Prioritizing Audio For Optimized Performance

Norman Varney

We've all heard the expression, "A chain is only as good as its weakest link." The problem is, most audio chains are a hodgepodge of links. When you make a change to a hodgepodge, is the change an actual improvement or just a change? This article will help you systematically and perpetually determine the weakest link in your system and forge links that you can rely on. And you'll learn that unless you have a firm audio foundation, it will constantly be moving.

Equivalent to a whisper at three feet, the average background noise in a quiet private residence is about 40 dB(A) SPL. The normal hearing threshold starts at 0 dB. We cannot hear any of the soundtrack information that falls below our background noise floor (See Figure 1). In the typical residential playback room it takes at least one second for sound to die down. One Mississippi. Don't expect to hear much low-level detail until one second after the soundtrack quiets down (See Figure 2). Most home theatre processors are not properly calibrated. Audio imaging may not relate well with the picture. Under these conditions, what can a new piece of electronics do to improve your experience or get you closer to what the artist intended? Absolutely nothing.

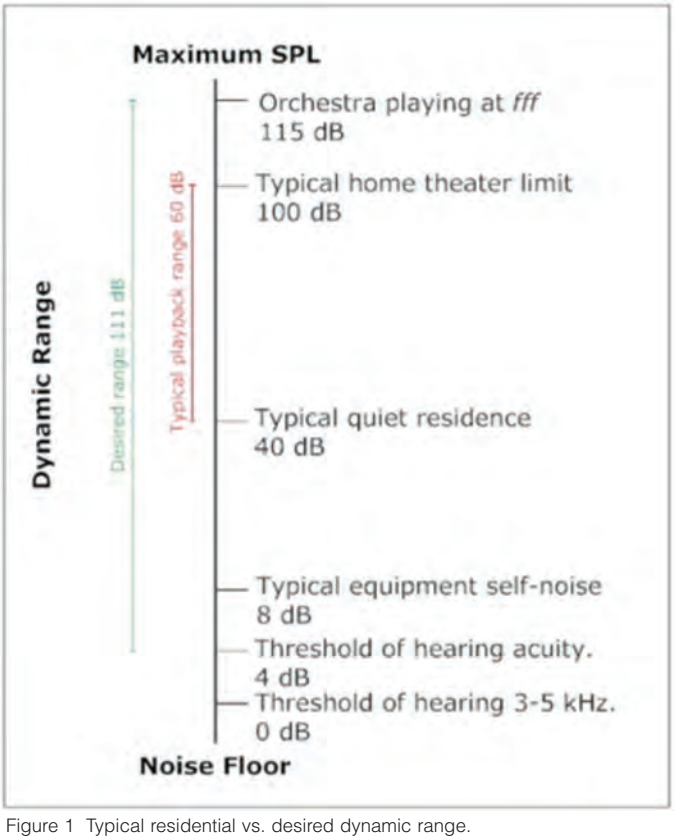

Figure 1 Typical residential vs. desired dynamic range.

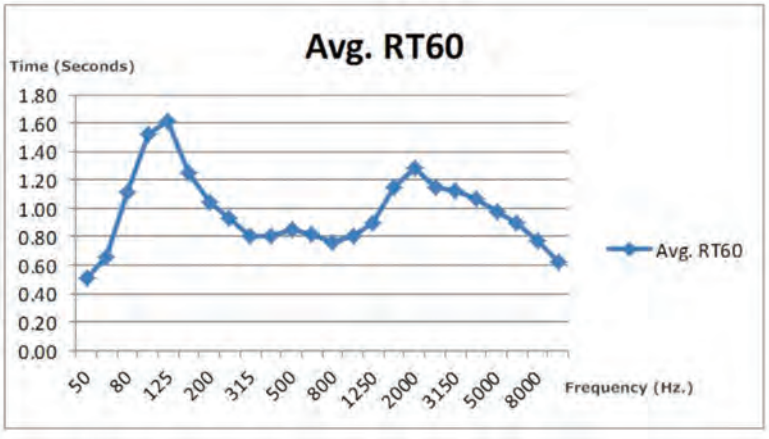

Figure 2 Typical residential reverberation times.

Audio is certainly a subjective subject. Like music, there are different measures of audio that trigger our emotions. Those triggers have been planted into our personalities over the years by our experiences. What we've been exposed to and influenced by becomes our reference. Be it good or bad, right or wrong, is a matter of personal opinion. However, no matter what form of passion we are talking about, there are those in any given field who are very experienced. They have developed and refined their senses above the average in particular areas. Often, this has more to do with choice than it does talent. In other words, someone can choose an interest, and along with it develop the physiological aspects associated with the interest through learning and practicing.

For me, and like most people in audio, my interest sprang from my love of music. I connected with music at an early age. I was interested in the sounds of the individual instruments, the rhythmic and harmonic interactions between them, the many moods and images they created, and the emotions felt. Also at an early age, I was exposed to a high-end stereo system by a friend of the family. I discovered that I could get closer to the artist with a bigger, better audio set-up. I experienced much more feeling and enjoyment. I was hooked. I wanted more. I needed high fidelity—accurate, high-resolution sound.

The information below is from my several decades of experience with audio playback and how to get the most from your investment. It's an overview of what matters most when it comes to achieving what the artists intended. Obviously, we can't go into depth here, the purpose of this article is to explain the fundamentals for audio playback that must be in place in order to create a solid foundation that will hold up strong and not shift or crumble. Without such a standard as a reference, distortions abound, causing confusion and skewing of the truth. We will also recognize a "chain"-of-command that dictates an order for accurate sound quality from beginning to end.

Regardless of whether you are into tubes or transistors, Abba or Zappa, movies or gaming, there is a hierarchy for optimal audio

playback. There can be circumstantial exceptions, but for the most part, depending on how an existing system falls into place on the list, the order probably won't vary by more than one or two numbered placements for any circumstance. Typically, you'll find that it is difficult, if not impossible, to achieve accurate results if you change the order. Remember that they interact with each other, which means much re-checking and re-adjusting.

You must course tune before you can fine tune. For example: there isn't much sense in applying a contact enhancer to your cable connections if they are coiled up, grouped with power cords, and/or not clean. The big stuff takes precedence over the little stuff. Your job is to sort through the big stuff on the list that is of issue, preventing your system from performing to its full potential, and progressively move down the list to the smaller stuff that can only make a difference after the bigger stuff is in place. Change the order—confusion and illusion, keep the order—truth. Get through the list, or at least to your point of satisfaction—fun and enjoyment. Don't be thinking that your audio nirvana will happen as soon as you can afford to buy that new controller, when, unbeknownst to you, your right rear channel's polarity is inverted. You haven't realized this because your room's reverberation times are too long, introducing spatial and tonal distortions, along with masking of resolution and limiting of dynamic range. The sound is unclear, and at the same time, you may not know what "clear" is supposed to sound like. Relating to another of our senses, imagine trying to fully experience sushi when you have mouthwash on your palate? Your taste sense will be tainted, dulled, and disappointing compared to what it should have been.

As enthusiasts, we need to understand and play by the same rules. As subjectivists, we need to acknowledge the hierarchy of audio influence and apply it before our opinion has much merit. As investors, we need to focus on the fundamentals before tweaking is justified.

Before we get started, let me suggest a few things to keep in the back of your mind:

• The best audio reference is unamplified music. Explore it whenever possible to develop a keen ear.

• Noise control must be in place before sound quality can be established.

• Mediocre equipment can sound great in an acoustically controlled environment, however state-of-the-art equipment can only sound mediocre in an uncontrolled one.

• Audio is more important to storytelling than picture.

What makes audio so subjective is based primarily on what we've been exposed to. Because of our personal experiences and influences, we develop sonic characteristics that we favor and others we dislike. What fills one's sail may not fill another's. For instance, macro and micro dynamics are very important attributes to me in an audio system. Another person may choose a wide soundstage as more important. Systems that sound hard and edgy annoy me. Another individual may prefer it. Another person may have never heard the many overtones and textures produced when a fine Guarneri cello is bowed across its deep C string. That person has no knowledge of such an experience and is probably content because of it. Those of us who have had an experience like that want to repeat it at will. Thousands of us spend thousands of dollars in vain trying to duplicate it and just end up spinning wheels.

Whether we are talking about a boom box or a world-class system, set-up, calibration, and acoustics control the outcome much more than does the equipment. The equipment relies on those three, and in that order. You're probably wondering, "Really, even a boom box?" Yes, even a boom box. Imagine you've got a stereo boom box playing in the bathroom while you're taking a shower. It's sitting on the sink five feet behind you. An old Stones tune is bouncing off of all the hard surfaces. Because of this, you are having a difficult time deciphering Jagger's lyrics as you sing along with the monophonic sound coming at you from all directions. In addition, the noise from the shower and exhaust fan is masking most of the information recorded (however, you sound great!). Now imagine the boom box in your closet. It is very quiet. The boom box is set up on top of your dresser and you are standing between the loudspeakers equidistantly at ear height. The balance control is calibrated so that the sound appears centered. Your wardrobe is preventing the sound from bouncing around. It's dynamic and articulate. Now you are able to pick out more of Mick's words, you can feel the rhythm and pulse causing you to move, you can hear slide guitar, piano, and shakers to your left, guitar to your right, with bass, guitar, and drums filling in the middle. You can hear details that weren't possible in the bathroom environment. In fact, you are noticing things you have never noticed before, and the song has been around for forty-one years! Go ahead, give it a try. I dare you.

Here's the basic list and overview of how these relationships work and what they mean to audio performance:

1. Noise Control

Noise control must be established before quality sound can exist. Noise comes in many forms. It can be introduced through many different means and many different pathways. Any sound that obstructs any of the recorded signal is noise. Any sound that is a distraction is noise. Any sound that is not a part of the original signal is noise. It can be generated from outside or inside the room, air-borne or structure-borne, acoustical or electrical, steady state, periodic, or incidental. It is possible, and better to reduce the noise floor than it is to increase the sound-pressure level.

2. Room Dimensions

Most people note the fullness of the sound first. This not only has to do with the low-frequency extension, but the accuracy of it. When the bass doesn't seem right, the system seems phony right off the bat. It turns out that the room has more say regarding linear bass response than do most any typical loudspeakers. The size of the room, and its dimensions, call out the supported low frequencies, which are dictated by their relational wavelengths. The room's boundary distances for length, width, and height create room modes. These modes are frequencies that when reflected back into the same oncoming frequency, create a resonance. The resonance has high-pressure (loud, coincident) and low-pressure (quiet, cancellation) points in the room, along with mathematical multiples of that frequency. Since there are three axes in the room, there are three fundamental resonate frequency modes, along with the multiples of each. When the mode frequencies are too close to each other, or when they are spread too far apart, they audibly stand out from the rest of the response. The result is non-linear bass, very unique to the room, and very noticeable to even those inexperienced. All rooms have modes, however, a room with nice distribution of the modes will sound much smoother. Rooms with particular mode problems can be resolved or mitigated by altering the dimensions, optimizing the loudspeaker and listener locations (see below), acoustical treatments, and/or electronic equalization.

3. Loudspeaker/Listener Locations

a. Room Modes

As discussed above, rooms have modes (low-frequency resonances), and we have to deal with them the best we can. Certainly the easiest and most effective way to avoid room modes is to keep ourselves and the loudspeakers away from their pressure peaks and valleys. Using an SPL meter and generating pink noise is all you need to actually see where the modes live. This can be sketched out on paper. You'll discover that the corners and sidewalls are not good places for loudspeakers or listeners. The smoothest frequency response will be away from those areas. Note that the difference between a high- and low-pressure point can easily be 30 dB SPL. Keep that in mind when telling your friends that your loudspeakers are flat +/- 3 dB down to 40 Hz.

b. Polarity

With your controller/processor hooked up and loudspeakers configured, confirm that all the drivers in the system move forward when given a positive voltage to the + terminal (there are loudspeaker designs, which reverse polarity for some drivers. Check with the manufacturer if unsure).

c. Bass, Soundstage, and Timbre

I. Ideally, we want the deepest, widest, most solid soundstage we can attain. There are numerous obstacles that prevent us from achieving this, but for now we are only talking about the loudspeaker/listener relationship. With the information gleaned from plotting out the room modes, we know what spots to avoid. Referring to them, we need to come up with a triangular footprint that will avoid them. An equidistant triangle for the right and left mains and the primary listening position (centered between the side walls when possible) is a good starting point.

Play some familiar music while trying out different positions. Initially, listen for good bass (least mode interaction). Start out discovering the best seat location, then work on the right and left main loudspeakers. Then try course-tuning your footprint by moving it front or back 1 to 2 feet, graduating to fine-tuning in 1- to 2-inch increments, all the while concentrating primarily on the bass response. Be sure that no loudspeaker blocks viewing of the screen.

II. Now let's focus on soundstage and timbre. Play a monophonic recording and strive for a big, solid soundstage, with rich sounding tone. Try changing the distance between the loudspeakers and/or between the loudspeakers and the listening position. Start with +/- 6 inches and fine-tune down to your personal limit. The soundstage will begin to separate, and the tone will thin out when the loudspeakers are too far apart.

Play a stereo recording to fine-tune the toe-in angle of the loudspeakers. This will determine both the upper-frequency response, as well as the soundstage perspective. Compare no toe-in versus toeing-in behind, at, and in front of your head. Use a laser beam to precisely aim the loudspeakers symmetrically. Toe-in is often a compromise between tone brightness and imaging specificity, of which your room and your loudspeaker's dispersion characteristics play a big role in, and of which you are the final judge.

The next most important loudspeaker is the LFE subwoofer. It needs to blend in with the mains so well that you don't notice it. Together they should sound like one voice both tonally and spatially. This works best when it is very near one of the mains (and probably on the inside). Two (identical subs) is better than one for many reasons.

Next is the center channel. As you are aware, this loudspeaker will provide the majority of the dialogue information. It will share a lot of that information with the right and left mains, so it needs to sound just like them. It is best located just below the middle of the screen to act cohesive with the picture.

For the surrounds, avoid the room modes, work on soundstage and timbre as the fronts. Also check imaging between front and rear for the right and left sides.

Ideally, the loudspeakers should sound and image as one, big, solid sphere with you in the middle. This is not easily achieved, as there are many constraints that can limit the possibility. You do the best you can with what you have. Regardless of the quality of your loudspeakers, they should be positioned to interact acoustically optimal within the room from the primary seat. When you get that seat right, it's magical, and all the others are that much closer to the target.

4. Loudspeakers

a. Matching timbre

From a sonic viewpoint, each loudspeaker should be the same model. From a more practical consideration, they should all be the same brand. The idea is to have the same sound reproduced from each loudspeaker, the same voice. Nobody mismatches their main right and left loudspeakers, and if they did, the image would fall apart. It is most important to try to keep the center channel as similar to the mains as possible because they are working together to build the front soundstage.

Tweeter orientation has a lot to do with this. Ideally, all the tweeters are at the same distance, the same height, and aimed at the primary position. Note that tilting loudspeakers may change timbre due to altering the arrival times between drivers. In addition, timbre matching includes matching amplifiers, interconnects, loudspeaker cables, cable lengths, etc.

b. Driver time alignment

Ideally, the signal from every loudspeaker driver in the system arrives at the sweet spot at precisely the same time. If not, the time, energy, and frequency responses will be misrepresented and skew the truth. Quality loudspeaker manufacturers work hard to get their driver, crossover, and cabinet designs to work as one in these domains. When the cabinets are not precisely positioned within the room, much of the magic the artists labored to achieve is lost. Your controller has two electronic band-aids called "delay" and "level," which can get you back in the ballpark when conditions are not perfect.

5. Seats

Five things to consider when selecting seats:

1) The back height should not be above the shoulders or it will reflect sound from the front and block sound from the rear.
2) The seated ear height should be closely aligned with the tweeters.
3) The seats should not be noisy when people move around in them.
4) The seat should not resonate. Check with a tone sweep from 20 to 200 Hz. while seated.
5) The seat should be comfortable, but not to the extent that it puts you to sleep.

6. Power Quality

a. AC Polarity

Both the wall outlet and the equipment can easily be wired incorrectly for AC. This often results in placing more voltage on the chassis(s), along with placing more noise onto the shields of interconnects. This produces an overall harshness to the sound, a grungy center fill, and a lack of a "black" noise floor, not to mention less-efficient protection. This can be checked with a volt/ohm meter or an AC

polarity tester. Both the wall outlet and each component (while disconnected from other devices) should be checked.

b. Clean, Tight, Large Surface Contacts

Many gremlins can be prevented and many areas of improved performance can be obtained by making the power supply and grounding system as sanitary as possible. The loop from service entry/grounding rod to equipment receptacle and back is a long and complex one, often treated without the respect it deserves.

c. Line Voltage/Frequency/Current/THD/ Harmonics/K-factor/Power factor

The list above is likely just to confirm that your power source is within tolerance. When it is not, it can sound terrible, even though everything else checks out fine. When equipment is run out of specification, it is hard on the electronics, can shorten their life or even cause damage. A common digital multi-meter can tell the basic story, a fancier one is needed for the rest. If suspicious, call the power company to perform a check.

7. Electronic Calibration

a. Electronic equipment signal impedance, signal-to-noise, frequency response, voltage, waveform, etc. should be verified or checked if suspect.

b. Loudspeaker load impedance, frequency response, hum, noise floor, etc. should be verified or checked if suspect.

c. Controller loudspeaker configuration/x-over, level, and delay fine-tuning.

8. Ambient Noise Floor

This is the composite acoustical noise of the environment at any given point in time. It is a measurement with the electrical systems powered up, but not playing a recorded signal. This would mean anything that introduces sound energy into the room that is not part of the recording. Common culprits are: outside noise, footfalls, HVAC, projector fans, etc. (could also include electrical noise like hum, etc. being amplified through the loudspeakers). Such noises cause distractions, mask resolution, and limit dynamic range. Sound blocks, breaks, absorption, and/or isolation must be incorporated along the sound path to alleviate the source(s).

9. Buzzes and Rattles

CAUTION: Perform the following with common sense. Avoid hearing, amplifier, and loudspeaker damage. While playing a slow-frequency sweep from about 20 Hz to 1 kHz at reference levels, listen for any noises that come from the room and not the loudspeakers. This can be from the structure itself, furnishings, or knick-knacks that resonate with a particular frequency. Do your best to eliminate it. Now sweep again, this time from 20 Hz to 10 kHz, while listening to each loudspeaker for rubbing or buzzing noises. Often a little tightening of the loudspeaker fasteners is all that's needed.

10. Room Symmetry

Room symmetry, especially in the horizontal plane (left side vs. right side), is important to the time, energy, and frequency domains. When the shape of the room or furnishings is different acoustically to the right ear than the left, the recorded signals arrive at the ears altered differently.

11. Reverberation Times

Lingering sound energy will cover up low-level details, lower the dynamic range, smear spatial cues and tonality, and reduce articulation. Ideally, the reverberation times are within a window of about 0.24 to 0.35 seconds, from about 125 Hz on up, increasing slightly below 125 Hz. Uniform reverberation times are difficult to achieve and highly sought after.

12. First Order Reflections

Attenuating the first order reflections so that they are a good 15 dB below the direct signal will help tremendously with timbre and spatial acuity. This can be done with absorption or diffusion at their points. Keep in mind that each loudspeaker most likely has six first reflections, therefore, it is easy to over-absorb, resulting in reverberation times, which are unnaturally short in the mid and high frequencies.

13. Shell Resonances Damping

Loudspeaker manufacturers do all they can to reduce driver and cabinet resonances from distorting the recorded signal. Your room's construction materials and methods can contribute a large amount of unwanted sound energy back into the room. For example: lightly hit a stud wall with your fist and it will sound like a drum, due to the membrane over an air chamber. Whenever you play a recording with that particular frequency (most everything), the sympathetic cavity will capture it, hold it, and release later in time. This re-radiated energy makes the room sound slow and muddy. Damping unwanted vibrations with a viscoelastic-constraining layer compound will result in a room that starts and stops with the recording, making it sound fast and articulate.

Another form of resonant re-radiation is from sympathetic bar or plate vibrations such as HVAC grills, amplifier heat sinks, drop-screen casings, knick-knacks, etc. Strike them and listen for any ringing. Sometimes a handclap can cause something to sing out and identify itself. Applying suitable damping material in the right area often alleviates the problem.

14. Subwoofer Vibration Isolation

We start again with the low frequencies, this time for two reasons; first because the low frequencies are so important to the believability factor, and second because they transfer the most energy to the structure, which can be disturbing to others outside the room, as well as those within, as the vibrations couple to the floor and then couple to the air. This is another example of how your structure behaves as a big, nasty loudspeaker. Isolation is best accomplished by introducing appropriate resilient elements between the floor and the subwoofer to float it. Another means of isolation is to place the subwoofer on top of a rigid platform of which the mass is much greater.

15. Loudspeaker Isolation

The same as above pertains to coupling of floorstanding, on-wall, in-wall, or on-shelf loudspeakers. In addition, loudspeakers in a bookcase can resonate, reflect, and diffract sound energy that distorts the original signal. Isolate it and bring the loudspeaker face out flush or beyond the cabinet face, then fill and brace the cavity or remove the cavity to eliminate resonance.

16. Component Isolation

Certainly turntables are the most susceptible to structure-borne and air-borne vibrations, but all electronics will benefit from being isolated from them. Primarily we are concerned here with motor-induced vibrations, which are structurally transferred to other sensi-

tive equipment. For example, loudspeaker motor system, to floor, to shelf, to turntable. Of course it's not only structure-borne vibrations, which are created in the scenario. There are also airborne vibrations, which impact the turntable/arm/cartridge/stylus system, as well as airborne vibrations that transduce to become structure borne. Turntables are especially vulnerable to footfalls and room modes. Tube electronics, CD, and Blu-ray Disc™/DVD players, etc. will also benefit from vibration isolation in varying degrees.

This is a good place to suggest physical isolation of equipment power transformers from other equipment to prevent stray EMI distortions.

17. Clean and Tight Contacts

It's amazing how much difference clean electrical connections make in the sound. Think microscopically and make sure dust, oil, oxidation, and other contaminants are removed so that connections are as unimpeded as possible. Clean, along with tight, means more contact surface area, which means better electrical transfer. Trace the signal from the wall receptacle to the loudspeakers. Don't forget about tube and phono cartridge pins. There are a lot of contacts, and they should be cleaned and retightened periodically.

18. Power Conditioning/Isolation

Depending on your particular environment, you may need dedicated equipment that filters out RFI. That topic is too big and varied to discuss here. Let's just say that inexpensive RFI/Surge protectors do more harm than good. Clean power will further improve everything from harsh tonality and flat soundstage to poor dynamics and slow transients.

Electrically isolating digital components from analog, and from each other, helps keep the power pure and prevents them from interfering with each other or anything else on the line. This means introducing isolation transformers and/or additional dedicated circuits.

19. Cable Isolation

It is assumed that your interconnects and loudspeaker cables are equivalent in quality to your electronics, which has more to do with broadband impedance matching than anything. Keep cables away from power lines, power cables, and power supplies. When required, cross at a right angle and separate as much as possible.

20. Cable Length Match Left and Right

Again, having much to do with matching impedance across the bandwidth, but also having to do with RFI/EMI. It's a good idea to keep at least the side channels symmetrical. Avoid the possibility of creating an inductor as a result of coiling up excess cable, which can limit current and the upper-frequency response. When required, the bigger the coil (fewer windings), the better, and the less circular the windings, the better.

21. Component Damping (CAUTION: Entering Tweeksville)

a. Tubes—can be very microphonic. Tube-damping rings can help alleviate the problem.

b. Chassis—can ring and transfer vibrations to the PC board. Interior surface-mounted damping tapes can control the resonance.

c. PC boards—can also resonate, causing physical movements of the electrical contacts and components, which can result in noise and blurring of the sonic information. Special damping tapes can mitigate resonance. Careful of manufacturer's warranty.

d. Electrical PC board components—as above.

In Summary:

A. Control physical and electrical noise

B. Optimize physical layout (room, loudspeakers, listener) for bass and imaging

C. Make sure equipment is operating to specification and calibrated

D. Optimize acoustic treatments for room modes, first order reflections and reverberation times

E. Isolate electronics physically and electrically

F. Upgrade equipment as needed

1. As a general rule for upgrading, when all qualities are equal, start with the source and work your way down. The improvements upstream will be of benefit downstream.

Audio playback is always a compromise, and each of us determines how much we want to invest in it. Regardless of price, the integrity of the chain begins with the first link, and in succession, every link in the chain relies upon the one before it. Apply this philosophy to audio and you will always be ahead of the game, rather than behind. Don't waste time and money buying and tweeking if your foundation is built on faults. 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.

Reprinted With Permission By Widescreen Review® The Essential Home Theatre Resource™