



APPLICATION NOTES

LIMITERS: BASIC CONCEPTS AND OPERATIONS

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1. Introduction

The main purpose of this application note is to provide better understanding on how to use the different types of limiters available in Powersoft amplifiers. This document is applicable to the following product lines: X series, T series, Otto/Quattro/Due Canali DSP+D series, Mezzo series and Loto DSP.

Choosing the correct limiter is not an easy task and many aspects need to be considered; e.g.: it can be difficult to decide thresholds and time constants to obtain the correct balance between protection and sound quality, hence every decision should be based on a wider knowledge of the component to limit.

Limiting may be considered an “art” and many different approaches and philosophies can be followed. For this reason, this guideline intends to simply provide a starting point on limiter parameters and how to handle them with Powersoft devices.

NOTE: Powersoft is not responsible for misuse of the information contained in this document and/or any potential loudspeaker or other damages derived from incorrect limiter settings. This document serves as a general guideline and is subject to the context in which it is applied.



2. Limiting, speaker damage and power compression

The limiting process in sound reinforcement is a way to **protect loudspeakers** from accidental damage; therefore, limiters are a safeguard against excessive signal peaks and/or signal long term average power.

Bear in mind that limiting does not only prevent occasional damage, but it first and foremost **guarantees a long loudspeaker life**.

Speaker limiter designers do not usually concentrate on colouring sound, but rather on speaker protection. Typical applications in the audio chain are:

- Controlling the energy of a signal.
- Controlling the peak levels of a signal.
- Reducing the dynamic range of a signal.

Remember that in sound reinforcement you are dealing with power signal (that means high voltage and currents), so the target with limiters is to protect the drivers from the two main causes of damage:



Figure 1 – Broken woofer

- **Over-excursion:** An impulsive signal can reach the speakers and cause damage due to over-excursion of the voice coil that is driven out of the mechanical limit. This can damage the diaphragm deforming or breaking it.

- **Over-heating:** Delivering high power for too much time may lead to overheating of the voice coil copper, the coil former, the magnet, the suspensions and the cone itself. Another effect is power compression, more noticeable in low frequency speakers. When there is power compression there is an increase of the impedance and a decrease of power with the result of less perceived loudness!

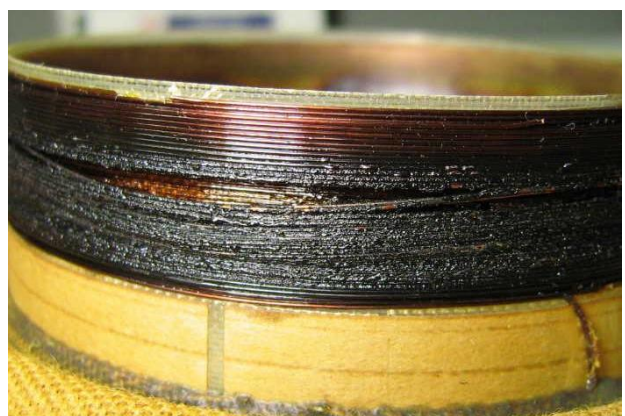


Figure 2 – Burned coil



3. Limiter type: RMS, Peak and Clip

To avoid mechanical and temperature related damages two kinds of limiters can be used:

- **RMS limiter:** Protects speakers against thermal damage when excessive power is applied for extended periods of time, resulting in overheating and eventually burning. Designers should be aware of the maximum long-term power safely applicable to speakers (AES power rating). An interesting approach to RMS limiting is one that uses coil temperature control looking at how the peak in the impedance curve changes when the speaker starts heating.

In *figure 3* we can see the relationship between the temperature and impedance curves: the green curve is the curve measured when the speaker is at 26°C, meaning it is cold. The orange curve is when the temperature increases to 38°C. We can notice that when the speaker starts heating up the impedance peak will become higher in value and will shift slightly in frequency. Therefore, being able to monitor the impedance changes in real-time will allow us to save our loudspeaker.

A complete knowledge of the driver's limits allows to keep the temperature level in a safe interval not only to avoid damage but to maintain the speaker in a "linear" zone avoiding power compression.

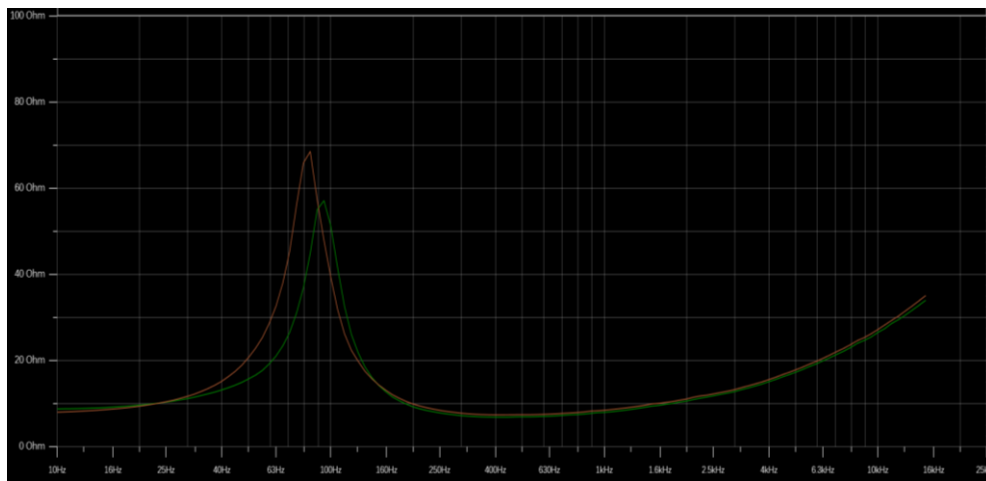


Figure 3 – Live impedance curves

- **Peak and limiter:** Protect against mechanical damages. Designers should set this limiter parameters as a function of both the maximum displacement (X_{MAX}) of the diaphragm and the speaker maximum tolerated voltage.

NOTE: Relying on peak limiting only for speaker protection can still lead to excessive long-term average power and consequential damages.



4. Limiter parameters

4.1 Threshold

When the input signal level exceeds the threshold, the limiter starts to reduce the input gain. Gain is reduced of an amount equal to the overshoot of the input signal with respect to the threshold. The threshold value is expressed in Volt because it depends on the power of the loudspeaker and its impedance.

4.2 Attack time

It is the time the limiter takes to get 70% of the total required reduction after exceeding the threshold level. In applications where we want to avoid speaker damage, the longer the attack time, the higher the risk of damaging the equipment. However, settings with a too fast attack time can generate distortions or a deep modification to the transient of the signal, especially with percussive sounds, resulting in poor perceived sound quality.

Typically, a good compromise is to set an attack time no longer than the lowest frequency you need to protect (i.e. 1 ms for an HF driver with X-over at 1kHz octave band).

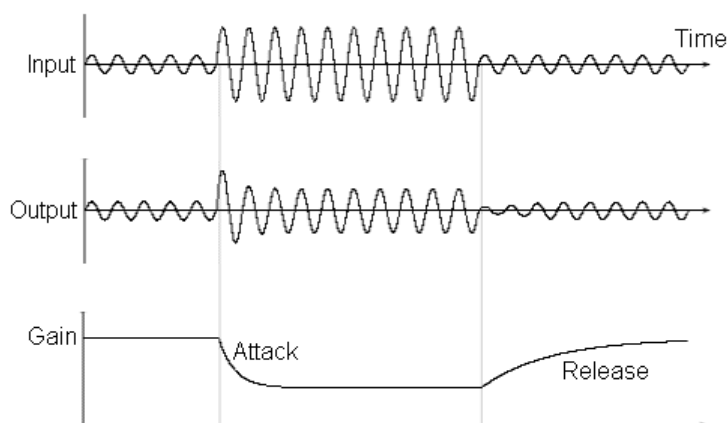


Figure 4 – Limiter acting on an audio signal

4.3 Release time

It is the time that the gain takes to go from the maximum reduction to 30% of reduction. In general, the release time, must be adequate to avoid a pumping effect and protect the speaker. The release time can be set between 1 to 32 times the attack time.

4.4 Soft knee

A soft knee slowly increases the compression ratio as the level increases, this way the changing from un-compressed to compressed sound is less audible. This value in Powersoft limiters is expressed in dB below the threshold.



5. How Powersoft limiters work

5.1 RMS Limiter

The RMS limiter is intended to prevent burning the driver's voice coil, while at the same time exploiting their maximum performance. The RMS limiter should not be engaged at normal working levels since a common musical signal has very high peaks, but a rather small average level.

5.2 Peak limiter

The peak limiter avoids potentially dangerous displacement of the cone (larger excursion with respect to the allowed values), and it is based only on the quantity of signal that is sent through that channel. Peak limiters, as well as RMS and Clip limiters, are independent from the number of parallel wired speakers: you can use the power and impedance of a single speaker or the power and impedance of the parallel circuit, the given result will be the same.

Pushing into a peak limiter can reduce the crest factor, thus "squashing" the dynamics of the original signal. For most applications, 3 to 9 dB of gain reduction is usually suggested.

5.3 Clip limiter

The Powersoft clip limiter is a "brick wall" limiter that blocks the driving signal, not allowing it to exceed the threshold. This limiter has a fixed attack time of 0.3 ms with a lookahead of 0.3 ms that allows to anticipate peaks before they occur and therefore with the benefit of less distortion by not having a hard clip. Clip limiters are very fast and are the last safety tool that can be used to avoid loudspeaker damage. To achieve the best result in quality and performance, it is suggested a gain reduction between 0 and 3 dB and to engage also Peak and Rms limiters.



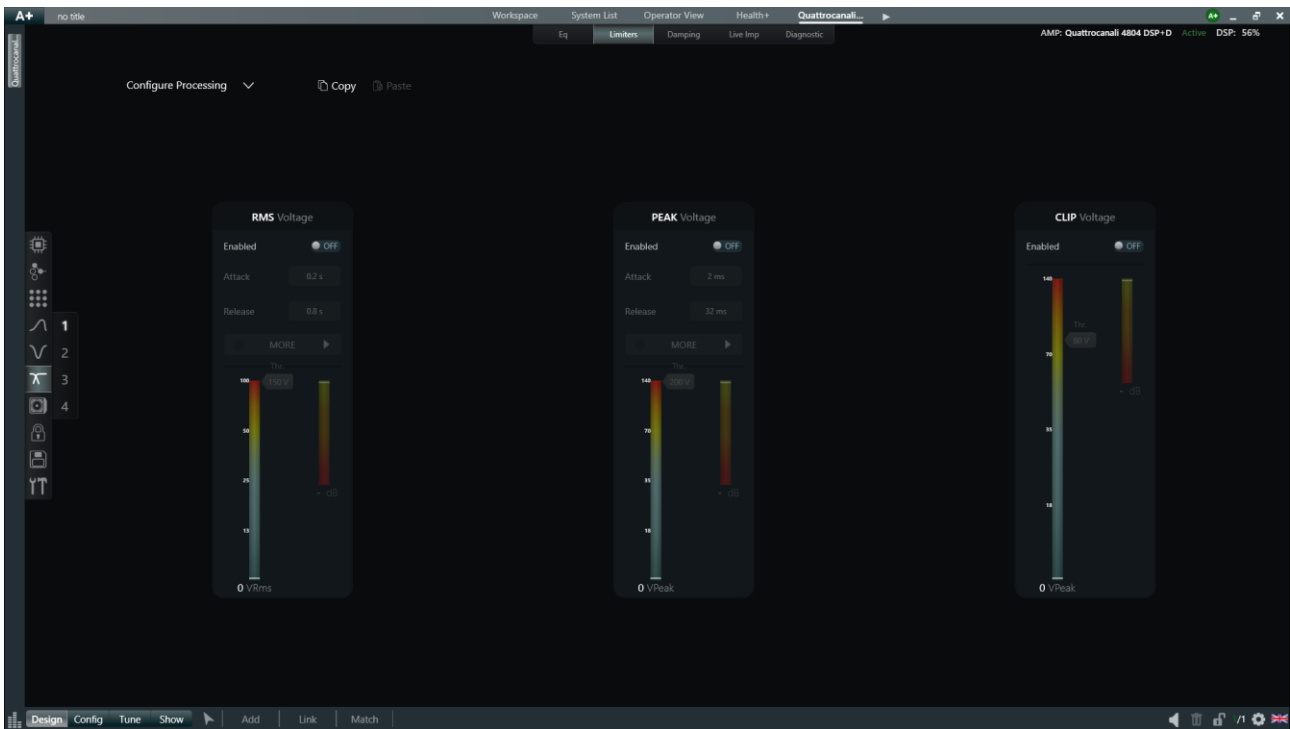


Figure 5 – Limiters in ArmoniaPlus.

6. How to calculate limiter values

To calculate Voltage thresholds, attack, and release time for the three basic limiters available in ArmoniaPlus, Powersoft has developed a tool called the Power Sharing Tool.

In this tool there is a dedicated section called “Suggested Limiters threshold” that can be used as a safety starting point while working with limiters.

Simply add the loudspeaker’s AES power, the nominal impedance and select its profile (or the way of the loudspeaker). Once these values are specified the tool will calculate and suggest a possible limiters configuration.

The tool provides calculations for both Low-Z loudspeakers and Hi-Z lines (100V, 70V and 25V)

Remember that this is only the starting point, especially for a multi-way loudspeaker where it is always suggested to analyse the behaviour of the ways with a musical or pseudo-musical signal.

In this way, tonality unbalances due to wide differences in gain reduction between the transducers can be avoided.



User Input						Comments
Amplifier model	T304					
Mains	230 V		16 A			
		Channel				
Loudspeaker data		1	2	3	4	
P _{AES} (or Hi-Z tap)		250 W	250 W	250 W	250 W	This should be the AES power for one cabinet or the tap value of a Hi-Z loudspeaker.
Loudspeaker type		Lo-Z	Lo-Z	Lo-Z	Lo-Z	Select: Lo-Z / 100V / 70V / 25V / Unused
Z nominal		8,0 ohm	8,0 ohm	8,0 ohm	8,0 ohm	Nominal impedance (Only necessary if Lo-Z)
#Cabinets in parallel		1	1	1	1	Number of parallel speakers per channel
Profile		FR	FR	FR	FR	Select: SW / LF / MF / HF / FR
User limiter		0 dB	0 dB	0 dB	0 dB	Select full power (0 dB) or reduce power with a negative dB value
		Channel				
Amplifier Output		1	2	3	4	
Power		500 W	500 W	500 W	500 W	Lo-Z speaker = P _{AES} x 2, Hi-Z speaker = rated power
Z		8,0 ohm	8,0 ohm	8,0 ohm	8,0 ohm	Overall impedance
Headroom		✓ 1,8 dB	✓ 1,8 dB	✓ 1,8 dB	✓ 1,8 dB	Dipswitch setting for Canali series
Suggested Limiters Treshold						
Clip voltage		94 Vpk	94 Vpk	94 Vpk	94 Vpk	
Peak voltage		72 Vpk	72 Vpk	72 Vpk	72 Vpk	
Attack Time Range		2 - 8 ms	2 - 8 ms	2 - 8 ms	2 - 8 ms	
Release Time Range		16 - 64 ms	16 - 64 ms	16 - 64 ms	16 - 64 ms	
RMS voltage		27 Vpk	27 Vpk	27 Vpk	27 Vpk	
Attack Time Range		0,3 - 0,8 sec	0,3 - 0,8 sec	0,3 - 0,8 sec	0,3 - 0,8 sec	
Release Time Range		0,5 - 2 sec	0,5 - 2 sec	0,5 - 2 sec	0,5 - 2 sec	

Figure 5 – Powersoft Power Sharing tool limiters section.

7. Conclusions

After this basic analysis of Powersoft limiters we can focus on two key points: the first one is that all Powersoft limiters are made to protect the loudspeaker, so it is best practice to have them always enabled.

The second one concerns the sound quality and good system design: the best performances in audio quality are achieved when, as mentioned previously, RMS limiters are able to do the heaviest part of the job in terms of gain reduction, then Peak limiters to control transients and Clip limiters as a final safety point.

By following this simple workflow, you will achieve the best audio quality from your system, ensuring its long lifespan.

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