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4 Series Program Limiter and "D-Max" Limiter

The **4 Series** units have two levels of dynamic protection on its outputs – a traditional program limiter, and a newly introduced "D-Max" limiter. Put simply, the program limiter is designed to prevent overheating of the voice coil of a driver, and the "D-Max" clip limiter will prevent over-excursion of the driver.

Program Limiter

High performance digital limiters are provided for each output with control over attack time, release time and threshold parameters. This level of control allows the user to balance the required subjective quality of the limiter against the driver protection requirements. It does also mean that an incorrectly set limiter may sound awful! In particular, as with all limiters, using too fast an attack or release time will result in excessive low frequency distortion. In the Design a Crossover sub-menu there is an option for automatic limiter time constants. Use this option if you are unsure how to set the time constants manually. XTA recommend the use of the automatic setting.

In this mode the time constants will be automatically set from the High-Pass filter frequency according to the table below.

The time constants are set by the high pass filter frequency for that channel.

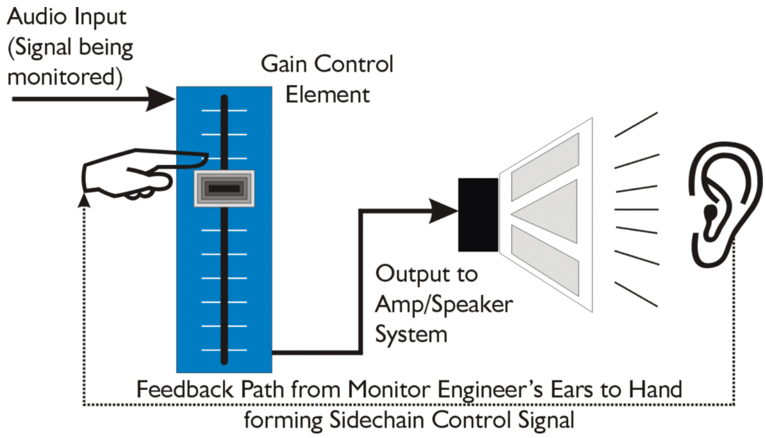
High Pass Filter	Auto Attack Time	Release Time
<10Hz – 31Hz	45mS	x16 (720mS)
31Hz – 63Hz	16mS	x16 (256mS)
63Hz – 125Hz	8mS	x16 (128mS)
125Hz – 250Hz	4mS	x16 (64mS)
250Hz – 500Hz	2mS	x16 (32mS)
500Hz - 1kHz	1mS	x16 (16mS)
1kHz – 2kHz	0.5mS	x16 (8mS)
2kHz – 32kHz	0.3mS	x16 (4mS)

"D-Max" Clip Limiter

The main limitation with traditional dynamics control is the inability of the processing to react truly instantaneously to the signal. One of the most significant advantages of digital signal processing over analogue is the ability to delay the audio signal precisely and without extensive complex hardware. The entire domain of digital signal processing is based around the combination of delaying, multiplying, and accumulating numbers (representing samples of audio) to implement all the filters and dynamics processing we have come to expect today.

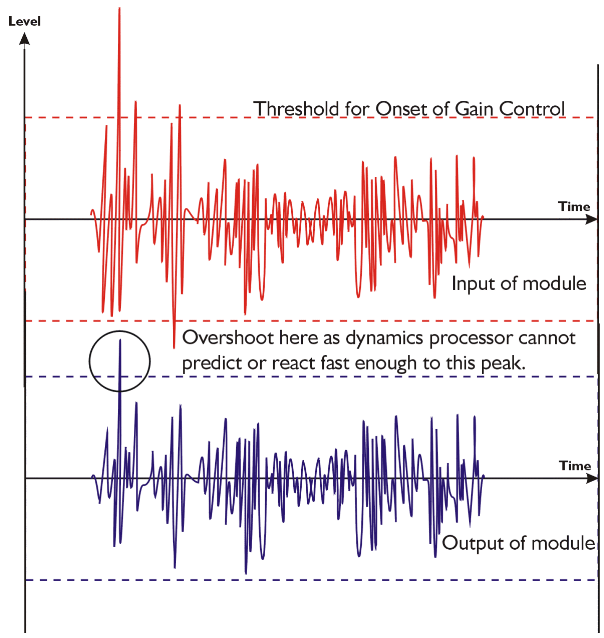
In the case of dynamics processing, being able to delay a signal allows the processor module to delay the main signal in relation to the sidechain (the signal being monitored relative to the threshold), so that it can compensate for peaks prior to the arrival of the main signal.

Consider the situation of a monitor engineer listening to a band perform. Having no access to dynamics processors, he has had to resort to manually 'riding the faders' in an attempt to keep control of the levels. Should the level of one of the channels on his desk reach an unacceptably high level, he will turn it down appropriately.



There is a hidden sidechain in operation even in this case. The main signal path is fed through the monitor desk and the gain controlled by adjusting the fader. The sidechain is formed by the feedback path between the engineer's ears checking the level and his brain instructing his hand to turn the fader down if the volume goes over the threshold he has chosen.

In this case, the delay between the signal actually going over the threshold, the engineer registering the situation, and then turning the signal down will be in the order of several hundred milliseconds at best. This will only be true if he is not distracted – in reality, it may be several seconds before any gain reduction is imposed on the signal to bring it under control.

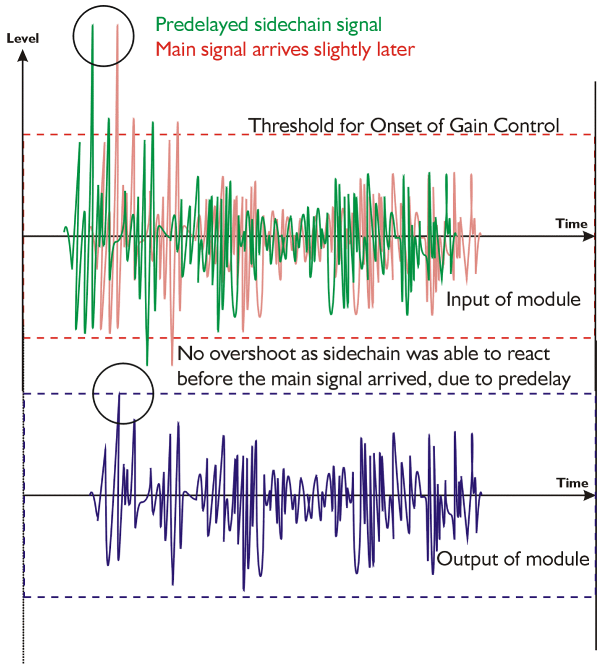


For an analogue dynamics processor, the situation is much better. Controlling the gain electronically, and not relying on a human sidechain feedback mechanism, it can react much more quickly.

The red waveform represents the input to the dynamics module, with the dotted line showing the threshold for gain control to occur. There are several peaks towards the start of this signal that are above the threshold, and so the dynamics processing should react to these as appropriate. (In this case reduce the gain).

The blue waveform shows the output of the dynamics module. The circled peak demonstrates that the processor has missed the first peak above the threshold (as it is very fast and short), but has 'caught up' shortly afterwards, keeping all other peaks under control. As it is unable to predict what is coming, this will always be a failing with analogue dynamics processing.

The **4 Series**'s "D-Max" limiter predelays the sidechain signal, resulting in a "zero overshoot" limiter, which is able to catch all peaks and provide a reliable absolute maximum setting for the output of any channel.



The predelayed sidechain is shown in green, with the main signal in red. As the main signal arrives slightly after the sidechain, the output from the unit does not suffer from the overshoot problem.

Remember that this delay is only in the order of tens of uS,and is a **predelay** – the sidechain is moved **back** in time in relation to the main signal. Inserting a delay into the **main** signal path of an analogue dynamics processor will achieve similar results, but with the penalty of delaying the main signal by the amount of look ahead delay introduced.

The "D-Max" limiter which appears in output lists just following the traditional limiter, has only two parameters to adjust:

```
OP1    Output 1   ClipLim
Rel= Medium  10dB Above
```

The release time (either Fast, Medium, or Slow) and the threshold. Note that the threshold is set to be a minimum of 2dB above the threshold of the program limiter – setting the threshold to 10dB Above, as in the example, means that no more than 10dB of overshoot above the threshold of the program limiter will ever be allowed.

The release time may also be set to follow the High Pass filter of the output – this is achieved through the Design a Crossover sub-menu, and will result in the display changing to show

```
OP1    Output 1   ClipLim
 Rel= Auto  10dB Above
```

Setting Accurate Limiter Thresholds

The limiters built into the **4 Series** are intended to be used for loudspeaker driver protection, as opposed to amplifier protection. All modern professional power amplifiers designed for live sound use have their own limiters, which are tailored to protecting the amplifier from clipping.

The following section describes how to set up the units' limiters to provide exceptional protection against driver overheating, and cone over-excursion.

Most speaker systems are given a power rating in Watts RMS. This is the maximum continuous power that the system will handle and often appears very conservative. In reality, as music program is far from continuous in nature, the peak power of the system is much higher – up to ten times the continuous figure. Any limiter, which is to protect the driver from damage, must be able to fulfil the following tasks.

- Have an attack time which is calculated to allow transients through but keep the RMS level below the speaker manufacturers specification;
- Have a release time which is sufficiently long to avoid the limiter itself modulating the program;
- Be intelligent enough to adjust the envelope of the limiter according to the frequency content of the program material.

The program limiters are capable of performing all these tasks. The only parameter that the user must set manually is the threshold, and it is crucial that this is done correctly. Consider the table below.

dB	Ratio	Vrms	Pwr 8 Ω	Pwr 4 Ω	Pwr 2 Ω
45	177.83	137.74	2371.71	4743.42	9486.83
44	158.49	122.77	1883.91	3767.83	7535.66
43	141.25	109.41	1496.45	2992.89	5985.79
42	125.89	97.52	1188.67	2377.34	4754.68
41	112.20	86.91	944.19	1888.39	3776.78
40	100.00	77.46	750.00	1500.00	3000.00
39	89.13	69.04	595.75	1191.49	2382.98
38	79.43	61.53	473.22	946.44	1892.87
37	70.79	54.84	375.89	751.78	1503.56
36	63.10	48.87	298.58	597.16	1194.32
35	56.23	43.56	237.17	474.34	948.68
34	50.12	38.82	188.39	376.78	753.57
33	44.67	34.60	149.64	299.29	598.58
32	39.81	30.84	118.87	237.73	475.47
31	35.48	27.48	94.42	188.84	377.68
30	31.62	24.49	75.00	150.00	300.00

Using this table it is a straightforward procedure to work out the required setting of the limiter thresholds for the system.

- ✓ First, check the RMS power rating of the speaker system, and its impedance.
- ✓ Look up this value in the table above, using the closest value below the rated power of the speaker system.
- ✓ Note the corresponding 'dB' value.
- ✓ Check the gain of your amplifier, which needs to be in 'dB'.
- ✓ Subtract this gain figure FROM that obtained from the table to find the required absolute setting for the limiter thresholds.

Note that, for safety, always set the limiter threshold 1 or 2 dB below the maximum allowable worked out using the above method.

xta ALERT ALWAYS REFER TO YOUR SPEAKER MANUFACTURER FOR LIMITER SETTINGS.

Additional, additional information!

There is actually look ahead delay on the program limiter and the clip limiter - this allows the limiter to have begun its attack phase just ahead of the signal arriving, allowing you to set the attack times better. The DP226 has had the slight predelay element since its inception, and it's one of the reasons that XTA crossovers sound as good as they do. The textbook linearity of the gain reduction algorithm is another major contributing factor – you'll not see any bumps or dips in the transfer function (the graph of input vs. output).

Traditionally if you were concerned about too much overshoot from the limiter, you would have just increased the attack time to try and compensate. As the look ahead action has already begun to turn the limiter down a few hundred microseconds before the main signal arrives (203uS for the program limiter, and a further 312uS for the clip limiter), the attack time can be set more accurately according to the lowest frequency you wish to control (so for 500Hz, 1 cycle passing would be 2mS attack time).

The clip limiter has a very fast attack time of 125uS (1 cycle at 8kHz) and coupled with the 312uS look ahead delay, will prevent anything escaping.

The release times for the clip limiter are Fast: 91mS, Med: 350mS, Slow: 800mS. Auto = Medium setting.