Micropower regulator has low dropout voltage

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Designed specifically to regulate the output of lithium batteries, which have a low terminal voltage at low temperatures, this circuit provides a stable 5.0 volts at 10 milliamperes for an input voltage as low as 5.2 V.

The low dropout voltage of the regulator (5.2 − 5.0 = 0.2 V) is attained in part by operating the circuit's output transistor in the common-emitter mode. As a result, its collector-to-emitter voltage drop is much lower than the base-to-emitter drop of transistors operated as emitter followers in standard regulators. And, because it uses a low-power operational amplifier operating from a single supply, and a low-current, low-voltage zener diode for the voltage reference, the regulator's idle current is only 250 microamperes.

Three lithium batteries drive the regulator shown in the figure. Their terminal voltage is usually 3 V per cell at room temperature, but it will drop to 2 V at −40°C.

Z_1 provides a low-voltage reference (1.22 V) to the noninverting input of the LM224 op amp, A_1. The Intersil ICL 8069CMQ zener has been selected because it requires only 50 μA of bias current and has a temperature coefficient of better than 50 parts per million/°C.

The 1.22-V reference is compared to the output voltage from a divider network (R_1,R_2, P_1), which is used to trim the output voltage to the desired value. Any voltage difference appearing at the output of A_1 drives transistor Q_1, and thus determines the drive current to Q_2. As a result, Q_2 conducts more heavily if the output voltage is low, or limits the application of battery voltage to the load if the output voltage is high.

There will be no observable change of output voltage for an input voltage variation between 5.2 and 10 V, over the temperature range of −40°C to +70°C. □

Dropout minimum. Voltage regulator for lithium batteries maintains 5-volt output for a minimum input voltage of 5.2 V. Output voltage is constant over the temperature range −40°C to +70°C. Using a low-power op amp operating from a single-ended supply, and a low-current zener, the circuit holds the idle current to 250 μA, well below the 2 to 10 mA required by standard regulators.