Regulating supply voltage all the way down to zero

by Brother Thomas McGahee
Don Bosco Technical School, Boston, Mass.

Precision monolithic voltage regulators make it fairly easy to design a high-performance power supply with a minimum of external components. These regulators have one general fault, however—they cannot regulate to any voltage lower than their reference, which is usually about 7 V. Sometimes, a voltage divider can be used to reduce the reference voltage, but if the reference voltage is reduced below approximately 2 V, good regulation can no longer be maintained.

The circuit shown in the figure, on the other hand, allows the reference voltage to be adjusted all the way down to the offset voltage of the regulator's internal op amp. REGULATOR$_1$ and its associated circuitry form a bias supply that provides a voltage of about −7 V for the V$^-$ terminal of the main regulator (REGULATOR$_2$). Since the noninverting input of this regulator is connected to the common ground of the circuit, its reference voltage appears to be +7 V with respect to this V$^-$terminal.

There will be a 7-V drop across resistors R_2 and R_3. When R_1 is set to its minimum value, the circuit's output voltage will be equal to the reference voltage. If the output is measured with respect to the V$^-$ terminal of REGULATOR$_2$, it will be 7 V. But if it is measured with respect to the common ground, it will be zero.

The maximum voltage available at the output is determined by the value of resistor R_2. For the component values shown here, the maximum voltage may be set anywhere from 16 to 39 V. But voltages above 30 V will not be regulated very well because the supply is using a 24-V transformer (T_2).

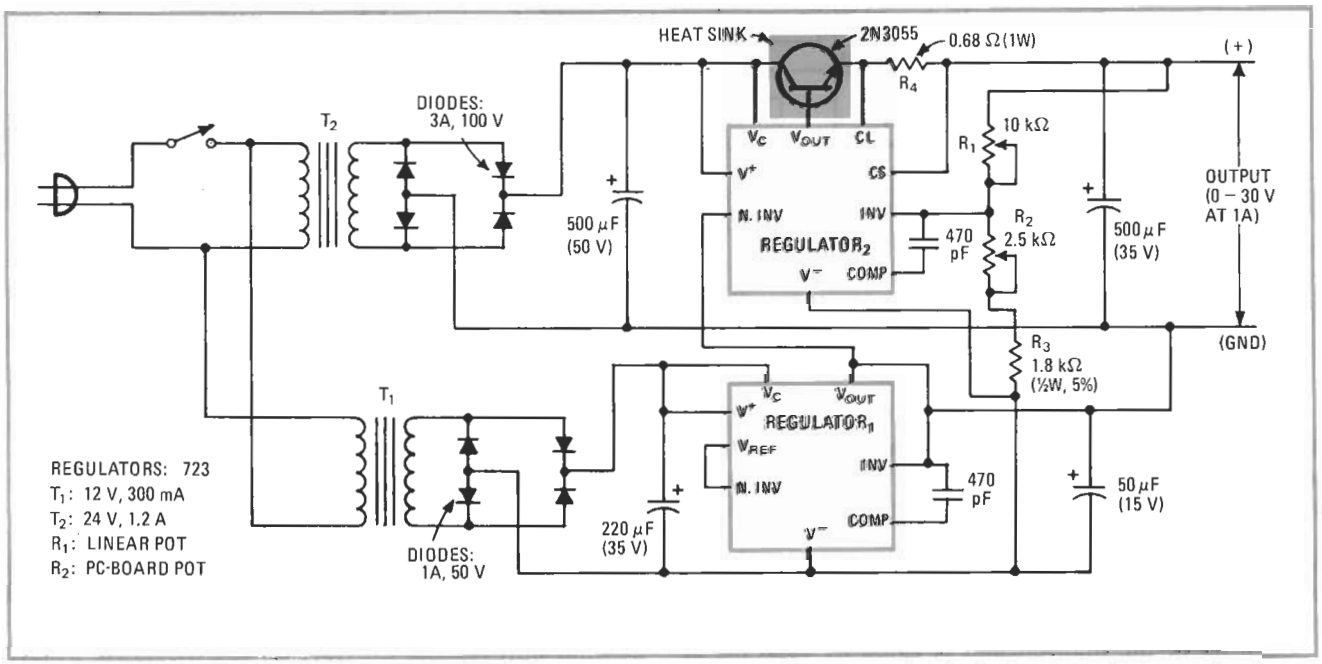
The equation for the output voltage is:

$$V_{OUT} = R_1 V_B/(R_2+R_3)$$

where V_B is the absolute value of the bias voltage (7 V in this case). The bias supply normally will be producing about 12 milliamperes of current. Under worst-case conditions, however, it may be required to provide a maximum of 40 mA. Transformer T_1, therefore, should be a 12-V unit capable of supplying at least 50 mA (since REGULATOR$_1$ will require some current itself).

The transistor at the output of REGULATOR$_2$ boosts the circuit's output current. Resistor R_4 acts as the current-limiting resistor. □

Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.



Variable supply. This power supply, which employs two IC voltage regulators, produces a regulated output voltage of between 0 and 30 V. REGULATOR$_1$ provides the bias voltage for REGULATOR$_2$ so that the latter device can operate with respect to a common ground. The lowest regulated output voltage, then, is approximately zero, rather than the reference voltage of REGULATOR$_2$.