

# Dolby® PC Entertainment Experience v4



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## Overview

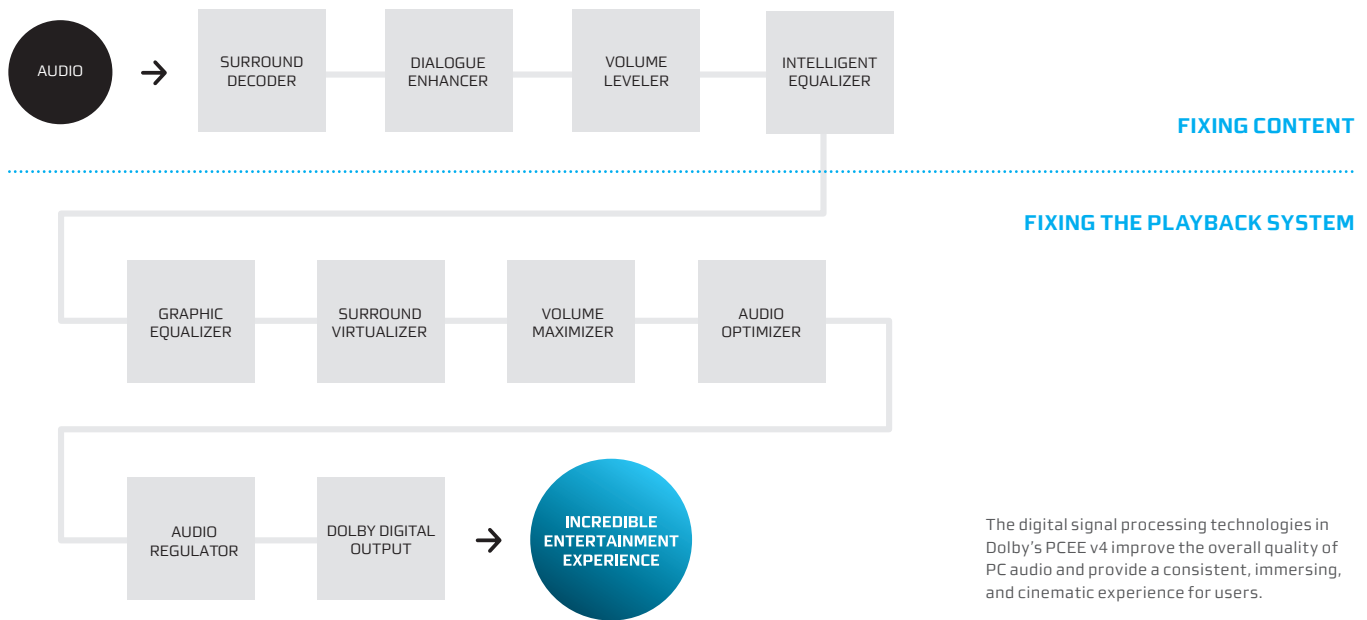
From humble beginnings as a productivity device, the personal computer has evolved into an entertainment hub for the digital lifestyle. People are increasingly using PCs to watch DVDs or video content online, listen to music, or play games. Additionally, many people have started connecting their PCs to their home theater and audio systems. Yet creating a high-quality audio experience on a PC presents many challenges. These challenges can be broadly grouped into two key areas: content and physical PC audio hardware (playback systems).

On the content side, PCs receive media from a variety of sources, and as a result, the quality and production of this content varies dramatically. For example, much of the user-generated content on the Internet is mixed poorly, resulting in dull sound and unintelligible dialogue. In addition, a large amount of the audio content consumed on the PC is not produced in surround sound, resulting in audio that lacks the depth and realism of the Dolby® cinematic experience. Finally, there are often extreme variations in volume levels between different pieces of content. Users may strain to hear dialogue in a movie and then rush to turn the volume down when switching to a music track. If that weren't annoying enough, adjusting the volume on a PC can be complicated, as many PCs require the user to first open the Windows® mixer in order to change the volume.

On the playback side, audio quality suffers as a result of small, inefficient speakers, under-powered amplifiers, and the lack of a surround sound speaker system—the result of the mechanical constraints of laptop and all-in-one desktop designs. The frequency response of these small speakers is often highly irregular, resulting

in unnatural and colored sound that lacks both low and high frequencies. The combination of small speakers with low-power amplifiers also means that the audio is typically not loud enough, even with the volume control at maximum. When these speakers and amplifiers are driven with a loud audio signal, they will often distort and cause annoying rattles in the physical enclosure of the PC. Lastly, the benefits of a high-quality surround sound audio signal are lost if this signal is limited to playback over built-in stereo speakers or headphones.

To address both content and playback problems on the PC, Dolby has developed an entirely new suite of digital signal processing technologies in the latest version of the PC Entertainment Experience. The Dolby PC Entertainment Experience version 4 (PCEE v4) was designed to improve the overall quality of PC audio and provide a consistent, immersing, and cinematic experience for users. PCEE v4 incorporates Dolby’s latest and most advanced algorithms utilizing both psychoacoustic and cognitive models of audio perception that leverage Dolby’s more than four decades of research into how people experience sound.



The digital signal processing technologies in Dolby’s PCEE v4 improve the overall quality of PC audio and provide a consistent, immersing, and cinematic experience for users.

All of these technologies are built upon a common processing framework based around a perceptually motivated signal representation. By breaking the audio signal into a multitude of frequency bands, the representation mimics the filtering of the inner ear. This representation thus provides an inherent match between Dolby’s processing and human audio perception. It also allows all of the technologies to share processing resources. This means that an unprecedented amount of audio processing can be provided to the user with modest computational expense.

In addition, while each of the individual technologies was developed to address one or more of the particular problems listed above, they were all designed to cooperate in an intelligent manner to provide the optimal audio experience for all types of

content and playback conditions. The result is a system in which the whole is greater than the sum of the individual parts, consistently delivering as much balanced, distortion-free, and immersing audio as possible from a PC.

For the average user, configuring each of the individual component technologies within the PCEE v4 suite is not necessary. PCEE v4 comes bundled with a small set of profiles (Music, Movie, and Game) that optimize the settings of the various technologies for the corresponding content. Advanced users can edit these presets and create new custom presets.

Following are technical descriptions for each of the component technologies within the PCEE v4 suite. They are separated into two categories: fixing content and fixing the playback system.

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## Fixing Content

The following four technology components—the Volume Leveler, Intelligent Equalizer, Dialogue Enhancer, and Surround Decoder—work to correct audio issues and defects in the user’s media content.

### Volume Leveler

The Volume Leveler is an advanced, high-quality volume control solution that maintains consistent playback levels when the user selects different content and playback (application) sources. For example, when a user switches between different songs in an iTunes® playlist, the volume stays the same. Similarly, if the user switches from listening to music in iTunes to watching a movie in Windows Media Player to having a video conference call on Skype™, the volume stays constant across all application changes.



The Volume Leveler gauges the perceived loudness of the audio and adjusts it to a consistent level.

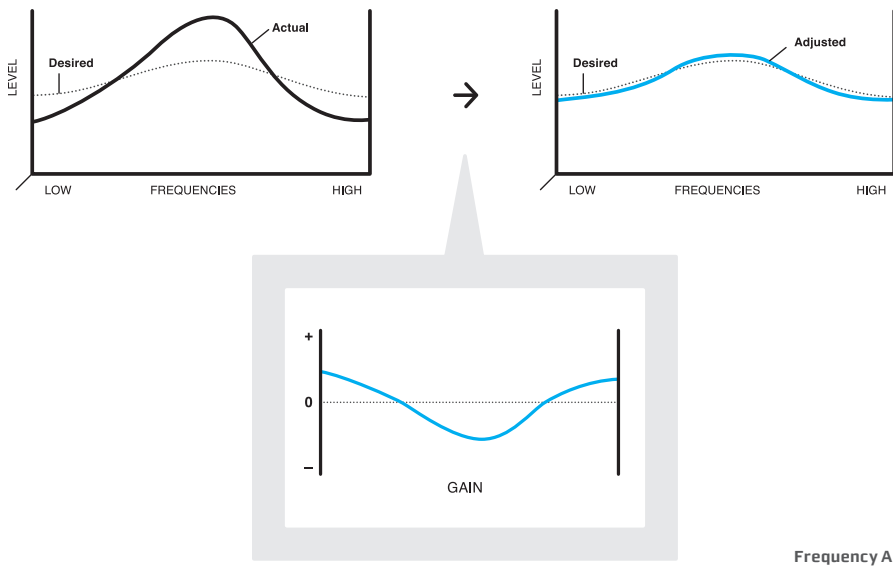
The Volume Leveler continuously “listens” to the audio using a psychoacoustic model of loudness perception to accurately gauge how loud a human will perceive the audio. This information is then used to automatically adjust the perceived loudness to a consistent level. At the same time, Auditory Scene Analysis, a cognitive model of audio perception, is employed to ensure that the loudness of the audio is not adjusted at inappropriate moments in the audio signal, such as during a naturally decaying note in a song.

In the course of making adjustments to the audio, the Volume Leveler is able to target its adjustments at individual channels of the audio as well as individual frequency bands to prevent “pumping” and “breathing” artifacts. The result is consistently leveled

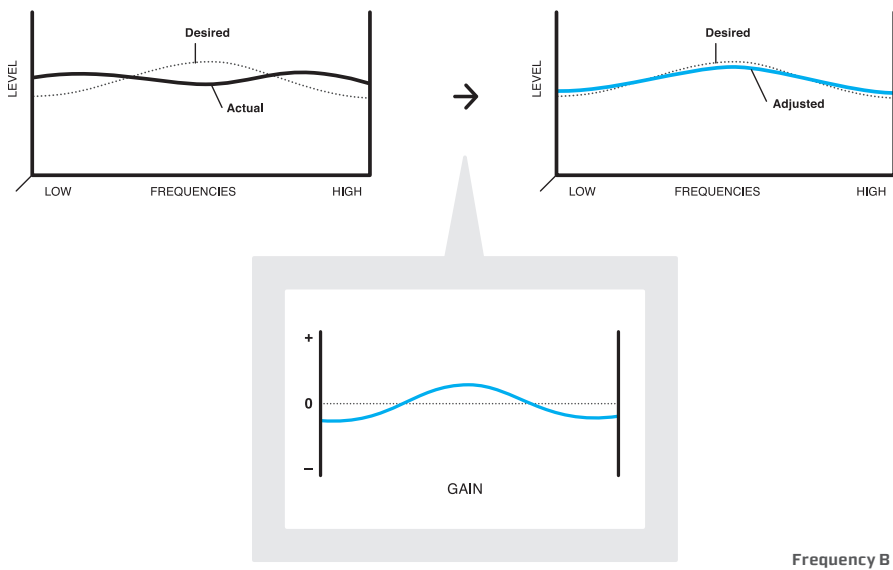
audio, free from the artifacts associated with traditional volume leveling solutions. For the advanced user, a leveling amount control is available. Less leveling allows greater differences between the softest and loudest parts of the audio, while more leveling applies tighter constraints to these differences.

### Intelligent Equalizer

While the Volume Leveler provides consistency in loudness, the Intelligent Equalizer is a new concept in audio processing providing consistency of spectral balance, also known as “timbre” or “tone.” It achieves this consistency by continuously monitoring the spectral balance of the audio, comparing it to a desired tone, and dynamically adjusting an equalization filter to transform the audio’s original tone into the desired tone. A user applies a particular tone by simply selecting a preset defining the desired relative balance between the different frequencies of the audio.



The Intelligent Equalizer monitors the range of frequencies and dynamically adjusts the audio to achieve the desired tone every time.



This may seem similar to existing equalization presets found on many audio systems, such as Jazz, Rock, or Voice, but such presets are *static* (not changing). They apply the same change across frequency regardless of the content and may therefore apply inappropriate equalization. For example, in a traditional EQ, if a static bass boost preset is selected and the audio content inherently has sufficient bass to match the user's desired entertainment experience, boosting the bass frequencies will produce too much bass, and likely cause distortion. By contrast, the Intelligent Equalizer is *dynamic*. If the audio already has enough bass in comparison to the user's desired preset, the Intelligent Equalizer leaves the bass alone. If the audio is lacking in bass, then the bass is boosted. The result is the desired sound without overprocessing and distortion.

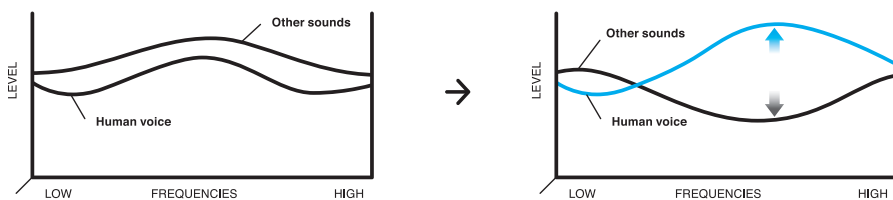
As an example, the Intelligent Equalizer can do wonders for music playback. A user may select a preset based on the tone of modern recordings. Older recordings are instantly "remastered" to modern standards, and modern recordings are left unprocessed because they already possess the desired tone.

### Dialogue Enhancer

The Dialogue Enhancer is a sophisticated algorithm that continually monitors the audio being played, detects the presence of dialogue, and dynamically applies processing to improve the intelligibility of the spoken portion of a recording. The Dialogue Enhancer computes features from the audio signal and feeds these to a pattern recognition system in order to detect the presence of speech from moment to moment. The Dialogue Enhancer performs two kinds of dynamic processing.

The first is dynamic spectral rebalancing of the dialogue to enhance those frequencies most important to intelligibility. When no speech is detected, the Dialogue Enhancer performs no processing. However, when speech is detected, the speech spectrum is altered if necessary to accentuate the speech content in a way that allows the user to hear it more succinctly.

The second key processing performed by the Dialogue Enhancer is frequency-dependent dynamic suppression of other sounds in the audio mix that are determined to be interfering with the intelligibility of the dialogue signal.



The Dialogue Enhancer accentuates the speech spectrum while dynamically suppressing other sounds that interfere with dialogue intelligibility.

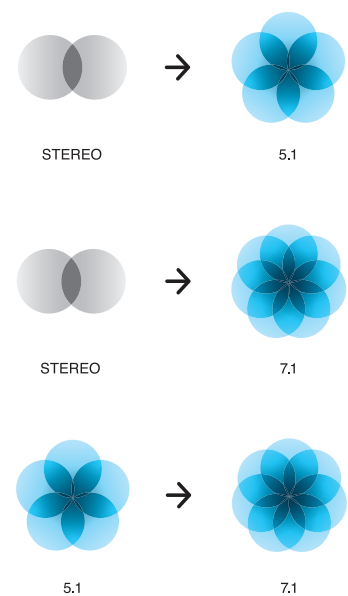
The Dialogue Enhancer has been designed to improve dialogue perception and understanding for both hearing impaired and non-hearing-impaired people. Some audio, such as user-generated content, may have low production value and therefore be hard to understand, particularly in noisy environments, even for people without a hearing impairment. The Dialogue Enhancer processes the audio to make the dialogue much easier to hear and understand for everyone.

The Dialogue Enhancer also applies knowledge of the characteristics of age-related hearing loss and processes the audio to improve the intelligibility of dialogue for users with this type of impairment as well. Some control is available for the advanced user to vary the degree of the two types of dynamic processing.

### Surround Decoder

The Surround Decoder is a next-generation frequency-domain matrix surround decoder that creates multichannel audio from as few as two input channels. The Surround Decoder can take normal stereo music content or surround-encoded two-channel movie content and create a high-quality 5.1- or 7.1-channel surround sound signal. The Surround Decoder can also take a 5.1 surround signal and upmix it to 7.1 channels. The resulting surround sound signal can then be sent externally to a multichannel home theater system or internally to the PCEE v4 Surround Virtualizer, discussed in the next section, for subsequent playback over built-in speakers or stereo headphones.

Unlike previous wideband technologies, the Surround Decoder operates on a multitude of perceptually spaced frequency bands for finer grain analysis and the ability to steer different frequency bands individually. The result is surround sound with precisely located audio elements and a spacious ambience rendering (that is, the part of the audio that is ambient—indirect, diffused sound—is spread around to make that part of the audio more enveloping).



The Surround Decoder can create 5.1- or 7.1-channel surround sound from stereo content, as well as upmix a 5.1 surround signal to 7.1.

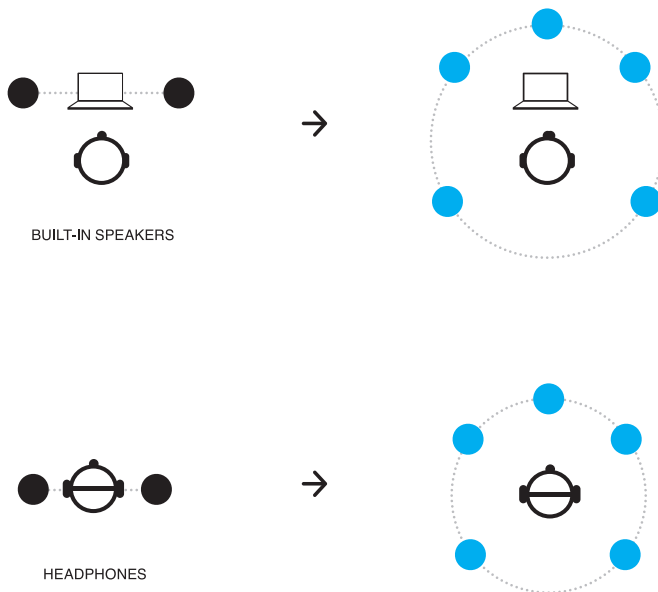
## Fixing the Playback System

The following six technology components—the Surround Virtualizer, Volume Maximizer, Audio Optimizer, Audio Regulator, Graphic Equalizer, and Dolby Digital Output—work to enhance audio despite limitations inherent to the playback system.

### Surround Virtualizer (for built-in speakers or headphones)

The Surround Virtualizer enables an existing surround sound signal, or one generated by the PCEE v4 Surround Decoder, to be rendered over a PC's built-in speakers or headphones. The Surround Virtualizer utilizes head-related transfer functions (HRTFs) to simulate the arrival of sound at the ears coming from the various speaker locations associated with either a 5.1- or 7.1-channel audio configuration.

The particular HRTFs that are used in PCEE v4 were chosen for their ability to work well across a large cross section of listeners and for their ability to produce an uncolored, natural sound. This is important because HRTFs are inherently personal to each listener; therefore, a “golden” set of HRTFs was chosen that works well for the majority of listeners.

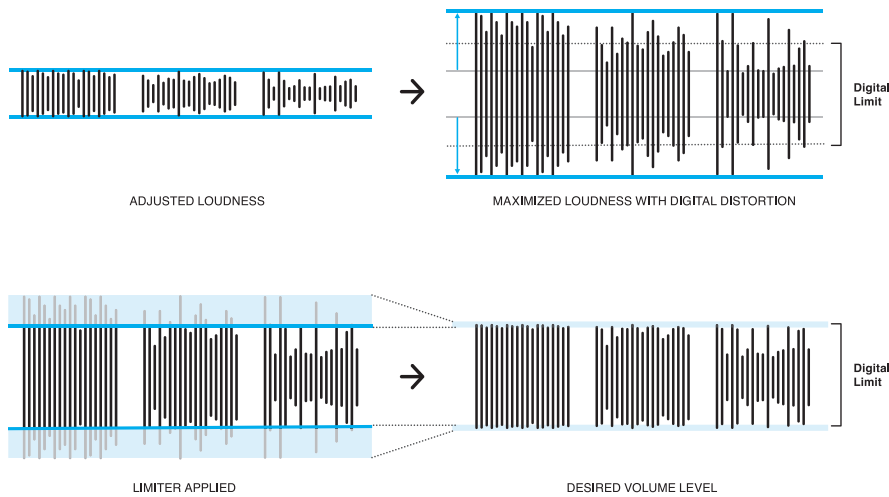


The Surround Virtualizer renders virtual 5.1 or 7.1 surround sound over built-in speakers or headphones.

In addition, the Surround Virtualizer intelligently and dynamically enhances the surround speaker channels of the multichannel signal in order to create a more enveloping virtual surround effect. When listening over a PC's built-in speakers, the result is a soundstage much larger than would seem possible from the small form factor of the PC. Over headphones, sound is freed from the standard perception of being confined to the listener's head, instead arriving seemingly from all directions. For the advanced user, a control is available to change the degree of the described enhancement to the surround speaker channels.

## Volume Maximizer

Making audio consistently loud over the small speakers associated with PCs is a major goal of the PCEE v4 suite, and the Volume Maximizer is a key technology in achieving this goal. After the Volume Leveler processes the audio to be at a consistent loudness, the Volume Maximizer boosts the level of the digital signal by as much as 12 dB. In doing so, certain parts of the signal may exceed the amplitude limits inherent to a digital representation. Without intervention, the signal would clip, causing large amounts of perceptually objectionable digital distortion. To eliminate this clipping while maintaining the desired boost in loudness, the Volume Maximizer employs a high-quality, low-distortion, look-ahead limiter. This limiter utilizes an intelligently interlocked combination of fast-acting, wideband peak control and multiband compression precisely tuned to yield the highest-level signal without digital distortion or pumping.



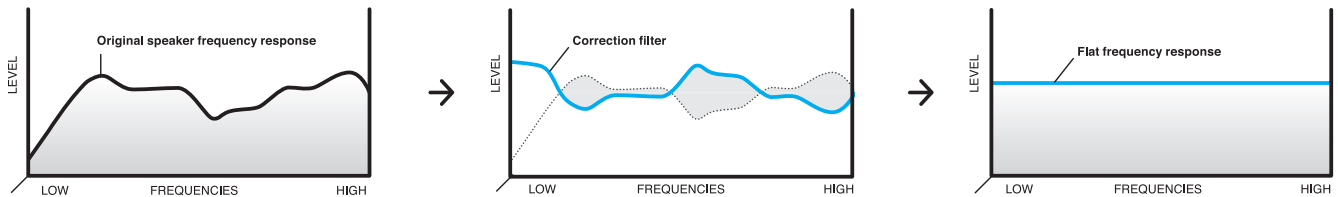
The Volume Maximizer boosts loudness while employing a look-ahead limiter to eliminate clipping, distortion, and pumping.

## Audio Optimizer

The frequency response of the typical small speakers found in a PC is highly irregular (non-flat), resulting in dialogue that sounds muffled or unnatural and music that usually lacks bass and treble. The Audio Optimizer corrects these irregularities with a set of filters that are custom-designed for each PC model prior to production. The design process involves the use of a calibration tool provided by Dolby which measures the frequency response of each speaker in the PC using a probe signal and a microphone.



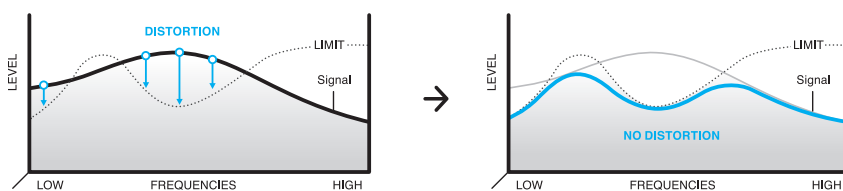
Based on these measured responses, a correction filter equal to the inverse of each speaker response is automatically computed and stored as a set of parameters for the Audio Optimizer. During playback, the Audio Optimizer digitally applies each filter to the audio signal being fed to the respective speaker. The Audio Optimizer's filters cancel the irregularities of the speakers, so that the listener perceives a flat frequency response—the type of response often found on high-end audio systems. The result is natural, balanced audio with more bass and treble, for content that sounds truer to the way its creator meant it to be heard.



The Audio Optimizer's correction filters cancel speaker irregularities to deliver a flat frequency response for more natural, balanced sound.

### Audio Regulator

The application of the Volume Maximizer and Audio Optimizer can result in extremely high-level digital signals that, when played through the small amplifiers and speakers of a PC, cause a significant amount of acoustic distortion. Both the amplifiers and speakers can be overdriven and the chassis of the PC may begin to resonate or rattle. The nature of this distortion is highly dependent on the specific components and physical design of the PC, and the degree of distortion may vary drastically between frequencies.



The Audio Regulator is tuned to each PC model with calibration set for each frequency. Levels are set and multiband compression is applied to eliminate distortion.

To eliminate or reduce this distortion while still maintaining high volume levels, the Audio Regulator applies multiband compression that has been tuned to the distortion characteristics of a particular PC model. Similar to the Audio Optimizer, the Audio Regulator requires a calibration procedure for each PC model prior to production. With the Audio Regulator, the calibration procedure involves probing a multitude of frequency bands with a test signal and measuring the amount of distortion in each band as a function of the test signal's level. Based on a maximum amount of allowable distortion, a limit is then set for each frequency band. These limits are stored as parameters for the Audio Regulator, which applies multiband compression such that the audio signal never exceeds the set limits in each frequency band. Signals that are lower than the limits are left alone, and signals approaching the limits are attenuated.

In addition, the Audio Regulator applies intelligent constraints to its compression so that the original timbre of the audio is roughly maintained even if the set limits vary drastically across frequency. The Audio Regulator is also coupled to the PC volume control so that as the volume is turned down and distortion control becomes unnecessary, the Audio Regulator's compression is reduced. The end result is an audio signal that produces a high level of loudness but never drives the PC into severe distortion.

### Graphic Equalizer

The Graphic Equalizer is a 10-band equalizer similar to those found standard on many PC audio applications. In those standard applications, users are often encouraged to adjust their content with static equalization profiles such as Rock, Jazz, or Voice. While the Intelligent Equalizer in PCEE v4 can be used to adjust content much more effectively and dynamically, the Graphic Equalizer allows users to tailor audio to their liking using the static characteristics of their playback systems rather than the dynamic characteristics of the audio content. For example, the Graphic Equalizer can be adjusted to provide a fixed bass boost while listening over a small pair of earbud headphones lacking in bass reproduction.



### Dolby Digital Output

As a delivery mechanism for high-quality, multichannel surround sound, PCEE v4 provides real-time encoding of the audio signal into the ubiquitous Dolby Digital format over either S/PDIF or HDMI™ outputs. Virtually all home theater systems provide decoding of Dolby Digital signals, so compatibility is not an issue. Using the Surround Decoder in combination with the Dolby Digital output, users can easily enjoy all of the audio content from their PCs in surround sound on their home theater systems.



## PCEE v4 Products

The Dolby PC Entertainment Experience is available in two bundles: Dolby Home Theater® v4 and Dolby Advanced Audio v2.



SURROUND DECODER	●		FIXING CONTENT
DIALOGUE ENHANCER	●		
VOLUME LEVELER	●	●	
INTELLIGENT EQUALIZER	●		
GRAPHIC EQUALIZER	●	●	FIXING THE PLAYBACK SYSTEM
SURROUND VIRTUALIZER FOR BUILT-IN SPEAKERS	●	●	
SURROUND VIRTUALIZER FOR HEADPHONES	●		
VOLUME MAXIMIZER	●	●	
AUDIO OPTIMIZER	●	●	
AUDIO REGULATOR	●	●	
DOLBY DIGITAL OUTPUT	●		

Dolby Home Theater v4 is Dolby’s flagship PC postprocessing solution that creates a home theater surround sound experience on a PC. With Dolby Home Theater v4, a user can experience all content—including music, movies, and games—in Dolby surround sound, whether listening on headphones, the PC’s built-in speakers, or an external audio system connected to the PC. Each Dolby Home Theater v4 PC model is professionally tuned by Dolby to provide the best possible audio reproduction. The Volume Leveler creates a consistent, natural volume level. Content being enjoyed over internal speakers is maximized without distortion. Dialogue in content is much easier to hear and understand. The Intelligent Equalizer acts like a real-time mastering engineer, making content sound the way the listener wants it to sound.

Dolby Advanced Audio v2 provides a personal surround sound experience on the PC. All content heard over the PC’s built-in speakers can be enjoyed in Dolby surround sound. The Volume Leveler creates a consistent, natural volume level whether listening over headphones or the PC’s built-in speakers. The Volume Leveler and Audio Regulator allow the volume over the built-in speakers to be maximized without distortion. Finally, the Graphic EQ can be used to adjust the tonal characteristics of the playback system.



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