Zen Variations #9

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Introduction

In ZV8 we dipped our toes into the waters of power JFET transistors using the new Lovoltech LU1014D in a simple circuit. The focus of the project was on the JFET itself, and except for a cascode transistor the rest of the amplifier used only passive components. Here in four installments we will increase the complexity of the circuitry around the JFET with an eye toward distortion performance surpassing any of the Zen projects to date.

Much of this project will make reference to ZV8 (AudioXpress, January 2006 and www.passdiy.com), which discusses the characteristics of the LU1014D power JFET and the circuit that forms the basis for this project. ZV8 also brought up the subject of load-line optimization, which we will exploit here, working the Drain to Source voltage (Vds) curve to reduce distortion.

For your quick reference, the most basic circuit is presented here as Figure 1.

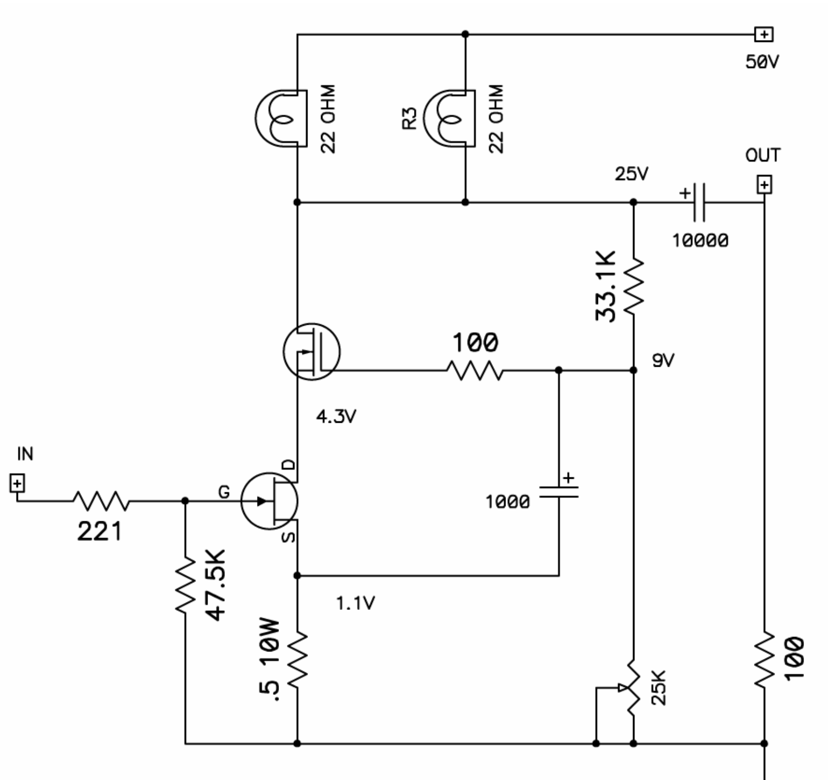

FIG 1 ZV8 WITHOUT FEEDBACK

Installment 1 – Supply Filter and Constant Current Source

We bias ZV8 with a pair of light bulbs, whose resistance offers about 11 ohms and delivers about 2.2 amps to the gain transistor. This has three drawbacks:

1) It is inefficient - the power supply must have about 50% higher voltage than the amplifier's peak output.

2) The light bulb resistances parallel the load, so that an 8 ohm load looks like 4.6 ohms, making the gain device work nearly twice as hard and raising the distortion.

3) It has poor power supply noise rejection – a portion of the noise in the power supply comes through the light bulbs to the output.

First, we will put in an active supply filter to reduce power supply noise and turn-on thump. Then we will replace the light bulbs with a 2 amp constant current source. It will not glow warmly on cold winter evenings, but it will draw less current, deliver about 50% more power, and has lower distortion and noise.

Figure 2 shows the replacement of the two light bulbs with the supply filter and the constant current source. Q4 is set up as a capacitance multiplier whose C3 and R8 time constant is set to 5 seconds. At this charge rate, the circuit will see minimal supply ripple and have a low turn-on transient. The supply voltage appearing on the Drain of Q3 enjoys some additional passive filtering from C2 and C6. Q4 drops about 4 volts off the supply, so that a 50V unregulated rail delivers about 46 volts at the Drain of Q3 (*Voltages in all schematics are approximate)*. We could DC stabilize the supply with zener diodes across C3, but that would make it more difficult to have such a slow turn-on, so we will use the constant current source to DC stabilize the bias current.

The constant current source is formed by N channel Mosfet Q3 controlled by NPN transistor Q5. We make use of the physical constant of the PN junction of the Base-Emitter voltage of Q5 for a reference, and the circuit works to maintain about .66 volts across the resistors R4 through R6, which makes for a constant current of 2 amps. R10 through R13 are there to provide a relatively constant bias current for the Collector of Q5, with C4 bootstrapping from the output.

There are few other changes to the circuit of Figure 1, but you will note the addition of an *audiophile-approved* bypass capacitor on the output, and variability in the value of R3. Later we will see that that this value can be used to optimize the performance around the characteristics of individual JFETs.

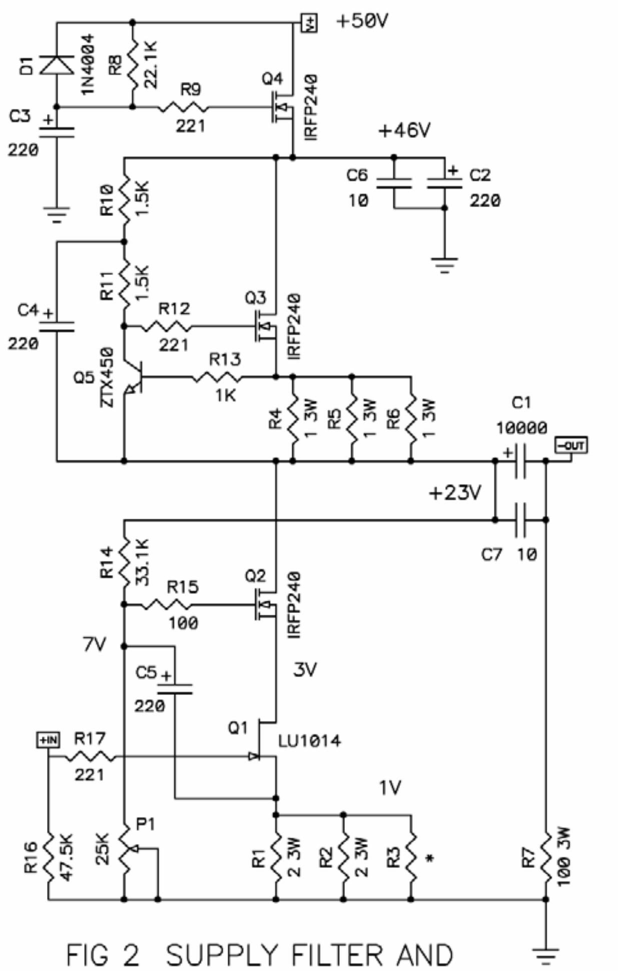

FIG 2 SUPPLY FILTER AND
CONSTANT CURRENT SOURCE

In Figure 2 we trim the value of P1 for a Drain voltage of one-half the supply voltage by adjusting the Vds of the JFET – if the voltage on the Drain of Q3 is 46 volts, then we want about 23 volts on the Drain of Q2. With the appropriate value for R3 (approximately 2 ohms) we will see minimum distortion and a Vds across the JFET Q1 of 2 to 3 volts. This comes out to about 4 to 6 watts dissipation for the device.

This particular circuit is a transconductance amplifier, that is to say a current source whose output impedance is mostly determined by the 100 ohm output resistor R7. To lower the output impedance we will later apply some negative feedback.

Figure 3 shows the comparative performance of the circuits of Figure 1 and 2, and we see an immediate distortion reduction by about half. What is less clear is that the light bulb version is clipping at about 10% distortion at 10 watts, while the current source circuit clips comparably at about 20 watts.