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**Telephony for hearing impaired people;
Inductive coupling of telephone earphones
to hearing aids;
Part 1: Fixed-line speech terminals**

Reference
RES/STQ-196

Keywords
coupling, hearing aid, inductive, telephony

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Foreword

This ETSI Standard (ES) has been produced by ETSI Technical Committee Speech and multimedia Transmission Quality (STQ).

NOTE: The present document prepare materials for a future update of ETS 300 381 [3] published in December 1994. The update of ETS 300 381 [3] may be updated into an EN, taking into account the contents of the present document.

Several administrations and operating agencies have expressed the opinion that it would be acceptable if the present document were to be made mandatory for public telephones and wherever telephones are installed on the basis of safety, e.g. in lifts. It would not be expected to be mandatory in all countries for all telephone terminals. However, if such a facility is made available, it should conform to the requirements of the present document, and labels and literature advertising the facility should not be related to a particular product unless it does in fact so comply.

Annexes A and D of the present document are normative while annexes B, C, E and F are informative.

The present document aims at enlarging the scope of the speech terminals, as the initial document only dealt with PSTN and ISDN speech terminals, and to update the measurement methods that have been changed, in particular with the use of HATS. In addition, some quality parameters have been provided.

The present document is part 1 of a multi-part deliverable covering telephony for hearing impaired people; inductive coupling of telephone earphones to hearing aids, as identified below:

Part 1: "Fixed-line speech terminals";

Part 2: "Cellular speech terminals".

Part 1 provides general principles and testing methods for inductive coupling with telephone earphones. It also defines the requirements for wired telephone earphones and the dedicated test methods.

Part 2 defines the requirements for cellular telephone earphones and the dedicated test methods.

1 Scope

The present document applies to fixed-line telephones having earphones (see ITU-T Recommendation P.57 [4]) which are intended for direct application to the ear (e.g. handsets, supra-aural headsets) and which are intended to provide, through the earphone, a magnetic field for coupling to hearing aids.

It specifies the level linearity and frequency dependence of the magnetic field strength produced by the handset and characteristics for the calibrated probe coil. It also specifies provisions for distortion, noise and signal to noise ratio of the magnetic field.

Provisions for DECT terminals, are within the scope of this part 1 of this multipart deliverable, even if it is a cordless technology.

Handsfree or loudspeaking devices are outside the scope of the present document.

The requirements for inductive coupling with wireless terminal earphones are outside the scope of the present document.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

[1] ITU-T Recommendation P.370: "Coupling hearing aids to telephone sets".

[2] ITU-T Recommendation P.64: "Determination of sensitivity/frequency characteristics of local telephone systems".

[3] ETSI ETS 300 381: "Telephony for hearing impaired people;Inductive coupling of telephone earphones to hearing aids".

[4] ITU-T Recommendation P.57: "Artificial ears".

[5] ETSI ETS 300 488: "Terminal Equipment (TE); Telephony for hearing impaired people; Characteristics of telephone sets that provide additional receiving amplification for the benefit of the hearing impaired".

[6] ETSI ETS 300 679: "Terminal Equipment (TE); Telephony for the hearing impaired; Electrical coupling of telephone sets to hearing aids".

[7] ITU-T Recommendation P.58: "Head and torso simulator for telephonometry".

[8] ETSI ES 203 038: "Speech and multimedia Transmission Quality (STQ); Requirements and tests methods for terminal equipment incorporating a handset when connected to the analogue interface of the PSTN".

[9] ETSI ES 202 737: "Speech and multimedia Transmission Quality (STQ); Transmission requirements for narrowband VoIP terminals (handset and headset) from a QoS perspective as perceived by the user".

[10] ETSI ES 202 739: "Speech and multimediaTransmission Quality (STQ); Transmission requirements for wideband VoIP terminals (handset and headset) from a QoS perspective as perceived by the user".

[11] ETSI EN 300 176-2: "Digital Enhanced Cordless Telecommunications (DECT); Test specification; Part 2: Audio and speech".

[12] ETSI EN 300 175-8: "Digital Enhanced Cordless Telecommunications (DECT); Common Interface (CI); Part 8: Speech and audio coding and transmission".

[13] ETSI I-ETS 300 245-2: "Integrated Services Digital Network (ISDN);Technical characteristics of telephony terminals; Part 2: PCM A-law handset telephony".

[14] ETSI I-ETS 300 245-5: "Integrated Services Digital Network (ISDN);Technical characteristics of telephony terminals; Part 5: Wideband (7 kHz) handset telephony".

[15] ITU-T Recommendation P.501: "Test signals for use in telephonometry".

[16] ITU-T Recommendation P.581: "Use of head and torso simulator (HATS) for hands-free and handset terminal testing".

[17] ANSI C63.19-2011: "American National Standard Methods of Measurement of Compatibility between Wireless Communication Devices and Hearing Aids".

[18] IEC 60118-13: "Hearing aids- Electromagnetic compatibility".

[19] IEC 60118-1: "Methods of measurement of electroacoustic characteristics of hearing aids; Part 1: Hearing aids with induction pick-up coil input".

[20] IEC 60118-4: "Methods of measurement of electroacoustic characteristics of hearing aids; Part 4: Magnetic field strength in audio-frequency induction loops for hearing aid purposes".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

Not applicable.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Composite Source Signal (CSS): signal composed in time by various signal elements
(ITU-T Recommendation P.501 [15])

level of magnetic field strength: value of the magnetic field strength expressed in Amperes per metre (A/m)

permissible range: range into which the measured level of the magnetic field strength needs to fall to comply with the present document

plane of measurement: plane parallel to the earcap plane at a distance of 10 mm

preferred range: range of magnetic field strength likely to be required for satisfactory performance by hearing aids designed primarily for coupling to magnetic loops often installed in auditoria

sound pressure level: acoustic sound pressure level is expressed in decibels relative to 1 Pascal (or dBPa)

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CSS	Composite Source Signal
DECT	Digital Enhanced Cordless Telecommunications
DRP	Ear-Drum Reference Point
HATS	Head And Torso Simulator
ISDN	Integrated Services Digital Network
PSTN	Public Switched Telephone Network
THD	Total Harmonic Distortion
VoIP	Voice over Internet Protocol

4 Introduction

4.1 General

It is recognised that there is a sizeable proportion of telephone users that have difficulty in conversing over a telephone connection due to hearing loss. To alleviate these difficulties special means have been provided in many national systems to enable hearing impaired users to couple their hearing aids inductively to the telephone receiver, and a number of national/international specifications define characteristics for this form of coupling. The present document addresses the requirements for successful inductive coupling of hearing aids to telephone sets.

Furthermore, it is also recognised that many hearing impaired users are able to have satisfactory telephone conversations while coupling their hearing aids acoustically to the telephone receiver, or even using the telephone handset without a hearing aid. This latter situation is possible due to the fact that, under good conditions, a telephone connection can be louder than a face-to-face conversation over a 1 metre air path by up to 30 dB.

The inclusion of inductive coupling does not reduce or replace existing technical standards that apply to a handset. Inductive coupling can be combined with other additional functionality, such as amplification or extra earpieces, provided specifically for people with special needs.

Provision of additional amplification in the mouth-to-ear path can greatly increase the proportion of telephone conversations involving hearing impaired users that are rated as "good". Such provision is defined in ETS 300 488 [5]. Certain national standards also exist to enable direct electrical connection of hearing aids to telephone apparatus, such as defined in ETS 300 679 [6].

4.2 Background

Magnetic induction systems incorporated in telephone handsets generate an alternating magnetic field with special characteristics which make the field detectable by hearing aids equipped with induction pick-up coils.

Reception of an audio-frequency signal via an induction pick-up coil can often allow an acceptable signal-to-noise ratio to be achieved in cases where the acoustical reception would otherwise be degraded by background noise.

The magnetic field strength, which enables induction pick up coils in hearing aids to function effectively, shall be high enough to produce an acceptable signal to noise ratio but not so high as to cause overloading of the hearing aid.

The value of the magnetic field strength given in the present document has been chosen so that these requirements are met as far as possible.

Measurement methods used in the present document are in accordance with those given in ITU-T Recommendations P 370 [1] and P.64 [2].

This standard applies, for terminals intended to provide a magnetic field for coupling to hearing aids, in complement with requirements and measurements methods defined in the relevant standards such as:

- For analogue telephones: ES 203 038 [8]
- For VoIP terminals: ES 202 737 [9] or ES 202 739 [10]

- For DECT terminals: EN 300 176-2 [11], EN 300 175-8 [12]
- For ISDN terminals: I-ETS 300 245-2 [13], I-ETS 300 245-5 [14]

NOTE 1: Care should be taken when designing hearing aids to include sufficient immunity to radio frequency interference to avoid disturbances arising from the detection of radio signals emitted by cordless and mobile telephones, as defined in standards such as ANSI C63-19, 2011: «Methods of measurement of compatibility between wireless communications devices and hearing aids» [17] and IEC 60118-13 « Hearing aids - Electromagnetic compatibility » [18].

NOTE 2: Provisions for DECT terminals, are within the scope of part 1 of this multipart deliverable, even if it is a cordless technology.

5 Requirements

5.1 Introduction

The following requirements in respect of magnetic field strength as a function of frequency shall be met at all settings of the volume control, if provided. These requirements concern the sensitivity at 1 000 Hz, the frequency response, the linearity, the distortion (THD) at 1 000 Hz and the signal to noise ratio and are defined by reference to the earphone sound pressure level at the artificial ear of the HATS.

The signal is measured at the HATS [7] DRP with diffuse-field equalization as described in ITU-T Recommendation P.581 [16]. The equalized output signal is power-averaged on the total time of analysis.

To test sound pressure level delivered by the earphone, the handset or supra-aural headset is placed on the HATS [7] as described in ITU-T Recommendation P.64 [2]. The artificial ear shall comply with ITU-T Recommendation P.57 [4].

5.2 Magnetic field strength level

The level of the magnetic field strength when measured in accordance with clause 7.2 shall be:

- Permissible range: -17 dB to -30 dB relative to 1 A/m.
- For an electrical drive to the telephone that gives a sound pressure level of -17 dBPa at the artificial ear of the HATS at 1 000 Hz or -15d Pa for the speech or speech-like signal, measured for the bandwidth 200 Hz - 4 kHz for narrow band and 200 Hz - 8 kHz for wideband).

NOTE: The preferred range is: -17 dB to -25 dB relative to 1 A/m. Hearing aids with magnetic pick-up coils primarily intended for coupling to magnetic loops in auditoria in accordance with IEC 60118-4 [20], are likely to require a field strength in the preferred range for effective performance.

5.3 Linearity of the magnetic field strength

The linearity of the magnetic field strength as a function of sound pressure level shall deviate by less than ±1 dB when measured in accordance with clause 7.3.

For an increase of sound pressure level of 20 dB the field strength shall increase by 20 dB ± 1 dB.

The requirement applies only to technologies where a receive linearity exists in the relevant terminal standard. The same linearity range as defined in the terminal standards applies to the linearity of the magnetic field strength without exceeding 20 dB.

5.4 Frequency characteristics

The frequency characteristic of the magnetic field strength shall lie within the template given in table 1 and as shown in figure 1, when measured in accordance with clause 7.4.

Table 1: Limits for the magnetic field frequency response

Frequency (Hz)	Upper limit (dB)	Lower limit (dB)
300	10	-10
500	*	-3
1 000	3	-3
2 000	*	-9
3 400	*	-18
3 400	*	- inf
7 000	7	- inf

NOTE 1: The limit levels at intermediate frequencies marked * in the table 1 lie on a straight line drawn between the given values on a logarithmic (frequency) - linear (dB) scale.

NOTE 2: The preferred frequency characteristic from 300 Hz to 3 400 Hz lies between ±3 dB.

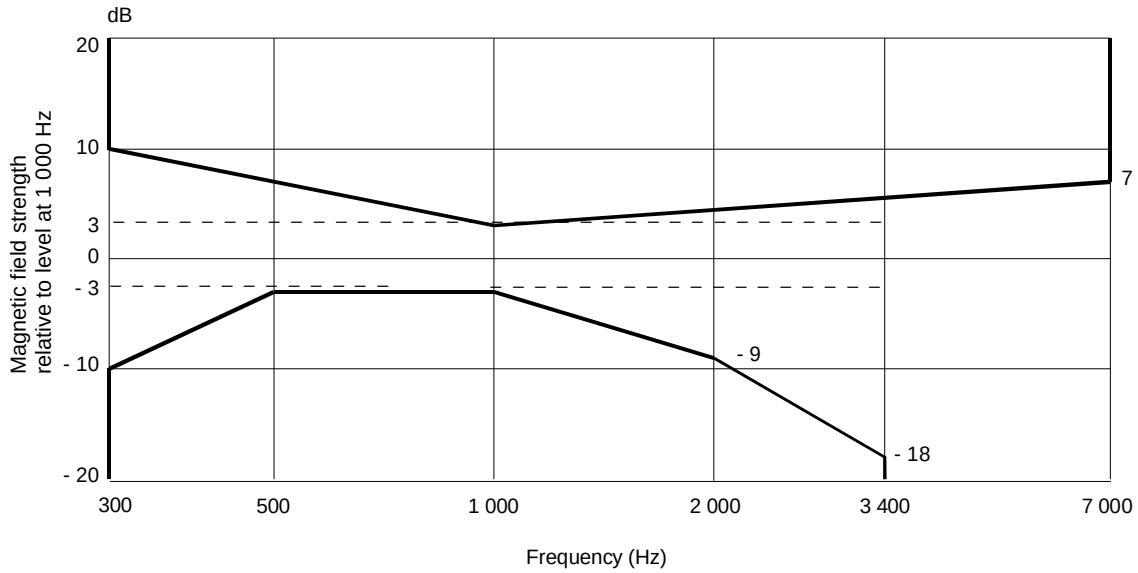


Figure 1: Magnetic field strength frequency characteristics

5.5 Distortion

The Total Harmonic Distortion (THD) of the magnetic field shall be less than 10 % and measured in accordance with clause 7.5.

NOTE: The requirement applies only to technologies where a receive harmonic distortion exists in the relevant terminal standard.

5.6 Signal to Noise ratio

The signal to noise ratio of the magnetic field shall be greater than 40 dB and measured in accordance with clause 7.6.

The signal to noise ratio refers only to magnetic noise.

6 The probe coil

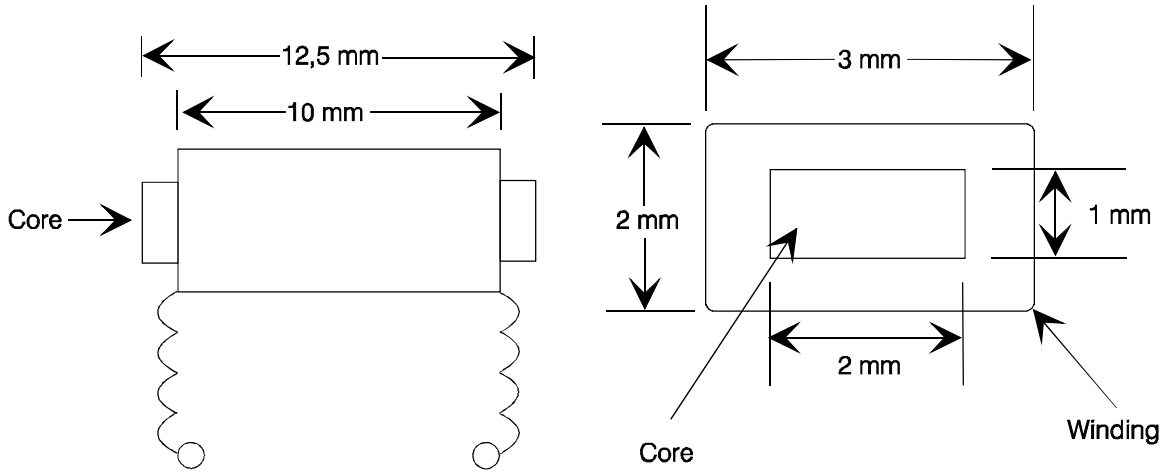
6.1 Dimensions

To minimise the loss of resolution when measuring the magnetic field strength, the following, maximum dimensions are recommended for the calibrated probe coil:

- Core: length 13,5 mm;
- Cross section: 1,5 mm x 2,5 mm;
- Winding: length 11 mm;
- Cross section: 2,5 mm x 3,5 mm.

The winding shall be shorter than the core.

An example of a coil is shown diagrammatically in figure 2.



NOTE 1: The magnetic field may be non-homogeneous within distances comparable to the length of the probe coil. The introduction of a magnetic core material may also redirect the magnetic field contours. Typically, the sensitivity of the probe coil will increase with frequency at 6 dB/octave.
NOTE 2: The probe coil may be combined with frequency correcting elements to obtain a flat frequency response.
NOTE 3: Figure 2 is not drawn to scale.

Figure 2: The probe coil

Alternatively, another type of probe coil may be used such as defined in figure 3 which provides brief details of a commercially available coil.

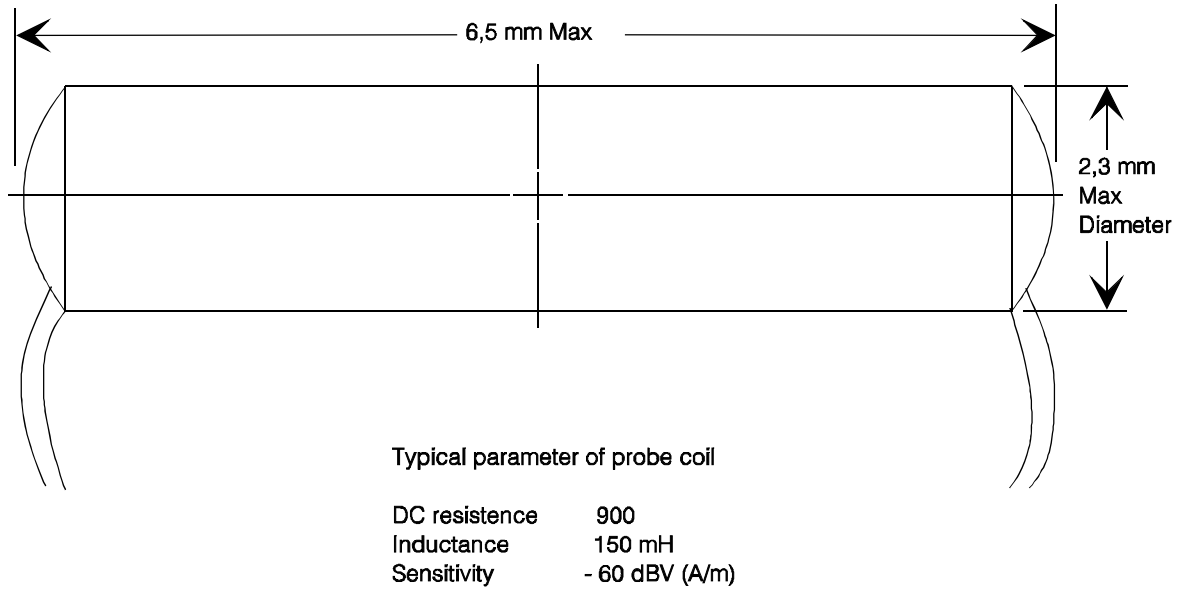


Figure 3: Alternative probe coil characteristics

6.2 Calibration of probe coil

The probe coil shall be calibrated; a suitable method is given in annex D.

6.3 Distortion

The probe coil shall introduce less than 2 % total harmonic distortion when measuring field strengths up to +2 dB relative to 1 A/m over the frequency range 300 Hz to 3 400 Hz. In assessing the distortion of the probe coil only harmonics up to 8 000 Hz need be considered.

6.4 Connecting leads for probe coil

To obtain a high sensitivity, the probe coil is likely to possess a relatively high inductive impedance. The connecting leads to the coil, in order to facilitate calibration, shall be of the order of 0,5 metre and their electrical effect on the signal at the measurement point cannot be ignored. Both calibration and measurement should be made using a suitable lead which is permanently attached to the probe coil, and which has stable physical characteristics. Furthermore, to minimise errors arising from different electrical terminations, the voltmeter used for measurements should be the same as that used for calibration.

7 Test procedures

Annex B gives step-by-step procedures for carrying out these tests.

NOTE: When measuring sampled systems, it is advisable to avoid measuring at sub-multiples of the sampling frequency. There is a tolerance of ±2 % on the generated frequencies, which may be used to avoid this problem, except for 4 kHz (for narrowband) and for 8 kHz (for wideband) where only the -2 % tolerance may be used.

7.1 Calibration of receive sound pressure level

The handset or supra-aural headset is placed on the HATS [7] as described in ITU-T Recommendation P.64 [2]. The used artificial ear shall comply with ITU-T Recommendation P.57 [4].

The HATS is diffuse field equalized as described in ITU-T Recommendation P.581 [16]. The equalized output signal is power-averaged on the total time of analysis. The signal is measured at the DRP.

A speech or speech-like test signal as described in ITU-T Recommendation P.501 [15] shall be used for linearity, magnetic field strength level, signal-to-noise ratio, frequency response and as conditioning signal (as first part of CSSignal) for harmonic distortion measurement. The harmonic distortion is measured on the sinewave at 1 000 Hz.

As a reference the drive level at the signal generator shall be adjusted to produce a sound pressure level, p_e, of -17 dBPa at 1 000 Hz at the artificial ear of the HATS. The level is adjusted to -15 dPa for the speech or speech-like signal, measured for the bandwidth 200 Hz to 4 kHz for narrowband and 200 Hz to 8 kHz for wideband.

NOTE: The levels correspond to the previous signal level of -14 dBPa at ERP, as in the previous ETS 300 381 [3].

7.2 Measurement of the magnetic field strength level

Place the centre of the calibrated probe coil (see clause 6) in the plane of measurement and orientate it in any direction for maximum coupling. Determine the magnetic field strength using the drive level as given in clause 7.1. Clause 5 gives the requirements for the field strength.

7.3 Measurement of the linearity of the magnetic field strength

With the probe coil positioned as in clause 7.2, increase the sound pressure level specified in clause 7.1 by 20 dB or the value given in the relevant standard (see clause 5.3) and measure the resulting magnetic field strength.

7.4 Measurement of frequency characteristics

With the probe coil positioned as described in clause 7.2 and the drive level as specified in clause 7.1, measure the resulting field strength. The magnetic field strength frequency characteristics shall fit within the template shown in figure 1 (see clause 5.3).

7.5 Measurement of distortion

The Total Harmonic Distortion (THD) of the magnetic field is analyzed on the range of 100 Hz to 8 500 Hz for a drive level specified in clause 7.1 for a frequency of 1 000 Hz.

7.6 Measurement of signal to noise ratio

The signal to noise ratio of the magnetic field is calculated as the difference between the magnetic field strength level and the A-weighted magnetic noise.

Annex A (normative): Packaging, labelling and user instructions

A.1 Packaging and labelling

Where the telephones are suitable for use by hearing impaired people, this shall be indicated by the inclusion of an agreed international symbol on the telephone sets themselves, the packaging, brochures and instruction leaflets as public signs that such facilities are available and conform to the present document. The recommended symbol is shown in annex C, figure C.1.

A.2 User instructions

Instructions which clearly describe the manner in which the instrument to be used in conjunction with hearing aids shall be provided with each telephone. The instructions shall show how the telephone is to be placed for maximum coupling efficiency and make reference to the use of the controls on the hearing aid, particularly the switch position necessary for induction pick up (the T position).

Annex B (informative): Step-by-step measurement procedures

Measuring the magnetic field radiating from an earphone.

The required sensitivity is the maximum magnetic field detected at a defined distance from the earpiece as a function of frequency for an input signal level at the exchange that gives the signal level as defined in clause 7.1.

1) Calibrate the artificial ear in accordance with instructions given in ITU-T Recommendation P.57 [4]. The signal is measured at the HATS [7] DRP with diffuse-field equalization as described in ITU-T Recommendation P.581 [16]. The equalized output signal is power-averaged on the total time of analysis. The application force for handsets is 8 N.

2) Calibrate the small magnetic probe coil in accordance with instructions given in clause 6.

3) Couple the earphone to the artificial ear.

4) Connect the terminal according to the relevant standard as defined in clause 4.2.

5) Set the signal generator to give a sound pressure level, p_e, of -17 dBPa at 1 000 Hz at the artificial ear of the HATS or of -15 dPa for the speech or speech-like signal, measured for the bandwidth 200 Hz to 4 kHz for narrowband and 200 Hz to 8 kHz for wideband according to clause 7.1.
A speech or speech-like test signal as described in ITU-T Recommendation P.501 [15] will be used for linearity, magnetic field strength level, signal-to-noise ratio, frequency response and as conditioning signal (as first part of CSSignal) for harmonic distortion measurement . The harmonic distortion is measured on the sinewave at 1 000 Hz.

6) Remove the artificial ear from the handset and with the centre of the probe coil 10 mm from the plane of the earcap, find the position and axis that gives maximum magnetic signal and compare with the recommended range of magnetic field given in clause 5.1.

7) With the probe coil held in the position as described in 6) above, determine the magnetic field as a function of frequency and compare with the recommended characteristic given in clause 5.4, figure 1.

8) With the drive signal defined in clause 7.1, increase the drive level so that the sound pressure level in the artificial ear increases by 20 dB and check that the magnetic field strength increases by 20 dB ± 1 dB compared with the measured level under 6) above.

Annex C (informative): Symbol indicating facilities for the hearing impaired

The following symbol is recommended for use with telephone apparatus that provide facilities for hearing impaired users.

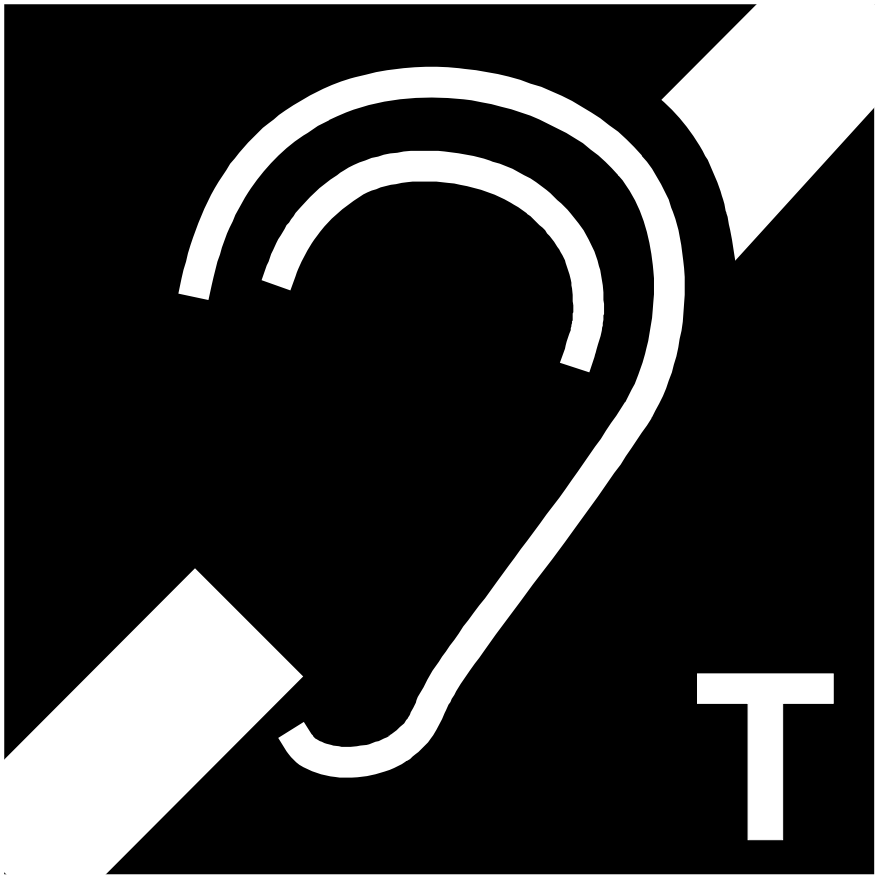


Figure C.1: Internationally agreed symbol to indicate availability of facilities for the hearing impaired

Annex D (normative): Calibration of the probe coil

In order to calibrate the probe, a homogeneous magnetic field of known intensity shall be available. The magnetic field strength at the centre of a square loop of one turn with a side of "a" meters and carrying a current of "i" amperes is given by:

$$H = \frac{2\sqrt{2}}{\pi} \bullet \frac{i}{a} A/m$$

The dimension "a" should be 0,5 m or more to ensure that the field at the centre is sufficiently well defined in magnitude and direction.

An alternative is to use for calibration a circular loop instead of a square one.

In this case, the magnetic field strength at the centre of a circular loop of one turn with a diameter of "d" meters and carrying a current of "i" amperes is given by:

$$H = i/d \ A/m$$

NOTE 1: This method is defined in IEC 60118-1 [19]. The dimension "d" should be 0,5 m or more to ensure that the field at the centre is sufficiently well defined in magnitude and direction.

In practice, it may be advantageous to construct the loop having several turns to reduce the current from the source. Essentially, constant current conditions should be maintained over the test frequency range, for example driving the coil from a low impedance generator through a series resistor having at least 100 times the impedance of the coil over the frequency range of interest. If the current drive is monitored during the calibration process any variations can be taken into account when deriving the probe coil sensitivity.

The test space shall be remote from any field disturbing magnetic material or other material in which eddy currents can be induced, so causing a field disturbance.

The sensitivity as a function of frequency of the probe coil shall be measured as the induced voltage over both leads of the probe coil with an accuracy of ±0,5 dB. This voltage is the standard in relation to the applied current per metre and shall be used for the measurement of the requirements specified in clause 5.

The total harmonic distortion of the magnetic field shall be less than 1 %.

The linearity of the coil in the measurement range shall be checked: For an increase of input signal of 20 dB the field strength shall increase by 20 dB ± 0,5 dB.

The coil that is used for the measurement does not have a flat frequency curve (output voltage versus frequency). The measured frequency curve of the coil shall be used to compensate the measured frequency response defined in clause 5.4.

NOTE 2: Further helpful information is given in IEC 60118-1 [19].

Annex E (informative): Components of the inductive field

The inductive field around a telephone earphone associated with the magnetic circuit of a telephone earphone capsule or with an additional coil installed for the purpose of providing an inductive field, may be considered as having 2 components (see figure E.1).

The axial component is perpendicular to the plane of the earcap and usually passes through, or close to, the centre of the earcap plane. The radial component radiates from the centre of the earcap and may be considered for measurement purposes as parallel to the earcap plane.

Hearing aid pick-up coils are usually installed in a vertical orientation to give optimum performance when coupling to room induction loops. It is, therefore, the radial component of the telephone inductive field that most usefully couples with the hearing aid pick-up coil.

It is recommended that the requirements of the present document should be met by the radial component of the telephone inductive field.

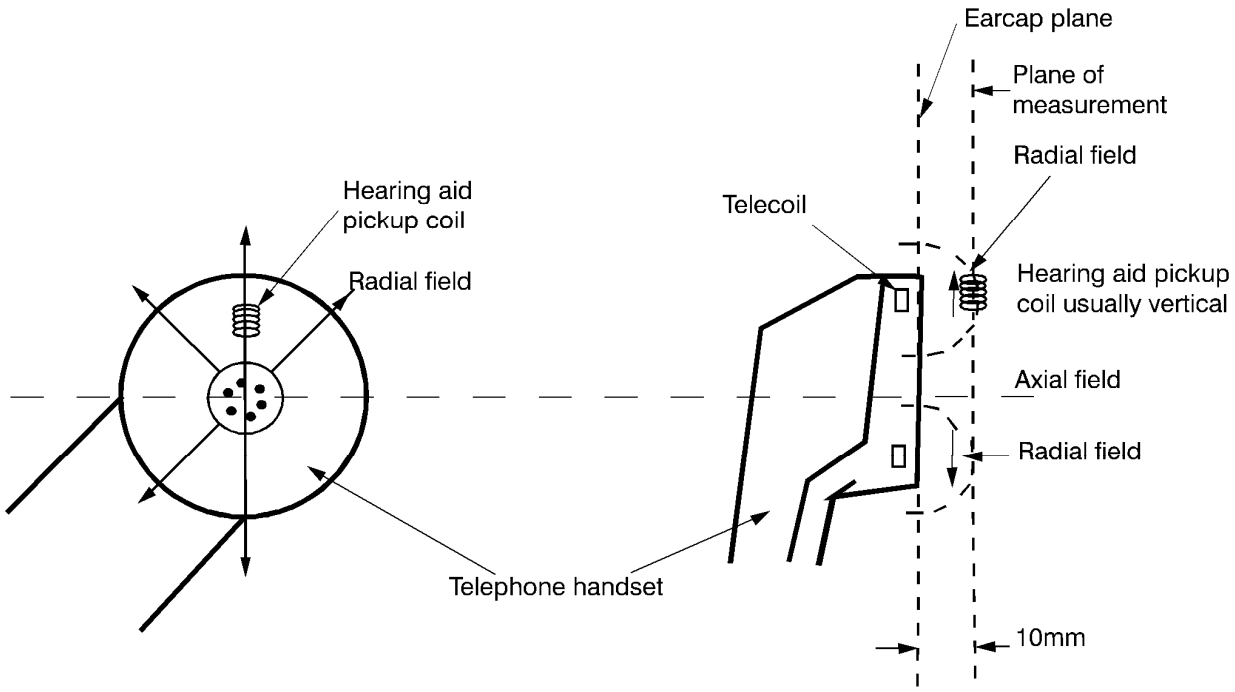


Figure E.1

Annex F (informative): Bibliography

For the purposes of the present document, the following documents have been referred:

- TIA-1083-A: "Telephone Terminal Equipment; Handset magnetic measurement procedures and performance requirements".

History

Document history		
V1.1.1	December 1994	Publication as ETS 300 381
V1.2.0	August 2012	Membership Approval Procedure MV 20121005: 2012-08-06 to 2012-10-05
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