It's All In The *Acoustic* Details

Part V: Audio Calibration

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If you have been following this series, you are already familiar with how important acoustic control is to the performance experience. It surprises me how people will spend a great deal of money on a new piece of equipment in the quest of the elusive audio nirvana before they even think about their acoustic foundation. Noise, reverberations, reflections, room modes, and/or asymmetry will trump a new piece of audio gear in almost every situation. You may hear a difference in sound quality when you introduce that new amplifier or interconnect, but is it accurate, or just different?

This part in the series is about audio system calibration, which is the final sequence before "system enjoyment" can be fully realized. Prior to blasting off to the moon, all systems must be confirmed with a go/no-go status, even the environment. Audio calibration includes electrical, physical, acoustical fine-tuning, and verification of the system setup.

Before delving right into the calibration itself, I would like to offer an analogy of what audio calibration means to those who fully incorporate it.

Imagine going to the Musée d'Orsay to study the Monet paintings there. You forget you're wearing sunglasses as you stop in front of the "Women In The Garden." The deep green glass tint darkens the image and changes the hues. Let's call this reverberation, which alters tone and masks small details.

You realize the error and remove the sunglasses. Details in the shadows now become visible and the objects illuminated by sunrays in the painting come alive.

As you study with more attention, you notice a spot on the canvas reflecting an overhead light, so you move to the side to avoid the distortion. Let's call this first order reflections. The large brush strokes capture the sunlight on the summer fabrics, and in contrast, there are small brush strokes used for the embroidery of a woman's dress, which invites you in for a closer look. This detail of examination requires your reading glasses, which suddenly puts things into clear focus. Let's call this loudspeaker/listener symmetry.

Now that you've paid attention to the colors, the textures, and the many small details that make up the painting, you step back to take it all in again, with new appreciations for the skill of the artist's hand. An ambiance of contentment shows through in each character's demeanor, while they enjoy picking and smelling the flowers. However, a toddler whining behind you prevents you from being fully engaged. Let's call this noise.

Finally, for a moment, you are alone in the room with perfect light and silence. There are no distortions or distractions. You are nearly one with the painting and nearly one with the artist. You have never had this experience until now. It's magical and yet real.

You wonder if you have this experience at home. You purchase a life-size print replica in the museum's gift shop to take home. It doesn't have any texture, and the colors

Converging Wilson Drivers

are not the same. It hangs behind glass that reflects everything in the room and the taupe wall paint detracts from the summer atmosphere. The reproduction cannot convey the same experience because there are too many distortions.

My point is, you can't fully enjoy a masterpiece in a poor environment. The Ferrari doesn't perform well on bald tires. You must cleanse your palette of the cheese plate before savoring the sautéed Chilean sea bass with spicy scented coriander broth. The stereo boom box isn't stereo unless your head is oriented correctly in front of it.

It matters not how high the quality of the electronics are if:

1. The noise floor is too high
2. The loudspeaker/listener/room positioning is chaotic
3. The equipment is not calibrated
4. Room resonances are not controlled
5. First order reflections are not controlled
6. Room reverberation times are not controlled

A poor environment will still perform poorly, regardless of the quality of equipment. The environment is a huge obstacle that the electronics cannot overcome. Mid-fi, set up right, will trump high-end set up wrong every time.

Some may be thinking that fancy Digital Signal Processing (DSP) can overcome environmental conditions. While the topic is a hot one, it cannot be addressed adequately in this small article. I will say three things about it here:

1) DSP should never be referred to as "room correction." It does not alter the signal once it leaves the loudspeaker and enters the room. It cannot lower the noise floor, remove rattles or resonances (for the most part), absorb or diffuse first order reflections, control reverberation times, etc.

2) Fancy DSP technology can absolutely improve the sound of a loudspeaker and/or help compensate for hearing loss.

3) Auto-level/delay DSP found in mid-fi home theatre is a wonderful thing. These consumers (the majority) would likely not experience a decent soundstage without it.

I would like to touch on the fact that we can easily become acclimated to, and tolerant of, poor sound. We can often get caught up in details and miss the artistic intent. We tend to notice things that are wrong. This is human nature. I'm often ruining the movie with complaints about plausibility. Audiophiles can discern the sonic characteristics of, say, one amplifier over another. Some may become so focused on it that it becomes a distraction. For the recording engineer, he will focus on the choice and placement of microphones, the acoustician on the venue, the videophile on black level, etc.

On the other hand, we can compensate for and/or dismiss many distortions to find artistic beauty. For example, I can enjoy listening to the Allman Brothers on a portable radio in a gym, however, not to the extent I do with the system in my dedicated room. My dedicated environment offers a much higher level of experience because it offers more information, with fewer distortions and distractions. The sound is richer and there is more for the auditory cortex to respond to.

Another example, one would likely recognize Morgan Freeman's voice even in the worst conditions, and be forgiving of the sound enough to ignore the distortions and allow oneself to be captivated by his narrative. We do this by modeling and filling in information from our auditory memories. This, too, is human nature. We desire to be interested in things, and we focus on the things we desire. We can choose to focus our attention on the good, or the bad.

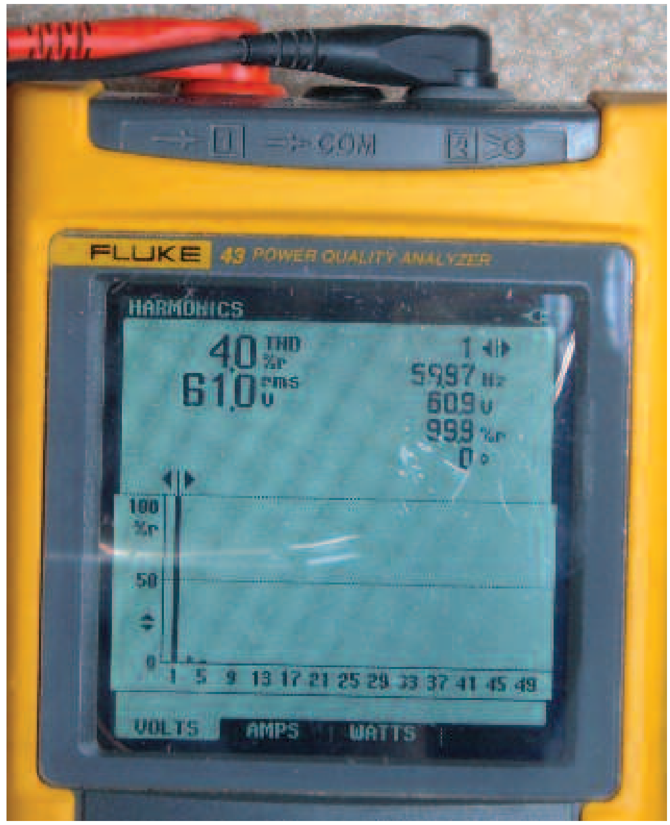
Most music is heard, not in concert halls, but in our living rooms and cars, small spaces with too much surface area relative to the room's volume. The close proximity of the room's shell draws attention to itself with sound bouncing all around us, along with resonances adding to the mix. A good recording captures the right balance of direct and reverberant sound. Our rooms tend to destroy the recording by adding their own sound to the original. We may not hear the intimacy, definition, warmth, or feel the intensity intended.

As we remove distortions, the experience becomes more involving, because the brain (in particular, the secondary auditory cortex) no longer has to work so hard removing what's not wanted and installing what is.

Calibration

Calibration means to check and/or rectify. It usually involves precise gradients for measurement and standards for reference. There are several areas, which require calibration in an audio system, in order for it to perform optimally. It is an electro-acoustical system. Our particular interest is for playback, or reproduction, of recorded sounds. This chain of events starts with an electrical power supply

Aiming Loudspeaker With Laser Beam



Acceptable AC THD And Harmonics

for which the electronics are fed energy, to amplify electrical currents enough to: 1) push and pull loudspeakers enough to 2) push and pull air molecules enough to 3) be sensed by the ears, in order to 4) be processed by the brain.

Calibration can be simple or complex. It is a matter of personal requirements and/or deviations to the standards. For some, it might only mean adjusting loudspeaker levels and delays, while for others, it means hiring a specialist who has the knowledge, experience, and tools required to spend a day or two optimizing the chain from the electronics to the acoustical room treatments.

When I perform complete electro-acoustical calibrations, I call it voicing. I picked up this term many years ago from pipe organ manufacturers who must "voice" the electronics and pipes of the organ to the room. If this is not done, certain "voices" will not be heard enough, while others will be heard too much, due to room resonances and reverberation times. My voicing involves calibration of the electronics, loudspeaker/listener positions, and acoustic treatments. It is the organizing of sound from the movement of electrons to the movement of air molecules.

When I voice, I have a checklist of over thirty basic tests to perform. Within these basic tests are hundreds of sub tests. Many of the basic tests are just to confirm that things are functioning to the standards in which they were designed. Sometimes they are not, and further sleuthing is needed in order to discover the reason for incompliance and be able to resolve the issue. I never have to perform all the hundreds of tests, only those needed. I also don't have the space to go into all of them here, so we'll just cover the basics. As with video calibration, when you change one thing, it may affect others, so you often have to go back and forth. This is not a "how-to calibrate," but rather an overview of the process and the areas that should be addressed or verified.

Adjusting SPL

AC Electrical

It makes logical sense that there is a hierarchy to calibrating a system. You typically don't start calibrating in the middle of the chain, unless there is something obvious. You start at the source for which the electrical signals are born, the AC power supply. Staying away from the high-end esoteric, or special needs, here are a few good basic practices:

a) **Quantity**. The electronic components draw current from the power supply, which must be of adequate quantity. If it is not, the sound may lose weight and impact, speed and authority, dynamics and soundstage. The number of circuits and their amperage is important at the design stage and is often an oversight. As in amplifier power, it is better to have more than you need, than not enough.

b) **Isolation.** It is wise to use dedicated circuits in order to prevent external equipment noise from contaminating the signal. Isolation starts with separation of audio power supplies from feeding other sources, such as lighting, but may also include separation of digital from analog and playback from recording. Again, this should be addressed at the design stage. Better systems will benefit from a large isolation transformer for these circuits. There are also some products that offer small isolation transformers for individual component isolation from the power line and from each other.

c) **Grounding.** Conventional grounding acts as a giant antenna and conductor of electrical noise. Home run grounding with isolated ground receptacles offers a "clean" ground, since the grounding network has fewer branches, fewer sources of noise, and is connected to the ground at a single point. Good grounding is important for safety, of course, but also for quiet power.

d) **Power conditioners.** Quality filtering of line and field coupled RFI and EMI of all but the utility frequency. Each year we add more and more noisy, sensitive electronics to our lines.

e) **Surge/Spike suppressors.** Cheap ones bought at the hardware store don't cut it. They offer little to no reliable protection and add noise to the system.

Checking Room Resonances

1. General AC Tests

a) **Outlets.** It amazes me how often I find outlets wired incorrectly, which hampers performance and safety. I sometimes find electronic component power supplies wired incorrectly as well. Polarity must be correct before we can continue. If not, you may be forever chasing your tail, wondering why it sounds weird.

b) **Line voltage.** Should be consistently at or very close to 50 or 60 Hz, depending on the country.

c) **Voltage harmonics.** Severe integer multiples of the fundamental can cause many types of problems.

d) **Current harmonics.** Non-linear loads produce current harmonics, which cause voltage distortion.

e) **THD.** Degree to which a waveform deviates from a pure sinusoidal form.

f) **Power factor.** Ratio of real power to apparent power. Inductive loads cause the amps to lag behind the volts. Power factor equals 1 when the voltage and current are in phase, and is zero when the current leads or lags the voltage by 90 degrees.

When any of the above results indicate problems with the basic power quality conditions, steps should be taken to remedy the trouble. Otherwise, the sound quality will be affected; equipment may produce errors, and/or even become damaged. There are other forms of AC distortions too numerous to mention here, and of which are fairly common. As more people are connected to the power grid, with additional load requirements and sensitive equipment, more problems arise.

2. Cable Dressing

If cable dressing (organizing) is disregarded, Electro Magnetic Interference (EMI) can wreak havoc on the performance by introducing noise and/or frequency altercations to the signal. Here are the most basic things to avoid:

a) Keep loudspeaker cables and interconnects well away from AC power cords and power supplies. Cross them at a right angle if necessary and try to physically separate the crossing point.

b) Avoid coiling cables. Doing so creates an inductor. Try to keep them short, or loop them so that they cross at a right angle.

c) Avoid sharp bends.

d) Avoid bunching and routing cables together. It may look nice, but isolation is key to performance. For example, even grouping low-level signal cables such as digital, phonographic, and other interconnects together will significantly lower the audio performance.

3. Loudspeaker/Listener Locations

As I mentioned before, a stereo boom box is not stereo unless your head is oriented correctly in front of it. Loudspeakers and listeners must also be located optimally in the room in several regards:

a) **Loudspeaker/listener angles.** Center channel directly in front, R & L about 30 degrees to each side, sides at 90 degrees, and rears 135-150 degrees, with the listener in the middle. A proper soundstage cannot be developed without this set up.

b) **Room modes.** The above loudspeakers/listener arrangement should be located within the room so as to avoid exasperating the modes optimally. This is best achieved with computer modeling and ears, and can be verified with test instruments.

c) **Loudspeaker aiming and coverage.** I start off with the L & R for stereo. Aiming the loudspeakers at the listener's ears means optimal frequency response, which equates to an accurate, deep, wide, and solid soundstage. Driver convergence and loudspeaker toe-in is critical. This is a very tedious process, which requires patience, experience, good ears, and in which a fraction of an inch can make or break the illusion.

d) **Boundary distances.** Loudspeakers and listeners close to boundaries will cause problems for timbre and imaging.

4. Basic Acoustic Treatment Layout

Verify that first order reflections are absorbed or diffused once the loudspeaker/listener positions have been determined and that bass absorbers are positioned correctly.

5. System Configuration

This is all about normalizing the processor, configuring for each loudspeaker size (cross-over), loudspeaker distance, subwoofer management, etc.

6. Electronics Verification/Adjustments

a) Loudspeaker driver polarity, channel verification, and polarity

b) Subwoofer(s) phase, crossover and level

c) Possibly check amplifier gain, signal level voltages, waveform distortions, channel frequency response tolerances, loudspeaker frequency/phase response tolerances, load impedances, electronic noise floor, hum, amplifier oscillation, and equalization

d) Loudspeaker rub and buzz

e) Channel SPL levels

f) Processor's readout for the 75 dBC reference level

Voicing Equipment

7. Acoustics

Acoustic treatments may include diffusers, bass traps, and wall/ceiling panels, as well as: door seals, damping materials, isolation pads, even plants, bookcases, throw rugs and pillows.

a) Fine tuning of the acoustic treatments may include adjusting for room modes, reverberation times, slap echo, first order reflection coverage, speech transmission index, and sound leakage to or from other rooms.

b) Room rattles

c) Ambient noise floor with HVAC and projector on and off

Over the years of voicing jobs I've performed, I'd say about eight out of ten systems have major flaws in their wiring that were not caught by the pros. By major, I mean flaws like the midrange driver not working in one loudspeaker, or the right rear playing the left side channel signal, for example. I recently voiced a dedicated room for a loudspeaker manufacturer and while listening, I thought to myself that the center channel loudspeaker did not timbre match the L & R mains as well as I had anticipated. Upon further investigation, I discovered that the tweeter was out of phase with the other drivers. After correcting the wiring, the client and I expected an improvement, but we were both surprised at the huge difference it made for the system. Of course, the client was embarrassed about the error, but interestingly enough, he had been happy with the sound prior to the fix. Now his happiness level is higher than he ever knew existed.

One of the joys of calibration for me comes after I'm done, and I watch the client take his seat for the first time to play a favorite recording, and after a few moments, a smile spreads across his face. He points out sounds he's never heard before, and I witness his excitement. The hour is late, yet he doesn't want to quit, he wants to go through his entire catalog in one sitting. New passion for the audio experience is created as the calibration orchestrates sounds to converge in an organized manner at a single point in space, time, and amplitude.

It's similar to putting together a 1,000-piece jigsaw puzzle. You start out by clearing a work area. Then you dump out all the pieces and begin flipping them over, to reveal their faces. You cluster the edge pieces in one spot and locate corner pieces. You sort the pieces by colors and identifying marks. Soon you've got the perimeter completed, along with several fragments of the picture. Partials are now lying around here and there, some inside and some outside of the framework. You begin to study the reference picture often to help guide you towards completion. Small fragments become large and some find connections to the border. Bridges are formed and sections completed. There are still many empty spots in the picture here and there with missing information. Finally, the last piece is put in place and the picture is whole.

Likewise, after calibration, the audio scene is suddenly complete and sharply in focus. **WSR**

About The Author
Norman Varney is the owner of A/V RoomService, Ltd, an acoustical firm specializing in sound quality, noise control, power quality and HVAC, offering design, modeling, testing and voicing services and many acoustical products. Prior to A/V RoomService, Norman was with Owens Corning at the Science & Technology Center where he was a Senior Engineer with the Acoustic Systems Business as the Acoustic Design Center Lead. Prior to Owens Corning, Mr. Varney worked at Music Interface Technologies where he designed critical listening and viewing environments, AC line conditioners, video cables and was Director of the Custom Installation and Home Theater divisions. He was the lead for the development of the 2C3D and 5C3D Certification programs, which recommended structural, electrical and system component set-up parameters for Spectral, Avalon, ASC and MIT. While there, he designed the very innovative and elaborate electrical system for the Scoring Stage of Lucas Film's Skywalker Ranch. Mr. Varney has written many articles for numerous magazines over the years, as well as given seminars and participated on panel discussions regarding acoustics. He became a member of AES in 1981 and has contributed to the Characterization and Measurement of Diffusion Coefficient Standards, and the Recording Academy's Producers & Engineers Wing Recommendations for Surround Sound Production. He continues to study and develop the science of subjective acoustic value-to-performance relationships. Norman can be contacted at www.avroomservice.com, or normanvarney@avroomservice.com.