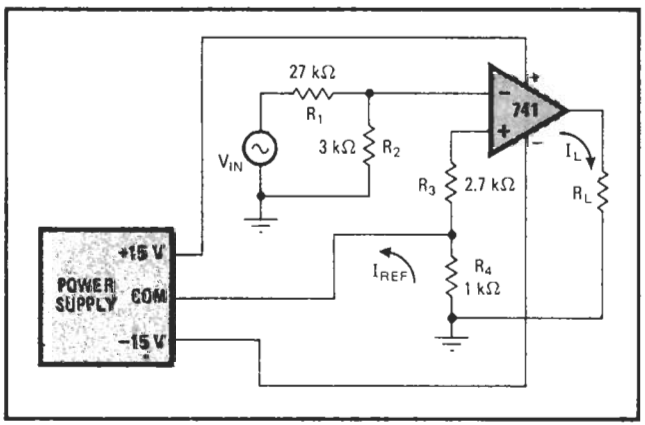
Controllable current source eliminates matched resistors

by James A. Stanko
State Univesity of New York, Stony Brook, N.Y.

A bipolar constant-current source that has a grounded voltage source and a grounded load is usually limited in accuracy and internal impedance by the degree of matching of two or more resistors. For the circuit below, however, no matched resistors are required; linearity and internal impedance are determined solely by the operational amplifier gain, offset, and power supply rejection ratio. This circuit takes advantage of the fact that the op amp's power supply can usually be floated.



Uncritical. Load current produced by this circuit depends on input voltage, not load resistance. Circuit does not require matched resistors for accurate control of current, but power supply must float.

To understand the operation of the circuit, remember that no current to speak of flows into the input terminals of the op amp under feedback conditions, and no voltage difference exists across the terminals. Thus, the op amp drives the common terminal of the power supply to the voltage level established at the inverting input. This voltage appears across the reference resistor R_4. It is set to a suitably low value by input attenuator R_1 and R_2 to avoid thermally induced errors caused by power dissipated in the reference resistor. The values of R_1 and R_2 are chosen to provide a convenient scale factor. The reference current thus established is exactly equal to the current flowing in the load, and therefore the load current is

$$I_L = -I_{ref} = -\frac{V_{in}}{R_4}\frac{R_2}{R_1 + R_2}$$

The value of load current does not depend upon the value of load resistance and can be controlled by the value of V_{in}.

The minus sign in the expression for load current indicates the degenerative feedback action of the circuit. If I_L increases, the extra voltage drop through R_4 drives the noninverting input of the op amp lower and thus decreases the output.

Resistor R_3 is made equal to the parallel combination of R_1 and R_2 to minimize any error caused by input bias current. For the values shown in the figure, input voltages up to ±10 volts produce current outputs up to ±10 milliamperes.

This circuit has been used for over a year to supply current to electromagnets. In this application it is boosted by an emitter follower for greater output current and more voltage compliance. □