Low-battery monitor delays system shutdown

The circuit of **Figure 1** gives an early warning of declining battery voltage. Then, to allow a controlling processor time for emergency housekeeping chores such as the storage of register data, the circuit delays system shutdown by a specified time interval (rather than waiting for battery voltage to decline further, to a specified lower level). Circuit components are chosen for low quiescent current, which protects discharged cells by minimizing the battery drain during shutdown: IC1 draws 1µA, IC2 draws 3µA, and R1/R2 draw 3µA, for a total shutdown current of about 7µA.

Also vital to the application is the tight tolerance (±1%) on IC2's comparator threshold, which allows precise monitoring of the NiCd battery's flat discharge characteristic. Positioning the low-battery warning right at the knee of this discharge curve enables a maximum extension of battery life.

IC1 is a low-dropout linear regulator that supplies 250mA of output current and drops only 350mV at 200mA. IC2 is a combination dual comparator and ±1%-accurate voltage reference. When V_{BATT} falls below the threshold set by R1 and R2, OUTB (pin 8 of IC2) goes high. This high level serves as a low-battery warning while charging C1 through R3. When the INA voltage at pin 3 reaches the internal reference level (1.182V ±1%), OUTA (pin 1) issues the shutdown command to IC1.

As an example, set the voltage threshold to 0.9V per cell for a 6-cell stack (5.4V). Then, 5.4V[R2 / (R1 + R2)] = 1.182V. Let R1 = 1MΩ; R2 then equals 280kΩ. Use 287kΩ. You can add ±25mV of hysteresis to this threshold by setting R4 = 49.9kΩ and R5 = 2.4MΩ, as explained in the MAX923 data sheet.

Assume 1MΩ for R3, then calculate C3 using the following equation:

$$V_{TH} = V_{OUTB}(1 - e^{-t/\tau})$$

where V_{TH} is the threshold voltage, V_{OUTB} is the output of the internal comparator (assume 4.9V), and τ = R3C1. Solving this equation for a one-second delay (t = 1) yields τ = 3.6sec. Therefore, C1 = 3.6µF.

As an alternative, you can choose a standard value for C1 such as 3.9µF, which also yields a delay time of about one second. A good low-leakage capacitor for this application is the surface-mount Novacap (p/n 1825Z395K250 for 3.9µF). Note that C1 must be fully discharged for the circuit to provide the full delay. C1 becomes charged while the system is in shutdown, and then requires about 6 seconds to discharge completely.

(Circle 6)

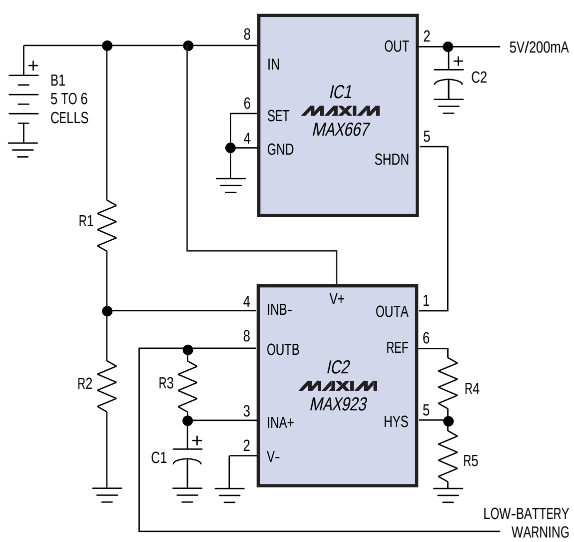

Figure 1. This 12V regulator issues a warning when the battery voltage is low, and shuts itself down approximately one second later. The shutdown current is about 7µA.