AURO-SPACE

The entry-level immersive sound technology for compact stereo systems

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AURO-3D® LEGACY / BACKGROUND

The reproduction of sound has seen an enormous evolution, even though the original intent has not changed: to deliver the most natural, immersive listening experience to the audience. Over the years the technology and formats to achieve this have been evolving, starting from mono. Stereo recording was the first major revolution and has been (and still is) the main audio format for many decades. Only since the mid 1990's, surround recording became popular in consumer homes, with the 5.1 format being the standard for more than 20 years.

Amongst audio professionals, however, it was always felt that this established format, originally developed for cinema theatres, was still not able to achieve the old-age goal for natural sound.
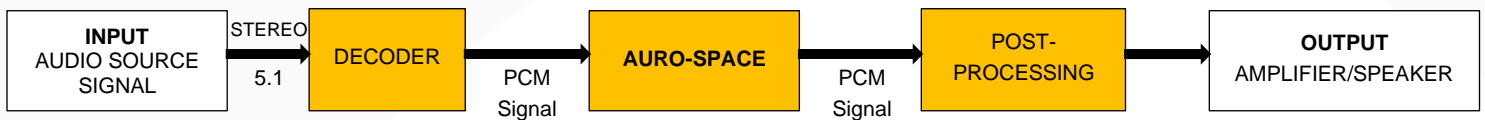
In 2005 the Auro-3D® listening format was introduced and finally the ultimate listening experience became available: 3-dimensional sound, sometimes referred to as multichannel sound with Height. Indeed, the introduction of the Height layer in the Auro-3D® format is considered to be the ultimate step in providing a lifelike immersive experience to the audience, both in movie theatres and the consumer home. In practice, it requires the deployment of a few speakers in three layers – Low, Height, Top – in specific positions all around the listening area. However, in the case of the consumer home, constraints like placement, integration, and budget, do not allow for the setup of the required number of speakers and the enjoyment of the full 3D sound experience. Instead, the market trends in the consumer audio world propose more and more compact sound equipment that integrate nicely and easily into home environments.

The emergence of soundbars for home cinema applications is a good example of such market trends that led to new challenges at NEWAURO's R&D center. In particular, it raised the following fundamental question: "How to bring the breathtaking Auro-3D immersive experience to consumer homes through compact sound systems such as soundbars located in front of the listening area only?" This is where the development of dedicated sound processing solutions found their motivation. In the specific case of compact stereo systems, the question found its answer in the Auro®-Space spatial enhancement algorithm.

Auro®-Space is a digital sound processing technology that was designed to offer to the end-user a first taste of the high-quality Auro-3D® listening experience by virtually creating a spatially enhanced version of the audio content (stereo to 5.1) played back on compact stereo systems such as stereo soundbars, TVs, car audio systems, etc…. Integrating the Auro-Space DSP solution in such a device allows the listener to make a first step into the amazing world of 3D audio by significantly improving the sound immersive experience from his/her regular stereo system.

AURO®-SPACE HIGHLIGHTS

Auro®-Space is an audio DSP feature designed to be integrated into an audio playback product between the typical bitstream decoders (such as PCM, MP3, AAC, Dolby Digital, etc…) and certain compatible post-processing blocks as illustrated below.

| INPUT
AUDIO SOURCE
SIGNAL | STEREO
5.1 | DECODER | PCM
Signal | AURO-SPACE | PCM
Signal | POST-
PROCESSING | OUTPUT
AMPLIFIER/SPEAKER |

The main capabilities of the feature are highlighted in the following.

INPUT/OUTPUT FORMAT SUPPORT

Auro®-Space supports input signals from stereo to 5.1 surround for an enhanced music and movie experience. The input signal should be in PCM format at the standard sample rates. The differentiation between stereo and multi-channel content is done seamlessly as the algorithm can automatically detect the number of channels of the input stream to be processed and adapt accordingly.

Auro®-Space is designed for stereo systems and is also capable of generating an additional Center and a Subwoofer output signal. Thus, all possible output configurations from 2.0 to 3.1 are supported.

SOUND ENHANCEMENT FEATURES

The Auro®-Space processing considerably enhances the sound performance of the playback device in which it is implemented. It provides a more immersive sound experience without any compromise on the sound quality, delivering rich and powerful bass while improving dialog clarity and intelligibility. The result is a major enhancement of the sound experience based on three key features:

- **Spatial Enhancement** provides an increased surround sound immersion enhancing all 3 dimensions – Width, Depth and even Height – of the sound stage leading to the premises of 3D sound. As the feature achieves a wider and deeper sound stage while virtually creating height sensation, it also improves the spatial resolution of the sound events. Thus, perception of sounds coming from above and sides is made possible allowing an actual feeling of being surrounded by sound.

- **Dynamic Sound Enhancement** produces deeper and tighter bass, extended highs, and maintains articulated midrange better defined in a wider space. Dynamic processing allows it to be played louder while controlling the tonal balance for a powerful sound experience.

- **Voice Enhancement** makes the central content, and in particular voices, clear and intelligible at all levels. Whether the input content is multi-channel with a dedicated center channel, or stereo without any center channel, Auro®-Space is capable of extracting the center information to increase dialogue intelligibility and voice presence in all situations.
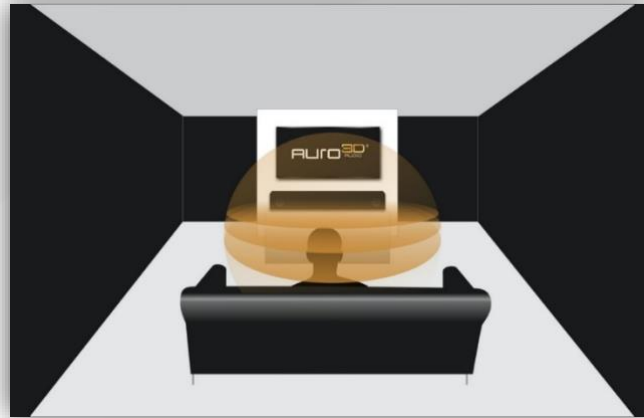
USER PRESETS

Auro®-Space provides enough flexibility to listeners to tailor sound to their needs thanks to 4 different presets available as user control:

- **Low** – Provides subtle settings for a spatial immersion slightly improved while focusing on a natural sound balance.
- **Medium** – Implemented as the default setting, it offers the best compromise between immersion and naturalness.
- **High** – Achieves the maximum level of spatial enhancement while providing the strongest amount of bass Auro®-Space is capable of. Ideal for those seeking the most impressive sound experience.
- **Voice** – Dedicated to voice enhancement while maintaining a minimum level of spatial enhancement, it is especially useful for radio content or TV programs.

OPTIONAL FEATURES

Auro®-Space comes with two optional processing blocks - a bass management unit and an output limiter - to simplify the integration into audio products and optimize the output signal to be sent to the speakers.

- **Bass management** – Set of cross-over filters used to send an optimized signal to the speakers by removing the low-end part and sending it instead to the subwoofer if available. Properly tuned, it makes the bass reproduction seamless, clean, and powerful.
- **Output limiter** – Single-band hard limiter used to prevent signals from clipping and protect the audio playback system from eventual damages. Properly tuned, it allows for maximum level output without artifacts

AURO®-SPACE ENHANCER: HOW IT WORKS

Let's dive a little bit deeper into the Auro®-Space design. As already mentioned, the main intention is to provide the listener with a 3D sound impression from a single compact stereo device, generally located at the front of the listening area.

Getting a 3D sound experience out of such a device including only two speakers, or three in case of a center channel, needs the development of a so-called 'virtualizer'.

The idea is to create virtual sound sources all around the listening area much beyond the actual position of the speakers that are close to each other. To do so, cutting-edge spatial sound processing technologies have been developed by NEWAURO's R&D center that allow best-in-class sound virtualization from a small number of speakers. Note that without any spatial processing, the sound experience would be close to monophonic, i.e. coming from only one direction. Instead, we can go beyond the limitations of regular stereo systems to offer that first taste of 3D sound to the listeners who will then perceive virtual sound coming from the sides and above the head. The Auro®-Space spatial enhancement algorithm combines different core technologies in a very specific way to enhance the surround sound experience. Those key audio processing technologies are described in the following.

- Decorrelation is a signal processing technique used as an upmix method to generate a Height signal and add the vertical dimension to the listening experience. In fact, unlike correlated audio signals, decorrelated signals are generally perceived as distinct audio events. Thus, creating a decorrelated copy of an input signal results in an upmixed signal that can be used to spatially enhance the original content. Auro®-Space's decorrelation algorithm, based on Auro's proprietary upmixer Auro-Matic®, makes use of this principle to create a Height signal decorrelated from the input and thus create more space around the sound stage.

- Virtual Height Filters are applied to the Height signal content upmixed by the decorrelation algorithm. They enable the height signal played through front-firing speakers to be perceived as actually coming from overhead.

- Crosstalk Cancellation Filters (XTC) are used to increase the width of the sound stage up to 180 degrees and also improve the spatial resolution of the perceived sound events, meaning they can be better localized in space. A crosstalk signal, also referred to as a contralateral signal, is a signal coming from a front side speaker, right side for instance, and reaching the opposite ear, that is left in that case. Cancelling crosstalk out or at least attenuating it allows the listener to perceive sound coming from the right speaker at his/her right ear only, and from the left speaker at his/her left ear only, leading to a much wider sound stage. XTC can be viewed as a virtualization technique dedicated to virtually move the front speakers to both sides of the listener's head, as illustrated below.
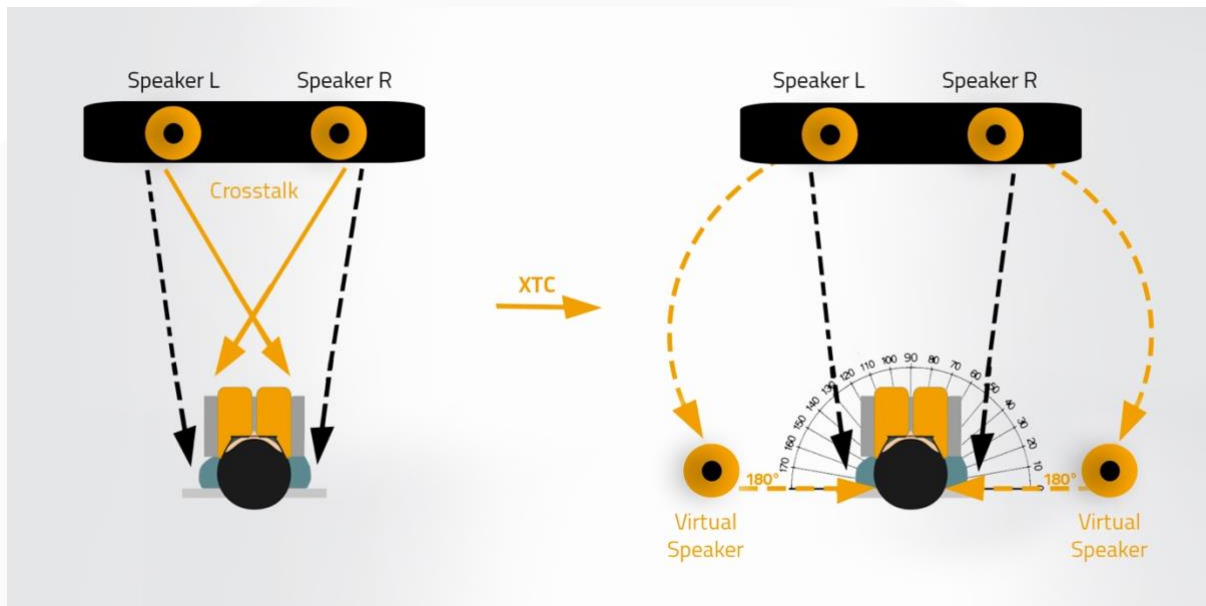
- **Center Extraction** technology is key to process the center channel including voice separately from the rest of the content that will be virtualized to create space and immersion. When the input content doesn't include a dedicated center channel like in the stereo case, Auro's proprietary center extraction technology is capable of generating the center content, in particular voice, to be processed separately to get a more present center image and to enhance dialogues and vocals.

Virtualizing sound generally introduces sound coloration. That is why controlling the tonal balance of spatially processed audio signals is critical. The experts at Auro were able to reduce the coloration of virtualized components to the absolute minimum and even enhance the global sound performances of non-virtualized ones, like the center. Auro®-Space further makes use of multi-band compressors to dynamically enhance the sound balance and get optimized bass at all levels.

IMMERSIVE SOUND FOR ALL

Auro®-Space is the entry-level, but still high-quality solution within Auro Technologies' portfolio. It is an affordable sound processing solution to elevate the experience of a stereo system to amazing new levels by delivering the excitement of 3D sound for music, games, and movies while enhancing existing audio-visual collections with high audio quality and full system compatibility.

RANGE OF APPLICATIONS

Auro®-Space is intended to be integrated into a wide range of stereo playback systems. Its unique design and support for output configurations from stereo to 3.1 setups makes it perfectly suitable for audio devices including two or three built-in speakers such as:

Entry-Level Soundbars without side- or up-firing speakers

TV Sets

Car Audio Systems

Smart Speakers

Any other stereo sound device with close range speakers like mobile devices can also be enhanced by the Auro-Space technology.

COST-EFFECTIVE SOLUTION

Each of the sound processing blocks used to create the Auro®-Space enhancer has been optimized to deliver a feature with low MIPS consumption to fit in a low-power DSP. The combination of low DSP requirements and high enhancement effects lead to a first-of-a-kind audio DSP technology on the market. It is the perfect cost-effective solution for almost any compact stereo reproduction product to make immersive sound possible for all.

At the time of the publication of this white paper, the following platforms are supported:

- TI-C66x
- ADI Griffin-Lite, Griffin Ultra-Lite
- ARM53 (Android10, Linux)
- x86-32|64 (Linux, macOS, Win10)