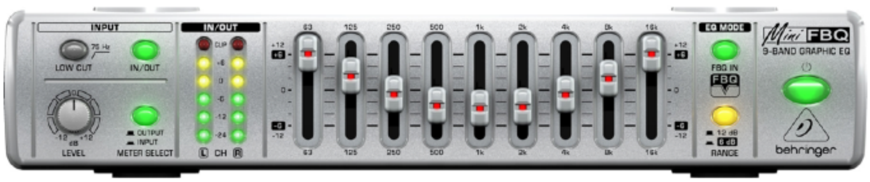
Headphone Essentials 8:

Some practical EQ applications



Note: this document is the sequel to *A headphone EQ Primer for Mac and Windows* at Headphone Essentials.

In the previous episode of this exciting and captivating series we learned how to use eqMac2 on a Mac or EqualizerAPO on Windows to customize the frequency response of a pair of headphones. In this episode we'll look at some practical uses we can put that ability to.

Using EQ to hear warm and cold

Back in episode 2 we encountered this summary of headphone enthusiast vocabulary:

Commonly used **frequency response vocabulary**

- **Neutral/flat/accurate**: all frequencies from sub bass to high treble are subjectively even in loudness.
- **Bright** or **cool/cold**: the higher frequencies are louder than the low and middle frequencies.
- **Warm**: the lower frequencies are louder than the middle or high frequencies.
- **Dark**: the high frequencies are rolled off (diminish in loudness).
- **Mid-focused** or **mid-forward**: the middle frequencies are louder than the low or high frequencies.
- **V-shaped** or **U-shaped** or **fun tuning**: bass and treble both louder than the mids.
- A **relaxed** tuning: something like warm/dark in that the high frequencies are toned down (but often the bass and mids are fairly neutral).

Back then, I was only able to provide one set of words to describe another set of words. Now we have the tools to actually hear what these terms mean.

Neutral/flat/accurate

I dedicated a whole unit in this series to demonstrating that there is no such thing as a neutral or accurate frequency response. That said, Fig. 1 is a reasonable enough approximation for us to work with:

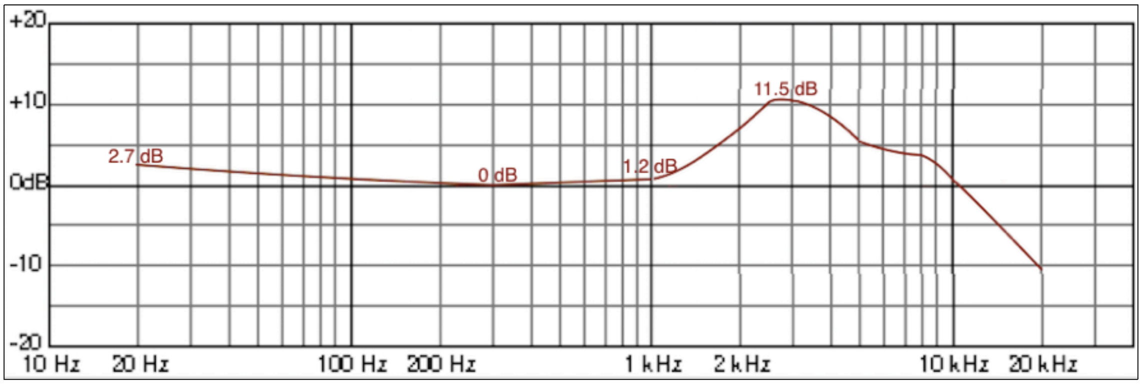


Fig. 1: H&M diffuse field + 1 dB/octave room gain

The numbers rounded to the nearest half-dB are:

20:**2½**, 25:**2½**, 31.5:**2**, 40:**2**, 50:**1½**, 63:**1**, 80:**1**, 100:**½**, 125:**½**, 160:**½**, 200:**½**, 250:**0**, 315:**0**, 400:**0**, 500:**0**, 630:**1**, 800:**1½**, 1k:**2**, 1.25k:**2½**, 1.6k:**3½**, 2k:**8**, 2.5k, **11½**, 3.15k:**11**, 4k:**8**, 5k: **6½**, 6.3k:**3½**, 8k:**2½**, 10k:**0**, 12.5k:**-2½**, 16k:**-4½**, 20k:**-7**

Now simply EQ your headphones to match that target, save as a new EQ, then have a listen to your favourite music. (Remember to be cautious with the Volume slider or knob if this EQ contains large elevations.) Next, use the Online Tone Generator to run through the frequency range. In theory, the only change in loudness you should hear, if any, is a gradual rise to about 2500 Hz, then a gradual tapering off after that. In fact, if you hear any other rises or dips you can EQ them out, then note them as potential corrections to your headphone's measurements.

Bright

To hear bright simply up the control points of your neutrality EQ starting with a minimal increase at 2 kHz, gradually increasing by ½ dB increments to maybe +4 dB at 10,000 Hz, the continue adding +4 dB from there on out. Alternatively, you could taper off the bass starting at 250 Hz, or do any combination of the two.

Warm, dark, etc.

Hopefully, you get the idea. To create a warm tuning start from your neutral EQ then add bass. To create a dark tuning start from neutral then taper off the treble. (So how does dark differ from warm? Got me.) And so forth. If you happen to already have a Harman 2018 EQ for your headphones by all means use that.

Using EQ to simulate other headphones

You can use exactly the same numbers-based EQ methodology explained in the previous tutorial to simulate the frequency response of one headphone on another headphone. For example, to make a Bose QC35 sound like a Sennheiser HD 650 (in this one important respect) simply use the raw frequency response of the HD 650 as the target curve.

In fact, Oliver and Welty used this same concept to conduct the listening test for their Harman targets. Rather than swapping multiple headphones on each listener's head (and thereby potentially introducing expectation bias), they had each subject wear a single headphone, then simply switched what were essentially EQ settings on the computer feeding sound samples. This worked because other sound characteristics, such as detail resolution and sound stage, were not relevant to their research.

Let's work through an example to make everything clear. I own three headphones that have Oratory1990 measurements available: M50x, Sennheiser HD 600's, and beyerdynamic 1990 Pro's. I can EQ any one of them to sound like either of the other two. Let's create an EQ to simulate the 1990's on the 600's. The Oratory1990 graphs for these headphones look like this:

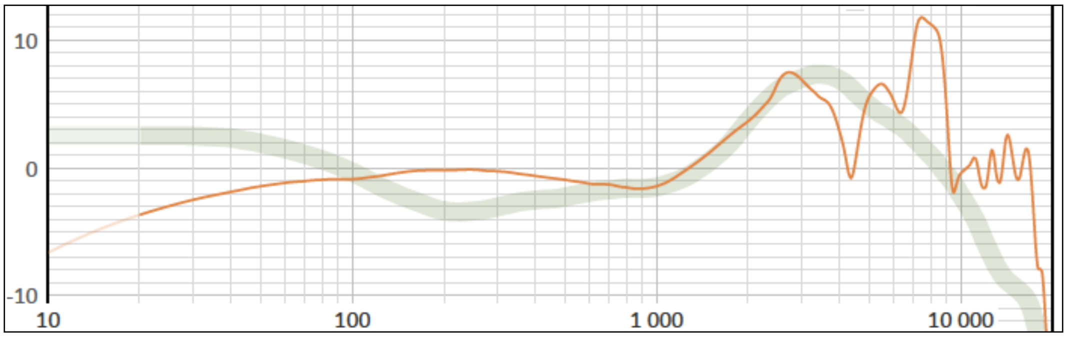


Fig. 2: Oratory1990 measurements for beyerdynamic DT 1990 Pro with analytical ear pads (target)

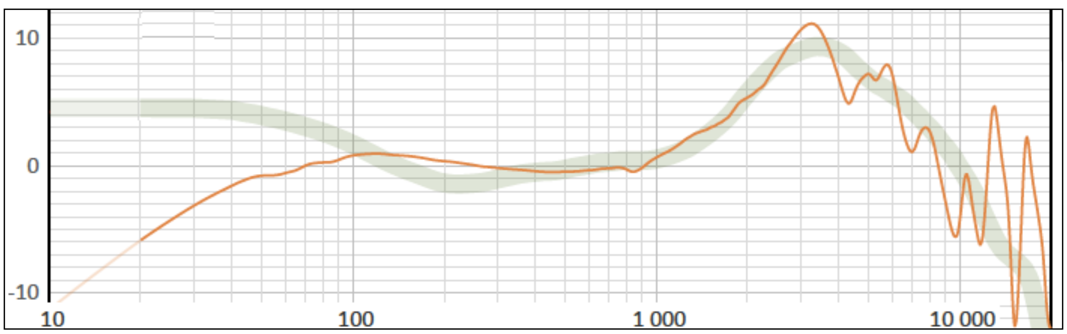


Fig. 3: Oratory1990 measurements for Sennheiser HD 600 (simulator)

Here's a little secret: There is a open source project called AutoEQ containing EQ material useful for users of EqualizerAPO on the Windows operating system. They have an automated procedure to generate a Harman 2018 EQ for the hundreds of headphones for which quality measurement data are available. This involves using sophisticated tools to convert graphs like Figs. 2 and 3 into numerical data. These data are available on the AutoEQ web site as CSV files for each headphone. If you click on the link for a headphone you want to EQ — for example, the DT 1990's — you'll get a new list of links to data files for that headphone:

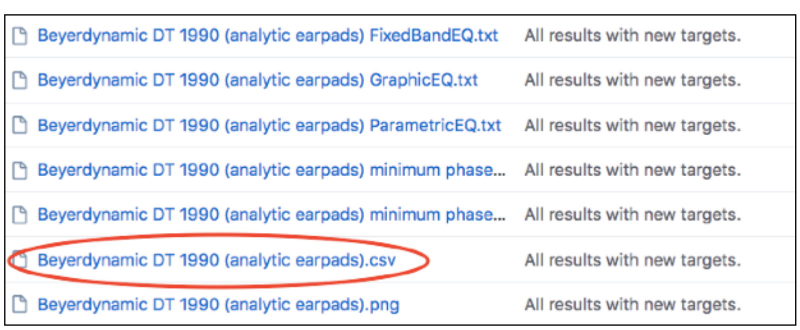


Fig. 4: AutoEQ screen for Oratory1990's DT 1990 measurements

Clicking on the CSV entry brings up a spreadsheet-like table of numbers used by the automatic EQ generation routine. The important thing is the first column labeled *frequency* and the second labeled *raw* contain all the information we need to create our eqMac2 EQs:

1	frequency	raw	error	smoothed	error_smoothed	equalization	parametri
2	20.00	-2.21	-5.46	-2.22	-5.49	5.49	5.45
3	20.20	-2.19	-5.47	-2.20	-5.49	5.49	5.44
4	20.40	-2.16	-5.47	-2.17	-5.48	5.48	5.43
5	20.61	-2.14	-5.47	-2.14	-5.47	5.47	5.41
6	20.81	-2.11	-5.47	-2.11	-5.46	5.46	5.40
7	21.02	-2.09	-5.48	-2.08	-5.44	5.44	5.38
8	21.23	-2.06	-5.45	-2.05	-5.43	5.43	5.36

Fig. 5: AutoEQ CSV data for the DT 1990

For example, in Fig. 24 we see the first row gives the dB value of -2.21 for the frequency of 20 Hz. Slight problem: few of the frequency entries are exactly what we're looking for. There is no 25 Hz entry. Instead, there is a 24.89 Hz and a 25.14 Hz entry. However, either one will do, since we are looking for integer or half-integer dB values, and these are both identical to a few hundredths of a decibel (-4.99 and -4.96). Both round out to 5.

So feel free to use this resource or simply to continue using the eyeball method we used above when working with the M50x measurement graph. Both results will be well within the limits of accuracy relevant to this material.

But if you're comfortable doing basic spreadsheet work, there's yet a further resource available. I've provided a .CSV file containing the 31-band frequency numbers for a variety of target curves and headphone measurements on my website here.

If your headphone and the one you want to simulate happen to be among the 70 I've included, all you need to do is import the CSV data into a blank spreadsheet, add a new row, then populate it with a formula subtracting your headphone's measurement value from the target measurement value of your choice for each of the 31 frequency value cells in that row.

If one or both headphones are not already on the list, grab the numbers for your headphone from AutoEQ and create a new row with them. If AutoEQ doesn't have an entry for a headphone you'll have to resort to the graph and eyeball method.

AutoEQ, spreadsheet or eyeball, what we need to do is simply subtract the dB numbers of the headphone to be EQ'd — the HD 600 — from the target dB numbers — the DT 1990 — for each of the 31 frequency values. When the number for the headphone to be EQ'd is smaller than the target number the result is a positive number, meaning we move the control point for that frequency upward. If the number for the headphone to be EQ'd is larger than the target number the result is a negative number, meaning we move the control point for that frequency downward.

Back to work. The 20 Hz number for the HD 600 is -6.44 and for the DT 1990 is -2.21. Subtracting we get +4.23, which rounds to +4. The 25 Hz number for the HD 600 is -4.94 and for the DT 1990 is -1.57. Subtracting we get +3.37, which rounds to +3½. Proceeding down the line we get:

20:**4**, 25:**3½**, 31.5:**2½**, 40:**2**, 50:**1½**, 63:**1½**, 80:**1**, 100:**½**, 125:**½**, 160:**1**, 200:**1½**, 250:**2**, 315:**2**, 400:**2**, 500:**1½**, 630:**1**, 800:**1**, 1k:**0**, 1.25k:**0**, 1.6k:**½**, 2k:**½**, 2.5k,**½**, 3.15k:**-2½**, 4k:**-2**, 5k:**½**, 6.3k:**1½**, 8k:**10½**, 10k:**6**, 12.5k:**2**, 16k:**7½**, 20k:**0**

Entering these numbers into eqMac2 or Peace we get:

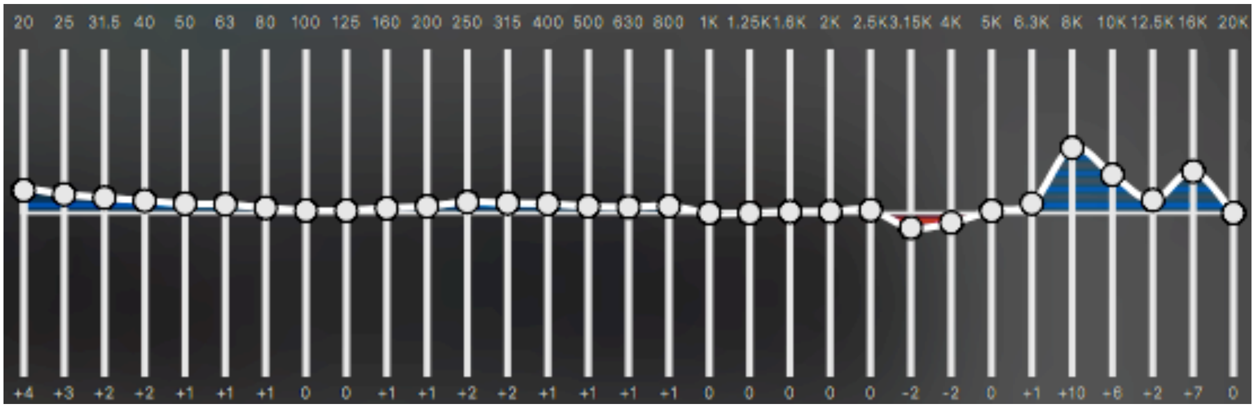


Fig. 6: EQ to simulate DT 1990 on an HD 600

(Remember to compensate for the 10 dB peak at 8 kHz depending on your listening loudness.) And listening to the HD 600 with EQ then the DT 1990 without EQ, it's eerie how nearly identical they now sound.

Note, however, that this is far from guaranteed. There are so many factors at play, as discussed in previous units in this series, including especially unit-to-unit variations, that reasonably similar is likely, very similar is at least not *un*-likely. If the two frequency response graphs are from different families of measuring rigs (HeadAcoustics for Rtings or InnerFidelity vs GRAS set-ups for the other quality sites) than the chances of a really good match decrease, especially below 100 Hz and above 2 kHz. If the graphs are from the same family of measuring rig but different sites, the match is likely to be better but still not as good as both graphs from the same site.

But in any case, we now we know *how* to use one headphone to simulate another. Why would we want to do so? Most obviously: to satisfy curiosity. Just what does a $6,000 headphone, like the Hifiman Susvara, or a $60,000 headphone, like the Sennheiser Orpheus sound like? The (approximate) tuning, at least, is just a simulation away. A less obvious use: to inform purchase decisions. Another less obvious use: to identify a non-obvious personal preference target. Let's explore both those uses in turn.

Using EQ simulations to research a headphone purchase

The frequency response, or tuning, of a headphone is far from its only sonic characteristic, but it is a very important one. Most of us do not live at all close to a store that carries more than the most popular headphones, like Bose and Beats. Even hearing an approximation of the tuning of a headphone we're researching for purchase can be very useful.

For example, a few years ago the Sennheiser HD 800 and HD 800S were very expensive and touted for their amazingly large soundstage — but also criticized for a piercing treble spike around 6 kHz (only partially tamed by the 800S model). An easy way to find out whether you can live with this issue is to simply raise the 6 kHz control point in eqMac2 by varying degrees then listen to music. If you want to hear the complete frequency response, just do a simulation using the Oratory1990 measurements.

Alternately, a particular headphone may be exactly what you're looking for *except* for its tuning. If you only plan to use that headphone connected to your Mac, you can change its tuning to taste. Which leads us to…

Finding your own target compensation curve, part 2

As I write this I have over 70 simulation EQ's listed in my eqMac2 selection dropdown. Most of

them have served me well by pointing out why I would *not* want to live with the tuning of one exciting new headphone model after another. The exception is the Focal Clear. I liked the simulation of this so much I used a slightly tweaked version of it as my go-to compensation target for several months. My DT 1990s give me excellent comfort, durability, soundstage, detail and dynamics. Tuned to match the Clear's frequency response (or at least the Oratory1990 measurements thereof) I had everything I wanted at half the cost and without any potential downsides of the Clears.

So another way to find your target curve is to simulate a variety of well-reputed headphones, then combine the bass of the one you like the bass of best with the mids of the one you like the mids of best, etc. If you find it all in a single headphone as I unexpectedly did, all the better.

Different scenarios, different EQs

In unit 6 I briefly mentioned the significant differences in the room acoustics used in audio production studios for mixing and mastering music recordings. I have whole albums in which every track has a bloated midrange and rolled off highs, for example. It's an annoyance, but I have to switch to a different EQ when I want to listen to those tracks, then switch back again after. I actually include an indicator of the necessary EQ in the album title in such cases.

Another obvious scenario is changing EQs to suit different genres of music.

Yet another context that benefits from EQ variants is often the daily commute. The noise levels on a commuter train or bus are typically not only loud but also bass heavy. Switching to a bass boosted EQ to compete with the din can make a significant difference. Or if you're using bass heavy headphones especially for your commute, the first lesson in unit 6 walks through removing the nearly universal midrange mutilation that accompanies a bass boosted tuning. Of course, some circumstances require an active noise cancelling headphone.

Worst case scenario: EQ'ing blindfold (but not deaf)

Early on I had been reading about the glories of open-back but only owned closed-back and was concerned about open-back sound leakage annoying others. So I bought a Sennheiser

HD 579 at a fire sale price as an open-back experiment. The reviews of the 579 were quite favourable. So much for reviews. To my ears without EQ their sound is truly a hideous thing. The challenge was to EQ them, given the only measurements for the HD 579 I could find were on a site called Reference Audio Analyzer. The measurements they provide seem to be compensated. But they provide no hint as to what they use to compensate, and taking them as being uncompensated proved futile (Fig. 7a). I tried using the measurements for the HD 599, another headphone in the same model refresh of the Sennheiser HD 5nn line-up as a starting point. But that was no-go as well (Fig. 7b).

The key proved to be a combination of two things: A) using the technique from the first lesson centred on the Online Tone Generator to suss out dips and peaks. And B) being day-in-day-out familiar with what headphones sound like when EQ'd to neutral (auditory flat). Departures from that begin to make themselves known (Fig. 7c). Once you have a headphone EQ'd to neutral you can go from there to any tuning you desire.

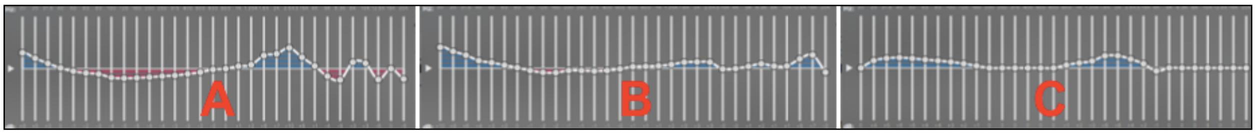
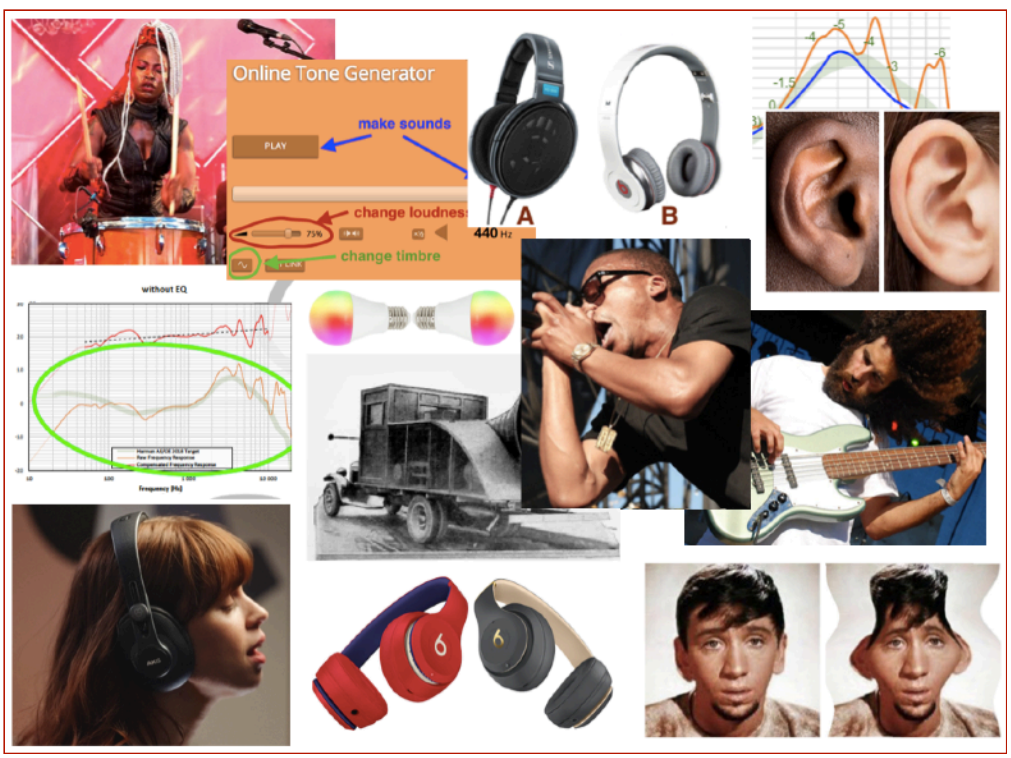


Fig. 7: HD 579 EQs: A = RAA approach, B = HD 599 approach, C = Online Tone Generator approach

The result is truly a frog-into-prince transformation. The once lowly HD 579 is now a much more capable and enjoyable companion to my other headphones. (Since I wrote the above, Crinacle published a HD 579 graph that very much nails its tuning.)

And that's a wrap



… Not only of this tutorial but of the entire Headphone Essentials series — or at least of my contribution to it. The series has concentrated heavily on frequency response. I'm sure there's much more to say. I'm just not the person to say it. Frequency response is all I really know. I hope you had a good time, and thank you for reading along.