

Playing with Ambisonics

This is the fifth article in our multi-part series that takes readers on a continuing quest for realistic recorded sound. The series began in the December 2014 issue with an introductory article titled, “The Continuing Quest for Realistic Recorded Sound Reproduction.” In January 2015, we explored “Quadraphonic” sound. Followed by “Surround Sound—The Next Generation: Dolby Laboratories,” in February 2015. Last month, we talked about “The 5.1 Alternative from Digital Theater Systems,” and this month we are moving on to ambisonics.

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Ambisonics was developed in the 1970s, primarily by Michael Gerzon and Peter Craven with the British National Research Development Corp. It is a full-sphere surround sound method, which means it can record sounds from above and below as well as from all horizontal directions. Like Quadraphonics, the channels do not carry speaker signals. Native ambisonic files (.amb) are in a “B-format,” which is decoded to produce the loudspeaker signals.

A web search will reveal a lot of technical information on ambisonics that you can review, if interested. But most of us do not have loudspeaker arrangements that fit an ambisonic pattern so I will mostly focus on the conversion of these files into stereo and surround sound formats such as 5.1.

Microphone Placement

First-order ambisonics is a 3-D extension of Mid-Side stereo. Two more figure-eight microphones

could be positioned for sounds arriving from front and back and above and below. Although there are practical reasons to not do it this way (e.g., the physical arrangement is large, which produces phasing problems due to difference in arrival times to the fairly wide-spaced microphone cartridges), it can be done.

Photo 1 shows a first-order B-format microphone using one omni and two figure eights, assembled by Daniel Courville (Ambisonic Studio) from the original Nimbus-Halliday design. Note that this array does not have above and below pickups. A preferred approach is a tetrahedral microphone, such as the Core Sound TetraMic shown in **Photo 2**. Its four cartridges are aimed Left-Front-Up, Right-Front-Down, Left-Back-Down, and Right-Back-Up. The output, recorded in this order, is called an A-format file. It can be easily converted to B-format with software such as VVMic from VV Audio. The



resulting first-order (more on this later) output signal is composed of W, X, Y, and Z components. W is the omnidirectional component (the Mid of Mid-Side). X is front minus back, Y is left minus right, and Z is up minus down.

I think a small first-order microphone array could be constructed from Panasonic electret condenser microphone cartridges with type WM-61A

being a good choice. It's small, inexpensive and has good sensitivity and frequency response. Although discontinued by Panasonic, they are available from other sources.

VVMic Software

The Visual Virtual Mic (VVMic) software comes in two versions: the stand-alone .exe, which includes reading an input file and saving an output file, and the VVMic.dll, a VST plug-in that uses the file I/O in the host. They are free so grab both. This software is a simple-to-use yet powerful file converter (see **Photo 3**). Besides converting A-format to B-format, it will decode B-format to a variety of outputs including stereo (user defined), quad, and 5.1 using typical loudspeaker placements for each.

Higher-Order Systems

A simple first-order system is not too useful because the spatial resolution is low—similar to quadraphonics. Higher-order systems greatly



Photo 1: Daniel Courville assembled this first-order B-format microphone array, which uses an AKG SE300B-CK92 omni and a pair of AKG SE300B-CK94 figure eights. These microphones were chosen because they have the same sensitivities. For “above” and “below” pickups, another figure-eight microphone would need to be placed horizontally parallel to the omni.



Photo 2: The TetraMic is an example of a compact ambisonic microphone.



Photo 3: The stand-alone VVMic software entry screen shows the user selections for ambisonic file conversions.



Photo 4: The Eigenmike from mh acoustics has 32 microphone elements on a 3.3" diameter sphere. Digital processing inside the sphere provides a multiplexed output on a single CAT-5 cable to the control unit.

improve the spatial resolution but at the expense of additional recording microphones and increased processing, which fortunately can be done in computer software. This processing is accomplished with what are called "virtual microphones" that can be pointed at any position on the spherical sound field to produce any desired output (e.g., stereo, quad, 5.1, 7.1, or even 22.2). At this point it may seem that ambisonics is the panacea we've been seeking. But, although microphone responses pointing in any direction can be synthesized, it does not enable the complete reconstruction of what a microphone at a different point in space would record. Hence, additional microphones are needed for higher-order ambisonics (HOA). As you might guess from the name, VVMic does its conversion with virtual microphones.

Microphone placement for effective HOA can be difficult because of physical size and phasing problems. One solution is the Eigenmike from mh acoustics (see **Photo 4**). It has 32 pickup elements arranged on a sphere 3.3" in diameter. The individual microphone outputs are combined using DSP (inside the sphere) to create a set of Eigenbeams, that is, vectors pointing to different directions in the sound field. The sound field captured by the microphone array can be electronically "aimed" in a desired direction by the software that accompanies the microphone. The bit-stream from the array goes to an Eigenmike Microphone Interface Box, which converts the multiplexed microphone signals to a 32-channel input for a Windows PC. These signals can be combined to produce B-format or other arrangements.

B-Format Processing

There are also other VST plug-ins available for B-format processing. The Five2B plug-in from Ambisonic Studio is a transcoder (converter) that takes a 5.1 surround input and produces a first-order B-format output with the Left channel at 72° left, the Right channel at 72° right, and the Center channel at 0°. The subwoofer is omnidirectional with the Left Side at 144° left and the Right Side at 144° right. In addition, this plug-in can be used with a five-channel microphone, for direct B-format recording. There are many other ambisonic plug-ins available from this source for first-, second-, third-, and fifth-order files.

(At this writing, these plug-ins are available for Mac OS X but not for Windows. Version 2 plug-ins are being developed by the original version author, Daniel Courville, for both the Mac and Windows. Check the website for updates.)

Courville provides step-by-step instructions

for converting first- and second-order B-format files to 5.1 files in his article “Decoding B-Format Music to 5.1 Surround.” His article is included in the Supplemental Material found on the *audioXpress* website. I won’t repeat all that information here but there is a point I want to emphasize. Like quadrasonics, first-order ambisonics is a quadrature system, which means it works best with the loudspeakers placed at the four corners of a square—diagonal speakers face each other. In a 5.1 system, none of the speakers (normally) face each other. And with 5.1, most of the sound comes from the front—Left, Center, and Right. Converting B-format to 5.1 has its challenges; a “good” decoder will try to maximize the channel separation while using audio information from a different set of axes.

VST Plug-Ins


Blue Ripple Sound has a free library of VST plug-ins (named TOA Core VST) for both Windows and Mac that provides the basic tools to produce a surround mix. (These plug-ins require 16 output channels, even if they are not all used, so a DAW such as Reaper is needed.) For example, with the TOA 2-Channel Panner (encoder) you can place each stereo channel in up to eight source directions in a mix with control of both azimuth and direction (four controls). The relative amplitudes can be set in the DAW. The TOA 5.1 Basic Decoder takes a 16-channel input and outputs a 5.1 surround mix. With these two plug-ins, we can take a favorite stereo track and convert it to a 5.1 stream. In all, the library offers 14 free plug-ins, including a 35-page User Guide version 1.1.4 in Adobe pdf format (see the Supplemental Material section on the *audioXpress* website).

A free B-format decoder can be downloaded from the Swiss Center for Computer Music for either Mac or Windows. It decodes to a variety of loudspeaker arrangements. Originally written for the Nuendo DAW, it has been tested with Audio Mulch and may work in other DAWs.

The University of York Music Technology Group also has some free VST tools, including the B-Plane Mirror, which lets you change the azimuth and elevation of the sources in a B-format file. I suppose this could produce some interesting effects.

You can download free B-format music files from several sources including: the Adriano Farina website for music he recorded at La Casa della Musica, Parma, Italy in 2007; the Ambisonic Studio website (click on any of the Music tabs); the last.fm website; and Ambisonia. The Ambisonic site is especially interesting because for most .amb files, you can also download the same music converted to 5.1 DTS.

A good two-page list of ambisonic sources can be found at www.ambisonic.net/gear.html and a general ambisonic reference can be downloaded from www.ambisonics.com.

I have included an .amb file in the Supplementary Material to get you started. It is a concerto in D major by Arcangelo Corelli as recorded by Adriano Farina. 

About the Author

Ron Tipton has degrees in electrical engineering from New Mexico State University and is retired from an engineering position at White Sands Missile Range. In 1957, he started Testronic Development Laboratory (now TDL Technology) to develop audio electronics. He is still the TDL president and principal designer.

Project Files

To download additional material and files, visit <http://audioxpress.com/page/audioXpress-Supplementary-Material.html>.

Resources

Blue Ripple Sound, Ltd., www.blueripplesound.com.

D. Courville, Ambisonic Studio, www.ambisonicstudio.com.

E. Deleflie, Ambisonia, the Music Research Centre, University of York, www.ambisonia.com.

Last.fm, www.last.fm/tag/ambisonic.

R. Tipton, “The Continuing Quest for Realistic Recorded Sound Reproduction,” *audioXpress*, December 2014.

———, “Quadrasonic,” *audioXpress*, January 2015.

———, “Surround Sound—The Next Generation: Dolby Laboratories,” *audioXpress*, February 2015.

———, “The 5.1 Alternative from Digital Theater Systems,” *audioXpress*, March 2015.

Swiss Center for Computer Music, www.dmalham.freemove.co.uk/vst_ambisonics.html.

University of York Music Technology Group, “VST Ambisonic Tools,” www.york.ac.uk/inst/mustech/3d_audio/vst/bfpmirror_help.html.

Sources

Reaper DAW

Cockos, Inc. | www.cockos.com/reaper

TetraMic

Core Sound, LLC | www.core-sound.com

Eigenmike microphone

mh acoustics, LLC | www.mhacoustics.com

Type WM-61A electret condenser microphone cartridges

Panasonic Corp. | www.industrial.panasonic.com

VVMic

VVAudio | www.vvavideo.com