

# BINAURAL BASICS

***Binaural recordings  
will add a new  
dimension to  
your audio world.***

JOHN SUNIER



ALTHOUGH MOST AUDIOPHILES ARE familiar with the term binaural, there's still quite a bit of confusion about it. Early in stereo history the terms binaural and stereo were used interchangeably, even though the two recording methods are totally different. Recording pioneer Emory Cook caused some of that confusion by calling his early 50's twin-grooved stereo LP's binaural when they were actually stereo.

Binaural recordings can open up a whole new realm to your listening enjoyment. We'll look at the history behind binaural sound and how it is made as well as present some high-quality binaural products.

## **The binaural difference**

If you listen to a stereo source from stereo headphones compared to the same source listened to from loudspeakers, you'll notice a much different sound

between the two. That's because most source material isn't designed for headphone listening. An unnaturally exaggerated effect is created with headphones, as though half an orchestra is on one side of your head and the other half on the other side, with a hole in the middle. Also, the music sounds as if it's happening inside your head rather than out in the room. No serious record producer would ever monitor a recording session solely on headphones; a proper setup of the highest quality monitor loudspeakers is required to get a feeling for proper balance in the mix.

## **Binaural background**

True binaural uses only two microphones, usually small electret condensers either set into the outer ears of an artificial human head, or at least spaced the same distance apart as an average pair of ears, and mounted on either side of a small baffle. The two

mikes feed two channels which are kept entirely separated from the source all the way to the final listener, whether live, a recording, or a broadcast. The listener wears stereo headphones and the original left ear signal must be routed properly to the left ear and the right to the right or the effect is compromised. The final result is for the listener to be sonically transported to where the sounds originated, rather than attempting to bring the sounds into the listener's room as with speakers. The left speaker signal is prevented from feeding into the listener's right ear, and vice versa, with binaural playback on stereo headphones. Figure 1-a-d shows various types of sound reproductions, including binaural.

With binaural recording, spatial placement within a 360-degree sphere is so realistic that even vertical placement is perceived. Reproduction of the ambience or reflected sounds in a hall is so correct that acoustical engineers can listen to such tapes and identify in which hall they were recorded. The only areas of location that are sometimes problematic are on a line directly in front of and to the rear

of the listener. That is dependent on several factors, including how our hearing mechanism works, differences in headphones, and individual differences as well as learned responses.

### Binaural history

The first use of binaural sound occurred in 1881 in Paris. Inventor Clement Ader mounted a series of primitive carbon telephone transmitters along the front of the stage of the Paris Opera House. The transmitters were grouped in pairs the same distance apart as human ears, with several pairs across. The leftmost of each pair were mixed together and fed to one telephone line, which listeners in their homes directed to their left ears using the ordinary phone earpiece. The rightmost of each pair were also mixed together and fed to a second phone line, which each listener had to have installed in their home. The result was that as opera singers moved about the stage, home listeners could "see" their movement while hearing the music with much greater fidelity than a single phone line could possibly provide. The original patent says "This double listening to sound... produces the same effects on the ear that the stereoscope produces on the eye." It's fortunate that a wide frequency response is not the most important parameter for conveying the binaural effect; phase accuracy and correct balance between the two channels is more important.

A similar project was carried out with an improved version of the Ader experiment in Berlin in 1925. During that same year more than one radio station in the U.S. did experimental binaural broadcasts using two different frequencies. Listeners needed two crystal sets, each feeding a separate earphone. The mikes in the studio were kept about seven inches apart, and therefore listeners with only one radio still heard a normal signal.

During the last 40 years there has been sporadic interest in binaural reproduction around the world, centered primarily in Europe and Japan. In 1970, *Stereo Review* issued a binaural demonstration LP of music and sound effects using the "Blue Max"

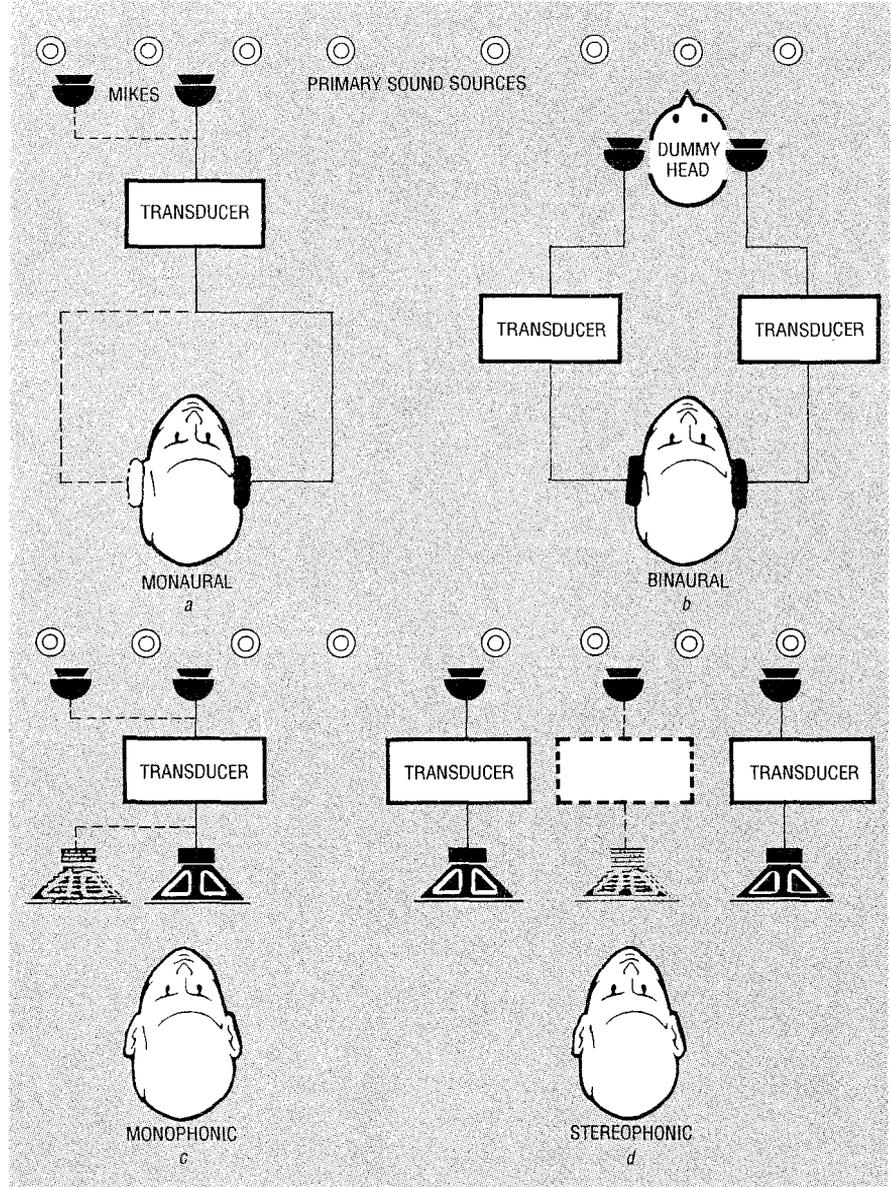


FIG. 1—SOUND REPRODUCTION SYSTEMS; monaural (a), binaural (b), monophonic (c), and stereophonic (d).

dummy head, which was hand-made for the project. Music excerpts from it are still currently available on a pre-recorded cassette. The Sennheiser microphone/headphone people in Germany issued a series of 45-rpm binaural demo recordings (long out of print now), which were well done and designed to promote their open-air phones and special binaural mike system. Diagrams of the placement of musicians and sounds around the listener aided in evaluating how precise the effects were.

One demo in particular was interesting. It featured a woman arriving on a train and being met by a man at the station. Placed among all the sound effects of the train, people, and station en-

vironment were the voices of the woman, speaking English, and the man, greeting her in German. Eventually they meet in front of the listener. All the while you can easily focus on either the German or the English and understand perfectly without serious distraction from the other voice, as would occur with stereo sound and certainly with mono reproduction.

This very functional use of binaural is currently being applied to military aircraft communication by researchers at the NASA-Ames Research Center. They use a powerful computer known as the Convolutron to process mono speech and signals from several sources, such as control

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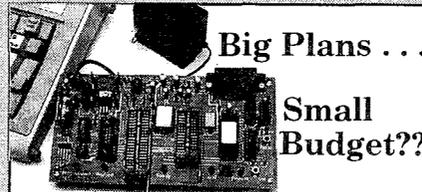
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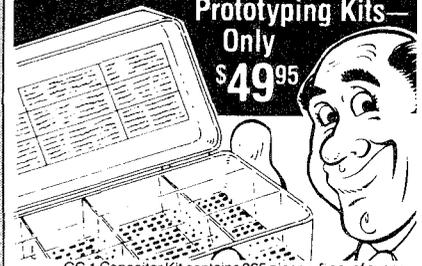


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is just as likely to happen when monitors with droopy high-frequency response are used. Many years ago, I remember reading about a technical survey of the speakers used in sound studios and how appalling their frequency performance was.

Frankly, experience has shown that there's no reason to trust the hearing acuity or good judgement of those responsible for the sound of our musical software. True, things are a lot better than in the early 1960's, when I first started looking into the problem

of why some records sounded so bad. But we need look back no further than the hundreds of shrill-sounding CD's released when the format was new to realize that incompetent engineering is not a rare phenomena in the record business. **R-E**

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REM

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towers and other aircraft, and assign them places in a 360-degree sphere so that pilots wearing stereo headphones can "steer" their binaural hearing to the voice they need to hear and ignore the rest. A demo tape mixed those artificial binaural voices into a loud background of helicopter noise and contrasted the very intelligible result with the same signals in both mono and stereo.

Much research is currently being done on the human hearing mechanism and the broad field known as psychoacoustics. Product approaches being promoted, such as Hughes SRS and Q Sound, are an outgrowth of that work. Those systems attempt to offer a binaural-like surround localization with loudspeakers rather than stereo headphones, and only a pair of them at that. With proper source material, mixing, and proper

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dard oscilloscope is the vertical circuitry. Although there are special considerations, this is really nothing more than an amplifier designed to have a response that's as flat as possible over the rated bandwidth of the scope. Remember that we're using the output of the amp to display changes in the input signal, and we don't want the amplifier to add its own two cents to either the shape or level of the input signal. The point of using a scope, after all, is to display unknowns in a signal, not add to them.

Just as the horizontal section should have several accurate sweep speeds, the vertical section should have several accurate settings for the gain. When you look at the display matrix, going one element to the right should represent a definite amount of time and going up one element should represent a definite amount of voltage increase. Even if you've never used a scope, you've probably heard people talking about the number of volts per division when they're referring to scope measurements. In the scope we're going to build, the equivalent would be to refer to volts per display element.

These three sections—horizontal, vertical, and display—together form the basis of every oscilloscope there is. Before we can even think about including some of the features found on commercial scopes—or even clearly understand what they do—we have to get the basics out of the way. The best way to handle this is to design a basic scope and then, once we have that stuff under control, we'll be in able to think about things like triggered sweep and other bells and whistles found on commercial scopes.

By this time you should know that the first step in any design job is to draw up a list of design criteria to formalize the project you have in mind. In this case the list isn't too long because the scope will be pretty simple—at least in the beginning. Here's our list:

1. The scope will have a maximum bandwidth of 1 MHz.
2. There will be eight selectable sweep speeds.
3. There will be eight selectable gain levels.
4. There will be a variable gain control.
5. The display will be in a twenty-by-twenty matrix.

You can change any of the criteria you want but, for the moment, it's a good idea to leave them all as they are. Once we get into the specifics of the design, you'll find it relatively easy to modify some of the features to adapt to any particular requirements you might have.

Before we start the actual design, we have to talk a bit about the display. Elementary arithmetic tells you that a twenty-by-twenty matrix calls for four hundred LED's and, even though you can get LED's in bulk quantities from mail-order houses at extremely low prices, you still have to do a lot of wiring to get them set together in the kind of matrix we need. Let's face it, it's a real pain in the neck to wire four hundred LED's.

When we get the scope designed, we'll investigate some alternatives to using LED's for the display elements—LCD screens are a perfect choice. I've seen pre-made LED matrix displays that come in various sizes and I'm currently going through my parts books and mail-order house catalogs to see what's available and who has them for sale at reasonable prices. If any of you know where these can be gotten, drop me a line and I'll put it, along with appropriate thanks, in the magazine.

I have a working version of the scope on my bench at the moment and I used four hundred LED's wired into a twenty-by-twenty matrix. It took a bit of time to get it wired but, from personal experience, I can tell you that it's not too bad and certainly not the worst thing I've ever had to do. It was, however, pretty high on my list of unpleasant experiences.

As we develop the circuitry for the scope, I'll base the display on the same sort of LED matrix I wired up on my bench but, between all of us, we should be able to come up with a more attractive alternative that still uses LED's. It's a mechanical problem, not an electronic one.

Once everything is done and we have the circuit working, we'll take a look at LCD panels. These have become readily available and you can find them at reasonable prices. We won't be doing this right at the beginning because the circuitry needed to drive them and the memory needed to hold the display is a separate topic in itself. First things first.

Next time we'll move into hardware design. **R-E**

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placement of the listener in the "sweet spot," those approaches can be quite convincing. When optimum criteria are not met, they can also sound worse than poor mono, and even at their best, they don't equal a good true binaural recording on good headphones.

There is one highly successful speaker approach that can be used with any binaural recording. It is the Binaural Panorama circuit included with the normal ambience, reverb, and Dolby Surround features of the Lexicon CP-1 and CP-3 Digital Audio Environment Processors. Correlation of the "trans-aural" signals of the left speaker sounds reaching the right ear and the right speaker sounds reaching the left ear are at the heart of this speak-

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er system. An adjustable delay line sends the properly correlated cancellation signals to each ear, something like Carver's Sonic Holography or Polk's SDS, but is more sophisticated and freer of the "phasesyness" of those approaches. One does have to sit in quite an exact sweet spot. Although it works well with only a pair of speakers, the addition of another matching pair in the rear, being fed a simple L-R signal improves the effect even further. With practice (some of this is a learned response too) the listener can even clearly image sounds to the rear and far sides, as well as vertically.

The crux of the matter is that just as some people have trouble