

Ambisonics Decoded

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I've just returned from the Summer CES (covering it for *Stereophile*) and I haven't recovered yet, mentally or physically. Trade shows can be (sorta) fun when you're there for your own pleasure, but *having* to see everything can be enervating.

Among the "esoteric" companies in the Pick-Congress, only two were showing anything connected with surround sound. (Audio/Pulse wasn't there, and Sound Concepts was concentrating on their Image Restoration Control.) One was a new firm, Benchmark Acoustics, showing an unusually good-sounding delay system; I hope to have one for review soon. The other was, of course, IMF Electronics, demonstrating Ambisonics. Although EMI still makes an occasional SQ recording and Audionics is manufacturing the Space & Image Composer, quad open-reel tape seems dead and ambience systems a bit soft. Ambisonics is, in effect, the only remaining system.

Actually, "remaining" isn't the right word. "Emerging" is more like it. There is a constantly-expanding catalog of discs and tapes, and new licensees are continually being added. Several companies will be producing Ambisonic hardware, including several "purist" British firms, as well as Aiwa! (This is ironic, since Aiwa is a division of Sony, an early SQ supporter.)

To get you into Ambisonics, let me first tell you what it isn't:

1. It is *not* a "quadraphonic" system. The idea of four separate sound sources is discarded, along with the (totally incorrect) procedure of positioning non-frontal sounds by "panning" them between speaker pairs — the "Pair-Wise Mixing" error discussed in the June 1980 issue of *The QUAD Quarterly*.
2. It is *not* a four-channel system. Only three channels (these are storage and transmission channels we're talking about, not speaker feeds) are required for full surround sound, without compromise. Four channels can be used if "periphonic" (with-height) reproduction is desired. The specific number of channels is determined mathematically, not by any desire to minimize costs or to double the number of channels used in stereo (for a sense of "symmetry").
3. It is neither a "discrete" nor a "matrix" system. The transmitted signals are *not* fed directly to the speakers, so there is no basis for using either term. But there is a more subtle and important distinction. None of the discrete systems (CD-4, QR, Q8, various W proposals) or matrix systems (SQ, QS, EV, etc.) is truly a *system*. They only provide a method of transmitting four channels of sound. Nothing is said about *how* these four channels are to be used. Ambisonics, however, is a total system, from microphone to listening room. It has only one purpose — to reproduce the sonic character of the recording space as accurately as possible. Because this requires accurate imaging from every direction around the listener (including above and below), it then becomes possible to produce *any kind* of artificial effect desired, or even mix the two. Ambisonics, therefore, rationalizes recording technology, both in the concert hall *and* the studio.
4. It is not based on wishful thinking or the need to get around somebody else's patents! It is based on psychoacoustic studies, controlled listening tests and sound engineering.

Which brings us to the technical side. I could spend 10 or fifteen issues of *MCS Review* and still not explain everything. So, instead of being comprehensive, I'm going to be as simple and direct as possible. First, I want you to forget everything you know about conventional stereo and quadrasonics. Let's start from scratch.

Pretend that we can have as many transmission channels as we like, as many amps and speakers as needed in the listening room, and the technology to produce any kind of microphone we need. What is the best way to go about describing the sound field (real or imagined) around the listener? Before I give the answer, you may want to put down the newsletter and think about it.

Here is the answer. Imagine that we have placed a single, omni-directional microphone in front of an orchestra. The recording made with it will be mono, but it will contain all the acoustical information about the sound of the orchestra, and the sound of the hall, at the mike's position. The only thing missing is directionality. This can be obtained with three added signals that specify front/back, left/right and up/down positioning. In Ambisonics, these three signals are called X, Y and Z velocity components, respectively; the omni (mono) component is called W.¹

So, we wind up with four signals (omni, plus front/back, left/right and up/down directionality). Quite different from conventional quadrasonics where the four signals are the speaker feeds! So how do we get the signals we have obtained to feed the speakers?

This is handled by an Ambisonic decoder. (It really should be called a "directional processor"; "decoder" has the unfortunate connotation of matrix quadrasonics.) I could simply say that the four signals are added and subtracted to produce the speaker signals, but it isn't hard to understand the process on a slightly deeper level.

Imagine a playback system in which all four Ambisonic signals are available to us. We've placed eight speakers in the room, four in the corners on the floor and four in the corners at the ceiling. What does the decoder send to the speakers?

The omni (W) signal goes to all eight speakers with the same amplitude and phase. The front/back (X) signal is sent to the four front speakers in-phase with the omni signal and out-of-phase with the omni to the four rear speakers. Likewise, the left/right (Y) directional signal is sent in-phase to the four left speakers and out-of-phase to the right four. [If you can't figure out what happens with the up/down (Z) component, then you haven't been paying attention.] In addition, the X, Y and Z components are adjusted in relative level to compensate for the exact position and layout of the speakers. This is done with a control on the front of the decoder, after measuring the length, width and height of the speaker array.

Is this really an improvement over quadrasonics? Consider that Ambisonics satisfies all the following directional hearing characteristics (and, by the way, no form of conventional stereo or quadrasonics gets even *one* of them right!)

1. Correct positioning of sound sources at *all* positions around the listener, both for low and high frequencies.
2. Zero phasiness. (Phasiness is that strange effect you hear when your speakers are out of phase. The image is smeared and vague, and there may be a "pressure in the ears" feeling. A complete phase reversal is not necessary; anything past about a 45° shift is audible.)
3. Correct imaging no matter which way the listener turns.

The necessary W, X, Y and Z signals can be generated by the Calrec Soundfield Microphone for live recordings, or by means of the simplest forms of signal processing in the studio. There is no limitation in combining studio effects with live sound. Almost anything the producer imagines can be created. He can make sounds come from anywhere around the listener and have any apparent size; he can rotate the sound field smoothly in any direction, make it come closer or go further away, or even cause it to pass through the listener's head and come out the other side! Needless to say, these effects are difficult or impossible to achieve with quadrasonic systems. For Ambisonics, they are simple.

The system I've been describing normally requires three transmission channels for surround sound, plus a fourth if height reproduction is desired, but, even using only two channels, amazing results can be achieved.

The omni, front/back and left/right (W, X and Y) signals can be matrixed to two channels which appear to be a high quality conventional stereo signal. When de-matrixed, there will, of course, be crosstalk. *But* it can be arranged so that this crosstalk has no effect whatsoever on the ability of the decoder to establish exactly correct imaging for every position around the listener! The catch is that the reproduction will no longer have zero phasiness. But even this can be ameliorated.

The decoder can be set to have less phasiness in front at the expense of more in the rear. This works beautifully with "ambience" recordings, since the ear is more tolerant of phasiness behind a listener, and since precise imaging of the reverberant field is not as critical as it is for the direct sounds.

The big question, of course, is how it sounds. Let me put it this way: Ambisonics does everything, and does it correctly, that quadrasonics was supposed to do, but never did.

Specifically: Imaging is crisp and precise, no matter which way you turn. Reverberation is coherently related to the direct sound, not just a "wash" of echo. Audience noises come from specific places behind the listener, with a definite size and position, rather than appearing as ghostly images from an echoing space. Moving toward one speaker does not cause the field to collapse in that direction. In fact, good imaging can be heard over a much wider listening area and for a much wider range of head positions than for stereo or quad. Naturally, all these qualities are better in the three-channel version, but the two-channel system (called UHJ) is pretty amazing.

In UHJ playback, the orchestra is clearly in front and the reverberation all around you, no matter which way you turn! This is achieved without *any* gain-riding, variable-blend, phase-cancellation or logic circuitry. A simple SQ or QS decoder cannot even begin to approach this level of performance. They require complex circuitry to trick the ear into thinking the channels have been properly separated, with attendant side-effects that are sometimes audible. UHJ achieves more natural-sounding effects with no electronic gimmickry at all.

No three- or four-channel Ambisonic recordings have been released. But there are over fifty two-channel UHJ discs and tapes available, covering everything from violin and vocal, through soundtracks and sonatas, to Dixieland and chamber music. One label, Nimbus, now records only with the Soundfield microphone. And the recent IMF Electronics records, judged merely as stereo recordings, would have to rank among some of the finest discs ever produced. They are worth hearing for this reason alone.

Now for some bad news. The IMF decoder retails, stateside, for (ouch!) \$658! (In England, it's £250.) This is rather expensive. The circuitry is simple, and it should be possible to make an excellent unit for about \$300. Since several British firms have been licensed to make Ambisonics products, there should be some less expensive decoders coming along in a few months. In the meantime, you may want to start collecting Ambisonic records. (Perhaps you already have one — the "North by Northwest" soundtrack score on Varese Sarabande.) For a list of Ambisonic recordings, send a long, self-addressed, stamped envelope to: IMF Electronics, 5226 State Street, Saginaw, Michigan 48603. [IMF Electronics folded in the mid-1980s. For a list of Ambisonic recordings now, check out [Mark Anderson's Ambisonic UHJ Discography - Ed](#)].

And be sure to mention where you read about Ambisonics!

This barely scratches the surface. If you have any questions, let me know. I hope enough readers will be interested to make covering Ambisonics in more detail in a future issue worthwhile.

¹For those who are technically inclined, the velocity components are figure-8 patterns facing front, left and up, respectively.

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