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The Basics of Look-Ahead Processing

By Frank Foti
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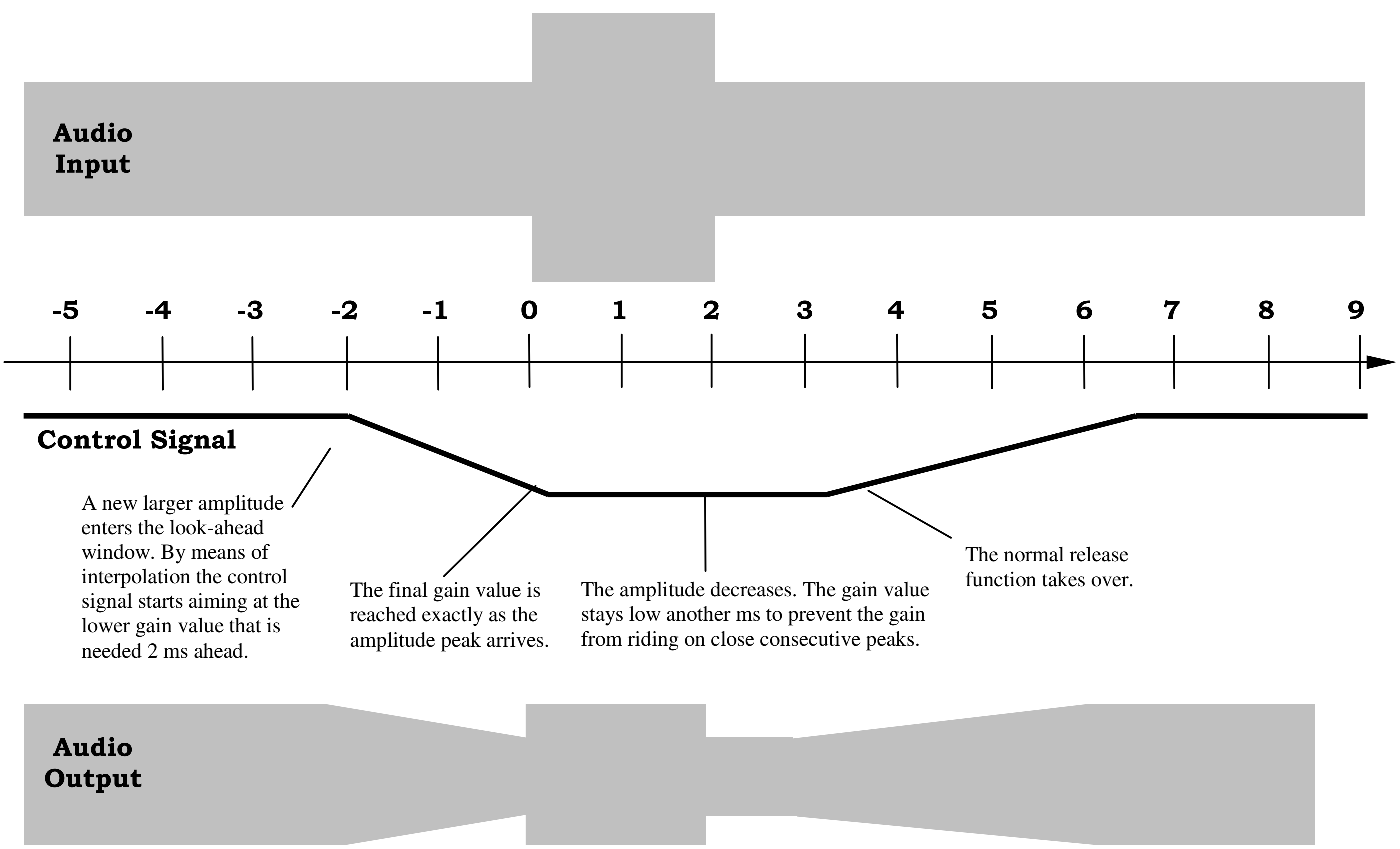
We have received quite a few inquiries about the usefulness of Look-Ahead Processing in a broadcast application. It certainly has benefits (but some drawbacks, too). Following is a quick overview of how Look-Ahead processing works, and some thoughts to consider.

The look-ahead limiter is not a new method of processing; it's been widely used by the British Broadcasting Corporation (BBC) for years. As recently as a few years ago, a new architecture designed by Cutting Edge and Swedish Radio was implemented in a multiband configuration for use with Classical and Jazz music programming. This innovative and successful design, Veris, is the popular clean-format plug-in software module for Omnia.fm. Additionally, the Omnia-3net has broken new ground in audio processing by employing look-ahead limiting that is optimized for bit-reduced audio. It is the world's first Multiband Look-Ahead processing system! (See our technical papers entitled "Audio Processing for DAB and the Internet" and "Broadcast Signal Processing and Audio Coding" for more information about processing for bit-reduced audio.)

Here's how a basic look-ahead processor operates. In essence, the processor has the ability to calculate the peak level of a signal over a specified period of time. While that is occurring, the audio is delayed by a like amount. Then, as the control signal is applied to the audio gain function, the audio peak is reduced at the precise time that the control signal reaches the maximum control level and the crest of the peak is reduced without truncation. This is how clipping is avoided.

The following diagrams show a simple view of how a look-ahead processor operates:



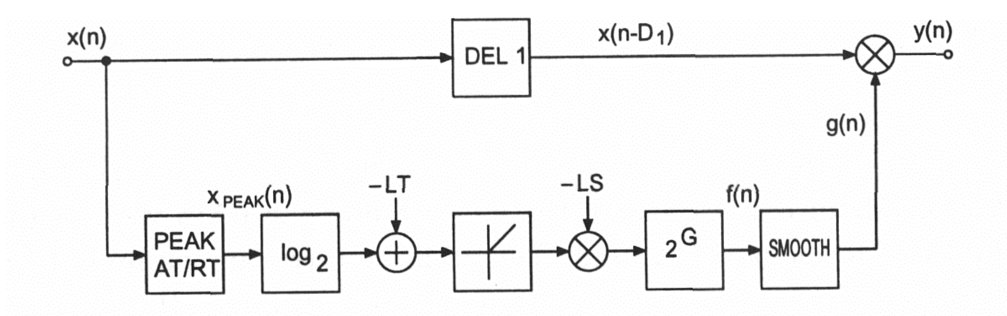
As the examples show, peak control is achieved without creating any harmonic distortion. If the diagrams were expanded to show detailed sinewaves, there would not be any peak truncation during the period of processing.

Unfortunately, there's no free lunch! A simple wide-band look-ahead processor will not create harmonic distortion, but will generate Intermodulation Distortion (IMD). This type of distortion has a different type of sound to it—sort of a *busy* quality—and can be as annoying as harmonic distortion (THD), especially with music.

Innovative Algorithm Design

All is not lost! The difference between these two forms of distortion is that THD is hard to eliminate and will contain out-of-spectrum components (although some can be removed through precise filtering). In the case of IMD, we know what will cause those products and how often. Therefore a processor can be designed to take advantage of look-ahead calculation time and add ancillary control signals that will monitor and remove IMD. Now, music can be controlled in a precise manner, and the audio quality will not suffer from the busy-ness of IMD as it is removed.

Additionally, a processor designed where the time constants of *attack* and *release* are optimized in a manner that provides a transient feel to its operation will sound very natural. In order to achieve this, the *attack* and *release* must be set faster as frequency increases. In the case of a look-ahead processing system, it will require different processing delays for each audio band. The block diagram below shows a functional overview of a single band of processing:



Look-Ahead Processor Block Diagram

Distributed Look-Ahead Processor

It is vitally important that the audio signal remain time aligned in order to maintain linear phase across the audio bandwidth. Distributed Look-Ahead Processors utilize matching delay functions so that at the point of recombination, all of the multiband processors are delayed an equal amount, and phase linearity is maintained. This unique multiband architecture allows each band to be properly adjusted for precise processing and natural sounding time constants. Total delay for the multiband section is set at 2.5ms. By employing a multiband processing system, IMD is further reduced, and then reduced even more by the program dependent IMD filters that each processor utilizes. The trick is to try and keep the latency delay as low as possible, or off-air monitoring for announcers is virtually impossible. Delay periods up to 10ms are thought to be generally acceptable. Omnia.fm without look ahead limiting has a 6.0ms input to output delay, while an Omnia.fm.veris employing look ahead limiting has a 9.0ms delay (still acceptable for off-air monitoring).

It is our feeling that using longer delay periods (which allow the processing control signals to be more lenient) can be avoided by implementing added IMD reducing filters in the control signals. Use of a long *attack* period is usually employed for smooth control of bass frequencies—but that technique has been outdated for quite awhile. Omnia has developed new techniques that allow faster control of low frequency signals without the associated aural side-effects. It is through this method that we are able to maintain shorter look-ahead latency.

This processing method has the ability to sound cleaner than a conventional processor setup for Classical or Jazz music, since it is not generating any harmonic distortion. In a side by side comparison, the conventional processor will sound softer as it must be operated liberally to avoid clipping. The Distributed Look-Ahead Processor allows signal peaks to reach maximum modulation without audible distortion, which generates a louder presentation while maintaining superior fidelity.

For aggressive music formats, we normally don't recommend the use of look-ahead limiting to achieve loudness. Why? Because there are proven successful methods to process audio for loudness that do not require long latency periods (as our market winning algorithms employed in Omnia.fm attest). With proper design and utilization of DSP, clean loudness can be created with minimal latency and no processing-generated aliasing distortion.

Using long look-ahead limiters should be viewed as a poor bandage to prevent processing-induced aliasing distortion, which the marketplace knows has been the fatal flaw in all other DSP processors except Omnia. We have even shown how composite clipping in the digital domain can be used effectively. Frankly, we're flattered that even the nay-sayers feel the need to copy our leading ways, and employ composite processing.

Our new Omnia-6fm pushes the envelope further in both the hard limiting/clipping domain, and in our composite processor as well. We are now employing a 96kHz base sample rate and utilizing the advantages of newer and faster DSP chips to achieve this growth in processing power. You can learn more about processing in DSP and processing induced aliasing distortion by reading our technical paper on the subject, found at www.omniaaudio.com.

When purchasing a processor, we feel users should consider carefully the benefits of a flexible architecture. With Omnia, the user can decide on the software structure most appropriate for the given task, and can use the same hardware platform without having to choose loudness over purity, or live without unacceptable levels of delay. Our research into processing never sleeps. Luckily, we got it right the first time, and our newest DSP effort isn't a poor attempt to rectify a fatal flaw. Of course, it's the sound that matters, and based upon the decision of the worldwide marketplace, it's clear that they agree as well!

- - F.F.

Cutting Edge (Omnia) is world-renowned for its innovative digital audio signal processing expertise. Its family of digital audio processors for FM, AM, TV, DAB, Internet, and broadcast audio production are setting new standards for audio quality in the broadcast and Internet industries worldwide. To find out more about Omnia, call +1 (216) 241-3343, or browse www.omniaaudio.com.