Tech Notes

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iEMatch

Rediscover the lost 2Bits…

It seems that analogue vs. digital volume control and the potential impact of the **iEMatch** accessory is still not widely understood.

Let us consider a few specific examples. In all cases a DAC with digital domain volume control, 5.3V maximum output with a 0dBFS Signal and 125dB rated signal to noise ratio at the maximum output is used. This is impressive performance, equivalent to 20.5 Bits.

In fact, it is not easy to match or exceed this kind of noise performance in the real world, with real electronics. And independent measurements (performed the same way we do ours and using a slightly newer Audio Precision test) set places this DAC closer to 120dB and 4.9V maximum output, which is still VERY impressive performance in the real world.

We will be using the real world figures of 120dB & 4.9V to calculate with.

Further, something we also commonly use is a figure of 105dB SPL at 0dBFS signals. First, 105dB is the THX peak level for THX certified movie theatres with 0dBFS and is bloody loud (try it and check for the THX Certificate at your movie theatre) and 0dBFS is the highest signal level without clipping in the digital domain.

Now, if we attach a headphone that gives 105dB (the) with 4.9V (e.g. HiFiman HE-6), we will get the full 120dB dynamic range as the digital volume control is at maximum. In fact, the background noise level will be at around -15dB absolute, that is 15dB quieter than the threshold of human hearing. So in this case, the audible dynamic range is 105dB (hearing threshold to maximum signal) and thus is equivalent to around 17.5 Bits.

However, if we take an IEM that gives 143dB (!!?? permanent hearing damage guaranteed) with 5.3V (e.g. Shure SE535)? In order to match the 105dB peak from the first case, we need to attenuate the signal by 38dB, or in another way of looking at it, by around 6.5Bit. Noise would now be at +23dB, quiet but clearly audible hiss.

In this case the audible dynamic range is 82dB and thus is equivalent to around 13.5 Bits. Yup, that's well be low CD quality. This is the consequence of using a high sensitivity headphone with an Amp that has a high dynamic range but also a high maximum output.

Now let’s add **iEMatch** in Ultra setting. The maximum SPL is now 119dB (STILL BLOODY LOUD) and noise is now -1dB, meaning the theoretical available dynamic is just a smidgen below 120dB and thus equals 20 Bits (if you like 120dB peak SPLs - some of us do!). At 105dB peak SPL we will have applied some 14dB of attenuation, or around 2.5Bits, so we again get 105dB audible dynamic range or 17.5 Bit.

So, in this specific case for the high sensitivity headphone adding **iEMatch** has restored 4 Bits or 24dB dynamic range. So **iEMatch** indeed "gives back" bits or dynamic range lost in the digital domain volume control.

But is there sense in using **iEMatch** with an external headphone amp? Absolutely.

Let’s consider the example above with a portable ESL IEM Setup (how freaked out is that - we absolutely love it).

The headphone is 117dB @ 230V (amp's max) and the amplifier has a gain of 54dB with the volume turned up to maximum. So in order to produce 117dB, the amplifier needs 0.5V input voltage.

dB
DECIBEL

This means that for a more normal 105dB we need to turn down the volume control substantially already if our source outputs 0.5V. Even most smartphones nowadays have more output than 0.5V and our 4.9V output DAC is WAY too loud if set to maximum undistorted output.

If we set the DAC to line out mode with 3V @ 0dBFS (and thus 116dB or 19.5dB dynamic range) and set the volume on the headphone amp to produce 105dB, the attenuation in the headphone amp volume control would be 28dB, putting the volume control VERY low on its travel, which generally does not sound as good (yes there is a technical reason) and leave very little usable volume control range.

On the plus side, using this analogue domain volume control does avid loosing bits and dynamic range of headphone (117dB) DAC 116dB are well matched. We can get more volume control range/travel if we instead use the DAC's digital volume control to drop the signal, but if we do this, we again start losing bits/dynamic range, if we lower the volume by 24dB (to 0.375V) we lose 4 bits.. imagine listening to Tidal streaming and paying for 16Bits but listening to 14Bits!

TIDAL

Or instead we add **iEMatch** and knock the 3V output down to 0.375V in the analogue domain. Now, with the headphone amp volume at absolute maximum our SPL will be 115dB with noise (from the DAC) at -1dB.

So, in two radically different cases of "too loud / noisy system" we have added i**EMatch** and have achieved almost perfectly "matched" systems where sensible maximum SPL and dynamic range are almost perfectly preserved. Hence, we (actually Head-Fi'r Bedlam Inside did on this thread: http://www.head-fi.org/t/695086/ifi-nano-ican-name-that-attenuator-competition-winner-no-1-winner-of-ican-nano-is/390#post_10540695) named it **iEMatch**.

Unfortunately, the huge range of headphone/IEM sensitivities and varying headphone amplifier gains mean that mismatches are almost inevitable.

At iFi we recognised this over 3 years ago and we started addressing this issue substantially in iFi's higher end products. Variants of **iEMatch** have been fitted to iCAN Pro, Retro Stereo 50 System and the iDSD micro which was the first product to include it. Now we have also made it available as an affordable standalone piece, after a rather protracted development phase, so even those who do not buy iFi gear (nudge nudge, wink wink) can enjoy the benefits.

So, we hope this clears up a bit what **iEMatch** is and does and why there are many applications, beyond just IEMs.

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About iFi
iFi audio is headquartered in Southport, UK. It is the sister brand of Abbingdon Music Research (AMR). They respectively design and manufacture portable and desktop 'ultra-fidelity' audio products and high-end audio 'home-based' components. The combined in-house hardware and software development team enables iFi audio and AMR to bring to market advanced audio products.