Simple circuit safely deep-discharges NiCd battery

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NiCd batteries possess an undesirable "memory" effect caused by partial discharges. The remedy is to do a complete discharge before charging again. Figure 1 shows a simple circuit which performs this feat.

Although relatively straightforward in concept, the circuit has three redeeming features: 1) It is powered by the battery being discharged. 2) After the battery is fully discharged current drain is only about 4 uA, usually well below the self-discharge of a battery alone. 3) Near end-of-charge the LED flashes.

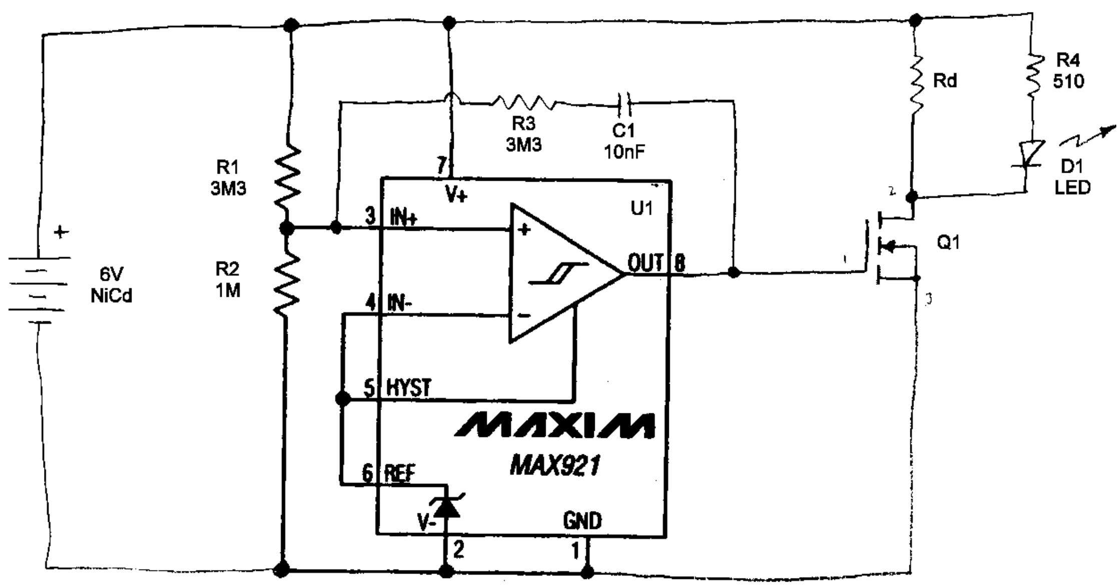

Figure 1. Schematic of battery discharge circuit.

The circuit discharges a battery at a rate determined by the value of Rd (ignoring LED current) such that

$$I_{discharge} = \frac{V_{battery}}{R_d}.$$

A NiCd or NiMH battery has a nominal cell voltage about 1.2 V at mid-charge and about 1.0 V at end-of-charge. It is important not to discharge past this voltage in as it may cause damage to the battery. The values in Figure 1 are for a 4 cell battery. R1 and R2 determine the end-of-voltage limit referenced to the built-in 1.182 V bandgap. When battery voltage is high comparator U1 turns on power N-channel MOSFET Q1 which discharges battery through Rd.

Once the end-of-charge voltage is reached things get interesting. R3 and C1 give positive ac feedback to insure the comparator fully switches and prevents the circuit from becoming a linear regulator. However, due to the intrinsic internal resistance of the battery there is also negative dc feedback. As the MOSFET turns off the battery terminal voltage and the comparator turns the MOSFET back on. The positive ac feedback is designed to overwhelm the negative feedback thus ensuring switching, but only for a short time and the circuit oscillates. The frequency is roughly

$$f = \frac{1}{2 \cdot p \cdot \left(R_3 + R_1 // R_2\right) \cdot C_1}.$$

Oscillation eventually stops when the battery voltage stays below the hysteresis threshold which is determined by the intrinsic resistance of the battery. The higher this resistance the longer the LED will flash. The circuit is actually taking advantage of the fact that this resistance is greatest at end-of-charge. Once the discharge cycle stops the LED stays off and the only current drain is from U1 and the R1/R2 divider – both small enough to leave the battery connected indefinately.

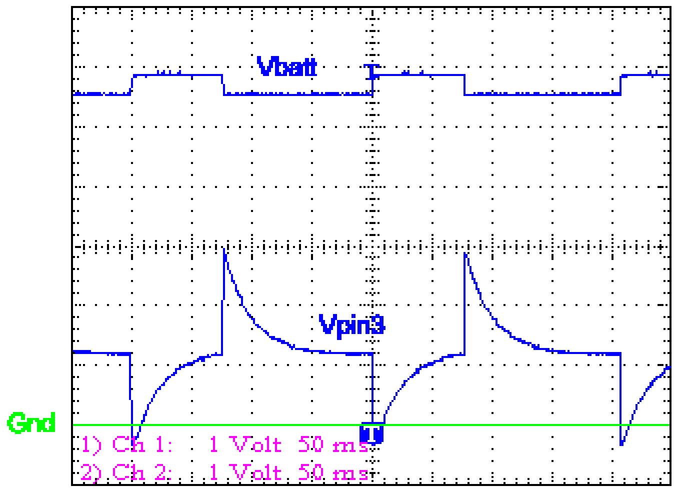

Figure 2. Oscilloscope waveforms of battery voltage and ac feedback near end-of-charge.