DESIGNER'S NOTEBOOK

A negative-voltage supply

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THE MOST VALUABLE TOOL ANY DESIGNER can have is his personal notebook. It's filled with all the results of his past experience—everything from shortcuts in design, to handy circuits, to easy ways to avoid production problems. The contents of the book all have one thing in common...they're the results of bitter experience and often expensive mistakes. The more experienced the designer, the fatter his notebook. You probably have one of your own even though it may not be as neatly organized as you'd like it to be.

Every month we're going to give you another page that you can add to your own personal notebook. None of the things will be a finished circuit or complete idea. Each of them will, however, be useful in designing larger systems and will save gallons of midnight oil. They'll range from perfectly obvious to wonderfully elegant and they only have to come in handy *once* to make them worth remembering.

I'll cover everthing from breadboarding, to actual circuitry, to production of the finished product. If you know a way to do the same thing that's easier, faster, cheaper, safer, or slicker, drop me a line and let me know about it. Designing something is tricky enough, and one of the first things to learn is to take all the help you can get. And since the point of this page is to share more than instruct, if you have something to say that's worth listening to, I'll turn the page over to you and we'll all learn something.

ONE OF THE MOST ANNOYING SITUATIONS you can run across when you're designing electronic circuits is the need for oddball numbers in the power supply. In the "Drawing Board" columns that appeared in the May through August 1983 issues of **Radio-Electronics**, we spent a lot of time learning how to handle power-supply designs that would take care of just about any contingency you might run across in a circuit design. We found out how to make cheap regulators do expensive things and how to safely get relatively monster amounts of current from tiny, three-terminal regulators. If you check back through the series, you'll see that we even went into what is ordinarily a real bear of a problem—namely, designing a variable supply that could go all the way down to zero-volts output.

There was a hitch, however. You can only get zero volts out if you can provide the circuit with a real negative reference-voltage—and therein lay the rub. It's always frustrating to need a few measly milliamps from a negative supply when all you have to work with is a supply that's giving you a positive voltage. Now, there are all sorts of schemes for generating something that can be used as a negative voltage or arranging for the rest of the circuit to bias itself halfway up the supply rail. All those things will produce a negative-like voltage, but they're a far cry from having a voltage that really lies below ground level.

A better way

Well, for all of you who have run up against that problem, and for anyone who might, here's a handy way to take care of it. The parts count is really low and the components are ones you probably have lying around.

The heart of the circuit shown in Fig. 1 is the 555 timer. For this application, that timer is set up in its astable mode—in other words, it's an oscillator. With the values shown, the frequency will be about 45 kHz and the duty cycle is pretty close to 50%. (We'll have more to say about that later.) Basically, the components that are connected to the output of the 555 are set up as a voltage-doubling rectifier. Diodes D1 and D2 work as steering diodes much the same as they would on any AC/DC converter.

On the positive half of the 555's output swing, D1 is forward biased, D2 is reverse biased, and C1 charges up. When the 555 goes into the negative half of its output cycle, capacitor C1 dumps its stored charge through D1 and charges up C2. Diode D2 prevents C2 from discharging through C1. What we wind up with is a negative voltage at the anode of diode D2 with respect to system ground and that voltage is renewed with every full cycle of the 555's output swing. With no load on the output you will get a negative voltage from the circuit that is just about equal to the supply voltage.

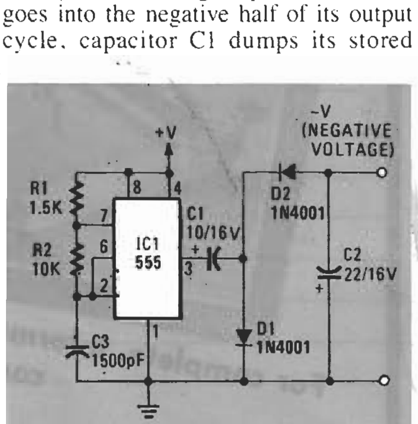

FIG. 1

But that's with no load. In practice, the negative voltage available will be several volts below the supply voltage—exactly how much below will depend on the amount of current you want to draw from the circuit.

The 555 can easily supply 200 milliamps but the most you can safely expect from the negative supply is about 60 milliamps since we're only renewing the charge on C2 during half the output swing of the 555. If you study the schematic closely, you'll see that capacitor C2 is only being used to store the charge originally on C1.

Now you can see why the frequency of the 555 is set fairly high—we have to renew the charge on capacitor C2 fairly often if we want to power anything remotely useful with the circuit. The duty cycle of the 555 has been set close to 50% because we have to allow time for capacitor C1 to discharge.

If you only need a small amount of current from a negative supply for your application—to power something like an op-amp, for instance—you'll find that circuit to be just what the doctor ordered. On the other hand, be aware that if you're looking for really serious amounts of power, that approach won't help and you'll actually need a split supply.

There's no reason why you can't regulate the negative supply by using a series regulator (any of the 79xx series). Since they only use a few milliamps to operate, there won't be any undue load on the circuit—there will be about a 2-volt loss, however.

The next time you design something that has to have a split supply, add up the current you'll need from the negative side and see whether this circuit can supply it. If so, why not give it a try: it's easy to pu together and a lot cheaper than a cente tapped transformer. R-