ISCE

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Engineering Note 38

AFILS and the 'ideal rabbit'

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Introduction

Diagrams showing how the (vertical component of the) magnetic field strength of a loop system varies as you walk down (or across) the middle have been published in many places, e.g. in British Standard BS 7594. However, not much is said about the implications of considering the curves in those diagrams in conjunction with the specification in IEC/EN 60118-4 that the field strength within the 'useful volume' shall not vary by more than 6 dB (for 'large loops' - those, normally horizontal and often at floor level, intended to serve several or many people).

An 'ideal' case

It happens that a floor-level loop 10 m square gives the most uniform field strength over its area at the conventional 'listening heights' - the perpendicular distance from the loop plane (the floor in this case) to the hearing aid of a person sitting (1.2 m) or standing (1.7 m). The greatest uniformity occurs at a height of approximately 1.4 m, which is very close to the average of 1.2 m and 1.7 m.

This is just how the Universe happens to work, but you can think of it as being specially designed for hard-of-hearing people if you like. Figure 1 shows the curves of vertical field strength versus distance down or across the middle of the 10 m square loop. The x-axis is in units of 10 m.

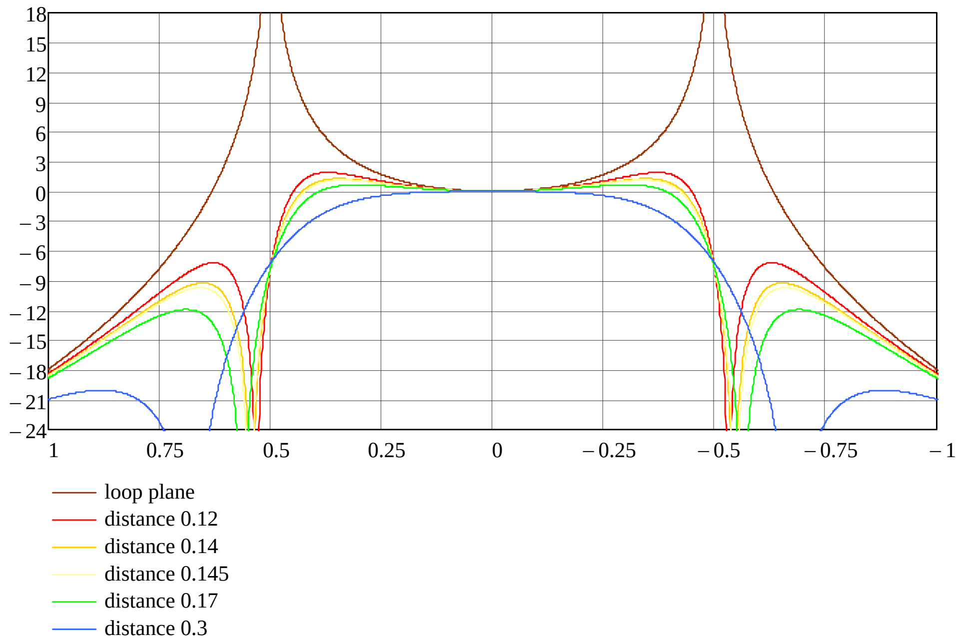

Figure 1 Field strength patterns at different distances from a 10 m square loop.

NOTE 1 - The curves are set to the same level at the centre, because we are looking at the relative shapes, not the absolute field strengths.

NOTE 2 - The 0 dB on this and the other graphs doesn't mean '400 mA/m'. Decibel scales on graphs are purely relative until a quantity value (a voltage, current or field strength, for example) is assigned to a specified level.

The two extreme curves, 'loop plane' and '0.3' (meaning 3 m above the floor - a ceiling loop, perhaps), look very different from the others. The huge 'rabbit's ears' of the floor-level curve mean that the limits of the useful volume at this level are well within the loop. The '3 m' curve shows that at this distance the highest field strength is in the middle, whereas that point has the lowest field strength at the other distances.

At all the distances except 'loop plane', the limits of the useful volume extend right out to the perimeter of the loop, IF we set the field strength at the centre to +3 dB ref. 400 mA/m, i.e. 560 mA/m. If we set it to 400 mA/m, the useful volume limits are where the curves cross the -3 dB line, inside the loop perimeter. We have not efficiently used up the whole of the 6 dB range we are allowed, because even the '1.2 m' curve does not cross the +3 dB line. We might *choose* to do that, but we don't have to.

NOTE - IEC/EN 60118-4 allows us to reduce the field strength if the system is not used by the general public AND the users agree that 'the sound is too loud'.

Now let's have a look at what happens with a huge loop - 100 m square. It is probably rare for such a large single loop to be used, but it, or something quite like it, has been done. Figure 2 shows that the distance no longer has any significant effect on the curve shape, but 'rabbit's ears' are very much in evidence. The x-axis now is in units of 100 m.

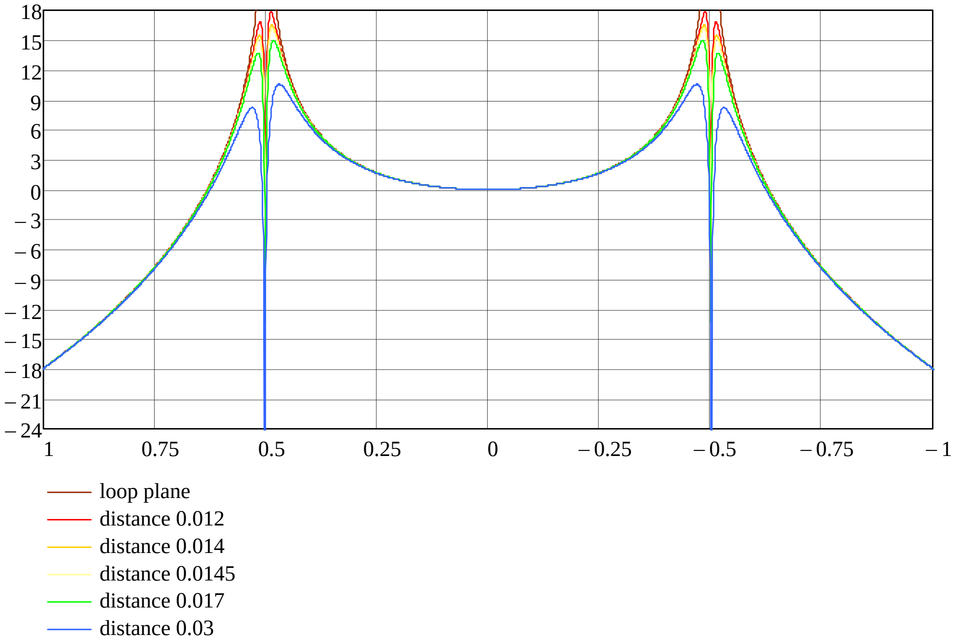

Figure 2 Field strength patterns at different distances from a 100 m square loop.

Now, where do we set the field strength, and at what level? It looks as if the best coverage means setting the field strength at 400 mA/m at the points about 40 m from the centre, where the curves cross the +3 dB line. It's actually easier, of course, to set it to 3 dB below 400 mA/m, i.e. 280 mA/m, at the centre (because we know where it is). However, supposing this is 'theatre in the round' and we don't need to cover the central area? We might then choose to set the field strength lower than 280 mA/m at the centre, especially if that means we can use a less powerful amplifier, and extend the 'useful volume' out to, say, where the curves cross the 9 dB line.

It is possible to look at this another way, if we exclude the 'loop plane' curve, which theoretically has infinitely tall 'rabbit's ears'. We can produce a 'universal' curve, which applies *to any loop system where the ratio of listening height to width is a particular value.* Figure 3 shows an example, where the listening height is 0.2 times the width of the (square) loop. Here, the x-axis is in terms of loop width

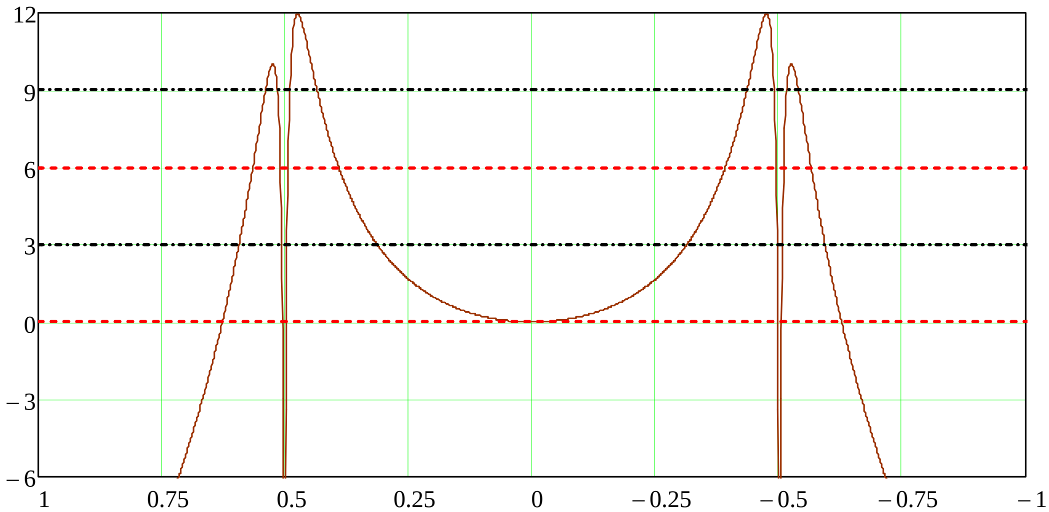

Figure 3 Field strength pattern for any square loop at a listening height 0.2 times the loop width.

The pair of dotted red lines show *one way* to set up the loop; the field strength is set to 280 mA/m in the centre (because it's easy to find that point) and the ±3 dB limits are met over about 0.8 time the loop width. Alternatively, we could look at the black dotted lines, *or any pair of lines (6 dB apart) between the red and black).* For the black lines, we would set the field strength at the centre (since we know where that is) to 200 mA/m. The ±3 dB limits are then met from approximately 0.3 to 0.45 loop widths either side of the central region (seating around a basketball court?).

The 'ideal rabbit' case

There is one 'ideal rabbit', whose ears are exactly 6dB high, and it lives in any loop where the listening height is 0.058 times the loop width, as shown in Figure 4.

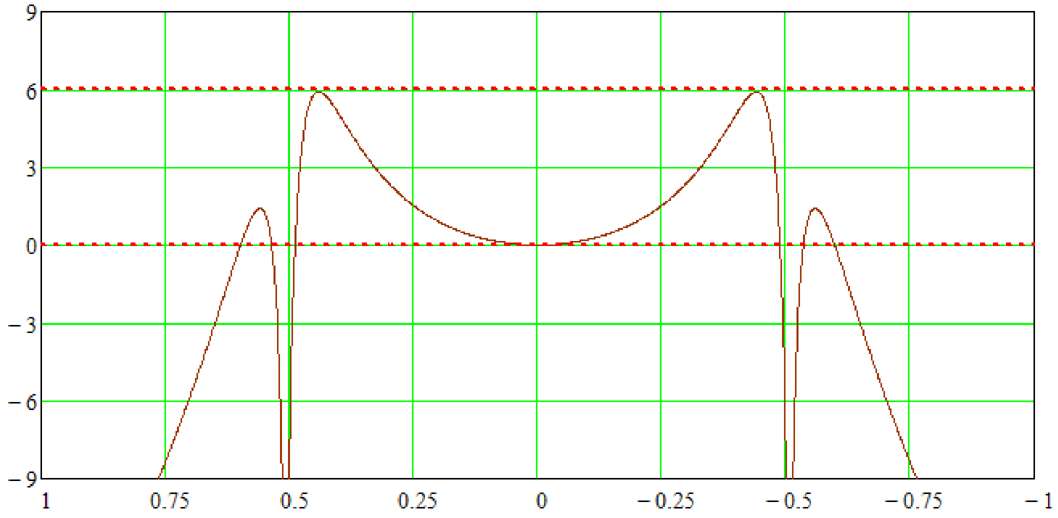

Figure 4 Field strength pattern for any square loop at a listening height 0.058 times the loop width.

In this case, we can use a graph of listening height versus loop width to set the *loop position*, as shown in Figure 5.

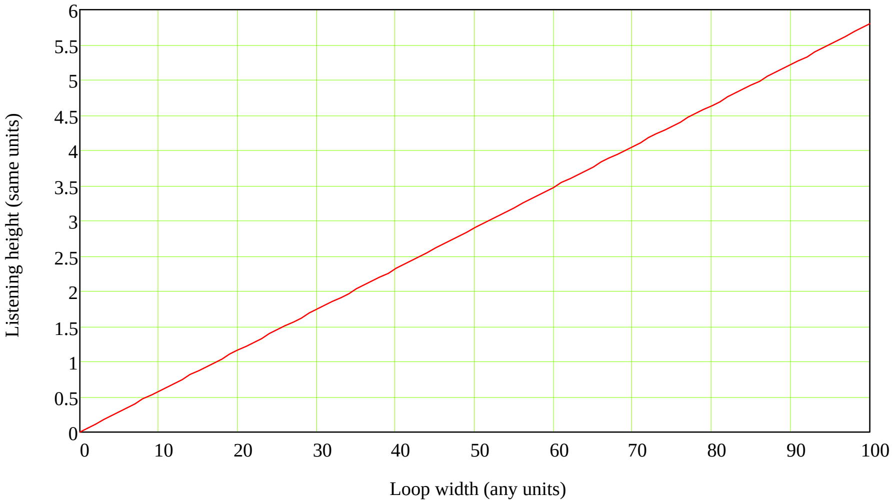

Figure 5 Relation between listening height and loop width (square loop) for the 'ideal rabbit' case

For example, if we have a 20 m square loop, the ideal rabbit will be happy with a listening height of 1.2 m (how convenient!). So we can put the loop on the floor. If we have a 50 m square loop, we need a listening height of approximately 3 m, so we would see if we could mount the loop 4.2 m above the floor. For such a large loop, the variation with height is small, so 4.2 m or 4.4 m or 4.7 m are all likely to be OK for both seated and standing people. It isn't advisable to try to employ the ideal rabbit design in loops smaller than about 10 m square, because the optimum listening height is very small and the variation of field strength with the height of the people is too great.