

# Impulsive Sound Suppression: Rationale, challenges and efficacy.

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Impulsive sounds can be annoying, uncomfortably loud or exceed hearing-aid output limits.

This study investigated the spectro-temporal properties of a range of impulsive sounds and the efficacy of impulsive sound suppression DSP algorithms for hearing aids.

## The Characteristics of Impulsive Sounds

Impulsive sounds are sudden loud sounds such as those caused by slamming doors. These sounds can be quite uncomfortable to hearing aid users and are short in duration.

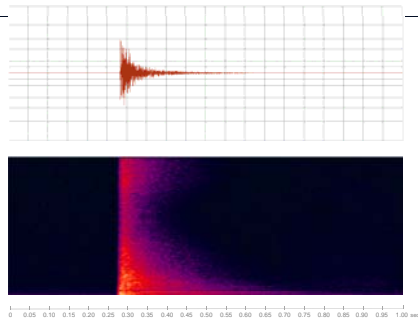


Figure 1. The time domain analysis (top) highlights the very fast rise time (over several tens of microseconds) and slower decay of an impulsive sound. The entire impulsive sound lasts for several tenths of a second. The spectrogram (bottom) shows the broadband spectrum characteristics of impulsive sounds.

Impulsive sounds are problematic for hearing aid users because traditional hearing aid algorithms, such as WDRC, can't respond quickly enough to control their loudness. The time constants for WDRC and other algorithms are typically several milliseconds at the fastest, which is at least 100 times too slow to cope with the rise time of an impulsive sound.

	Rise Time	Decay Time	Duration
Impulse Sound	< 0.1 ms	> 20 ms	20 to 500 ms
Average Sustained Syllable			150 to 200 ms
	Attack Time	Release Time	Duration
WDRC Slow Acting <sup>(1)</sup>	> 100 ms	> 400 ms	300 ms
WDRC Fast Acting <sup>(1)</sup>	< 10 ms	10 to 50 ms	10 to 60 ms
Output Limiting <sup>(1)</sup>	< 5 ms	20 to 100 ms	20 ms

Table 1. Temporal characteristics of an impulsive sound compared to speech, and hearing aid time constants.

## How Does the Impulsive Sound Suppression Algorithm Work?

In order to detect an impulsive sound as fast as possible, Dynamic Hearing's Impulsive Sound Suppression (ISS) algorithm monitors the signal levels at the front-end of the signal processing chain. This avoids the delays in frequency domain 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. Impulsive sounds are detected by monitoring the instantaneous level. When the level rises quickly and substantially exceeds the average environmental sound level, then an impulsive sound is deemed to have been detected. Otherwise speech or other non-impulsive sounds are assumed. The suppression part of the ISS algorithm 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 quickly in order to control this large peak properly. The gain is then restored in a carefully controlled way that ensures that the sound quality is natural.

## Performance Efficacy

Recordings for the study were made using a BTE hearing aid and 2cc coupler in a B&K Anechoic Test Box. The hearing aid was programmed with Dynamic Hearing's ISS algorithm. Recorded impulsive stimuli were presented to the hearing aid. Recordings of the hearing aid output were analyzed using Adobe Audition software.

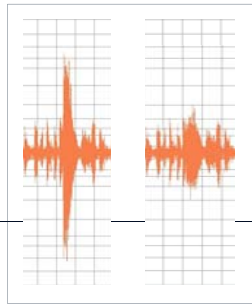


Figure 2 shows a recording of a door slam during male speech. In the right panel the ISS algorithm was activated and has successfully reduced the impulsive sound while preserving the speech.

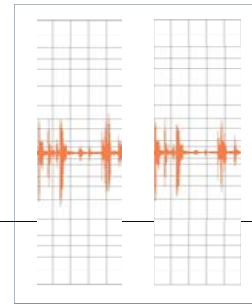


Figure 3 shows a recording of quietly jingling keys in speech. The impulses generated by the keys is much less intense than the door slam in Figure 2. Figure 2 and Figure 3 demonstrates the effect of comparing the impulses to the average environmental sound level, where in the Figure 3 right panel, the softer impulses are reduced by the smallest amount by the ISS algorithm.

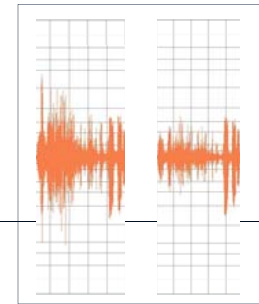


Figure 4. The sound of rustling paper is made up of closely spaced multiple impulses. These can be substantially louder than the ambient environment, as shown in the left panel. The recording of paper was made during male speech. The right panel shows the effect of the algorithm which has correctly detected and reduced the impulsive spikes while preserving the speech signal.

## Comparing Algorithms From Different Manufacturers

Figure 5 below compares impulse suppression algorithms from two different manufacturers. The hearing aid fittings were not matched. A sound file of a door slam was recorded through each device with impulse noise suppression algorithms turned off (top) and on (bottom). The same door slam is highlighted in each panel. Comparing recordings of the two devices it is evident that the rapid onset of the impulse is similar in the two top panels. In the bottom panels, it can be seen that both manufacturers achieve suppression. The device on the right still shows a significant spike at the onset. The device on the left has no spike, as it has reduced the power at the onset when the level is at its highest. The gain is quickly restored to ensure that the softer impulse tail is unaffected, allowing natural sound quality to be achieved.

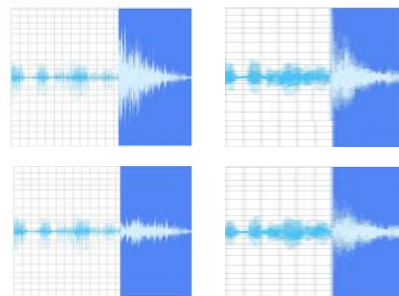


Figure 5. The top figures have no impulse suppression algorithms active. The bottom figures show the difference in impulse suppression algorithms between manufacturers.

## Conclusions

Impulsive sound suppression algorithms have recently been introduced in some hearing aids, but little research has been published on the dynamic characteristics of common impulsive sounds, the challenges of effective suppression, or the efficacy of different approaches to different approaches to impulsive sound suppression.

### The study lead to five main conclusions:

- Impulsive sounds are very intense and are very short in duration.
- Comparing the rise times with WDRC and output limiting time constants shows that these algorithms are not sufficient to adequately protect the hearing aid user from impulsive sounds.
- Test box measures showed that the ISS algorithm preserves speech.
- The ISS algorithm is successful in reducing the intensity of impulsive sounds.
- Impulse suppression performance varies across manufacturers.

<sup>(1)</sup> Dillon, H (2001). *Hearing Aids*, Boomerang Press, Sydney.