ISCE

The Institute of Sound and Communications Engineers

Engineering Note 21.2

Measuring AFILS with pink noise

J M Woodgate *FInstSCE*

ISCE Engineering Note No. 21.2

Measuring AFILS with pink noise

J. M. Woodgate F Inst SCE

1 Introduction

People who know about AFILS in depth have long been concerned about the confusion over the requirements for magnetic field strength in the first edition of IEC/EN 60118-4. The major emphasis is on 100 mA/m, with just a passing reference to a value 12 dB higher, i.e. 400 mA/m.

In fact, this passing reference is really about the amplifier capability; it has to be able to create a field strength of 400 mA/m for at least 0.125 s, in order to handle peaks of speech signals without significant distortion and achieve, if possible, a reasonable signal-to-magnetic noise ratio without overloading hearing aids. The 100 mA/m figure is a long-term average, and long-term means at least 60 s. For some speech signals with noticeable pauses, a longer period is necessary in order to obtain a stable average value. Furthermore, only SOME signals create both a short-term value of 400 mA/m AND a long-term value of 100 mA/m; some have a larger ratio than 4:1 and some have a smaller ratio. This applies to 'natural' signals with no non-linear processing. Add in compression and noise-gating, and even AGC, (which is only truly linear processing under ideal conditions), and quite large differences from simple assessments occur.

AFILS field strength meters have until now followed the apparent requirement in the standard for a field strength of 100 mA/m, and that is labelled '0 dB'. Many people have interpreted that to mean that if the meter reads 0 dB sometimes, the AFILS is set up correctly. It isn't: the reading should reach +12 dB occasionally; that's 400 mA/m. Only a meter with at least a 60 s averaging time would be required to read 0 dB = 100 mA/m, but there ARE no such meters because the reading would be so sluggish as to be unusable. If the level changed, you'd have to wait for up to 3 minutes for it to settle to the new value!

The new edition of IEC/EN 60118-4, on the other hand, puts most emphasis on **400 mA/m** and makes that the 0 dB reference. Meters conforming to the new standard will have 0 dB corresponding to that field strength, not 100 mA/m. The Neutrik Minilyser, in 'loop' mode already has this set up.

However, the new standard does NOT say that any particular AFILS must be set up to produce 400 mA/m. It only says that the amplifier must be capable of producing that field strength. (This is tied in with manufacturers' specifications of the space that can be served.) There are many reports of systems set up to 400 mA/m being assessed as 'too loud' by the people who use them, and their judgement is of course very important. The standard therefore allows a lower field strength to be set up if the USERS require it.

Because of the effects of different signals and processing in loop amplifiers, the new standard puts very much emphasis, too, on FOLLOWING THE MANUFACTURER'S INSTRUCTIONS on how to set up the system. It simply isn't possible for the standard to specify just one type of test signal and one set of target values, because they would work for some amplifiers but not for some other, equally satisfactory ones.

In particular, it is necessary to be very careful when using pink noise as a test signal, as is widely favoured. Pink noise resembles speech in respect of frequency spectrum (to some extent) and in not having a specific frequency or a constant voltage. But in other respects. it's quite different. For example, its 0.125 s value and its 60 s value are very little different, certainly not 12 dB or so. It's possible to use pink noise to set up an AFILS, but it IS necessary to understand in depth what you are doing and why.

2 Pink Noise

Pink noise has equal energy in each octave of frequency, or each decade or each half-octave or third-octave. Its spectrum, measured with a wave analyser or computer Fourier analyzer with constant absolute bandwidth, e.g. 10 Hz, falls at 3 dB per octave with increasing frequency. Its spectrum is roughly like the long-term average spectrum of programme signals, which is standardized in IEC 60268-1. But it differs from programme signals in two very important respects:

- it doesn't include any pauses, which are characteristic of speech and of some music;
- its amplitude-probability distribution is Gaussian, whereas that of programme signals tends to be exponential.

Amplitude-probability distribution (APD) can be described by the question, 'How likely is it that the instantaneous amplitude (voltage or current) is greater than x% of some measured or measurable value?' For noise signals, it's best to take the r.m.s value as the 'measured or measurable' value, because the peak value is theoretically infinite. This is very convenient in the case of a Gaussian APD, because a lot is known about that from (fairly) elementary statistics, and the r.m.s. value is known to statisticians as the standard deviation, σ (sigma). For example, a widely-quoted result is that the probability of the value exceeding ±3σ is 0.27%. Unfortunately, the approximately exponential APD of programme signals isn't nearly so well-defined.

0.27% doesn't seem like much, but it could happen at any time, and even with only 5 kHz bandwidth, it has 5000 chances every second, and the probability is far greater than Camelot offers. The important point to note is that:

the peak value is much higher than the r.m.s. value

(or is it? See below.)

Since the peak value of a pink noise signal is expected to be much higher than the r.m.s value, while its r.m.s. value is practically independent of averaging time from 125 ms upwards, and for speech signals we know that 100 mA/m is associated with the long-term average, while 400 mA/m is associated with a short-term average (125 ms) that for speech signals represents a sort of degraded peak measurement, we might consider setting up an AFILS with pink noise to get an 0.125 ms (or 60 s) r.m.s. field strength of 100 mA/m, knowing that the peak value is then around 12 dB (4σ) to 14 dB (5σ) higher, depending on how improbable we want to get!

At least, it should be. But if you pass pink noise (in fact, any noise signal) through a overloaded amplifier, the peak-to-r.m.s. ratio (the 'crest factor') can be reduced from maybe 4 or 5, as produced by a good noise generator to something much less – maybe 2. ***And there is no way a true r.m.s field strength meter will tell you that; and you might well be hard put to it to see the clipping on an oscilloscope.*** To make matters worse, *it might not matter in one case, but matter very much in another.* This is because clipping may or may not sound bad; it depends on exactly how the amplifier behaves when overdriven. And it may not sound bad on speech signals but be horrible with music signals.

However, the low-cost field strength meters that are on the UK market don't have true-r.m.s. detection, which is quite costly. They have nominally peak-responding detectors, with a range of attack and release times, approximating to the BS 7594 recommended Peak Programme Meter specification. So they do measure clipped noise signals more realistically, but still don't actually tell you that clipping is present. If the meter reads 200 mA/m, is that because the long-term average is 100 mA/m but the crest factor has been reduced to 2 by the overloaded amplifier, or is the long-term value only 50 mA/m (assuming a 4:1 crest factor. Or are you using a Bruel & Kjaer noise source with a crest factor of 5, and the long-term value is only 40 mA/m?

Sometimes, it is said that pink noise is less demanding on an unregulated power supply, so that the voltage drops less than with a sine wave signal of the same r.m.s.

value. This could be so, for a particular design, but it is pretty unlikely, considering that the peak current demand can be more than four times the average, even if it doesn't happen very often. Also, the noise signal demands current pulses at much lower frequencies that the normal 1 kHz test frequency. This is why it's important to band-limit the noise at the low-frequency end as well as the high-frequency end; attempting to push 20 Hz or lower through an AFILS amplifier is simply abusing it.