International Association for Hearing Accessibility

The care and feeding of neck loops for assistive hearing

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Introduction

A neck loop is a personal induction loop about 230 mm in diameter, intended to be used with a static or hand-held source of audio signals and transmit them magnetically to the user's one or two hearing aids equipped with telecoils.

Until recently, there was no standard method for measuring the sensitivity of a neck loop in terms of the input voltage required to produce a magnetic field strength of 400 mA/m at the ear of the user. This has been remedied by the publication of EN 62489-1:2010 + Amendment 1:2015. However, the committee decided it would be premature, since the method of measurement had only just been standardized, to follow up with even recommendations for sensitivity.

The situation in the field is reported (especially in the USA) to be unsatisfactory; many neck loops seem not to produce sufficient magnetic field strength. Of course, the reports rarely say what the source of signals was. Nevertheless, there is clearly a need to study the subject, both to improve the field situation and to follow up with a further amendment of the standard to specify, or recommend, sensitivity.

Relations to existing standards

The original treatment of electrical values at the interface between an amplifier and headphones was in IEC 60268-15, later replaced by IEC/EN 61938:1996 and then the 2013 edition. For static audio sources, the recommendation is a source voltage of 5 V and a source resistance of 120 Ω; this was found to produce reasonably constant sound pressure levels for headphones of impedance 8 Ω to 2000 Ω. In the 2013 edition an attempt was made towards consistency with the controversial EN 50332-2, which is intended to address the incidence of hearing damage caused by listening to music through headphones at high sound levels for long periods. This attempt is unfortunately technically unsatisfactory and needs replacing (work is in progress).

The EN itself is not notified under the Low Voltage Directive, but it is normatively referenced in IEC/EN 60065, 60950-1 and 62368-1, so products as described effectively have to conform. However, products intended for hearing assistance are not within the definition in the scope of the EN:

> **portable audio equipment**
>
> *battery operated binaural small audio equipment used with earphone, which is intended to be mainly used for listening to the music outdoors. D.C, operated players with separate a.c. adapter are included*
>
> *NOTE Players with loudspeakers and equipment with one-ear earphone are excluded: however this does not mean that only the devices covered by this standard may cause hearing impairment. Only the big difference in daily use decreases the risk caused by home equipment even at higher listening level*
>
> (Unfortunately, this, too, is less than satisfactory, but the authors of this document were resistant to advice.)

Manufacturers of these products seem to be using a source resistance of 50 Ω, irrespective of the battery voltage, but the standard requires that no more than 150 mV can be developed across a 32 Ω load, and that limits the source voltage, with 50 Ω series resistance, to 384 mV, which is about 1.1 V peak-to-peak, implying a battery voltage of at least 1.5 V . The 150 mV is supposed to be measured unweighted, with a meter complying with Class 1 of the withdrawn standard EN 60804 and an averaging time of at least 30 s. EN 60804 has been replaced (in two stages) by EN 61672-1:2013, in which 'unweighted' means 'Z-weighting'.

The required magnetic field strength of 400 mA/m is measured with an averaging time of 125 ms (or with a peak programme meter which gives very nearly the same result on programme signals but not on noise signals). The 150 mV is measured with the 'simulated programme signal', a noise signal with a specified spectrum. If this is produced by a good noise generator that does not suffer from 'hiccups' (changes in average output lasting tens of seconds or more), there is no difference between the 125 ms average voltage and the 30 s (or more) average voltage. In fact, there seems to be no need to measure for 30 s or more.

Note This would not be true if the test signal were speech or music; the 'simulated programme signal' simulates only the long-term spectrum (averaged over tens of seconds at least). It does not simulate the variation of the envelope of amplitude with time, or the amplitude-probability distribution, of programme signals.

Measurement of the magnetic field strength

The method of measurement specified in IEC/EN 62489-1 is easy to implement if a field strength meter has, or is modified to have, an external telecoil. The measurement jig is shown in Figure 1, but it is not very suitable for production-line testing. For this, a measured loop can be placed around a close-fitting circular former. The voltage that was measured during the standard test is applied. The magnetic field strength can then be measured at any convenient point, such as the centre of the circle, and used as the reference for testing other loops.

Note It might be sufficient in production to measure the DC resistance of a simple passive loop without a transformer.

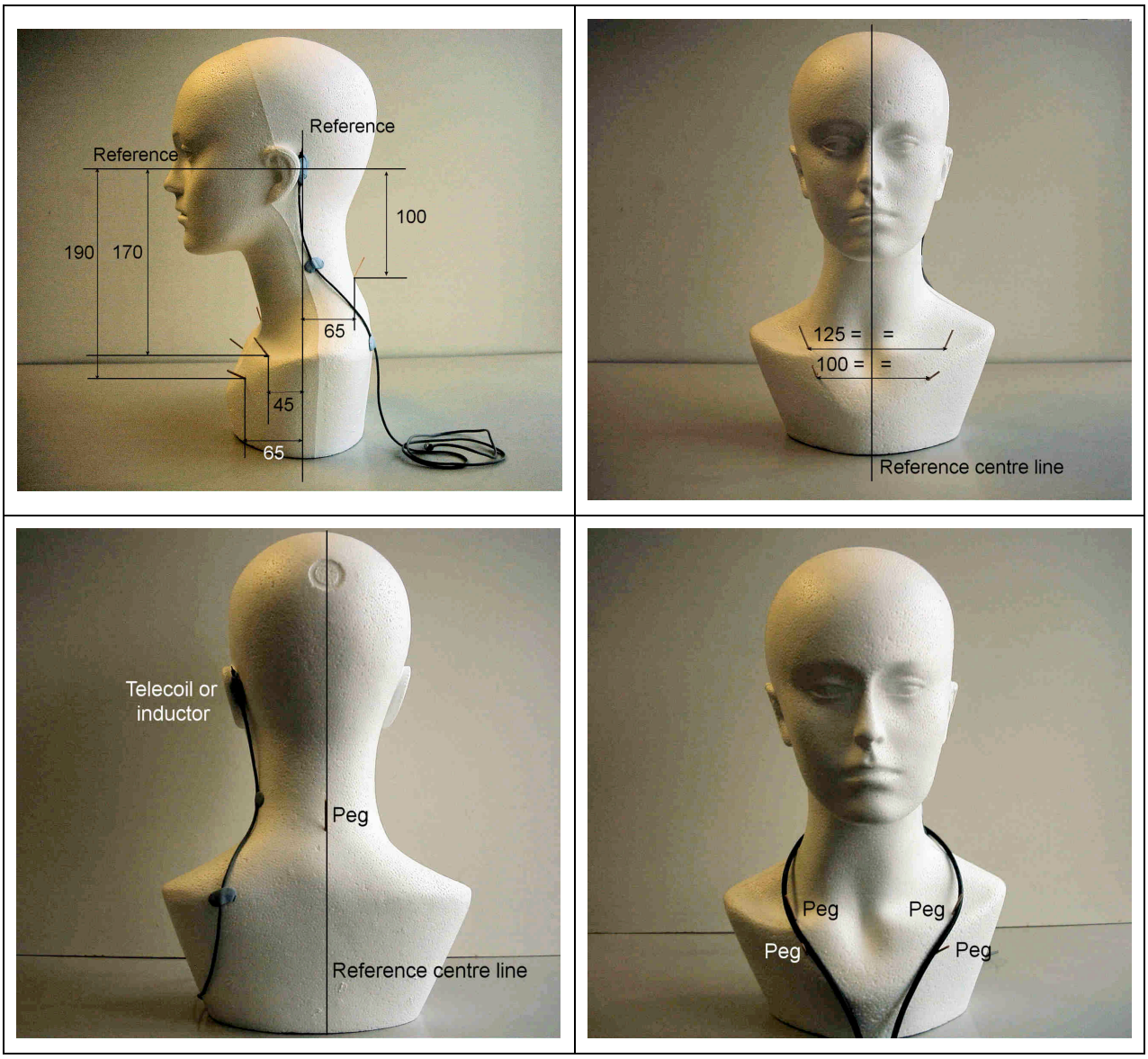

Figure 1 Neck loop measurement jig (IEC/EN 62489-1)

Designs of neck loops

General

Different designs are optimal for different audio sources. The principles are:

- to avoid, if possible, an amplifier or a transformer. (The latter can be costly but clearly requires less attention than a battery-powered amplifier.);
- to minimize the number of turns of a multi-turn loop (whether passive or active).

Measurement shows that a magnetic field strength of about 750 mA·turns is required to produce 400 mA/m on the IEC/EN 62489-1 jig. The exact value depends on the size and flexibility of the loop. For assistive listening, battery-operated devices are mostly used, so energy efficiency is important. That suggests using a Class-D amplifier to drive the loop, but this raises so many possibilities that no general analysis is likely to be useful.

For analogue drive, it is clear that the most energy-efficient loop has minimal resistance, so needs to be current-driven, using a current-drive amplifier, not, obviously, a series resistor. But few ALDs (Assistive Listening Devices) have current-drive amplifiers; they are optimized for headphones, so a loop should 'look like' headphones. For background information on headphone specifications, see Annex A.

A neck loop with many turns might have inadequate bandwidth, in the sense that the inductive reactance at 5 kHz exceeds the total resistance of the loop plus the source resistance of the amplifier feeding it. This is usually an issue only if an attempt is made to use voltage drive and rely on the resistance of the loop wire alone to keep the current independent of frequency.

ALD using one 9 V PP3 primary battery

Such batteries are available in a range of different technologies and capacities (usually expressed in mA·h). Primary batteries mostly have 550 mA·h, and re-chargeables now have around 200 mA·h, up from the original 110 mA·h. For optimum life, long-term average discharge currents should be around 10 % of the current cited in the capacity, so 55 mA and 20 mA. These are 'long-term average' currents, so relate to a magnetic field strength of 100 mA/m.

To see what this means in practice, we can consider an LM386 audio amplifier, which works down to an end-of-life battery voltage of 6 V, when it delivers 4 V peak-to-peak, or 1.4 V RMS, across an 8 Ω load. The current is thus 175 mA, so to get 750 mA·turns we need 4.3 turns, say 5 turns. With a durable wire size, the loop resistance is almost negligible, so we need an 8.2 Ω series resistor. A new battery gives 6 V peak-to-peak, 2.1 V RMS and a current of nearly 260 mA, which gives a maximum magnetic field strength of 1300 mA/m, 4.8 dB more than necessary, but not excessively so. Under these conditions, the average battery current is 44 mA, so primary battery life is good, and the intermittent use of a rechargeable is not ruled out. However, a 16 ohm loop is more suitable for a rechargeable battery. It needs 10 or 11 turns, because the magnetic coupling between turns is not perfect, so the inductance, and therefore the field strength, does not rise precisely as the square of the number of turns.

ALD using two 1.5 V cells

There is rather a limited choice of audio amplifiers that operate with a 2 V supply, end-of-life for a 3 V battery supply. One such is the LM4910, and even this is not guaranteed to work with less than a 2.2 V supply. With a 3 V supply, it gives 35 mW into a 32 Ω load, i.e. 1.06 V and 33 mA. This requires a loop of more than 750/33 = 23 turns ('more than' because the magnetic coupling between turns is not perfect). It also gives 40 mW into a 16 Ω load, i.e. 0.8 V and 50 mA. This requires a loop of more than 15 turns.

Amplifier for use with audio sources complying with EN 50332-2

The above sort of amplifier is also suitable for feeding a loop from the maximum permitted 150 mV output of 'portable audio equipment' within the scope of EN 55032-2. For 1.06 V output, the amplifier voltage gain is set to 7.1, which is well within its capability, as it has 80 dB open-loop gain.

Impact on IEC/EN 62489-1

This study can lead to sensitivity specifications for passive neck loops in a new amendment for IEC/EN 62489-2. Four types can be specified:

Type 1

Suitable for audio sources powered by one primary 9 V battery.

DC resistance 8 Ω ±5 %

Maximum input voltage for 400 mA/m on the IEC/EN 62489-1 jig 1.4 V

Note (advisory) Number of turns 5 or 6, depending on the wire size and the loop construction

Type 2

Suitable for audio sources powered by one primary or rechargeable 9 V battery.

DC resistance 16 Ω ±5 %

Maximum input voltage for 400 mA/m on the IEC/EN 62489-1 jig 1.4 V

Number of turns 11 to 13, depending on the wire size and the loop construction

Note (advisory) Number of turns 11 to 13, depending on the wire size and the loop construction

Type 3

Suitable for audio sources powered by two primary 1.5 V cells.

DC resistance 32 Ω ±5 %

Maximum input voltage for 400 mA/m on the IEC/EN 62489-1 jig 1.06 V

Note (advisory) Number of turns 23 to 26, depending on the wire size and the loop construction

Type 4

Neck loops with transformer or amplifier

Input DC resistance ≥32 Ω

Maximum input voltage for 400 mA/m on the IEC/EN 62489-1 jig 1.06 V

Annex A – A note on headphones

A survey of relevant headphones indicates that their impedances (usually at 1 kHz with no comment on what happens at other frequencies) vary from 24 Ω to 40 Ω.

Their sensitivities are mostly specified in SPL/mW at 1 kHz, contrary to the SPL/V specified in IEC/EN 60268-7 and EN 50332-1 and -2, which latter also specifies the use of the simulated programme signal. These milliwatts, anyway, are just as notional as the 'power input' (often ludicrously rendered as 'power output') of a loudspeaker, because the impedance of a headphone (without amplifier) is not purely resistive and varies with frequency.

The EN 50332-2 limit of ≥75 mV for 94 dB SPL translates into ≤116.5 dB SPL/V. 1 mW in 32 Ω is produced by 179 mV, -15 dB(V), so the limit translates to ≤101.5 dB/mW, much less than most available headphones offer if the sensitivity at 1 kHz is reasonably representative of the sensitivity measured with the simulated programme signal (i.e. the frequency response of the headphone is reasonably flat; if it has a peak around 3 kHz the two sensitivities may match quite well). For 16 Ω headphones, the limit is ≤98.5 dB/mW, with the same reservation.