Preface: Dear reader,
we continue "effective-ly" with a third article written by Bernd Meiser, this time looking at the MXR Distortion+ device. I remember well how, when it became known here in Germany in the mid-1970's, it was the go-to distortion device. Personally, I did not like it a lot, preferring the pre-amp overdrive of my, at the time, Fender Twin Reverb in conjunction with a Compact Phasing A that could be abused to get a 20 dB boost. Still, there is no denying the Distortion+ represented a kind of breakthrough – it is a most important stomp box.
Have fun, T.Z.

From the "Effect-ive!" series of articles:

Distortion: MXR D+

By **Bernd C. Meiser**, translation by **Tilmann Zwicker**

Well then ... at the beginning of the 1970's (when "Classic Rock" was its bloom), there was not much disagreement that a nicely overdriven tube amplifier would generate a cool sound. If only that weren't connected to such LOUDness - it often simply got TOO loud. It quickly became obvious that this "clipping" of the power stage that the amp was undergoing at full load needed to by called in by some other means. As always, the human mind got highly inventive ... and in the present article we are going to take a look at what has been devised in terms of "signal clipping": the emergence of the so called "Distortion"-devices.

MXR Distortion+

The first truly successful distortion pedal was the 1973 "Distortion+" by the MXR company. This fireball, and the Phase 90 stomp box, were the starting points of this then-very-young firm that would become very successful over the following years. The 9-Volt-operated Distortion+ sports two knobs and is in fact of quite simple build, requiring merely two circuit sections (see **Fig 1**). The first consisted of an adjustable high-gain amplifier with a high-impedance input, and the second included a clipping stage working with two anti-parallel connected Germanium diodes, and an output level control. That was it!

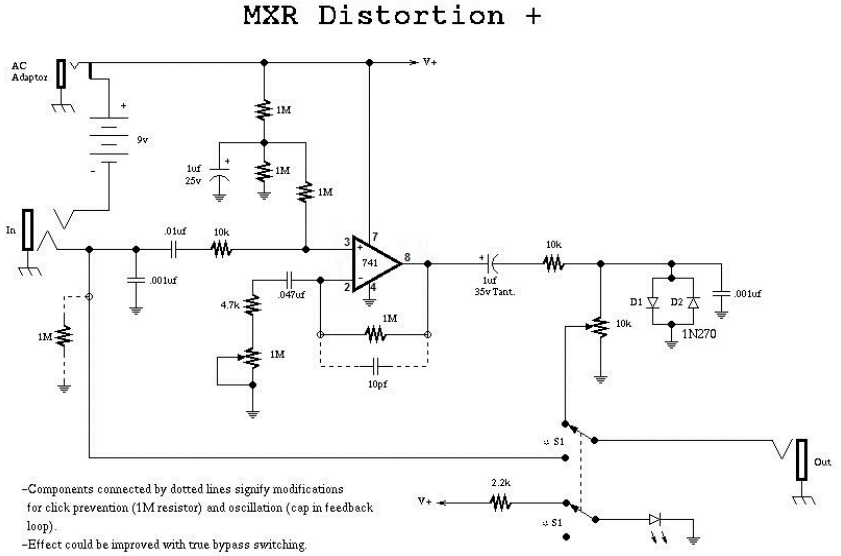

FIg 1: schematic of the MXR Distortion+ (this is, by the way, the schematic of the reissue-version of the pedal; the original had no LED-indicator nor an AC-adaptor-jack).
Source: https://elektrotanya.com/mxr_distortion_plus_sch.pdf/download.html

In the MXR D+ we find the very first globally successful operational amplifier (OA), the µA741 deployed as gain device. This OA had been on the market since 1968 and it worked very well in the MXR D+ – even from today's perspective its technical data will raise more than one eyebrow. This goes to show again that what sound good is not necessarily of technical perfection, especially since the overall performance depends a lot on the circuit design. More on the subject of OA and chip-performance is discussed in the article "Chipology" (*translator's remark: still to be translated*).

Input circuit

At the "+"-input of the OA (pin #3), the bias (half of the supply voltage) is set via the high-impedance R1 (1 MOhm). Here's a first tip (more to follow) for all you DIY guys out there : the circuit can be made a bit more low-noise if this resistor is replaced by a metal-film type. The input impedance of the µA741 nominally amounts to 2 MOhm (the manufacturer specifies 300 kOhm as a lower tolerance limit – quite a range, that is!). The input impedance of the whole circuit therefore formally consists of the parallel connection of those 2 MOhm, and the just mentioned 1 MOhm bias resistor. The circuit receives the signal via a 10 kOhm resistor and a 10 nF capacitor connected in series - the latter unfortunately of the ceramic type. If you want to do better, go ahead and replace it by a film capacitor. While you are at it, do also replace the 10 kOhm carbon resistor by a metal film one – its systemic noise enters in its full detrimental glory into the final noise considerations, and metal film is simply much better than carbon here. The input circuit lacks a pull-down resistor and will generate a significant "pop" as the effect s switched on – another conducive modification therefore is soldering a 1 MOhm resistor in parallel to the input of the circuit - as indicated in the schematic.

In order for the pickup not to sound too trebly but rather a bit fatter and less "fizzy", a 1 nF capacitor is connected in parallel with the input. With the resonance frequency of the pickup audibly lowered that way, the distortion sounds a bit smoother while not too much of the top end is sacrificed.

Gain

With the configuration of a 1 MOhm potentiometer and an RC series circuit in the negative feedback branch (at pin #2), the signal is amplified with little frequency dependency at small and middle gain. This frequency-neutrality gets lost as the gain is turned up: at full gain (47 dB @ 1 kHz), the 4,7kOhm + 47nF low-pass in the negative feedback branch becomes fully effective, giving the overall gain a high-pass characteristic. The cutoff frequency is 720 Hz ... well, that does ring a bell, doesn't it! Indeed, it is this cutoff frequency (and even same-value components setting the characteristic) that we find in later overdrives, such as the Boss OD1 and the Ibanez TS-808, as well. The world's a small place!

In any case, the way the cutoff frequency "sneaks" in is a very sensible countermeasure against too much booming and mud in the bass register - well done! At maximum gain, and given that the OA is subject to significant inter-specimen tolerances, there is a small chance that oscillation may occur in some devices. If that happens, soldering a small capacitor between pins #2 and #8 as indicated in the schematic will take care of the issue.

Diode clipping

Let's now look at how the Germanium diodes of the type 1N270 introduce clipping. They are driven from the OA via a 10kOhm resistor (for current limiting), and a 1 µF tantal capacitor separating the potential. (Another DIY-suggestion: the tantal capacitor is best replaced by a film capacitor.) In order to re-cap on diode characteristics, reading of the article on diode-theory is much recommended (*translator's note: that article also waits for translation ...*). At small driving voltages, the Ge-diodes retain a high impedance but drop to low impedance very quickly as the voltage rises – voltages of over approx. 0.15 V are increasingly compressed (**Fig 2**).

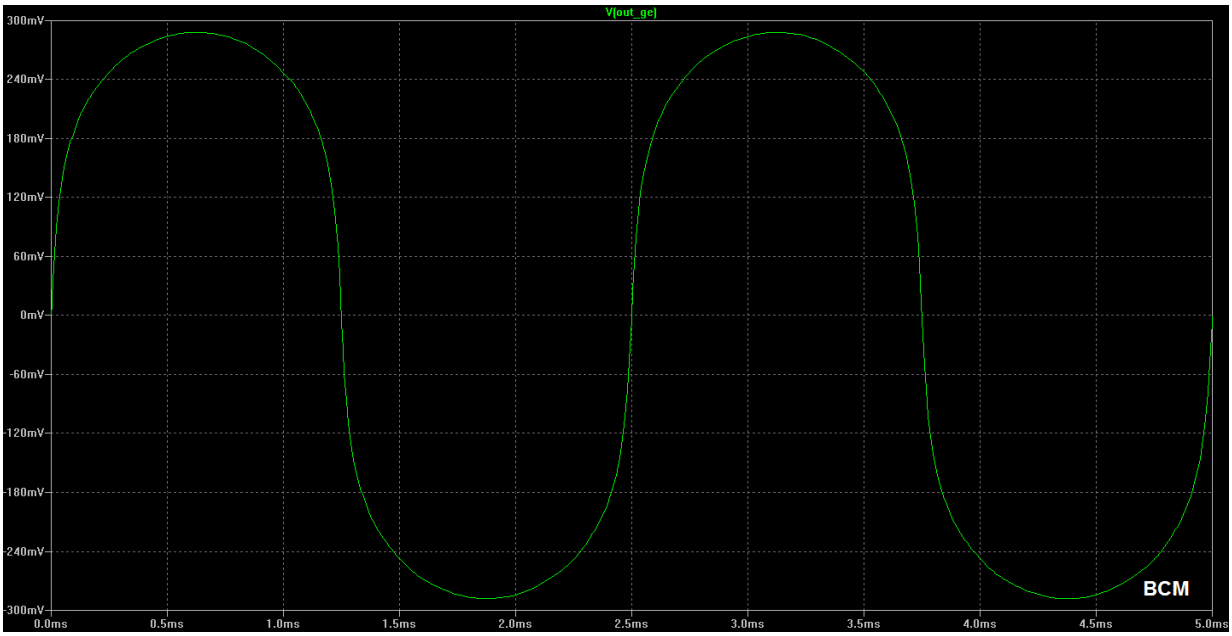

Fig. 2: Diode clipping for Ge-diodes

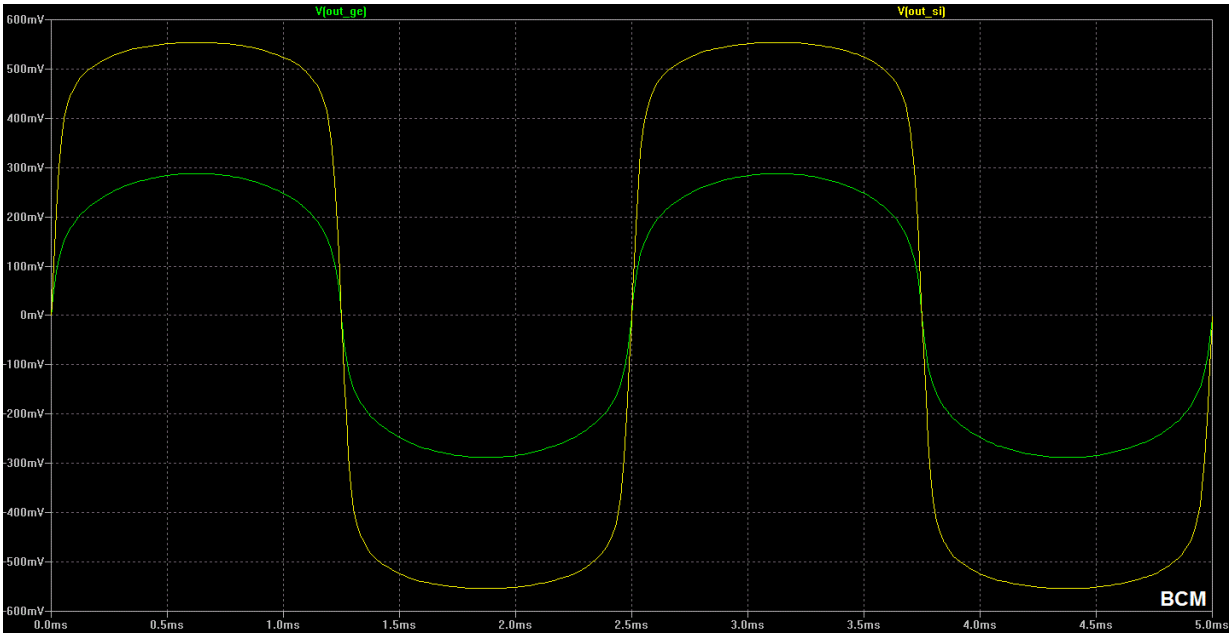

Fig. 3: Diode clipping: Si- and Ge-diodes in comparison

At this point it is interesting to directly compare Germanium (Ge) and Silicon (Si) diodes - see Fig. 3. The extraordinary rounding-off of the input signal effected by the Ge-diodes is seen in green in the figure. While the Ge-diodes begin to rather softly limit the signal early on, the Si-diodes (yellow) work more with an immediate leveling off of the signal, i.e. they clip. Parameters for **Figs 2 and 3**: driving voltage is 4 Volts peak-to-peak, the current-limiting resistor is 10 kOhm.

This different "rounding off" optically visible in the figures of course find an acoustical and mathematical correspondence in the spectral domain (not shown here): the Ge-characteristic sounds softer, milder, and more agreeable, while Si is louder and harder. In order to further soften the distortion sound (i.e. to attenuate the harmonics some more), there is a small capacitor (1 nF ceramic) connected in parallel to the diodes. If the Ge-diodes were to be replaced by Si-types (e.g. the 1N4148), a larger capacitance of 2,2 nF or even more might serve well here – and generally a film-type capacitor should be employed in this position in the circuit (more DIY tips, if we're starting to do a mod-job anyway!).

Subsequent to the clipping, we have a simple volume control that feeds the output without any buffer.

It is worth mentioning that the Distortion+ sported merely a SPDT-switch (even in the reissue version, the signal path is afforded merely on pole of the DPDT-switch because the other pole is used to switch the LED). This renders the input circuitry of the device constantly connected to the guitar, even in the "effect-off" operation – and therefore the 1 nF-capacitor always lowered the pickup resonance, whether the Distortion+ was switched on or not. That even the bypass-signal was always affected was something that players of 1970's-Stratocasters might even have appreciated. The CBS-made pickups of the time are said to by rather treble-heavy, possibly due to a reduction in the number of turns of the coils that might have made (given the high demand for Stratocasters and massive backorders) for faster production.