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Tuning A Sound System

John F. Allen

Imagine that you are listening to a new set of loudspeakers that you just brought home. You are excited to set them up in your listening room and play some of your favorite recordings. The sound of your new loudspeakers is wonderful, just as you had hoped it would be. Then, after a while you begin to notice that a couple of bass guitar notes are louder than all the others. Every time these notes are played, they are louder than they should be. They seem to boom. At first it's distracting, then annoying. You begin to think something may be wrong with the loudspeakers. The truth is, it may not be the loudspeakers, but the way the loudspeakers and your listening room react together. This is a common acoustic event in rooms of all sizes and is often misunderstood. Few may realize that it can also affect live orchestras.

This article will attempt to explain what can happen in listening rooms and what can be done to correct anomalies. I am limiting my discussion to systems using large full-range, floor-standing loudspeakers without subwoofers. That being said, the information may also be helpful with other smaller systems.

I was named sound director of the Boston Ballet in 1988. It was the same year that Jonathan McPhee became the music director and conductor. We met at the season's first orchestra rehearsal. Ballet orchestras perform in orchestra pits in front of the stage. Much of the audience cannot see them. Due to the size of the ballet's pit orchestra performing in Boston's largest theatre, the sound needed to be amplified.

My position was out in the house where I could hear what the conductor could not: how the combination of live and amplified music sounded in the room where the audience would be sitting. As the orchestra rehearsed, I was startled when one of the notes of the timpani boomed throughout the room. Whenever it happened, this note seemed to explode in the air. The timpanist wasn't hitting anything harder. There was nothing wrong with his drums. It wasn't the sound system either. What's more, neither he nor the conductor knew anything about it. If someone wasn't there to hear it, they would never have known it was happening until perhaps a music critic mentioned it in a review.

I was very concerned. With sound systems alone, I typically have an equalizer to fix something like this and make things sound the way they should. But this was a live, living breathing symphony orchestra. There was no equalizer, no knob to turn.

During a break, I first spoke with the timpanist, Fred Buda, one of the best percussionists in the country. He was startled to hear what I was saying. He confirmed that there was nothing wrong with any of the timpani. I then spoke with the conductor. Jonathan was surprised that he had not heard it but was not too concerned as he knew what to do. He simply told Fred to play with a harder stick.

This slightly changed the tone but, strangely enough, not the note. As Jonathan explained, it changed the sound from "fluffier" to more focused. That's all that was required. The boom was gone. In other words, to adjust for the acoustics of the room, Jonathan had equalized, or "tuned," the orchestra acoustically rather than electronically. Over the years I have experienced similar challenges when working with orchestras. They are always corrected in one way or another.

It is important to tell this story because many music lovers and audiophiles might believe that orchestras always sound perfect no matter where they play, that acoustic issues like this don't exist or they aren't significant. This is simply not the case. This is why there has to be someone out in the room that can hear the total sound of the orchestra and the room. As is often repeated, the hall really is an instrument, a part of the orchestra. In the case of a listening room, the room becomes part of the loudspeakers and listeners hear them both.

The "boom" I experienced in the 4,000-seat theatre with the Boston Ballet is called by different names. Most seem to refer to bass modes, room modes or room resonances. It can happen in virtually all types of spaces from living rooms to live theatres, movie theatres and concert halls. Where there is a sound system and loudspeakers, the solution is simple. Rather than altering the way an instrument or instruments are played, a sound system can be electronically equalized or "tuned" for the space it occupies. While bass traps and other acoustic devices can be effective, they tend to act on a wide range of frequencies. In other words, they are neither precise nor selective. A good equalizer is both selective and precise to a fraction of a decibel.

There are loudspeakers that can require equalization to improve a poor frequency response. Flawed recordings may also be improved with equalization. These are matters beyond the scope of this article, as they are totally unrelated to room

acoustics and must be dealt with separately.

Since its introduction, equalization has often been criticized, sometimes rightly so. This is due to the fact that audiophiles and engineers have relied on various measurement systems to tell them what adjustments are needed. These measurement systems do not measure what we hear, nothing does. This means that we hear one thing and are forced to measure something else. This often results in excessive adjustments that are generally wrong, resulting in sound that isn't as good as it should be. The solution is rather straightforward. If the measurement system is misleading, use something else.

Equalization is sometimes referred to as "room equalization." Of course, there is no such thing as equalizing a room unless one starts tearing down walls. Equalization is better described as equalization for the effects of the room. If the room exaggerates certain frequencies, an equalizer simply reduces the level of those frequencies. The room still exaggerates the notes, but the sum of the sound system and the room becomes balanced and normal.

As all rooms are different, the effects one encounters in different rooms will be different. There is no one-size-fits-all solution. Identical rooms can and often do require different equalizations to make identical systems sound the same. A listening room with a vaulted ceiling may sound nearly perfect while another room in the same house with a flat ceiling may exhibit a substantial bass boom or resonance of certain frequencies.

One of the ways woofers work is by getting control of the air in the room. Some have even referred to them as air pumps. In fact, they are. The better the woofer, the greater the control. Large woofers, and especially horn-loaded woofers, are super air controllers and, as with all good woofers, bass peaks can be excited. Uncorrected, the resulting sound is typically described as boomy. Because the room and the loudspeaker work together, it is this combination that needs to result in a smooth natural bass response.

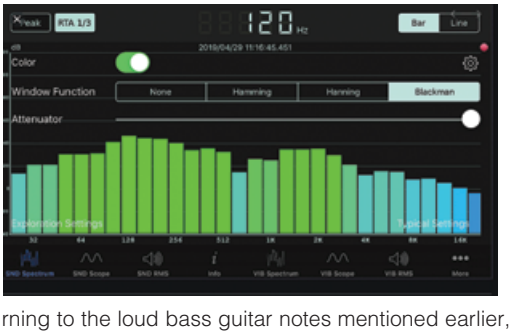
So how does one determine what adjustments are needed when "tuning a sound system?" The typical approach is to play test signals and measure the resulting sound with an analyzer of some kind. Historically, sound engineers have relied on such methods to guide them. As mentioned, none of these measurement systems and approaches measure what listeners actually hear. So the measurements need to be interpreted in some way. But how? Test signals are not music and do not behave the same way in rooms. In all the years that I have worked with symphony orchestras, no conductor has ever turned to me and asked how the music measures. They ask how it sounds. They've used their ears to listen to and balance the orchestra. I used my ears to listen to the music they were making and how it sounded out in the hall where the ears of the audience will be.

In other words, ears are the most important analyzer. It's sound after all, what famed acoustician Leo Beranek described as "a pressure wave in the air at a frequency we can hear." The steps provided in this article are written to help guide a sound system owner through a procedure where one can properly correct for any bass issues a room may have so that he or she can get all the enjoyment possible from their music system. Some have been led to believe a myth that needs to be debunked, the myth that some measurement system exists that by itself can magically "fix" loudspeakers. While I have seen a computerized tuning system do a decent job with the middle and high frequencies of some inferior loudspeakers, I have yet to see one be anything but completely lost when it comes to frequencies below 500 Hz.

All one really needs for accurate music reproduction are good loudspeakers and proper calibration or tuning for the room. It should also be remembered that accuracy has nothing to do with taste. In fact, using the word "accurate" when it comes to sound systems and loudspeakers is presumptuous. There is no such thing as perfect accuracy in audio. The notion that a sound system can present a listener with all the sound, just as it went into the microphones, is simply not possible. Music, acoustics and audio technology are too complex. As amazing as audio technology can be, it does have limitations. What is possible is to provide an extremely satisfying illusion of the original live performance. Once one has good loudspeakers, all that's left is to tune the sound output, as needed, to match and compliment the room they are in. Tuning is an exercise that may indeed prove too difficult for some. It is a challenge. So if one is not comfortable that they can equalize a sound system on their own, it is hoped that by reading this they can at least understand when it is necessary, what is involved, and appreciate the results when it is properly done.

When resonances are heard, rather than guessing, one can quickly see which frequencies are involved by using a real-time analyzer cell phone app, one fast enough to follow the sound as it happens. Just hold it in your lap. Do not try to use the microphone that comes with some preamplifiers and receivers. These are only used for setting levels. The image below is a screen shot of a real time analyzer app on a cell phone. Learning to use this may take some time.

When tuning a system, watching this app while listening to a recording can help you focus on which frequencies are causing a bass peak, but only if you hear one. When you do hear one, the display will help show you which one-third octaves need to be reduced. Your ears will also tell you when you have reduced them enough and that the sound is natural. Since the booming frequencies are in the bass, one should look at the frequencies between 40 Hz and 400 Hz. Observe which of the one-third octave bands are peaking the most. For instance, the image below shows a peak at 125 Hz, a common frequency band requiring equalization. But again, unless you hear a bass peak, there isn't one, no matter what the analyzer shows. The important thing to remember is that the analyzer is not measuring what you are hearing. It will NOT tell you there is a problem or when a problem is corrected. Only your ears can do that.



Returning to the loud bass guitar notes mentioned earlier, these are among the kinds of sounds that make tuning easy. If you are listening to the notes of a bass guitar, you know that you need to look at the bass frequencies, again between 40 Hz and 400 Hz. One or more of those bands will show the highest readings. Let's say it's 100 Hz and 160 Hz. Temporarily reduce these one-third octave bands in the equalizer by perhaps -10 dB and then listen

again. By making a 10 dB reduction, you will immediately know if you are adjusting the right frequency band. Then repeat the procedure by first returning the adjustment(s) to -1 dB.

Continue by reducing the adjustment by another -1 dB each time, then listen again until the sound is right. The sound will get better, but perhaps still not perfect. Perhaps you are still hearing and seeing other bands reading high. Continue adjusting other bands and listening until natural tone is achieved. Be patient, this will take time. One also needs to be careful not to overdo it as the sound may become too thin. In the end, as seen below, there are typically four or five such bands that may need to be adjusted, some more than others. But once they are properly set, they become a permanent part of the sound system. Once equalization is done, it is done forever, unless the room is somehow changed.

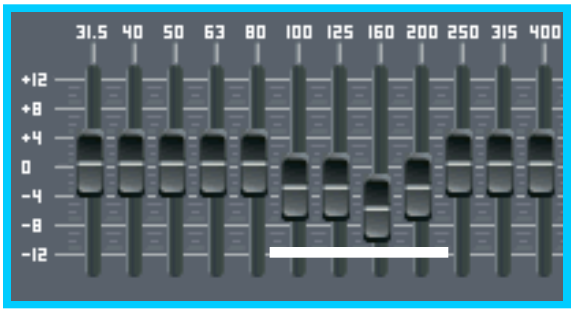
The examples above are typical of the equalization adjustments that may be required in a listening room. Perhaps surprisingly, they are also typical of those required in much larger rooms such as movie theatres.

One recording that has been found to be especially helpful exciting bass peaks is the Telarc recording of the Boston Symphony performing *Beethoven's Piano Concerto #5 with Rudolf Serkin and Seiji Ozawa*. This recording is available on YouTube. You will certainly find other recordings that excite bass peaks. Just be sure that the peaks are not in the recordings. It may be helpful to check this with headphones.

An analyzer is, therefore, often most helpful as a way to quickly see the frequency bands that look excessively active when ears determine that they don't sound right. The analyzer itself cannot indicate if anything is wrong or right. How could it? When listening to music over a perfectly tuned system, a real-time analyzer display may look anything but flat. In fact, it won't. But if the sound is natural and smooth, it doesn't matter what an analyzer shows. **WSR**

Watch an interview about the Boston Ballet with Sound Director John Allen: https://vimeo.com/7788017.

John F. Allen is the founder and president of High Performance Stereo (hps4000.com) in Las Vegas, Nevada. In addition, he has served as the sound director of the Boston Ballet and has mixed live concerts of the Boston Symphony, the Boston Pops orchestras, military bands, jazz ensembles as well as other orchestras. He is also the inventor of the HPS-4000® motion picture sound system and in 1984 was the first to bring digital sound to the cinema. A frequent presenter at technical seminars and colleges, his in-depth articles on the subject of sound have appeared in motion picture industry publications for the past 40 years.

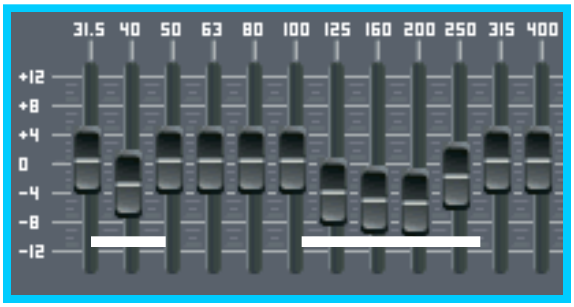


100 Hz = -3.0 dB
125 Hz = -3.0 dB
160 Hz = -6.0 dB
200 Hz = -3.0 dB

All of the equalizations displayed on this page show how different rooms behave with identical speakers. Though the adjustments are not the same, the resulting tone accuracy is the same.

125 Hz = -4.0 dB
160 Hz = -5.0 dB
200 Hz = -5.5 dB
250 Hz = -2.0 dB

As with the illustration above, these are typical of the equalizations required. Only the few necessary frequency bands are used.



40 Hz = -3.0 dB
125 Hz = -4.0 dB
160 Hz = -5.0 dB
200 Hz = -5.5 dB
250 Hz = -2.0 dB

This room had a peak at 40 Hz. While peaks in the bottom octave don't occur often, they can happen.

100 Hz = -5.0 dB
160 Hz = -7.0 dB
200 Hz = -5.5 dB

This equalization and the one below happen to be for the same speakers in two different rooms.

100 Hz = -5.0 dB
160 Hz = -9.5 dB
200 Hz = -7.5 dB

This is similar to the one above but still different. These differences are quite normal and should be expected.