Some practical applications of EQ
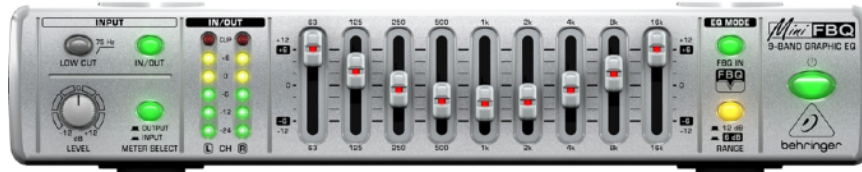
> **Note**: this document is the sequel to *EQ'ing headphones on a Mac Computer* at Headphone Essentials.

> **Also note**: You can use this tutorial on a Windows computer by using EqualizerAPO with the optional Peace GUI add-on. See the **Addendum** at the bottom of the preceding tutorial.

In the previous episode of this exciting and captivating series we learned how to use eqMac2 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 high 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 (frequency balance): 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 truly neutral or accurate frequency response. That said, Fig. 1 is a reasonable enough approximation for us to work with:
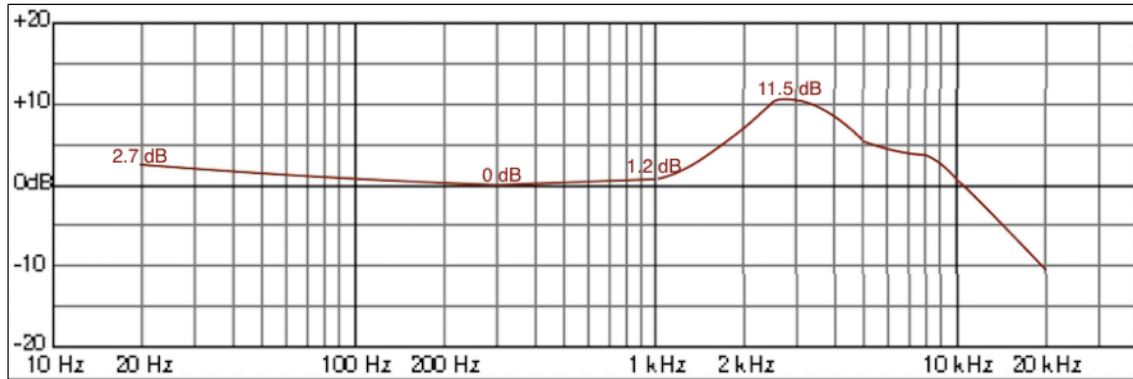

Fig. 1: H&M diffuse field + 1 dB/octave room gain

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 <u>Online Tone Generator</u> 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 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 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 the 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 have 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:
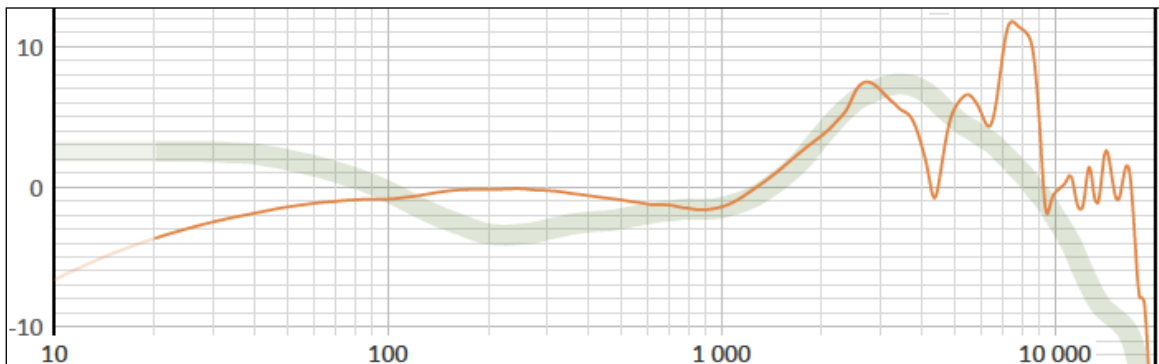

Fig. 2: Oratory1990 measurements for beyerdynamic DT 1990 Pro with analytical ear pads (target)
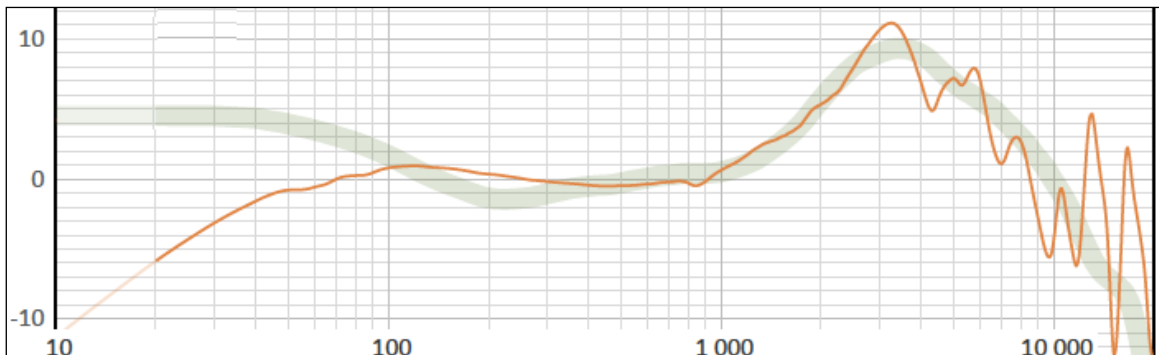

Fig. 3: Oratory1990 measurements for Sennheiser HD 600 (simulator)

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:

🗋 Beyerdynamic DT 1990 (analytic earpads) FixedBandEQ.txt	All results with new targets.
🗋 Beyerdynamic DT 1990 (analytic earpads) GraphicEQ.txt	All results with new targets.
🗋 Beyerdynamic DT 1990 (analytic earpads) ParametricEQ.txt	All results with new targets.
🗋 Beyerdynamic DT 1990 (analytic earpads) minimum phase...	All results with new targets.
🗋 Beyerdynamic DT 1990 (analytic earpads) minimum phase...	All results with new targets.
🗋 Beyerdynamic DT 1990 (analytic earpads).csv	All results with new targets.
🗋 Beyerdynamic DT 1990 (analytic earpads).png	All results with new targets.

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:

	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	-2.05	-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 at https://daystarvisions.com/Music/31-band_HP_EQ_values.csv.

If your headphone happens to be among the 50 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 your headphone is 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 your 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.

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**

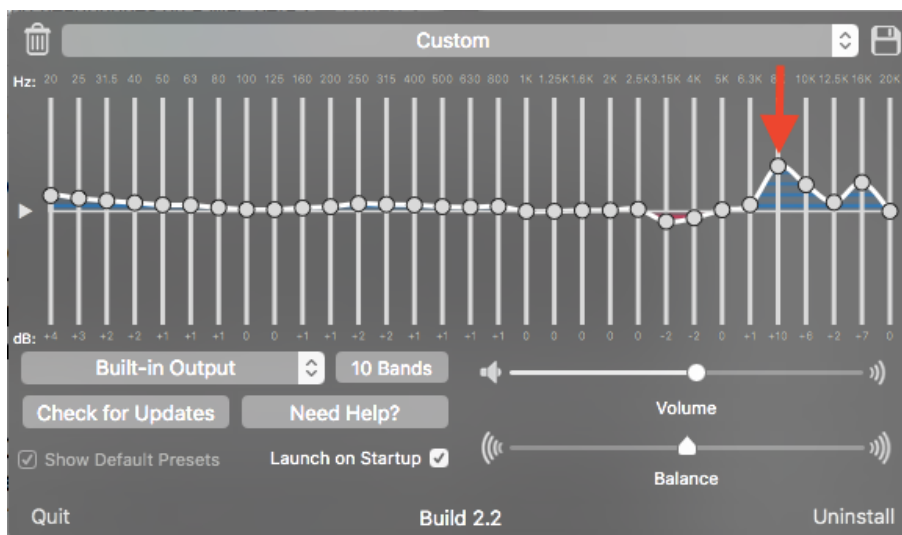Entering these numbers into eqMac2 we get:

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

(Remember to drop the 10 dB peak at 8 kHz if you're a loud listener.) And listening to the HD 600 with EQ then the DT 1990 without EQ, it's eerie how nearly identical they now sound.

Nevertheless, there are a few caveats to EQ simulation to note. As I write this only Oratory1990 and Head-Fi are using the ultra expensive GRAS 43AG coupler+pinnae and Audio Precision analyzer that are required for this level accuracy. Resolve Reviews at headphones.com has started using this set-up as well, but it will take a while for him to accumulate a meaningful number of measured headphones.

That said, I've seen a handful of measurements from even this equipment for headphones that I don't own that make me scratch my head, given how far they differ from InnerFidelity's, Crinacle's and Rtings.com's measurements for the same models in the upper mids region, not to mention listener reports. In general, InnerFidelity, Crinacle and Rtings differ from each other and should only be used to get an approximate idea of a headphone's frequency response as compared to other headphone's measured by the same site. But when all three agree fairly closely with each other, while disagreeing with Oratory1990, I simply don't know how to interpret that. The Focal Elear and DCA Aeon Flow 2 Closed are examples of this anomaly.

So 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 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's 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.

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 use it, together with some tweaking to compensate for a bit of hearing damage, as my go-to compensation target. 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've got everything I want 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.

EQ'ing blindfold

Early on I had been reading about the glories of open-back but only owned closed-back and was concerned about sound leakage annoying others. So I bought a Sennheiser HD 579 at a fire sale price to give open-back a go. The reviews 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 refresh of the Sennheiser HD 5— 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 Online Tone Generator to suss out dips and peaks. And B) knowing what a proper amount of rise then fall peaking around 3 kHz actually sounds like. Once you become familiar with what headphones sound like when EQ'd to neutral or to your personal preference curve departures from that begin to make themselves known (Fig. 7c).

Fig. 7: 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 quite an capable and enjoyable companion to my other headphones.

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. In any case, I hope you had a good time and thank you for reading along.