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Using the TECRON® TEF System 10 Acoustic Analyzer

This new and useful acoustical device can be used in the construction of studio, theatres, clubs, etc. The following article explains just what measurements can be made, and how to make them.

STUDIO DESIGNERS AND acoustic consultants now have access to one of the most powerful analytical tools ever made available: The TECRON TEF System 10. This is a portable computer designed to make quick, accurate measurements of room acoustics and sound systems. It includes a keyboard, built-in monitor screen, and two built-in disk drives for data storage and operating software.

This sophisticated instrument is based on the development of Time Delay Spectrometry by Dr. Richard C. Heyser. The TEF System 10 generates a frequency sweep into a sound system, then picks up the sound of the sweep through a tracking filter. This tracking filter can be time-offset to compensate for sound-propagation delay. By varying the bandwidth and time-offset of the tracking filter, you can look at the spectrum of the direct sound by itself, or certain sound reflections, or both.

The tracking filter also greatly increases the signal-to-noise ratio of the measurement, so that accurate tests can be run even in noisy environments, with conversation going on in the background.

The TEF System 10 permits measurements of energy vs. frequency (frequency response), energy vs. time (energy level of sound reflections vs. time), and frequency response vs. time ("3-D" display as shown in FIGURE 1). It

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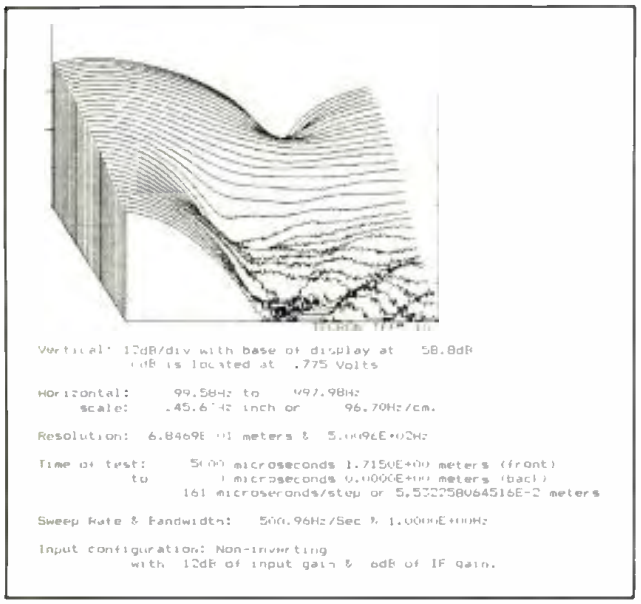

Figure 1. A 3-D display on the TEF screen.

also makes phase measurements and Nyquist plots. Measurements made at different times or places can be compared and differenced.

SUGGESTED APPLICATIONS

The TEF System 10 can remove all the room reflections from the measurement, leaving only the direct sound. This means you can actually measure the anechoic frequency response of a speaker cluster after installation. Or you can see the effect of early sound reflections on the speaker-system response, excluding the room reverberation.

Acoustic consultants use the TEF System 10 to pinpoint acoustic problems such as confusing echoes, early sound, and so on. They can measure the absorption-vs.-frequency of acoustic treatments in situ.

With the TEF System 10, you can see on the screen what you hear with your ears. For example, the analyzer can show the pattern of sound reflections in a room. FIGURE 2 shows a typical display of the energy level of sound reflections vs. time. The tallest line to the left is the direct sound, followed by discrete early reflections, followed by closely-spaced random reflections, or reverberation.

If a strong cluster of reflections occurs more than 20 milliseconds after the direct sound, intelligibility can be impaired. With the TEF System 10, you can determine the arrival time and source of these reflections.

Once the problem reflections are identified, the offending surface can be modified to diffuse or absorb the incident sound. Only those surfaces causing the problem need to be acoustically treated—not the entire room. This can save the expense of unnecessary modifications.

The TEF System 10 is a necessary tool for the design of Live End-Dead End (LEDE™) control rooms. LEDE design requires that several criteria be measured and controlled, including direct/diffuse sound ratio, rear-wall reflection delay and level, sound decay, and speaker time alignment. The TEF System 10 performs all these measurements.

It can be used as a regular computer, too. The TEF System 10 includes three Z-80 microprocessors that let you run CP/M or BASIC programs such as circuit analysis, sound system design, or even word processing. Of course, you can write your own programs for particular applications.

USING THE TEF SYSTEM 10

Being a computer-age test instrument, the TEF System 10 takes a little getting used to. There are no knobs to set. Instead, all control settings are done through the keyboard (aided by prompts from the built-in monitor screen). This offers a notable advantage in that settings can be recalled and duplicated exactly whenever needed.

To use the TEF System 10, it helps to be familiar with personal computer operation. The instruction manual assumes the user has no experience with computers, and explains step-by-step how to get started. If you need help in the field, the computer has instructions built into the software that can be recalled through the keyboard.

Let's run through a typical test procedure. Assume you've been asked to improve the acoustics and the sound system of a new auditorium. Musicians who play on-stage complain that the sound is so "confusing" that they can't play together. In addition, a theatre critic reported that she couldn't localize the reinforced sound. Others claim that the reproduction is unnatural.

So you carry in the TEF analyzer, a measurement microphone and stand, a mini computer and power amplifier, and some cables. First you tackle the musicians' problem. To simulate the instruments and ears of the musicians, you place the speaker and the microphone on stage. Then you connect the TEF sweep output to the power amp driving the speaker. You connect the microphone to the input of the TEF analyzer.

Next, you insert the floppy disk containing the TEF program. The monitor screen lights up, asking you to type in your name and the date. Then you hit "M" to read the Main Menu (a list of options). The Menu appears.

To document the test, you type "J" to choose a job number. Then you type "e" to set up the ETC measurement (Energy Time Curve). This measurement shows the energy level of the room reflections vs. time.

After entering the needed information, you type "E" to run the ETC measurement. The TEF System 10 plays a sinewave sweep through the speaker on-stage. The measurement microphone receives the direct sound from the speaker, as well as the room reflections. These reflections are displayed as a function of time on the TEF monitor screen.

You see a cluster of reflections centered around 200 milliseconds after the direct-sound pulse. When you move the microphone toward the rear wall of the auditorium, the delay decreases. This shows that you're approaching the source of the reflections (in this case, the rear wall).

So, you've discovered that the rear wall is echoing the stage sound back to the musicians (after a delay of 200 milliseconds). That's why they can't play in sync. You break up the rear wall with some splayed reflecting panels, re-measure, and find that the echo has disappeared.

Now let's take care of the localization problem. This particular auditorium uses a main speaker cluster over the stage, as well as distributed speakers near the audience. The main cluster is far from the audience, while the distributed speakers are close to the audience. A digital delay has been inserted in the audience-speaker lines to compensate for propagation delay.

However, an ETC measurement reveals that the direct sound from the main cluster arrives slightly after the direct sound from the distributed speakers. There's been a miscalculation in setting the delay.

Due to the Haas effect (precedence effect), some audience members localize the sound at the earliest sound source (the distributed speakers). The signal feeding the distributed speakers should arrive at the listener a little later than the direct sound from the main cluster. That way, the audience will localize the sound up-front near the stage. TEF measurements indicate visually when the delay is properly set.

Some theatre critics have complained that the system sounds tonally imbalanced. So you place the measurement microphone in an audience location and run a frequency-response measurement of the main cluster's direct sound. This is done by typing "t" to set up the TDS measurement parameters, and by typing "T" to run a TDS sweep.

The screen shows a deep notch in the response around 2 kHz. The frequency of this notch corresponds to a signal delay of about .25 milliseconds. This might indicate that some of the speaker-cluster components are staggered in space (and time), rather than being time-coherent.

After inspecting the cluster, you align the acoustic centers of the drivers using the TEF display as a guide.

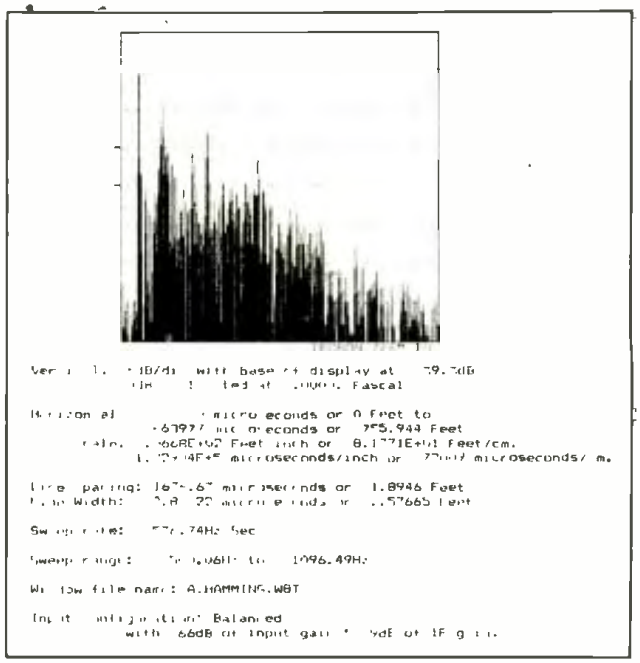

Figure 2. An ETC display showing the energy level of sound reflections vs. time.

The notch disappears. You play some music through the system and are impressed with the improvement.

After about two hours in the building, you will have gathered an enormous amount of data, all on disk. It's time to pack up and leave.

That evening at home, or even a week later, you power up the machine, insert your disks, and begin the process of analysis. The digitally stored data can be assembled in any form you wish: frequency-response curves, phase vs. amplitude (Nyquist), or phase vs. frequency.

You will be able to see differences between any two sets of data, as the computer subtracts one set of data from the other and displays only the remainder. You may even wish to difference data from various halls as part of your research. You can make hard-copy printouts for yourself or your clients.

The amount of data you have obtained with the TEF analyzer will enable you to suggest precise areas of further investigation. That additional research, like the original analysis, can be accomplished more quickly and easily than in the past.

IN CONCLUSION

The TEF System 10 offers surprising insights into the behavior of room acoustics and sound systems. If you're an acoustical or audio design consultant, you now have a new tool to speed up your analysis and verify your predictions.

After using the Tecron TEF System 10 for over a year in my own work, I've consistently been impressed with the elegant handling of data and the amount of sophistication packed into the portable package. Watching the TEF System 10 in action is a fascinating process (which, incidentally, always impresses clients). It makes you feel like the future is here. ■

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