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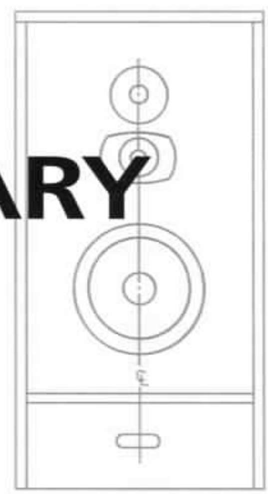
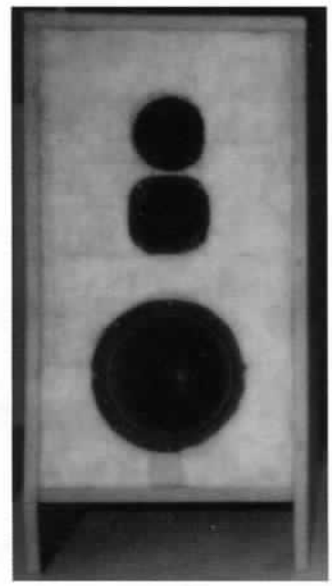

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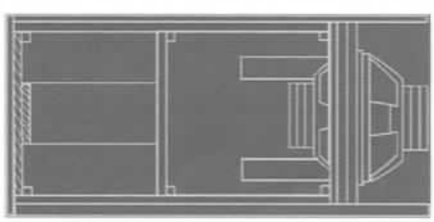

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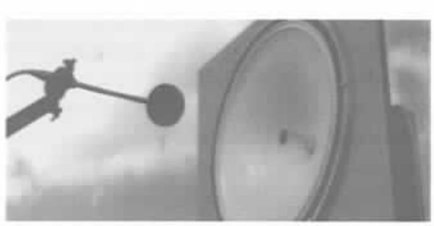

STROBOSCOPIC CHECKS ON SPIDER ACTION

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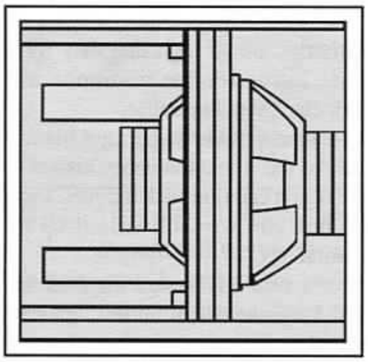

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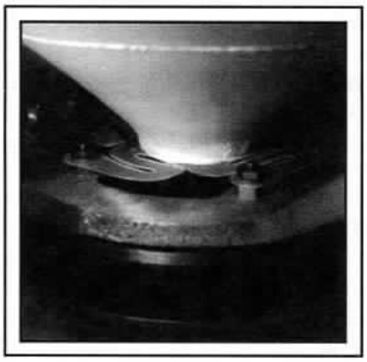

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LOW COST STROBOSCOPIC SPIDER ANALYSIS

By Tom Perazella

Since the early days of experimentation with electronic flash, one of the most interesting applications has been stop-motion or "stroboscopic" analysis. Dr. Harold Edgerton has been called the father of electronic flash, and he received popular recognition by photographing subjects such as milk droplets striking a pool of milk and bullets penetrating apples.

However, as entertaining as these subjects might have been, the greatest benefit is that it allows researchers to visualize repetitive motions otherwise imperceptible because of their high speeds. Compared to some of the other techniques for analyzing speaker components, the relatively inexpensive stroboscope provides a surprisingly good overall view of what is happening to a spider. Before covering the specifics of this technique for driver analysis, a review of the principles involved may be helpful.

EYE RESPONSE

One basic limitation of human vision is that you cannot discern the details of motion that occurs at frequencies higher than 30Hz. At higher frequencies, the eye integrates the motion into a "blur" of a certain visual density. The higher the frequency, the more uniform that density, and its value is a function of the density and size of the moving object in relation to the background.

For example, if you rapidly spin a white disk with small radial slits in front of a dark background, the slits will appear almost as light as the white segments of the disk. If the slits are then enlarged to the point where only narrow white segments remain between them, the spinning disk will appear dark. The density, or conversely, the apparent brightness at any point of the disk is a function of the time integral of light reflected from the disk at that point. The eye continuously integrates light from all points, resulting in the blurring effect.

STOP MOTION

To prevent this blurring, you can limit the time that light strikes a moving object while in a specific position. The electronic flash is an ideal device to accomplish this lighting control. Instead of a constant production of light, the flash device stores electrical energy and then discharges it very rapidly through a gas-filled tube, resulting in a very bright flash of light in a short time period.

If the duration of the flash is sufficiently short, the amount of the object's movement is inconsequential. If its movement is periodic, you can arrange to fire the flash at the same point in each period, with the visual result of "freezing" the motion. This can be especially valuable in observing a distortion of the object at a point of high stress in the period.

SLOW MOTION

As valuable as observing a particular point in the period can be, it is sometimes useful to observe the complete range of movement or distortions that can occur in an object during the whole period. By adjusting the time between firings of the strobe to be longer or shorter by some fixed amount in relation to the period of the object, the illumination will occur at a different point in the period with each flash. The result is that the object appears to be moving in slow motion. The closer the period of the flash to the period of the object, the slower the motion appears.

THE STROBOSCOPE

The stroboscope is an electronic flash optimized for stop-action work in several key areas as follows:

- The duration of the flash is very short, much shorter than a typical photographic flash. Special circuitry and flash tubes make this short duration possible.
- Stroboscopes generally have a narrow angle of illumination. This is necessary to concentrate the lower light levels produced at short flash durations onto a specific area of interest.
- In addition to an external sync, there is an internal time base to trigger the flash in a stable, repetitive manner.

USING A STROBOSCOPE

To get the best results from a stroboscope, you must take account of several factors:

1. The reflectance of the subject relative

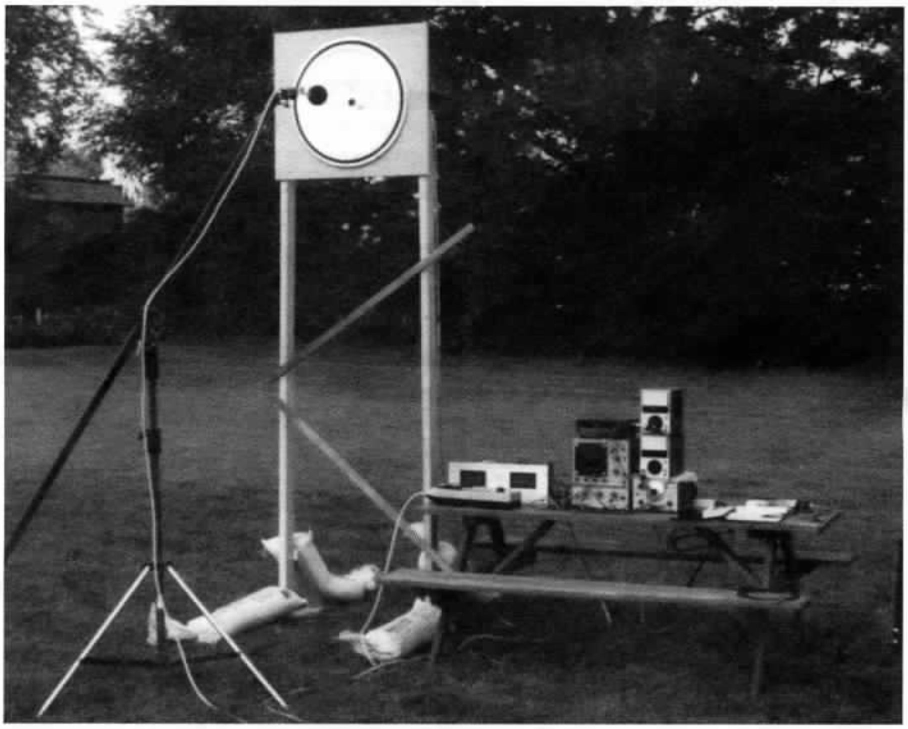

PHOTO 1: Test setup for 24″ woofer.

PHOTO 2: Microphone position used for testing.

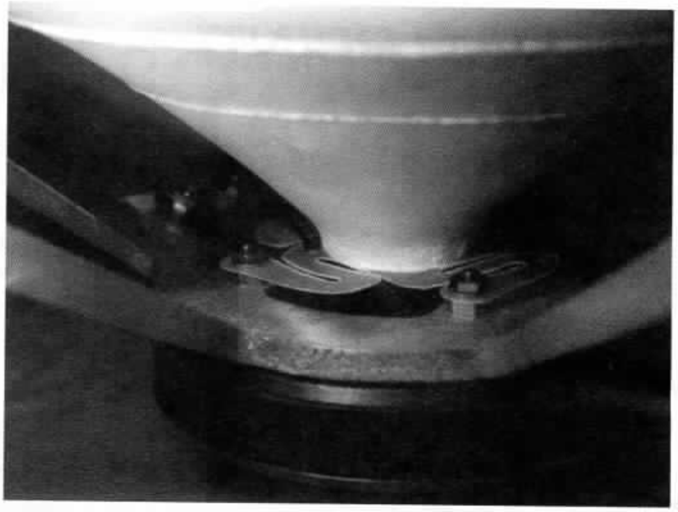

PHOTO 4: "S"-shaped spider construction.

to the background. The greater the difference, the more visible the motion. If you're viewing a light object, use a dark background, and vice versa. The basic product-photography trick of outlining the edges of dark objects with chalk can help in differentiating the object from the background.

2. Use appropriate lighting levels. Visual observation is not too critical, since the eye has a very broad range of light acceptance. However, if the contrast ratio between the object and background is too great, the eye will have difficulty. This ratio is even more important when using photographic or video capture, as these media are more limited in accepting ranges of brightness.

3. Adjust the viewing or photographing angle to best show the motions in question. The eye and camera are most sensitive to movements perpendicular to the axis of vision. Conversely, motions along the viewing axis are the most difficult to discern. If motions occur in multiple planes, try to view them from various angles.

4. Position the light to take maximum advantage of surface textures and contours. The more oblique the lighting in relation to surfaces, the more prominent textures and contours become. The changes of lighting on these surfaces help the brain process visual changes into the perception of motion.

5. There is an optimum range of perceived speed. You should adjust the stroboscope so that the viewed motion is slow enough to see details, yet not so slow that the overall motion is not readily apparent.

ABOUT THE AUTHOR

Mr. Perazella is the Director of Information Systems for a national retailer of professional photographic equipment headquartered in the midwest. Prior experience includes work as a criminalist in the San Diego and Long Beach (CA) crime labs and director of marketing for a photographic wholesale distributor. In addition to speakers, Mr. Perazella has designed commercial high-powered electronic flash equipment as well as numerous pieces of audio electronics for his own use.

A CASE STUDY

The versatility of the stroboscope is illustrated by an analysis of an audible anomaly that appeared while I was testing a 24" woofer. The manufacturer of this driver claimed an f_S of 13Hz, but MLSSA analysis indicated it was 27Hz. The manufacturer was skeptical of MLSSA analysis and asked for testing of the driver in an open environment. To satisfy the manufacturer's objections, I conducted tests the old-fashioned way, i.e., making point-by-point measurements in an open field. *Photo 1* shows my test setup.

I measured using a Bruel & Kjaer type 2209 sound-level meter feeding a digital voltmeter, two analog voltmeters, and an oscilloscope. *Photo 2* shows the mike position in relationship to the driver. Test results were within experimental tolerances of those achieved with MLSSA. During the tests, however, when drive levels exceeded 2V RMS at 27Hz, I noticed a howling at higher frequencies. The scope trace confirmed a higher frequency component on top of the base frequency. *Photo 3* shows the resultant waveform from an input of 5V at 27Hz.

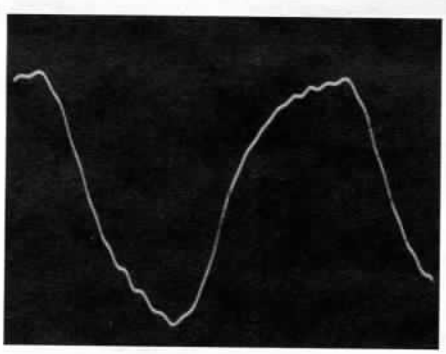

PHOTO 3: Waveform at a 5V level at 27Hz. Note the high-frequency component.

I measured relative acoustic outputs at 31.5Hz and 500Hz using the Bruel & Kjaer 1613 octave filter set attached to the 2209 sound-level meter. Relative levels at a 12" mike-to-driver distance and a 6V drive at 27Hz were 111dB at 31.5Hz center frequency, and 82dB at 500Hz center frequency.

A study done by Eric Busch of DLC Design states that the sensitivity of the ear at 27Hz is approximately 50dB below that at 200Hz. Unfortunately, data for the 500Hz center frequency was not available in that study, but extrapolating from other studies, the difference would be even greater at the higher frequency. The measured 29dB difference, when compared to the greater than 50dB sensitivity of the ear at 500Hz, confirms the degree of audibility of the higher frequency component.

At first, I suspected cone breakup. To see if this was the case, I used a stroboscope to view the cone motion with the same drive conditions. No breakup was apparent.

SPIDER SCRUTINY

The spider was the next area I examined. This particular driver had a spider style popular years ago. It appeared to be machined from a sheet of glass/epoxy material in such a way that four S-shaped fingers connected the base of the cone to the basket. *Photo 4* shows that construction.

To view the spider in motion, I positioned a stroboscope so that part of the light struck the spider itself and part was reflected from the white cone material, resulting in partial direct and partial backlighting. I observed the spider's motion while applying signals at 27Hz at various voltages, adjusting the stroboscope to yield an optimum perceived motion as described above.

Since I had not worked with this type of

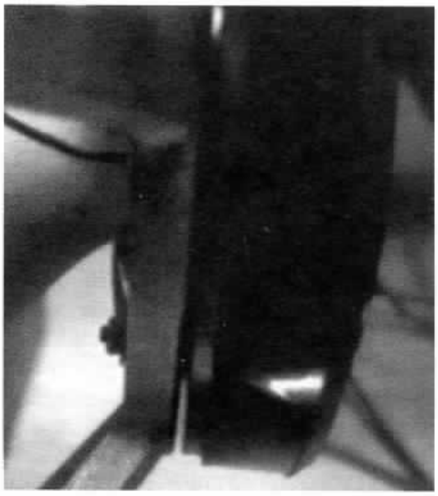

PHOTO 5: The driver at rest before the test.

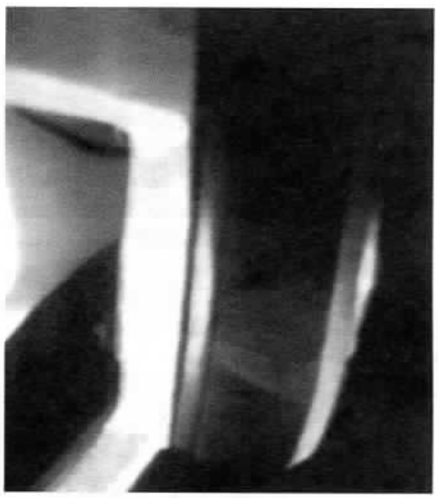

PHOTO 6: The cone in a rearward portion of its stroke with the tip of the spider also rearward.

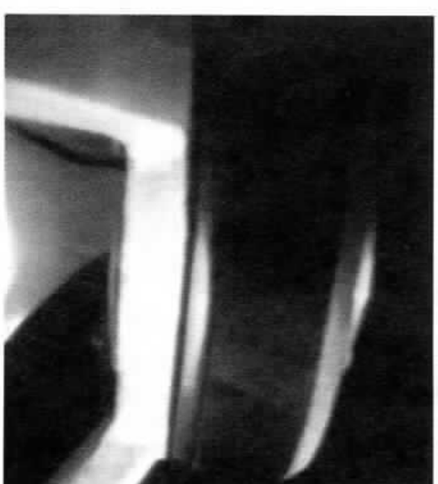

PHOTO 7: The cone moving outward with the tip of the spider actually leading the cone movement.

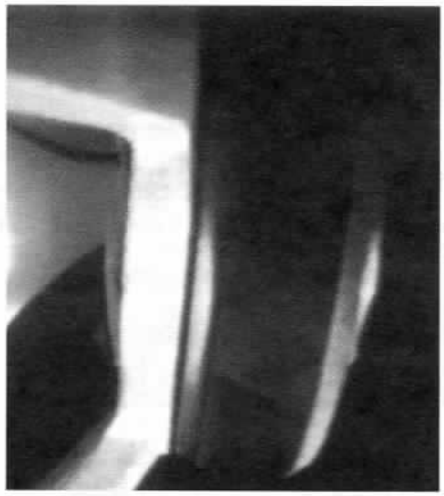

PHOTO 8: The cone continuing its outward movement with the spider still leading.

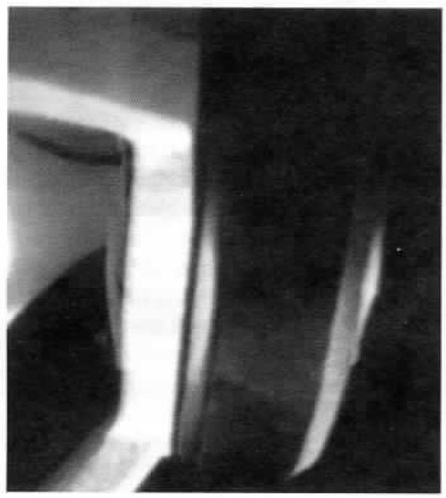

PHOTO 9: The cone continuing to move outward with the tip of the spider slowing down.

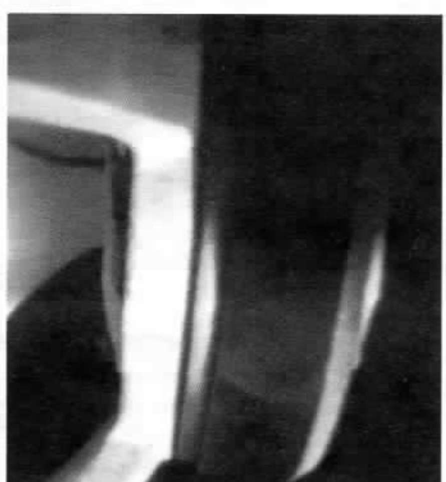

PHOTO 10: The cone further outward with the tip of the spider moving backward.

PHOTO 11: The cone moving significantly inward with the tip of the spider staying outward.

PHOTO 12: The cone moving again toward the front with the tip of the spider moving backward.

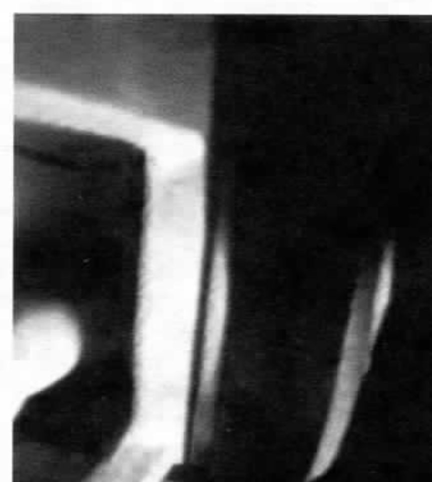

PHOTO 13: Using a finger to damp the oscillations of the spider.

spider construction before, the results were quite surprising. As the spider traveled through the center part of its range of movement, the tip of the "S" portion fluttered back and forth at a frequency higher than the fundamental. In addition to this flutter, I noted a torsional vibration in the spider sections, also at a higher frequency.

RECORDING THE EVIDENCE

The next step was to record this motion on video so the results could be sent to the man-

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the same situation as for a vented or closed box. If the woofer is only used above the frequency range where resonant effects dominate, it is possible to obtain increased sensitivity over the bare driver. I encourage Mr. Jones to write up configurations he has found to perform well for the benefit of all readers.

AD INDEX

AS I WAS SAYING...

To continue my response to Thomas H. Eberhard's letter (*SB* 5/96, p. 54), the latest version (1.1.0) of Mac SLM© lets you save the measurement as a text file, enabling its importation into a spreadsheet, analysis, or graphics program. I sent Mr. Eberhard an upgrade version and user's manual. As it turns out, he had not received the printed manual with his order, which is necessary to experience the program's full potential.

Along the same vein, I give H. Donn Hooker (*SB* 5/96, p. 58) some sympathy regarding MathCad.© I use version 3.1 for consulting and personal projects, such as designing the DSP filters in Mac SLM. You should first read the book and then practice using the program. Quite powerful in some ways, MathCad is weak in optimization and in the facilities provided by the Maple© subset.

Beware that some impedance measurements are normalized by the impedance of free air, which radically changes the system of units.

Dr. Victor Staggs
Orange, CA

Aftershock Subwoofer

from page 42

phase. Removing the 55-ltr chamber and thickening the walls made Aftershock sound a little more solid; however, the response measured the same as it did before the overhaul.

SUMMARY

If you can get your hands on some old professional bass-instrument or sound-reinforcement speakers, take a little time to restore them, analyze what you have, and use the knowledge available in *Speaker Builder*, you may surprise yourself with incredible results and save yourself a ton of money. Warning: if you live in Southern California, watch one of those PBS specials on earthquake-proofing your house and take the precautions before putting your Aftershock into service, or you may hear some crashes that were not in the original soundtrack!

Spider Analysis

from page 57

ufacturer. I used a Sony MVC5000 video camera for this session, utilizing the composite video output available to drive both a monitor for real-time viewing and a VCR for recording. I used several different levels and recorded the results. Frame grabs from the video showing representative results are shown in *Photos 5–13.*

As you can see from the photos, there were significant motions at frequencies higher than the fundamental. These vibrations, coupled to the air both directly and through the base of the cone, were quite audible.

To confirm this spider motion as the source of the errant sounds, I conducted another basic test using the stroboscope to visualize the results. I again fed the test signal to the driver, and, while watching the vibration of the spider under the stroboscope, I placed my index finger on a point of one leg where it was attached to the basket. I then moved my finger up the spider until the strobe showed that the vibrations were damped, all the while listening for changes (*Photo 13*). The reduction in the high-frequency anomalies was consistent with the reduction of vibration I noted. Since I subjected only one of the four legs to this test, the anomalies were not totally removed, but the effect was clear.

In summary, a stroboscope can show motions in drivers that you cannot see with the naked eye. Additional advantages include its moderate cost, its portability, and the fact that you can use it with a wide range of objects. A little care in basic lighting techniques greatly enhances visual results, extending the range of objects that can benefit from this technique.