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The Sound Designer's Springboard

by Pat Brown

A Quick, Accurate Method for Measuring Room Acoustics

One way to make computerized room models more accurate is to "tweak" them using measured data. This requires octave-band reverberation times which are easily extracted from the room impulse response that can (should) be gathered during the site survey.

One of the main obstacles to performing acoustic measurements as part of a site survey is the time and complexity involved in the setup. Let's face it, unless you're recording balloon bursts or starter's pistols, it can take a lot of stuff to make impulse response measurements of spaces. This can discourage data collection in general and is one reason why many acousticians have preferred recording impulsive sources instead of performing transfer function measurements.

But it doesn't have to be that way. It is possible to get high resolution, low noise measurements with less time on-site than that required to record pop balloons. It involves a combination of simple, off-the-shelf tools that will all fit nicely into a Pelican™ case. If you are interested, read on.

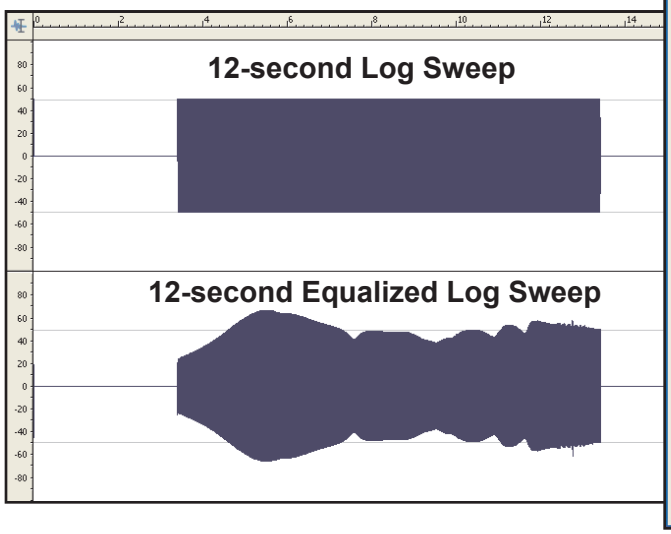
Simpler, Faster

Here is a way to dramatically simplify and speed-up the system setup for measuring IRs. The investigator only needs to make a recording of a test sweep played into the space. GratisVolver™ (www.catt.se) is used to process the recording to recover the impulse. We have covered this in previous articles, but I will provide a short review here. The big speed increase comes from the use of a powered loudspeaker to stimulate the room. Powered loudspeakers abound, but it is especially useful to have one that runs on batteries and incorporates a CD player. The device described in this article is the Lightspeed Delta X10, but the principles can be applied to any similar unit or group of components. This unit even has an internal wireless receiver!

The Default Configuration

The internal loudspeaker configuration is two-way with 10-inch LF and a small, broad dispersion HF (Figure 2). This default configuration is ideal because it allows

Figure 1 - The sweep stimulus can be pre-equalized to produce the desired response when played back over the powered loudspeaker.



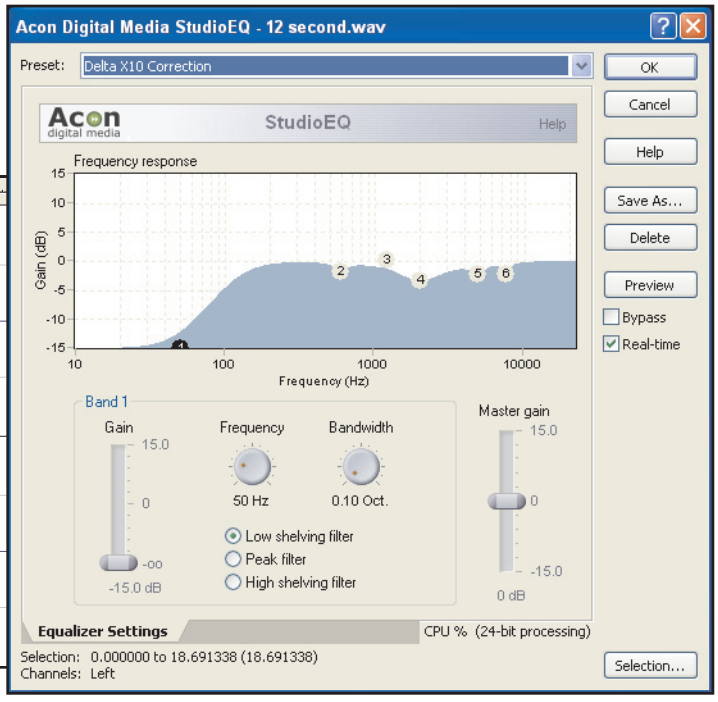


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Figure 2 - The Lightspeed Delta X10 is a self-contained two-way powered loudspeaker. An internal battery provides ample time for a whole room survey. CD player (for stimulus) and wireless receiver are also available.

the direct-to-reverberant ratio for a medium directivity device to be established. The use of a moderate directivity source for room testing is a very good place to start. Higher or lower directivity tests can also be performed by substituting other loudspeakers using the switched external loudspeaker jack on the back of the X10. The internal electronics can then be used to drive a "talker" loudspeaker or a dodecahedron.

Signal Processing

It may be desirous to equalize the direct field to a flat axial frequency response or flat power response, depending on what is being investigated. Powered loudspeakers do not typically provide an option for high resolution equalization, but there is a simple, accurate way to have it anyway. Since we are using a well-defined logarithmic sine sweep as stimulus, and the internal CD player as the source, the stimulus can be pre-equalized in a wave editor to produce the desired response. Figure 1 shows the raw test stimulus along with one modified to produce flat axial response for the direct field. An appropriate stimulus file can be created for each source that you wish to use. The Direct-X plug-in parametric equalizer is from Acon Digital Media.

Other Sources

The investigator may wish to use other directivities during the site survey, such as a "talker" loudspeaker or an "omni" dodecahedron (Figure 3). The X10 provides a switched external loudspeaker jack that bypasses the internal loudspeakers when a tip-sleeve jack is plugged in. I typically use a Meyer MM4 for a talker loudspeaker and a dodec as an omni for reverberation testing. A test CD was created and includes sweep tracks pre-equalized for each of these devices. The user simply connects the desired loudspeaker and selects the appropriate track.

Microphones

The most often-asked question is "What mic should I use, and where should I put it?" I use three different microphones for site surveys. All three are stereo, which is important since two-channel measurements preserve the room ambiance and source localization in the recorded files. The first thing that comes to mind

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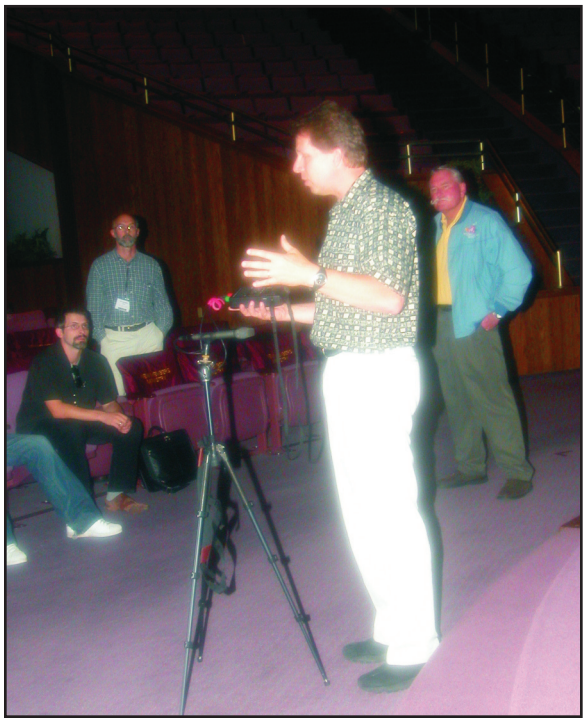
Figure 3 - An omni and talker loudspeaker can be used to assess the effects of different directivities on the IR. They connect to the external speaker jack on the X10, and the appropriate equalized sweep file is selected for playback.

with microphone selection is the question of *accuracy*. It should be remembered that any stereo or binaural recording is inherently inaccurate, since there exists no "gold standard" for stereo mics. We are only after a representation of what the space sounds like, and a variety of 2-channel microphones are available that are up to the task. Here is a brief description of the ones in my tool bag.

1. *On-Ear mics* - These are Countryman B6 condenser mics mounted on foam ear-canal inserts (Figure 5). This "poor man's dummy head" encodes the recordings with the transfer function of the outer ear and torso reflections. It is the most "human like" of the mics.



2. *Stereo stand-mounted* - Sometimes it is not practical to use the On-Ear mics, so I keep a stand-mounted stereo mic in the bag. The Audio-Technica AT825 is pictured (Figure 6) and is ideal due to it's integral high-pass filter, integral windscreen and small form-factor.

3. *Stereo boundary* - Here's one you may not have considered. If you are measuring room decay times, stand-mount mics are great. If you wish to get an accurate look at the loudspeaker's direct field, the floor bounce will be a problem. For room's with hard, flat floors (i.e. gymnasiums, convention centers) a boundary placement can be used to remove the floor bounce, which would otherwise produce severe coloration of the direct field. Most stereo microphones are physically too large to get close enough to the boundary at high frequencies. The Audio-Technica AT849 allows two-channel recordings to be made on a boundary (Figure 7). This eliminates the interfering effects of the boundary while preserving the localization properties of the loudspeaker. The mic is small and can easily be moved about the space to the desired location. The whole measurement session goes faster since there is no stand to position.

One additional mic you may consider is a simple omni. I consider these more useful for loudspeaker measurements than room surveys, but you never know what you may have to do while you are at a facility. For that reason my Earthworks M30 is also in the bag.

Whichever mic you use, a portable recorder will be required. The Marantz PMD660 is small, light, and runs for hours on 4 AA batteries (Figure 8). It has XL input jacks and 48V phantom power.

On with the Testing

Once the parts and pieces of this setup are assembled, IR testing is very fast and very accurate. Our recent Sound System Design class took a short field trip to Southeast Christian Church. We used the occasion to gather some IRs of the main sanctuary and outer lobby (Figure 4). Six measurement positions were used, and all data was gathered without a single connection to any wiring at the facility (not even AC!). Since a portable recorder is used, the investigator is free to roam the room and select any desired measurement position.

Figure 4 - Preparing for a measurement using a stand-mount stereo mic and compact flash recorder.

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The Supporting Cast...


Fig. 5 - These mics fit in the ear canal.


Fig. 6 - A stand-mount stereo mic.


Fig. 7 - A stereo boundary mic for flat floors.


Fig. 8 - A flash recorder rounds out the field.

Enhanced Stimulus Wave File

The stimuli included with GratisVolver include a 12 second and 24 second log sweep. One of these must be played into the room and recorded. An advantage of Wave file stimuli is that you can add some additional useful information to the sweeps. I have added a short speech track prior to the sweep, and a low level music track afterward (Figure 9). The speech track accomplishes two things:

1. It lets me know that the sweep is about to start.
2. It provides a recorded reference to which convolutions made with the extracted IR can be compared.

The musical passage allows time for the microphone to be moved to the next test position. This makes it unnecessary to return to the CD player between test positions - just let it play and move from point to point for recordings. You can either make one long wave file or break it into a file for each test position. The silence in the wave file can be used to document the noise floor of the space (a future article). See the following page for a complete description of the IR extraction process. *pb*

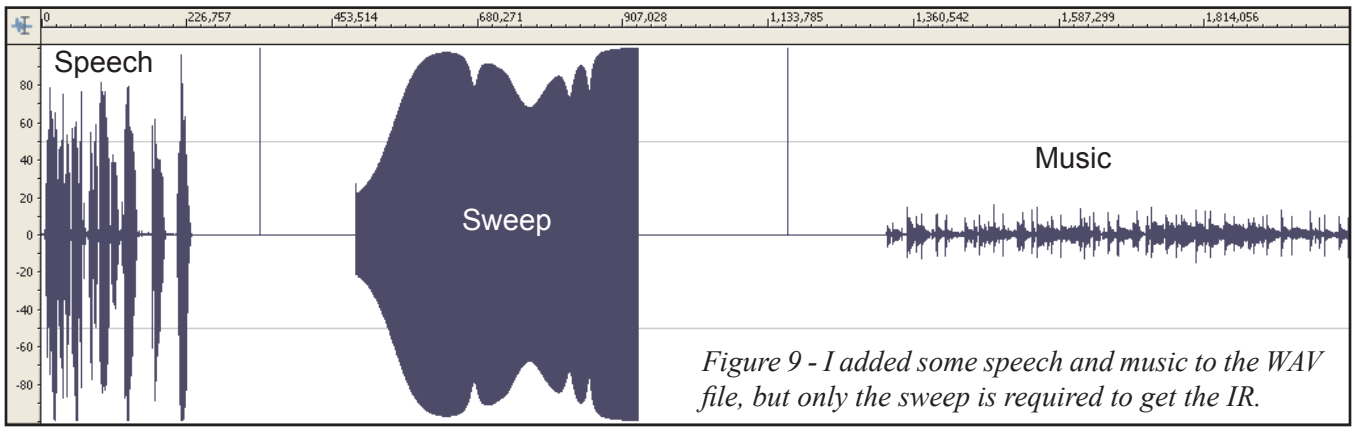

Figure 9 - I added some speech and music to the WAV file, but only the sweep is required to get the IR.