

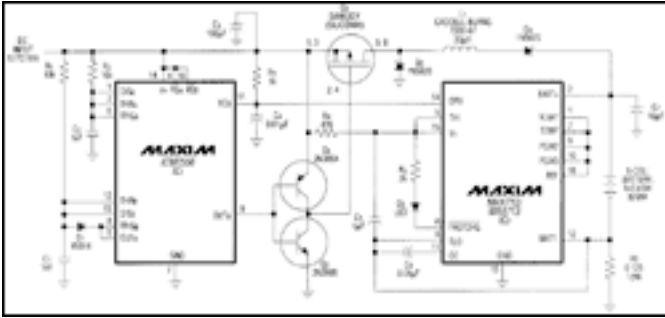
APPLICATION NOTE 426

One-Hour Battery Charger Has Switch-Mode PWM Control

Because battery charges control power, they resemble regulators in some respects. Linear chargers, for example, are less efficient than switching types when operating at high current and a large $V_{IN} - V_{OUT}$ difference.

A linear charger, powered by a 15V car battery and delivering 2A while charging an 8V, 6-cell NiCd stack must dissipate 14 watts. Efficient chargers therefore employ switch-mode DC-DC conversion for deriving battery-charge voltage from V_{IN} .

An efficient fast-charge circuit (**Figure 1**) features a controller chip that normally implements linear regulation with an external pnp transistor. This circuit, however, substitutes a p-channel MOSFET for the pnp and implements switch-mode PWM regulation with the help of an inductor, two Schottky diodes, and a 60¢ dual timer (IC₁). The timer's "B" side is configured as a one-shot that receives nominal 70kHz triggers from the free-running "A" side.



[More Detailed Image \(PDF, 231kB\)](#)

Figure 1. This two-IC circuit provides efficient charging at a two-ampere rate for series connections of NiCd or NiMH cells.

During a charge, IC₂ monitors the slope of battery voltage vs. time. The MAX712 (for nickel-metal-hydride batteries) terminates charging when the slope reaches zero; the MAX713 (for NiCD batteries) terminates charging when the slope goes negative. As a backup provision, you can program an internal timer to terminate charge after 1/4, 1/2, 1, or 2 hours (times a multiple of 1.5X or 2X).

As a further backup, comparator circuits in IC₂ monitor the battery temperature, preventing charging if the battery is too cold and terminating charging if the battery becomes too hot. In every case, the IC applies a trickle charge of $C/16$ (125mA in Figure 1) after termination of the fast charge.

You can program IC₂ for charging 1 to 16 cells in series. The device simultaneously monitors and regulates battery voltage and charge current (via current-sense resistor R_6), and issues drive signals at the open-drain output DVR. These signals implement pulse-width modulation by altering the duty cycle of Q₁'s gate drive.

Constructed with narrow-SO surface-mount components, the circuit fits easily into notebook computers and other portable equipment. When delivering two amperes it can charge a stack of six sub-C cells in less than one hour. The efficiency is 89% for $V_{IN} = 12V$ and $V_{OUT} = 9V$, and the power dissipation is virtually constant at 2.3W for $V_{IN} = 11$ to 16V and $V_{OUT} = 3$ to 9V (V_{IN} must exceed the maximum battery voltage by at least 1V). Heat sinks are unnecessary because no component dissipates more than 0.5W.

Application Note 426: <http://www.maxim-ic.com/an426>

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