DESIGN SHOWCASE

Load-Disconnect Switch Consumes Only 8μA

Deep discharge can damage a rechargeable battery. The **Figure 1** circuit, by disconnecting the battery from its load, halts battery discharge at a predetermined level of declining terminal voltage. Transistor Q_1 acts as the switch. The overall circuit draws about 500μA when the switch is closed and about 8μA when the switch is open.

Choosing the upper and lower voltage thresholds V_U and V_L lets you set values for R_1, R_2, and R_3:

$$R_1 = R_2*[(V_L/1.15) - 1],$$
$$R_3 = 1.15*R_1/(V_U - V_L).$$

To start the circuit, battery voltage (V+) must exceed V_U. The micropower voltage detector IC_1 then powers IC_2, but only while V+ remains above V_L. Otherwise, the loss of power to IC_2 removes gate drive from Q_1, turning it off. As shown, the circuit disconnects a 3-cell nickel-cadmium battery from its load when V+ reaches a V_L of 3.1V. An approximate 0.5V hysteresis prevents the switch from turning on immediately when the load is removed; V+ must first return to V_U (3.6V).

IC_2 is a dual charge-pump inverter that normally converts 5V to 10V. The capacitors C_2, C_3, and two diodes on the chip's positive-voltage side form a voltage tripler that generates an approximate 2(V+) gate drive for the high-side, floating-source MOSFET switch Q_1.

Gate drive declines with battery voltage, causing the on-resistance of Q_1 to reach a maximum of ≈ 0.1Ω just before V+ reaches its 3.1V threshold. A 300mA load current at that time will cause a 30mV drop at the disconnect switch; the drop will be 2 to 3mV less for higher battery voltages. Resistor R_4 assures turn-off for Q_1 by providing a discharge path for C_3.

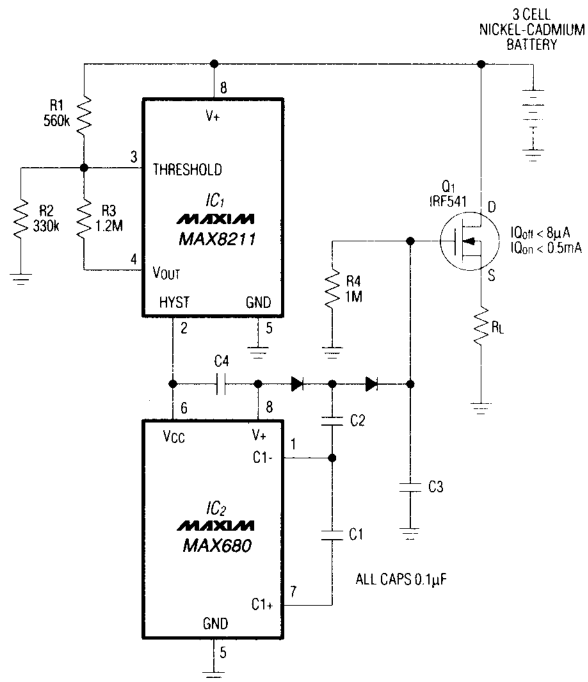

Figure 1. When battery voltage drops below a threshold set by R_1 and R_2, the voltage-detector chip (IC_1) removes power from the charge pump IC_2, which turns off the high-side switch Q_1 by removing its gate drive.

(Circle 3)