Introduction

Over the past three decades, professional audio engineers have sought better and better tools for optimizing sound systems in response to ever-increasing awareness and expectations of sound quality from both audiences and customers. Beginning with simple real-time spectrum analyzers (RTAs) used with a pink noise source, system designers and engineers have employed response analysis to examine the inner workings of audio systems in the ongoing quest for optimization.

RTA analysis, however, is severely limited by its inability to provide time and phase response information — critical elements for loudspeaker and system alignment. More powerful dual-channel analyzers that *can* provide this critical information (by directly comparing the output of a system to its input) have existed for some time. Until recently though, dual-channel analyzers were simply not accessible to the mainstream audio professional due to their high cost. Then, in the mid-nineties, standard PC computers reached a point where they had the computational power to run *software-based* implementations of dual-channel FFT-based audio analyzers. Put simply, we could now do on our lap-top computers what was once the sole domain of prohibitively expensive and often physically cumbersome analyzers.

SIA Software Company began developing SIA-Smaart in 1995 to provide sound system contractors, acoustical consultants and audio professionals with an accurate and practical sound system optimization and analysis tool. SIA-Smaart 1.0, originally distributed by JBL Professional as JBL-Smaart, was first released as a commercial software product in 1996 and immediately established itself as a powerful and accessible tool for the audio professional. Since its debut, SIA has maintained continuous development program for Smaart. Throughout its development, SIA has added powerful features and measurement functionality to Smaart with each revision that directly reflected the input of its substantial user base.

SmaartLive 4.0 represents the next step in the evolution of the Smaart Real-Time module. Propelled by the desire to refine and redesign Smaart's user interface, SmaartLive features intuitive, user-friendly navigation that allows for both an easier initial learning curve as well as more streamlined, efficient expert operation. Coupled with this new interface, SIA has extensively overhauled the program's underlying analysis engine to provide dramatic improvements in the speed and ballistics of real-time measurements. We hope you will agree that SmaartLive represents yet another quantum leap forward in both usability and power of a product that has become the tool of choice for professional sound system optimization and control worldwide.

Smaart FAQs (Frequently Asked Questions)

Q: What are some of the most important capabilities of SIA SmaartLive?

SIA SmaartLive offers the functionality of a dual-FFT real-time transfer function analyzer as well as a standard FFT-based real-time spectrum analyzer (RTA) entirely implemented in software. The Transfer Function display provides a frequency-domain comparison of two signals yielding precise frequency (magnitude and phase) response for the device or system under test in real-time. This is an extremely powerful tool for assessing the performance of an entire sound system, a specific part of a system, or a single system component. Additionally, this dual-channel measurement technique is "stimulus-independent," meaning that it works with a wide variety of signal types, including music as a test signal.

Utilizing another variant of the dual-channel transfer function technique SmaartLive can produce very precise and repeatable impulse response measurements, useful for acoustical analysis, and measure delay times with resolution approaching 2/100 milliseconds. This high degree of precision makes SmaartLive an excellent tool for aligning multi-driver loudspeaker systems, loudspeaker arrays, and distributed sound systems. Impulse response measurements in SmaartLive can be stored as a standard Windows wave file making the data fully compatible with Smaart Acoustic Tools.

In addition to it's time- and frequency-domain measurement capabilities SmaartLive can also be used remotely control a growing list of third-party equalizers, system processors, and other devices. This capability greatly streamlines the process of sound system setup and optimization by allowing you to measure, analyze and control sound system performance and parameters from a single application.

Q: What are some of the important capabilities of SIA Smaart AcousticTools?

The Smaart Acoustic Tools package consists of two application modules; Analysis and Intelligibility. Below are some of the most important features of each program.

The Analysis Module:

The Smaart Analysis module reads audio data stored in any standard Windows wave (*.wav) file including impulse response files recorded in the Intelligibility module or SmaartLive. The Analysis module can open one or two wave files at a time and can transform time-domain data in the wave file(s) into its frequency domain representation, using a series of Fast Fourier Transform (FFT) calculations. Both time and frequency characteristics of recorded signals can then be displayed, compared and analyzed a number of ways.

The Analysis module is primarily designed for use in analyzing impulse response data and includes tools to help you find reflections, reverberation and decay information and early-to-late energy ratios. Other possible uses for this program include speech analysis or any application where you need to analyze the time and frequency characteristics of recorded signals.

The Intelligibility Module:

Like the Analysis module, the Smaart Intelligibility module is primarily designed for analyzing impulse response data. As the name implies, the Intelligibility module allows you to calculate several objective measures of speech intelligibility including %ALCons, Clarity, STI and RSTI, and several quantitative acoustical values, all from a single impulse response measurement. The program includes an internal impulse response recorder that can measure the impulse response of a room/system using either a Maximum Length Sequence (MLS) technique or the same dual-channel transfer function technique used in SmaartLive to measure delay times.

The Intelligibility module also uses a standard Windows wave file as its native data file format, allowing you to analyze data acquired through SmaartLive or virtually any other source. Unlike the Analysis module, the Intelligibility module operates entirely in the time domain. In addition to the standard time vs. amplitude display, the program can display the result of Schroeder Reverse Time Integration and Energy Time Curve (ETC) calculations based on the same wave file data. The Intelligibility module can also filter and display the raw time-domain wave file data in octave and 1/3-octave passbands "on the fly" and can write filtered data to new wave files for use in other applications.

Q: Can you really make accurate measurements using off-the-shelf and/or built-in computer sound hardware?

Yes! There are two main reasons for this. The first is that SIA-Smaart uses only the Analog-to-Digital section of the computer's sound hardware. The 16-bit A/D converters used in even inexpensive and/or built-in computer sound hardware today are really better than you might imagine in most cases. The second reason has to do with the nature of the dual-FFT transfer function measurement technique used for both real-time frequency response (SmaartLive) and impulse response/delay measurements (SmaartLive and Smaart Acoustic Tools).

Because both the reference (stimulus) and measurement (system response) signals in a dual-channel transfer function measurement travel through the same components as they enter the measurement system (the computer) and the object of this exercise is to find the *difference* between the two signals, many imperfections in the computer's audio input section will tend to "cancel out" of the measurement almost entirely. We have performed a number of head-to-head tests comparing our software (using off-the-shelf sound hardware) with precision audio analyzers and dedicated hardware/software measurement systems costing tens of thousands of dollars. In every case, the differences in measured results have been extremely small across the entire audio spectrum.

Notes:
We do recommend that you use only the Line level inputs on off-the shelf computer hardware. The analog preamp circuitry used on the microphone inputs rarely approaches the quality needed for professional measurement applications.

It should be noted that the MLS measurement option in the Intelligibility module (included in Smaart Acoustic Tools, see above) may tend *not* to be as forgiving of the computer's audio section as the dual-channel transfer function technique. When using a single-channel (stimulus-dependent) measurement technique such as MLS, it is unavoidable that part of what you end up measuring is the measurement system itself and it becomes much more vital that both the input and output stages be as clean and transparent as possible.

Q: What external hardware do SmaartLive and AcousticTools require?

To use SmaartLive effectively and/or perform impulse response measurements using Smaart Acoustic Tools, you will probably need a few pieces of outboard equipment. A typical Smaart measurement will include some combination of the following:

1) A measurement microphone. This should be a high-quality omnidirectional with very flat response across the audio spectrum — or at least across the frequency range you need to measure. There are a number of microphones available from Earthworks, Josephson, ACO Pacific and others in the $400 - $500 (USD) price range that are excellent for use with Smaart. And depending on your application, you might be able to get along with an even less expensive microphone. For example, you may not necessarily need a microphone that is flat all the way to 20kHz if the system you want to measure only goes up to 15kHz. If you have a high-quality SPL meter available with an audio (AC) output, this can also work well as a measurement microphone.

2) A small mixer of some kind is typically used to provide level control to the computer, and preamplification and phantom power for the microphone(s) in a Smaart measurement system. Using a mixer will also allow you to switch between multiple measurement points in a system easily without repatching cables. We recommend that you look for a mixer with channel mute switches so that once the input levels from various sources have been matched, you can simply turn the signals on and off when switching between measurement points.

3) A signal source. An internal signal generator is provided in both SmaartLive and the Intelligibility module in Smaart Acoustic Tools. Note, however, that the computer can only be used as a signal source if the sound hardware is capable of full-duplex operation (playing and recording simultaneously) and it may still be desirable to have an external signal source available in many cases. The best value for an external signal source is probably a portable CD player and a reference disk with a pink noise track. You may also want to invest in (or build) an inexpensive pink noise generator. You may want to have a CD player on hand in any case as this will allow you to use music for the final stages of setting up a system with SmaartLive. When selecting a CD player try to find a model with a repeat function so that you can play specific tracks more or less continually.

4) Y cables and adapters. These are used for patching the measurement system into various points in the signal path of a sound system — typically across system EQs. Using Y-cables to split the signal allows you to take the output from a number of points along the signal chain without interrupting the operation of the system while you re-patch cables and to "A/B" between various measurement points easily.

Q: Can SmaartLive compensate for irregularities in the frequency response of inexpensive measurement microphones?

The short answer is "no." We recommend that you use a very flat, well-behaved, omnidirectional microphone when performing measurements with Smaart Pro. There are several on the market for under $500 (USD).

The long answer is that while it would be a fairly easy to do simple magnitude compensation for single-channel RTA mode measurements, attempts to compensate for microphone response in more complex operations (such as real-time Transfer Function and impulse/delay measurements) would almost certainly introduce more errors than were "corrected." The reason for this is that the "dips and peaks" in the frequency response of lesser quality microphones vary widely with angle (pitch and yaw) and are the result of frequency dependent delays (i.e., phase response problems). To correct for this would require complete complex spherical response data for each microphone on a unit-by-unit basis. And even if the necessary data were available, the sheer number of calculations you would need to perform in real time would require much more processing power than PCs can now provide.

Q: Do SmaartLive and AcousticTools generate any kind of stimulus signal?

Yes. SmaartLive module can generate pink noise, variable-frequency single and dual sine wave signals, and can loop any standard wave file continuously, allowing users to create their own test signals. The Intelligibility module in Smaart Acoustic Tools provides a pink noise generator for use in dual-FFT impulse response measurements and an MLS generator for MLS measurements. Note that to use the computer as a signal source for measurements, your sound hardware must be capable of full-duplex operation (playing and recording simultaneously).

Keep in mind, that SmaartLive is a stimulus-independent measurement system and allows you to make measurements using a wide variety of test signals. Use of the internal signal generator is entirely optional and depending on your measurement application, you may still want to keep an external signal source such as a CD player on hand. For sound system optimization, particularly in the final stages of system setup when qualitative judgements are required, it is often desirable to use recognizable program material (e.g., music) as a test signal, thereby making your own ears part of your measurement system (as they always should be). The dual-FFT transfer function impulse measurement option in the Intelligibility module is also stimulus-independent however pink noise is typically the test signal of choice for most acoustic measurement applications.

Q: What types of test signals do you recommend for measurements?

Most measurements in both SmaartLive and Smaart AcousticTools are stimulus-independent and will work with a wide variety of internally or externally generated test signals. The exception is that MLS measurements in the Smaart Acoustic Tools Intelligibility module require the use of the program's internal MLS signal generator.

Pink noise is often the best choice for a test signal in the initial stages of setting up a sound system and/or for capturing a room impulse response for acoustical analysis. Using random noise helps to ensure that you have sufficient energy at all frequencies to make solid measurements. For the later stages of system optimization with SmaartLive, using music as a test signal allows you to make qualitative judgments as you make final adjustments to system EQs and crossover filters.

Q: Is there an upgrade path to SIA SmaartLive for Smaart 1.x and Smaart Pro (version 2.x and 3.x) users?

Yes. Registered users of Smaart Pro 3.x can purchase the upgrade version of SIA SmaartLive 4 for USD $245 + shipping, handling and any applicable local taxes or duties. The upgrade version requires you to have the installation disks for a previous version or to have a valid copy actually installed and working on your computer prior to installation. Registered users of SIA-Smaart Pro 2.x and JBL-Smaart 1.x can purchase the standard version of SmaartLive at a discount. The prices are $395 for a Smaart Pro 2.x user or $445 if you own Smaart 1.x.

Q: What type of computer do I need to run SmaartLive or Smaart AcousticTools?

Both Smaart Acoustic Tools and SmaartLive require a computer running Windows 95, 98, 2000 or Windows NT 4.0 (or higher). SmaartLive and the impulse response recorder in the Acoustic Tools Intelligibility module require 100% Windows-compatible sound hardware capable of 16- to 24-bit sampling resolution, 44.1k or 48k sampling rate. A stereo line level input should also be considered an _absolute requirement_ for both packages.

To utilize the internal signal generators in SmaartLive or the Intelligibility module, the computer's sound hardware must be capable of full-duplex operation (playing and recording simultaneously). Note however that the use internally generated signals is actually _required_ only for MLS measurements in the Intelligibility module.

In terms of processing power, SmaartLive is generally more demanding than Acoustic Tools. For SmaartLive we recommend a 166-233 MHz Pentium, Pentium MMX, or equivalent CPU as a practical minimum. SmaartLive will run on slower computers however you will probably not be satisfied with its performance. The user interface tends to become unresponsive on slower machines and the program will provide less frequent display updates. When considering a new computer for use with SmaartLive, a 300 MHz (or faster) Pentium II, Celeron, Pentium III, or equivalent is strongly recommended. 32 MB of physical RAM should be considered an absolute minimum and we strongly recommend 64Mb or more. The minimum display resolution supported in SmaartLive 4 is 800 x 600. Smaart Acoustic Tools supports 640 x 480 or higher.

Please note that SIA does not recommend or endorse specific computer models for use with Smaart software products.

Q: Do SmaartLive and Smaart AcousticTools run on a laptop computer?

Yes. SIA SmaartLive and Smaart AcousticTools run on any computer that satisfies the minimum hardware requirements (see above). Most notebook computers have 16-bit stereo sound hardware built in and this type of sound hardware has proven to be very acceptable for all but the most critical measurement applications. The one caveat is that *a stereo line level input is an absolute requirement*. If your computer lacks sound hardware or a line level input, there are PCMCIA sound cards and USB audio interface devices on the market that allow you to add or upgrade notebook audio I/O capabilities. When shopping for a new computer though, we strongly recommend holding out for a model with a built-in line input. Even if you already plan on upgrading the computer's audio I/O with a PCMCIA or USB device, it's nice to have access to the internal sound hardware as a back-up.

Q: What about technical support?

SIA is committed to providing the best technical support possible. Support for SIA software products is available through our web site, by e-mail or by telephone. On the SIA web site (www.siasoft.com), you can find Application Notes, Case Studies and answers to frequently asked questions as well as product news, updates, and an on-line web support forum. Maintenance updates, and information of interest to Smaart users is posted on the web site as it becomes available. For technical support via e-mail, the address is support@siasoft.com. The telephone number for SIA technical support (in the USA) is (+) 1-508 234-9877.

Q: How can I purchase SIA Software Products?

Thanks for asking! You can order SIA SmaartLive and Smaart AcousticTools directly from SIA via telephone or secure e-commerce web site at **www.SIAsoft.com**. We accept VISA, MasterCard, and American Express cards and can usually ship within one business day to anywhere in the world. The SIA online web store can be found **www.siasales.com**.

Our toll-free order number for the USA and Canada is **1-877-SMAART3** (**1-877-762-2783**). If you are calling from outside the USA and Canada or have questions about our products, call   (+) **1-508 234-9877.**

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