Compression and Limiting in Distortion Boxes

There is compression and limiting in every overdrive, distortion, fuzz, squash, saturation or crunch circuit. There is no way around it. To explain why, we need to first understand compression and limiting.

Let's examine limiting first since it is somewhat more simple in design. A limiter has a threshold, above which the gain of the circuit is reduced. There are other parameters that apply but basically that's it in a nutshell. The amount of gain reduction can usually be varied. The sharpness of the onset of the limiting (sometimes called the knee) may be set so that the limiting happens abruptly or gradually over an increase of tens of millivolts.

As an example, we can use a 1v signal as the threshold (0dB for purposes of discussion) in our limiter. A signal that is above 1v will be reduced in strength. If the ratio is 3 to 1 then a +3 dB signal increase above the threshold is required to get an additional +1 dB of output. Therefore, a +6 dB signal into our limiter would give a +2 dB output, and a +9 dB signal would yield +3 dB out - notice the 3 to 1 relationship. Any signal below the threshold passes through unaltered, i.e. 0.7v input gives 0.7v output.

The gain reduction does not have to be 3:1 as in our example. It might be 2:1 or 5:1 or even infinite! In the case where the limiting is infinite, no matter how high the input signal goes above the 1v threshold, the output will be limited to 1v. This sounds like clipping, doesn't it? Exactly! Diode clipping is hard limiting at a nominal 0.7v threshold.

So, we're making some progress - diode clipping is a type of limiting. What about compression?

Compression also has a threshold, though it may also be referred to as a rotation point. Input signals above the rotation point will have the gain reduced and signals less than the rotation will be amplified.

Let's make an example compressor using the same 1v control level as with the limiter example above, also with a 3:1 ratio. At an input of 1v (0 dB) the output will still be 1v and a +3 dB signal yields +1 dB out just as before. However, with the compressor, the low level signal of -3 dB will be -1 dB on the output instead of unaltered as with the limiter. A -6 dB input will be -2 dB output. The compressor has an effect on the gain of the signal both above and below the set threshold (or rotation) while the limiter only changes signals greater than the threshold.

Typically, a fuzz (overdrive, distortion, crunch, saturation, squash, et al) will have a gain stage to amplify low level signals and a pair of diodes to clip the highly amplified signal. This has the effect of sounding like a compressor-limiter since low level signals are amplified and signals

greater than the threshold are hard limited.

When you have the diodes from the signal to ground, the limiting has a very high ratio because of the log response of the diode conduction. It takes a lot of signal increase to raise the output once the threshold is exceeded (oh, you didn't know that the 0.7v is not a hard and fast limit?). Diodes in the feedback loop of an opamp (non-inverting) also have a very high limiting ratio, but not as high as diodes to ground because the maximum gain reduction of the opamp feedback loop is unity, or gain = 1.

Low level signals are boosted because of the gain of the fuzz. If the gain is low, you get a low compression ratio and if it is high the ratio effect is higher. The net effect of the limiting of the diodes with the low level gain is to reduce the dynamic range of the output signal, which sounds like compression with limiting.

Diodes to ground give a hard limit threshold, as will diodes in the feedback loop of an inverting opamp gain stage. This is a somewhat harsh distortion effect. A pair of back-to-back diodes in the feedback loop of a non-inverting opamp will yield a slightly softer distortion because no matter how hard the diodes conduct, the output of the opamp will be a minimum of unity. This effect is very easily seen on an oscilloscope.

Circuits that use diodes to ground, such as the ProCo Rat or MXR Distortion+, will have a more compressed sound than the TS-808 clones that have the diodes in the feedback loop of the non-inverting gain stage, but there is a prominent amount of the effect in any overdriven signal.

In the case of a circuit such as the fuzzface, which does not use diodes for clipping, a different type of distortion is taking place yet the end result is much the same. When a transistor (or tube) circuit is driven with a strong signal, there is a point at which the transistor is not capable of driving the output to the full voltage extremes determined by the circuit design. Example: if you have a simple transistor 10x gain stage powered by a 9v battery and you input a 1v signal, the output should swing to 10v but it cannot. The transistor will conduct hard on and hard off at the extremes of the signal, which will be less than 9 volts. What happened to the ends of the signal? They were clipped off and distortion is the result. Once again you have amplification of low level signals and clipping of peaks so it sounds like compression-limiting.

The net result is that there is both compression and limiting in every distortion circuit. An easy way to dilute the compression/limiting is to feedforward some of the normal signal to the output and blend it with the distorted sound. This lessens the perception of the compression and introduces some dynamics into the output. There are several commercial distortion boxes with this feature.
