Loudspeaker protection

BSS Audio

Limit, *n. lim-it*, boundary ; utmost extent ; restriction ; *v.t.* to set bounds ; to confine within certain bounds ; to restrain ; to restrict

Introduction

A limiter is a device which limits the gain of an audio signal when the level reaches a particular **threshold.** A well designed limiter sounds as musical as possible, minimising the audible effects of the distortion which is intrinsically created by squashing the signal.

Limiters are primarily used to restrict the maximum signal level applied to another piece of equipment, for example a tape machine, radio transmitter or loudspeaker. This note is only concerned with the use of limiters to protect loudspeakers.

? The threshold is usually a user set level, which activates the limiter (or other feature) when the signal exceeds it.

Why use a limiter?

A limiter helps to stop you from blowing up your loudspeakers when you stuff too much signal into them. There are two principal ways in which you can do this:

• Tear it up (*"excessive cone excursion"*) - a single audio **transient** moves the loudspeaker cone far enough and fast enough so that it suffers permanent damage to its suspension, causing horrendous distortion - or worse still, actually breaks.

• Fry it (*"driver overheating"*) - a high level of signal carries on for so long that the coil overheats and burns up.

Knowing the limits

Another use of a limiter is to avoid using a horn-loaded loudspeaker in a part of its operating region where it will distort heavily due to turbulent air flow in the horn throat. Although the driver may not suffer permanent damage, the effect is very undesirable.

About power amplifier and loudspeaker ratings

Before you even look at the limiter settings, you need to understand the power ratings of your loudspeaker and power amplifier. This is more complex than it seems, since not all speaker manufacturers measure power in the same way. The details are beyond the scope of this note, and you will need to get information from the makers of your power amplifier and loudspeakers.

Case 1 - your amp has more than enough power to overheat the loudspeaker

In this case, you need to adjust your gain structure and power amp sensitivity so that the loudest signal that you can safely use with the loudspeaker is well below the amplifier's clip point. If you make the amp too sensitive, you run the risk that an accident (such as dropping a microphone or breaking a cable) will apply a massive signal to the speaker, and you also will have to operate the mixer at a lower signal level, resulting in more noise. If you make the amp too insensitive, you won't get full power.

? A transient is a temporary, short-lived signal with a higher amplitude than the rest of the signal - a 'spike' in the signal.

Case 2 - your amp has less power than will overheat the loudspeaker

Perhaps surprisingly, this is also dangerous. In fact it is potentially even more dangerous, especially in a system with passive crossovers. If you don't have enough power in the amp, you are likely to turn the level up until it **clips**, which will generate large high frequency transients which can kill your drivers. A typical example is a bass guitar or kick drum signal which is loud enough to clip the amplifier: the low frequency driver is just fine, but the high frequencies applied to the tweeter are enough to destroy it.

Clipping occurs when the amplifier cannot provide the signal level demanded, and cuts, or 'clips', the top and/or bottom.

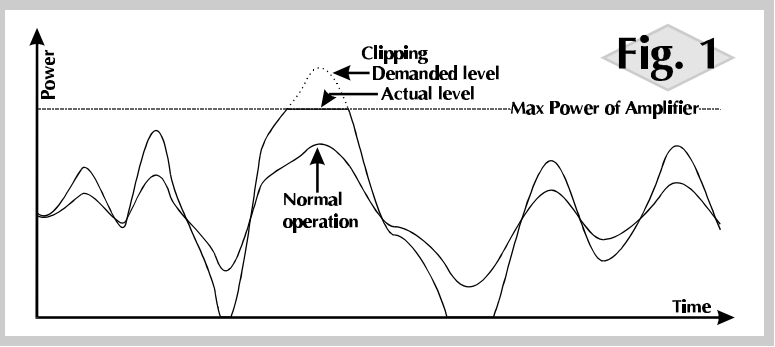

Fig. 1

This effect is much less likely to occur in a system using active crossovers throughout, which is one of their major benefits.

So I should NEVER clip the amp?

Some engineers deliberately run power amplifiers into clip in order to squeeze higher **SPLs** out of their subwoofers. While this can work, it is extremely risky if you don't know exactly what you are doing, and in any case this practise tends to degrade the sound quality. Many subwoofer cabinets will tune out the extra harmonics generated, but it's hard to predict exactly how, and any of the careful maths that has been done about setting limiter thresholds and crossover band gains tends to fall apart. This technique only works if you have a lot of experience with your particular rig, and even then it doesn't always work all that well. It is absolutely certain that you should not clip an amplifier on anything other than sub-bass - quite apart from any damage you may cause, it sounds dreadful!

SPL, or Sound Pressure Level, is a measure of the sound pressure in dB - referenced to 20 micropascals for air.

What limiter level should be set?

Having established that you need limiters, how do you set them up? Your main control, often the only one, is a threshold setting.

You want to set your limiter threshold so that when the volume is up and the limiter is operating hard, the signal level is just below the point at which the loudspeaker is likely to overheat. The maths for this is difficult, so you will either need to rely on experience, or use manufacturer's data for a particular combination of amplifier and loudspeaker.

If you're using the limiter to avoid horn throat distortion, you will need to listen carefully and set the threshold at a point where you think the distortion is becoming unacceptable. Be sure to try different types of program. You can also use a measurement microphone and feed the signals into a distortion analyser. You can then start at a low limiter threshold, and turn it upwards until the onset of distortion.

Once you have set the limiter correctly you should be relatively safe from overheating, but there is a catch. If you are careless or over-exuberant, and push the limiter too hard, you will be effectively operating the limiter as a crude compressor. See the next section on how to read your meters to understand the effects of this.

At this stage, you are probably relying on the

manufacturer of your limiter to ensure that excessive cone excursion is prevented. The limiter on BSS Omnidrive products is a two-stage design with two different threshold levels. The lower threshold prevents overheating, and is the one set by the user. The upper threshold is essentially a brick-wall to protect against cone excursion, and is set at a fixed level above the lower.

The user is allowed some control over this in the shape of a “fast/normal” setting. If your loudspeaker will accept a long excursion beyond the overheat or distortion point, you should set the limiter to normal. If you are planning on overdriving your system regularly, the fast setting is safer, but the effect of the limiter may be more audible if the system is driven very hard.

About reading meters (how far do you go?)

As you reach the end of a typical rock’n’roll or dance gig, you may well be gradually turning up the volume on the PA, and you need to know how far you can go. Ordinary level meters, as found on most crossover products, are of some use, but don’t actually tell you where you are relative to your chosen limiter threshold. Some products have a single LED “Limit” indicator, which is better than nothing, but it doesn’t give you an idea of how much **headroom** you have left when you’re not yet limiting.

? The available signal space in dB between the current signal level and the 'onset of overload distortion/clip' level.

The BSS Omnidrive range of products are special; they show the level of the signal relative to the limiter threshold. This gives you a clear idea of headroom, helping you judge more accurately how to set the PA volume.

For maximum volume, you want the meters to be just flashing the peak light at the very loudest notes. This means that you’re operating the PA about as loud as you can without major **compression** of the signal.

? Gain reduction caused by the onset of limiting.

If you drive the system harder, so that the bar graph LEDs are all lit for most of the time, your loudest notes are not actually getting any louder (because the limiter is working), and you are applying fairly vicious compression to your entire audio program - or worse still, to some bands but not necessarily all. This will cause major distortion and muddiness of your mix without making the loud notes any louder.

While the loud notes are not getting any louder, the rest of the mix is, so the average power applied to your speaker is increasing. This effect is what makes it possible to destroy speakers that are supposedly protected by limiters.

If you really want this level of compression of your mix, you are better off using a real compressor on your mixer output, rather than relying on the limiters in your loudspeaker system. This will achieve the desired result more musically, but be warned - using a real compressor too aggressively will produce the same dangerous increase in average programme level.

The trouble with full-range limiters

Firstly, it is almost impossible to set sensible attack and release times for the limiter that will properly operate over the full audio bandwidth. If you set short attack and release times, low frequencies become distorted. If you set attack and release times long enough to work well at low frequencies, fast transients at high frequencies are not trapped in time to prevent damage.

Secondly, with a full-range limiter, excessive frequencies in one crossover band will cause gain reduction in all the other bands as well - when the bass player hits some notes too

Attack is the time taken for the circuitry to respond to the overload and reduce gain (to the limit threshold in this case).

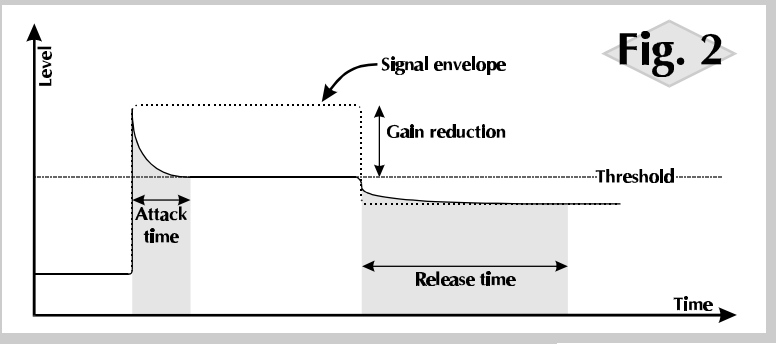

Fig. 2

Release is the time taken for the circuitry to return the signal to its normal state, once it has passed below the threshold.

hard, the limiter **attenuates** the vocals!

At BSS, we tend to put our limiters in crossover or loudspeaker management products. This allows us to optimise the characteristics for the individual frequency bands, even if it does mean that we have to provide more limiters!

The limiters on BSS Omnidrive products are self-adjusting for the critical **attack and release** time parameters: these are set automatically according to the crossover frequency at the lower end of the band.

What is mid-filter limiting?

Mid-filter limiting is a technique pioneered by BSS, and is used in all of our crossover products, both analogue and digital. It avoids problems found with traditional designs.

The first traditional design approach uses a full-range limiter placed at the input of the crossover. This has the problems mentioned above, namely that loud bass reduces the level of mid range and treble, and the compromise that all full range limiters have with regards attack and release times.

In the second traditional approach, the limiter is placed at the output of the crossover filters. Frequencies in the main part of the crossover band are attenuated more by the limiter than frequencies on the slopes of the band. So the unwanted frequencies have higher levels than they should, and the net effect is a widening of the band, passing more frequencies through than would be expected (See figure 3).

Attenuation is the reduction, or making smaller, of the signal.

BSS solves this by placing the limiter half-way through the crossover filters. The filters in front of the limiter restrict the signal so that excess signal on one band does not cause limiting on the others, and the filters after the limiter reduce band spreading. The result is a more natural sound, even when the limiters are applying significant gain reduction.

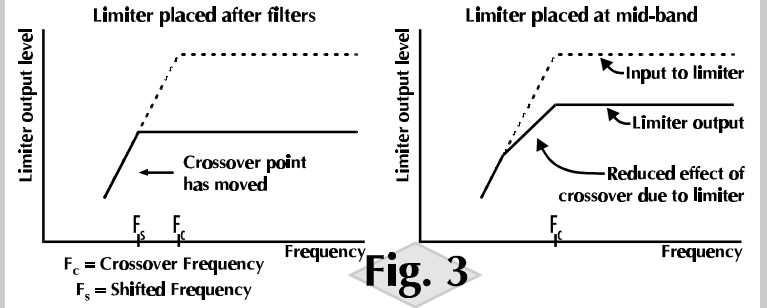

Fig. 3

Software versions

The two-stage limiter with a normal/fast setting is available on the following software releases:

FDS-355 V1.10 Omnidrive Compact

Please contact your BSS reseller if you need an upgrade.