

Technical Brief: A Novel Audio Amplifier MOSFET Trans-Impedance Stage

Béla Géczy

A typical high-end audio power amplifier consists of three stages: an input transconductance stage which converts an input voltage to an output current; a second transimpedance gain stage which converts the current into a voltage; and lastly a current amplifier stage which drives the speaker/load. This Technical Brief will discuss a novel MOSFET Transimpedance stage.

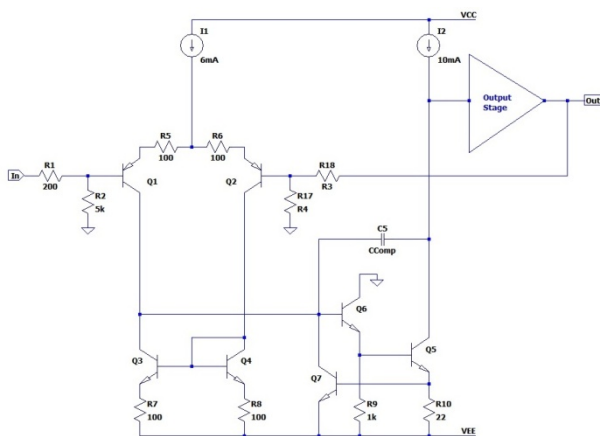


Figure 1

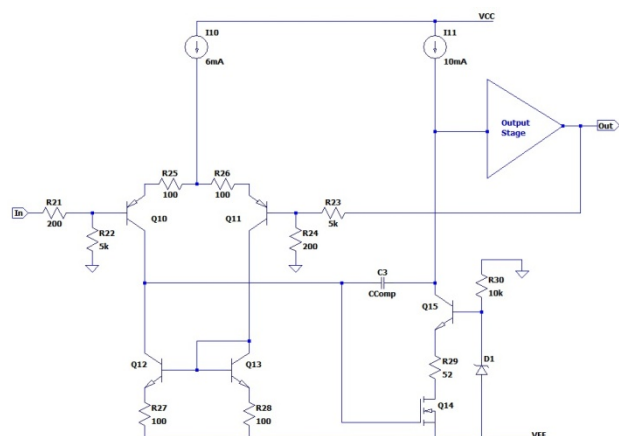


Figure 2

Figure 1 and 2 are simplified schematics showing the three stages of an audio amplifier. In Figure 1, Q1-Q4 plus I1 comprise the input stage, Q5, Q6, and Q7 plus I2 form the ubiquitous Transimpedance Stage (TIS), also known as a Voltage Amplifier Stage (VAS), and lastly the output stage is shown by its own block.

Referring to Figure 1, Q5 is the TIS transistor; a common emitter amplifier loaded by a 10mA current source. Q6 is an emitter follower (sometimes referred to as a Darlington connection) to provide current gain which decreases the load of the input stage thus increasing the gain of the input stage. But by adding this transistor, the current sink capability of Q5 can be very high in an overdrive situation, well in excess 100mA. Optimally, the current range of Q5 should be from zero to 2 times the TIS current source which here would be 20mA. This allows a +/-10mA output of the TIS. Therefore, Q7 is added to limit the maximum output current of Q5.

A novel alternative is shown in Figure 2. Q14 is the TIS transistor. In this design the Q14 MOSFET is operating in its Ohmic region and is used as a voltage controlled resistor. Q15 is connected in a common base configuration (also acting as a cascode), providing a fixed voltage at its emitter. Therefore R29 plus the resistance of Q14 drain to source determine the output current of the TIS. R29 limits the maximum current out and in this case the TIS output current is limited to +/-10mA.

Advantages of the new design:

- There is only one active transistor in the forward signal path, Q14 (Q15 plays a passive role), whereas in Figure 1, all three TIS transistors are in the active forward signal path. (It can be argued that Q7 is not in the forward signal path as it is only active in an overdrive situation. However, even in the “normal” operating condition, a small current error term is always injected by this transistor. High end audio seeks to eliminate all error terms no matter how slight their contribution may be.)
- No DC base current error term as is the case of Q6.
- Higher TIS output impedance provided by the Q15 cascode.
- Higher Open Loop Gain.
- Well defined and symmetrical TIS output current.
- A higher control voltage is available at the gate of Q14 which allows the use of larger resistors at the emitters of the input stage current mirror which in turn lowers the input stage noise contribution to the over-all amplifier as well as having a greater balancing effect of the current mirror.

Conclusion:

The overall Total Harmonic Distortion of this novel TIS design is equal to or less than the traditional TIS as described by Figure 1. Considering its overall advantages, I see no reason why this implementation will not be seen more in future designs.