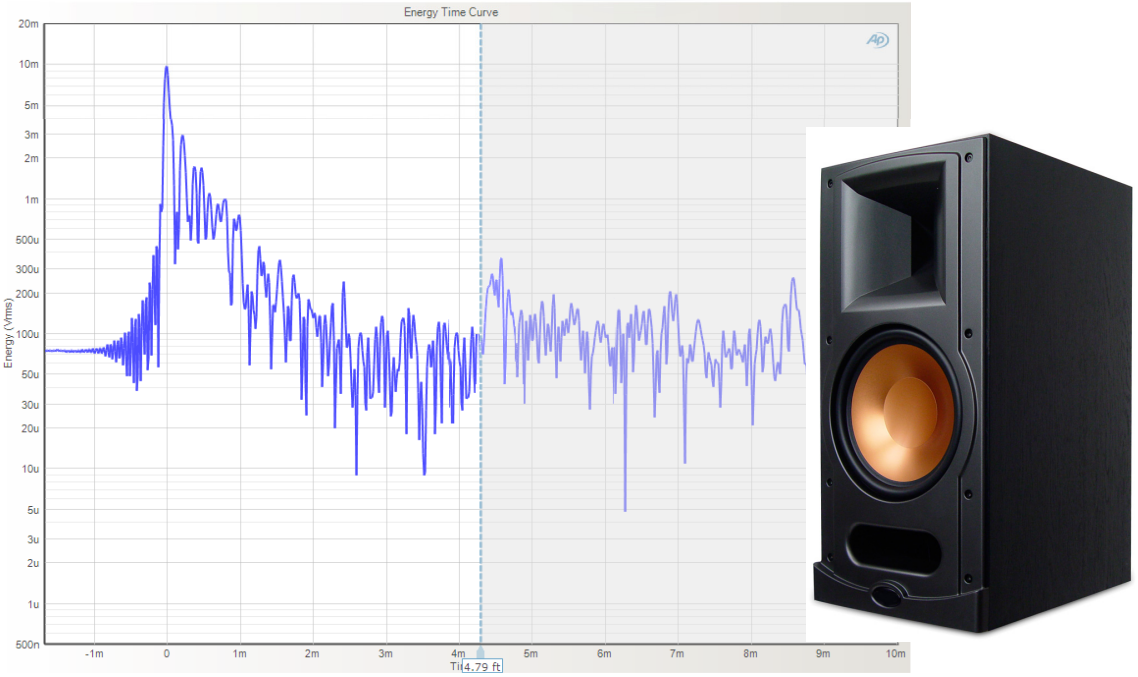
Acoustic Response

Measuring speakers



At some point, nearly every audio engineer wants to measure acoustic response—that of a loudspeaker, a car audio system, a portable media player, or of any number of sound-making devices. However, very few engineers have an anechoic chamber available—those huge, multi-million dollar rooms with thick foam covered walls.

The big problem for acoustic test is reflections from the walls, floor, and ceiling. The anechoic chamber has virtually none, and our typical room has a good deal of them. So, we've got to apply some special techniques in order to make highly accurate measurements in less than ideal conditions.

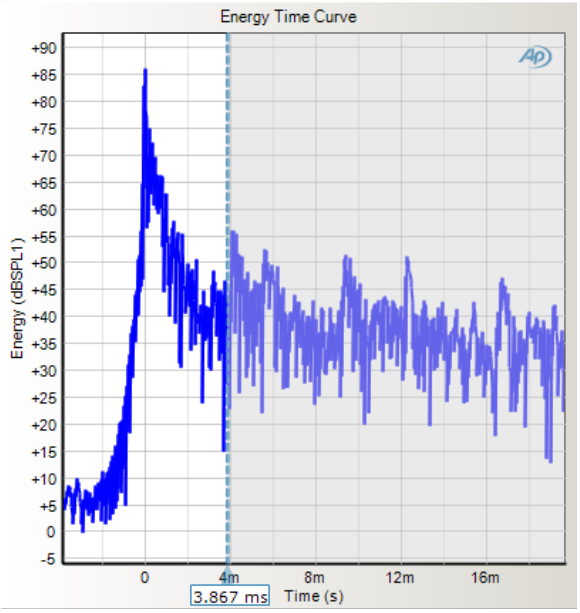
Log-swept chirp (also known as continuous sweep) is the best acoustic testing method available today. It has the ability to exclude room reflections and give comprehensive and accurate results. But not all analyzers and speaker testers are the same in ease of use, the breadth of their tests, or the high accuracy of the data.

Inside, we look at some of the important features that you'll need in an acoustic audio analyzer, the problems you may encounter in a non-ideal testing environment, the needs of good production line testing, and the range of measurements and results that should be produced.

Use Case:
Product R&D

Using a general purpose audio analyzer for speaker testing saves you the cost of purchasing dedicated speaker test equipment, while delivering highly accurate results and greater flexibility.

When not testing in an anechoic chamber, being able to see the first reflection graphically is critical. In the APx500 software, for example, the reflection can clearly be seen in the Energy Time Curve and in the Impulse Response. By dragging a cursor over either graph, you can time gate the results to exclude reflections. The measurements and graphs automatically recalculate to match the new time window. Features like these speed the set-up and save lots of time.



A good analyzer should be able to display all of the essential acoustic response measurements shown on the facing page, and it should do it within a few seconds with a single click of the mouse. Note the comprehensive THD (total harmonic distortion) results, allowing analysis by frequency and also by individual harmonic. Chirp has a big advantage here over the old MLS (maximum length sequence) method, in that distortion can be distinguished from the fundamental. This makes accurate frequency response measurement, as well as detailed distortion analysis, possible.

Acoustic response testing is ideal for:

Loudspeakers, portable DVD players, laptops, TVs (analog, S/PDIF, or HMDI input), car stereos, portable hi-fi / boom boxes, iPod docks, clock radios, PC speakers, GPS systems, powered speakers, home theatre systems, reference monitors, and PA systems.

Use Case:
Production Line

On the production line it's critical to test speakers for proper performance, whether you are producing them yourself, or sourcing them from a contract manufacturer and performing quality assurance.

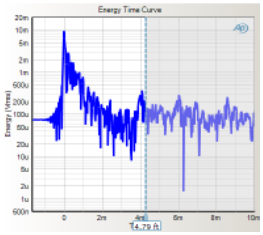
Noisy factory environments can make measurement difficult. That's why it's important to have synchronous averaging and smoothing. Synchronous averaging lets you average multiple acquisitions, improving the signal to noise ratio. Smoothing gets rid of small variations in response that may be due to reflections, noise, and positioning, which could cause erroneous out-of-limits results.

The best audio analyzers can run a whole gamut of tests automatically in just a few seconds using a single acquisition. The results can then be displayed on screen or saved to a file. By automating the system with established pass/fail limits, operators can rapidly run tests just by clicking "Go." It should be possible to set up an automated sequence such as this without writing a line of code.

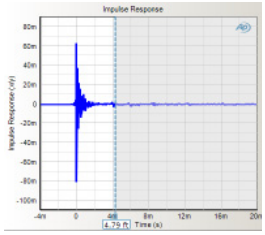
Having full control over the stimulus signal is a necessity. Parameters such as start and stop frequency, pre-sweep time, and sweep time should be adjustable to optimize speed and performance, and to protect tweeters and small speakers.

Essential Acoustic Response Measurements

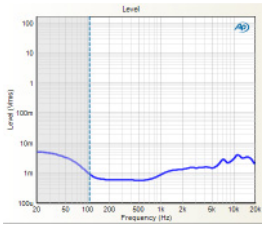
(results using APx500 software and an APx525 analyzer)



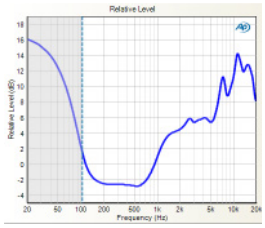
Energy Time Curve: The system's energy dispersal in time. Useful for viewing the signal alignment, and for inspecting the arrival of the direct signal, early reflections, and spurious outputs caused by leaks or resonances in the speaker enclosure.



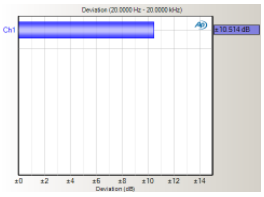
Impulse Response: Useful for studying artifacts that move or spread the stimulus in the time domain, such as delay, reverberation, echo, or reflection. An easily adjustable time window is a plus.



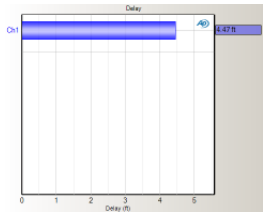
Level - Absolute (frequency response): Features such as averaging and smoothing help to remove insignificant response variations that make the general trend hard to see. A shaded area that indicates indeterminate data due to the length of the time gate is valuable.



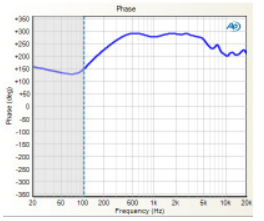
Level - Relative (frequency response): Like level, except that instead of absolute units, it is measured in relative units with the 0 dB point determined by the user.



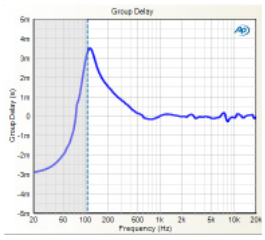
Deviation: The total range of level variation across the frequency range. Controls to specify a minimum and maximum frequency range to consider in the deviation measurement are useful.



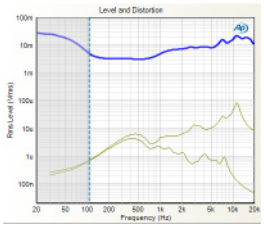
Delay: The acoustic delay as sound travels from the speaker to the measurement microphone. This is primarily useful for setting up an acoustic response test.



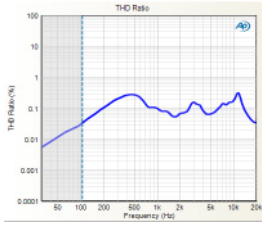
Phase: A graphical display of phase vs. frequency. Important for tracking down driver, cabinet, and cross-over problems.



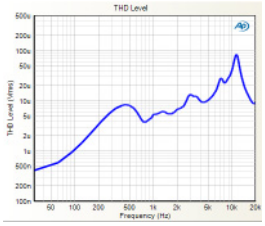
Group Delay: A measure of the rate of change of phase shift as a function of frequency. Group delay can also be described as a time delay of a group of frequencies with respect to the generator.



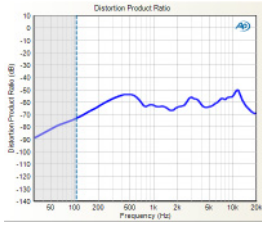
Level and Distortion: Both the level vs. frequency and the distortion vs. frequency of the speaker. It's especially useful to have separate traces for the second and third harmonics.



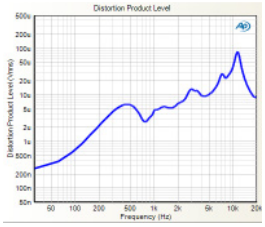
THD Ratio: The ratio of the total harmonic distortion to the total signal, plotted against frequency.



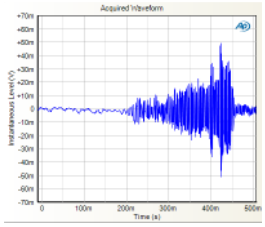
THD Level: The total harmonic distortion of a speaker plotted against frequency.



Distortion Product Ratio: A display of selected harmonic distortion products as a ratio plotted against frequency. Being able to choose any harmonic from 2nd through 20th enables more detailed analysis of distortion issues.



Distortion Product Level: A display of selected harmonic distortion products as a level plotted against frequency. Being able to choose any harmonic from 2nd through 20th enables more detailed analysis of distortion issues.



Acquired Waveform: A time-domain display of the waveform as acquired after passing through the speaker.

APx525

APx500 Series Audio Analyzer Key Specifications

SYSTEM PERFORMANCE

Residual THD+N (20 kHz BW)
–105 dB + 1.3 µV [APx520-26]
–103 dB + 1.4 µV [APx585/6]

GENERATOR PERFORMANCE

Sine Frequency Range
0.1 Hz to 80.1 kHz [APx520-26]
5 Hz to 80.1 kHz [APx585/6]

Frequency Accuracy
2 ppm [APx520-26]
3 ppm [APx585/6]

IMD Test Signals
SMPTE, MOD, DFD

Maximum Amplitude (balanced)
21.21 Vrms [APx520-26]
14.4 Vrms [APx585/6]

Amplitude Accuracy
±0.05 dB

Flatness (20 Hz–20 kHz)
±0.008 dB

Analog Output Configurations
Unbalanced & Balanced

Digital Output Sampling Rate
22 kHz–192 kHz

Dolby / dts Generator
Yes

ANALYZER PERFORMANCE

Maximum Rated Input Voltage
300 Vrms (bal) / 160 Vrms (unbal) [APx520-26]
110 Vrms (bal/unbal) [APx585/6]

Maximum Bandwidth
>90 kHz

IMD Measurement Capability
SMPTE, MOD, DFD

Amplitude Accuracy (1 kHz)
±0.05 dB

Amplitude Flatness (20 Hz–20 kHz)
±0.008 dB

Residual Input Noise (20 kHz BW)
1.3 µV

Individual Harmonic Analyzer
d2–d10

Max FFT Length
1024K points

DC Voltage Measurement
Yes

A2LA ACCREDITED
Accredited by A2LA under ISO/IEC: 17025 for equipment calibration

Acoustic Response

Pre-Sweep time
Default 100.0 ms, minimum 0 s, maximum 1 s

Sweep time
Default 350.0 ms, minimum 200.0 ms, maximum 2.5 s

Extension time
Minimum 0 s, maximum 3 s

Smoothing
None, 1/24, 1/12, 1/6, 1/3, 1 octave

Distortion products
Up to 20th harmonic

Signal Acquisition averages
Default 1, minimum 1, maximum 1000

Time Window length
Minimum 0 s, maximum unlimited

Simultaneous Channels
APx520, 525 2; APx521, 526 4 (3, 4 analysis only);
APx585 8, APx586 16 (9-16 analysis only)

APx Series Analyzers

The APx525 analyzer is an excellent choice for making acoustic measurements. It has two analog and digital channels, suitable for measuring both speakers and electronics. If you have need for more channels, consider the APx526, APx585, or APx586 instruments with 4, 8, and 16 input channels respectively.

AP also offers a measurement microphone kit which includes the most common configuration for speaker testing—a pre-polarized, ½" system with a free-field capsule. Order MMK2 (kit) or MMC3 (calibrator).

Additional Resources

APx500 User Manual
http://ap.com/display/file/25

MMK2 Data Sheet
http://ap.com/display/file/115

APx Loudspeaker Test
http://ap.com/products/apx/loudspeaker

For more information or a demonstration, please contact your local AP sales partner. http://ap.com/contact

Audio precision

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