HUM Audio LAAL

Mastering Limiter

This all-analogue feed-forward limiter has the sort of look-ahead function normally found only in digital devices.

HUGH ROBJOHNS

Established in 1999 in Poland, the HUM of HUM Audio Devices is an acronym for Human Unhindered Maker, apparently. The company currently offer a small but growing range of products, comprising three ribbon microphones (two active models, one with a one-inch and the other a two-inch ribbon, plus a remote-controlled stereo mic), a mic preamp (also with remote control), an ambitious modular analogue console launched at GearFest UK in the Summer, and the subject of this review, the LAAL, which is a rather unusual mastering limiter. LAAL stands for 'look-ahead analogue limiter', so before diving into the details of the LAAL itself I thought it would be useful to provide a brief overview of analogue look-ahead limiters more generally.

Delay-line Limiting

One of the inherent problems of all dynamics processing is the accidental introduction of unwanted distortions as side-effects of modifying a signal's instantaneous dynamics. There are many causes for these distortions, such as non-linearities in the gain reduction circuitry, or the way in which the side-chain time constants relate to the signal's component frequencies. For example, a very fast release time can often result in 'envelope modulation' whereby the amount of gain reduction varies according to the instantaneous amplitude of a low-frequency waveform. Another well-known issue is the way a very fast attack time constant results in misshaped transients, creating clicks or transient distortion.

This last issue is particularly pertinent to protective peak limiters that are designed primarily to prevent transient overshoots from overloading the signal path. Controlling fast peaks inherently needs a very fast response time, but a conventionally fast attack inevitably 'reshapes' the initial transient in a way that often creates audible distortion. Consequently, a slower compromise must usually be found in standard limiters, balancing absolute transient control with acceptable audible artefacts.

A better way to overcome this problem of transient control is to anticipate an upcoming signal peak and thereby introduce the appropriate amount of gain reduction in advance of the peak's arrival (see Figure 1). In a normal feed-forward limiter, the input signal is split in two, with one part feeding the gain-reduction element (GR) and the other part feeding the side-chain processing (SC). The side-chain can therefore only respond to signal peaks at the same time as they arrive at the gain-reduction element. In order to anticipate the peak, the side-chain needs to become aware of the signal before it reaches the gain-reduction element, and in practical terms that requires the signal to be delayed slightly before it reaches the gain-reduction element, to give the side-chain time to react and reduce the gain before the peak arrives.

In the digital world short delays are very easy to implement, and many advanced DAW limiter plug-ins work in exactly this way, using an approach often called 'look-ahead limiting'. Achieving the appropriate delay in the analogue world is nowhere near as easy — but it's not impossible. In fact, the delay-line limiter concept was first implemented in the analogue domain back in the late 1960s for the critical protective limiters that were necessary in broadcast radio transmitters. If you're interested, one of the first such designs, the BBC AM6/7, is explained in a lovely 1967 BBC Monograph that's available online: www.bbc.co.uk/rd/publications/bbc_monograph_70.

So now you're wondering how a high-quality, analogue audio delay can possibly be created for the main signal path through the limiter, and the solution adopted in that BBC design (and others) was a chain of 'all-pass' analogue filters. I explained the concept of the all-pass filter in detail in an article about how phaser effects pedals work back in *SOS* August 2021 (https://sosm.ag/how-phasers-work). But in case you haven't read that yet, an all-pass filter is essentially a special form of audio equaliser. Normal equalisers are designed to change the signal amplitude at different frequencies and, as a (usually) benign side-effect, the phase response changes too. An all-pass filter is a special case where the frequency-amplitude response remains completely flat and unchanged, but the frequency-phase response is intentionally changed — and a phase shift is effectively the same thing as a very short delay (at a specific frequency). By chaining together a lot of carefully designed all-pass filters, sufficient phase shifts can be created across the entire wanted frequency spectrum to work as a very short analogue delay line. In this context we tend more often to refer to its 'group delay' rather than phase shifts, but it's really the same thing.

In the case of that early BBC AM6/7 design, a chain of 10 second-order all-pass filters were employed, courtesy of a series of custom inductors and numerous capacitors, all of which required a large circuit board! This arrangement created an overall delay of 320 microseconds (0.32ms) for all frequencies up to 16kHz. A third of a millisecond might not sound like much of a delay, but it is sufficient to allow a fast gain-reduction element to wind in the required attenuation in time. Obviously, the use of a delay line in the main audio signal path means there will be some latency through the device too, but at only 0.32ms or so it's much less than might be expected from converting to digital and back, and in the context of a mastering or broadcast limiter (which will always be at the end of the signal chain) such a small latency is generally irrelevant.

I casually mentioned the feed-forward limiter topology earlier. Many limiters use a feedback configuration, in which the side-chain input is derived from the output signal (rather than the input) specifically so that it retains absolute control over the output level. That's not possible in a look-ahead limiter, which must always employ a feed-forward arrangement, since the side-chain has to monitor the incoming signal so it can react to transients before they reach the gain-reduction element.

The LAAL

Physically, the LAAL is a beast of a machine, occupying a 3U rackmounting chassis that extends about 115mm behind the rack ears. It weighs a hefty 9.4kg and, even though it's entirely solid-state, it consumes around 70W of power from its internal linear power supply — this is switchable for 120V/60Hz or 240V/50Hz mains supplies, to which it connects using the usual IEC C14 socket. A fancy shielded mains cable is included with the machine. Aside from the power inlet, other rear-panel connectivity comprises just four XLRs for the electronically balanced left and right inputs and outputs. »

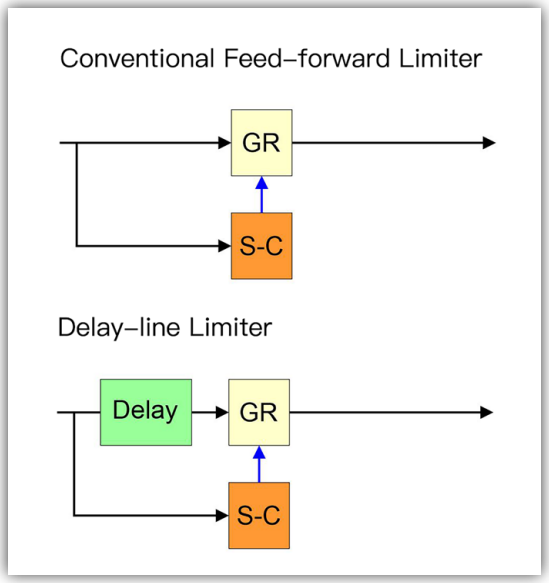

Figure 1: in a delay-line limiter, the main audio path is delayed a tiny amount (<1ms) by a network of all-pass filters, so that the control path 'sees' the signal fleetingly before it arrives at the gain reduction stage.

HUM Audio LAAL
£8790

PROS
- Virtually unique analogue technology in the mastering world.
- Extremely effective and transparent.
- Useful additional functionality.
- Ultra-precise mastering-style I/O level controls and metering.
- Dynamic Transient mode avoids HF dulling side-effect.

CONS
- Very expensive.
- Unusual threshold calibration not documented in the manual.
- Mirror image controls can take some familiarisation!

SUMMARY
Delay-line limiters are virtually unheard of in the mastering world due to the complexity of their analogue delay circuitry, yet their inherent benefits are perfectly suited to that role, as the LAAL easily demonstrates.

» Construction is to the highest standards, with a double-shielded toroidal mains transformer bolted to the rear panel, with separate secondaries to power the audio (±24V) and control circuitry. The analogue audio is implemented entirely with discrete transistor op-amps, accepting a maximum input level of +24dBu, while the output can provide a whopping +30dBu. Self-noise is claimed to be -102dB (A-weighted), although the best I could acquire was -85dB A-weighted relative to a +4dBu input; I suspect the published figure is referenced to the onset of limiting at +13dBu (see below). THD+N is quoted as 0.026% and my Audio Precision test agreed with that. The analogue delay line introduces just 0.2ms of look-ahead latency.

Somewhat unusually (and, for me, confusingly at first) the LAAL's two sets of operational controls are arranged in a mirror image. HUM chose this layout to ensure perfectly symmetrical internal audio circuit paths, which they claim is important for the unit's precision. Channel matching is claimed to be better than 0.1dB, and the side-chain circuitry is thermally compensated to ensure stability and repeatability regardless of environmental conditions.

In mastering applications, the ability to reset controls precisely is critically important, so every function on the LAAL has either a rotary switch or a button. Each channel features large input and output coarse level controls spanning -10 to +12 dB (in 2dB steps), and these are supplemented with adjacent fine trim controls covering -1.0 to +1.2 dB (in 0.2dB increments). The release time constant switch presents 2, 5, 10, 20, 50 or 100 ms options, while the attack time is effectively fixed by the delay line duration and is not adjustable.

There are no ratio or threshold controls either, since the former is effectively ∞:1, and the latter is fixed at +13dBu (see below). Consequently, setting the LAAL up is a case of choosing a release time to suit the material, increasing the input control(s) to push a portion of the signal above the fixed threshold to achieve the desired amount of gain reduction, and then adjusting the output control(s) to set the required maximum output level.

"The Dynamic Transient mode introduces a variable shelving HF boost, with the boost level depending on the amount of gain reduction and the release time setting... and to my ears it works very well indeed."

Two full-height 40-LED meters bracket the centre panel, with the first (green) meter showing the input signal level, scaled from 0 down to -20 dB. It seems odd for an analogue limiter to have a meter scaled like a digital device, but HUM have done it this way as the top zero point indicates the onset threshold of limiting. The top 3dB of the input meter is marked very finely in 0.2dB steps, then 0.5dB steps down to -6dB (which is the middle of the total range), and 1dB steps thereafter. There's no ability to monitor the output level directly from the LAAL — but in a mastering suite there will always be an output level meter somewhere!

With both coarse and trim input level controls at their zero marks, an input level of +13.0dBu reaches the top (zero) of the meter, as I mentioned earlier, and any signal level above that causes the limiter to act. So, after the green input meter reaches the top of its scale, any further level increase exceeds the limit threshold and the first red GR light illuminates (from +13.1dBu). More input level causes the red GR meter to descend, covering a 12dB range in 0.2dB increments down to -5.0dB, and 0.5dB steps from there on.

A limiting threshold of +13dBu isn't always what's needed and if, say, the aim was to limit at +8dBu (5dB lower), the input level would simply need to be boosted by 5dB. Setting the coarse input control at +4 and the trim to +1 would achieve that, as would setting the coarse at +6 and Trim at -1. In this way the highest limiting level is +24dBu, and the lowest is -0.2dBu.

A trio of illuminated buttons either side of the centre section engage a Peak Hold function for the gain-reduction meter, activate the Dynamic Transient mode, and introduce an inter-stage transformer into the signal path. The last is claimed to add "warmth and body" to the overall sound, which it does through a gentle increase in odd-harmonic distortion.

The manual is quite vague about the Dynamic Transient mode, simply saying that it "regenerates transients proportionally to the limiting level" and that "it plays a major role in preserving space and details in the sound". I found

The balanced analogue I/O are on XLR connectors.

A peep inside reveals the high quality of construction that you'd expect in top-end mastering devices.

the difference very subtle, but I tended to prefer it engaged. Quizzing the designer about how this function works, I was told that the Dynamic Transient mode introduces a variable shelving HF boost, with the boost level depending on the amount of gain reduction and the release time setting. So if the peak level is attenuated by 3dB, the Dynamic Transient function adds 3dB of HF at the same time. The idea is to compensate for a common side-effect of limiting — a tendency to dull the sound slightly — and to my ears it works very well indeed. Apparently, the Dynamic Transient circuitry is quite complex and took a long time to develop and optimise to preserve headroom.

Located in the very centre of the unit are a few shared functions. The first is the power on/off button, and this device features a 'soft start' to avoid audible thumps through the monitors. On either side are buttons to activate a rotary Stereo Width switch (with six widening positions), and a Detect Link function, which is better known as side-chain linking (and whose purpose is to prevent stereo image instability).

Four further buttons along the bottom are arranged, yet again, in mirror-image pairs, and these activate for each channel a relay hard bypass of the whole unit, or a soft bypass, retaining the stereo width and transformer circuitry while disabling the limiter sections.

In Use

The intention behind a look-ahead limiter is to maintain extremely accurate peak control without damaging the initial transients, and the LAAL achieves both very well indeed. I can't fault its performance in these regards. Switching the transformers into circuit gives a slightly fuller and richer low end, while the Stereo Width control provides a useful range of image enhancement, particularly through the mid and high ranges — low frequencies seem to remain well centred and solid. Even with 5dB of active gain reduction showing almost constantly on the meters, I often found it quite hard to tell if the LAAL was even switched in to my mastering chain without looking — it is that transparent in its operation. The LAAL is also incredibly simple to configure and use — even if the mirror imaged controls took me a while to get used to! The I/O controls and metering allow extremely precise adjustment of the limiting threshold and output level, which is perfect for mastering, of course. So I can easily appreciate why this unit has already become very popular with high-end mastering studios, here in the UK and elsewhere.

Naturally, a limiter of this quality and precision is expensive but, since the LAAL is almost unique in the mastering market (all-analogue delay-line limiters for mastering are beyond rare, and the only other one I'm aware of is made by ADT-Audio to custom order), I think it's fairly priced amongst its comparable peers.

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ALTERNATIVES

The only technologically equivalent current product I'm aware of is the **ADT-Audio U795** module for their V700 system, although I believe it is only available built-to-order. Other mastering limiters at a broadly similar cost include the **Manley SLAM! Mastering Version**, **Shadow Hills Mastering Compressor**, and **Elysia Alpha Compressor**. Another popular mastering dynamics processor that's less expensive is the **Maselec MLA-4**. But although these are all more versatile dynamics processors than the LAAL, none of them offer the delay-line benefits.

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