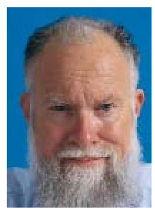


BOB PEASE *obtained a BSEE from MIT in 1961 and is Staff Scientist at National Semiconductor Corp., Santa Clara, Calif.*

What's All This Ripple Rejection Stuff, Anyhow? (Part 2)

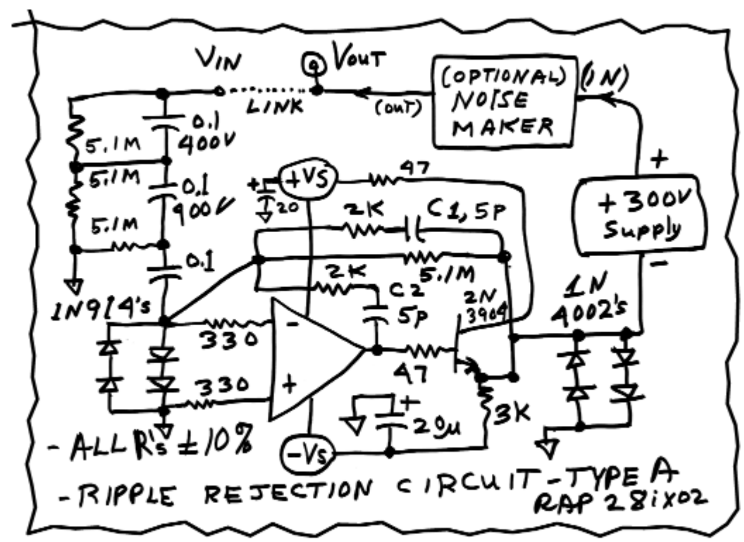
As I said a few months ago (ELECTRONIC DESIGN, *Feb. 4, p. 70*), the study of ripple rejection will continue. Some guys asked me, "How can I convert a high-ripple voltage supply to a low-ripple one, or to a *very* low-ripple one?" I am reminded of the little girl who pondered over the Sunday School teacher's question: "What must we do to receive forgiveness of sin?" After some thought, she replied, "First, you have to sin...."

So first we have to make some ripple. Figure C, located on my Web site at *www.national.com/rap/ripplerej.html*, is a floating, battery-powered sawtooth oscillator, which I will call a NoiseMaker. Its task is to add ripple on top of the output of a quiet high-voltage supply and make it noisy enough that we can see if our ripple-rejection circuits are working—and exactly how well.

The circuit of Figure D (found on the above Web page) is not much more than an ac-coupling network found in any ac oscilloscope. But it includes safety factors and safety networks to protect the scope. After all, most scopes won't stand 300 V dc on their ac inputs. The coupling capacitors aren't rated for that. It also helps to define the bandwidth.

The circuit of Figure E (same Web page) is an ordinary ac pre-amp, because the supply we studied in February had just 100 µV ac rms of noise. But when we get through, the noise will be so low that we'll need a pre-amp to evaluate it.

Now, how does the circuit of the figure on this page (Ripple Rejection Type A) work? Every op amp, if fed a noisy feedback path, can be made to try to amplify a counter-error signal to cancel out that noise. Even if the NoiseMaker produces 0.25 V rms of noise, the error voltage at the input of the op amp need not be more than a millivolt. That's enough to make the output move to cancel out that noise, as seen at its input.



This circuit's limitation is the op amp's gain-bandwidth product. So the amplifier must have a lot of GBW product, but its CMRR or PSRR are not very important. I think I'll try an LF411, with good bandwidth, or an LMV751, with 7 $nV/\sqrt{Hz}$ and low I_B. If we can keep the op amp's gain above 100 at 10 kHz, we can get a 100:1 improvement at that frequency, and even more at lower frequencies. Could we use a bipolar op amp with lower V_N and worse I_N? Not impossible, but unlikely. Hey, I'll try anything—once....

NOTE: In every application, the best choice of amplifier, and the best way to optimize the noise, depends on the impedances and on the specified bandwidth for which low noise is required. When things start changing, the optimization changes a lot. The rules for this example are: For a 3-dB bandwidth of 20 Hz to 10 kHz, get the lowest noise possible with the NoiseMaker specified—95 mV p-p at 26 kHz, plus the 100-µV rms broadband noise of the basic Philbrick R-300.

What are the results? What's the best noise, with the best amplifiers? I didn't get this optimized before the deadline for this column. Further, I want to try out a special version of the Sallen-Key filter. We'll call that Ripple Rejection Circuit Type B.

I'll have the results by next month. Then we'll see which circuit is good, which is better, and which performance is best, with what amplifier, to reject the noise of the NoiseMaker. We'll find out which circuit gives the lowest noise with the NoiseMaker turned off. Have you ever seen a 300-V power supply that had less than 1 µV rms of noise? See you in a month!

All for now. / Comments invited!

RAP / Robert A. Pease / Engineer
rap@galaxy.nsc.com—or:

Mail Stop D2597A
National Semiconductor
P.O. Box 58090
Santa Clara, CA 95052-8090

P.S. When I built this circuit, I carefully put a 330-Ω resistor in the input path, in series with each of the 400-V, 0.1-µF mylar caps. But I neglected to draw them into the published schematic. Please add those in. Otherwise, the high charge during turn-on would fry the 1N914s! /rap