Surround sound for digital radio

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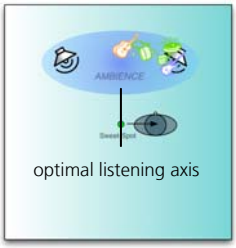
Why Surround Sound?

„Bring Carnegie Hall to your living room!“ could be the slogan for multi-channel music. The sound experience is made possible by a special setup of speakers, the so-called 5.1 surround home theatre system. Three of the five speakers are positioned in front of the listener, two in the rear, while the subwoofer produces the resounding low notes and can be placed out of sight. The listener is instantly engulfed by the music and is able to feel it physically. This spatial experience is created by delivering the ambient reflections and reverberation tails of a concert hall or of a studio environment via the rear speakers. Through the integration of the center speaker, the sound panorama remains stable in a larger space. Additionally, the surround-sound effect encompasses the listener from all directions.



Stereo Playback

Surround Playback

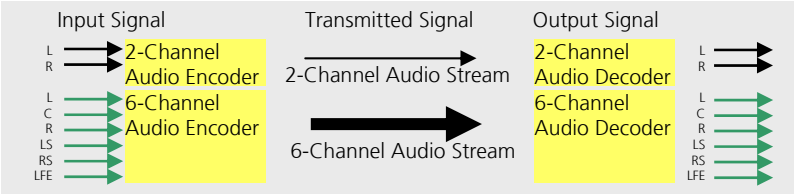
Surround loudspeakers cannot only be used to present more true-to-life audio but also to artfully edit and remix multi-track recordings; thirdly, they can also be used as pure effect channels. This adds a new dimension to the artistic freedom in audio production for music, audio books or films.

Transmission of Multi-Channel Sound

Compared to the stereo format, surround sound almost triples the volume of data, and data compression becomes even more crucial for an economic multi-channel transmission. Various compression methods are possible:

Discrete Coding

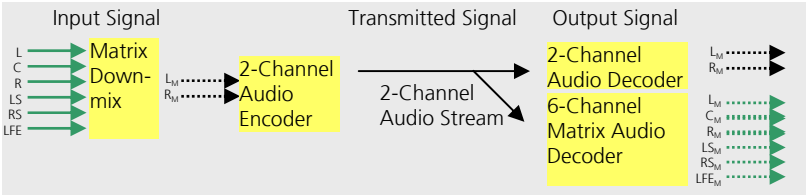
Using this method, the channels are coded independently; this results in a very high quality, yet at rather high data rates (e.g. 192-256 kbit/s with MPEG-4 AAC or 384 kbit/s or more with Dolby Digital). Many broadcast applications require lower data rates than that, and discrete coding only provides either surround or stereo audio in one bit stream.



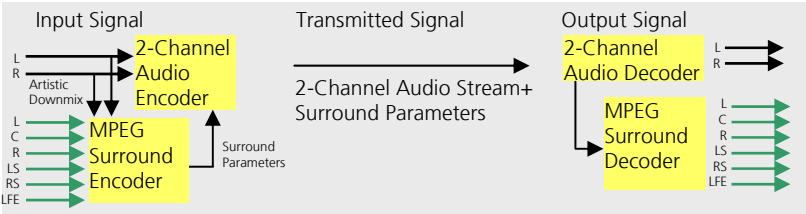
If broadcasters only transmit a surround signal and do not simulcast stereo audio, the stereo receivers have to generate some automatic stereo downmix from the surround signal.

Matrix Coding

To transmit multi-channel music in a bit-efficient manner, broadcasters often use a type of matrix coding. The multi-channel sound is matrix-encoded into a two-channel stereo downmix signal by using fixed calculation rules. The downmix contains basic information about the original distribution of the signal parts, and the matrix-decoder generates the multi-channel feed out of the stereo downmix. In many cases, there will be parts of the signal appearing in channels where they were not intended to be in the first place. This leads to an imprecise spatial sound image and therefore a limited audio quality. Stereo systems won't reproduce the stereo downmix in a perfect quality either because it was generated for surround systems.



Spatial Coding
Spatial coding allows for stereo compatible surround sound in very high quality with the low bit rates of stereo transmission. The multi-channel signal is represented by a mono or stereo downmix along with a very compact set of surround parameters. The downmix signal can be extracted automatically – according to common EBU/ITU standards – or artistically (see picture), such as a uniquely adapted version from the sound engineer. The set of surround parameters contains the required cues for the spatial sound perception of the original acoustic scene.
A key advantage of spatial coding is the efficient representation of the surround sound at a high quality level. One audio coding standard that works with spatial coding is MPEG Surround. It has a data rate of about 3 to 16 kbit/s for surround parameters. The downmix signal can be compressed with any audio codec, for example MPEG-4 HE-AAC (as used in DAB+) but also with MPEG Audio Layer 2 (as used in DAB).
PAD multimedia data such as Dynamic Labels (title/artist information, new headlines etc.) or Slideshow are not affected by the surround data.
The audio signal is fully compatible with legacy stereo setups as they decode and play the stereo downmix and ignore the surround side information – avoiding simulcasting of surround and stereo signals.



Typical characteristics of multi-channel compression methods

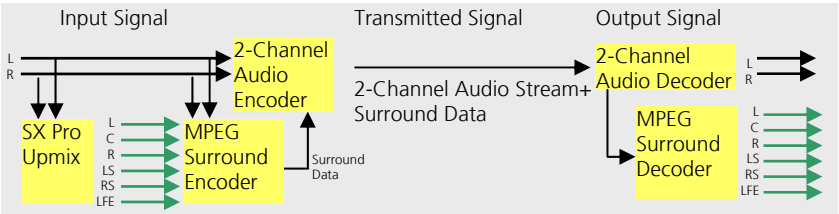
Multi-channel Coding	**Discrete**	**Matrix**	**Spatial**
Bit rate needs	Very high	Low	Low
Audio quality	Very high	Moderate	High
Compatible to Mono/Stereo	No	Yes, but poor audio quality	Yes
Artistic Downmix	No	No	Yes
Some Example Products	Dolby Digital, DTS, MPEG-4 AAC	Dolby Pro Logic II, Neural, SRS	MPEG Surround, MP3 Surround

Making 6 out of 2 – Upmix Processing

In case of limited availability of surround sound content, some form of upmix processing is inevitable. A matrix-based upmix on the receiver side is one possibility. However without any influence on the upmix process, the broadcaster has no control over the resulting output sound quality for the listener. In many cases, this results in unclear and often low surround quality.

Doing the upmix process on the broadcasting side is possible, for example, with a new algorithm called SX Pro, developed by Fraunhofer Institute for Integrated Circuits IIS. It analyzes the stereo audio signal to identify characteristic sound elements and – in default mode – redistribute those elements to create a natural sound image. The centered sound elements (such as lead vocals) will be reproduced over the center front channel while the ambient sound (e.g. applause) comes from the rear channels.

If those six or more channels are coded with the aforementioned MPEG Surround, the original stereo signal can be used as a compatible artistic downmix. Therefore, the radio broadcaster has full control over the resulting sound quality – in the surround *and* stereo decoding mode. For multichannel transmission the broadcaster has full creative control over the upmix process, deciding whether to create a natural upmix that is close to the original stereo image or to highlight the multi-channel effect through creating an impressive version with a powerful surround image. And for stereo receivers, the known quality from the stereo original will be used.



On the Receiver Side

MPEG Surround is backwards compatible, so all mono or stereo receivers will ignore the surround parameters. Advanced receivers however, can evaluate these parameters and reproduce high quality surround sound.

Even at high speed, digital radio reception in a car is very stable. Since most modern cars are equipped with more than two speakers, automotive surround sound can potentially enhance the entertainment experience in the car.

Mobile devices for digital radio benefit from the new surround sound as well: MPEG Surround features a special binaural mode that generates surround sound on conventional headphones

And of course, playback in the living room is possible with the appropriate speaker setup.

Cost-efficient Distribution

The enormous advantage of DAB with MPEG Surround for broadcast stations is that they can offer significantly improved audio services at practically no additional cost while their programmes remain fully backward compatible with mono or stereo receivers. This is achieved by a fully backward compatible signal at very low additional bit rates.


WORLD
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