Super Simple Current Limiter   XESSIL

XEN Audio
April 2019

Very often when testing or operating headphone amps or power amps, it is useful to incorporate some form of current limiting to prevent damage to expensive output devices due to accidental short circuits, etc. In such cases, the exact value of the current limit is not crucial, and an accuracy of 20% is usually sufficient. Various designers incorporate this into the amplifier circuit itself, but we found this to interfere with the sound. So we always but this upstream in the power supply, ideally before the regulator. The penalty is that the caps after the regulator still store some energy that needs to be drained.

When putting this in the power supply, what is desirable is a relatively low output resistance when not close to the limiting current, i.e. so-called minimum invasion. Ülacing the current limiter upstream of the voltage regulator will allow the latter to “mask” it further from the amplifier circuit.

The simplest way one can think of is to use a depletion MOSFET configured as a current source at the limiting current (Fig. 1). For example, a DN2540 with a source resistor of 20R will make up a 200mA current source. During start-up, the MOSFET will see the full voltage and limiting current, which limits the maximum voltage that can be deployed. Of course, one can always use multiple devices in parallel to increase the current capability. For the DN2540 to function properly, it needs minimum 3V additional voltage headroom. The “problem” with the DN2540 is that the Zout is not quite low, in the order of 25 ohm in addition to the 20R source resistor required.

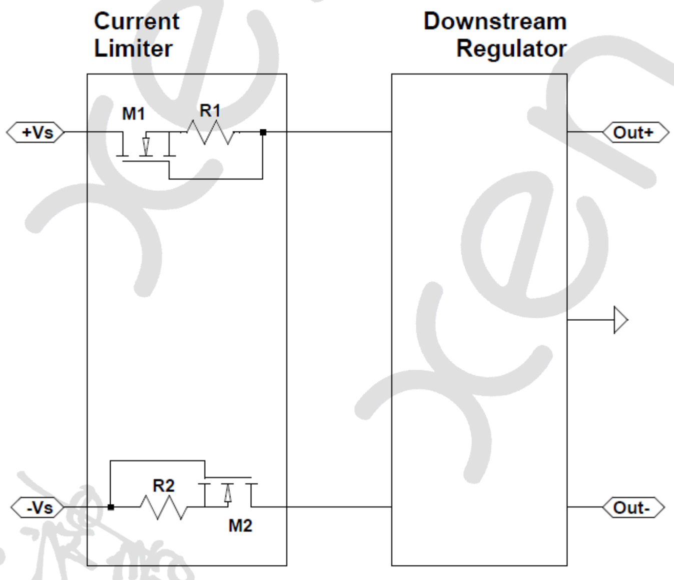

Fig. 1   Depletion MOSFET current limiter

Another widely used circuit makes use of a sensing resistor to switch on and Vbe of a small signal device, which in turns switches off the pass device (Fig. 2). The impedance of the limiter is then determined by Re of the pass device at normal bias, plus the sensing resistor. Again, using the above example of 200mA current limit, Zout is approximately 3.5R. And additional voltage headroom is minimum 1x Vbe + Vce(sat) of the pass device.

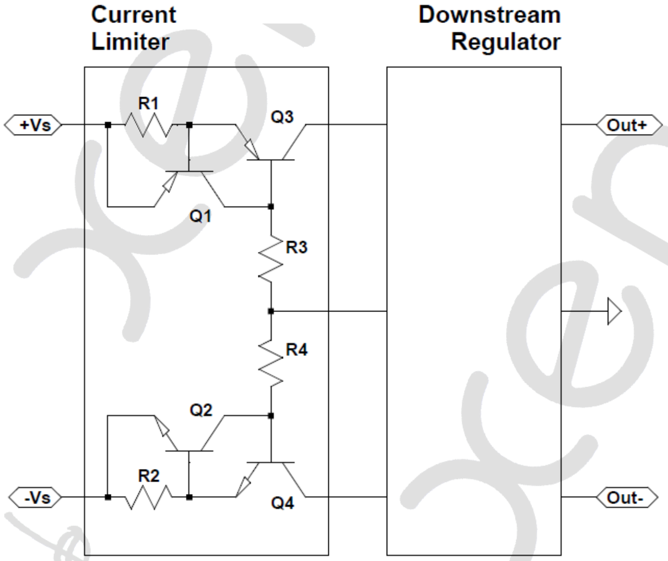

Fig. 2 Current limiter using R sense and Vbe

Can it be still simpler ?
Since we are using BJTs anyhow, we know that the base current is proportional to the collector current, and this ratio (hfe) can be measured with most digital multi-meters or other simple means. We can therefore limit the collector current automatically by limiting the base current.

This is simply done with one resistor connecting the base to Gnd. Assuming we know the supply voltage upstream, and the hfe of the pass device, the desired base resistor value is simply :

Rb = (Vs-0.6) x hfe / I_lim

For example, the upstream supply voltage is 25V, and the limiting current is 200mA. The pass device has an hfe of 100. That gives a base resistor value of 12.2k. The maximum base current is about 2mA (Fig. 3).

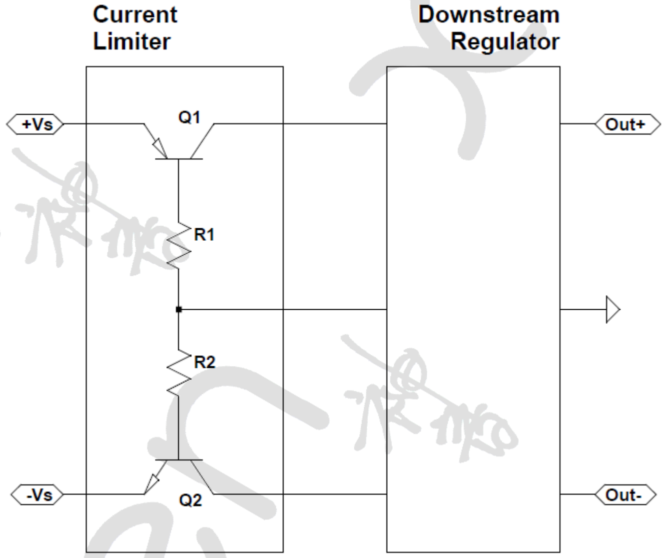

Fig. 3 Current limiter using base current limit

As no resistor is involved along the output current path, the Zout of this limiter is only Re, which is well below 0.2R for 100mA DC Bias. The voltage headroom required is in theory only 1x Vce(sat) of the pass device.

It is obvious that the same can be applied to a negative supply using an NPN pass device instead.