Limiters and How to Set Them Correctly

Your amplifier has two levels of dynamic protection on its outputs – a traditional program limiter, and a peak limiter.

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 for the type of signal in the pass-band will result in excessive low frequency distortion. There is provision, within the remote software application, to set automatic limiter time constants. Use this option if you are unsure how to set the time constants manually. We recommend the use of the automatic setting.

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

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)

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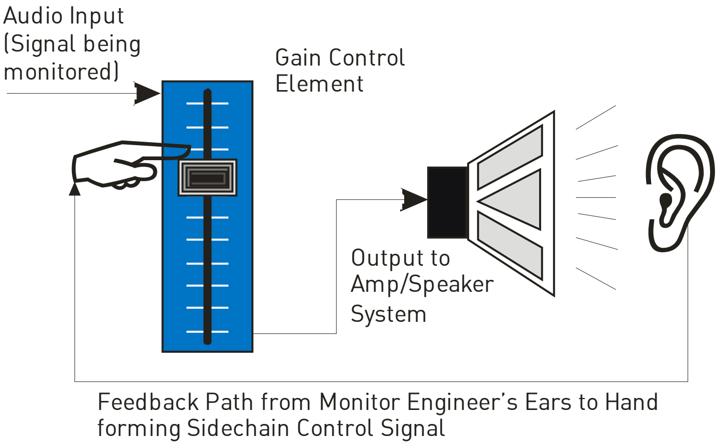
Peak Limiter

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.

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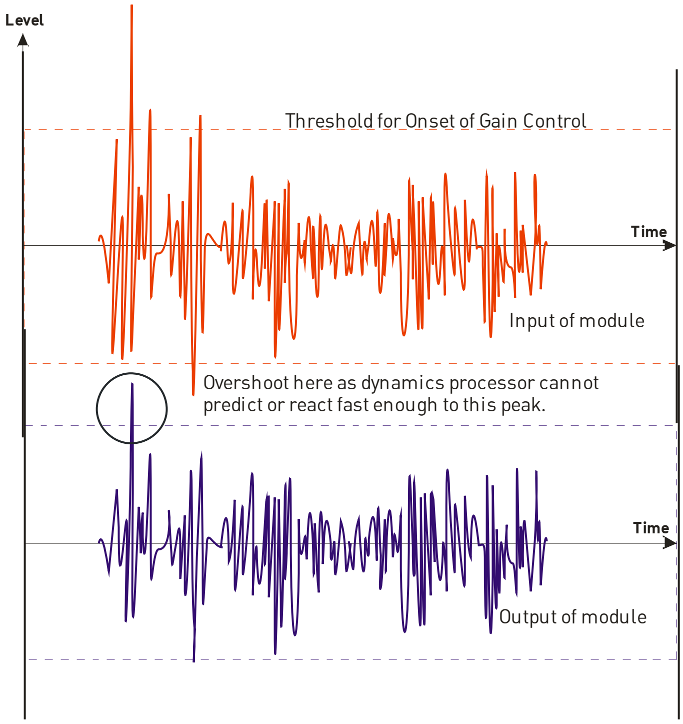
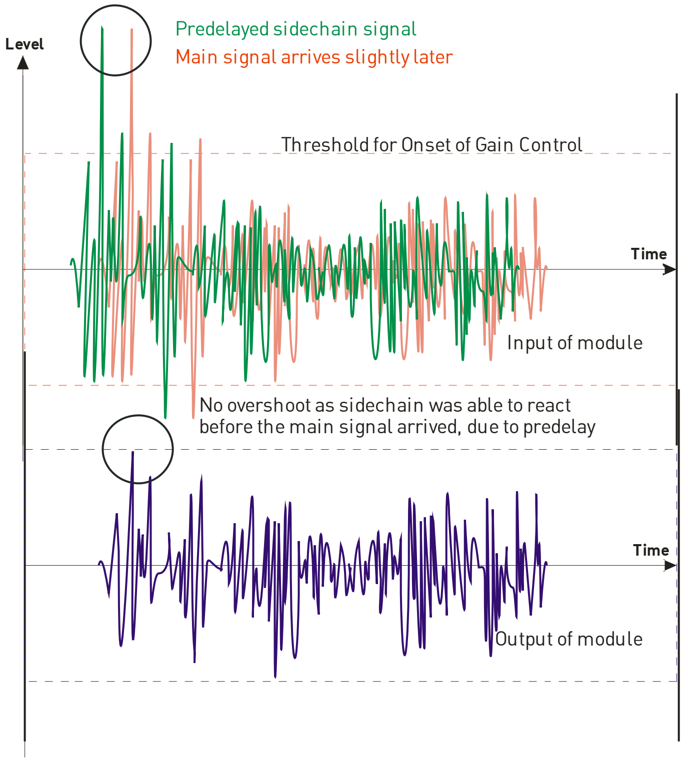


For an analogue dynamics processor, the situation is much better. Controlling the gain electronically, and not relying on a human sidechain feedback mechanism, it can react much more quickly.

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 peak limiter pre-delays 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 pre-delayed 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 microseconds,and is a **pre-delay** – 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 peak limiter follows the RMS limiter, has only two parameters to adjust – the release time 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" means that no more than 10dB of overshoot above the threshold of the program limiter will ever be allowed.

The release time can also be automatically set if the RMS limiter has automatic time constants enabled and so are set by the high pass filter frequency for that channel.

Setting Accurate Limiter Thresholds – Program Limiter

Introduction

The limiters built into your amplifier are intended to be used for loudspeaker driver protection, as opposed to amplifier protection. The amplifier has additional limiters which can adapt automatically to both temperature and incoming mains conditions to stay operational and playing music for as long as possible.

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 RMS 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.

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Amplifier Outputs' Program Limiter Lookup Table

Note that the setting of the auxiliary outputs' limiters need to be referenced to the external amplifier's gain for correct operation. A separate lookup table and explanation is given overleaf.

Consider the table below.

dB Limit	Power 32Ω	Power 16Ω	Power 12Ω	Power 8Ω	Power 4Ω	Power 2.7Ω[1]	Power 2Ω
48				4721	9442	Bridge Mode Operation Not Possible	
47				3753	7506		
46				2982	5964		
45				2370	4741		
44				1884	3768		
43				1496	2993		
42	298	595	892	1189	2377	3396	4755
41	236	472	629	944	1888	2698	3777
40	188	375	500	750	1500	2143	3000
39	149	298	397	596	1192	1702	2383
38	119	237	315	473	946	1352	1893
37	94	188	251	376	752	1074	1504
36	75	150	199	299	598	853	1194
35	59	118	160	237	474	678	949
34	47	94	125	188	377	538	754
33	38	75	100	150	299	428	599
32	30	60	79	119	238	340	475
31	24	47	63	94	189	270	378
30	18	36	50	75	150	214	300
29	15	30	40	60	120	178	240
28	12	24	31	47	94	139	188
27	9	19	25	38	76	113	152
26	8	15	20	30	60	89	120
25	6	12	16	24	48	71	96
24	5	10	13	19	38	56	76
23	4	8	10	15	30	44	60
22	3	6	8	12	24	36	48
21	2	5	7	10	20	30	40
20	1	4	5	7.50	15	22	30

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

The section in grey will only be relevant when pairs of output channels are bridged. Under these conditions, the available limiter threshold range will increase by 6dB to +48dB.

The minimum impedance for bridged channels is 4R, so this section of the table is left intentionally blank. Driving the amplifier into loads lower than those recommended will result in the channels muting and may result in damage to the affected channels.

[1] 2.7Ω is the ideal subwoofer load of 3 x 8Ω drivers in parallel for most efficient power delivery

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Auxiliary Outputs' Program Limiter Lookup Table

Note that the setting of the amplifier outputs' limiters does not beed referenced to the amplifier's gain as this is predetermined for the internal power amplifier sections. A separate lookup table and explanation is given on the previous page.

Consider the table below.

dB	Ratio	Vrms	Pwr 32Ω	Pwr 16Ω	Pwr 12Ω	Pwr 8Ω	Pwr 4Ω	Pwr 2.7Ω	Pwr 2Ω
45	177.83	137.74	593	1186	1581	2372	4743	7027	9487
44	158.49	122.77	471	942	1256	1884	3768	5882	7536
43	141.25	109.41	374	748	997	1496	2993	4434	5986
42	125.89	97.52	298	595	793	1189	2377	3513	4755
41	112.20	86.91	236	472	629	944	1888	2797	3777
40	100.00	77.46	188	375	500	750.00	1500	2222	3000
39	89.13	69.04	149	298	397	596	1191	1765	2383
38	79.43	61.53	118	236	315	473	946	1042	1893
37	70.79	54.84	94	188	250	375	752	1114	1504
36	63.10	48.87	75	149	199	299	597	885	1194
35	56.23	43.56	59	119	158	237	474	702	949
34	50.12	38.82	47	94	125	188	377	556	754
33	44.67	34.60	38	75	100	150	299	443	599
32	39.81	30.84	30	60	79	119	238	352	475
31	35.48	27.48	24	47	63	94	189	280	378
30	31.62	24.49	19	38	50	75	150	222	300

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.

As an example, for a subwoofer rated at 2000W and 4R, working with an amplifier which has 32dB of gain, the limiter threshold would be calculated as follows:

"First, check the RMS power rating of the speaker system, and its impedance." **2000W, 4R**
"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." **41dB**
"Check the gain of your amplifier, which needs to be in 'dB'." **32dB**
"Subtract this gain figure FROM that obtained from the table to find the required absolute setting for the limiter thresholds." **41 – 32 = +9dB**
"Note that, for safety, always set the limiter threshold 1 or 2 dB below the maximum allowable worked out using the above method." **with safety, +8dB**

Setting Accurate Limiter Thresholds – Peak Limiter

Assuming the RMS limiter has been set correctly and, just as importantly, attack and release times have been chosen as appropriate to the driver to be protected, the peak limiter is typically set to limit overshoot to 3dB above the RMS limiter threshold. This would allow peaks of twice the RMS power level to reach the outputs. If the driver has a peak power capability of more than double the rated RSM power, then this value can be increased.

To calculate the setting for the peak limiter it's:

$$10 \times (\text{Log}^{10}(\text{Peak\_Power} / \text{RMS Power}))$$

So for example, a 15" driver has a quoted RMS power handling of 800W, and a peak power handling of 1600W, the calculation is

(1600/800) = 2
Then $\text{Log}^{10}(2) = 0.3010$
Then 10 x 0.3010 = 3.010 or 3dB

Speaker manufacturers may quote AES power in place of RMS power and "Program" instead of "Peak". These terms, whilst not strictly interchangeable, are similar as a "pair" of measurements. AES tends to be a slightly more conservative rating given the definition of how it is measured.

If AES power is quoted, then it normally is paired with the "Program" rating and so the calculation of the threshold for the peak limiter is still valid.

Setting Appropriate Attack and Release Times

As stated earlier in this appendix, having control over the attack and release times of the program limiters 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. When setting limiter attack and release times during the crossover configuration there is an option for automatic limiter time constants. Use this option if you are unsure how to set the time constants manually. See page **Error! Bookmark not defined.** for details on how to turn this option on.

We recommend the use of the automatic setting.

In this mode the time constants will be automatically set from the high pass crossover filter frequency according to the table below:

High Pass Filter	Auto Attack Time	Auto 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)

Only the release time may be adjusted for the peak limiters, as attack time is always set to "zero-overshoot" and so cannot be changed. The release time may be set to "slow", "medium" or "fast" – we recommend using the automatic setting which is selected for both limiters at the same time as part of the crossover configuration, detailed on page **Error! Bookmark not defined.** of the Delta DSP operator's manual.