»**EYE-POPPING 3D**
Toshiba's 3D LCD Delivers Fine Color and Detail »PAGE 54

»**SURFING WEBTV 2.0**
Can Sony and Google Optimize the Web Video Experience? »PAGE 70

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Audio's Next Wave

GoldenEar's Triton Two Speakers Bring You Rich, Balanced Sound, Great Imaging, and Deep, Deep Bass

»PAGE 58

War of the Remotes

Is Your Favorite Controller Obsolete Or on the Cutting Edge?

»PAGES 22 & 92

2 Super Interviews

Exclusive Talks with The Black Crowes' Chris Robinson and Mod/Retro Singer Nellie McKay

»PAGES 28 & 38

Plus

DIY Sound Measurement
Tweak Your System Like a Pro with a Few Basic Tools

»PAGE 34

Visible Value
Epson's Excellent Budget Projector

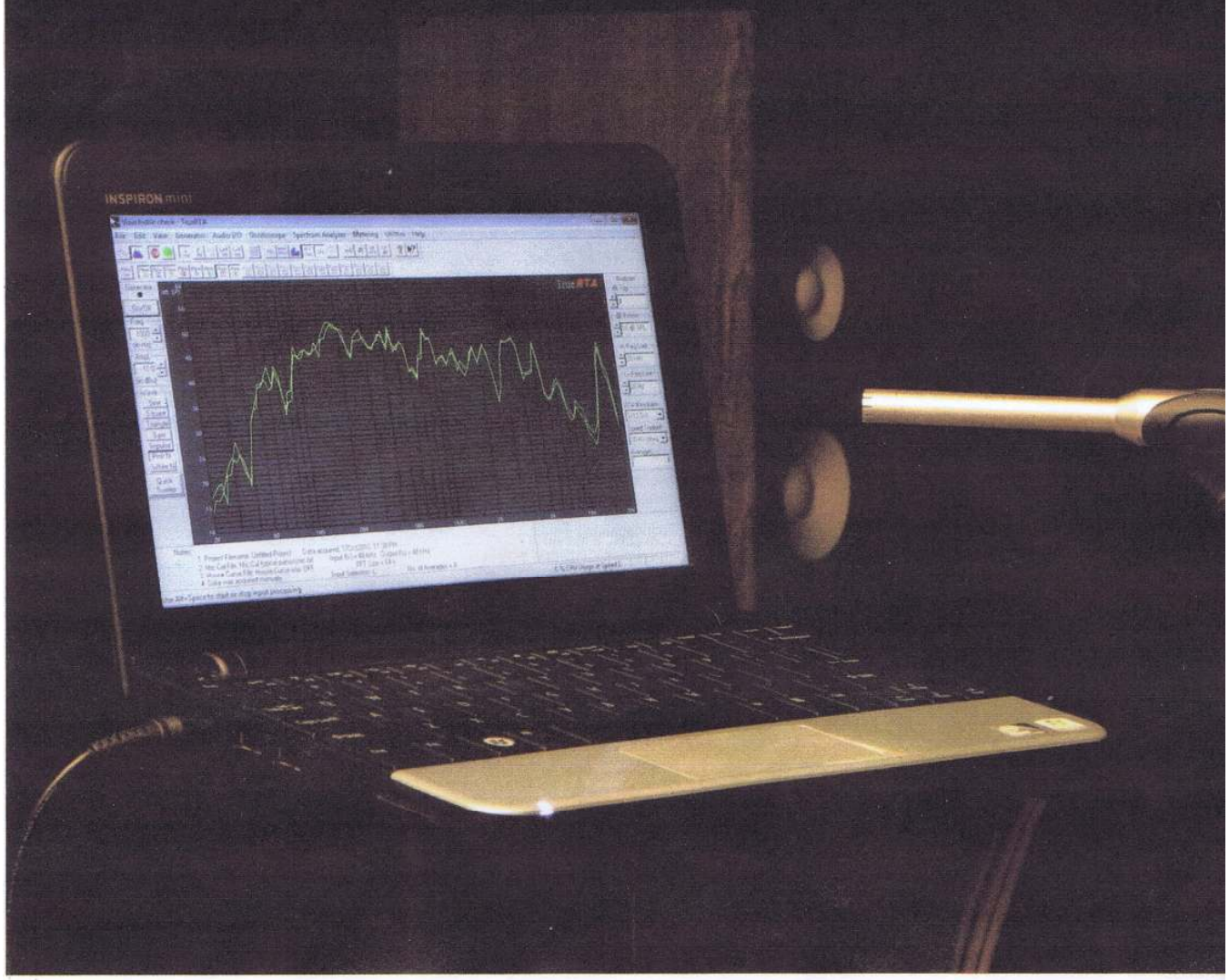
»PAGE 50

JANUARY 2011 Vol. 78 No. 1

DIY Audio Measurement

Tweak your system like a pro using only a few cheap tools.

Story and photos by BRENT BUTTERWORTH



Do you trust your ears? I don't. By that I mean I don't trust my ears. Frankly, though, I don't trust anybody's. I've heard laymen enthuse about systems that had little more to offer than a few notes of booming bass. I've heard audio veterans trash impeccably engineered speakers – and praise speakers that showed glaring technical flaws. I've even caught myself thinking that a speaker had excellent detail when it really just had excessive treble. Or being impressed by a subwoofer's power, only to realize later that it had nothing much to speak of happening below 50 Hz. Of course, we can't enjoy an audio system unless it pleases our senses, so on some level, we have to trust our ears. But there's also value in knowing that your system is performing as it should, that you're getting something close to what the musicians or filmmakers intended. In other words, you want to trust, but verify.

Thanks to the ubiquity of computers and today's ample supply of inexpensive but incontestably impressive electronics, audio enthusiasts can now perform measurements that will confirm (or cast doubt upon) what their ears tell them. Using these measurements, you can find out what your system's doing *and* optimize it.

No, I'm not recommending you don a lab coat and undertake the same sorts of comprehensive product measurements we do here at ***Sound+Vision***. That level of testing is costly, requires specialized knowledge and equipment, and will get you spurned at parties when you tell people what you do. I'm suggesting you test what's most important to you: the sound you hear when you're sitting on your couch. Fortunately, that kind of testing is cheap and relatively easy to pull off, and it requires so little time and effort that no one need know you're geeking out. (Come to think of it, though, the lab coat might make a cool accessory.)

What are we measuring, anyway?

The fundamental goal of a high-quality audio system is to replicate the audio signal that comes into it. To do this, the system must have a flat frequency response — in other words, it must respond to all frequencies of sound equally instead of boosting certain frequencies at the expense of others. Using measurement gear, we can find out quickly and precisely if the sound that arrives at your ears is reasonably similar to the original signal.

For the purposes of this article, we're going to focus on measuring bass response. The acoustics of most rooms will mangle the output of a subwoofer or a full-range speaker, turning a theoretically smooth frequency response into a graph that looks like the Grand Tetons. By measuring, we can find out which frequencies your room is treating unfairly. You can then move your subwoofer or speakers, adjust your subwoofer crossover, add more subwoofers, or add an equalizer, then run the measurement again to see if you fixed the problem.

Measurements are less valuable at frequencies above 200 Hz or so, because the response of an audio system in a room tends to be much smoother at these frequencies. However, you will be able to see if your system is severely boosting or cutting midrange and treble (reason, perhaps, to upgrade your speakers), and you'll also be able to confirm that all your speaker drivers are operating properly.

Assembling Your Toolkit

The basic tools of an audio system evaluation kit are a measurement microphone and a computer running audio measurement software. The trick is, the frequency response of your measurement system has to be flat. If you use, say, a typical vocal mike with a "presence peak" at 2 kHz, you'll think your system has a bump at 2 kHz when it doesn't.

Fortunately, there's now a pretty good measurement mike that costs less than many special-edition Blu-ray Discs: the Dayton Audio EMM-6. The Web site partsexpress.com sells it for about $50. You can also find an almost identical mike, the Behringer ECM-8000, for about the same price. You'll need a stand for the mike, too; a $25 cheapie will suffice.

The response of the EMM-6/ECM-8000 is almost perfectly flat, marred only by a few slight dips of –1 dB or less. Computer software can easily compensate for these minor errors by applying a reverse correction curve that nulls out the flaws generic to the EMM-6/ECM-8000. However, even different samples of the same microphone vary slightly, so if you want to get absolutely perfect measurements, use a calibrated mike instead. A calibrated mike has been individually tested, and comes supplied with correction data that can be plugged into a computer so its corrected response is dead flat. Partsexpress.com offers a free, downloadable calibration file with each EMM-6, and you can also purchase calibrated EMM-6 and ECM-8000 mikes from cross-spectrum.com.

The EMM-6 and ECM-8000 require phantom power: a separate DC supply that sends voltage up the cable to power the mike's internal preamp. Fortunately, there's a phantom power supply with a street price of about $20: Nady's SMPS-1X. You can also use a mike preamp with phantom power, but make sure it's a straightforward design with flat frequency response, such as the Rolls MP-13 or the ART USB Dual Pre. (You can measure the response of a mike preamp using RightMark Audio Analyzer, a free software package available at rightmark.org.)

A laptop computer is your best bet for audio measurements: It's quiet, it's portable, and it has a built-in display. You can get audio measurement software for a Mac, but there's a much better selection of PC software for low-cost scientific/engineering applications. Almost any PC laptop will do, even a $300 netbook. And just as this was going

to press, I found an iPhone-based hardware/software app that will also work — for more info, search soundandvisionmag.com for "StudioSix Digital."

While lots of audio measurement software applications exist for the PC, the one that seems to have captured the hearts of engineers and enthusiasts is True RTA, available at trueaudio.com. Most speaker engineers I know keep a copy on their computers.

As its name implies, True RTA is a real-time analyzer, sometimes referred to as an audio spectrum analyzer. Through a connected microphone, it "listens" to the sound your system is producing and then shows you the level of sound at each of numerous frequencies. True RTA also includes a test-tone generator, which produces pink noise, sine waves, etc., using your computer's sound card. The idea is that True RTA spits out the test tone through a cable connected from the computer to your system, listens to the result through the microphone, and shows you graphically how your system is altering the sound of that tone.

You can download a free copy of True RTA, but the resolution of the free version is only 1 octave, so instead of getting 12 or 24 discrete bars between, say, 40 and 80 Hz, you just get one bar that tells you the total energy in that band. The 1/6-octave version of True RTA ($69.95) is adequate for the measurements you'll be making, but the 1/24-octave version ($99.95) is a worthwhile step up.

To set up your system for measurement, connect the mike to its power supply or preamp, connect the power supply/preamp to your computer's mike input (or its USB port if you're using the ART USB Dual Pre), and connect your computer's headphone output to your audio system. Obviously, you'll need adapters to make these connections.

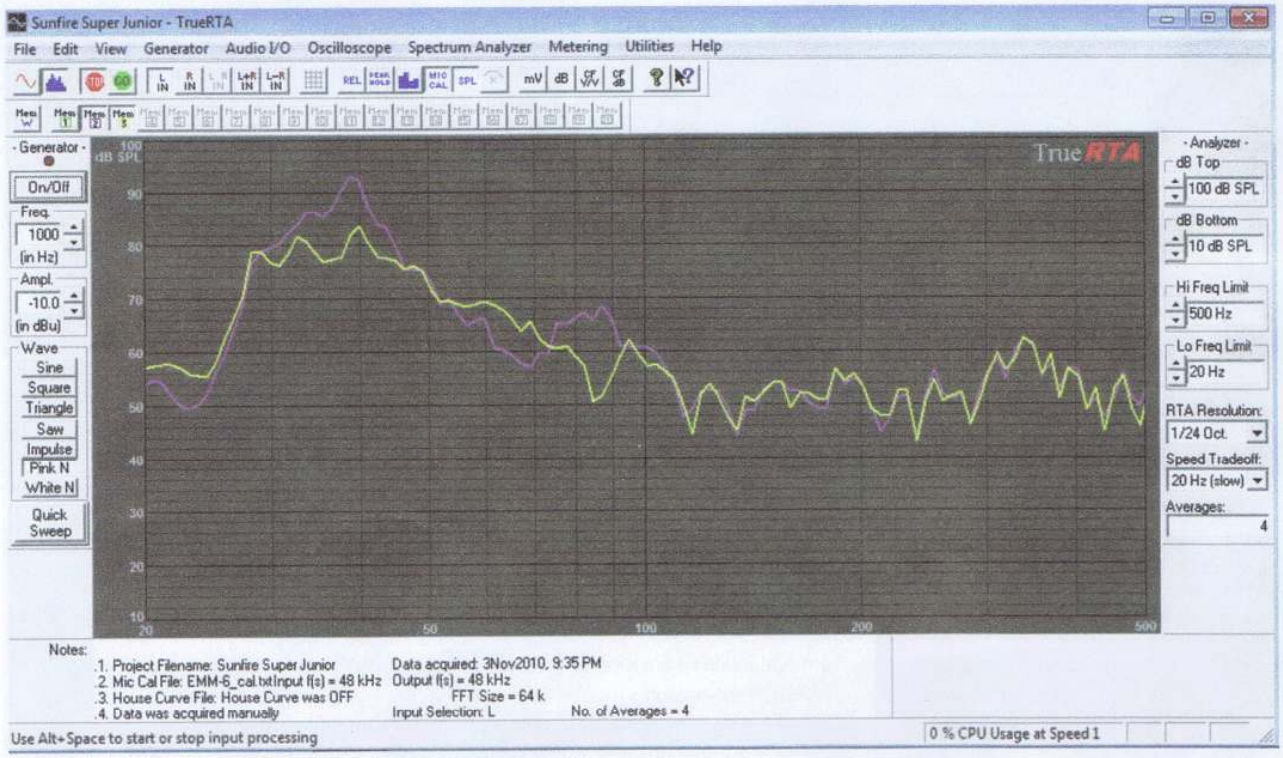
When you run your measurements, be sure to have all your speakers running, not just the subwoofer. This way, you'll include the bass produced by your main speakers, and you'll be able to gauge the effects of the subwoofer crossover in your receiver or preamp/processor.

Making Weird Noises

The first decision you have to make when measuring your audio system is: Do you care about the quality of the sound your entire family hears, or do you only care about the sound *you* hear? While the latter stance might seem selfish, it's simpler because you only have to make measurements from your favorite seat. If you want to make the sound good in *every* seat, you'll have to run a measurement in every seat, then average the measurements.

There's no need for me to detail True RTA's operation when you can read about it in the User's Guide. I will warn you, though, that before using it, you have to load a microphone calibration file — either the one that came with your mike or the generic ECM-8000 file provided with the software. You also have to calibrate True RTA to cancel out any flaws in your computer's internal sound card. Both steps take only seconds.

You may also want to calibrate True RTA's sound-pressure level (SPL) reading. SPL isn't critical here, because you only care how



See the Sound

True RTA lets you see which frequencies in your room are giving you problems. If you see unevenness below 80 Hz, you can fix it by moving your subwoofer, moving your listening chair, or using an equalizer. Then measure again and compare.

Pro Tools

A measurement mike is a key component of any audio test toolkit. You can score Dayton Audio's EMM-6 for $50 from partsexpress.com. It also sells an almost identical mike, the Behringer ECM-8000, for about the same price.

loud one frequency is relative to another, not how loud they are on an absolute basis. However, if you want to get the SPL readings in the ballpark, just play a test tone, place a RadioShack or other brand SPL meter next to the measurement mike, and enter the SPL reading in decibels into True RTA.

The basic procedure for one-seat measurement is simple. Position the microphone so that it's in the same place your head would be when you're seated. Select the pink noise generator in TrueRTA, then click the On/Off button. You should hear noise coming from the speakers. Now click the Go button to activate the analyzer. Hit the Stop button and you'll see the frequency response for your system. Save the graph by going to View/Save to Memory. If you're focusing on bass, turn the high-frequency limit for the graph down to 500 Hz. You can now see which bass frequencies are giving you problems. (Using True RTA's Quick Sweep feature is easier than using pink noise, but I find it unreliable.)

If you see unevenness below 80 Hz or so, try to fix it by moving your subwoofer, moving your listening chair, or using an equalizer such as the SVSound AS-EQ1, the Velodyne SMS-1, or the Behringer Feedback Destroyer. If you see unevenness at your subwoofer crossover point (typically 80 Hz), try reversing the phase on your subwoofer or selecting a different crossover point if your receiver offers that capability.

After you've made your correction, run the measurement again. You can now see how the new measurement compares to the original. Keep experimenting until you get the smoothest possible bass response.

With just a little bit of work, you may achieve truly astonishing results. Instead of bass that sounds like the indistinct, annoying boom of a hopped-up Honda Civic passing by, you'll get the same realistic, accurate, tight bass heard in the best movie theaters and recording-studio control rooms. And all for a couple hundred dollars — plus another $25 or so if you opt for the lab coat. SV

partsexpress.com
rightmark.org
cross-spectrum.com
trueaudio.com