**Preface:** Dear reader,
another "Effect-ive!"-article by Bernd Meiser: this (5th-) one concentrating on the Boss DS-1. By now, I feel that over the almost 50 years I have been concerned with playing and investigating the guitar, I have missed out in too much guitar stuff, because – again – I have actually never tried the DS-1! It seems me and my buddies for a long stretch of time were way too swallowed up in the "I ain't usin' no transistor distortion pedal stuff!"-movement,... had I known then what setup I was (and am) using later, I may have been much more open-minded already then, and checked out the DS-1. Anyway, here's the discussion of that device. T.Z.

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

# Three degrees of Distortion: Boss DS-1

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

In the summer of 1978, Boss introduced the distortion DS-1 pedal (together with their fine CS-1 chorus pedal), after they had successfully started to market the overdrive OD-1, the 4-stage phaser PH-1, and the filter-pedal SP-1. The DS-1 was to prove itself to be a long-running top-seller. It can be found in two versions hat differ in circuit design and thus also to some extent in sound. The present article looks into the first edition of the device.

## *Boss DS-1*

Let's check out the schematic in **Fig. 1**. Right at the input we find the obligatory impedance converter Q1 with an input resistor of 470 kOhm that put only a marginal load onto the pickup line (*translator's note: although of course an overall input impedance of the impedance converter of 1 MOhm would have been preferable in order to influence the guitar output even less - and later stomp boxes often upped their input impedance to that level. But in the DS-1 this would have necessitated a different circuitry with a FET or an OP-amp at the input)*. The resonance of the pickup is preserved almost to its full extent. Subsequently we find the "silent switching" system, comprising the switching FET-arrangement Q6 (*translator's note: the control circuit for switching Q6 and Q3 is not shown)* . The latter is of a high-impedance configuration that generates very little load for the impedance converter - well done. Note: with a low-impedance load (as it is the case e.g. in the TS-9), the BJT (bipolar junction transistor) impedance converter reacts with slight one-sided signal limiting clipping when driven with a strong signal (see the article about impedance converters (*translator's note: this article is yet to be translated*).

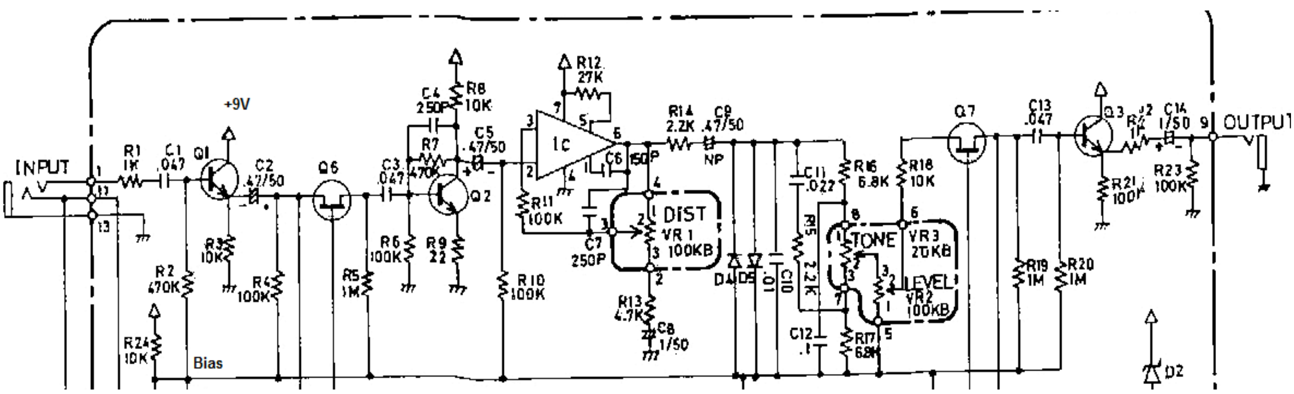


Fig1: Schematic of Boss DS-1

## *Transistor amp - the first degree*

What follows in the signal chain is a transistor circuit (formed of Q2) that provides audible "crunch" to the signal. Looking at the transmission characteristic (**Fig. 2**), we observe a monotonously decreasing curve between +4 Volts via 0 Volts down to -4 Volts, where it sharply turns off into the horizontal that also represents the drive limit at that point. That continues slight curvature equates a nice kind of fine harmonic distortion that an operational (OP-amp) amplifier would not be able to deliver. OP-amp circuits either have a straight-line characteristic between the drive-limits, or that straight line is heavily bent – usually employing semiconductor diodes – to serve for overdrive purposes. It is difficult to realize an in-between characteristic - with simple means, anyway. In the present case, the designers made short work and deployed a transistor stage.

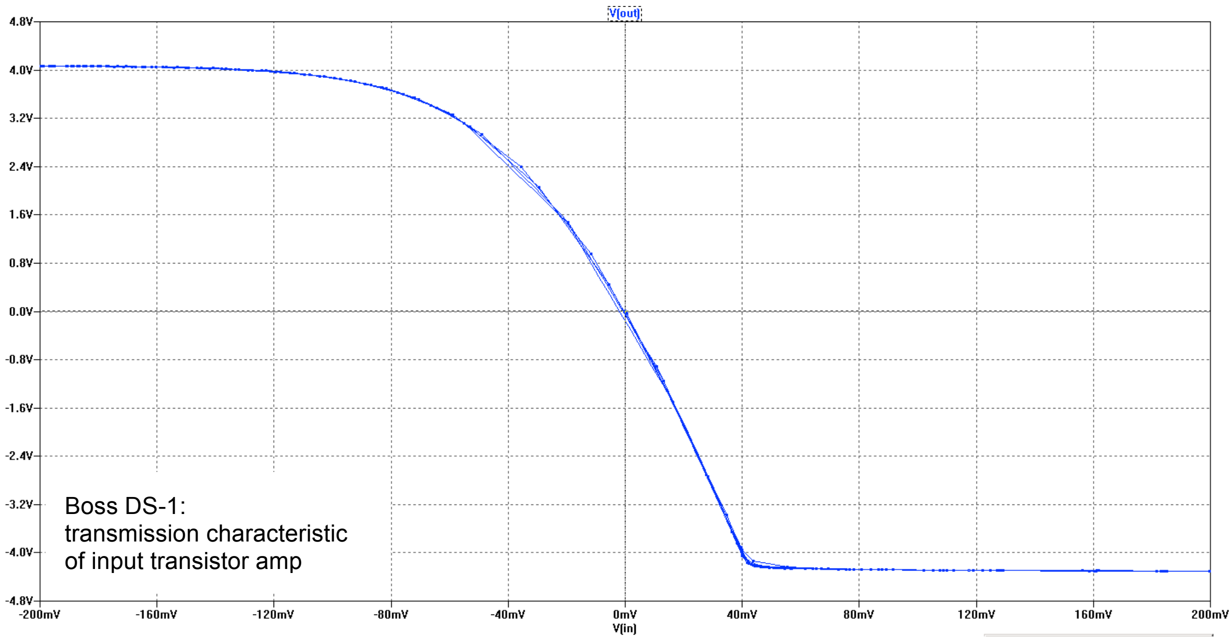


**Fig. 2:** Boss DS-1; transmission characteristic of input transistor amp

The Q2-arrangement operates as an inverter. For those not as well versed in transistor-ology: as an OP-amp circuit, this would be the "inverting OP amp" with a (negative-) feedback resistor from the output to the "–"-input and an input resistor from the circuit input to the "–"-input of the OP-amp. Our transistor circuit here is based on the same principle: the feedback resistor of 470 kOhm is connected between collector (= output) and base (= "–"-input) and serves in a double role also adjusting the operating point of the transistor. In the latter role, it cooperates with the 100-kOhm-resistor between base and ground. The formal input resistor of the Q2-circuit we need to add the output impedance of the impedance converter Q1 and the "on"-resistance of switching FET Q6 resulting in approximately 550 Ohm. There is also a coupling capacitor of 47 nF (more on that later) that takes care of the separation of the potentials. Feeding these values (550 Ohm, 470 kOhm) into the formula for the inverting OP-amp, we calculate a massive gain of 850 = 58 dB. Out comparably whimp-ish single-transistor stage won't reach that - in reality we get about 36 dB i.e. a factor of 65. As we will see, that is more than good for our purposes here.

On order not to make the distortion to be generated not too "prickly", the 470-kOhm feedback resistor has the 250-pF capacitor C4 connected in parallel. And then, there is a high-pass constituted of the already mentioned input resistor (550 Ohm) and the 47 nF input capacitor with a resulting cutoff frequency (-3 db) at 600 Hz. This attenuates the bass distinctly – anyone wishing for more bass at this point may simply double this C3 = 47 nF. Regarding basic harmonic distortion and frequency response, the signal is now optimally preconditioned for further processing. By the way: we will get back to this subject matter in another article – but I shall not reveal more here ... (*translator's note: this article is yet to be translated*).

## *Gain OP-amp - the second degree*

The now pre-processed signal is now fed to an amplifier chip of a type that is rarely found in FX-pedals: the TA71236P, which is a single OP-amp accommodated in an 8-pin SIL-housing and made by Toshiba. It is marketed as OP-amp for special HiFi-preamp application – but in fact nothing special when looked at more closely. The wiring seems a bit muddled – in particular the two small capacitors of a few pF each at the output are a bit bewildering; they "slow down" the OP-amp ... that will be enough knowledge about them for now. The gain of the Toshiba amp can be adjusted from 1 to about a factor of 20 using the "Distortion"-pot. (Note: if you require more drive, you could simply half the value of the resistor R13 (4,7 kOhm) at the lower connection of the Distortion pot). The signal is now ready to deal with the "clipping"-arrangement of the silicon-(SI)-diodes.

## *Diode-clipping - the third degree*

The diode-clipping section – driven via current-limiting resistor R14 (2,2 kOhm) – will be well known. Of particular interest is the third (green) curve in the transmission characteristic of the clipping stage shown in **Fig. 3**. The line abruptly stops at rather exactly the +/-0,6-Volt-diode-voltage and continues horizontally. This is not owed too the dynamic diode-clipping, but the OP-amp has hit its ceiling! Despite further rising input voltage, the OP-amp simply cannot give us more at the output – and the diode downstream of the OP-amp cannot but mirror this fact. The triangle-waveshape voltage used for testing was peak-to-peak $V_s$=200mV; the gain generated by the OP-amp is the parameter in the figure.

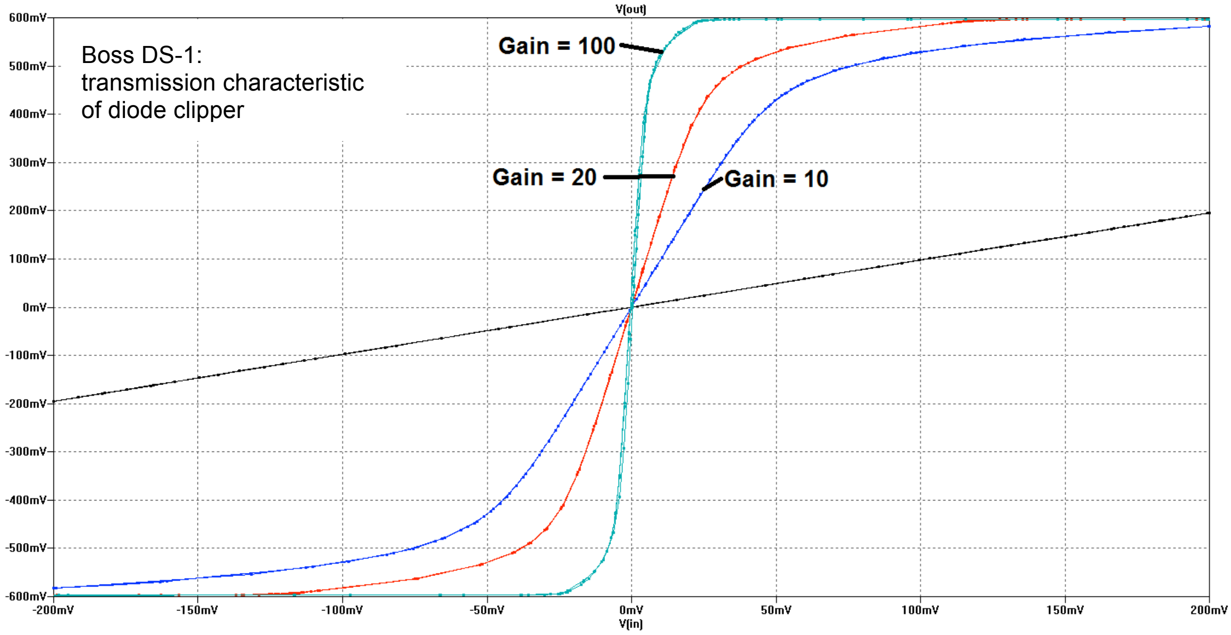


**Fig. 3**: Boss DS-1; transmission characteristic of diode clipper arrangement

The blue curve with lower gain shows a different behavior, giving a continuously decreasing incline in the first quadrant. Many of us will recognize this transmission characteristic: indeed, it is a modified "ln"-function (**l**ogarithmus **n**aturalis, natural logarithm). In fact, all three of the curves depicting the diode clipping are such modified ln-functions (cf. basics of diode theory) - except for that clipping at +/- 0,6 Volt, where the modified ln-function changes over into a line with inclination "0". To explicitly show this matter, I have added, in **Fig. 5** below, the pure ln-function to the clipping-graph of Fig. 4 for comparison. Such an ln-function is generated in its wider sense in particular by so-caller "overdrive"-circuits.

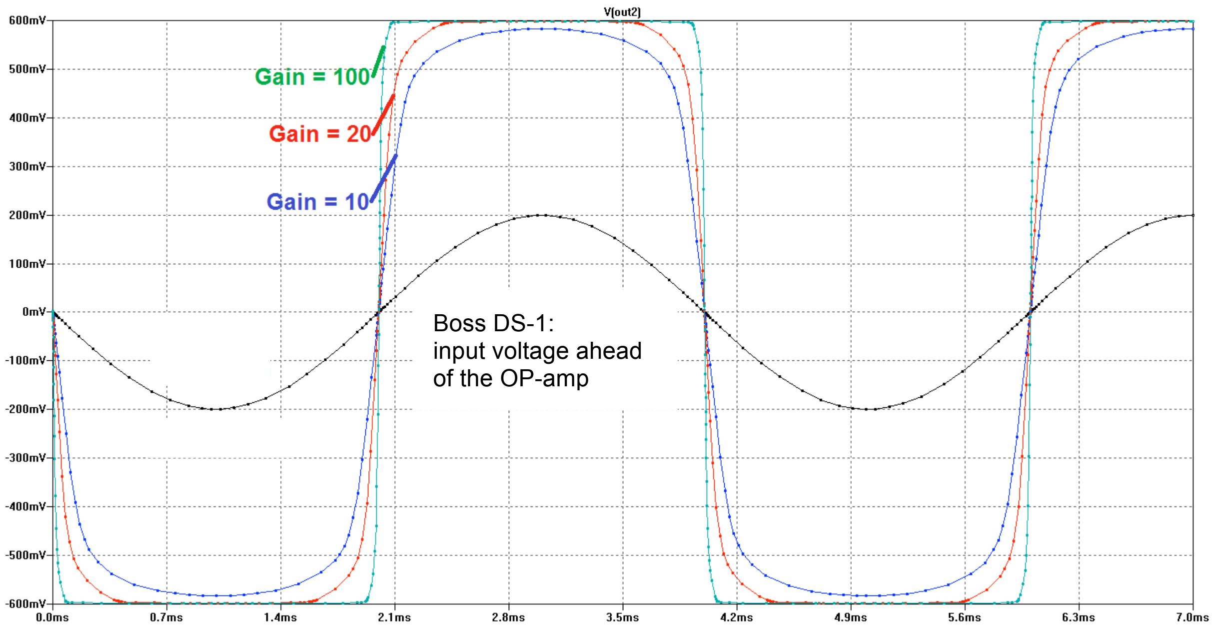


**Fig. 4**: Boss DS-1: signal across the anti-parallel SI-diodes

But check out **Fig. 4** first: here we see the plot of the signal curve across the SI-diodes.

As testing voltage ahead of the OP-amp, this time a sine-shaped voltage of $V_s$= 200mV peak-to-peak was used – for the present discussion it is better suite than the more analytical triangular voltage. Again, the gain of the OP-amp is the parameter. We clearly see how the output voltage across the diodes is continuously compressed at a gain of factor 10. At the gain-factors 20 and 100, we recognize in addition the limiting effected by the OP-amp as its output stage goes into clipping against the supply voltage.

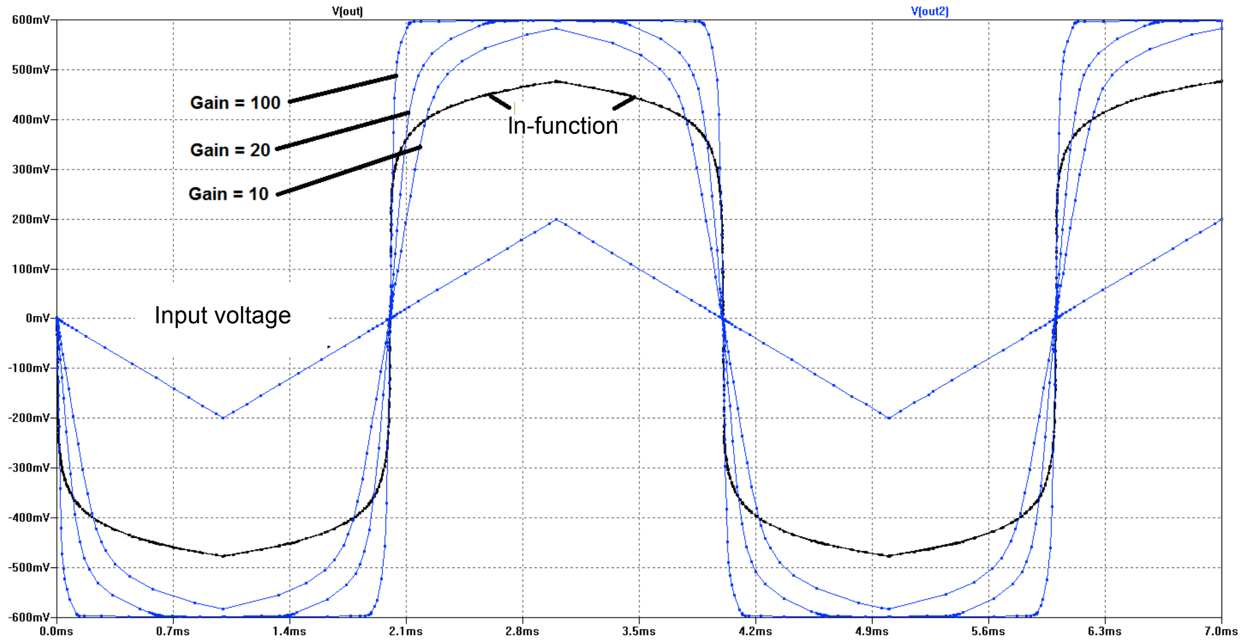


**Fig. 5**: as Fig. 4 but with triangular input voltage and the ln-function indicated.

## *Tone-Filter*

The tone-filter is well-known from the Big Muff Pi offered from the early 1970's by Electro-Harmonix. One branch is formed by a low-pass, the other by a high-pass, and in between we find a pot to cross-fade between the two transmission characteristics. In other words, you can choose between bass-boost and bass-boost, and in between there is a slight middle-notch as transition. We shall dissect this tone filter in a dedicated article concentrating on the Big Muff Pi (*translator's note: this article is yet to be translated*).