



Environmentally Aware
Feature-Packed DSP Hearing Aid Amplifier

IMPULSE NOISE REDUCTION

IMPULSE NOISE REDUCTION IS DESIGNED TO suppress sudden loud sounds such as slamming doors, which can be quite uncomfortable to hearing aid users. These types of sounds can be quite problematic because they are so short in duration that traditional algorithms such as WDRC can't respond quickly enough to control their loudness. The rise time of an impulse is of the order of tens of microseconds, whereas the time constants for WDRC are typically several milliseconds at the fastest, which is at least 100 times too slow.

Some hearing aid users are also disturbed by soft impulsive sounds such as the clicking of a computer's keyboard, or rustling paper. The Impulse Noise Reduction module can also be configured to control these softer sounds if required.

The suppression of impulsive sounds is performed in such a way as to reduce its loudness to an acceptable level while minimizing the adverse effects on other sounds such as speech. The naturalness of impulsive sounds is also preserved as much as possible while they are being suppressed.

An impulsive sound has a very fast rise time and has a broadband spectrum. These two facts are used to implement an effective detection and suppression scheme for impulsive sounds.

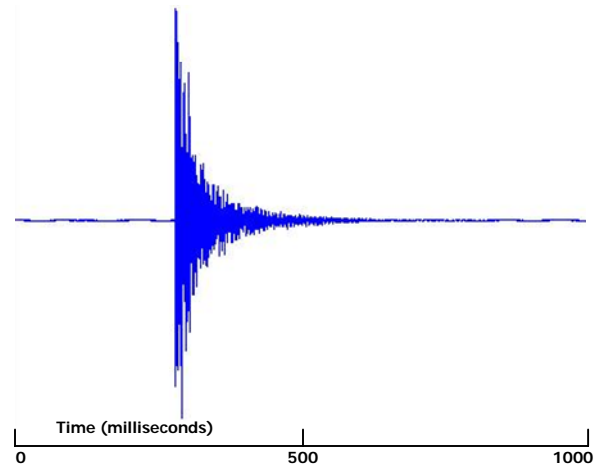


Figure 1. This recording of an impulsive sound illustrates classic characteristics. Note that the rise time is extremely fast (over several tens of microseconds), while the decay is much slower. The entire event takes place over several tens of milliseconds.

In order to detect an impulsive sound as fast as possible the Impulse Noise Reduction module monitors the signal levels at the front-end of the signal processing chain, before any of the frequency domain analysis is performed. This removes the delays that are inherent in the implementation of frequency domain analysis. This is particularly critical in the Ultra-Low Delay architecture of *Scenic* as the signal processing delay is only around 1ms, which is significantly lower than the time required to perform frequency analysis. Due to the broadband nature of an impulsive sound the time domain signal at the front-end proves to be quite appropriate for detection purposes.

Impulse Detection

The impulsive sound detection is achieved by monitoring the long term peak power of the ambient sound along with the instantaneous level and rise time. When the instantaneous level rises fast and exceeds the long term peak power, then an impulsive sound is deemed to have been detected. The use of the long term peak power criterion ensures that the impulsive sound is substantially louder than the normal environmental sounds before it is detected. This reduces the chance of false detection. A final absolute threshold is also applied to the detection to ensure that only impulsive sounds of a particular level are detected. This threshold is useful because it can be used to adjust the sensitivity of the module. For users that only find loud sounds like door slams disturbing, this threshold can be set quite high. For users who are disturbed by quieter sounds like the clicking of a computer keyboard, this threshold can be set quite low.

Impulse Suppression

Due to the broadband nature of impulsive sounds, the suppression part of the Impulse Noise Reduction module works by reducing the broadband gain in a controlled way. A large amount of the power in an impulse is near its start, so the gain is reduced quite fast in order to control this large peak properly. The gain is then brought back up to its nominal level in a carefully controlled way that ensures that the sound quality is natural. Preserving the natural quality of impulsive sounds is an important feature of the Impulse Noise Reduction module, because it is important that users can still recognize these sounds when they are being suppressed, both for safety reasons and to ensure a pleasant experience. The level of suppression is controlled by both the low term peak power level and the detection threshold. The gain is only ever reduced by enough to bring an impulse down the larger of these two, which reduces the chance of impulses being over-suppressed.

The combination of the long term peak power measure, the absolute threshold and the temporal shaping of the gain all ensure that the effect of the Impulse Noise Reduction module on normal speech is minimal.

The two thresholds ensure that the impulsive sounds are not over-suppressed, while the gain shaping ensures that the gain is restored quickly enough that minimal speech information is lost. Interestingly an unsuppressed impulsive sound will have a masking effect on the signal that follows it, so even a relatively slow release of the gain reduction doesn't have adverse effects on speech intelligibility.

Settings

The Impulse Noise Reduction module has the following adjustable settings:

Enable:

Activates the module

Strength:

Specifies the detection sensitivity and suppression strength. The range is 50-110 dB SPL.