

Intrinsic Fidelity Testing

“What’s wrong with conventional listening evaluations?”

Glad you asked. Although the performance of a preamp, line stage, or power amp in your system is of primary interest (at least for now), there are so many variables that such evaluation is difficult, uncertain, and likely to change. These variables include:

1. The rest of your audio system. You might like a low damping factor tube amp because its speaker Z -dependent bass peak compensates a speaker/room bass attenuation. Or you might like your preamp’s HF rolloff because it “tames” the HF edginess and graininess of your CDs.
2. Recordings. Most popular music, and even some classical recordings, have been “produced” with bass rolloff, compression, and various midrange/treble “equalization.” This is because of the infamous “loudness wars”; sales are proportional to dB SPL.
3. LF hearing loss at the usual lower-than-live playback SPL (Fletcher-Munson effect). Together with variable #2, this is a good reason to use (good) tone controls, instead of colored components (expensive tone controls).
4. The uncertainties in evaluating a component. Preconceived notions about what a different or modified component “should” sound like, listening from a different position (moving your head 1° can make over 1dB difference at 10kHz), and relying on memory are notorious in their ability to influence perception.
5. Not having heard live music (especially unamplified acoustic instruments and singers) for too long. How many times have you tweaked your system and been satisfied with it for some time, and then went to a concert and thought, “so this is what it should sound like”?

If, on the other hand, the component in question has the highest possible intrinsic fidelity to its input signal, it might not currently provide the best overall system sound. But when you upgrade other components and/or get better recordings, or upgrade from CDs to SACDs, DVD-As, or vinyl, that component’s superior transparency will become evident.

INTRINSIC FIDELITY TEST

Figure 1 shows the general setup. The input/output levels should be matched to 0.05dB, because wideband differences of 0.2dB are audible. If the component has significant frequency response variations, the best you can do is level match at 1kHz, or some frequency at which the component’s gain is around the 300Hz-3kHz average.

A power amp should be loaded with a reactive network approximating real-world speaker loads. An actual speaker would be best, but it would need to be acoustically isolated (e.g., wrapped in blankets in a large box in another room). Preamps can be load-sensitive, so if the attenuator and listening amp don’t provide a low enough load impedance, add a parallel load resistor. The selection of attenuator pot value can help.

The component should be driven to several dB below clipping if a power amp, or to a representative normal-use

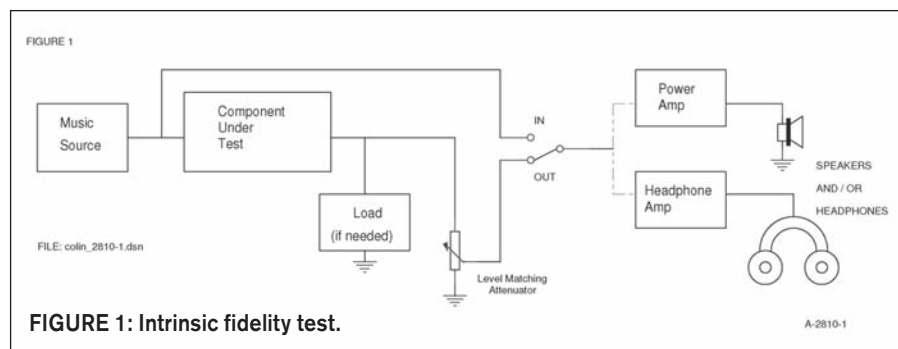
level if a preamp. The component might need input attenuation or gain. Phono preamps can be tested if preceded by a very accurate inverse RIAA network, with the “In” position of the A/B switch coming from the inverse RIAA network’s input.

To ensure near (but not at) clipping level drive for a power amp, an oscilloscope at the output is best. But as a substitute, you can set the power amp’s gain (with its own input attenuator if it has one, or an external one) if you know the source player’s peak output. With CD players, the Red Book full-scale output standard (0dBFS) is 2.00V RMS sine ($\pm 2.83V$ peak). The CD and SACD players I’ve measured (Sony) produce up to $\pm 3.2V$ peak with “hot” recordings.

LISTENING

In this test, any audible difference is undesirable. If the output sounds better than the input, you have the “expensive tone control” effect. (Or, as some ads would have you believe, some magic time-machine circuit that removes recording studio distortion!)

With a very transparent, neutral, and quiet component, you might not hear any difference. If this is so, congratulations! Following are some suggestions for maximizing the sensitivity of the test, while also guarding against the influence of thought processes (when listening for



very subtle effects, thoughts, expectations, and so on can make you believe you hear something that disappears with enough patience, relaxation, and persistent repetition):

1. Use high-quality headphones, which can remove room acoustics, eliminate frequency response changes due to head movements, and have much higher resolution than most speakers. It's good to also listen with your speakers, because a very slight effect heard on high-quality phones could be inaudible in normal speaker listening. And I suppose it's possible that the room-enhanced speaker stereo ambience sound field could be more revealing of subtle spatial effects that the tested component could be producing.
2. Choose the best available recordings. Vinyl, SACD, and the rare DVD-A that uses its full resolution format are the most revealing. Conventional 16/44 CDs just don't have as much resolution and grain-free transparency. However, because in this test it's only differences, not preferences, that we're listening for, even pink noise and electronic impulses can reveal some effects. But the best musical sources will, of course, be the most revealing.
3. Be prepared to spend at least an hour with the A/B switch. I recommend several switching methods:
 - a) listen to an entire musical piece in each switch position.
 - b) switch after the first few seconds of a piece (preferably one that "starts with a bang"), then quickly reset the track to the beginning. Repeat at least 20 times.
 - c) Find a sustained violin ensemble harmony, piano chord, sung note, horn tone, reverb tail, and so on, and rapidly switch back and forth. Listen without thinking about which position the switch is in. It's best to allow all thoughts to evaporate and just enjoy the music. If you notice a difference, that's when it's time to focus. But remember that focusing on one thing excludes others, so after analyzing one perception, "remember to forget" again, and proceed.
4. The following might seem silly, but

it can be revealing: temporarily connect both switch positions to the same point (input or output). Then perfect your acting ability by pretending you're still comparing two different signals. You might be surprised at the influence of the normal music variations, or of head motions if using speakers. If nothing else, this silly exercise can provide a "noise floor calibration" for establishing a limit on reliable and consistent audibility thresholds.

THE EFFECT OF SMALL FREQUENCY RESPONSE VARIATIONS

As I mentioned, 0.2dB variations can be audible. However, they're not necessarily perceived as such. Through a phenomenon that can be called "psychoacoustic mapping," frequency response variations can affect imaging, focus, and spaciousness. Generally, bass/lower midrange emphasis increases perception of space, and treble emphasis increases perception of tonal details and image focus.

A little experimentation with an equal-

izer or tone controls will help you recognize these effects. Then if, say, a preamp appears to improve detail, it could be a simple and mild HF boost. Because this also increases any edginess in the source material, a simple treble tone control could make this preamp's use satisfactory. This sounds obvious, but it serves as an example of the potentially overwhelming number of variables affecting overall sound quality.

POSSIBLE EFFECTS OF THE SWITCH AND ATTENUATOR

1. I mention this in the interest of true science. Remember, "science" doesn't mean just measurements. The term literally means "the open-minded search for truth." I personally don't believe the switch and attenuator (if of good quality) have any perceivable effect, but my mind is open to the possibility.
2. The music signal has already traveled through many resistors, capacitors, attenuators, cables, amplifying devices, and possibly transformers (and switches, connectors, and so on). And

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the recording medium most likely has far more degradation than all of the above components used in recording.

3. If you still think the switch and attenuator could have effects, you can perform an intrinsic fidelity test on them alone (e.g., use a second switch for the "component under test" in Fig. 1). The same applies to cables and connectors. Note: I use Caig "Deoxit Gold G5" (formerly called "Pro Gold") spray on all connections. Using this on a clean tin-plated connector provides a better contact than a dirty gold-plated one!

RESULTS OF SOME TESTS

First, a note on my hearing. For the scientists, my threshold is within 3dB of the standard "good hearing for young people" audiogram. I have a good friend whose threshold is 20dB above (less sensitive than) the standard audiogram, yet he can easily hear the superior resolution of vinyl and SACDs (in that order) over 16/44 CDs. For the audiophile, my hearing has been praised by

Ed Dell and Joe D'Appolito regarding my speaker reviews in *aX*.

I've performed the intrinsic fidelity test on two components so far:

1. "Mad Katy" 250W stereo tube amp (*aX* June/July '06): There were infrequent times when I thought I might have heard a difference, but if so it was on the edge of my perceptibility. Furthermore, very extensive listening made me doubt there was any audible difference.
2. "The LP797 Ultra-Low Distortion Phono Preamp, (Sept. '07 *aX*)" preceded by a stereo pair of very accurate (± 0.03 dB) inverse RIAA networks ("Tweaking the Passive Inverse RIAA Network," *aX* Aug. '07), overall (combined) gain trimmed to ± 0.01 dB at 1kHz. I heard absolutely zero difference. No coloration, distortion, noise, hum, nor loss of spatial or tonal resolution, nor change in dynamics.
3. While not an intrinsic fidelity test, I performed a conventional A/B comparison of the outputs of "Mad Katy" and a 70W per channel solid-state

amp. Using both recorded music and live miked voice and a bell, I easily heard the difference. The tube amp had that natural voice "roundness of tone," and very natural reproduction of the bell's transient "clink" and resonating "clang." (I also compared the reproduced sound on excellent ribbon-tweeter speakers, to the live bell and voice). The solid-state amp, by comparison, made vowel sounds slightly "constricted," and made the bell sound slightly "electronic," instead of like real metal vibrating.

COMMENTS

The following are my personal opinions, based on much observation—but nevertheless they are beliefs, and as such are open to debate. I welcome your (favorable or unfavorable) responses. All I ask is that they are respectful; please don't accuse me of being biased or having tin ears!

1. In the phono preamp test, with no audible difference, the signal traveled through eight caps (two in the inverse RIAA network), many resistors, one JFET, three op amps, and some ordinary (but good quality and clean) RCA cables.

All resistors were 1% metal film (but not "exotic" brands). All caps were metalized polypropylene. All connections were cleaned and sprayed with G5. The unity-gain trimpots (in the inverse RIAA network) were precision 14-turn cermet units.

Because of the no-sonic-difference result (very carefully auditioned for an hour of switching), I conclude that claims of the audibility of (ordinary but good quality) resistors, film caps, wire, and the best op amps are unfounded.

2. I believe that such claims are the result of one or more of these factors:
 - a) The claimants' assertions are based on memory (listening, soldering in a different resistor, and so on, then after many minutes listening again). Memory is notoriously unreliable (ask any courtroom judge), plus you're probably not re-listening in exactly the same position in the room; this strongly influences the frequency response you hear. Also, the SPL is probably not

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matched to the required 0.2dB or better.

- b) The influence of beliefs and expectations. Please don't be insulted; these influences are well known by audiological researchers. There was a story in *Stereophile* of an experienced audiophile who bought a simple wall clock that the manufacturer claimed (if you can believe this) would "purify the AC line from timing imperfections in the whole house!" (and I'll sell you the Golden Gate Bridge for \$10). It was the infamous "Tice Clock."

Anyway, the audiophile installed this clock behind his refrigerator out of sight. After about a month, he told a friend that the clock improved the sound of his very expensive music system—better resolution, less noise, and so on. Then his friend revealed the truth to him: on the day the audiophile installed the clock, the friend secretly unplugged it! The poor audiophile wouldn't speak to his friend for several months!

- c) Here's a factor that's less controversial: Many circuit designs can be overly sensitive to a component's value and its parasitics (e.g., the Effective Series Resistance of a cap). This can be caused by potentially unstable feedback loops, power supply interactions, excessive tube or transistor bias-point changes (with signal amplitude, line voltage, or temperature), RF interference, and so on. Such factors can also make a component overly sensitive to cable capacitance and inductance. You can merely replace a 5" piece of wire, then notice a difference.

But the heat of soldering could permanently change a resistor's value or the leakage of a cap, not to mention the surface leakage of a PC board that had been high due to humidity. If the circuit is overly sensitive to such things, the audible difference would be wrongly attributed to the atomic structure of the replaced wire! (Another factor could be different ground capacitance if the new wire position is different).

3. If you really believe that, say, a 5" piece of wire can make an audible difference, please perform a careful intrinsic fidelity test on it. If you then hear a consistently reliable difference, I'll believe you and not use that kind of wire!

4. I realize that it's possible to have (as an example) ten elements (resistors, wire, and so on) that individually have a degradation that's below audibility, but when combined these degradations (especially if of the same nature and polarity) sum to an audible level. This is, of course, a good reason to use the highest affordable quality parts, at least up to a point.

5. The opposite side of that argument is the extremely revealing nature of a very careful and extensive intrinsic fidelity test. If the differences heard are very small, the component's effect will likely not be audible in normal use.

6. There's some opinion that after listening normally for some time—say several months—you can notice subtle effects that aren't revealed in, say, an hour of even rigorous evaluation. I find this to be untrue; I've listened with some particular components for over a year, and any "accumulated observations" were revealed in that first hour of intrinsic fidelity testing, and with greater sensitivity.

Furthermore, hearing has evolved to be very adaptable in "tuning out" benign anomalies such as small amounts of 2nd harmonic distortion and mild frequency response deviations.

CONCLUSION

Intrinsic fidelity testing serves two purposes: It allows the most sensitive evaluation of an electronic component, free of other (system and source) variables, and it can be very informative about the effects of various circuits, topologies, and parts, on sound quality. *ax*

NOTE

This article was written before, but is now published after, my article "An A/B/I Switch" (June '07). The philosophy of that switch is described here.

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