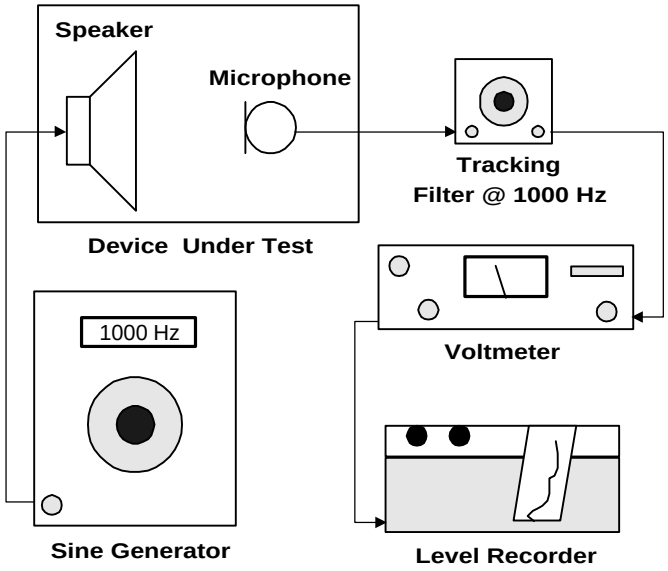
HARMONICTRAK™ Algorithm for Fast and Accurate Swept Sine Measurements

LISTEN, INC. electroacoustic transducer test system, SOUNDCHECK™, operates on the same principles as a traditional swept sine measurement system consisting of a sine generator, voltmeter, tracking filter, and level recorder. The main difference is that all these functions are implemented in software as virtual instruments, called "VI". The advantages of software-based instruments are numerous. SOUNDCHECK takes advantage of today's high-speed personal computers, data acquisition cards, and Windows™ software platforms, saving thousands of dollars in hardware costs and optimizing usability. The system is also modular, which means you can upgrade as your needs change.

In a traditional hardware-based test system, a sine generator performs a continuous sweep through the frequency range of interest. As the sine generator sweeps, a band pass filter, "tracks" the frequency of the sine generator to suppress noise and harmonics, which occur at other frequencies. The voltmeter or "measuring amplifier" then detects the RMS level, and outputs a proportional DC voltage to a synchronized chart or level recorder. The level on the chart recorder corresponds to the sound pressure level measured at each frequency. (See Fig. 1)

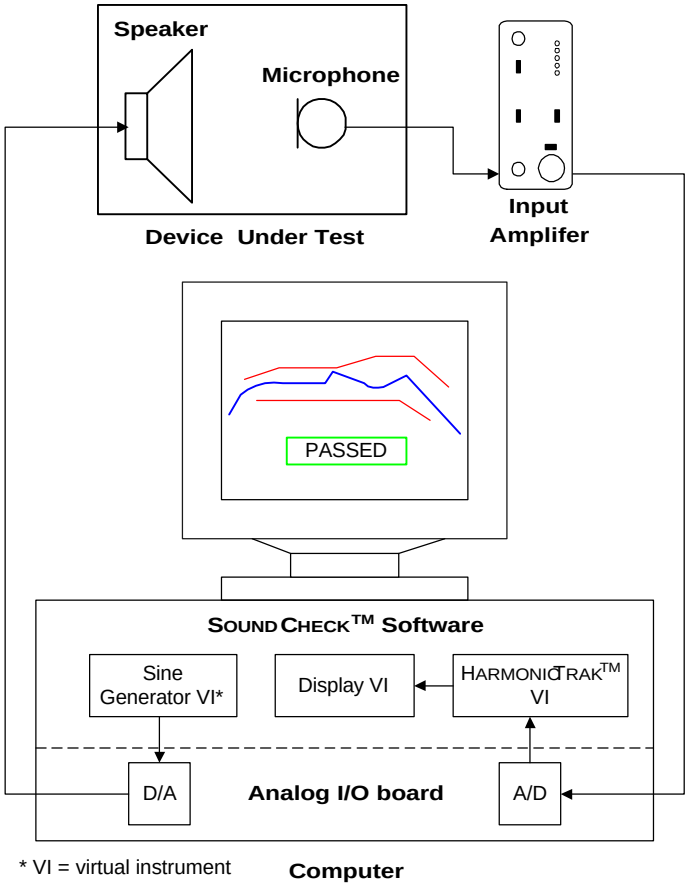
Fig. 1 Traditional Hardware-based Test System



The corresponding frequency resolution is limited by the sweep rate, filter bandwidth and the level recorder writing and paper speed. If the sweep rate is too fast, frequency and amplitude "smearing" will occur. This is particularly noticeable if the transducer's response exhibits any sharp peaks or dips, which is usually the case.

SOUNDCHECK uses a similar but improved approach, sweeping in discrete steps. Each frequency step can contain numerous cycles that are synchronously averaged to minimize the effect of background noise. Transducer settling (transient ringing) is also minimized by discarding the first few cycles at each new frequency step and providing a phase continuous transition between frequencies. This provides higher frequency, amplitude, and phase accuracy, as well as excellent noise suppression.

Fig. 1 SOUNDCHECK™ Software-based Test System with HARMONICTRAK™



The choice of a stepped sine test signal has many advantages:

- Low crest factor for testing at high levels uses less measurement dynamic range and does not provoke unwanted non-linearities in linear response measurements.
- Synchronous averaging produces high measurement S/N ratio. Useful for testing in noisy areas such as factory production floors.
- Well defined test frequencies and levels for testing to international standards
- True Harmonic Distortion testing capability (NOT THD + noise!)

Because sine waves have a low crest factor (i.e., peak to RMS ratio), tests at high levels can be performed without damaging the transducer under test. This is particularly useful for distortion

measurements. The deterministic nature of a sinusoidal test signal allows for minimum averaging to achieve a high signal-to-noise ratio. Also, sine excitation is often required to fulfill domestic and international test standards, especially those that require distortion. This testing technique can conform to any frequency format and saves time by testing only the specified frequencies. In addition, no data format conversion or interpolation is required.

Instead of using a tracking filter that can only measure one harmonic at a time, SOUNDCHECK uses a proprietary FFT-based algorithm, called HARMONICTRAK™ (patent-pending). HARMONICTRAK is equivalent to a parallel bank of individual tracking filters that measure all selected harmonics simultaneously. This parallel analysis technique saves considerable measurement time over the traditional serial analysis method. (See Fig. 3)

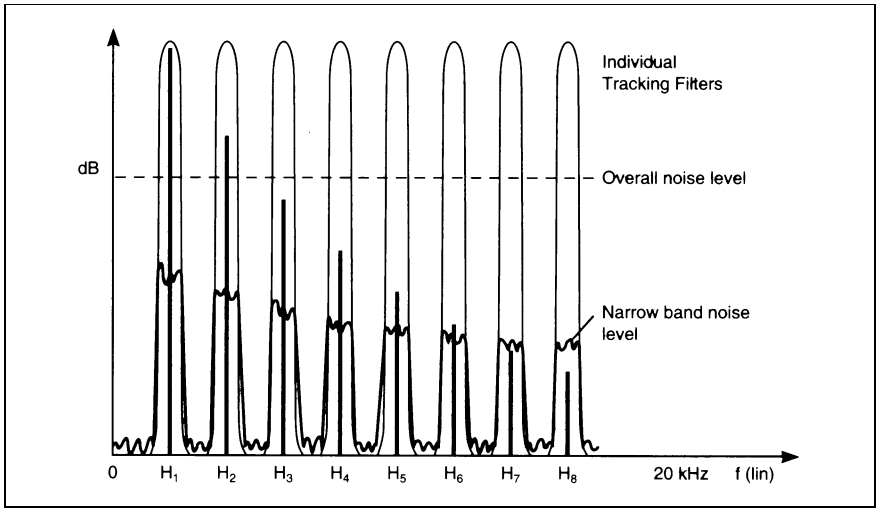


Fig. 3 Total Harmonic Distortion (THD) measured with HARMONICTRAK™(includes selected distortion components)

A common alternative for distortion testing is to attenuate the fundamental with a notch filter. (Fig. 4) This measurement technique, however, cannot distinguish the amplitude of individual harmonics (e.g., 2nd, 3rd, and 4th harmonics). Moreover, the measurement is susceptible to background noise. For example, it is common for background noise to be higher than the electroacoustic transducer distortion making it impossible to discern distortion from noise.

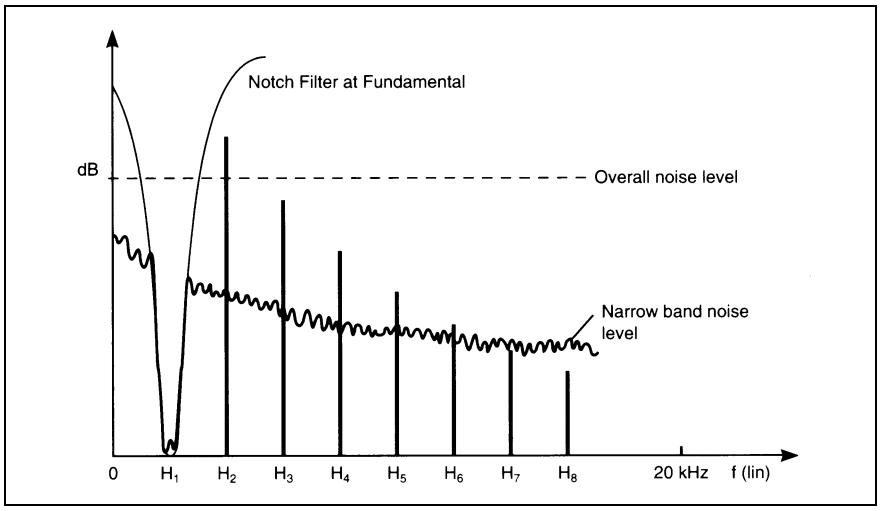


Fig. 4 THD+N measured with a "notch" filter (includes overall noise level)

HARMONICTRAK's capability to separate out individual harmonics is ideal for detecting and analyzing different kinds of transducer faults, such as rubbing voice coils, loose particles in the gap, and buzzing or rattling. (Please read our application note on Rub & Buzz Measurements with SOUNDCHECK for more detailed information on how this works.)

SOUNDCHECK with HARMONICTRAK provides improved speed, accuracy, and flexibility in performing electroacoustic transducer measurements, including frequency response (amplitude and phase) and harmonic distortion.