

THE TRANS*NOVA TOPOLOGY

Jim Strickland 4/11/92

Power amplifiers employing the Transnova topology were manufactured from 1982 to 1987 under the Acoustat name. The basic principles involved were granted U.S. patent 4,467,288 in 1984. The new Hafler 9300 and 9500 Trans*nova designs incorporate the best features of the patent and the original design--improved dramatically with a highly refined, low voltage version of the Hafler double-differential front-end pioneered by Erno Borbely and refined by Harry Klaus and Jim Strickland for the XL and SE series.

The most important teaching of the Strickland patent was the possibility of configuring the output stage of a power amplifier so as to allow full voltage gain to coexist with 100% local negative feedback--as present in a unity-gain voltage-follower output. At first, this utopian situation seems impossible. Thus we will proceed with a slight tutorial showing how this happens.

Figure 1 shows how a follower stage is connected. Let us observe just why and how this connection is said to have 100% local negative feedback. When any change in input to the gates causes the joined sources to "follow" the input, the output signal is subtracted 100% from the input to form the effective input seen by the devices. The "legendary" low output impedance and reduced distortion for this connection result from this operation.

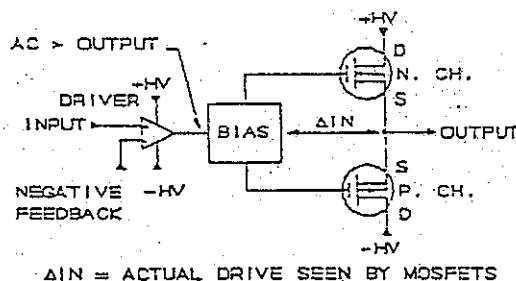


FIGURE ONE: FOLLOWER

To understand the generation of low output impedance, imagine that with the gates held immobile, a signal coming back from the load tries to change the potential at the output terminal. If a one volt change were forced on the joined sources, it would have the same effect on output current as if the gates had been moved one volt (in the opposite direction). If the MOSFETS produce one amp/volt (one mho or one Siemens, of transconductance), we would then say a one ohm output impedance exists, since a one ohm resistor would also produce one amp per volt.

The problem here is that we have obtained this "load control" at the very high price of having to give up all voltage gain in the output stage. It will be shown later that we have indeed given up much more than this.

Figure 2 shows the basic connections of the Trans*nova output configuration--without drive connected. The purpose of this part of the tutorial is to show that the 100% local negative feedback is still present in this revised connection. Consider again a voltage coming back from the load, imposing a one volt change on the output terminal, now the "connected" drains (via the power supply system). This one volt change passes back through the parallel RC network virtually 100% onto the MOSFET gates, owing to their extremely high input impedance. Thus again we see a one volt (output) change yield a one amp current, and hence generate a one-ohm output impedance.

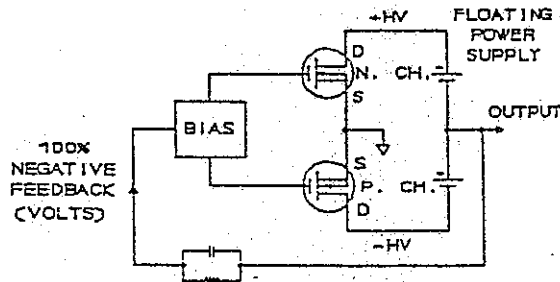


FIGURE TWO:
TRANNOVA FEEDBACK MODEL

Thus we see that both connections have effectively 100% local negative feedback. However, we must now show how to drive the Trans*nova circuit, or all we have created so far is an expensive resistor. The magic and the invention of Trans*nova is exactly here, as shown in Figure 3. To let the 100% feedback return from output to gates in this circuit, we must drive the gates from a special type of electronic configuration which produces output currents which are highly "blind" to the voltage at the circuit point into which the current is delivered.

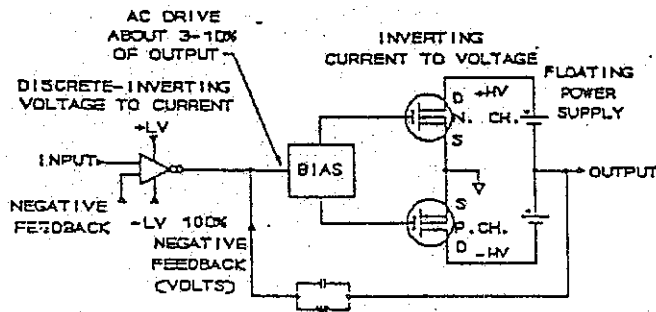


FIGURE THREE:
TRANNOVA SYSTEM

Fortunately this behavior is virtually exactly what most bipolar and FET devices do--i.e. operate as "pentodes", as if they had a screen grid between input and output. The driver stage of Trans*nova is thus a highly refined bilateral current source--a transconductance stage--driving the MOSFET gates directly. So now the 100% local negative feedback is still present, because any voltage change coming back from the load side of things is not reduced. However, the important thing is that it now takes exactly the same gate voltage swing to drive the MOSFETS it would have, had the feedback RC network never been added.

Lest it appear we have fooled Mother Nature here, let it be clarified that what we have done is only find a better realization of Her rules. In fact there is a "payback" here--we must supply higher signal current to the gate "node" than we would have had to without the RC (shunt) feedback. We will soon see this is actually an advantage.

Quo vadis?

Indeed, where are we going? What have we achieved by retaining the full voltage gain of the output stage? Firstly, the output-stage gain now allows us to employ a low-voltage front-end/driver design, running on +/- 24 volts. The ramifications of this change go far beyond obvious initial expectations. By preserving the voltage gain of the output stage, we have radically improved its power gain for a given bandwidth, since power = voltage X current. Thus significantly less driver power is needed for a given bandwidth. We can take advantage of this high transfer efficiency by adjusting the low voltage front-end for much higher Class A operating current than typical high voltage designs can feasibly use. Such higher-current drivers are inherently fast, and can be made extremely so by the vehicle of cascoding--to radically reduce Miller-capacitance effects.

THE RESULTING AMPLIFIER

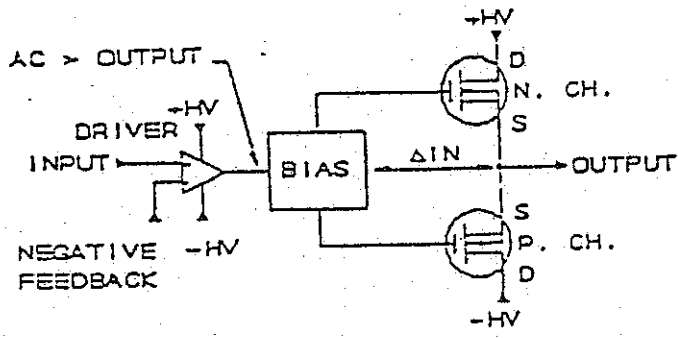
The synergies above result in an amplifier having only three stages, in lieu of typically five. High slew rates and bandwidth are inherent, with outstanding high-frequency stability, for a given level of distortion. The shorter loop is capable of superior sonic performance. The low-voltage front end is also far safer--being almost never found at the scene of PC board fires.

Another inherent advantage of designs which utilize gain-type output stages is their reaction to capacitive loading. Follower designs react to capacitive loading by increasing the capacitance seen by the driver stage. Gain-type output stages react the opposite way, accommodately reducing their input capacitance, when exposed to more output-load capacitance.

This occurs because significant capacitive loading reduces the open-loop gain of the output stage, resulting in a simultaneous reduction of both the magnitude and leading-phase character of the Miller-capacitance feedback back through, or around, the stage. Gain-type outputs are inherently more tolerant of capacitive loading, and are thus particularly suited to sonically clean, chokeless designs.

IN CONCLUSION

Trans*nova amplifiers are better power amplifiers because they use less stages and devices in the signal path by utilizing innovative connections which extract the maximum out of each and every high performance component. This kind of simplicity is always good--our common sense, our instruments and our ears tell us it is right.



$\Delta IN = \text{ACTUAL DRIVE SEEN BY MOSFETS}$
 FIGURE ONE: FOLLOWER

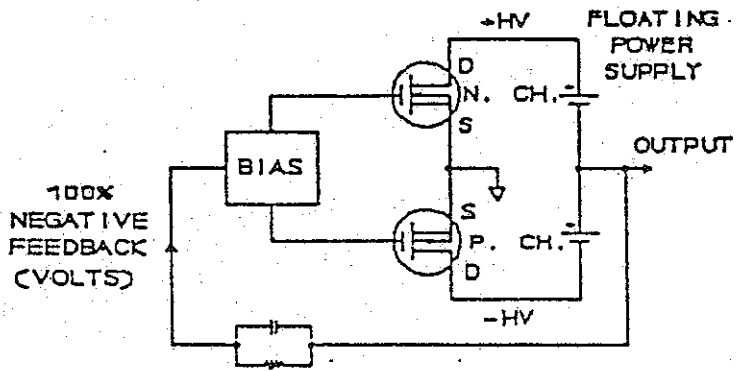


FIGURE TWO:
 TRANSNOVA FEEDBACK MODEL

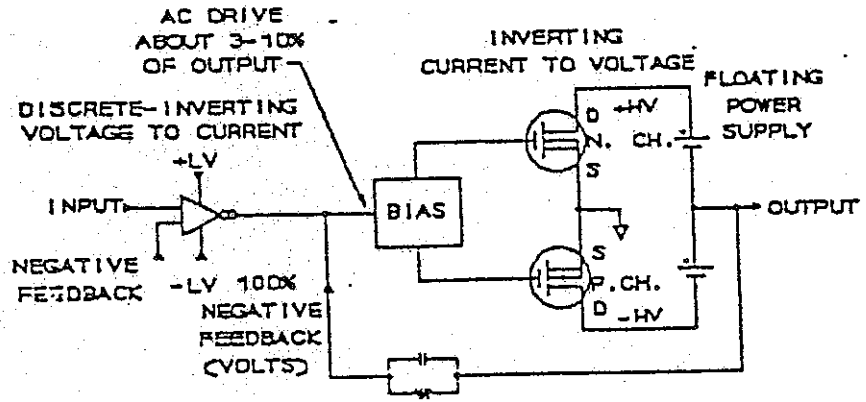


FIGURE THREE:
 TRANSNOVA SYSTEM