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REALTRAPS - How to Tune Your Room

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..EQ ACOUSTICS SERIES..

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By Ethan Winer

Few project studio owners enjoy the luxury of owning a purpose-built control room. So it's common to see people mixing in bedrooms, basements, or whatever space is available. While you can certainly get good results in almost any room if it has enough acoustic treatment, you'll get even better results if you can optimize the room's size and shape. In this article I'll explain how the dimensions of a control room affects its accuracy, then show how to get the best results from whatever room you have available.

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MODES DEFINE THE ROOM

At the most basic level, a room is simply a band-pass filter. Or more accurately, three band-pass filters, with one filter corresponding to each of the three dimensions - length, width, and height. Not unlike music played through a graphic equalizer with three of the bands boosted all the way, a room imparts its unique sonic signature on all sound produced within it. In this case the filter frequencies are determined by the room dimensions. So for a room that's 12 by 10 feet and 8 feet high, the three filters are tuned to approximately 47 Hz, 57 Hz, and 71 Hz respectively. Additional level boosts occur at harmonically related multiples: 94, 141, 188 Hz, and so forth for the 12 foot length, and likewise for the two other dimensions. These boosts are the result of natural resonance - or *modes* in acoustic lingo - which is short for *modes of vibration*. Besides increasing the level of those frequencies, room modes also increase their decay time, so notes at those pitches linger after the musician stops playing.

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There's nothing we can do about room modes - they're a fact of life - but it's definitely possible to minimize the inevitable coloration they add by choosing optimum dimensions. One way to reduce the effect of room modes is to space them as evenly as possible. If a room is a perfect cube, say, 8 feet in all dimensions, there will be a huge resonance at 72 Hz, with other lesser resonances at every multiple of 72 Hz. Therefore, a room where all three dimensions are different is better than a cube because it has in-between resonant frequencies instead of one enormous peak. Even better is to design the room to have more resonances that are closer together. This is done simply by making the room larger while keeping the proportions the same. Top

Small rooms have fewer modes that are spaced farther apart than large rooms of the same proportions because the first mode in a small room is at a higher frequency. For example, when the longest dimension in a room is only 8 feet, the modes for that dimension start at 72 Hz and are 72 Hz apart. In larger rooms the first mode is at a lower frequency so the subsequent modes are closer together too. Therefore, a large room has a flatter low frequency response because it has more total modes, and they're spaced more closely. Since the modes begin lower, the additional boosts also give more overall output at those lower frequencies.

Playing music in a room with poor mode distribution is like listening through a 5-band graphic equalizer with two or three bands turned up all the way. A room with good mode spacing is more like having a 31-band equalizer with all the bands turned up. The frequency response still isn't perfect, but all those peaks combine to yield an overall response that's reasonably flat. Top

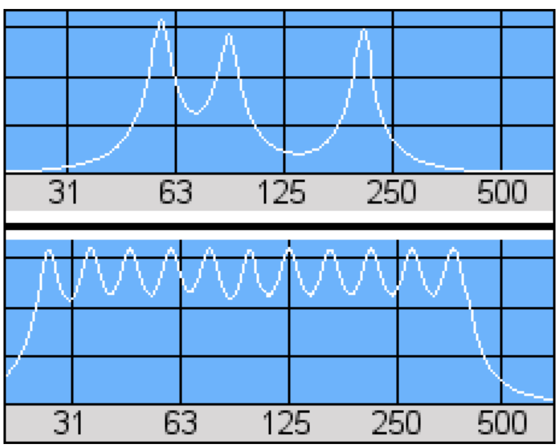


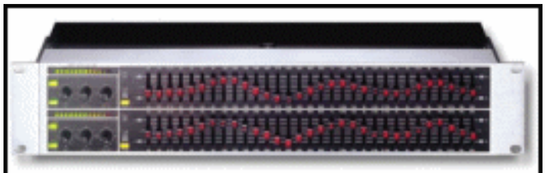
Figure 1: The natural response in a small room, top, has resonant peaks that start higher in frequency and are sparser than for a larger room, at bottom. Click the image for a larger version.

The upper graph in Figure 1 shows the low frequency response created by the first few modes in a poorly shaped small room; the lower plot reflects a larger room having better dimensions and thus more modes, more evenly spaced, and with less distance between them. Since the larger room's modes start at a lower frequency, and occur at more closely spaced intervals, the result is an overall flatter and more extended low frequency response.

If you're designing a room and want to determine the acoustic effect of varying the dimensions, or you need to choose which of several existing rooms would be the best to mix in, you can download my free **Graphical Mode Calculator** program shown in Figure 2 below. This program runs on any DOS or Windows computer, and displays the modes as numbers and also graphically so you can easily see how evenly they're spaced. Top

ROOM TUNING

Contrary to conventional wisdom, tuning a control room does *not* necessarily mean adding an equalizer to the monitor chain. Although control room monitor EQ was common years ago, these days most acousticians reject equalization as a way to achieve a flat low frequency response. The main reason EQ is not useful for correcting the low end in a room is because the response can change a lot depending on where you sit. I've measured changes as large as 15 dB across a physical span of only four inches at 100 Hz. So any EQ correction you apply is valid for a very small area only.



Since every location in the room is different, no single EQ curve can give a flat response everywhere. Even if you hope to correct the response only at the mix position, there's a bigger problem - it's impossible to counter very large cancellations. For example, if acoustic interference causes a 25 dB null at 50 Hz, adding that much boost with an equalizer will cause your power amplifier to clip on loud passages, or will damage your speakers or at least increase their distortion. And at other locations where 50 Hz is already too loud, applying EQ boost will make the problem even worse. Top

EQ cannot always help at higher frequencies either. If a room has ringing tones that continue after the sound stops, EQ can make the ringing a little softer but it will still be present. The same is true for low frequency reverb and ringing, which obscure clarity as bass notes ring out and overlap into subsequent notes. EQ can help to reduce the most blatant modal peaks, though not peaks created by acoustic interference from a nearby boundary. To reduce modal peaks properly, you need a parametric EQ and also a way to measure the room to a resolution of 1 Hz or finer. Even then, EQ helps only a little because the amount of boost varies around the room. So the best you can hope for is to lower the average level a little at that frequency.

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A much better way to tune a room is with absorption that reduces the response-skewing reflections that are the root of all these problems. Besides improving the frequency response of the room, absorption also helps by making the reverb time more uniform at different frequencies. Previous articles in this series introduced the use of absorber panels and bass traps, and *this* is the correct way to tune a room. I distinguish absorbers based on the range of frequencies over which they operate, using a "crossover frequency" of about 300 Hz. This dictates both the type of absorbers you'll use, and also where you place them. Top

Mid and high frequencies are easy to tame using thin panels made of foam or rigid fiberglass mounted in various places on the walls and ceiling. Low frequencies are a different matter entirely - for effective bass trapping acoustic panels need to be very thick, and placed in the room corners including the wall-ceiling junctions. Other types of bass traps can be used, including membrane traps, wood panel traps, slat resonators, and thick blocks of foam shaped for corner installation. A Google search on "bass traps" will yield a month's worth of further reading, plus links to commercial acoustic treatment vendors, and plans to build your own panels and traps.

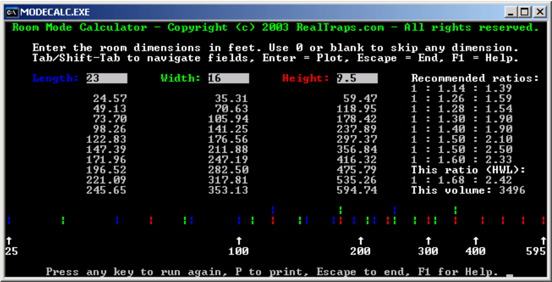

Figure 2: You can download the ModeCalc program from the author's web site to assess the mode frequencies and spacing for any rectangular room. The online Help explains how to use the program and interpret its results. Click the image for a larger version.

Adding bass traps to a room improves its low end response and makes it more like a larger room for two reasons: The modal peaks are reduced, and reflections that skew the response up or down are also reduced. Because substantial low frequency absorption is needed in all rooms, it's important to use a mix of bass traps and mid/high frequency absorbers, not just thin materials that absorb mainly mid and high frequencies. Rooms treated using only thin panels made of foam or rigid fiberglass are often too dead sounding, yet boomy at the same time. This is why blankets, carpet, egg cartons, and other such "room treatment" usually make a room sound worse than if it had no treatment at all. Top

THIS MUST BE THE PLACE

Now that you know what types of absorbers you need, let's look at where to place them. As I already explained, bass traps should be mounted in the room corners. This is the best place for bass traps because this is where low frequencies tend to collect in a room. However, mid and high frequency absorption should be placed more evenly around the room, as well as at the points of first reflection.

In **Improve Your Monitoring** (EQ magazine, May 2004) I explained the importance of using absorption or diffusion to avoid early reflections and thus ensure good stereo imaging, so I won't belabor that here. In many rooms, once you've installed enough bass traps and placed absorption at the early reflection points, little additional treatment is needed. However, if your room has large areas of bare wall, or a reflective floor and also a bare ceiling, additional mid/high frequency absorption is needed. Since the goal is for sound to be balanced evenly around the room, I prefer some mid/high frequency absorbers on each surface, rather than covering one entire wall only. You can do this by placing 2x2 or 2x4 foot acoustic panels in a striped or checkerboard pattern. If you have a reflective floor, you'll need additional absorption on the ceiling. Top

SO NOW WHAT?

Okay, now you know what you need and where to put it, but how can you tell when a room has enough absorption? The "free" way is to simply clap your hands while standing in

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different parts of the room and listen for excess ambience and obvious echoes. If you can hear any specific tones ring out right after clapping, that means more absorption is needed. In particular, look for parallel opposing surfaces that are both bare. Again, don't treat just one surface; rather, put less absorption on *both* surfaces.

Even better than hand claps is to actually measure the room's decay time at 1/3 octave intervals. This requires a dedicated audio analyzer - either hardware or software - that can display the reverb time separately for each 1/3 octave band. I use the ETF program from **www.acoustisoft.com** because it's affordable and performs all of the important tests needed to analyze a room. However, other packages are available to do the same sorts of measurements, including Smaart from **www.siasoft.com**, SpectraFoo at **www.spectrafoo.com**, TEF available from **www.gold-line.com**, Terrasonde (**www.terrasonde.com**), among others. Top

Besides heading up ***RealTraps*** *where he designs acoustic treatment, Ethan Winer also moderates the* ***Acoustics*** *forum at MusicPlayer.com. Stop by any time with your acoustic questions, or just to say Hi.*

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