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INTERNATIONAL STANDARD

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Electroacoustics – Hearing aids – Part 16: Definition and verification of hearing aid features

Électroacoustique – Appareils de correction auditive – Partie 16: Définition et vérification des caractéristiques des appareils de correction auditive

IEC 60118-16:2022-03(en-fr)

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The text of this International Standard is based on the following documents:

Draft	Report on voting
29/1110/FDIS	29/1116/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at http://www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 60118 series, published under the general title *Electroacoustics – Hearing aids*, can be found on the IEC website.

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ELECTROACOUSTICS – HEARING AIDS –

Part 16: Definition and verification of hearing aid features

1 Scope

This part of IEC 60118 gives definitions for common hearing aid features such as noise reduction or feedback reduction, etc. Only acoustical inputs are considered. Binaural features are currently not covered in this document. In addition, measurement procedures are described to verify hearing aid features. The objective is not to evaluate the performance of features but to verify their existence and functionality.

Furthermore, definitions and procedures are kept as general as possible so that this document can be applied to various types of hearing aids, for example, air-conduction hearing aids or bone conduction hearing aids. To this end, the general definition for the term "hearing aid" given in IEC 60118-0 is adopted, and this document does not refer to any specific ear simulator or acoustic coupler but uses a general definition of a coupler. However, if a general view is not applicable or leads to unclear or complex wording, the situation for an air-conduction hearing aid only is considered. Nevertheless, an explanation is given on how this document can be applied to hearing aids which do not use air conduction.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60118-0:—[1], *Electroacoustics – Hearing aids – Part 0: Measurement of the performance characteristics of hearing aids*

IEC 60118-15, *Electroacoustics – Hearing aids – Part 15: Methods for characterising signal processing in hearing aids with a speech-like signal*

IEC 61260-1, *Electroacoustics – Octave-band and fractional-octave-band filters – Part 1: Specifications*

ISO 21748, *Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty evaluation*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

[1] Fourth edition under preparation. Stage at the time of publication: IEC FDIS 60118-0:2022

3.1
sound pressure level
SPL
ten times the logarithm to the base 10 of the ratio of the square of the sound pressure, p, to the square of a reference value, p_0 expressed in decibels, where the reference value, p_0, is 20 µPa

[SOURCE: ISO/TR 25417:2007, 2.2, modified – The abbreviated term has been added and the symbol, formula and notes to entry have been omitted.]

3.2
1/f noise
pink noise
random noise having a continuous spectrum and such that the power spectral density is proportional to the reciprocal of the frequency in the frequency range considered

3.3
signal-to-noise ratio
SNR
difference in sound pressure level between the target signal, usually speech, and the interference signal, usually noise

3.4
hearing aid
wearable instrument intended to aid a person with impaired hearing

[SOURCE: IEC 60118-0:—, 3.2]

3.5
reference point
point related to the hearing aid sound inlet port(s) for the purpose of defining the position of the hearing aid

3.6
hearing aid user
person wearing a hearing aid to alleviate hearing impairment

3.7
measurement coupler
device through which the output of a hearing aid can be measured

Note 1 to entry: For an air-conduction hearing aid, usually the acoustic coupler according to IEC 60318-5 or the occluded-ear simulator according to IEC 60318-4 is used as a measurement coupler and for a bone conduction hearing aid, the coupler according to IEC 60318-6 or a skull simulator is used.

3.8
hearing aid program
HAP
set of parameters, defining at least the frequency characteristic and possibly other parameters of the signal processing of a hearing aid that can be selected by the hearing aid user or that are automatically selected by the hearing aid to adapt the signal processing to specific listening situations

3.9
configurable hearing aid program
configurable HAP
hearing aid program with an adjustable set of parameters, which can be configured and reconfigured to meet the individual needs of the hearing aid user without influencing the processing in other programs

Note 1 to entry: Usually fitting software provided by the hearing aid manufacturer, a computer and a programming interface are used to configure the set of parameters.

Note 2 to entry: The fact that a hearing aid program is configurable has the benefit that the signal processing can be optimized to the individual needs, for example, for a specific listening situation for this specific user.

3.10
non-configurable hearing aid program
non-configurable HAP
hearing aid program configured by the manufacturer or automatically by the hearing aid depending on the listening situation, which cannot be reconfigured either by the hearing aid user or by using the fitting software without influencing the processing in other programs

3.11
listening situation
situation in which a hearing aid user requires a specific signal processing

Note 1 to entry: This definition is intentionally different from the term "acoustic environment" in ISO 12913-1:2014, 2.2 and 3.4.

3.12
noise reduction
feature of the signal processing of a hearing aid intended to reduce noise with respect to the absolute level or relative to the level of a target signal

3.13
noise reduction for speech enhancement
feature of the signal processing of a hearing aid intended to increase the signal-to-noise ratio even if speech and noise are presented simultaneously from the same direction and have the same long-term average spectrum

Note 1 to entry: It is possible that the increase in signal-to-noise ratio will not increase speech intelligibility.

3.14
gain reduction for noise
feature of the signal processing of a hearing aid intended to decrease the gain for noise compared to the gain for speech even if speech and noise are presented successively from the same direction and have the same long-term average spectrum

3.15
feedback
return of some of the energy of the output signal from the hearing aid to the input of the same hearing aid

3.16
critical feedback condition
situation where feedback causes a whistling noise at the output of the hearing aid

3.17
feedback reduction
feature of the signal processing of a hearing aid to reduce or completely avoid the occurrence of the critical feedback condition without reducing gain

Note 1 to entry: Changing the feedback path, by, for example, increasing the sealing of the earmold, is not a part of the signal processing and therefore not understood as feedback reduction.

3.18
hearing aid channel
feature of the signal processing of a hearing aid that enables individual adjustment of the gain and the parameters of an automatic gain control for a certain frequency range

Note 1 to entry: A hearing aid channel can consist of multiple hearing aid bands.

3.19
hearing aid band
feature of the signal processing of a hearing aid that enables individual adjustment of the gain for a certain frequency range

3.20
maximum power output
MPO
maximum level at the output of the hearing aid which is adjustable by the output limiter

3.21
output limiter
feature of a hearing aid that allows one to define and redefine a limit for maximum power output (MPO)

3.22
fitted maximum output sound pressure level
fitted OSPL90
maximum output SPL of a hearing aid when measured after fitting with 90 dB input SPL

[SOURCE: IEC 60601-2-66:2019, 201.3.206, modified – Note to entry has been omitted.]

3.23
functional test setting
FTS
setting of the hearing aid where all accessible features in the fitting software are manually disabled and a linear gain is applied equally to the reference test setting of the gain control according to IEC 60118-0

Note 1 to entry: The difference between reference test setting (RTS) as defined in IEC 60118-0 and the functional test setting (FTS) is due to the fact that not always all features are accessible in the fitting software and can be disabled.

3.24
rank
<of a matrix> number of singular values of a matrix A that are equal to or exceed 0,95 which is written as rank(A)

3.25
singular values
<of a matrix> number of positive real values in linear algebra which can be computed for a matrix as a result of a singular value decomposition (SVD)

4 Application to non-air-conduction hearing aids

Definitions and procedures in this document are kept as general as possible so that this document can be applied to various types of hearing aids, for example, air-conduction hearing aids or bone conduction hearing aids. However, in some subclauses and definitions, a general view is not applicable or leads to an unclear or complex wording so that only air-conduction hearing aids are considered.

NOTE For example, a sound pressure level is considered for the output signal of the hearing aid. However, this holds for air-conduction hearing aids only. For bone conduction, the output is a force, and for other devices the output can be any other physical quantity.

To apply this document to devices other than air-conduction hearing aids, it is required that:

- the input signal is an acoustic sound pressure,
- the output signal can be quantified by another physical quantity,
- and a measurement coupler exists that enables the measurement of this physical quantity at the output of the hearing aid.

For bone conduction hearing aids, the output sound pressure level shall be replaced by an output force level. In addition, for bone conduction hearing aids, references to IEC 60118-0 shall be understood as references to IEC 60118-9.

5 Test equipment

5.1 Acoustical requirements

For the presentation of acoustical input signals, as the test space a test room or a test box can be used and the following requirements apply.

a) The input sound pressure level at the hearing aid reference point shall be controlled and monitored by means of a reference microphone (pressure method) or by using the substitution method according to IEC 60118-0.

b) The sound pressure level indicated by the reference microphone shall be accurate within ±2 dB for sinusoidal input signals with sound pressure levels between 40 dB SPL to 90 dB SPL over the frequency range from 100 Hz to 10 kHz. A reduced frequency range from 200 Hz to 8 000 Hz or from 200 Hz to 5 kHz may be used and shall be stated.

c) The measurement of sound pressure levels with the reference microphone shall be accurate within ±0,5 dB at the frequency of calibration.

d) The measurement of sound pressure levels with the reference microphone shall be accurate within ±1,5 dB in the range from 200 Hz to 4 000 Hz and ±2 dB in the range from 4 000 Hz to 10 000 Hz for frequencies that are not calibrated (see list item c)).

e) The accuracy of measurements with the measurement coupler shall be stated for the frequency of calibration.

f) For the measurement coupler, the expanded uncertainty for the indication of output level relative to the indication at the frequency of calibration shall be stated for a frequency range of 200 Hz to 5 000 Hz, 200 Hz to 8 000 Hz, and 100 Hz to 10 000 Hz, if possible. A frequency specific uncertainty or the greatest uncertainty within the frequency range can be stated.

g) Octave-band and fractional-octave-band filters according to class 1 or class 2 of IEC 61260-1 shall be used.

h) Unwanted stimuli in the acoustic test space, such as ambient noise and mechanical vibrations shall be sufficiently low so as not to affect the test results by more than 0,5 dB. This can be verified if the output level of the hearing aid falls by at least 10 dB when the signal source is switched off.

5.2 Examples of test signals for common listening situations

In Table 1, a list of test signals is provided that can be used for the different listening situations. As speech signal, the international speech test signal (ISTS) as defined in IEC 60118-15 is used (see also [8][2]). In addition, as a speech shaped noise the international female masking noise (IFnoise) with the same long-term average spectrum as the ISTS is considered [9]. All examples of test signals listed in Table 1 have a crest factor < 20 dB. If other signals are used, these signals shall also have a crest factor < 20 dB.

Table 1 – Examples of test signals for different listening situations

Listening situation	Test signal
Speech in quiet	ISTS at 55 dB SPL
Speech in quiet	ISTS at 65 dB SPL
Speech in noise	ISTS at 70 dB SPL mixed with IFnoise at 68 dB SPL
Speech in babble noise	ISTS at 70 dB SPL mixed with ICRA noise track 7 at 65 dB SPL
Noise	IFnoise at 70 dB SPL
Noise	Traffic noise car motorway at 70 dB SPL
Noise	1/f noise at a 1/3-octave-band-level of 50 dB and with a frequency range of 100 Hz to 10 000 Hz
Noise	1/f noise at a 1/3-octave-band-level of 50 dB and with a frequency range of 200 Hz to 8 000 Hz
Noise	1/f noise at a 1/3-octave-band-level of 50 dB and with a frequency range of 200 Hz to 5 000 Hz
Noise	1/f noise at a 1/3-octave-band-level of 50 dB and with a frequency range of 1 000 Hz to 5 000 Hz
Music	Orchestra at 75 dB SPL
Music	Piano at 75 dB SPL

6 Verification of noise reduction

6.1 Noise reduction for speech enhancement

The following procedure describes a method to verify the existence and functionality of the noise reduction for speech enhancement according to the phase inversion method described in [10] or [11]. All signals are presented acoustically from the same sound source. Moreover, the frequency range of the output signals should be limited to a frequency range of 200 Hz to 5 000 Hz.

a) Program the device to FTS and reduce the gain additionally by 10 dB or as defined by the manufacturer.

b) Activate the noise reduction for speech enhancement.

c) Present a sequence containing the following signals to the hearing aid and record the output signals:

- 5 s; pause (part 1, resulting in the recorded output signal y_1);
- 60 s; ISTS at 70 dB SPL mixed with IFnoise at 68 dB SPL or at levels as defined by the manufacturer (part 2, resulting in the recorded output signal y_2);
- 5 s; pause (part 3, resulting in the recorded output signal y_3);

[2] Numbers in square brackets refer to the Bibliography.

- 60 s; ISTS at 70 dB SPL mixed with IFnoise with inverted phase at 68 dB SPL or at levels as defined by the manufacturer (part 4, resulting in the recorded output signal y_4);
- 5 s; pause (part 5, resulting in the recorded output signal y_5);
- 60 s; ISTS with inverted phase at 70 dB SPL mixed with IFnoise with inverted phase at 68 dB SPL or at levels as defined by the manufacturer (part 6, optional, resulting in the recorded output signal y_6);
- 5 s; pause (part 7, optional, resulting in the recorded output signal y_7).

d) Superpose the recordings in the following way:

$$s = \frac{1}{2}(y_2 + y_4) \quad \text{processed speech signal} \tag{1}$$

$$n = \frac{1}{2}(y_2 - y_4) \quad \text{processed noise signal} \tag{2}$$

$$v = \frac{1}{2}(y_2 + y_6) \quad \text{verification signal (optional)} \tag{3}$$

NOTE The relative time alignment of the output signals is critical for this post-processing. An appropriate time alignment can usually be reached for instance by presenting all parts of the signal within one signal and cutting the recorded signal according to the corresponding number of samples.

e) Compute the sound pressure level L_s of the processed speech signal s, L_n of the processed noise signal n, and L_v of the test signal v. For each signal, the interval between 15 s to 60 s is considered only.

f) As an optional verification of the measurement setup, L_v shall be 10 dB lower than L_s and L_n.

g) The difference $L_s - L_n$ is the SNR at the output of the hearing aid. If this output SNR is at least 1 dB higher than the SNR of the input signal, the existence and functionality of the noise reduction for speech enhancement have been verified.

6.2 Gain reduction for noise

The following procedure describes a method to verify the existence and functionality of a noise reduction, which reduces the gain if only noise is available. All signals are presented acoustically from the same sound source. Moreover, the frequency range of the output signals should be limited to a frequency range of 200 Hz to 5 000 Hz.

a) Program the device to FTS and additionally reduce the gain by 10 dB or as defined by the manufacturer.

b) Activate the gain reduction for noise.

c) Present a sequence containing the following signals to the hearing aid and record the output signals:

- 5 s; pause (part 1, resulting in the recorded output signal y_1);
- 60 s; ISTS at 70 dB SPL or as defined by the manufacturer but equal to the level of the IFnoise in part 4 (part 2, resulting in the recorded output signal y_2);
- 5 s; pause (part 3, resulting in the recorded output signal y_3);
- 60 s; IFnoise at 70 dB SPL or as defined by the manufacturer but equal to the level of the ISTS in part 2 (part 4, resulting in the recorded output signal y_4);

- 5 s; pause (part 5, resulting in the recorded output signal y_5).

d) Compute the sound pressure level of y_2 and y_4 for the interval of 15 s to 60 s which results in L_2, L_4.

e) If the difference $L_2 - L_4$ is higher than 2 dB, the existence and functionality of the gain reduction for noise have been verified.

7 Strategies of hearing aid programs and their verification

7.1 General

Clause 7 describes how to verify the existence of the different types of HAPs – user selected HAPs and automatically-selected HAPs depending on the listening situation – which are configurable or non-configurable. HAPs not related to acoustical input are not included in this document. Each of the following test procedures distinguishes between a number of hearing aid programs, which should be considered independently and cannot be directly summed up to a total number of programs. In addition, Annex B includes particular guidance and examples for all of the following test procedures.

7.2 User-selected hearing aid programs

7.2.1 Description

For this strategy, a specific number of hearing aid programs can be selected by the hearing aid user. To this end, the user has to classify the listening situation and choose the appropriate HAP accordingly (see Figure 1).

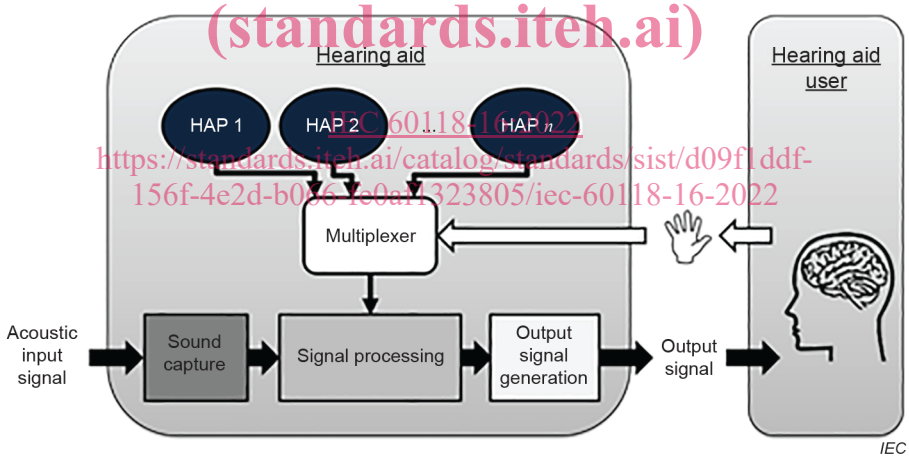

Figure 1 – Visualization of user selected HAPs

7.2.2 Verification

For the verification of user-selected HAPs, each of the programs shall be defined by a different signal processing strategy or set of parameters. If any two HAPs are defined by the same strategy or parameters, they will be regarded as being the same program. In the case of configurable HAPs, it shall be ensured that different programs provide different output characteristics.

If the change of a HAP affects the directional characteristics of the hearing aid only, this shall be considered in the signal presentation, for example, by presenting signals from different directions.