

How to setup limiters

TruePower limiter: how can I protect and preserve in the time my preferred speaker

I Compression, Limiting and speaker damage

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 power.

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

The aim of limiters is implementing a special case of (dynamic) compression that is typically used as an "artistic" way of sound shaping. Speaker limiter designers, however, don't usually concentrate on coloring sound, but rather on speaker protection. Typical compressor 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) and not with small signals (that can have relatively high voltages but low currents). The target with limiters is to protect the drivers from the two main causes of damage:

- ▶ 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 magnetic gap (where displacement exceeds X_{max}). This can damage the diaphragm (breaking or deforming it).
- ▶ Over-heating: Delivering high power to the voice coil may lead to overheating of the voice coil copper and the relative magnetic gap. This can damage the isolation of the copper. Another evident high power driving effect is power compression, noticeable in low frequency speakers.

2 Limiter type, peak and RMS

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

- ▶ Peak limiter: Protects against mechanical damages. The peak limiter may also be used to control amplifier clipping. Designers should set this limiter's parameters as a function of both the maximum displacement (X_{max}) of the diaphragm as well as the speaker's maximum tolerated voltage.
- ▶ 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. 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 that avoids power compression.

NOTE: Relying on peak limiting for power control may be very harmful and can lead to speaker destruction.

An important thing to consider is that peak limiting can raise up the RMS power level. Let's see an example. Suppose you want to limit a sub woofer rated as follows:

- ▶ 1000 W Program power.
- ▶ 250 W continuous power.
- ▶ 8 Ω

This means the speaker can be driven with peaks of about 90 V. Let's suppose that you want to play it safe and limit the system to 70 V (about 3 dB less, therefore a power of about 600 W).

Now, suppose that for some "reason" the FOH engineer decides that the low end is too "weak" and starts to push hard the woofer increasing the low end signal. Let's now assume that the low end was driven with a signal having a crest factor of 6 dB, raising the loudness results in peak compression and therefore in a crest factor change, assume from 6 dB to 3 dB. Power compression could start to act and for this reason the FOH decides to raise everything up one more time, bringing the driving signal to 1dB crest factor.

Crest Factor (dB)	Peak/RMS Voltage (V)	Peak power (W)	RMS power (W)
6	70/35	612	153
3	70/49.5	612	306
1	70/62.4	612	486

TABLE 1: RMS voltage and power vs crest factor

As you can see the peak limiter is working correctly, as it maintains the level below the 70 V, but the RMS power increase up above the maximum allowed level, this because is dependent by the crest factor of the musical program. For this reason is very important use two limiters, one for over-excursion protection and one for thermal protection (RMS power).

3 Limiter Parameters

1.1 Threshold

When the input signal level exceeded the threshold the limiter starts to reduce the input gain. The gain is reduced of an amount equal to the overshoot of the input signal respect to the threshold.

1.2 Attack time

It's the time the limiter takes to get full input signal 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 will generate distortion or a deep modification to the transient of the signal; since transient information in the attack portion conveys brightness character, especially with percussive sounds, immediately reducing it with the compressor will result in a poor perceived sound quality. On the contrary too slow attack time may result in inadequate speaker protection. Typically a good compromise is setting an attack time no longer of the lowest frequency you have to protect (for example, 1 ms for 1 kHz).

1.3 Release time

It's the time that the gain takes to go from the maximum reduction to no reduction. In general, the release time, has to be adequate to avoid *pumping* effect and protect the speaker. The release time should be set between 1 to 32 times the attack time.

1.4 Hold time

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

1.5 Soft knee

A soft knee slowly increases the compression ratio as the level increases, in this way the changing from un-compressed to compressed sound is less audible.

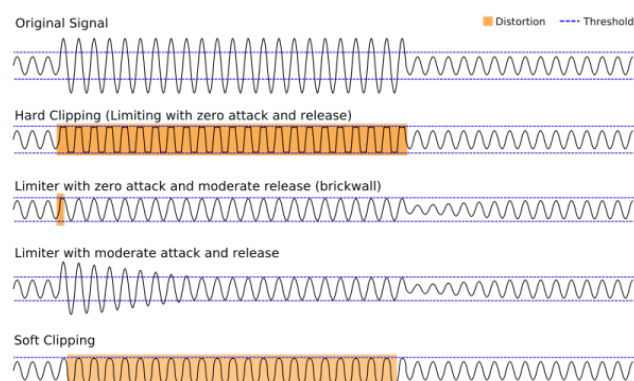


FIGURE 1: Distortion changing vs Limiter modification

4 The power in the loudspeaker

1.6 Speaker basis

There are many kind of speaker designs, but in this document we will discuss the most common drivers type: electro-mechanical transducer using a voice coil rigidly connected to a diaphragm (generally a cone). The voice coil in moving coil drivers is suspended in a magnetic field provided by the loudspeaker magnet structure. As electric current flows through the voice coil (from an amplifier), the magnetic field created by the coil reacts against the fixed field surrounding the magnet and moves the voice coil (and so the attached cone). In order to generate sufficient force, the wire in a moving-coil driver must be long enough and wound into a coil. To keep this coil from being too large and heavy, the wire must be thin, so even when it is formed of copper (one of the most electrically conductive metal) it has appreciable resistance. In a drive-unit of nominally 8 Ohms impedance, the resistance of the voice-coil is typically around 6 Ohms. Therefore the amplifier will see a complex impedance consisting of real part and an inductive part, from the electrical point of view this leads to an inherent inefficiency of direct-radiating moving-coil loudspeakers (typically less than 5%). This means that considerable electrical power is dissipated in the coil resistance, just as with the incandescent light bulb, little of the input energy is put to good use and the rest appears as heat.

Although speakers are designed to tolerate voice coil temperature of 200°C, heat is the most important enemy in burnout speakers since it has other considerable side-effects on the sound quality and system linearity. Most of the problems are related with the increase of the wiring resistance, but also with the partial degradation of the driver's magnetic field at high temperatures. Here are some temperature related issues:

- ▶ Efficiency reduction
- ▶ Power compression
- ▶ Damping reduction
- ▶ Linearity loss

From an end-user point of view all this issues leads to a reduction of the perceived SPL (this is especially true in the low end frequency band), bringing the user to "push more sound" into the speakers system, and more the signal you push more the heat produced by the speaker and thus less the "expected" power provided by the system. This situation can lead very fast to a destructive domino effect, especially in undersized system, or to an equilibrium where the system doesn't burnout but remains for many hours at a very high temperature. The second scenario although doesn't leads to an immediate break up will diminish the entire life of the system.

In order to reduce and/or control these effects it's necessary use an RMS/Power limiter. In the next chapter a short explanation will be provided and the Powersoft TruePower limiter will be explained in order to understand how it's possible to control the heating (and thus power compression) in order to maintains consistent performance, also some further ideas will be provided.

1.7 Apparent power: Real power and reactive power

An alternating current (AC) circuit consists of a sinusoidal source and a resist load, the two quantities (V and I) reverse their polarity at the same time. At every instant the product of voltage and current is positive, indicating that the direction of energy flow does not reverse. In this case, only real power is transferred.

If the loads are purely reactive, then the voltage and current are 90 degrees out of phase. For half of each cycle, the product of voltage and current is positive, but on the other half of the cycle, the product is negative, indicating that on average, exactly as much energy is flowing towards and backwards the load. There is no net energy flow over one cycle. In this case, only reactive energy flows: there is no net transfer of energy to the load.

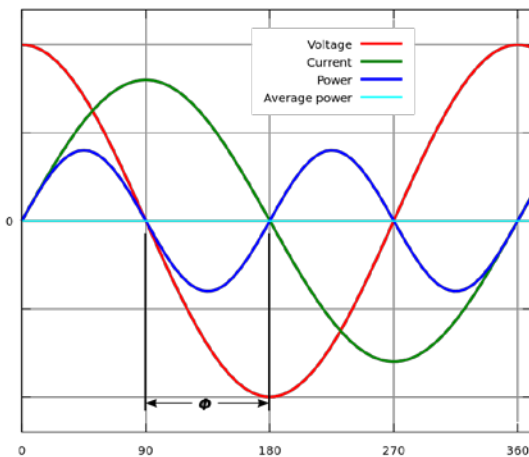


FIGURE 2: Instantaneous and average power calculated from AC voltage and current with a zero power factor ($\Phi=90^\circ$, $\cos(\Phi)=0$). The blue line shows all the power is stored temporarily in the load during the first quarter cycle and returned to the grid during the second quarter cycle, so no real power is consumed

Practical loads have resistance, inductance, and capacitance, so both real and reactive power will flow to real loads. Power engineers measure apparent power as the magnitude of the vector sum of real and reactive power. Apparent power is the product of the root-mean-square of voltage and current.

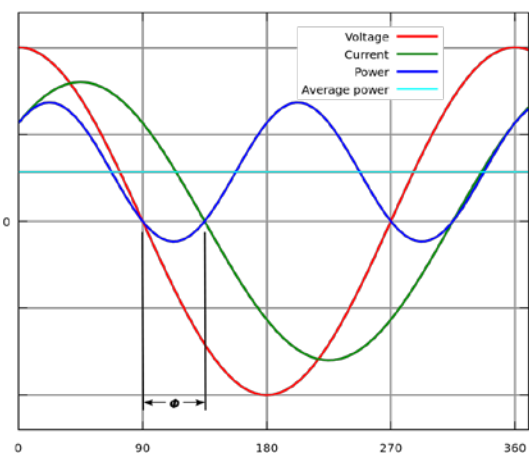


FIGURE 3: Instantaneous and average power calculated from AC voltage and current with a lagging power factor ($\Phi=45^\circ$, $\cos(\Phi)=0.707$). The blue line shows some of the power is returned to the grid during the part of the cycle labelled Φ

Energy flowing in the system has a strictly relation with impedance and thus with voltage, current and phase (or power factor) between voltage and current, as consequence the following powers, can be found in a system (we are assigning measurement units to differentiate em):

- ▶ Real power (P) or active power watt [W]
- ▶ Reactive power (Q): volt-ampere reactive [VAR]
- ▶ Complex power (S): volt-ampere [VA]
- ▶ Apparent power (|S|), that is the magnitude of complex power S: volt-ampere [VA]
- ▶ Phase of voltage relative to current, that is the difference (in degrees) between voltage and current: angle $[\Phi]$

Reactive power does not transfer energy, so it is represented as the imaginary axis of the vector diagram. Real power moves energy, so it is the real axis. The physical unit for all forms of power is the watt (symbol: W), but this unit is generally reserved for real power. Apparent power is conventionally expressed in Volt-Ampere (VA) since it is the product of rms voltage and rms current. The unit for reactive power is expressed as VAR, which stands for volt-ampere reactive. Since reactive power transfers no net energy to the load, it is sometimes called "wattless" power. The relationship among these three quantities lies at the heart of understanding power exchange into a loudspeaker. The mathematical relationship among them can be represented by vectors or expressed using complex numbers:

$$S = P + jQ \text{ (where } j \text{ is the imaginary unit).}$$

This analysis is based on one frequency but can be straightforward extended for the whole speaker bandwidth considering the impedance function, also remember that resistive component is strongly related to the temperature (and then heat).

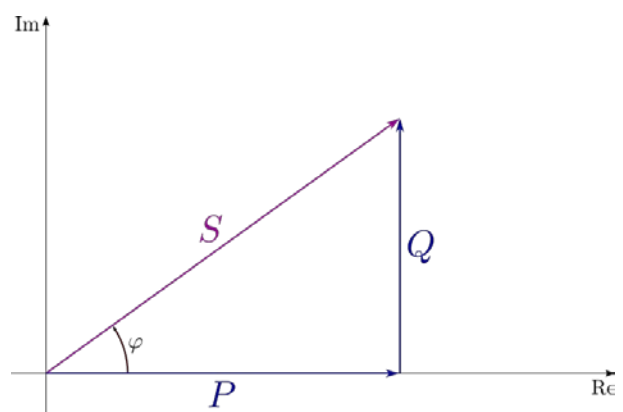


FIGURE 4: The complex power is the vector sum of real and reactive power. The apparent power is the magnitude of the complex power. Real power (P), Reactive power (Q), Complex power (S), Apparent Power (|S|), Phase of Current (Φ)

5 Power delivered to a speaker, a real case

The test purpose is to explain the variability of the Cos (Φ) and therefore the different amount and type of power delivered to the driver in different context (low amplitude signal/ high amplitude signal) and with different limiters.

For this test a I2NBX100, 12 inch neodymium LF drivers is used, with a minimum impedance of 6.5 ohm and rated 500 W AES. The test will be performed with a 50 Hz pure tone in input, this frequency value it's about half way between the resonance point and the minimum impedance, further test should be done but for our purpose this is enough.



FIGURE 5: The driver and its test case

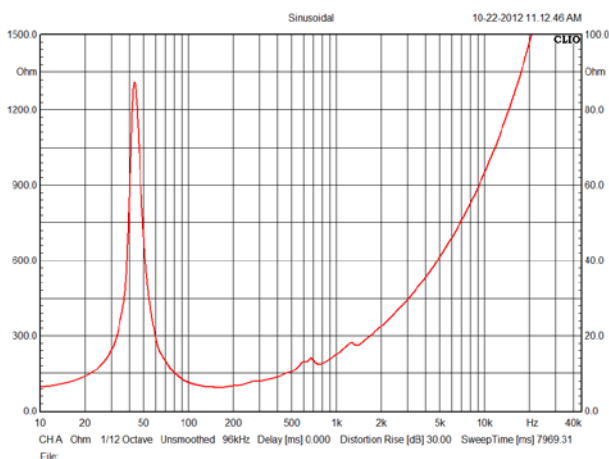


FIGURE 6: The impedance curve of the speaker measured in the open cabinet

1.8 Low signal case

A 50 Hz pure tone signal with an amplitude of 0.79 Vrms is feeded into a K10 with 32 dB gain and thus connected to the speaker. The measure are taken with an interval of 40 minutes.

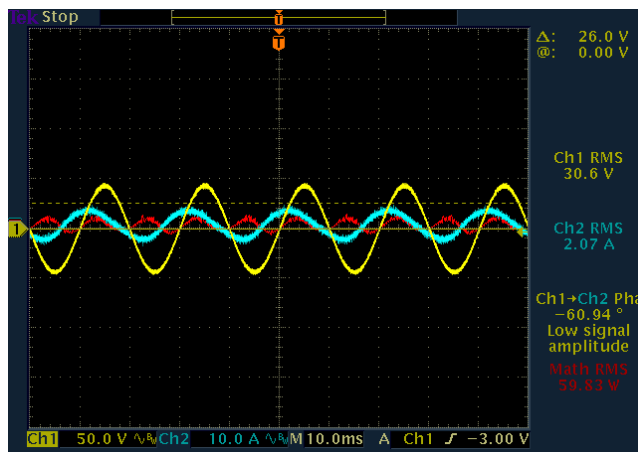


FIGURE 7: Measure sample, low amplitude input signal @ 21°C

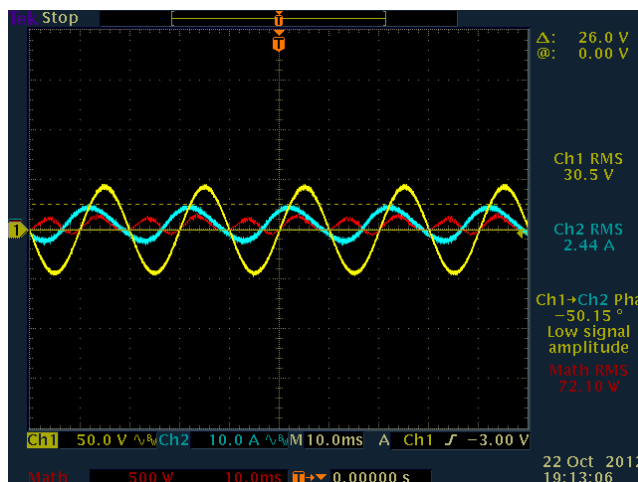


FIGURE 8: Measure sample, low amplitude input signal @ 23.1°C

With this little signal the speaker behavior is slightly modified, the augment of the dissipated real power is noticeable (from 30 W to 47 W).

External T (°C)	Vout (Vrms)	Iout (Irms)	Cos (Φ)	Papp (VA)	Preal (W)	Preact (VAR)
21,1	30,60	2,09	-61,32	63,98	30,69	-56,10
24,8	30,5	2,46	-51,19	75,15	47,06	-58,53

TABLE 2: Measurements variation in relation to temperature raising, low amplitude signal

1.9 High power signal without limiter

A 50 Hz pure tone signal with an amplitude of 1.70 Vrms is feed into a K10 with 32 dB gain and thus connected to the speaker: three measures are taken with an interval of 20 minutes.

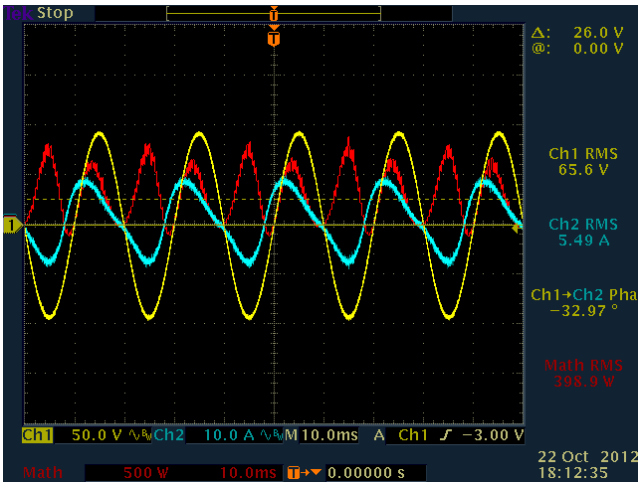


FIGURE 9: Measure sample, high amplitude input signal @ 32.3°C.

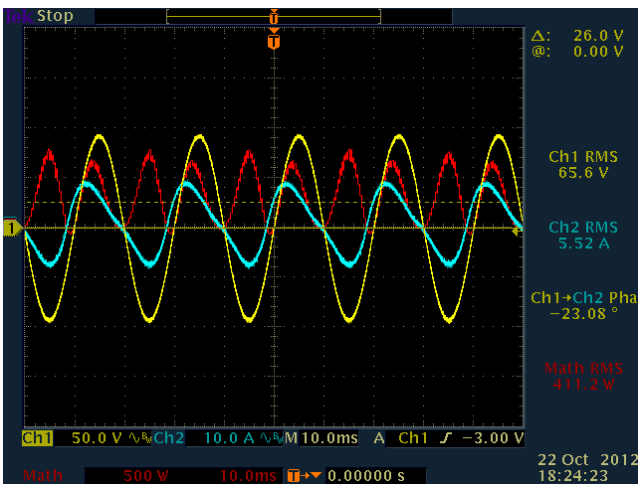


FIGURE 10: Measure sample, high amplitude input signal @ 54.4°C.

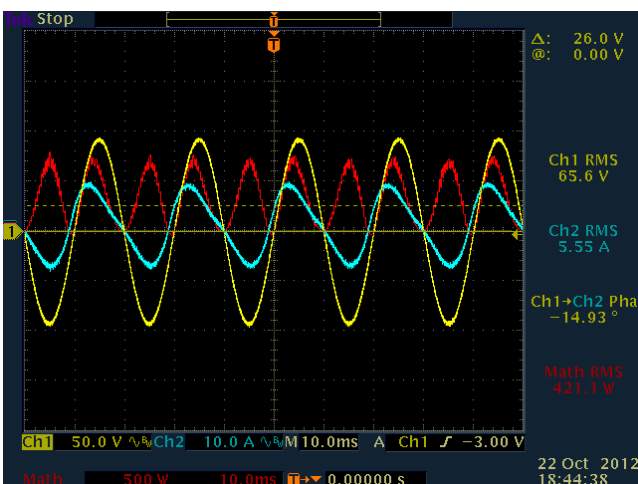


FIGURE 11: Measure sample, high amplitude input signal @ 65.2°C.

External T (°C)	Vout (Vrms)	Iout (Irms)	Cos (Φ)	Papp (VA)	Preal (W)	Preact (VAR)
32.3	65.58	5.50	-35.09	360.49	324.91	-228.25
54.4	65.6	5.53	-24.29	362.77	330.61	-149.21
65.2	65.60	5.54	-16.29	363.36	348.70	-101.90

TABLE 3: Measurements variation in relation to temperature raising, high amplitude signal

1.10 Conclusions

The first evident and well know issues with speakers when getting hot is the modification of the Re value, this leads to modify Qes and the minimum value of impedance with consequence on efficiency and speaker tuning. This effect is well know as thermal power compression. Remember that at very high temperature the power compression may be very high (4/5 dB), and can trig a domino effect leading to the speaker burnout in the worst case. But in any case leads to a speaker life reduction due to the high temperature of the voice coil.

Average power/ rated power	Power compression (dB)	Equivalent series resistance for 8Ω driver (Ω)
10%	1.4	1.0
20%	2.0	1.4
50%	2.8	2.1
100%	4.5	3.8

TABLE 4: Typical resistance increase due to voice coil heating (not the 12" in the example). Notice the exceptionally high value (3.8 Ohm) when the driver reaches it thermal limit

So how manage the thermal power compression? This can be achieved by an accurate selection of the right speaker components for the application but also with an adequate limiting policy and limiter method. The common method to guarantee speakers protection is to use a Voltage RMS limiter, Powersoft provide another type of limiter: the Truepower limiter. In the next chapter a rough comparison between an RMS limiter and the Truepower will be performed introducing the benefits and the drawbacks that this method introduces, especially focusing on the safeness of the speaker, but also how to control the real power delivered (and therefore dissipated) to the voice coil. Also an idea for temperature estimation, and thus control will be introduced.

6 Speakers power handling

In order to perform power limiting the most common (and probably the only available) limiter used is the Voltage RMS Limiters. This limiter act as a gain control to limit the RMS voltage applied to the transducer with the appropriate time constants depending on the bandwidth of operations and on the type of transducer used. If the “density” of the voltage signal driving the transducer exceeds the estimated maximum continuous power being delivered to transducer itself, the voltage gain of the signal is reduced. This is done in an attempt to keep the “estimated” load power within safe thermal limits of the transducer itself. The term “estimated” is due to the fact that we have an unknown variable in the power calculation using only the Voltage readings, but as mentioned above, the impedance of the transducer itself is quite more complicated: in the audio frequency range the impedance of the transducer plus cabinet combination varies considerably, both in module and in phase, especially at low frequencies.

The best and common practice when working with Voltage RMS limiter is to set threshold starting with an estimated minimum impedance, making compromises between a high power output and transducer safety: while the voltage limiter may be set to exceed the thermal capabilities of the transducer, at the same time, when the impedance is higher than estimated, it does not allow full power to be transferred to the load, same voltage but higher impedance means less power than desired. A similar estimation is done for the AES specs.

Consider, for example, the previous 12” low frequency driver rated with an 8 Ω nominal impedance, with a minimum impedance of 6.5 Ω; it is rated as 500 W AES. This speaker is capable of sustaining 57.0 Vrms. Roughly speaking the AES ratings define the sustainable power as an RMS voltage applied to a transducer continuously and then calculating the equivalent power on the minimum impedance at cold conditions. However, as we will see the real power component delivered to the load is much less than that given by the AES ratings: the average impedance in operation conditions is higher than the minimum impedance used in calculating AES ratings (impedance at cold conditions). This temperature raising effect is due to the current flows through the voice coil, the heating up is increasing its impedance, and in turn, increases the average system impedance. This is caused by the fact that only a part of the power delivered to the load is reactive, thus not generating heat into the voice coil, but also another part exists, and is the active component that dissipate energy in heat. The consequence is that a so rated low frequency transducer at the end of the AES power rating test has a voice coil resistance that is almost doubled and therefore an average impedance that is actually twice the nominal, where the reactive components remains unchanged but the real part increases. The consequence is that trying to limit the output power acting only on the voltage has some limits in terms of predictability and control of the real power delivered to the load. Two cases of limiting, with an RMS limiter and a Truepower limiter, are reported.

1.11 High power signal with Voltage RMS limiter

A 50 Hz pure tone signal with an amplitude of 1.70 Vrms is feed in a K10 with 32 dB gain and connected to the speaker. A voltage limiter is enabled set to 360 W @ 8 W (expected Vout = 53.6 Vrms). Three measures are taken at 20 minutes interval.

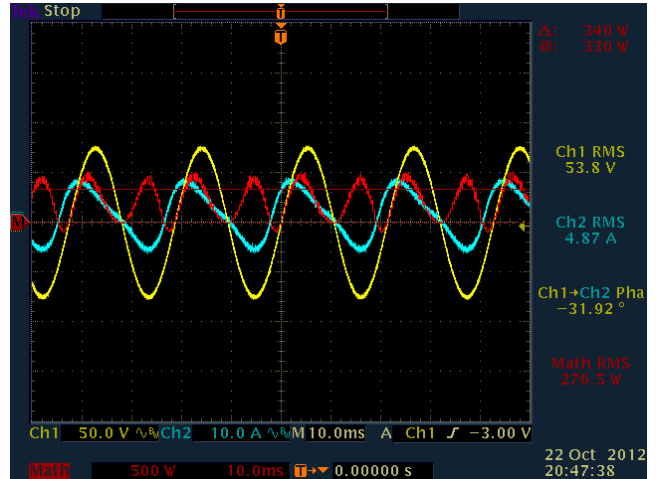


FIGURE 12: A measure sample with an high amplitude input signal and a voltage limiter enabled at 360W, 8 ohm at 32.3°C

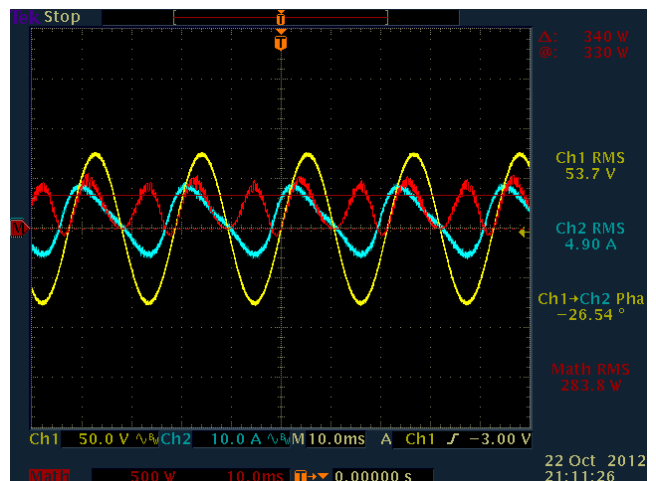


FIGURE 13: A measure sample with an high amplitude input signal at 54.4°C

External T (°C)	Vout (Vrms)	Iout (Irms)	Cos (Φ)	Papp (VA)	Preal (W)	Preact (VAR)
38.2	53.8	4.87	-33.15	262.01	219.34	-143.26
53.5	53.76	4.9	-27.53	263,26	233,41	-121,65
59.2	53.72	4.92	-25.15	264.89	239.75	-112.58

TABLE 5: Measurements variation in relation to temperature raising, low amplitude signal

Note as the real power increase with the temperature rising, substantially changing the loudspeaker performance although the voltage applied is stable at 53.7/53.8 Vrms.

1.12 High power signal with Truepower limiter

A 50 Hz pure tone signal with an amplitude of 1.70 Vrms is feed into a K10 with 32 dB gain and thus connected to the speaker. A Truepower limiter is enabled and set to 360 W. Two measures are taken with an interval of 1 hour.

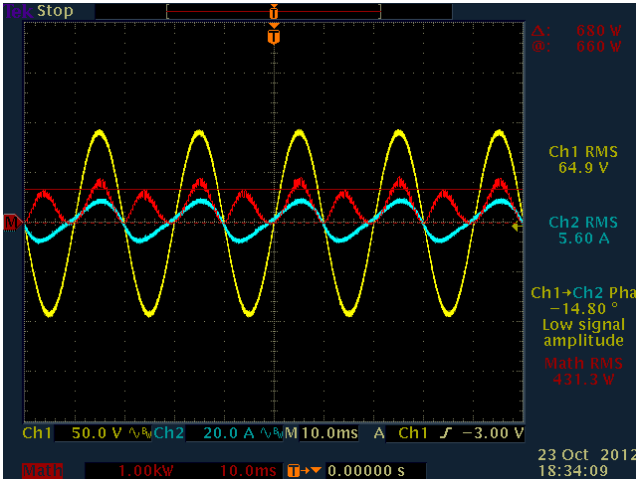


FIGURE 14: A measure sample with an high amplitude input signal and a TruePower limiter enabled to 360 W at 61.9°C

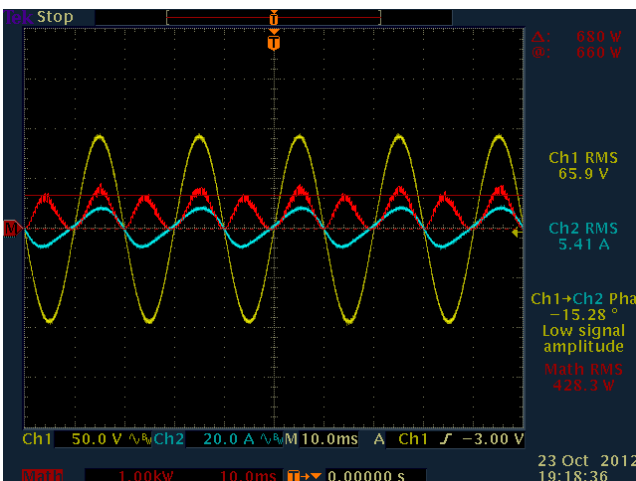


FIGURE 15: A measure sample with an high amplitude input signal and a TruePower limiter enabled to 360 W at 61.9°C

External T (°C)	Vout (Vrms)	Iout (Irms)	Cos (Φ)	Papp (VA)	Preal (W)	Preact (VAR)
61.9	64.73	5.64	-17.75	364.88	347.51	-111.22
81.3	65.45	5.45	-12.36	356.57	347.86	-79.16

TABLE 6: Measurements variation in relation to temperature raising, high amplitude signal

Note as the real power remain stable with the temperature rising, the performance will be affected in this case but this is more related to the threshold limiting value chosen than the effectiveness of the limiting system. What we can see is that value is too high although is slightly less than the manufacture suggested

value of 500 W AES, so the speakers was overdriven and became hot (remember this happens easily in real world, especially in close cabinets), deeply changing the impedance curve where the minimum impedance is 7.5 Ω (@ 140 Hz) at 81°C, respect to the 6.5 Ω (@ 160 Hz) at 20°C case. Another things we saw in our test is that tuning power limiter also allows to control the temperature of the speaker; while this is not true by limiting just the RMS output voltage.

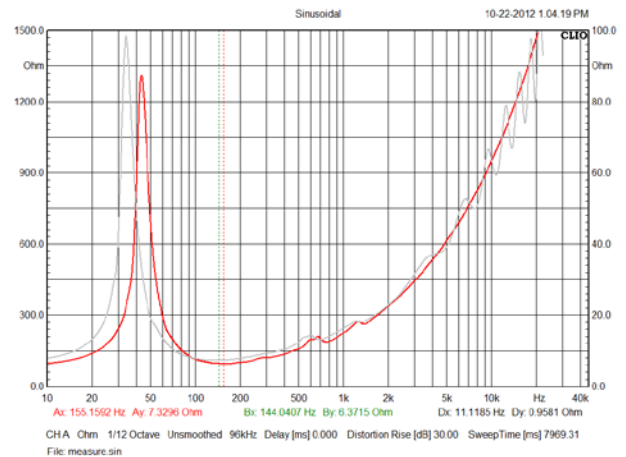


FIGURE 16: The impedance curve of the speaker measured in open space at 20°C and 81°C

What we found empirically is that this transducer can deliver in the “real condition operation” no more than 200/250 VA. With this apparent power delivered the real “thermal” power is something lower and stable, around 80% ($\Phi = 30^\circ @ 50 \text{ Hz}$ and $\text{Cos}(\Phi) = 0.8 @ 50 \text{ Hz}$). This leads that a speaker nominally rated 500 W AES actually can thermally dissipate not far than 160 W, 1/3 of AES ratings, that is a lot less than 500 W. Also we give an idea: controlling power and reading of the minimum impedance value and frequency variation we could have a very simple model to estimate the speaker temperature in order to create an adaptive control to maximum speaker performance, this could be a field to develop in the future.

1.13 Conclusions: RMS Voltage limiter VS Truepower limiter

Why an RMS limiter is not perfect suitable to control the output power? Trying to control the output power using an RMS voltage limiter only you'll find some drawbacks:

- ▶ Due to the thermal drift of the components during the normal operation you can't have control of the real power handling but only of the modules of the voltage.
- ▶ You need to guess the correct voltage limiting threshold, but that will be always a rough estimation. In cold condition may be too much limiting leading to a less SPL while in hot condition could be useless since you'll obtain only heating production that worst the situation.
- ▶ It's very difficult try to handle power compression phenomena.

To avoid this problem you need a direct control of the gain reduction basing the limiting on the real power component delivered to the voice coil, the one that make the driver hot. Powersoft TruePower limiter is the limiter that modulate the gain tracking the impedance curve (with a square factor) allowing to control the real output power and thus the temperature of the voice coil controlling the voice coil resistive component.

Also time constants are very important but these are referred to an empirical evaluation of the thermal capacity of the voice coil size, large voice coils take longer to get hot (large mass) etc. Also, inertia material, surface (dissipation capabilities) affects the maximum power handling. It will exists a relationship between the dimension of the coil and the max power keeping in calculations thermal dissipation power.

7 How Powersoft limiters works.

1.14 A general note regarding limitings

A correct limiting is not an easy task and is multifaceted, based on a number of knowledge of the component to limit, thus may be difficult decide thresholds and time constrains in order to obtain the correct equilibrium between protection and sound quality.

Limiting may be an “art” and many philosophies can be followed. For this reason with this guideline we want provide just a starting point on how select parameters and how to handle it with the Powersoft devices.

In any case Powersoft can't be responsible of any potential damage derived from any wrong limiter settings.

1.15 Peak limiter

The peak limiter avoid potentially dangerous displacement of the cone (larger excursion respect to allowed values), and it's based only on the measured output peak voltage. We suggest, to use the declared Peak power or twice the program power.

The peak limiter is independent from the number of parallel wired speakers (voltage is applied to all the components in a parallel circuit). Thus, in a parallel circuit of speakers the peak power that has to be taken is from only one loudspeaker.

$$P_{peak} = \frac{V_{peak}^2}{R} \xrightarrow{\text{yelds}} V_{peak} = \sqrt{P_{peak} \cdot R}$$

FIGURE 17: Peak power and relative voltage power (R is the nominal impedance of only one driver)

The time constant shouldn't affect the musical signal (it's not a “colouring” dynamic compressor) therefore it tries to keep unaltered the shape of sound, avoiding modification of the fast transients and limiting only if the phenomena persists for more than one/two periods.

FREQUENCY RANGE (Hz)	ATTACK TIME (ms)	ATTACK/RELEASE RATIO	RELEASE TIME (ms)
<63	16	x16	256
63-125	8	x16	128
125-250	4	x8	32
250-500	2	x8	16
500-1k	1	x4	4
1k>	0.3-1	x2	1-2

TABLE 7: Suggested limiter parameters in relation to frequency band

1.16 Power (RMS) Limiter

Given the low efficiency of electromechanical transducers, a lot of the power reaching the voice coil is transformed into heat. The power limiter is intended to avoid melting the voice coils of drivers while at the same time exploiting their maximum performance. All the power limiters are basing their operations on the temporal behavior of the voltage and the current, this means that the amplifier knows the true amount of real power delivered to the load. A correct power limiting requires the knowledge of the component heat dissipation to achieve a good compromise. Therefore may be difficult and a little bit empirical to decide thresholds and time constants. Power limiters behavior is based on a mix composed by threshold, temporal behavior of the output readings (voltage and/or current) and the type of output readings monitored. The power limiters should be used to protect the drivers from melting. It should not be engaged at normal working levels. Check the gain reduction: in order to obtain the optimal sound it should not be greater than 2-4 dB even for the loudest piece of music. Please note that a common musical signal has very high peaks, but a rather small average level (high crest factor). A continuous tone has a much higher average power even if it “sounds” less loud to the human ear. This must be taken into account while setting up limiter parameters. On the K Series amplifiers and DSP4 there is also available the Cross-Limiting Function. This feature is real useful in multiway system (on a K Series only with Bi-Amp system) because maintains equilibrated the level between the ways if only a driver is in the protection state and thus the gain is reduced. For example if an HF is suffering (a long throw section in a cluster) to keep homogeneity in the sound the LF section is reduced of the same amount with the same time constrains.

1.16.1 TruePower

The TruePower limiter is a Powersoft technology useful to avoid overheating of the voice coil and can be used to avoid power compression. The DSP provides the measurement of the real power delivered (and then dissipated) to the coil, not the apparent power handled by the line.

From some empirical consideration reported above the following relation can be taken.

$$P_{REAL\ RMS} = \frac{P_{AES}}{3}$$

FIGURE 18: Max RMS and AES Power ($P_{REAL\ RMS}$ is the real component of the maximum power that can be dissipated by the coil)

If the P_{AES} is not available P_{RMS} can be used but some evaluation on how this measure is obtained must be done (see the recommendations in the next chapter about the RMS power). If no other values are given this rule of the thumb can be used: the P_{AES} can be estimated in 6 dB lower the peak power ($\frac{1}{4}$ of the peak power).

Keep in mind that with the TruePower limiter it's necessary to keep in the calculation how many speakers you need to drive, this is because the real power is based not only on the output voltage but also on the output current.

Deciding the time constrains may be very empirical and could lead to headaches. Follow TABLE 8 as a guideline.

Driver voice coil (inches) and application	True Power threshold (W)	Attack time (ms)	Decay time(ms)
1" Tweeter	10-20	100	300
1.5" Tweeter	20-30	150	300
2" Horn driver	20-40	200	400
3" Horn driver	30-50	300	500
4" Horn driver	40-60	500	3000
2" Midrange	30-100	500	3000
3" Midbass	50-150	1000	5000
4" Woofer	100-200	2000	5000
4" Woofer	150-250	4000	8000
6" Woofer	250-500	6000	10000

TABLE 8: Direct proportion between voice coil dimension, thermal inertia and constant time

1.16.2 Power vs V @ 8 Ω

This is a pure voltage RMS limiter based only the voltage module read from the amplifier output. Differently from the Truepower limiter this processing doesn't know anything about the real part of the power but has the advantage that is independent from the number of cabinets linked together like the peak limiter.

Some considerations are necessary for the power threshold, you can use the P_{AES} if available, otherwise the P_{RMS} can be used. Albeit the RMS parameter is a value related to the max manageable power, it should be verified because the value can be higher of the real manageable power. Often constructors declare the AES/RMS power in the minimum impedance point of the

speaker which may leads to an overestimation of the real values.

In any case to preserve the driver in the long term time a further reduction of the power should be considered, the suggestion is to take into account a further reduction up to 3 dB respect to the calculated value.

To set the value you need to recalculate your driver threshold with the equivalent power at 8 Ω. Powersoft limiter accepts the power (equivalent) at 8 Ω as input threshold, this is straightforward if you need to protect a driver with 8 Ω of nominal impedance, a little bit more complicated if you need to apply to driver with different nominal impedance. Let's suppose you have a speaker of 4 Ω, with max power of 500 W RMS, you need to recalculate the equivalent power at 8 Ω. To achieve this you need to calculate what is the V_{rms} of the cone at 4 ohm with the, following formula:

$$V_{RMS} = \sqrt{(P_{RMS} \cdot R)}$$

FIGURE 19: RMS voltage and power

The RMS voltage of the above rated speaker is $V_{RMS}=44.7\ V$. Now you need to calculate what is the equivalent delivered power to a speaker with nominal impedance of 8 Ω:

$$P_{RMS\ equivalent} = \frac{V_{RMS}^2}{8}$$

FIGURE 20: RMS power equivalent vs V @ 8Ω

Also, you can transform directly the equivalent power @ 8 Ω with:

$$P_{RMS\ equivalent} = \frac{P_{RMS} \cdot R}{8}$$

FIGURE 21: V² RMS substitution

That in the example this becomes 250 W. This is the threshold that you need.

Time constants should be the same of the TruePower, please refer to TABLE 8.

1.16.3 Power vs I @ 8 Ω

It's very similar to the case Power vs V @ 8 Ω with the difference that the reading variable is the current and not the voltage and the expression that has to be used is:

$$P_{RMS\ equivalent} = I_{RMS}^2 \cdot R$$

FIGURE 22: RMS power vs current



Via Enrico Conti, 5
50018 Scandicci (FI) Italy

Tel: +39 055 735 0230
Fax: +39 055 735 6235

General inquiries: info@powersoft.it
Sales: sales@powersoft.it
Application & technical support: support@powersoft.it
Service & maintenance: service@powersoft.it

www.powersoft-audio.com