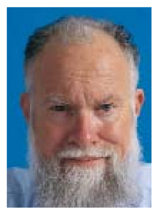
pease porridge



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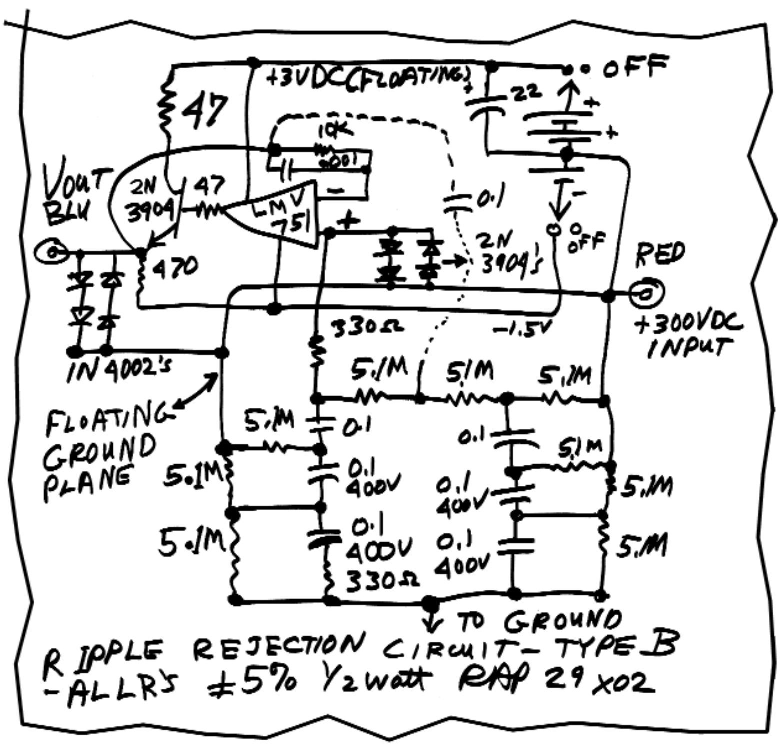
What's All This Ripple Rejection Stuff, Anyhow? (Part 3)

Okay, I wish I could tell you guys that I have improved the old R-300's noise down to 1 µV rms, on top of its 300-V dc output. I tried. I applied both the Type A servo amplifier from last month (ELECTRONIC DESIGN, *Nov. 11, p. 84)* and the new Sallen-Key filter, Type B, shown in the adjacent figure. It's battery powered, and the LMV751 runs well on three AA cells. (If you want long and cheap battery life, use C or D cells instead.) I also used the level-shifter, and the pre-amp and NoiseMaker shown at *www.national.com/rap/ripplerej.html*.



Actually, I was able to work the noise down from 75 to about 9 µV rms, using each of the Type A and B circuits. I tried to get it lower, but the spatial orientation of the magnetic flux in the neighborhood would have made it very hard to get anything below 9 µV. I'll never say never, but it's not easy. Magnetic fields are nasty and hard to shield or screen out. Layout is critical and not easy. Maybe I'll just put longer wires on the pre-amps and move them far from the R-300, the transformers of all the power supplies, and the voltmeter. Might work!

Further: Look at the careful filter structure of the schematic diagram of the figure, Type B. There should not be much 1/f noise. But I had plenty of jitter, wobble, and 1/f noise—much more than I expected. There was maybe 10 to 20 µV of jitter. I considered the layout and the characteristics of the mylar capacitors (400-V capacitors running on less than 150 V dc), yet I couldn't find much of a clue as to what was causing the noise.

Then I thought about the resistors. Can an AB 1/2-W, 5.1-MΩ resistor running at 150 V generate enough 1/f noise—current noise—to make a poor reading? Maybe so. I will study this later, just not this week. There are some trick tests that I'll want to run.... Hey, I never looked this closely before!

I did get some good data on the ac ripple-rejection, using my NoiseMaker (schematic is on my Web site) to try to cut the ripple of an 85-mV p-p (26-mV rms) noise at a 26-kHz nominal switching frequency, with lots of harmonics at 52 and 78 kHz. Although the Type A circuit improved the 26 mV to 0.88 mV, Type B did a bit better at 0.83 mV. But that was NOT unexpected. So it's not too hard to get a 30-dB noise improvement by employing a cheap, low-noise op amp, such as LMV751.

Both schemes worked pretty well. But Type A didn't like to tolerate a lot of capacitive load from the op-amp's output to ground—that is, the capacitance from the power-supply *low* terminal to ground. It was able to drive the R-300's capacitance. But adding a coax cable over to the voltmeter made it grouchy at 4 MHz. So I just had to bring the voltmeter (HP3400A) over by the amplifier.

Yet Type B would surely be grouchy if there was a lot of capacitance from $+V_{OUT}$ to ground. So any fast, nimble, low-noise amplifier may get grouchy about capacitive loads. In some cases, a series R-C damper can help. There are no easy answers. If I got a "hotter" op amp with a lot more than 4 MHz of GBW product, that would certainly help; and some 26- to 52-kHz noise can be filtered with extra L and C. So this analysis is encouraging.

In all of these studies, I never got a shock, never caused a BANG, and never blew up any components or op amps (except when my thumb absent-mindedly nudged a ±2-V supply up to ±12 V). So I don't feel bad, figuratively and literally.

All for now. / Comments invited!
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