

GUEST COMMENTARY

## Surround: HD Radio's Wow Factor

### 5.1 Surround Sound for Radio Is An Imminent and Welcome Change

by Steve Church

Your car probably has four speakers, or more. But you are using them to listen to two-channel FM broadcasts — a technology that was invented in the 1950s.

Now imagine that your radio is pumping out immersive digital surround music and cinematic production effects, the sort of thing that you hear in a well-equipped movie theater or on a state-of-the-art home surround set-up. Wouldn't you think this to be a much better way of introducing the benefits of digital radio broadcasting to the public than the "improved stereo" message HD Radio offers now?

Look around and you will see plenty of action in the surround audio sphere. DVD Video audio tracks are universally in the 5.1 format. You will see surround speaker setups in any store that sells audio or video equipment. Even computer shops are full of 5.1 sound cards and speaker systems. The new DVD Audio and SACD disks are almost always produced in surround.

#### Surround sense

While the focus for multi-channel audio has been elsewhere, surround actually makes a lot of sense for radio.

A lot of listening occurs in cars, and the environment there is good for enjoying multi-channel music, as there is no problem to find space for the four or five speakers and sub-woofer. In contrast to an office or home, you are in a stable position relative to the speakers. High-end audio systems that play DVD Audio surround disks in cars are coming soon to the market. The

Acura TL and some new Cadillacs will include this as factory standard.

But there hasn't been much talk yet about surround for radio. That is because the technology needed to accomplish it effectively has just recently been invented, and is only now being introduced.

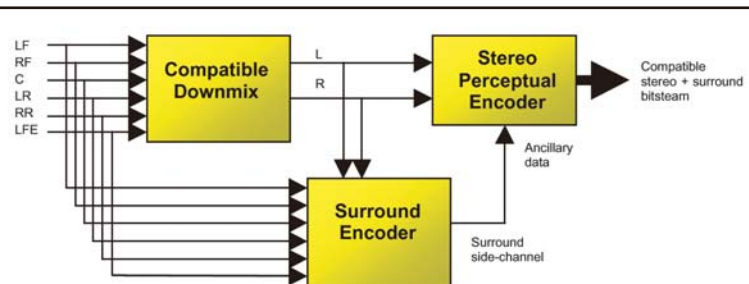


Figure 1: Encoding (transmitter) side

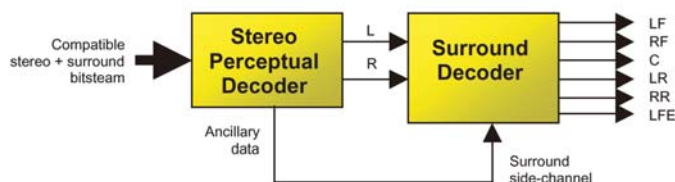


Figure 2: Decoding (receiver) side

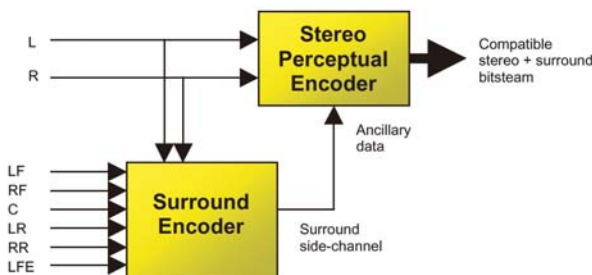


Figure 3: Encoder with external downmix process

Just a few years ago, it seemed we didn't have enough bandwidth for quality stereo in IBOC, let alone surround. But multi-channel audio coding technology has advanced quite amazingly, and with surround a real possibility for radio broadcasting, you can expect to hear a lot about it in the coming months.

Fraunhofer Institute (FhG), inventors of MP3 and most of MPEG AAC, has been pushing the frontiers of audio perceptual research. The latest result, achieved in partnership with Agere Systems, is a powerful spatial audio coding system that takes advantage of state-of-the-art knowledge in aural perception.

From psychoacoustics studies, we know that only three factors are required for the perception of a spatial image: level difference, time difference and

than 20 kbps, a rate that is possible in HD Radio's ancillary data channel. The total bit rate can be set to 96 kbps, the capacity of HD Radio transmissions.

We demonstrated this system to a number of engineers at NAB2004 in private meetings and in a hotel room with a high-quality surround set-up. The near universal reaction was, "Wow! That works!" Many listeners went on to comment that surround, powered by this technology, would be the "killer app" for HD Radio.

Where will we get the music to play? In fact, there is a lot of material already available in multi-channel, such as a few hundred DVD Audio and SACD surround discs to get us started. These are perfect source material for surround HD Radio, and are off-the-shelf today. A bit

coded using any perceptual codec. Because there are no changes to the basic codec, this stereo signal can be received by stereo radios. The spatial encoder extracts the various spatial cue parameters from the multi-channel input, which are transmitted in an ancillary data channel. The decoder, if present in the receiver, recreates the original multi-channel audio.

In the diagrams, you can see that we need to have a downmix function to create the compatible stereo channels from the multi-channel source. The most obvious way to do this is with simple linear combiner, as follows:

$$\begin{aligned} L &= L_{\text{front}} + a * L_{\text{rear}} + b * \text{Center} \\ R &= R_{\text{front}} + a * R_{\text{rear}} + b * \text{Center} \end{aligned}$$

where a and b are constant scale factors, with the values usually ranging from .5 to .7.

But this simple procedure is far from the best. We must present a stereo mix to listeners without multi-channel receivers that sounds as good as a stereo-only broadcast. Simply collapsing the front and back signals into a two-channel representation may cause confusion in the normal binaural cues and degrade stereo listening. And it almost certainly will sound different from the version that listeners are used to hearing.

The FhG system allows a producer to make a manual downmix, thus preserving artistic freedom and allowing flexibility to adapt to different kinds of audio material. Because almost all music released in surround format also has a stereo version on the same disk that could be used as input to the encoder, this stereo version is what would be heard by listeners with non-surround radios — with no modification or compromise of any kind.

Maybe you remember the quadraphonic systems from the 1970s that had a brief and unsuccessful run on vinyl and at a few radio stations? Don't confuse this modern multi-channel perceptual approach with those, or any of the many descendants that are vying for radio's attention. While these latter systems have new names, they simply act as lipstick applied to the withered old lips of the failed '70s vinyl quad schemes. They have the critical drawback that only

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## Wouldn't you like to listen to your station in surround? Isn't this a win for all?

coherence between channels. The key to FhG's new multi-channel system is that these difference values are represented with compact coding, rather than transmitting the individual audio channels. The encoder estimates the values as a function of frequency (that is, within each of a number of sub-bands) and transmits them to the decoder in an ancillary stream that accompanies the main coded audio stream.

### Killer app?

That's all well and good, I hear you asking, but will this work with HD Radio? The astonishing answer is: yes. The FhG spatial encoding system is compatible with HD Radio's current codec for the stereo channels. And the side-channel for spatial information is less

perfect, but still useful, are the Dolby Digital and DTS 5.1 audio tracks that accompany DVD video clips and concerts.

With surround broadcasting up and running, record companies will have a powerful incentive to release new material in multi-channel. If the music industry offers music in a surround format, and radio promotes it, they will be selling their libraries all over again as happened with the transition from vinyl to CDs. They should love radio moving to surround broadcasting and be supportive with audio material.

### Multi-channel approach

The block diagrams illustrate how an encoder/decoder pair would work within a broadcast channel. The stereo signal is

fixed-scale downmixes are possible, so stereo compatibility suffers.

This is one reason the '70s-era matrix systems didn't catch on, as they had a weird, soft and indistinct quality in stereo. Clearly, this is an important issue for broadcasters. With most people listening in stereo, we can't afford to compromise our fundamental service.

Another problem with matrix schemes is poor surround separation. Matrix systems must mingle everything into a two-channel signal, a crippling constraint on performance. They can have only a few dB of separation between some of the channel pairs. Which channels get the separation and which don't are design compromises, and each system deals with this differently.

Because FhG's spatial encoding uses an independent digital side-channel and a modern perceptual approach to spatial cue encoding, it offers high separation that does not depend on the nature of the audio or that needs to be compromised for stereo compatibility.

By the way, beware of matrix demonstrations using material in one or two channels at a time. These are deceptive because a steering circuit — a gain processor in something like a noise-gate configuration combined with an operation that dynamically varies the matrix coefficients — detects this directional condition and steers the strongest signal into the target channel, while reducing gain or providing some kind of cancellation in the other channels. This approach is also a leftover from the '70s, having first been used in the Vario-Matrix "logic" schemes.

With normal programming, which has material present in all channels simultane-

ously, the separation is dependent upon the underlying matrix scheme and is much poorer than the demonstrations suggest. At NAB, we let people listen to the difference between Dolby ProLogic 2, a state-of-the-art matrix system, and the FhG system. It was unanimous that the FhG system was far superior.

### **Crossroads**

We think radio deserves better than a simulated or matrixed system. Broadcast, cable and satellite television will have true 5.1 surround sound, as do DVDs. Back in the days of the transition from mono to stereo, some records were released in a "re-channeled for stereo" version and were not taken seriously by anyone who cared at all about sound. Radio is a crossroads. We can either let the other digital media overtake us, or we can ride the tech wave and remain relevant.

A well-produced DVD surround disc offers a remarkable listening experience, and more and more people are going to have that experience. Not taking advantage of the best technology is going to put radio in a bad position compared to alternatives. Imagine what would have happened if radio was stuck at AM fidelity when compact disks came along. Something similar is going to happen if we make the wrong choices now.

The ISO/MPEG audio group has noted these recent advances and their market potential, and has begun working on Spatial Audio Coding. FhG will submit their spatial approach to MPEG for consideration and testing, and chances are good that it or some varia-


tion will eventually be approved as an international standard. Thus there will be the usual advantages of MPEG: an independent confirmation of performance, and assurance of fair and equal access to licensing.

One lesson from DAB in Europe is that "improved digital sound" is not enough to cause listeners to buy new and more expensive radios. We need a significant and clear message to motivate change.

Have a look at any shop that sells car audio gear. See all the multi-speaker setups? The subwoofers? The early adopters who are looking for the maximum aural experience? What about all the people with surround home theater systems? Wouldn't immersive audio on your air appeal to them — and be a good thing for your station? Wouldn't you like to listen to your station in surround?

And isn't this a win for all? Listeners get something compelling, new and interesting. They already know about 5.1 from their exposure to home theater and could readily imagine the benefits of having that experience in their cars. FM radio stations again take the lead in offering a superior audio technology. HD Radio gets a clear and understandable value proposition. Record companies get to sell their libraries all over again — and in a format less amenable to MP3 copying.

Programmers and production directors get to create cinematic high-wow-factor promo pieces to breathe new life into programming. So, when do we start?

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