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## Correcting the Room

*Acoustic correction circuits are home theater's missing piece*

By Mark Fleischmann

The advent of high-definition television, the digitizing of surround sound and the steady rise of custom installation have all contributed to the ongoing improvement of the home theater experience. But the best may be yet to come. Using digital processing to correct a room's acoustic flaws may be the most important innovation of the next 10 years.

As any good system designer or installer knows, the room — after good hearing and eyesight — is the most crucial of home theater system components. Rooms with poor acoustic properties suck energy from speakers and electronics alike, making even the best gear operate distinctly beneath its potential. Imaging becomes vague. Subwoofers become one-note wonders. Music loses its snap, and movies rumble instead of roar. Customers wonder why they spent as much as they did, and reputations hang in the balance.

If a consumer is building his dream home, he'll have the luxury of dictating acoustically ideal dimensions for the home theater, preferably with the help of a consultant who's knowledgeable about acoustics. But most installations are born into existing rooms. Then the challenge is to minimize the acoustic problems of that space.

Acoustic room correction isn't a new idea — just look at any recording studio, or any listening room damped with diffusors and absorbers. But the idea of doing it digitally has been building steam for almost a decade, and the solutions, in various shapes, are finally coming to market. Room correction may well be the ultimate audio tweak for the end user, and the installer who hopes to make the customer happy.

### ROOM MODES

Every room — except for the anechoic chambers in which manufacturers test speakers — has resonant or room modes. These modes cause peaks in certain areas of the audio spectrum, so that even a speaker designed to provide a relatively flat frequency response will sound louder at certain frequencies. Peaks that result from parallel walls are called axial modes. Where four surfaces are involved, tangential modes result. Oblique modes involve the ceiling and floor as well as the walls.

Standing waves are stationary patterns of high and low volume caused by waves bouncing between opposite walls. The frequency of the standing wave depends on the distance between walls. Effectively, the room becomes a resonator. Bloated midbass is a typical standing-wave problem.

These problems worsen if certain room dimensions are identical or multiples of one another. If two sets of walls have a common resonance, the problem is

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even harder to correct. Walls themselves can contribute to resonance problems by becoming resonators. Room correction measures room modes from the listening position. Depending on the product, the correction may involve only one or two peaks, or sonic treatment may be applied across the whole frequency spectrum.

### **THE OUTBOARD EQ SOLUTION**

Smart installers have been using outboard equalizers to solve these problems for a long time. The two common implementations for a frequency equalizer is the graphic type, which can boost or cut the amplitude of fixed frequency bands, and parametric, which allows the setting of the actual frequency band, as well as the boost/cut. Some equalizers have both functions, and setting them up usually involves the use of simple SPL microphones and a real time analyzer (like the R-2 THX audio analyzer).

AudioControl offers several surround-compatible equalization products, including the eight-channel Diva, which can be configured for, say, 7.1-channel systems, or 6.2-channel systems (with two subs). Though it has an analog in and an analog out, the processing is done with a pair of 24-bit Motorola microprocessors, capable of 160 MIPS. In addition to both graphic and parametric EQ, it can also perform digital delays, compression, expansion and limiting. Its high- and low-pass filters contain many more options than you'd typically find in a pre-pro or sub, and there are 24 individual user memories to store settings for a variety of applications. This product looks like a winner for anyone who can afford the \$9,995 price tag, which includes installation and calibration. Audio Control also offers real time analyzers, including the SA-3052 (\$1,359) and the more elaborate Lasys (\$4,995).

For those on a tighter budget, the Gold Line EQ2 (\$1,000) is a 10-band parametric EQ with delays, crossover, and six memory presets. It covers two channels, enough for subwoofer correction, or two full-range speakers, and of course can be used in multichannel multiples. The unit connects to a PC via the serial port and comes with software that integrates with Gold Line's DSP30 real time analyzer. It is available with XLR or RCA connectors.

THX certified EQs include the Rane THX 44 (\$1,099), which handles the LCR plus sub channels. There's also a Rane THX 22 (\$499) which handles an additional two channels (you can find the THX Room EQ Manual on the Rane Web site, at [www.rane.com/pdf/thxeq.pdf](http://www.rane.com/pdf/thxeq.pdf)).

Conventional outboard EQs are the right solution for a consumer who's happy with his current preamp-processor. With correct setup, the lengthening of the signal path is more than offset by the correction of gross flaws in frequency response. But most outboard equalizer products have analog inputs. By contrast, incorporating EQ into the pre-pro itself not only simplifies the system but has the added benefit of moving the EQ process entirely into the digital domain.

### **THE HIGH-END APPROACH**

Pre-pros with room correction usually come with mic inputs and computer software to facilitate and streamline the setup process. SPL microphones plug directly into the pre-pro, and the measuring and correction procedures are done with a PC as part of the overall product setup. Essentially, the product becomes its own real-time analyzer.

TacT had been offering highly effective two-channel room correction products for several years before becoming the first company to build room correction

into a pre-pro. That product is the TCS, recently updated with a pair of MkII versions: six channels (\$11,990) and 10 channels (\$13,990). The TCS uses 24/96 processing, has eight hardware configuration presets, and allows separate correction settings to be applied to each channel. The TCS can also pass a digital signal to TacT's 2150S digital amplifier (\$4,190), thus keeping the signal in the digital domain until it reaches the amp's speaker outs. TacT has such a dedicated following that the company even has its own Yahoo user group.

Meridian, one of the leaders in digital audio solutions for home and studio, has overhauled its 861 surround pre-pro to include room correction functionality. Version 4 of the 861 (\$14,740) uses the EF20 DSP card with Motorola processors running in 48-bit mode. Up to 60 filters can be applied to a multichannel profile. The correction concentrates on low-frequency room correction because — and here I am vastly oversimplifying Meridian's position on this issue — that's where problems can be most easily fixed without causing undesirable side effects.

The Krell Showcase (\$4,000) offers several types of EQ filtering with four memories. There are six crossovers for subwoofers (from 40 Hz to 120 Hz) plus high- or low-pass filtering for speaker or room correction. Peak and notch filters correct frequency bulges (the width of the peak or notch is adjustable). And for more subtle correction, you can use bass and treble shelving. The filters can apply to any one speaker, or all speakers, and can be overlapped to provide truly comprehensive room correction.

### **TRICKLING DOWN**

Infinity has made integrated room correction technology a part of several of its speaker lines. The most affordable example of the Infinity RABOS (Room Adaptive Bass Optimization System) is built into the \$799 Alpha 1200s subwoofer.

To implement it, you need the \$60 RABOS kit, which includes a test CD with bass tones and a sound pressure level meter designed especially to measure bass tones. Run the tones, measure them with the meter, log the numbers on a frequency response chart, connect the dots, and you have a quick-and-dirty picture of the room's primary (and probably secondary) bass peaks. Lay the plastic Q-Finder, made of hinged sheets of plastic, over the chart to calculate the frequency width of the needed correction.

If you'd rather not do the calculations, the Infinity Web site has a RABOS calculator (located at [infinitysystems.com/homeaudio/webrabos/rabos1.aspx](http://infinitysystems.com/homeaudio/webrabos/rabos1.aspx)). Then use the parametric EQ controls built into the sub to dial in the center of the peak frequency that needs correcting, the level of the cut, and the width. I've tried it and it works.

The Pioneer VSX-49TXi (\$4,500) and VSC-45TX (\$1,400) receivers come with what Pioneer calls a Multi-Channel Acoustic Calibration Circuit (MCACC). A microphone plugs into the receiver. The process automatically checks ambient noise levels, speaker size and several other things before performing its surround analysis with pink noise and timing pulses. A seven-channel, nine-band EQ does the correction, however, it does not affect the sub. The user can manually override the automatic process with his own settings. Pioneer's lower-priced VSX-43TX (\$1,200) offers a manual-only version of MCACC.

Even Bose has reacted to the room-correction trend with its Lifestyle 35 (\$2,999) and Lifestyle 28 (\$2,499) — all-in-one systems that include speakers,

amplification and a DVD-Video drive. The user wears a headset outfitted with mics, thus identifying acoustic conditions to the system, which takes about 10 minutes to make adjustments. Earlier versions of the two systems don't have the room correction process, which is called ADAPTiQ, but a DVD-based software upgrade is available. While these Bose systems don't require an installer, they illustrate how mainstream room correction has become.

### **THERE ARE LIMITS**

Before you get excited about the prospect of using room correction as a panacea to fix all kinds of problems, be advised that at least one manufacturer has made a credible claim that room EQ has some pitfalls of its own. According to a Meridian white paper, "The Gentle Art of Room Correction," one obvious problem is that the EQ itself might introduce ringing and phase errors. The paper goes on to discourage anyone from using an EQ to simply invert frequency response because that brings a number of other problems.

For instance: "To change a non-minimum phase response into a linear phase response requires that [the] signal starts to emerge from the filter before the sound has arrived at its input. This requires the filter to know what is going to happen in the future." If the filter did have such predictive powers, it would also introduce pre-echoes, and the time needed for the signal to pass through the system might lead to video sync problems.

Canceling a large notch might require more headroom than a typical amp offers. And "a dip in one place in the room may be a peak in another," so treating a single listening position "can make the sound significantly worse for everyone else in the room." Moreover, "while humans can tell the difference between direct and reflected sound, a measuring microphone cannot" — serious problems with imaging may result.

This is not a complete summary of Meridian's white paper, so read the whole thing on Meridian's Web site ([www.meridian-audio.com/w\\_paper/Room\\_Correction\\_scr.pdf](http://www.meridian-audio.com/w_paper/Room_Correction_scr.pdf)). The bottom line — as implemented in the Meridian 861 — is that the company believes room correction should be attempted only with the frequencies below 250 Hz, and should concentrate on controlling the most problematic room modes, not inverting the frequency response curve.

### **PHYSICAL CORRECTIONS**

Some problems can only be solved physically. A resonating wall may need reinforcement. A single sheet of lightly reinforced sheetrock, for example, acts as a diaphragm, and has a discernibly hollow sound when you knock on it. Better results can be had from two layers of sheetrock with closely spaced studs and insulation placed between the studs to absorb sound. Practically every kind of wall has a note of its own but some are far worse than others.

There are well-established and simple methods of absorbing or diffusing reflections from side walls, corners, and other surfaces which affect the off-axis performance of speakers. Consumers who own large libraries of anything — music, movie software, books — should be encouraged to line their walls with shelving to reduce the need for acoustic manipulation products to a reasonable minimum. Bass traps are another option.

However, correct speaker placement is always the most cost-effective method of acoustic manipulation. There isn't much to be done with in-wall or wall-mount speakers (unless they have pivoting drivers). But consumers may be surprised how much better their floorstanding or stand-mount speakers will sound when

moved away from the wall a few feet into the room.

### **BEFORE AND AFTER**

After those angles are covered, stubborn room modes may remain, and that's where the emerging technology of digital room correction can make a major contribution to system performance and consumer satisfaction. Before-and-after demos can illustrate the benefits dramatically. The most effective ones I've heard (TacT, at various trade shows) concentrate on the bass.

Your showroom should include at least one carefully set up installation with room correction to provide a before-and-after demo. If you don't operate from a showroom, it should still be possible to take an equalizer on the road and do a quick demo showing how a room's biggest midbass peak can be neutralized.

Once your customers hear the difference between a room riddled with frequency aberrations and one where the response has been corrected through the right room correction solution and careful professional setup, acoustic correction will make the top of their wish lists, and probably yours, too.

*Mark Fleischmann is the author of Practical Home Theater. For more information, call (800) 839-8640 or visit [www.practicalhometheater.com](http://www.practicalhometheater.com).*

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