How Induction Loops Work

The induction loop enables an audio frequency signal (such as speech) to be transmitted to a listener by means of a magnetic field. This is done by controlling the current flow in a wire proportional to the audio signal, which then creates a magnetic field around the wire. A coil mounted in a hearing aid or other suitable receiver (Such as the Current Thinking ETRX loop receiver) receives the magnetic field in much the same way a transformer works, with the loop acting as the primary and the receiver's coil as the secondary. The elimination of a direct sound path helps to reduce the interfering effects of distance and background noise, which causes particular problems for hearing aid users.

The pickup coil in a hearing aid is usually selected by means of a switch marked 'M' for Microphone and 'T' for Telephone (the coil within the hearing aid is normally used to pick up the magnetic field from a telephone earpiece). Sometimes a combined position is provided allowing simultaneous use of both microphone and coil. For hearing aid purposes only the magnetic field in the vertical direction is considered. This conforms to the general mounting direction of coils in hearing aids, however, if a listener bends his or her head then a change in sound level will almost certainly be noticed. Normally the listener should listen within the area of the loop.

System Design

A basic loop system is quite simple to put together. In fact it is rather like a standard sound system but with the loudspeaker replaced by the induction loop.

Sometimes a public address or sound system may already be installed, or perhaps a more sophisticated arrangement may be planned with inputs from various sources.

Where a satisfactory sound system is already installed the loop amplifier can be fed from the mixer or pre-amplifier stage of the system. This will save on duplication of microphones if these have been well chosen and sited in the first place but still give independent control of signal from the loop.

In the absence of an existing sound system it will be necessary to provide microphones and inputs to the loop amplifier for any other signals. When microphones are to be used it is vital that they are positioned to pick up sound, which is free from reverberation and other noises. If the microphones receive a poor signal then the signal transmitted to the listener will be poor no matter how good the design of the loop and other equipment. It is also necessary to ensure that the microphones are matched electrically to the amplifier so that it is 'driven' adequately when the loop is in operation.

It is important to consider the loop itself as forming an integral part of a sound system. A British Standard Code of Practice for the 'Planning and Installation of Sound Systems' BS 6259: 1982 gives valuable information to engineers on various design aspects of such systems.

Field Strength

The most important part of setting up an induction loop is the strength of the magnetic field. Fortunately international agreement has been reached on the most appropriate field strength for hearing aid purposes and this specification is the subject of a British Standard - BS 6083 pt.4 (1981): *Magnetic field strength in audio induction loops for hearing aid purposes*. The Radio Communications Agency regulations covering the use of induction loops are aligned with the recommendations of this standard (as generating a magnetic field creates an electromagnetic field i.e. a radio wave).

The recommended field strength is 0.1 amp/metre to correspond with the ***long-term average level*** of a speech signal. However, the natural peaks of speech can exceed the average value by as much as four times and consequently the maximum field strength produced by the loop must be sufficient to meet these needs i.e. 0.4 amp/metre. The particular value of field strength was selected on the basis of sensitivity tests on typical hearing aids and considerations of adequate (magnetic) signal to noise ratio. Before commencing a major installation it would be wise to measure the level of background 'magnetic noise'. In some situations this could be too high to permit the satisfactory operation of a loop. The recommended frequency range is 100-5000 Hz (±3 dB relative to the level at 1000 Hz).

The standardised value of field strength should ensure that when a person listening through a hearing aid switches from 'T' to 'M' the sound of someone speaking normally should be about as loud as the signal from the loop. Any gross departure from the recommendation could result in an unsatisfactory system. How this field strength relates to amplifier output requirements will be covered in a later section.

Note: Although a certain level of electromagnetic radiation emits from an Induction loop, a licence is not required to operate such a loop. The Radio Communications Agency document MPT1370 does, however, require that these systems conform to the field strength requirements laid down in BS 6083 part 4 and the upper frequency response is limited to 16 KHz.

Calculating The Loop Current

The following analysis relies only on calculations of current. Magnetic field strength is proportional to current flowing in the loop and consequently 'power' is required only to overcome the resistance of the loop wire. As large loops, or loops with several turns (N), have relatively high values of inductance (proportional to N^2) problems exist in the maintaining the magnetic field strength at the higher frequencies. This is where the application specific amplifiers come into their own with the feedback control based on current and not voltage as with normal speaker amplifiers. Although this point should be considered, it has not been included in this simple analysis. The following will assist in deciding the type and 'size' of amplifier required.

AMP/METRE: **A magnetic field strength of 1 amp/metre exists at the centre of a circular loop of diameter one metre when a current of one amp flows in the loop.**

These following calculations relate to simple loop shapes, squares and rectangles and are quite satisfactory for most applications.

For a square loop of one turn the field strength at the centre is given, with a being the length of each side, by:

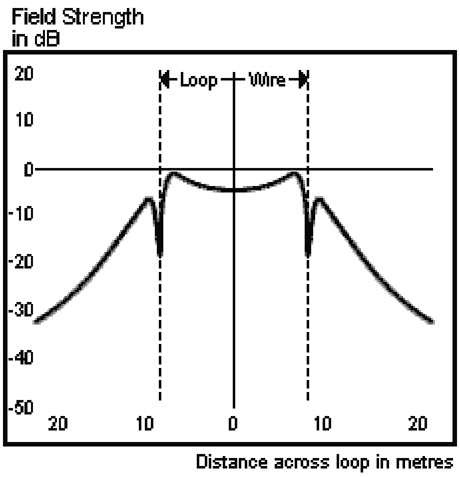
$$H = \frac{2\sqrt{2}}{\Pi} \bullet \frac{i}{a}$$

This means that a magnetic field strength of 0.1A/m would be generated by a current i:

$$i = \frac{\Pi a}{20\sqrt{2}} \approx \frac{a}{9}$$

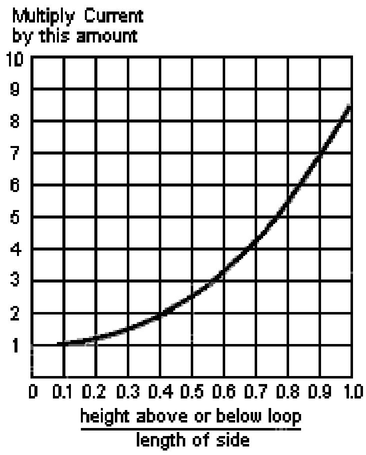
However, because the natural peaks of speech can exceed the average value by some 12dB, the short term maximum current requirement from the amplifier will be about four times the average value, so:

$$i \approx \frac{4a}{9}$$



Naturally this calculation gives the field strength only at the centre of the loop but we need to know about the distribution of the field over the whole area of the loop. The next diagram shows how the field at ear level of a seated listener will vary across a loop 15m x 15m, if it is assumed that the loop is laid at floor level. The analysis is based on equations from standard magnetic theory (which are too long to go into here).

EFFECT OF HEIGHT



Sometimes it will be necessary to fix the loop some way above or below the 'listening' plane. The next graph can be used to find the increased current needed to offset such a difference in height First the height should be expressed as a ratio of the loop size, then by checking off this ratio on the axis of the graph the curve will show the factor by which the current must be increased.

RECTANGULAR LOOPS

Even for long, narrow loops the field strength over the centre of the loop will not differ by more than three decibels from the corresponding field strength values for a square loop based on the smaller dimension of the rectangle. Therefore the square loop calculations we have shown can be used as a guide with the knowledge that the actual field from a rectangular loop will be a little more or less depending on the height above the loop. This simple rule holds good if the height is no greater than the length of the shorter side of the rectangle.

COMPLEX LOOP DESIGNS

When highly irregular shapes are involved, or an intricate design is planned, exact computation is not practicable and estimates should be supported by tests with the loop in place.