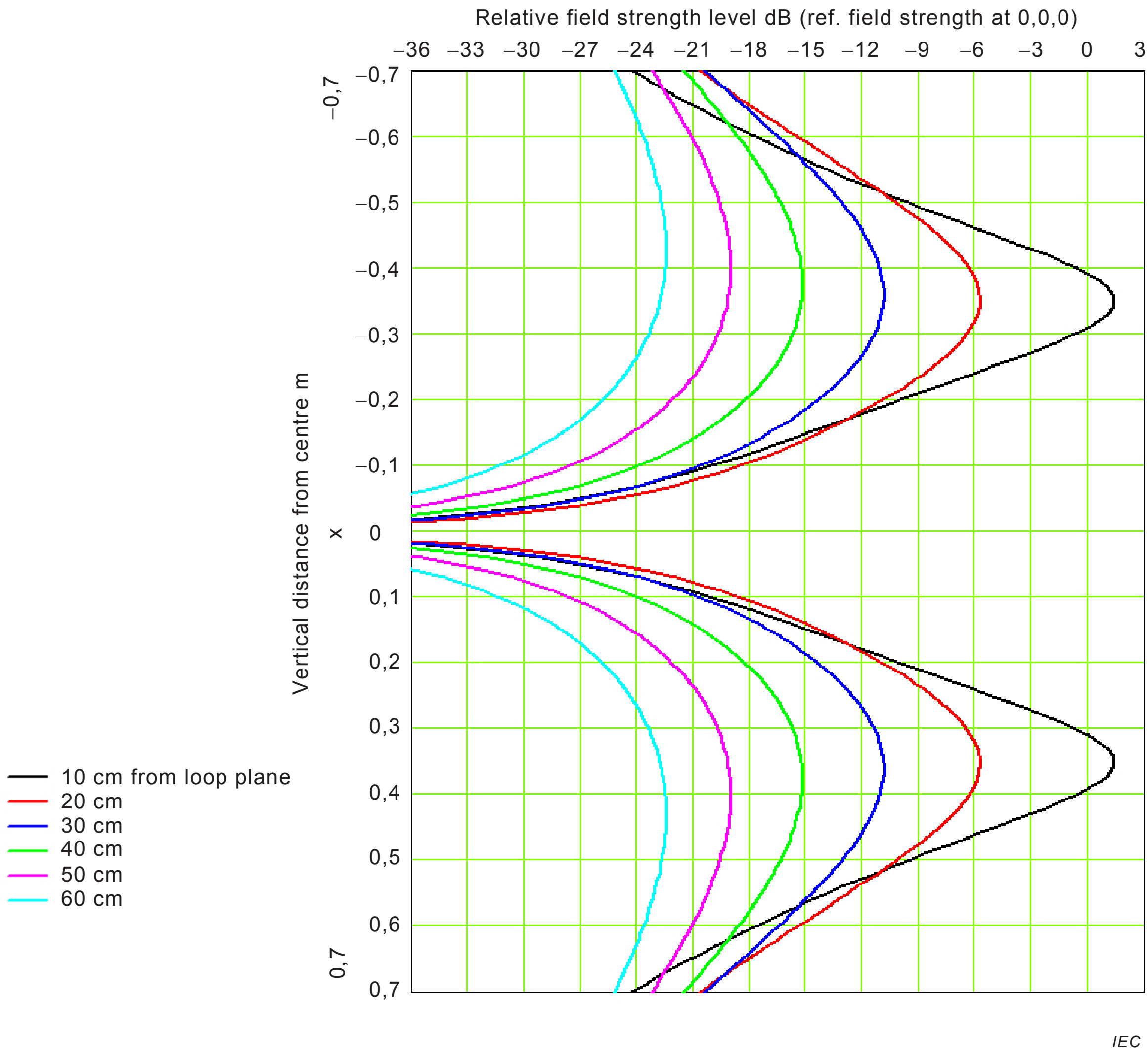


Figure A.1 – Field pattern of a vertical loop

Since the range of listening heights is 50 cm, it can be seen from the above that an optimum range of field strengths, taking into account the variation in distance from the loops, is from about 12 cm above the centre of the loop to about 62 cm above the centre. (Note that the loop conductor is 35 cm above the centre, so the upper lobe of the field pattern in Figure A.1, including the field outside the loop, is used.) This means that the centre of the loop should be 108 cm above the floor, so the lower edge should be 73 cm above and the upper edge 143 cm above the floor. It is equally effective to set the centre of the loop at 182 cm above the floor, so that the lower lobe of the field pattern is used.

NOTE These loop positions are for a loop 70 cm square: for other dimensions the optimum loop positions can be determined from a field pattern plot similar to that in Figure A.1.

Figure A.2 shows that with the former arrangement, there is no problem with coverage from side-to-side. The dimensions are in metres, and an inverted diagram shows that this applies to the latter arrangement.

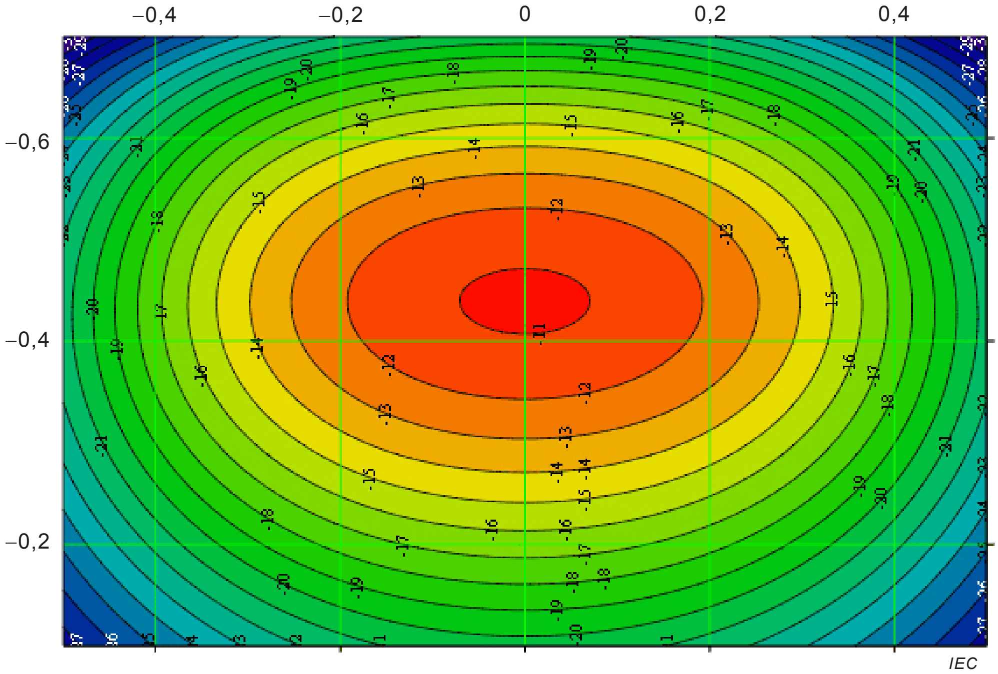


Figure A.2 – Contour plot of field strength of vertical loop

This is for a 70 cm by 70 cm loop, at a distance of 0,3 m. The field strength level is relative to that at the centre of the loop and in its plane.

The measurement heights of 1,2 m and 1,7 m relate to the users, not the systems, so apply equally to counter systems, but an additional set of measurements at a height of 1,45 m is essential, because a poorly-designed installation may have a null there. At this height, the field strength level ref. 400 mA/m at some of the points may be up to, but not greater than, +12 dB.

For the points in the plan view, a less stringent requirement is appropriate for a counter system, because several people are likely to close around a refuge and all wish to hear, whereas for a counter system, ideally only one person should be able to hear.

Annex B
(informative)

Measuring equipment

B.1 Overview

To fulfil the underlying aim of the standard – to ensure that induction-loop systems are designed, installed and set up correctly – it is necessary to make the recommendations for the technical requirements for the measuring equipment as simple as possible, because if only costly equipment can be used, the performance of many installations is unlikely to be measured. The status of a recommendation is that a reason is required for not observing it.

B.2 Signal sources

B.2.1 Real speech

The recommended sources are CD recordings of speech, without data compression. Other stated sources may be used, but it should be noted that there may be significant differences in the results obtained from measurements using different speech signals.

Where recorded speech is used, the recording should be reproduced with suitable equipment, whose output voltage should be capable of being set to the ranges 0 mV to 10 mV and 0 V to 1 V. The output source impedance should be 1 000 Ω or less.

If local speech sources are used, several different speech samples should be tested to ensure that variability between speakers does not invalidate the measurements.

B.2.2 Simulated speech

The recommended sources are as follows.

- The recording on CD supplied as a supplement to the ITU P.50 standard [2]. The male speech should be used.
- The reference speech signal (ISTS). See 6.3.3.3.

The recording should be reproduced with suitable equipment, whose output voltage should be capable of being set to the ranges 0 mV to 10 mV and 0 V to 1 V. The output source impedance should be 1 000 Ω or less.

B.2.3 Pink noise

This source should produce pink noise with a peak-to-peak voltage (as measured with an oscilloscope) to true r.m.s. voltage ratio of at least 8, with a one-third-octave band spectrum flat within ±1 dB from 100 Hz to 5 kHz, band-limited to be –3 dB or below at 75 Hz and 6,5 kHz. The output voltage should be capable of being set to the ranges 0 mV to 10 mV and 0 V to 1 V. The output source impedance should be 1 000 Ω or less.

The band-limiting filters should be at least of the third-order; such an active filter requires one operational amplifier section. The band limitation is specified so that the signal interacts with AGC systems in a manner similar to speech.

B.2.4 Sine wave

See 6.5.

B.3 Magnetic field strength level meter

B.3.1 General recommendations

B.3.1.1 Magnetic pickup coil

This should have a cross-sectional area of less than 100 mm^2. The axial length of the coil should be greater than the mean diameter. Its position within the instrument, and the direction of its maximum sensitivity, should be clearly marked.

B.3.1.2 Measurement range and indication

The measurement range, which may be divided into two or more sub-ranges for increased resolution, should ideally cover –62 dB to +8 dB relative to 400 mA/m. However, for many purposes, a range of –52 dB to +8 dB is sufficient, and this can be obtained using freely-available low-cost display driver devices. For both of the recommended types of meter, these recommendations for the ranges, and thus the markings of the indicator, refer to r.m.s. values of a sinusoidal signal. The resolution should be ±1 dB or better in the range of levels from –3 dB to +6 dB relative to 400 mA/m. Meters should be calibrated to read 0 dB in a sinusoidal magnetic field at 1 kHz, whose strength is 400 mA/m r.m.s.

The indication may be by means of a moving-coil meter, an LED dot or bar display or an LED or LCD digital display. A 'peak hold' feature may be provided; in which case, the measured 'peak hold values' may be greater than the 60 s average values (see 8.2.7) by approximately 2 dB. A preset control for setting the sensitivity may be provided (see Annexes E and F).

B.3.1.3 External connections

One or more output connectors should be provided, for the connection of headphones and other measuring equipment, such as a spectrum analyzer. For headphones, the output should conform to the relevant requirements of IEC 61938 [5], but see also Clause E.5. For external measuring equipment, an output of approximately 1 V r.m.s. at maximum level indication is usually suitable. The source impedance should be 1 000 Ω or less. Connecting a load conforming to the specification of the meter should not cause a change in the measured result by more than 0,2 dB.

B.3.2 Peak-programme meter (PPM) type

The peak-programme meter type may be a specially designed instrument. It should incorporate a full-wave peak rectifier, giving dynamic characteristics similar to those of the Type II meter specified in IEC 60268-10.

Simplified specifications for the meter dynamics, derived from IEC 60268-10, are:

- a 10 ms tone burst at 5 kHz should produce a reading of −2 dB ±1 dB below that produced by a continuous 5 kHz sinusoidal signal;
- the time between the removal of a 1 kHz sinusoidal signal producing an indication of 0 dB and the indication falling to –20 dB shall be 2,3 s ± 0,5 s. If the indicator is not a moving-coil meter, this may be determined by measuring the variation with time of an appropriate voltage internal to the equipment, using a storage oscilloscope.

B.3.3 True r.m.s. meter type

The true r.m.s. meter type may be a specially-designed instrument, or a sound level meter whose microphone is replaced by a magnetic pickup coil, with an equalizer added to produce a substantially flat frequency response in the unweighted measurement mode. It is necessary that the meter incorporates a true r.m.s. rectifier, and meets the relevant requirements for a Class 2 sound level meter specified in IEC 61672-1, except as specified in B.3.1.2.

B.4 Field strength level meter calibrator

A calibrator should produce a magnetic field strength level of 400 mA/m r.m.s. at 1 kHz within a volume large enough to include the whole of the pickup coil of the meter with which it is intended to be used. Additional frequencies of 100 Hz and 5 kHz should be provided, to enable the responses at these frequencies to be checked. See also Annex F.

B.5 Spectrum analyzer

A spectrum analyzer should provide one-third-octave band analysis over at least the frequency range 100 Hz to 5 kHz. The filter characteristics should conform to those specified in IEC 61260 [6].

Where the spectrum analyser is part of the field strength meter, filters with centre frequencies 100 Hz, 1 kHz and 5 kHz only need to be provided. Additional filters enable a better analysis of system performance when assessing losses due to metal.

Annex C
(informative)

Provision of information

C.1 General

The following requirements are intended to ensure that the end user of the system, the persons responsible for the installation and/or operation of the equipment, and the manufacturers of the equipment be provided with adequate information to ensure that induction-loop systems operate in keeping with the requirements of this standard.

The installer should provide at least the following information.

C.2 Information to be provided to the hearing aid user

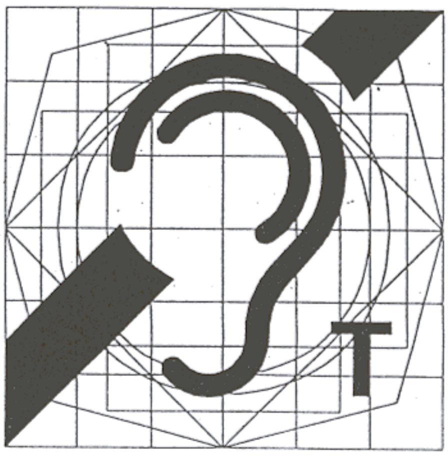
A sign should be placed in a prominent position close to the entrance, or entrances where there are more than one, of the area where an induction loop is installed. The sign shall be of sufficient size to be easily read and constructed of durable material. An example of such a sign is given in Figure C.1. The same symbol should be used to indicate the presence of induction coupling on telephone handsets.

A plan indicating the useful magnetic field volume should be placed beside the above-mentioned sign or incorporated in it.

The name, or position, of the person responsible for the proper operation of the loop system and how to contact them should also be given.

For small area induction-loop systems e.g. window counters, a sign should be placed in a prominent position where the hearing aid user is expected to be normally situated.

Clear instructions on how to use the induction-loop system should be available to hearing aid users on request.



SOURCE: ETSI TR 101 767.[7]

Figure C.1 – Graphical symbol: inductive coupling

C.3 Information to be provided to system installers and by them to users

The following information should be provided:

- the plan specified in Clause C.2;
- the specifications for the amplifier and associated equipment as given in Clause C.4;
- the field strength set up as described in 10.4 (including the notes);
- the setting of the control positions to provide the required field strength in the specified magnetic field volume;
- the method by which the magnetic field strength can be monitored to ensure consistent day-to-day operation of the system;
- the appropriate position of microphones, the signal requirements for external playback devices and the setting of appropriate controls to ensure that the specified magnetic field is produced under normal operation;
- the effect of other electrical equipment used in the area where the loop system is installed.

C.4 Information to be provided by the manufacturer of the amplifying equipment

See IEC 62489-1.

Annex D
(informative)

Measuring speech signals

The previous edition of this standard referred to a 'long-term average level' of speech signals as a reference value. However, this 'long-term average level' cannot be formally defined, as shown by these measurements of a speech signal, using a true r.m.s. meter with different averaging times.

Averaging time s	**Relative level at maximum reading** dB
0,5	0
1,5	–1
5	–2
15	–5
60	–12

Furthermore, a meter with a long averaging time cannot practicably be used for setting the system gain control so as to obtain 100 mA/m 'long term average' at the reference point. Even with a 15 s averaging time, this would be a difficult and inaccurate process, for three reasons.

- After every adjustment, it is necessary to wait for at least 3 time-constants, i.e. 45 s, for the voltages in the time-constant circuit to stabilize at the new input level. (This effect can be seen on such a meter if a pink noise signal is measured.)
- Even with a 15 s averaging time, the meter reading is far from constant, and a choice has to be made between estimating an 'average' reading or taking the maximum reading over a certain (but unspecified and unrecorded) time period.
- The measurement does not determine whether the induction-loop system can produce the higher field strengths necessary for the reproduction of the speech signals without unacceptable amplitude distortion.

Using a 0,125 s time-constant, the reading is, of course, variable from moment to moment, so that the user also has to use some subjective averaging in this case.

On the other hand, the peak programme meter is designed so that a reliable reading of the maximum level can be obtained without undue operator fatigue. Numerous experiments have shown that a peak programme field strength meter, substantially of the Type 2 specified in IEC 60268-10, scaled in r.m.s. values for a sine-wave signal, reads 560 mA/m when the short-term r.m.s. (125 ms average) field strength of a typical speech signal is 400 mA/m.

Induction-loop systems, using no compression (as distinct from automatic gain control) or only a moderate amount, set up in this way are found in practice to be eminently satisfactory in terms of signal level. The meter responds immediately to changes in the gain control setting. If the amplifier is overloaded on programme peaks, this is shown by the failure to achieve 560 mA/m.

Annex E
(informative)

Basic theory and practice of audio-frequency induction-loop systems

E.1 Properties of the loop and its magnetic field

A basic induction loop is a conductor carrying an audio-frequency current which surrounds the area where reception is required. A current flowing in the loop conductor produces a magnetic field, whose strength is measured in amperes per metre. The field strength produced by a given current varies greatly from place to place within and outside the loop. See [8], [9] and [10]. Such loops produce detectable magnetic fields outside the required volume, and size constraints can have a significant impact on the design of such loops. Techniques exist for reducing the spill of signal outside the wanted volume, and for covering very large areas. See Annex I and [11].

Figure E.1 shows a loop, and a diagrammatic representation of the magnetic vectors. The direction of these vectors follows the circular lines, and thus there are vertical and horizontal components. The variation of the field strength in space is very large (as shown in Figure E.2). Along line Z1, which is in the plane of the loop, the field strength reaches an extremely high value close to the wire. Displacement from the loop plane (such as shown by line Z2) assists in obtaining a more acceptable field distribution. The line labelled 'system null line' shows that the points at which the vertical component of the magnetic field is zero lie at increasing distances outside the loop perimeter as the height of the listening position above the loop plane increases.

For most audio-frequency induction loop systems, the listeners are standing or sitting, so that the axes of the telecoils in the hearing aids are normally vertical, and thus respond to the vertical component of the magnetic field of the loop. In hospitals and places of worship, however, the axes of some telecoils may be horizontal or at some intermediate angle, so the relevant component of the magnetic field is then important. At the geometrical centre of a single-turn square loop of side d (in m), the field strength H (in A/m) produced by a current I (in A) is given by $H = 2\sqrt{2}\ I/(\pi d)$ (in A/m), and is vertical (strictly, it is perpendicular to the plane of the loop). Provided that the sides d_1, d_2 of a rectangular loop are not extremely different, this formula is applicable if d is taken as $\sqrt{(d_1 d_2)}$.

For information desks, etc. the loop is often positioned in a vertical plane, and then the effective vertical component which exists at the level of the top wire, and beyond, is used to drive the hearing aid. Care is necessary, as lowering the listening position to the axis of the loop results in no useable signal being received.

It can be shown that the most uniform vertical field strength within the projected area of a rectangular loop (provided the ratio of the length to width is not very large) is obtained at a distance from the plane of the loop of 0,12 times to 0,16 times the width of the loop. Figure E.2 shows the distribution of the vertical component across a loop as a function of the position and elevation of the listening position. This has been calculated for a loop 1,5 times longer than the width, but the change from near square to an aspect ratio of 4 is quite small. This figure also shows that greater spacing of the listening position from the loop plane (or a loop of smaller dimensions) can be used at the expense of loss of field strength. The worst location for a loop is at head-height (this should be borne in mind if there is a proposal to route a loop conductor from floor level up and over a doorway). The curves are labelled with the distance from the loop as a percentage of the loop width, while the horizontal axis gives position as a percentage of the loop width. The vertical scale indicates the field strength variation in decibels.

E.2 Directional response of the telecoil of a hearing aid

While the directional response of a telecoil may be slightly affected by metal parts in the hearing aid, the theoretical response follows a cosine law. This means that the response is reduced by only 3 dB at an angle of 45° to the magnetic axis, and reduced by only 9,3 dB at 70° off axis. See Figure E.6.

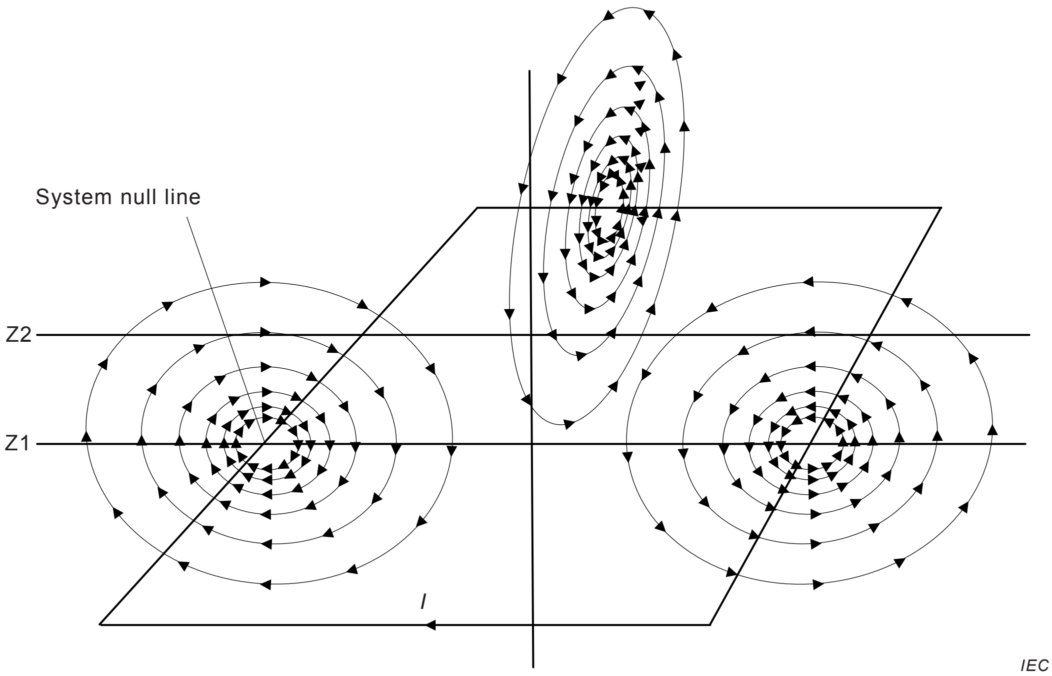
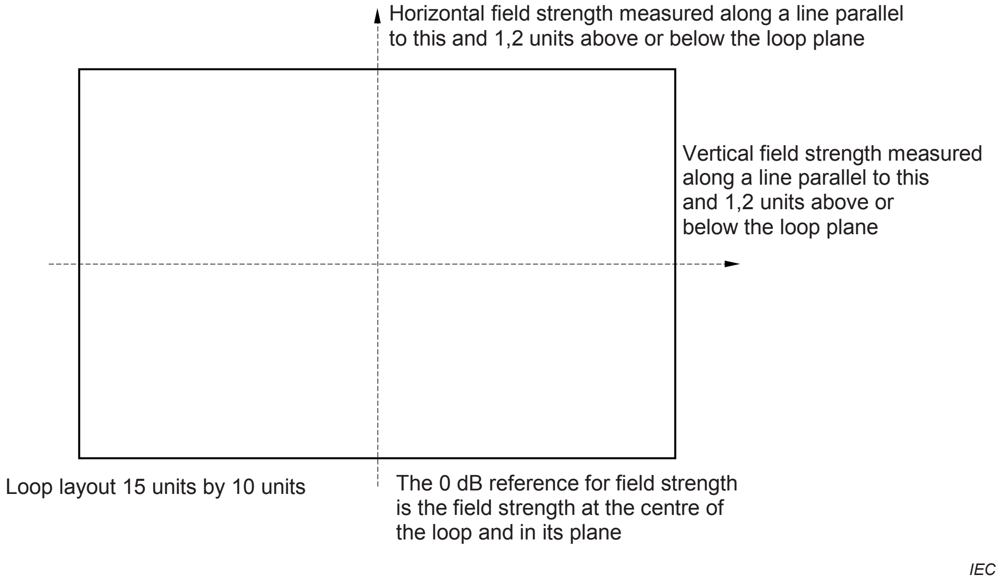
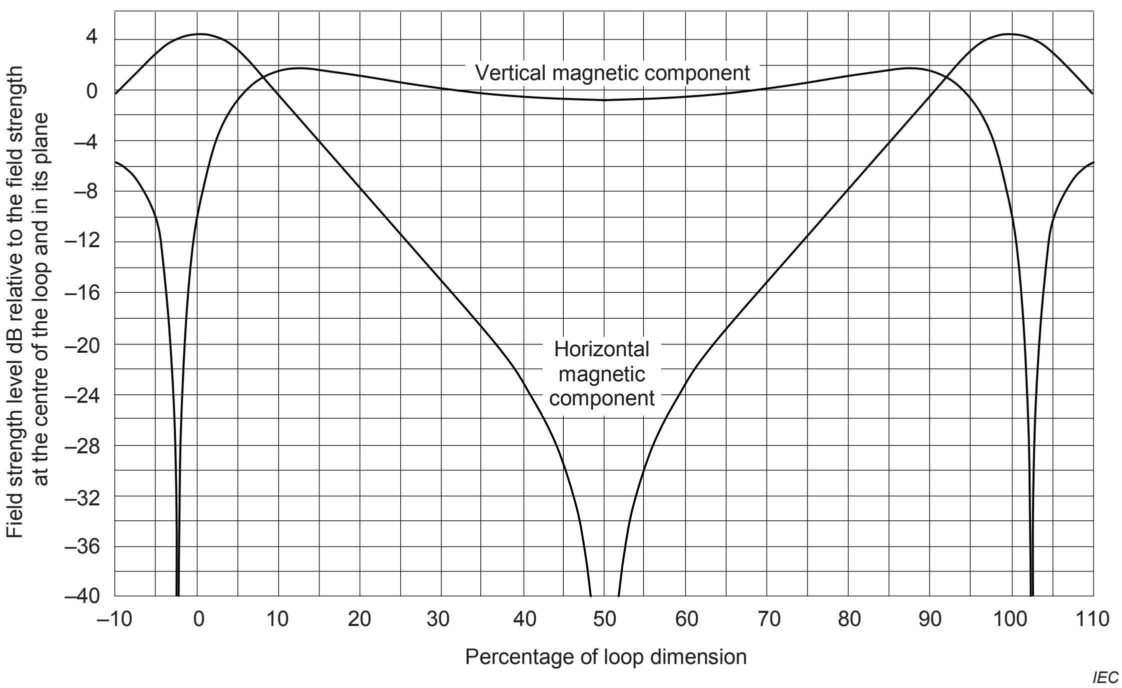


Figure E.1 – Perspective view of a loop, showing the magnetic field vector paths



a) Geometry of the loop and positions of measurement of the field patterns shown in b)



b) Patterns of the vertical and horizontal components

Figure E.2 – Strengths of the components of the magnetic field due to current in a horizontal rectangular loop at points in a plane above or below the loop plane

Figure E.3 shows the spatial variation of the vertical field, showing that, at large separations from the loop plane, the null points are well outside the loop perimeter, and that the field strength outside the loop may be high enough to be usable, or, high enough to interfere with other loop systems in the vicinity, or both.

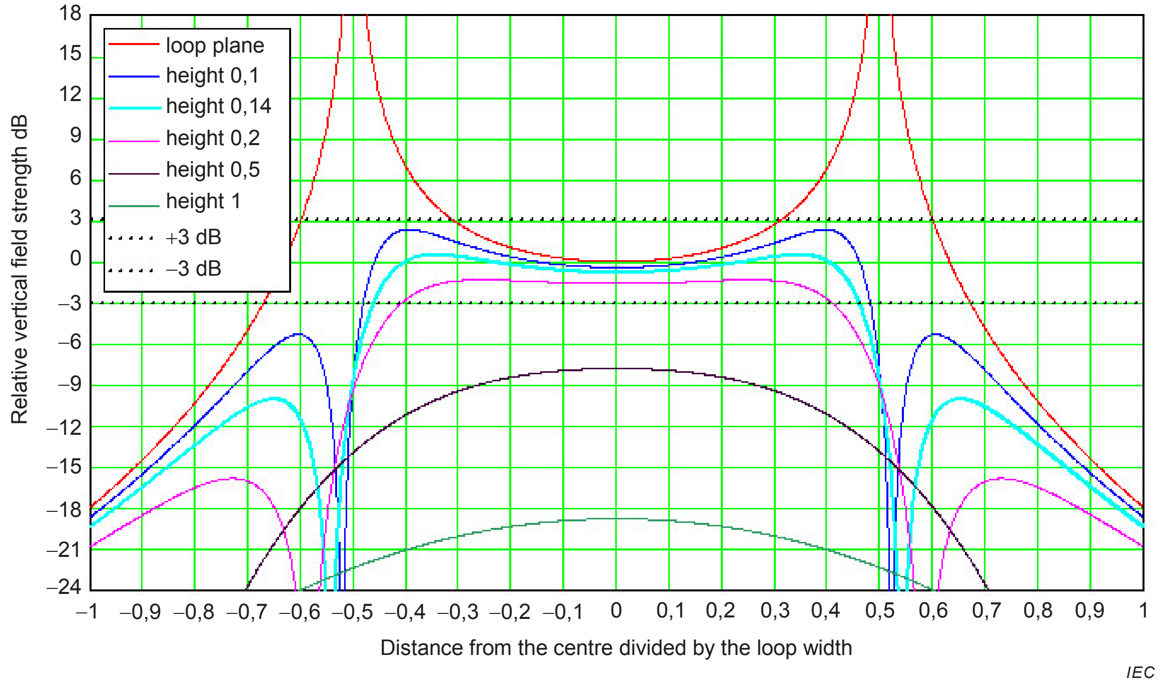
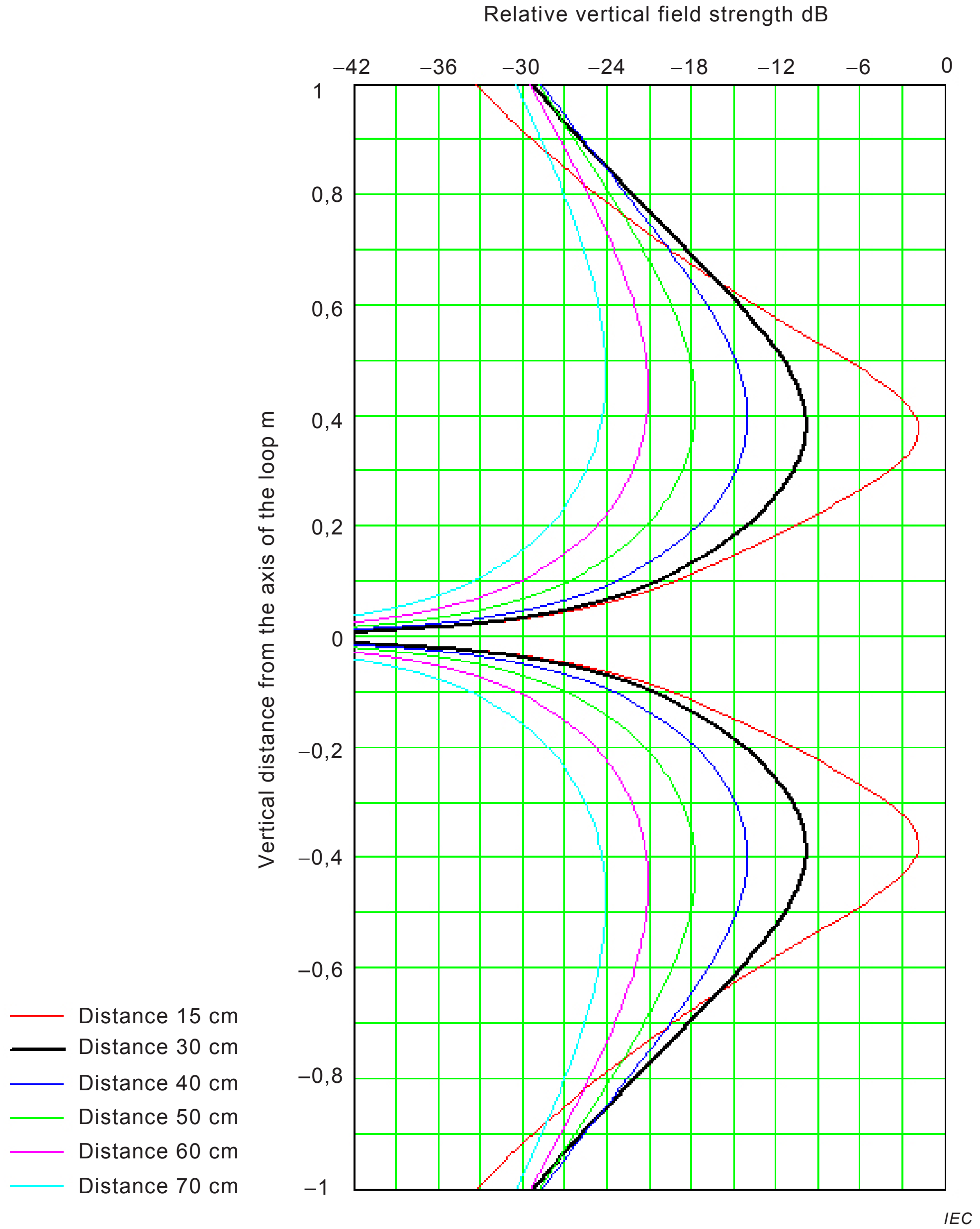


Figure E.3 – Field patterns of the vertical component of the magnetic field of a horizontal loop

Figure E.4 shows the field patterns due to a vertical coil, such as may be used in a system at an information point (see Annex A). These coils are often of rather small dimensions, so that the height is much larger in proportion than for a horizontal loop in a room. To obtain sufficient field strength at the height of a standing person, the field strength at the height of a child or person in a wheel-chair has to be very high. This can place severe demands on the magnetic noise level due to the system (see 9.3). The high field strength may also cause some hearing aids to function incorrectly (without permanent damage).

Near the horizontal axis, and the plane, of the loop, the field strength varies greatly with height. It is thus desirable that users of the system should not be able to stand very close to the loop.



NOTE 'Distance' is the horizontal distance of the pick-up coil (telecoil) from the plane of the loop. The field strength level is relative to that at the centre of the loop.

Figure E.4 – Field patterns of the vertical component of the magnetic field of a vertical loop 0,75 m square

Figure E.5 shows a perspective view of the field pattern of a typical loop system at an optimum height above the loop. The rise in field strength as the loop conductor is approached from the centre of the loop can be clearly seen, together with the very sharp null at points just outside the loop perimeter, where the field vectors are horizontal.

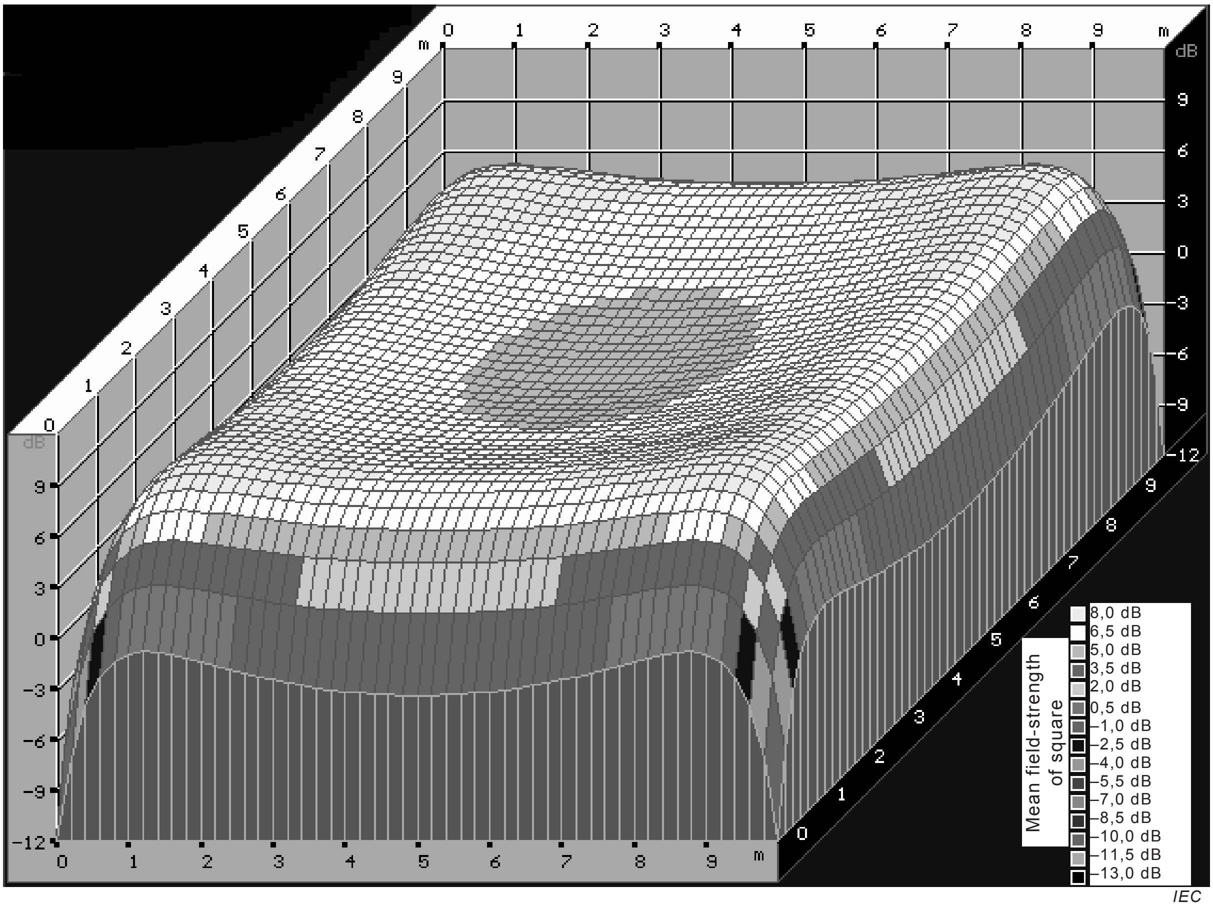
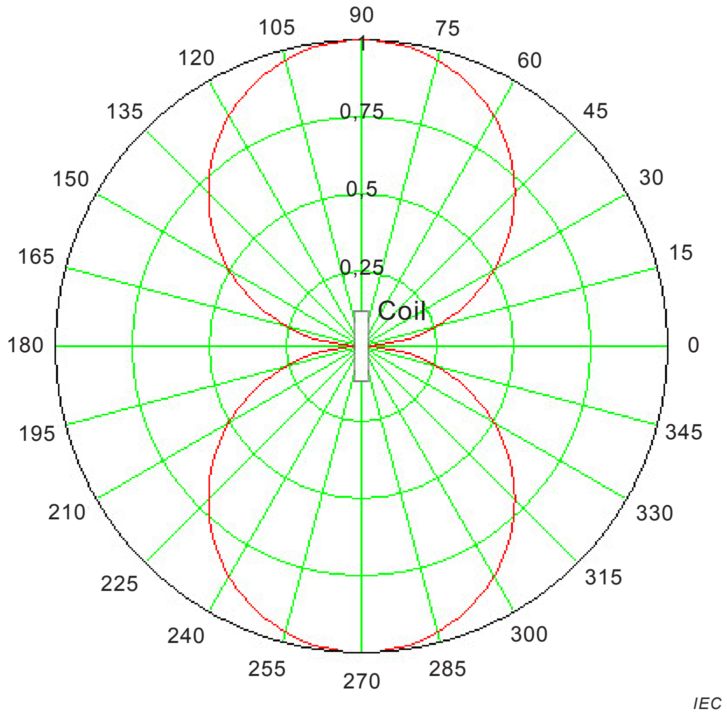
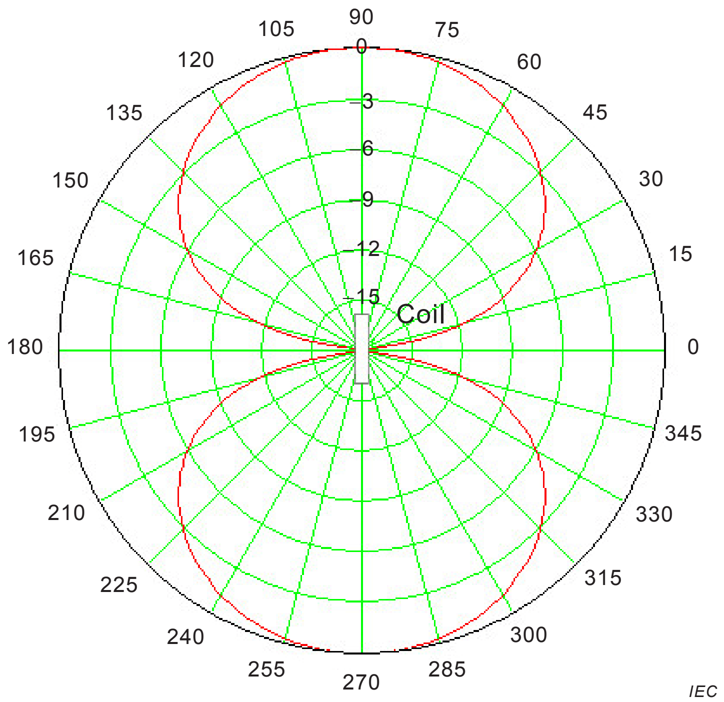


Figure E.5 – Perspective view of the variation of the vertical field strength level at an optimum height above a horizontal rectangular loop



a) Directional response, linear amplitude scale



b) Directional response, decibel amplitude scale

Figure E.6 – Directional response of the magnetic pick-up coil (telecoil) of a hearing aid

E.3 Supplying the loop current

The loop has resistance and inductance, both of which can normally be calculated with sufficient accuracy for design purposes. Both the resistance and the inductance are proportional to the perimeter of the loop, not the area. The resistance is proportional to the number of turns in the loop, and the inductance is approximately proportional to the square of the number of turns.

The resistance R of a single turn square loop of side d (in m), with conductor area a (in m^2) and resistivity ρ (in $\Omega \cdot m$) is given by $R = 4\rho d/a$ (in Ω).

The inductance L of a single turn is given by a much more complicated formula, but a close approximation, for loops of more than a square metre in area, using a conductor that is not unusually thick or thin, is given by the simple formula $L = 8d$ (in μH). Copper foil may provide a lower inductance than round copper wire. The presence of magnetizable material inside or close to the loop may change the inductance.

The inductance causes the impedance of the loop to rise at high audio frequencies; the impedance is 1,4 times the resistance at the frequency f at which the inductive reactance $2\pi fL$ is equal to the resistance R. It can be shown that for single-turn square loops up to 5 m side, a conductor of sufficiently high resistance to make the rise in impedance significant only at frequencies above 5 kHz is still capable of carrying the necessary value of loop current, provided that the signal is speech, music or pink noise. For larger loops, a flat frequency response up to 5 kHz can only be obtained by compensating for the rise in loop impedance.

While there are several methods of achieving this (see IEC 60268-3), the normal technique is to use an amplifier with an output source resistance sufficiently high to eliminate the effect of the loop inductance. Such an amplifier is called a 'current-drive amplifier', because it tends to keep the loop current constant even though the loop impedance varies with frequency.

The output source resistance (see IEC 60268-3) of the amplifier does not need to be very large. Most loops have a resistance of only a few ohms and an output source resistance of ten times the loop resistance is normally sufficient. Very high values of output source resistance may induce stability and EMC problems.

The amplifier must be able to produce enough output voltage to drive the required current through the loop impedance. At low frequencies, this voltage is simply given by $U = IR$, where I and R are defined above. At higher frequencies, an increased voltage $U_h = I\sqrt{R^2 + (2\pi fL)^2}$ is required. But because the energy in the spectrum of speech falls at high frequencies, the value of f in this formula need not be as high as 5 kHz. A value in the range 1,5 kHz to 2,5 kHz is usually satisfactory. If the system is intended to carry music signals, then a frequency near to 2,5 kHz is likely to be appropriate. This relaxation of the maximum achievable field strength is not a relaxation of the requirements for frequency response.

E.4 Signal sources and cables

E.4.1 Microphones

It is extremely important that microphone types and positions should be chosen so as to minimise the amount of reverberation in the signal sent to the loop. Directional types are almost always preferable, and derivatives of the basic cardioid pattern, including boundary-layer types may sometimes be a good choice. In principle, we need to collect the wanted sounds with as little room reverberation and ambient noise as possible. This sometimes requires the use of extremely directional microphones. Costly microphones are not normally necessary, but electret types that require a battery should be avoided, because of the need for regular maintenance. Dynamic microphones are not generally recommended due to low sensitivity and the risk of magnetic feedback. However, with careful design, and precautions to keep all microphones and their connecting cables away from the loop cable, they can be used successfully.

E.4.2 Other signal sources

Musical instruments using magnetic pickups can, under certain conditions, act as effective induction-loop transducers, resulting in equipment-damaging electronic feedback. Experimentation in placement of these instruments relative to the loop system may be required.

E.4.3 Cables

Precautions are necessary to prevent malfunctions due to current induced in cables by the magnetic fields. See [12].

E.5 Care of the system

The system should be checked for correct operation by a trained person at regular intervals, and before use. This can be done using a portable receiver with indications (e.g. LEDs) of field strength at –6 dB and 0 dB as a minimum. An output for headphones, with a gain control, should be provided.

The maximum gain of the headphone amplifier should be set so that the sound from the headphones is at a comfortable listening level when the indicator of 0 dB is lit. Excessive gain is likely to produce a pessimistic impression of the background magnetic noise level, and an over-optimistic assessment of the magnetic field strength due to the system, apart from producing potentially harmful sound pressure levels.

Maintenance should be necessary only at infrequent intervals, but the system components should be inspected regularly so that any damage can be repaired as soon as possible.

E.6 Magnetic units

A current flowing in a closed circuit of finite area produces a magnetic field in the neighbourhood of the circuit. The field strength is proportional to the current and, for circular loops or rectangular loops with a fixed ratio of length to width, it is inversely proportional to the perimeter (not area) of the circuit. Consequently, it is expressed in units of amperes per metre. (If the circuit is a multi-turn loop, the field strength is multiplied by the number of turns).

NOTE It can be helpful to consider the analogous situation in electrostatics, where a voltage between two conducting plates generates an electric field in their neighbourhood, and its strength is proportional to the voltage and inversely proportional to the distance between the plates, so it is expressed in units of volts per metre.

In this standard, the relevant requirements are expressed in terms of magnetic field strength. However, other magnetic units are also in use, so it is appropriate to describe the relationships between them. The names of some of the quantities expressed in these units have also been officially changed (a very long time ago) but the old names are still in use.

- Magnetic field strength (formerly 'magnetomotive force') was expressed in oersted in the CGS magnetic system. For practical purposes, 1 Oe = 79,58 A/m.
- Magnetic induction (formerly 'flux density'); this is now expressed in tesla (T). It is related to the field strength by the equation, $B = \mu_0 \mu_r H$, where μ_0 is the permeability of free space ($4\pi \times 10^{-7}$ H/m), and μ_r is the relative permeability of the medium in which the magnetic field exists. For induction-loop systems, the medium is air and $\mu_r = 1$. Consequently, the magnetic induction due to a field strength of 1 A/m is 1,256 µT. The magnetic induction was expressed in gauss (Gs) in the CGS magnetic system, and this unit is still in common use. For practical purposes, 1 Gs = 100 µT. Because in this CGS system, $\mu_0 = 1$, an induction of 1 Gs in air is produced by a field strength of 79,58 A/m.

Annex F
(informative)

Effects of metal in the building structure on the magnetic field

The magnetic field produced by the loop induces currents in metal work in the building. These currents act so as to modify the field strength pattern in space, and in a frequency-dependent manner. Theoretical analysis is extremely complex except in a few idealized cases.

Current flowing in a closed loop formed by metal in the building tends to reduce the field strength within its perimeter due to a current in a larger loop enclosing it. Because the coupling between the loops is by mutual inductance, the reduction increases with increasing frequency. This effect is most noticeable where the metalwork is in a floor or ceiling, close to the loop conductor.

The effect of metal in walls is particularly difficult to predict. The effect of metal within the perimeter of the loop may cause an ***increase*** in magnetic field strength ***outside*** the perimeter.

High-frequency loss increases with distance from the loop conductor. The effect of metal loss can thus be counteracted by the use of arrays of small loops.

Figure F1 shows the field pattern of a typical loop system without nearby metal, while Figure F.2 shows the effect of metal in the floor below the loop.

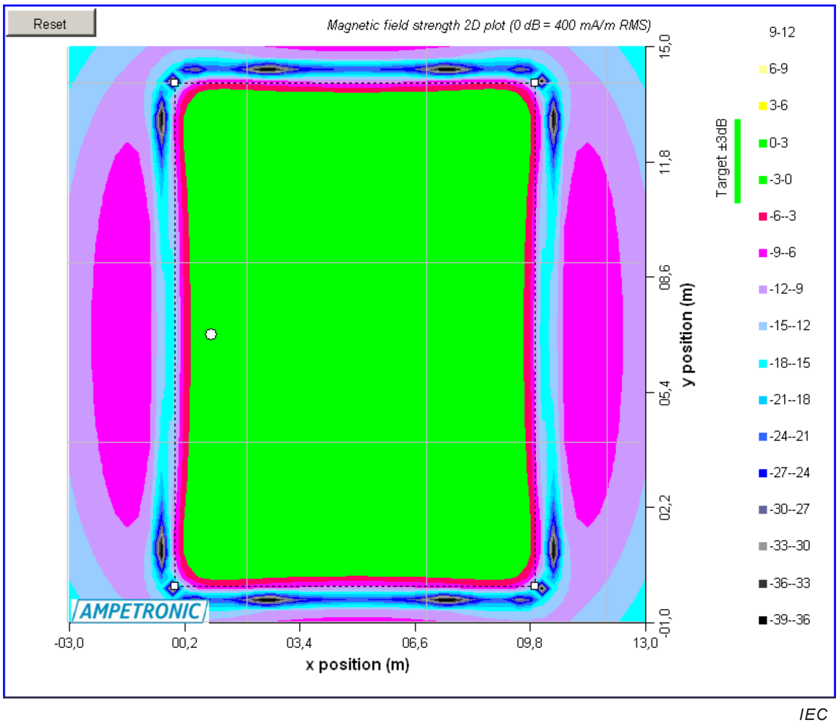
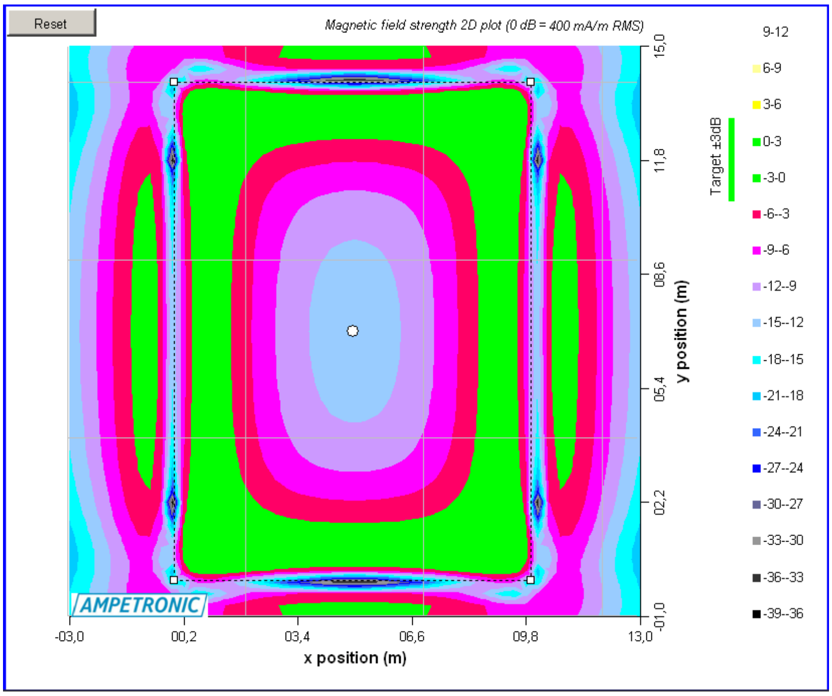


Figure F.1 – Magnetic field pattern of a 10 m by 14 m loop, 1,2 m above its plane



IEC

NOTE There are areas of decreased field strength inside the loop and areas of increased field strength outside it.

Figure F.2 – Magnetic field pattern of a 10 m by 14 m loop, 1,2 m above its plane, showing the effect of metal (iron) in the floor

Annex G
(informative)

Calibration of field-strength meters

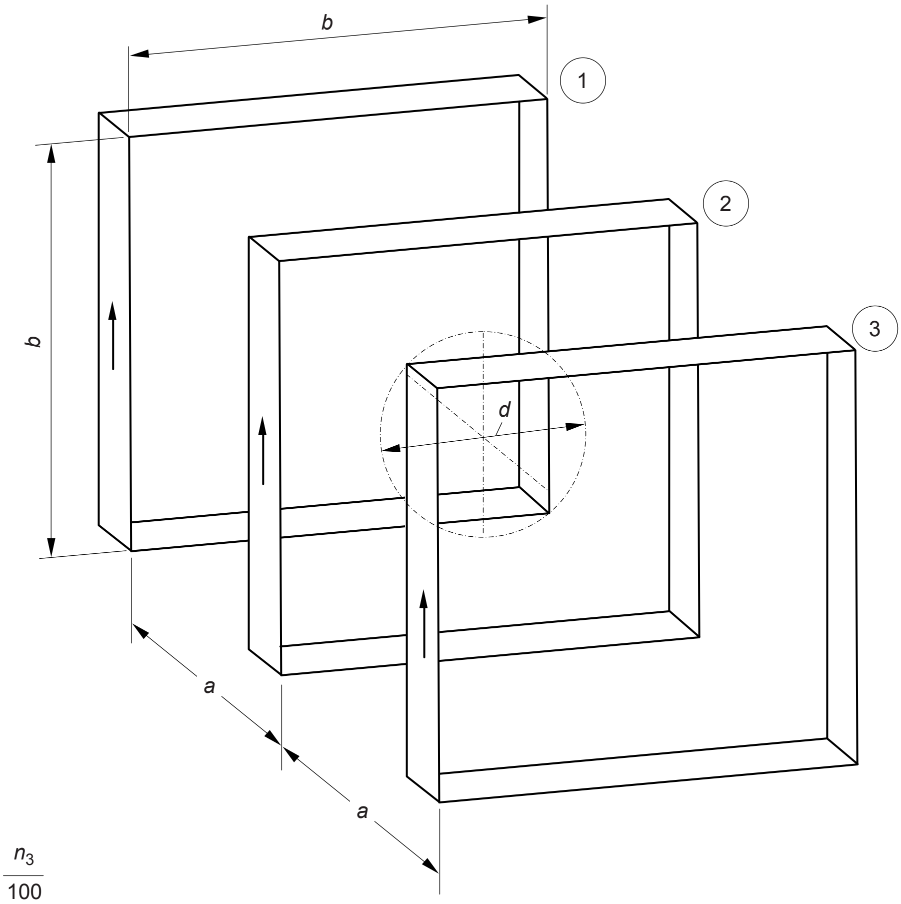
Sound level meters need frequent calibration checks, in case the microphone sensitivity has been affected by ambient conditions. It isn't so necessary for magnetic field strength meters, but a calibrator is desirable. The following types of calibration coil are acceptable:

- 1 m or 0,5 m diameter calculable loop – big and unwieldy;
- 30 cm diameter calculable single-turn loop;
- 30 cm diameter multi-turn loop (needs calibration check but can be driven from an audio signal generator).

It is also practicable to use square coils of similar dimensions:

- Helmholtz coil (IEC 60268-1) [13], see Figure G.1.

These calibrators can be used to check both sensitivity and frequency response.



$a = 0{,}375\ b$
$d = 0{,}5\ b$

$$\frac{n_1}{100} = \frac{n_2}{36} = \frac{n_3}{100}$$

n_1, n_2, n_3 Numbers of turns on the coils 1, 2 and 3
d Diameter of the spherical volume within which the field strength is uniform

IEC

Figure G.1 – Triple Helmholtz coil for calibration of meters

The relation between the field strength in the central spherical volume and coil current depends on the dimensions of the structure. For given dimensions, it can be calculated by using the formulae given in [11]. It is advisable to check by measurement with a suitable magnetic field strength meter.

Annex H
(informative)

Effect of the aspect ratio of the loop on the magnetic field strength

H.1 Overview

The magnetic field strength varies in a complex manner in three dimensions in the space around the loop. It is therefore not easy to show its behaviour in a two-dimensional medium, especially when, as in this case, two variables (length of the shorter side and the ratio of the lengths of the sides, i.e. the aspect ratio) are required in addition to three variables for the three space dimensions.

Figure H.1 shows the variation with loop dimensions and aspect ratio (long side/short side) of the current required to produce a field strength of 400 mA/m at a point 1,4 m above the centre of a rectangular loop. It should be understood that the variations at other points may have quite different profiles.

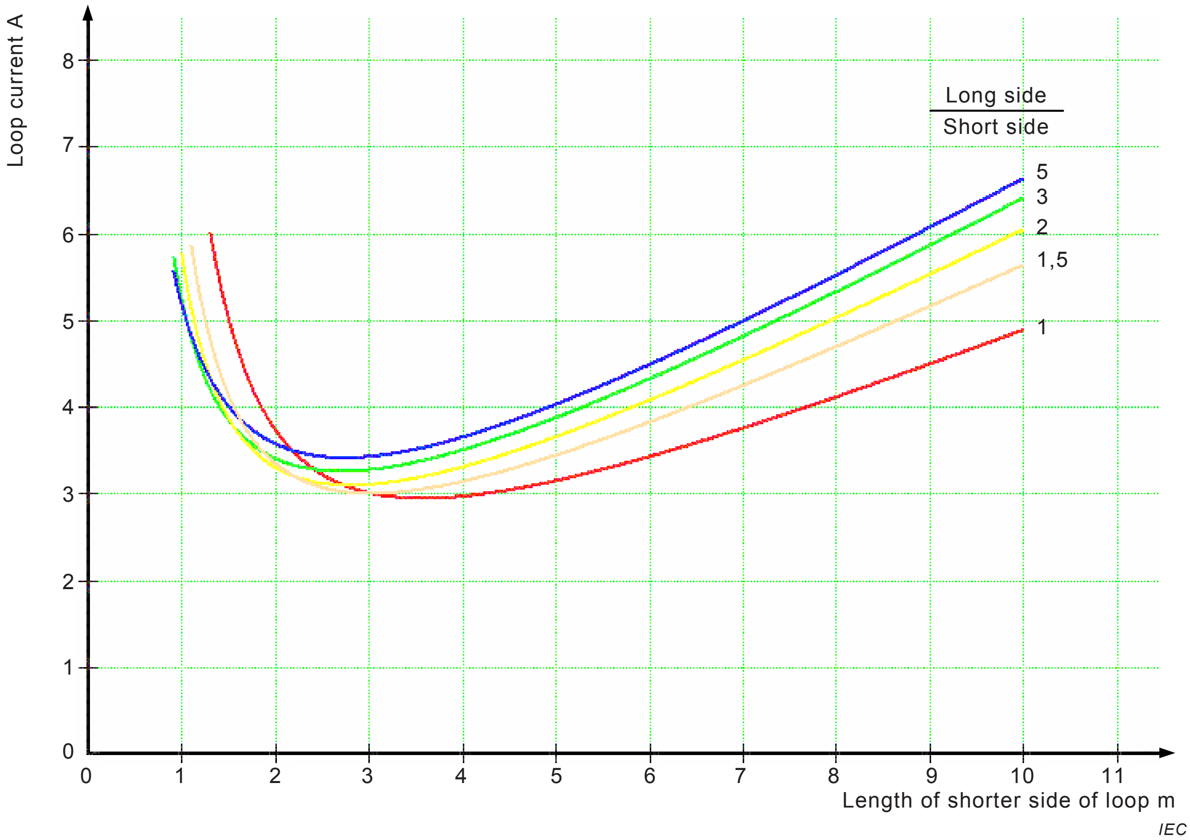
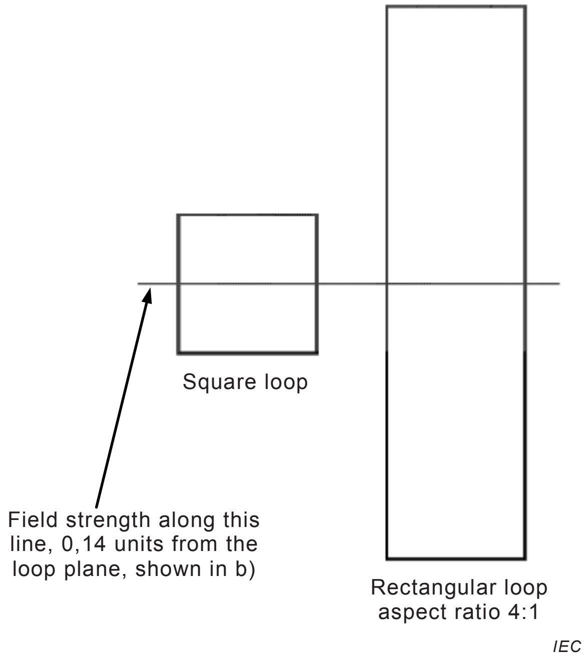


Figure H.1 – Variation of the current required to produce a specified magnetic field strength at a specific point with the dimensions and aspect ratio of the loop

It may be noted that for aspect ratios exceeding 3, the aspect ratio has little effect on the current required.

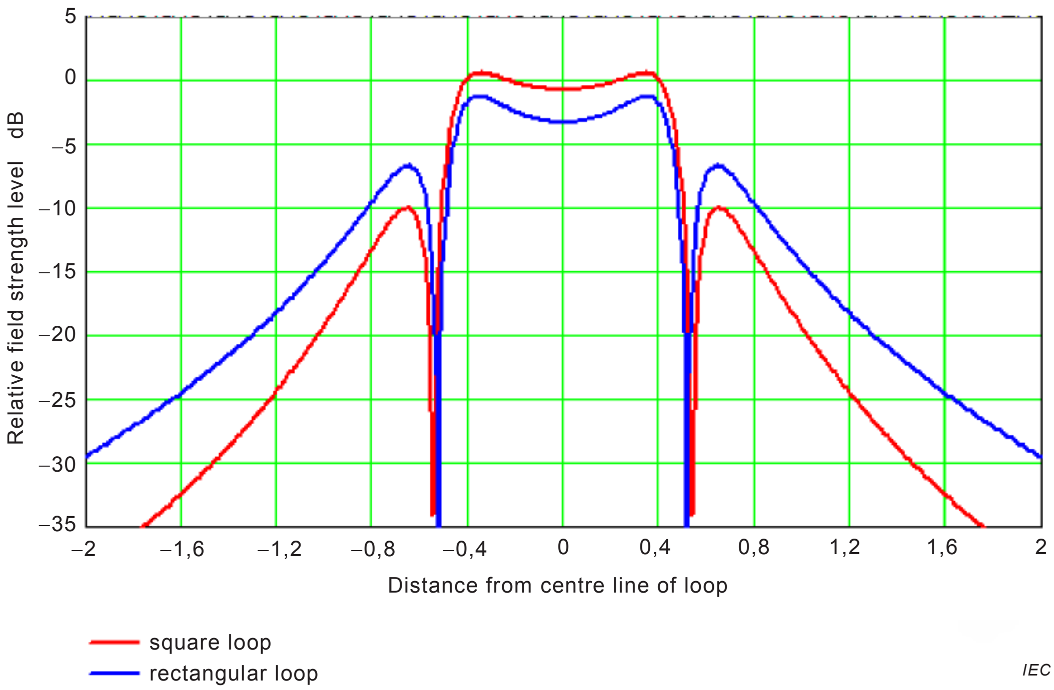
H.2 Effect of aspect ratio on field patterns

Figure H.2 a) shows plan views of a square loop and a rectangular loop of the same width but an aspect ratio of 4. Figure H.2 b) shows the field patterns produced with the same current flowing in each loop. The variation of field strength across the centre line of the loops is approximately the same. For the same loop current, the rectangular loop produces a lower field strength inside its perimeter, but a higher field strength outside it.



NOTE The rectangular loop has more resistance and inductance as well, proportional to its larger perimeter.

a) Loop plans



b) Field strength patterns

NOTE 1 The distance scale is expressed in terms of loop width.

NOTE 2 The rectangular loop gives, for the same current, less field strength inside the loop and more field strength outside it.

Figure H.2 – Square and rectangular loops

Annex I
(informative)

Overspill of magnetic field from an induction-loop system

I.1 General

Designers, installers and owners of an induction-loop system should note that loops produce detectable magnetic fields to both sides, above and below the useful magnetic field volume. This overspill may cause interference with other equipment that is sensitive to magnetic fields such as electric stringed instruments and low-cost dynamic microphones, or to users of other nearby systems, or cause loss of confidentiality.

I.2 Examples of overspill issues

These are typical examples.

- Where stringed instruments with magnetic pickups (e.g. electric guitars) or low-cost dynamic microphones are used close to a system, a feedback loop may be created where the magnetic field is received by the magnetic pickup, and the signal is then amplified by the guitar player's or venue's sound system and fed back into the system loop, either electrically or via microphones and loudspeakers, to be received again by the pickup, and so on. This can result in unwanted noises and potentially cause the amplifier to overheat and fail.
- Where two systems are installed, for example in two adjacent lecture rooms, the signal from one may be distracting to users of the adjacent one. Signals from a system installed in a meeting room may cause interference to hearing aid users in adjacent rooms who are using their telecoils for telephone conversations or listening to other programme material via a neck-loop.
- Where two counter systems are installed at adjacent service counters, for example in a bank, a hearing aid user might be able to hear and understand a confidential conversation between people at the adjacent service counter.
- Where a local government council chamber is equipped with a system, a journalist with suitable reception equipment may be able to hear and understand speech from the council’s proceedings from a corridor, or even from a public road outside the council chamber building.
- Where two adjacent cinema auditoria equipped with systems are showing different films, one for children and one for an adult audience, the adult film soundtrack may be heard by children in the adjacent auditorium.

I.3 Addressing overspill issues

The level of overspill that is acceptable at any location depends on the consequences of the overspill The level of overspill field strength from one system to the intended useful magnetic field volume of another system should be no higher than the required level of background magnetic noise in every case, but particular requirements for lower levels of overspill field strength should be determined by risk analysis and specified contractually. It is not practical to screen the overspill magnetic fields or to stop them completely. However, a variety of methods may be employed to reduce overspill or to avoid its effects.

- Make smaller loops, or the loop wire may be positioned to make a larger separation between the system and the place where overspill is to be avoided.
- Loop antenna configurations such as ’figure-of-eight’ and phased loop arrays may be used to reduce overspill in one or more directions. See 5.4.14 of IEC 62489-1:2010.

- Physical barriers can be used to keep people away from places where overspill is at a level considered to be problematic.
- The system can be turned off and alternative hearing assistance methods employed when confidential matters are being discussed. But it should be noted that RF systems, including radio microphones, can be intercepted a long distance away, and infra-red systems may leak signals through windows and glazed areas. Expert assistance is likely to be required to achieve the reductions in overspill needed to meet contractual requirements.

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2 While the analysis presented here is confined to the interior of loops, the formulae are also valid outside the loops, as demonstrated in [10].

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