



A Guide to Wadia Technology

Wadia Digital Volume Control

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The Wadia Digital Volume Control was developed to take advantage of one of the most compelling advantages of Compact Discs: digital audio signals can be processed without additive losses and distortion that are inevitable in analog processing.

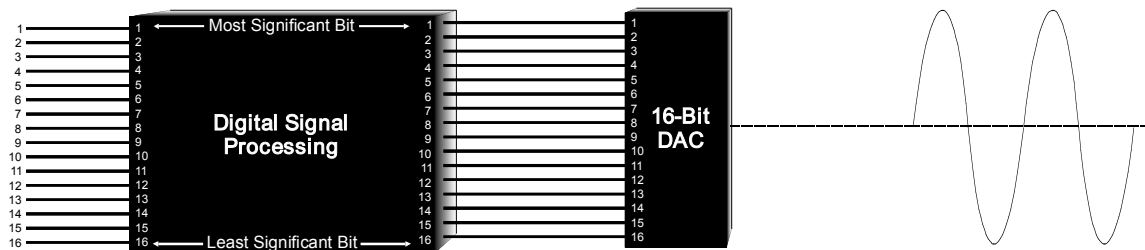
The Digital Volume Control is a key element in the Wadia Direct-Connect system. Along with the rest of the features of Wadia's Direct-Connect system, the Digital Volume Control allows the output from the CD playback system to be connected directly into a power amplifier. Bypassing the preamplifier — and the inevitable losses caused by the connections and circuitry within — provides a significant improvement in performance.

Digital attenuation has been criticized for being detrimental to sound quality. Over the years, there have been numerous unsuccessful products that provide evidence of the negative side effects of poorly designed digital attenuation. Yet, Wadia has built a reputation on musical performance with products using digital volume control.

The difference is in the execution. Wadia engineers have continuously refined the digital volume control for almost 10 years. By identifying the potential weaknesses and using innovative technology, Wadia has created a volume control that is unique and demonstrably superior to others on the market.

How Does a Digital Volume Control Work?

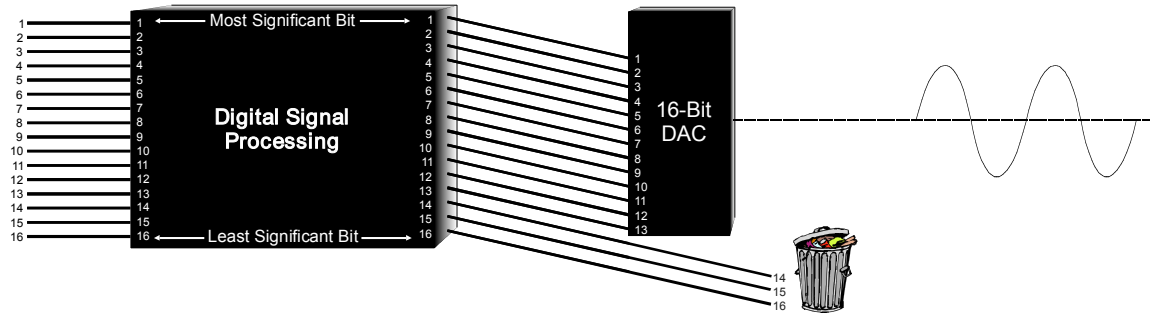
A digital volume control adjusts the volume by means of mathematical manipulation of the music signal while it is in the digital domain. This manipulation can be performed by a digital signal processor. The volume-adjusted digital signal is then fed to the digital-to-analog converter. The drawing below shows a simple system, with a 16-bit input from a compact disc a 16-bit digital-to-analog converter, and the analog output.



Drawing 1. A digital system, showing 16-bit input, passing through a DSP, a DAC, and the analog output.

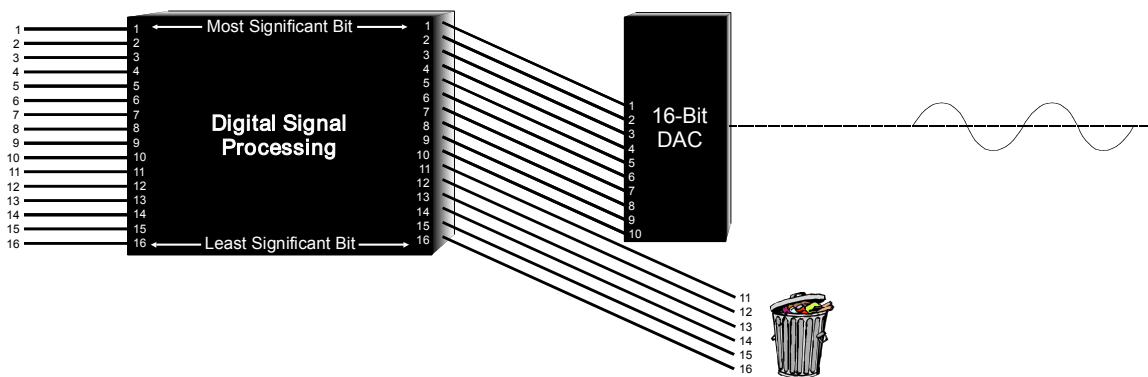
Digital volume controls function by multiplying the each successive word in the original signal data stream by a coefficient that is less than one. For example, if the incoming signal is multiplied by a coefficient of 0.5, the output will be half of the original value. This corresponds with a volume reduction of 6 dB. In a binary system, a reduction of 6 dB is the same as shifting the signal towards the least-significant bit by one bit.

In the drawing below, the 16-bit signal is attenuated by a factor of eight, resulting in a volume reduction of 18 dB. The resolution is now reduced to 13 bits, with three bits lost.



Drawing 2. The signal is shifted three bits towards the least-significant bit, three bits of resolution are lost, and the analog output is reduced 18 dB.

Continuing to reduce the volume reduces the resolution as well. In this case, a volume reduction of 36 dB results in a resolution of 10 bits, as illustrated below. Based on this loss of resolution, it is clear why digital attenuation has garnered a reputation for degrading sound.

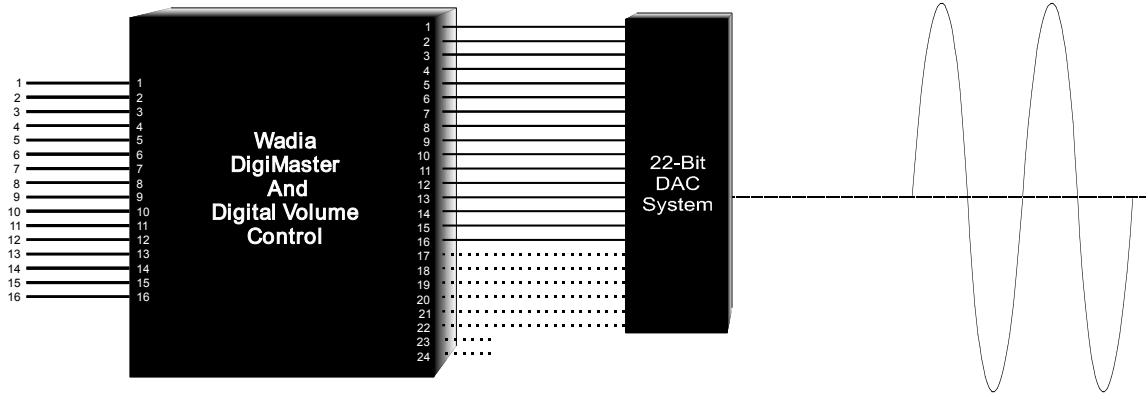


Drawing 3. This signal is further attenuated, shifted by six bits. Now six bits of resolution are lost, and the analog output is reduced 36 dB.

Why is Wadia's Digital Volume Control Different?

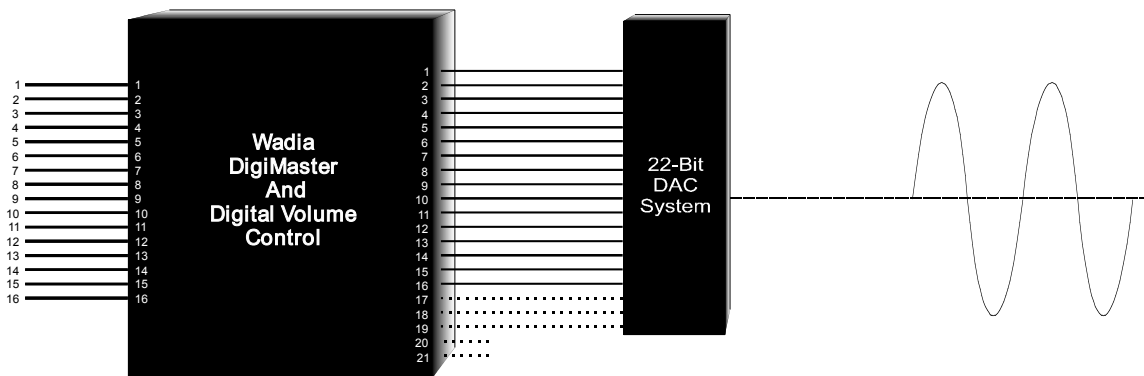
The key to Wadia's Digital Volume Control is overall system resolution. Wadia products have 24-bit input capability, 24-bit processing and DAC resolution of 21 or 22 bits, depending on model. As a result, a 16-bit signal from a CD can be attenuated without loss of the original 16-bit information.

For example, below is an illustration of a Wadia decoding system with 22-bit DAC resolution. This system has a 16-bit input from the compact disc fed into Wadia's patented DigiMaster system. The DigiMaster performs digital filtering and resolution enhancement, producing a 24-bit signal. The additional bits are represented by the dotted lines being fed to at the six least-significant bits of the 22-bit DAC, plus 2 additional bits that are not yet used.



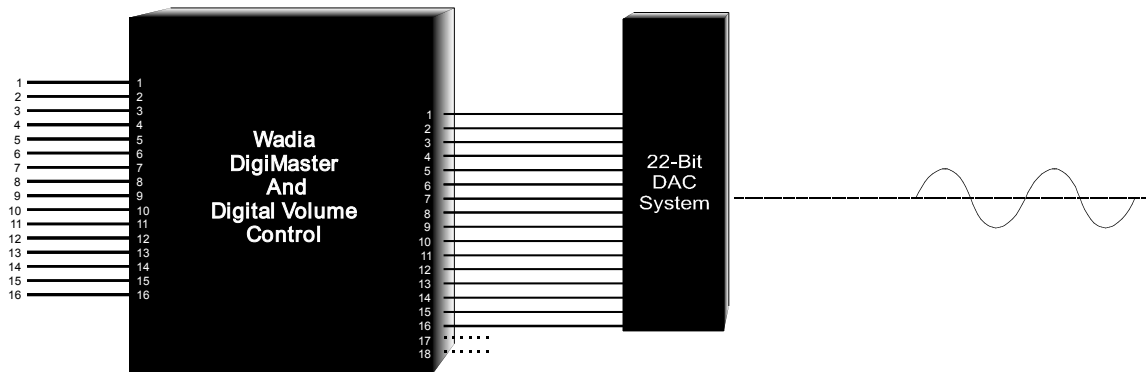
Drawing 4. Wadia's Decoding System, showing the 16-bit input from the CD, the 24-bit output from the DigiMaster Filter fed into a 22-bit DAC.

When this system is attenuated, the original 16 bits are shifted towards the least-significant bit, as shown below. In this case, the system is attenuated by 18 dB. Notice that three least significant bits from the DigiMaster Interpolation are lost, but the original 16-bit information from the CD is preserved.



Drawing 5. Wadia Digital Volume Control, showing 18 dB of attenuation, but retaining 19 bits of resolution.

Even with the volume reduced by 36 dB, as shown below, the original 16-bit signal from the CD is preserved intact. Any attenuation beyond 36 dB will reduce the resolution below the theoretical 16-bit capability of CD format. However, there are many CD recordings that do not attain the full 16-bit resolution capability of the CD format due to losses in processing during and after recording. In fact, CDs with less than 14-bit resolution are common. If the volume is turned down all the way to the lower limit — 50 dB of attenuation — the Wadia Digital Volume Control retains 14-bit resolution.



Drawing 6. Wadia Digital Volume Control, showing 36 dB of attenuation, but retaining all 16 of the original digital signal from the CD.

Digital Volume vs. Analog Volume

Strictly speaking, digital attenuation does reduce resolution. This brings rise to the question of whether this loss of information is an acceptable trade-off. To decide, it is necessary to examine the alternative, analog volume controls and associated circuitry, and their negative side effects.

In a conventional pre-amp based system, there is a loss of resolution caused by analog circuitry and connectors in the signal path. Although analog degradation is not expressed in terms of “lost bits of resolution”, it is none-the-less lost musical information. Unlike the Wadia Digital Volume Control, the degradation and noise of the analog circuitry are present under all conditions, regardless of playback volume level.

With the Wadia Digital Volume system, the resolution loss increases as the volume is reduced. At a zero level of attenuation, there is no loss of resolution. As long as the volume level is in the upper part of its range, the loss of resolution is extremely low. Wadia’s Digital Volume Control can be optimized so that for any system, critical listening takes place with the Digital Volume Control near the maximum, where resolution is greatest. Therefore, during critical listening, there is better resolution, lower noise — and better sound — than with a conventional preamplifier.

Running a Wadia with Digital Volume Control into a Preamplifier

Although they perform best when connected directly to a power amplifier, Wadia CD playback systems function superbly when connected to conventional preamplifiers as well. Setting the volume control to its maximum setting, there is no compromise involved — no circuitry, no processing, no switches, solder contacts — that interferes in any way with the sonic performance.

Customers who are interested in using a Wadia connected to their preamplifier often ask whether they are “paying extra” for a feature they will not use when buying a Digital Volume Control-equipped product. In fact, if Wadia were to manufacture a CD playback system such as the Wadia 860 CD Player, for example, but intended to be used only with a conventional pre-amplifier, it would contain exactly the same circuitry as our Digital Volume Control version. The only difference would be that the digital signal processing

program features which control the volume would be eliminated, which would not result in any cost savings, nor any improvement in sound.

Bypassing the Digital Volume Control

Literally speaking, the Digital Volume Control cannot be bypassed. Because there are no components associated with the Digital Volume Control in the signal path, there are none to bypass. The Digital Volume Control can be deactivated by setting it to its maximum volume level.

In an analog system a bypass switch can be used to route the signal around the volume control, but even in bypass mode the signal must still pass through the switch itself and the circuit board traces associated with it. Many listeners can attest to the fact that any additional analog circuitry — even seemingly simple switches and solder contacts — can cause noticeable sonic degradation.

Since the Digital Volume Control uses a mathematical calculation to perform the volume adjustment, one might ask whether this program step can be eliminated, and whether this would result in an improvement in sound. However, the program step where the digital volume calculation is performed is a program step that would be performed even if the unit did not have a digital volume control.

All digital filters used in CD playback have a program step where the final result of the filter is scaled to match the resolution of the DAC. This scaling is performed by multiplying the signal by a coefficient — the same operation that is performed by the digital volume control. Wadia engineers selected this as the most advantageous point in the program sequence to perform the digital volume control calculation, since it does not add extra program steps.

The only change that occurs when the volume is adjusted downward from the maximum setting is that the value of the coefficient used in the scaling step is reduced slightly. This results in a measurable reduction in resolution of 0.083 dB for each step down in volume. There is no greater or lesser change at any specific point in the volume control range.

The Proof is in the Listening

While there is no “perfect” volume control, our conclusion is that the Wadia’s Digital Volume Control is the best available solution to the challenge of controlling levels in a high performance music system.

Ultimately, sonic evaluation is the only way to confirm or refute the viability of the Wadia Digital Volume Control. We do careful comparisons using the finest and most expensive preamplifiers and our conclusion, and that of music-lovers worldwide remains unchanged: there is no preamplifier that can improve on the sound of the Wadia Digital Volume Control.