# Engineering Note 41

## What about Skin Effect?

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Disclaimer

## What about Skin Effect?

The hi-fi people tend to get fluttery about skin effect, and are often supplied with costly remedies involving precious metals. So what is it, and does it affect professional audio?

A current in a wire creates a magnetic field inside the wire as well as outside. We don't usually have to consider the internal field but it does have an effect; it reacts with the current that generated it to force the current out of the centre of the wire towards its surface, hence 'skin effect'. The result is that the wire is effectively thinner and so has an increased resistance. Note that this is a real resistance, not an inductance.

Calculating the effect involves some advanced mathematics – Bessel functions – and can easily venture into a region where the functions are not well-behaved, reaching very large numbers that fluctuate a lot. Luckily, a good, simple approximation exists.  Using this, we can find how much extra loudspeaker line loss the skin effect produces, as shown in the table below. It's clear that the thinner wires used for other purposes do not have an appreciable skin effect at audio frequencies, but of course digital and radio-frequencies may produce it in thinner wires. Even so, the effect is rarely troublesome in practice.

This table applies to 100 m of copper wire. While the numbers for aluminium wire are different, this rarely causes an additional problem. But the effect is much larger for iron and steel wire, because their magnetic permeability is much larger. The frequency range is extended to 25 kHz to allow for ultrasonic surveillance signals.

| Frequency Hz | AC resistance Ω/100 m | | | | |
|---|---|---|---|---|---|
| | Area mm^2 | | | | |
| | 1 | 1.5 | 2.5 | 4 | 6 |
| 50 | 1.67 | 1.12 | 0.68 | 0.42 | 0.28 |
| 100 | 1.67 | 1.12 | 0.68 | 0.42 | 0.28 |
| 200 | 1.67 | 1.13 | 0.68 | 0.42 | 0.28 |
| 400 | 1.67 | 1.13 | 0.68 | 0.42 | 0.28 |
| 800 | 1.67 | 1.13 | 0.68 | 0.42 | 0.28 |
| 1000 | 1.68 | 1.13 | 0.68 | 0.42 | 0.28 |
| 2000 | 1.68 | 1.13 | 0.68 | 0.42 | 0.29 |
| 4000 | 1.68 | 1.13 | 0.69 | 0.43 | 0.30 |
| 8000 | 1.68 | 1.14 | 0.71 | 0.47 | 0.34 |
| 10000 | 1.69 | 1.15 | 0.73 | 0.49 | 0.37 |
| 20000 | 1.75 | 1.23 | 0.84 | 0.62 | 0.49 |
| 25000 | 1.79 | 1.28 | 0.91 | 0.69 | 0.55 |

I originally made a table of the losses in dB, but it's a mathematical pest to convert those values for longer and shorter cables.