DESIGNER'S NOTEBOOK

Precision rectifiers

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WHEN YOU TALK ABOUT RECTIFIERS, THE first thing that comes to mind is power supplies, but rectifiers are also used in many other circuits. Converting AC to DC is necessary in many RF circuits, and most circuits that measure real-world quantities first have to rectify sensor voltages. But even though regular diodes and bridges are adequate for many rectifying jobs, sometimes a different approach is needed.

The rectifying circuit you build for a power supply will work perfectly well when you're eliminating batteries, but it will be completely useless for RF. The reason is simply that the input voltage is less than the voltage needed to turn a diode on. Even small-signal germanium diodes require about 0.3 volts to turn on. That may not seem like much, but, if you are working with signals in the millivolt range, you'll have to find another way to handle the problem.

Circuit designers have two standard methods of dealing with the situation. They can amplify the AC signal and then rectify it, or they can do both at once with a precision rectifier. All things considered, the latter method is a much better way to get the job done.

The one-step approach to building a precision rectifier requires some way of isolating the positive and negative halves of the incoming AC, but after that AC has been amplified to a usable level. The circuit shown in Fig. 1 is a straightforward way of combining both amplification and rectification.

I designed the circuit with a 741 op-amp since it is cheap and readily available. If the performance specs of the 741 aren't to your liking, you can just as easily substitute any other op-amp. Higher input impedance, lower offset voltage, frequency limit, and slew rate are among the factors you should consider when choosing an op-amp. Examine the requirements of your application and choose an appropriate device.

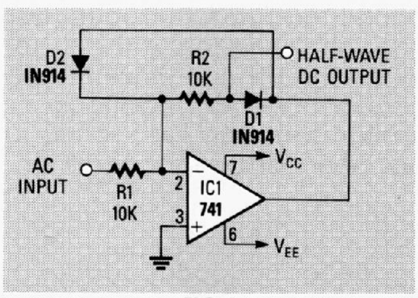

FIG. 1

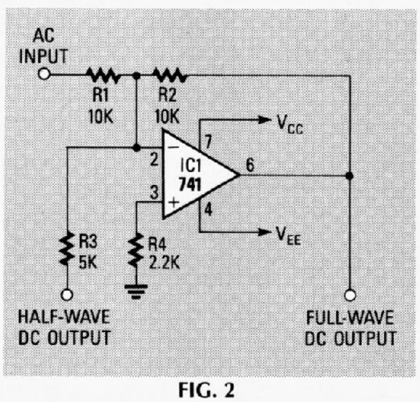

FIG. 2

How it works

The circuit's theory of operation is similar to that of a diodes-only rectifier. During the negative half of the AC cycle the output of the 741 forward biases D2 and current flows only through that diode. During the positive half of the input swing, however, D1 is forward-biased, so current will flow through it and through R2. Therefore, DC will only show up across R2 during the positive part of the incoming AC cycle.

Because we're rectifying the voltage in the feedback loop of the op-amp and not at its input, the circuit will be able to handle very small AC signals. The inherent high gain of the op-amp allows us to rectify signals that are substantially below the voltage needed to forward-bias even small-signal germanium diodes.

The op-amp shown in Fig. 1 is set up as an inverting amplifier, so the output waveform will be 180° out of phase with the input. You could switch inputs on the op amp to turn it into a non-inverting amplifier, but the phase difference comes in handy if you want to build a precision full-wave rectifier.

A simple summing amplifier can be used to turn our circuit into a precision fullwave rectifier, but a bit of thought has to go into picking the summing resistors. As shown in Fig. 2, we're adding the original AC signal and twice the output of the halfwave rectifier discussed above.

If R1 and R3 (in Fig. 2) had the same resistance, the output of the halfwave rectifier and the negative half of the input AC would be equal in magnitude, but 180° out of phase. In other words, the net result would be a voltage of zero. We can solve that problem by mixing in twice the halfwave voltage.

If you decide to build the full-wave rectifier, it's a good idea to use a 747, which has two 741's in a single IC package. **R-E**