LIMITERS – HOW AND WHY TO USE THEM

1. Speakers reliability

The efficiency of loudspeakers is very low (usually less than 5%) and the main part of energy supplied to them is converted into heat. Although the voice coils are designed for operation at a temperature up to 200°C, heat is the main cause of speakers "burnout".

Most of the problems associated with wires resistance increase with the increase of temperature, but there is also the problem of partial magnetic field degradation at high temperatures. Problems associated with temperature are as follows:

- ► Power Compression
- ► Efficiency reduction
- ► Damping degradation
- ► Linearity loss

1.1 Power Compression

The first obvious and well-known problem of voice coils heating is an increase in its resistance (Re). This effect is well known as power compression. Re increase also causes Qes increase, which significantly affects the efficiency of the speaker and cabinet setting. Power compression can be quite significant (up to 4.5 dB) at high temperatures. The following table shows the level of the power compression and the equivalent series resistance of the coil at different load levels.

Average power / Rated power	Power Compression (dB)	Equivalent series resistance for 8-ohms speaker
10%	1.4	1
20%	2	1.4
50%	2.8	2.1
100%	4.5	3.8

From a perspective of users, all these effects lead to a reduction of sound pressure. As a result, the user has to increase the signal level, which leads to greater heat generation and further increase in voice of coil heating.

This may promptly lead to a speaker breakdown, especially in low-power systems, or to an equilibrium in which a speaker operates at a very high temperature for many hours. The second scenario, though not immediately leading to failure, may significantly reduce the service life of the speaker.

In order to reduce or control these effects it is advised to use limiters.

2. Limiters

Limitations in the sound system are used for the protection of loudspeakers against overloading and assurance of long-term fail-safe operation.

Limiters are used to protect the speakers from two main problems:

- excess cone displacement, tending to cause mechanical damages to a speaker;
- overheating, tending to cause voice coil damage.

2.1 Limiter types

There are two main types of limiters:

Peak limiter: Protects against mechanical damages. Limiter's parameters depend on the maximum displacement (X max) of the diaphragm and the speaker's maximum tolerated voltage.

RMS limiter: Protects speakers against thermal damage when excessive power is applied during long periods, resulting in overheating and further burning. Limiter's parameters depend on the maximum long-term power safely applicable to speakers (AES power rating).

Peak limiter always has higher value than the RMS limiter. Use of peak limiter alone may not protect speakers from damage. Let us consider an example:

Suppose we need to set a limiter to subwoofer speaker with the following parameters:

- Re – 8 Ohms
- AES power rating – 1000 W

Acceptable peak voltage will be about 126V, but we want to work safely and are going to limit the voltage to 100 V, which is approximately 2 dB less, therefore we get a 600 W peak power.

Now suppose that for some reason the sound engineer decides that the bass level is not sufficient and begins to increase it.

Then, if the low frequency signal has a 6 dB crest factor, increase of the volume starts activating peak-limiter and peak factor of the signal decreases, for example, up to 3 dB. But the greater is the volume the stronger will be power compression and to compensate it the sound engineer will raise the level of the signal again. As a result, the peak factor can drop to 1 dB.

RMS voltage vs peak factor

Peak factor	Peak / RMS	Peak Power	RMS Power
6 dB	100 / 35 V	625 W	153 W
3 dB	100 / 49.5 V	625 W	306 W
1 dB	100 / 62.4 V	625 W	486 W

The table shows that the peak limiter works properly. It holds a peak voltage at 100V level. At the same time, RMS power depends on the peak factor and strongly increases with the decrease of peak factor. For this reason, it is important to use both limiters – the peak limiter to protect from mechanical damage and RMS limiter for speaker protection from thermal damage.

3. Limiter parameters

3.1 Peak limiter

Peak Limiter in SigmaStudio has 3 adjustable parameters:

► Threshold

When the input signal level exceeds threshold, limiter starts to reduce the input gain. The gain is reduced to an amount equal to the overshoot of the input signal with respect to the threshold. The threshold is measured in dB in relation to reference value.

► Decay

Speed of the linear decay ramp is applied to the output gain until it reaches the current target output gain. It is measured in dB per second (dB/s), and mathematically corresponds to a more common release time.

Release Time - is the time that the gain takes to go from the maximum reduction to no reduction. In general, release time has to be adequate to avoid pumping effect and to protect the speaker.

► Hold

Hold time is useful to avoid distortion when fast release time is needed. It is possible to avoid too much distortion of the waveform shape by setting hold time longer than a cycle of the lowest frequency reproduced. It can also be used to avoid the pumping effect.

3.2 RMS limiter

RMS Limiter in SigmaStudio has 3 adjustable parameters:

► Threshold

When the input signal level exceeds threshold, limiter starts to reduce the input gain. The gain is reduced to an amount equal to the overshoot of the input signal with respect to the threshold. The threshold is measured in dB in relation to reference value.

► RMS TC

The time constant that determines how rapidly the compressor responds to input signal level changes, e.g. the "Attack" time. It is measured in dB per second (dB/s), and mathematically corresponds to a more common attack time.

► Decay

It controls the rate at which the compressor gains decreases in response to decrease in the input signal level, e.g. the "Release" time. It is measured in dB per second (dB/s), and mathematically corresponds to a more common release time.

4. Calculation of limiter parameters

To calculate limiter parameters, it is recommended to use a calculation table. It can be found on the CD, attached to the amplifier, or can be downloaded from the download sections of the corresponding amp models of our website.

4.1. Threshold calculation

Peak and RMS limiters calculation

Amplifier parameters		
P amplifier (nominal power handling), W	on the load, Ohms	**K** amplifier gain
700	4	68,3
Speaker parameter		
P_NOM (nominal power handling), W	**R spkr, nominal, Ohms**	**Vpeak speaker**
350	8	74,8
P_CONT (continuous power handling), W	**R spkr, nominal, Ohms**	**Vrms speaker**
700	8	47,3
Threshold for peak limiter,dB		-7,8
Threshold for RMS limiter, dB		-12,5

For limiter threshold calculations, you shall specify the following parameters:

Amplifier parameters:

To calculate gain of the amplifier, it is necessary to specify its output power per load resistance.

Speaker parameters:

To calculate the allowable levels of voltage, it is necessary to specify the nominal and continuous speaker power and its impedance. Nominal power is used to calculate the RMS limiter threshold, continuous power is used to calculate the peak limiter threshold.

The calculation results can be seen in the green field of the table. The table gives results applicable to the majority of cases. However, the final decision is preferably taken after more detailed research of speaker. If the

speaker is still cold after a long use, the threshold can be raised by 1-2 dB. If the speaker is overheated and there is the smell of the heated coil - the threshold must be reduced by 1-2 dB.

In any case, there will always be a compromise between reliability and high performance of the speakers.

4.2. Time constant calculation

Peak limiter time constant calculation

The lower limit of the speaker frequency band, Hz	40
Decay (dB/s)	32,5
THOLD (msec)	25

RMS limiter time constant selection

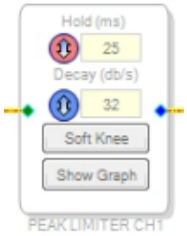
Voice coil diameter	Power	RMS TC	Decay
1" Tweeter	20 - 50 W	500 dB/s	9 dB/s
1.5" Tweeter	50 -75 W	250 dB/s	10 dB/s
2" Horn driver	50 -100 W	100 dB/s	11 dB/s
3" Horn driver	75 -125 W	50 dB/s	12 dB/s
2" Midrange	75 - 300 W	50 dB/s	13 dB/s
3" Midbass	100 - 500 W	25 dB/s	14 dB/s
4" Woofer	500 -1000 W	10 dB/s	14 dB/s
4" Woofer	500 - 1500 W	5 dB/s	15 dB/s
6" Woofer	1000 - 2000 W	3 dB/s	16 dB/s

Time constants of the peak limiter depend on the minimum frequency of the speaker range. For example, for a subwoofer it can constitute 40Hz, when for a driver it will be – 1100Hz.

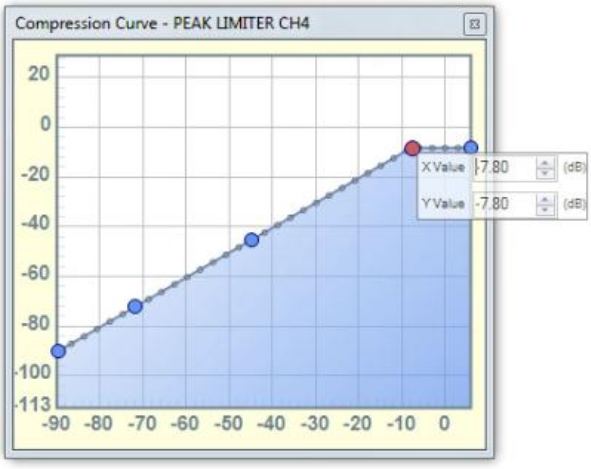
Time constants of the RMS limiter can be approximately determined depending on the kind of the speaker and its voice coil diameter.

5. Setting SigmaStudio limiters

5.1. Peak Limiter

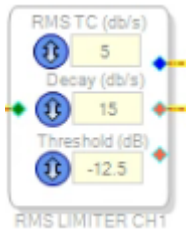


Enter time constant in the appropriate fields. In order to enter the threshold, click Show Graph in the Peak Limiter block to open the Compression Curve window.



Use right-click on the circles of the curve to set calculated control points.

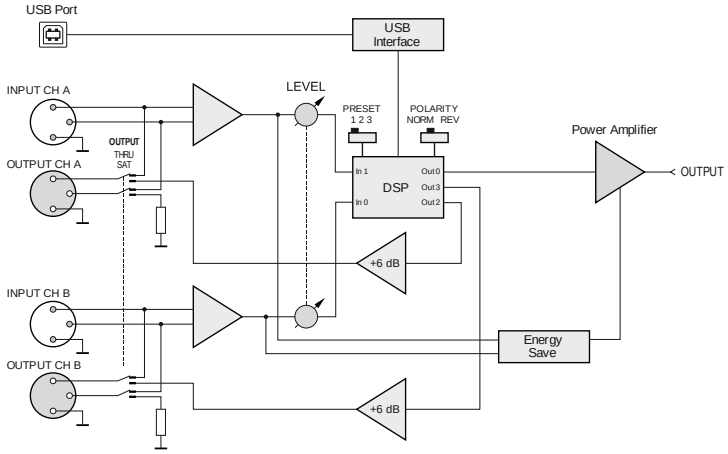
5.2. RMS Limiter



Enter time constant and threshold value in the appropriate fields.

5.3. Line outputs limiters

Level of the signal sending to the line output is raised by 6 dB after the DSP (see block diagram of the amplifier).



Level control, located on the input panel adjusts the level of signal sent to the amplifier and line outputs. Extra 6 dB of gain make it possible to align the speaker`s level using the level controls of the systems, connected to the line output.

Therefore, you need to take into account extra 6 dB of gain when calculating the threshold for linear outputs. In any case, first study the block diagram of your amplifier.