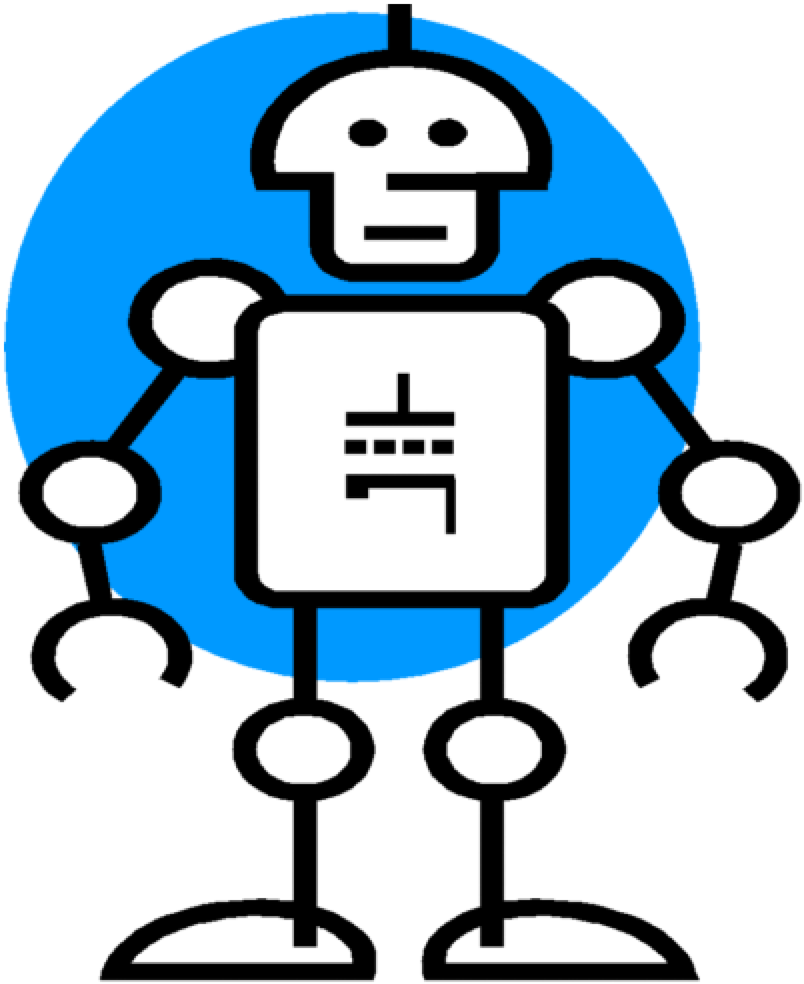
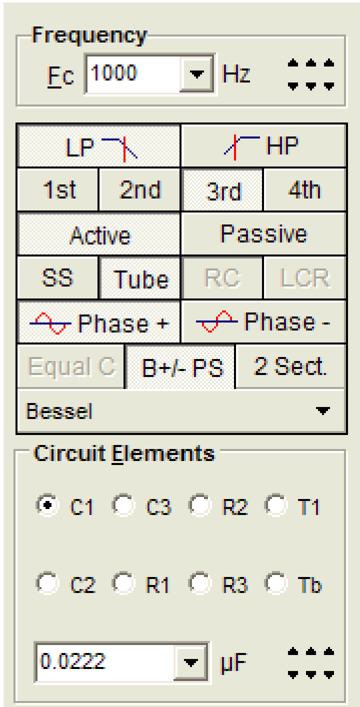
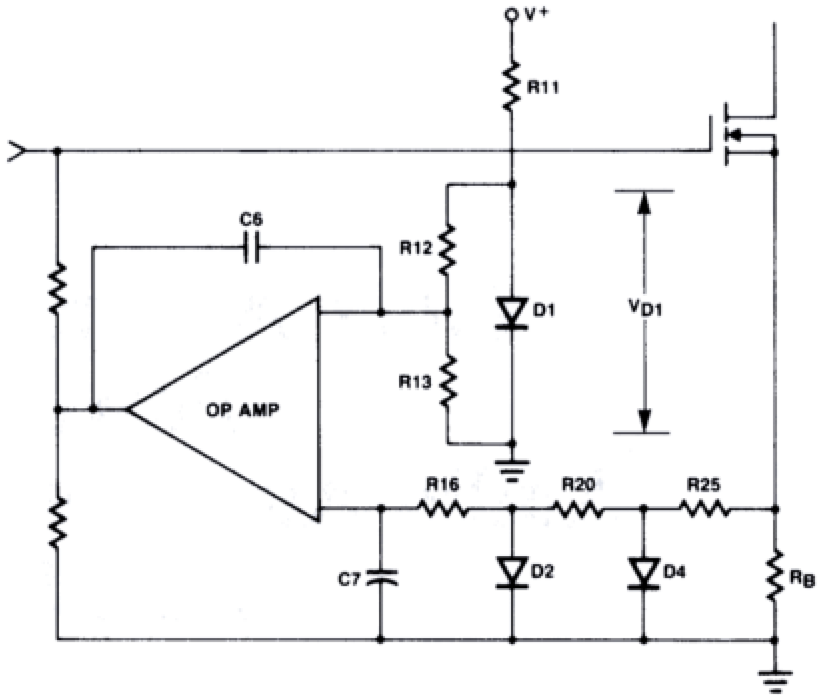
17 April 2005





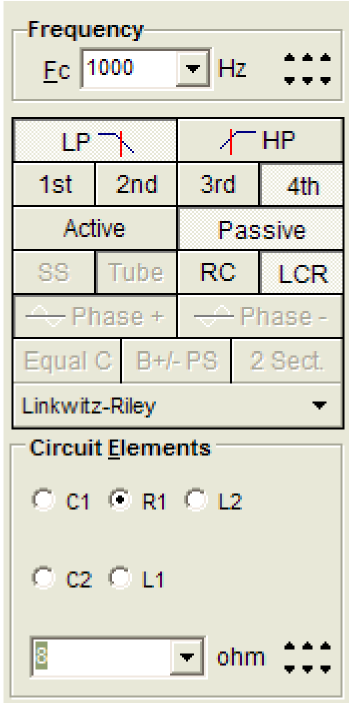
Class-AB auto-bias circuits

If the usual DC servo circuit did not work perfectly with a class-A amplifier, what hope do we have for an auto-bias circuit for class-AB amplifiers? A few techniques have been tried. At the complex end, we could build a circuit that only sampled the bias current when no signal was present or a circuit that ignored error signals beyond the class-A mode of operation. This approach would work best with a small CPU-based circuit that would monitor the current at startup, while the input was shorted to ground, and then would lock the bias via digital potentiometer until the amplifier was turned off. Of course, some amplifiers never are turned off and idle current can drift over a relatively short amount of time. The alternative, throwing away correction signals that occur beyond class-A is much simpler to implement, as it only requires a few extra diodes.



Op-Amp Bias Control for Class AB
Figure 2

The above circuit appeared in Siliconix's MOSPOWER Applications Handbook, 1984; and originally appeared in a paper in the June 1982 IREE (ICCE). If the circuit does not make any sense to you, you are not alone. The first time I saw the circuit, I felt that it was time to tear up my big-brain club card, as I could not see how this circuit could work. If the top input on the OpAmp is the inverting, then the OpAmp amplifies positive-going errors in bias positively! Watch out; amplifier on fire! If the top input on the OpAmp is the non-inverting, then the OpAmp applies positive feedback to the non-inverting input, which must also spell D-A-N-G-E-R. The circuit that should have appeared is shown below. The transistor at the OpAmp's output inverts the OpAmp's output, making the whole circuit work, as the OpAmp's non-inverting input effective becomes the servo's inverting input.

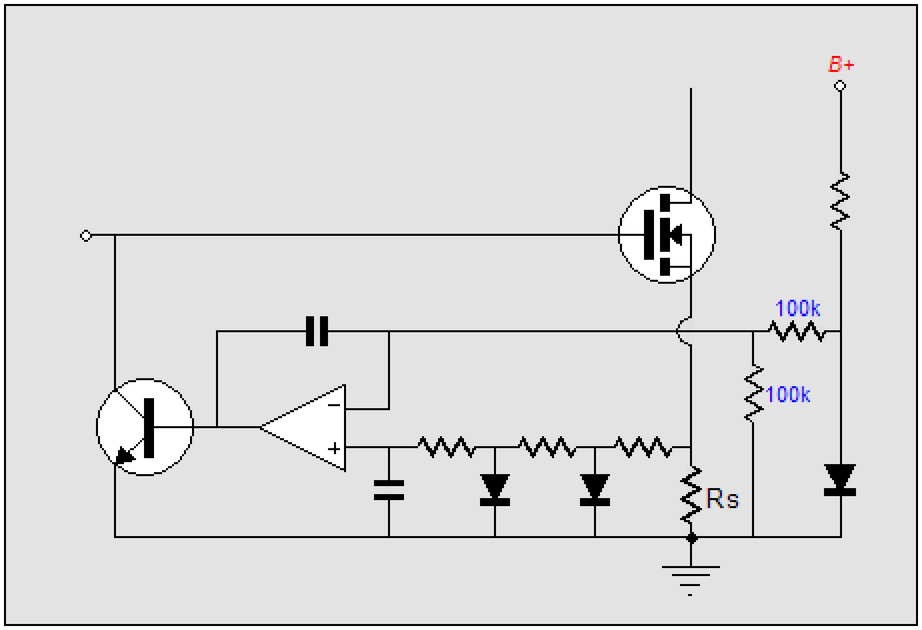


The Tube CAD Journal's first companion program, TCJ Filter Design lets you design a filter or crossover (passive, solid-state or tube) without having to check out thick textbooks from the library and without having to breakout the scientific calculator. This program's goal is to provide a quick and easy display not only of the frequency response, but also of the resistor and capacitor values for a passive and active filters and crossovers.

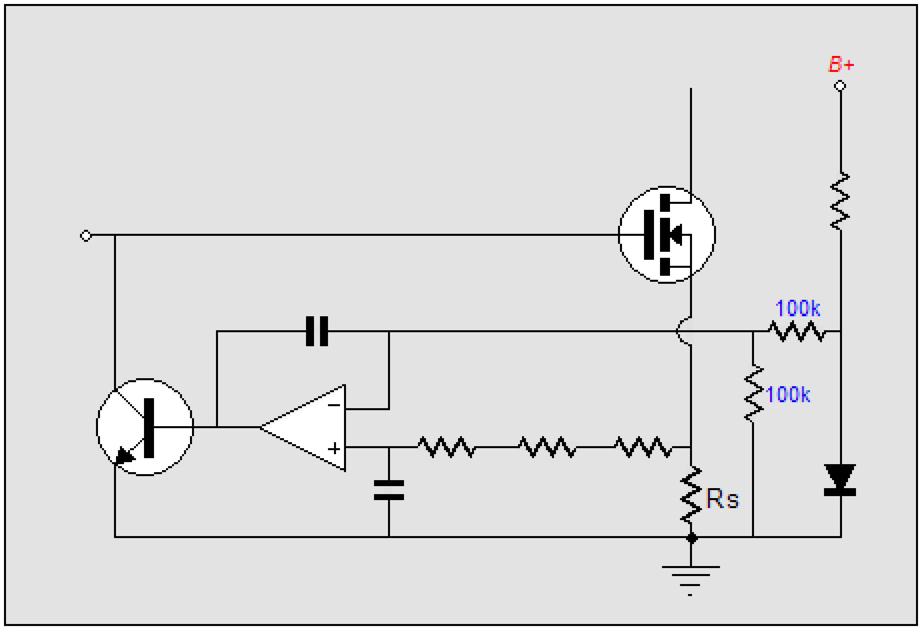
TCJ Filter Design is easy to use, but not lightweight, holding **over 60 different filter topologies** and up to four filter alignments:

Bessel,
Butterworth,
Gaussian,
and Linkwitz-Riley.

While the program's main concern is active filters, solid-state and tube, it also does passive filters. In fact, it can be used to calculate passive crossovers for use with speakers by entering 8 ohms as the terminating resistance. Tube crossovers are a major part of this program; both buffered and un-buffered tube based

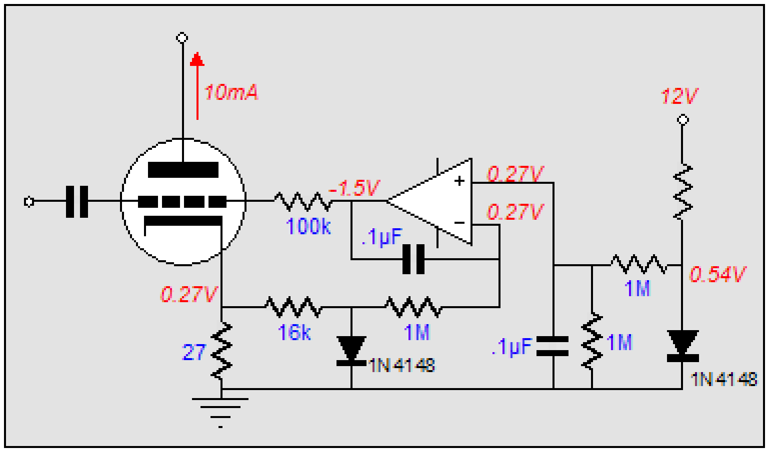


How does it work? The voltage reference is derived from halving the voltage drop across the diode at the extreme right. Since class-A operation ends when the output stage current exceeds twice the idle current, we need to bisect the clipping voltage produced by the shunting diodes. The two 100k resistors define a 50% voltage divider that yields exactly half of the clipping voltage. As long as the amplifier is run in class-A, the shunting diodes never become forward biased and, thus, never conduct, effectively falling out of the circuit. Under these conditions, the DC servo strives to maintain an average idle current equal to the reference voltage divided by resistor Rs.



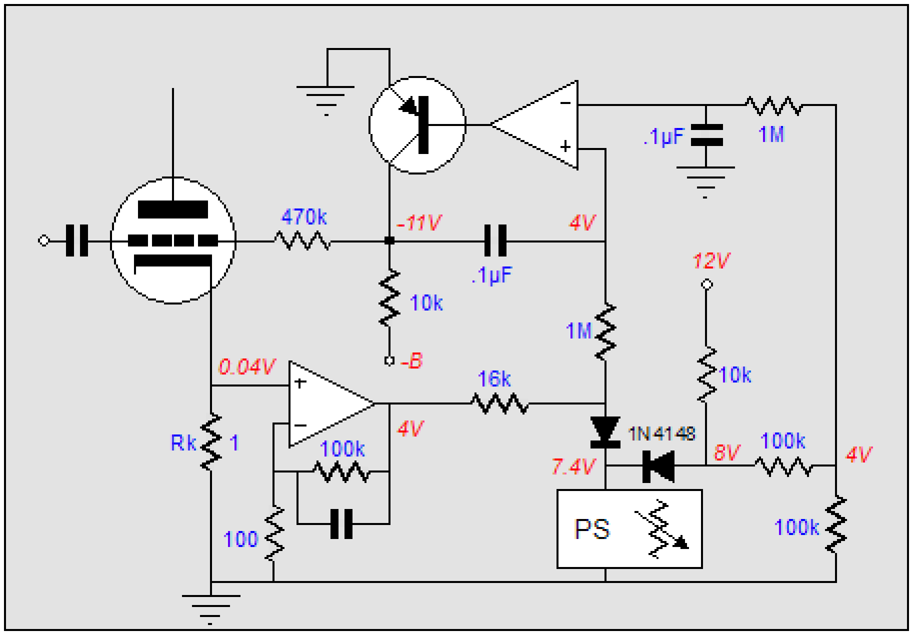
When the amplifier is called upon to produce more than a small fraction of a watt (when it falls out of class-A), the shunting diodes become forward biased and conduct, clipping the maximum voltage that can be presented to the OpAmp's non-inverting input. Since the clipping voltage is twice the reference voltage, won't the capacitor at the OpAmp's non-inverting input become charged to that value? No, it cannot; as the input signal presented to it looks like a square wave with a peak magnitude equal to twice the reference voltage, which averages outs to close to the voltage reference. Interestingly enough, this circuit works best when the amplifier is putting out almost all of its potential power, as at lower signal levels the square wave looks more like half-wave rectified sine waves. So, how well does this circuit work? Not that bad, after some tweaking. The bias voltage does drift during prolonged signal bursts, but with careful selection of the resistors feeding the shunting diodes, the drift can be reduced substantially.

What about tubes? Enough already with MOSFETs. The same circuit can easily be used with triodes, tetrodes, pentodes, FETs, IGBTs, and transistors—after suitable bias arrangements have been made, such as a negative bias voltage for the tubes and FETs. The circuit below works quite well and only uses one shunting diode.



Over ten years ago, Morgan Jones has created an extremely clever class-AB auto-bias circuit specifically for tubes that works on the same principle of clipping the error signal. His circuit uses an OpAmp to amplify the voltage across a 1-ohm cathode resistor by a hundredfold. This magnified signal is then clipped at an adjustable level and fed back into an OpAmp that feeds a grounded-emitter amplifier, which inverts the voltage. Very slick, however, it too experiences bias drift under sustained signal bursts.

(I would do his circuit differently, of course, as I even do my own circuits differently the next time I build them. I would include the PNP grounded-emmiter amplifier in the OpAmp's AC feedback loop, which would simplify the design slightly.)



The future

So far, we have seen that no auto-bias circuit is perfect, with each bringing its own set of problems. Living in pure class-A and driving purely resistive loudspeaker is not practical. What we need is circuit that can adapt to the demands made on the amplifier and still produce a steady bias. Such a circuit exists. But it will have to wait until the next blog entry, as I am way over my typing limit.

//JRB