THE ART OF EQUALIZATION FOR CUSTOM HOME THEATERS

With an understanding of room acoustics and audio analyzers, installing dealers can take steps to ensure optimal sound performance.

By Gregory Miller, Gold Line

Every room has an acoustical signature as distinct as your fingerprint. Some frequencies of sound are excessively absorbed, resulting in too low a sound level. Some frequencies get trapped in a harmonic oscillation between the walls, and will be very loud in one spot and too soft in another. And some early reflections, which are close in level to the original sound from the loudspeaker, fool your ears into mistaking the direction from which the sound originated.

Remember, all home theater is a grand illusion. Trying to convince the brain of the illusion requires an understanding of how the brain perceives the world. The field that combines the physics of sound with the perceptions of the brain is called "psychoacoustics." Our brains have evolved over millions of years, and have learned a whole series of simple tricks to guess what is happening around us.

Amplitude Direction Finding

The most important of these tricks in a home theater setting is "amplitude direction finding." Because most surfaces will absorb some sound, the brain assumes that the direction of the loudest sound is the original direction of the sound.

To test this theory, close your eyes and snap your fingers. Your brain will tell you exactly where the sound came from. A home theater takes this a step further, and moves the volume level between the loudspeakers to create the illusion that the sound is coming from that direction. If you want the acoustical image to move left, you make the sound louder from the left. This is one of the critical reasons why custom installers need to accurately set reference levels on a home theater processor.

Every modern processor has a reference specification for finding "0" reference level in a test mode. Then using a sound pressure level meter, as measured from ear level at the center listening position, the system must produce 75 dB in "C" weighting from every loudspeaker. If you fail to do this, then speakers that are louder or softer than another in the system will produce a level that your brain will perceive as coming from an incorrect position.

Since your clients' audio components were manufactured precisely, and you position them exactly as the manufacturer recommends why should the levels be incorrect? The answer is the room. The room has subtly changed the sound levels, and your reference test restores the overall balance for acoustical imaging.

The brain has two additional methods of direction finding. Because the path of a reflected wave is always longer than the path of a sound that came directly to the ear, the brain has an incredible ability to measure thousandths-of-a-second differences in arrival time. This is the concept behind the delay in surround speakers. And, of course, the brain receives information from the eyes. If you see someone speaking in the middle of the screen, the brain expects the sound to come from the person speaking. If the ears disagree with the eyes, the brain gets fussy. Then you begin to be drawn out of the film, as your brain judges what it sees as somehow unreal.

A tuned home theater not only sounds better, but the viewer is more intensely pulled into the film experience when all of the psychoacoustic clues follow the pattern the brain naturally expects.

Real-Time Analyzers

Real-Time Analysis (RTA) is the measurement of the level of individual frequencies. The theory behind the system is that if you play a track of sound recorded with exactly the same level at every frequency- "pink noise"-then any change in the level, as measured in the room, represents inaccurate musical reproduction.

Over the past 20 years of manufacturing RTAs, we have accumulated a bag of tricks we use daily, but most of these have never been published in manuals or books. The use of a real-time analyzer is a skill, and over time any user will get better at it. The basics, however, are not difficult; any interested custom installing dealer can grasp them.

The first step in making the measurement is to set the processor to its flat position, which is Dolby Pro Logic mode. Do not use the THX mode when making the measurement; THX mode has its own re-equalization curve, which is only supposed to be used after the room has been adjusted to flat response.

Next, place the microphone from the RTA at ear level, near the center listening position, with the microphone pointed toward the ceiling. The microphone should be held in a microphone stand or other stable holder, and should have a microphone cable long enough so that the RTA can be placed near your processor. Your RTA should be set to flat response, and medium decay, in 1 or 2 dB scale.

Then play pink noise through one speaker at a time, starting with the center speaker. With some systems, you may need to turn off the subwoofer so that only the center speaker produces the pink noise.

If you use an external battery-operated pink noise generator, insert the noise into your auxiliary inputs on the processor. As the center channel is created from information in the left and right channels, a Y cable is necessary to split the output from the pink noise generator.Most electronic stores charge a couple dollars for simple adapters that can convert the generators typical ¼ inch plug output to two RCA plugs. Typically, the pink noise is turned up to a sound pressure level (SPL) of 80 dB. The reference level on the RTA is set to 63 dB. When the pink noise is turned on, the reference level line will be very close to the level of sound at 1,000 Hz, as shown on the RTA.

First, you want to confirm that the basic systems work. On a front speaker, you should be able to clearly see the crossover rolling off all frequencies below 100 Hz. The crossover is not an absolute limit to the frequencies, but will instead gradually decrease the levels below 100 Hz. You should also see a roll-off in the higher frequencies above 6.3k Hz. This results from the off-axis frequency response of the microphone.

Now, you might ask why you don't simply point the microphone toward the speaker to avoid this problem. The answer is a little complicated. Essentially, you need to perceive sound from the direct field of the speaker as well as energy from reflections in the room.

Dolby and Lucasarts have done extensive testing to find out which method works best. They've concluded that the vertical microphone is best for home theater. In between 100 Hz and 6.3k Hz, the frequency response should be as flat as possible. In most applications, you can use an equalizer to adjust the level of an individual frequency. If you use a 1/3-octave equalizer, the frequencies marked on the sliders are the same frequencies as those marked on a 1/3-octave RTA. These frequencies have been set by the ISO standards committee and are uniform on all products.

The Rule of Three

The first step in setting the EQ is to work on the excessively loud frequencies that is, those above the reference line on the RTA. We use a method called the "Rule of Three."

Look for three adjoining bands higher than the reference level. Then, adjust the middle frequency on the equalizer. We like to see a maximum of +2 dB above reference line with the center frequency.

In most cases, this will place the adjoining frequencies at reference, or just slightly below reference. The trick is to use as few EQ filters as possible to get a smooth transition. EQs are like a two-edged sword. An over-reliance on them can degrade the sound, but they can improve almost any home theater system when used with a little finesse.

Once you complete the EQ of the center channel, repeat the process with the left front channel. The concept is not only to get flat response, but also to get similar response to the center. This is called "timbre matching" and results in smooth panning of the sound between speakers.

If you use an external pink noise generator, use only the left channel RCA for left, and the right channel RCA for the right channel. When your left or right front speakers are close to a wall, this sometimes results in an acoustical problem called a "boundary interaction." To check for this problem, try placing a large pillow behind the speaker at a 45-degree angle to the wall. If the sound as measured by the RTA improves, consider moving the left or right speakers farther from the walls, or using an absorptive panel to reduce the interaction from the wall boundary.

Most systems do not EQ the surround channels. If you choose to do so, then the frequency response follows the same rules as those with the front speaker. But in some AC-3 systems, the surrounds may be driven full frequency.

Subwoofer Analysis

The next challenge is the subwoofer. This is the most difficult area of analysis. Because low-frequency sound waves are very long, they can build up in a room in a ratio to the distance between the walls.

These so-called standing waves are not clearly visible in 1/3-octave resolution, nor can they be effectively corrected with a 1/3-octave EQ. This is why THX requires at least 1/6-octave resolution for EQ below 80 Hz. Some EQs use 1/6-octave graphic filters, and some use parametric filters.

In a parametric filter, its width and center frequency are both adjustable. Whichever type of EQ filter you use, make sure you have an RTA with the highest possible resolution at low frequencies. Many professionals choose 1/12-octave analysis, which is available on modern digital signal processing-based RTAs.

If the 1/12-octave RTA analysis shows a strong spike at any of the listening positions, try moving the location of the subwoofer. Low-frequency sound is relatively non-directional, so location will not have much effect on imaging. Often, however, you can find a place in the room where the standing wave cancels itself out by pressurizing the lowest point in the wave. In some cases, changing the polarity of the sub will also flatten frequency response, although we rarely use this method.

In general, you will not be able to add boost to a subwoofer because every 3 dB of boost from the equalizer doubles the necessary amplifier power. If your sub runs out of steam at 35 Hz, you can't make a bigger sub with an EQ.

Time Averaging

Once you have adjusted all the speakers, take a high-resolution measurement of each one, using a function called "time averaging." This long sample of the sound should be at least 20 seconds. You can make slight, final adjustments to EQ based on the time-averaged measurements.

Finally, changing EQ will adjust your system reference level. The last step is always to go into test mode and reset the levels, so that every speaker produces exactly 75 dB in C weighting from the central listening position. This step is critical to proper imaging, so take a few minutes to get the levels just right.

A future article will discuss the use of a four-channel multiplexer, multiplots of data, and other advanced analysis functions that pros use. In the meantime, find an analyzer, look at the data, and always use your ears. The RTA will efficiently lead you in the right direction, but ultimately your ears will be the final arbiter of sonic quality.

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