



Technical Whitepaper

This document explains the technology and applications of the first suite of Audistry's features. The paper is intended for engineers and other technical staff in DSP and consumer product manufacturing organizations. It provides technical details of the operation and audio performance of Audistry features, and explains how they can dramatically improve the audio performance of your products.

The features of Audistry

Audistry features represent a whole new approach to some familiar audio enhancements that influence consumer choices every day.

This approach is based on our knowledge, experience and unparalleled background in the development of sophisticated audio technologies, advanced acoustic research, architectural acoustics, surround-sound simulation and live sound performance.

Our background in applied digital audio applications and the underlying know-how and technologies brings a fresh thinking to audio. This enables us to improve both the quality and impact of feature enhancements, bringing a new level of sophistication to the post-processing audio market.

Audistry will make your products stand out from the rest.

Audistry has five features:

Sound Space Expander – a sound stage enhancer for stereo speaker systems

Sound Space for Headphones – a 3D stereo image enhancer for stereo headphones

Natural Bass – a bass enhancement system for speakers and headphones

Intelligent Volume Control – a peak limiter and expander that provides a pleasant listening experience by making the loud sounds softer and the soft sounds louder.

Mono-to-Stereo Creator – a mono-to-stereo audio converter.

All these features are designed to work perfectly together, when used in any combination. We will examine each of these features in more detail.

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Sound Space Expander

Sound Space Expander is a stereo image-widening system that can widen the perceived stereo field of speakers without making it sound unnatural or artificial.

The challenge: to produce a stereo image from close-set speakers

Stereo image-widening is desirable in any situation, but is particularly effective where stereo speakers have to be placed close to each other, such as in portable stereos, PCs and TVs. In these situations the stereo effect is diminished and the sound becomes close to mono.

The challenge is to widen the stereo field without altering the balance of the soundscape.

Conventional image-widening systems often produce a number of undesirable side effects, including:

frequency-smearing – some frequencies of a particular instrument are panned further than others, making it hard to pinpoint the position of the instrument in the stereo field

loss of center – by spreading the image wider, the clarity and volume of sounds in the center diminish proportionally, causing a loss of bass and instrument separation, and unnatural-sounding vocals or dialogue.

We have an extensive background in creating and controlling three-dimensional sound fields using DSPs. An example of this is our implementation of real-time, three-dimensional audio fields that create realistic sound simulations for playback, over large multi-speaker systems and headphones.

The solution: symmetry and advanced technique

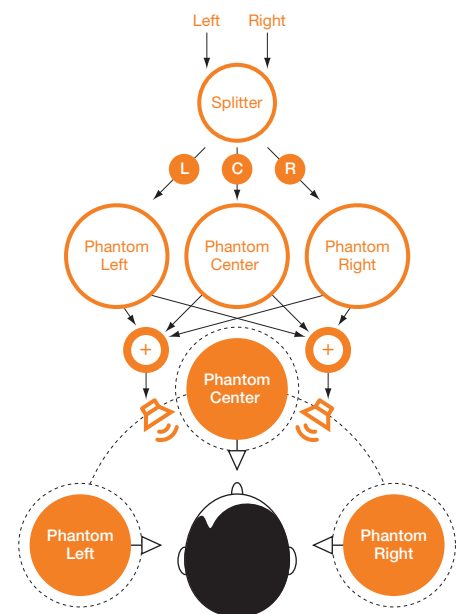
Sound Space Expander embodies the experience and techniques of this research. It applies the same principles that work in multi-speaker systems to stereo systems to provide a convincing sound image to the listener, while maintaining the integrity and balance of the sound.

Using the symmetrical positioning of the speakers and applying our advanced patented technique, Sound Space Expander creates stable, solid stereo images with a very wide field that 'wraps' around the listener. By focussing on the left-right panned elements of the sound, while carefully maintaining the stable localization of the center channel, Sound Space Expander creates a clean and convincing sound field around the listener.

In expanding the image, Sound Space Expander also un.masks sounds that were previously obscured in the 'clutter' of the mix. This increase in angular separation enables the listener to hear the complete frequency spectrum of each individual sound element in a clearly-discernible lateral location.

The listener can choose the width of image they want, by setting Sound Space Expander to Full, Half or Off.

This diagram illustrates how Sound Space Expander works:



The result: a wide stereo image from a narrow sound source

Sound Space Expander produces a wide stereo image and in the process it improves the separation of instruments without diminishing the center of the mix.

This means that a superb sound stage enhancement can be created over closely-spaced stereo speakers, while maintaining the intent, quality and integrity of the content.

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Sound Space for Headphones

Sound Space for Headphones is a stereo field enhancer that enables the listener to hear sound through headphones as if it were a spread stereo field, positioned in three-dimensional space in front of them.

The challenge: to make headphones sound natural

External sounds arrive at each ear at different times, but because headphones are so close to the ear, they cannot reproduce these variations in timing. Consequently, a major drawback of headphones is listener fatigue: the sound requires more effort to process than sounds usually heard from ‘outside’.

Another drawback of headphones is the ‘inside the head’ effect. Any sound located in the dead center of the stereo image seems to the listener to be coming from inside their head, while those elements that are panned left or right sound as if they are directly beside them. This is unnatural, and never occurs in real life.

The challenge is to defeat these effects by producing a more natural headphone listening environment. Some approaches to date have addressed the ear fatigue issue, but have not treated the ‘inside the head’ effect. Uncorrelated and indiscriminate use of reverb to move the sound ‘out of head’ can adversely affect the EQ and result in a boomy, unnatural sound.

The solution: simulating real loudspeakers

Sound Space for Headphones creates the illusion of clearly localized sound sources, outside the head. It takes two input channels and presents them as three distinct locations: left, center and right. This simulates the effect of being in front of a set of loudspeakers; as far

as the listener’s ears are concerned, they don’t feel like they are wearing headphones at all.

Sound Space for Headphones does this by sending some of the left signal to the right ear and vice versa, simulating the way sound propagates to our ears in real acoustic environments. This crosstalk is more like real life and creates a normal stereo field, where speakers are placed in front of the listener, helping to get the sound ‘out of head’ and reducing listener fatigue.

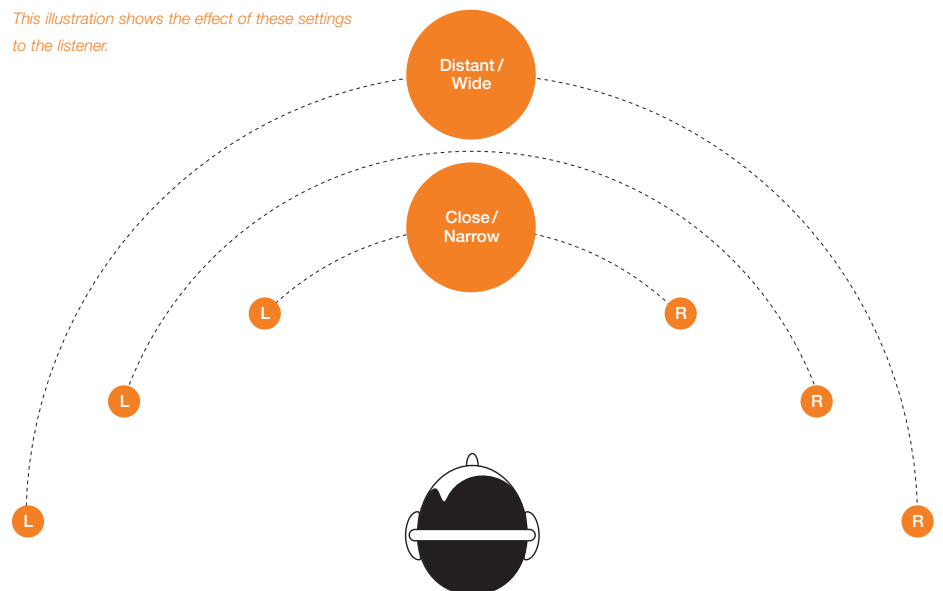
The listener can choose from seven settings that determine the dimensions of the soundscape. No matter which one they choose, the center of the soundscape is always directly in front.

Sound Space for Headphones also creates different room simulations at these soundstage widths, so the listener can choose the type of virtual room they find most comfortable for listening to a particular type of music.

The result: privacy and mobility in real stereo

Sound Space for Headphones eliminates the ‘inside the head’ and listener fatigue effects, and instead provides a realistic 3D stereo image. As a result, the listener can enjoy all the benefits of headphones, such as privacy and portability, but with the comfort and full 3D soundscape of an open speaker system.

This illustration shows the effect of these settings to the listener.



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Natural Bass

Natural Bass is a low frequency enhancement algorithm that harnesses the natural characteristics and performance limitations of audio systems. Natural Bass enables speakers to produce as much bass performance as possible without distorting the sound or risking damage to any components.

In short, Natural Bass is designed to produce an optimal, more natural-sounding bass response from speakers of almost any size.

The challenge: to produce authentic bass from small speakers

Bass response is a function of speaker area and displacement, so it is never going to be easy to get natural sounding bass from a three-inch speaker, small speakers struggle to create the fundamental wavelengths. In the many products where small speakers are essential, such as portable stereos and televisions, reproducing an authentic bass response is a significant issue for the audio engineer. It is also considered a key feature by consumers.

The challenge is to overcome the natural roll off characteristics of a given speaker and extend it lower in frequency. The added challenge is to do this without over-extending the cone excursion capabilities of the speaker, which can produce low frequency distortion and possibly damage components.

Various methods have been tried, including harmonic reinforcement that adds upper harmonics that the speaker can produce. This is done on the basis that the listener's brain will add the lower frequencies it, perceives should be there, but which are not being produced by the system.

Unfortunately, if used as the sole method of bass enhancement, this method often produces non-harmonic distortions as the filter tries to generate harmonics of frequencies that are an amalgam of multiple instruments. This results in an unnatural, discolored and often 'muddy' sound.

Using simplistic EQ or allowing consumers to boost bass frequencies indiscriminately can lead to further distortion (particularly during transient peaks), and an unbalanced, unnatural sounding output.

The solution: knowing the capabilities of the system

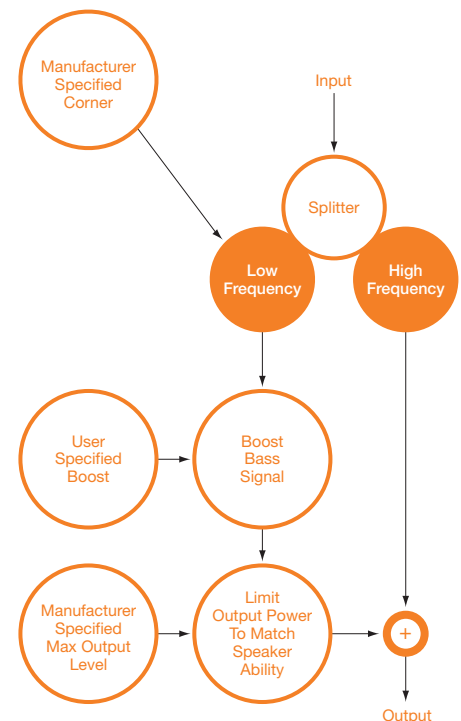
We believe the best bass frequencies are the ones your ears actually hear, so we've focused on how best to manage the bass energy emitted by a set of speakers.

Natural Bass works by knowing and working within the capabilities of the speakers in the system. Every speaker has its own characteristics and limitations that can be accurately measured, and Natural Bass uses this information to optimize the amplitude of the lower frequencies, maximizing the output of bass energy to the speakers without overloading them or discoloring the sound.

To cope with both the sudden transients and relatively long fade times common to bass instruments, Natural Bass combines two fundamental techniques: it compresses the initial peak of a note, then expands the 'tail', and gauges the amount of output that the speaker can handle.

Positioned after the master volume control, Natural Bass optimizes the bass response while guarding against sudden peaks: with the volume set low, the bass is still clearly audible, but when it is turned up, there is no risk of a sudden bass transient damaging the speakers or creating distortion.

This schematic diagram shows the basic operation:



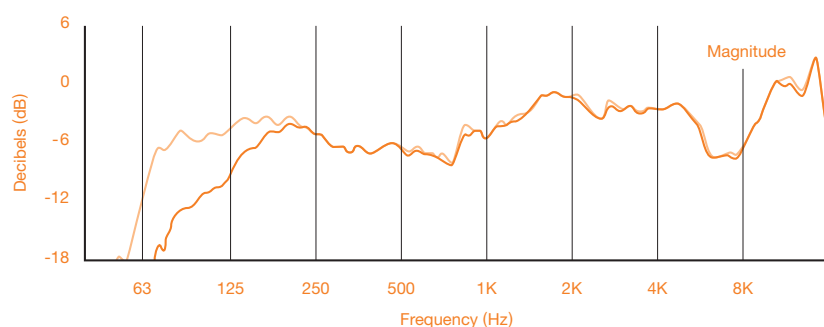
When implementing Natural Bass, the engineer determines the corner frequency, leaving the listener to choose from seven levels of boost.

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Natural Bass – continued

This graph shows the difference in the amount of bass energy that Natural Bass produces. The upper line in the range from approximately 50 to 250 hertz is the result with Natural Bass switched on.



It is clear from this graph that Natural Bass makes a significant improvement in the low frequency performance of the speaker, across the entire bass spectrum. Most importantly, the area between the lines on this graph represents real, measurable energy; actual sound waves that Natural Bass has allowed the speakers to produce, not just perceived fundamentals.

The result: the best possible bass response

Natural Bass achieves up to an octave of downward extension in the bass response on most speakers. With Natural Bass switched on, the speakers in any system always produce their best possible bass response.

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Intelligent Volume Control

Intelligent Volume Control is a dynamic range compressor designed specifically to suppress sudden level peaks and boost sudden level drops. It is designed for listening environments where the full dynamic range of a piece of audio is not suitable.

The challenge: to manage large volume variations sensitively

Many movie soundtracks and classical music recordings contain large and sudden volume variations. Whether it's an action film or Beethoven's 9th symphony, these sudden changes mean that the right volume level for the quietest part can be too high for the loud sections and vice versa.

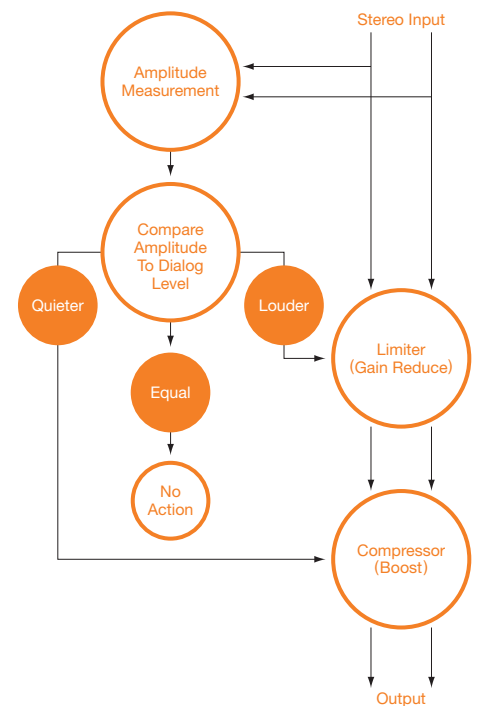
If there is background noise or any restrictions on the allowable volume (e.g. children sleeping or neighbors), it can be very difficult to set the volume at the right level for comfortable listening. The challenge is to manage these sudden volume changes so that the listener can enjoy the entire film or piece of music without having to make continual volume adjustments. In short, to make the quiet sounds louder and the loud sounds quieter, without producing a squashed, uncomfortably pressured feeling.

The solution: finely-tuned limiting and compression

Most audio sources are designed so that the loudest section will leave plenty of headroom, but the amount of that headroom can vary significantly. For example, in a movie soundtrack, an explosion can be anywhere from 18 to 26db louder than the dialogue.

Intelligent Volume Control takes care of sudden peaks by limiting them to a more acceptable level, and uses compression to boost sudden drops in amplitude. By continually monitoring the output of the sound source, Intelligent Volume Control can step in instantly to adjust the volume to a preset level, without the distortion or audible 'squashing' effects often associated with conventional limiters.

The following schematic diagram illustrates how Intelligent Volume Control manages amplitude variations:

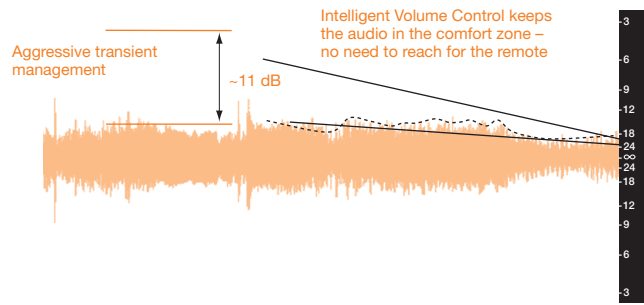
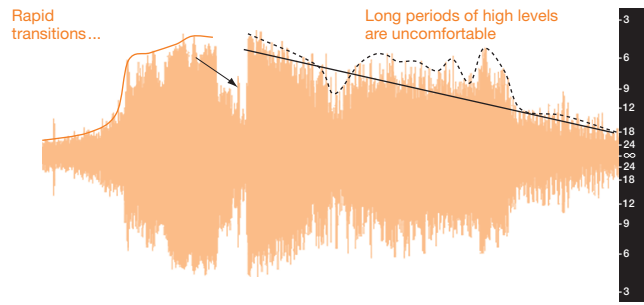
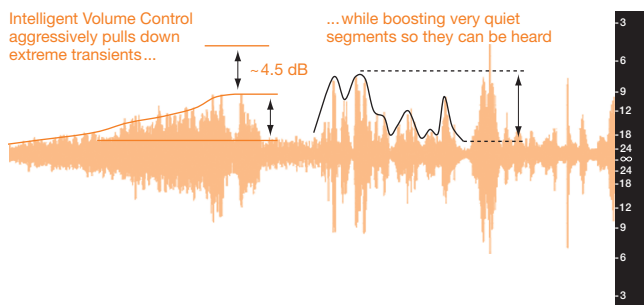
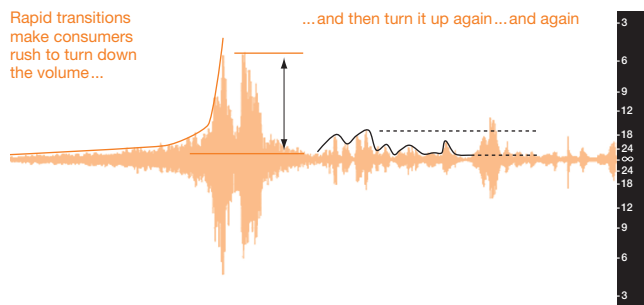


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Intelligent Volume Control – continued

The charts below show some typical amplitudes from a movie soundtrack, with and without Intelligent Volume Control.



The result: smooth and effective volume management

Intelligent Volume Control makes it possible to listen to audio sources that have a large dynamic range without having to make continual volume adjustments. It can also be used for noisy situations where the dynamic range needs to be adjusted to get above the noise floor.

With Intelligent Volume Control switched on, the listener can still get the full effect of dramatic sound changes, without the discomfort and inconvenience caused by large volume peaks, or the frustration of being unable to hear soft passages easily.

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Mono-to-Stereo Creator

Mono-to-Stereo Creator is a mono-to-stereo signal converter that generates stereo output from a mono input signal.

The challenge: to turn mono into stereo

Making stereo out of mono has a large number of potential applications, most notably AM radio, and television in countries where TV sound is broadcast in mono.

The two-channel stereo field has been the standard for decades, and is the natural delivery scheme for audio. When listening to live music for example, the sound comes from 30 degrees left to 30 degrees right, so a single mono source is not a realistic representation of sound.

Until now though, there has been no really convincing way to extract information from a mono signal that can be panned left and right. Previous attempts to do this have used all-pass filters that separate phase information into two signals.

The solution: replication without major alteration

Mono-to-Stereo Creator replicates the mono source and produces a stereo image with the same spectral response as the original, and without unexpected equalization changes.

Designed to be built-in and 'invisible' to the operator, Mono-to-Stereo Creator provides a uniform frequency spread so that the mono source sound appears to be smoothly balanced between the two speakers, but spread across the whole width of the audio field in a pleasing and non-distracting way.

For all intents and purposes, it is stereo, which can then be enhanced with all the other components of Audistry. Thus, in combination with these components, Mono-to-Stereo Creator makes it possible to turn a mono audio source into a wide stereo image with enhanced bass and volume peak management.

Best of all, Mono-to-Stereo Creator has an auto-detect mode so you can leave it on all the time and simply never have to listen to mono again.

The result: genuine stereo from mono sources

The beauty of Mono-to-Stereo Creator is its simplicity: it is a simple problem solved in a surprisingly elegant and effective way. What is important is the difference to the listener; after all, anyone who hears stereo never wants to go back to mono.

Conclusion

The Audistry suite of products provides a whole approach to the issues of sound enhancement in consumer audio products, fresh thinking that will fundamentally change consumer expectations.

Audistry is more than just a new set of tools, it's the embodiment of the years of experience, intimate audio knowledge and quality engineering that only Dolby can offer.

We are sure that you can see a great application for Audistry in your products. If you would like to know more about any of them, please contact us.

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Audistry technical specifications

Within an Audistry implementation there will be a number of features. These features are controlled through a number of parameters, some of which are for 'manufacturer' only use and others for consumers.

The table at right provides a comprehensive list of the controls available in the Audistry product bundle.

Full Feature Name	Description	Operating Modes	Default	MIPS
Estimate¹				
Sound Space Expander	Sound stage enhancer for stereo speakers	On/Off Width (0,1)	On ² 1	6 MIPS
Sound Space for Headphones	Sound stage enhancer for stereo headphones	On/Off Mode (0-6)	On 3	10 MIPS
Natural Bass	Dynamic bass extension	On/Off Boost Level (0-7) Corner frequency ³ (0-19) Output capacity limit	On 4 Manufacturer ⁴ Manufacturer	8 MIPS
Intelligent Volume Control	Automated volume control to reduce dynamic range	On/Off Depth (0-2) Anticipated input level (0-6)	On 1 Manufacturer	4 MIPS
Mono to Stereo Creator	Mono to stereo enhancement	On/Off Auto detect (On/Off)	On ⁵ On	3 MIPS 3 MIPS
Volume	Volume Control	On/Off Volume (0-Full Scale)	Off Manufacturer or User mode	1 MIPS
Other Functions	Post gain Input channels Sample rate Version	On/Off (1,2) 32KHz, 44.1kHz, 48kHz Read only	Manufacturer Manufacturer Manufacturer n/s	

Contact us for detailed performance information for individual DSPs by emailing licensing@audistry.com

- ¹ Fixed Point DSP optimised estimate, does not include Main Loop overhead ~ 4 MIPS.
- ² Sound Space for Headphones and Sound Space Expander should not be on at the same time.
- ³ Factory selected speaker corner frequency parameter 41Hz-574Hz.
- ⁴ The setting in these parameters are not visible to the user of the product.
Information on what these parameters should be set to can be found in the Audistry Integration Manual.
- ⁵ Must be turned off if Sound Space for Headphones is on.

The Audistry team can be contacted by email at: licensing@audistry.com