Keywords: battery charger, buck-mode switching regulator, synchronous rectifier, charge pump, charging efficiency

**APPLICATION NOTE 851**

# Battery Charger Delivers 2.5A with > 96% Efficiency

Oct 12, 1995

*Abstract: This design note shows how a circuit with modified feedback paths transforms a switch-mode power supply into a highly efficient battery charger. The battery charger is based on a step-down controller, the MAX797, and charges up to six cells with > 96% efficiency at higher output voltages.*

A related idea appeared in the October 12, 1995 issue of *EDN*.

Battery chargers are usually designed without regard for efficiency, but the heat generated by low-efficiency chargers can present a problem. For those applications, the charger of **Figure 1** delivers 2.5A with efficiency as high as 96%. It can charge a battery of one to six cells while operating from a car battery.
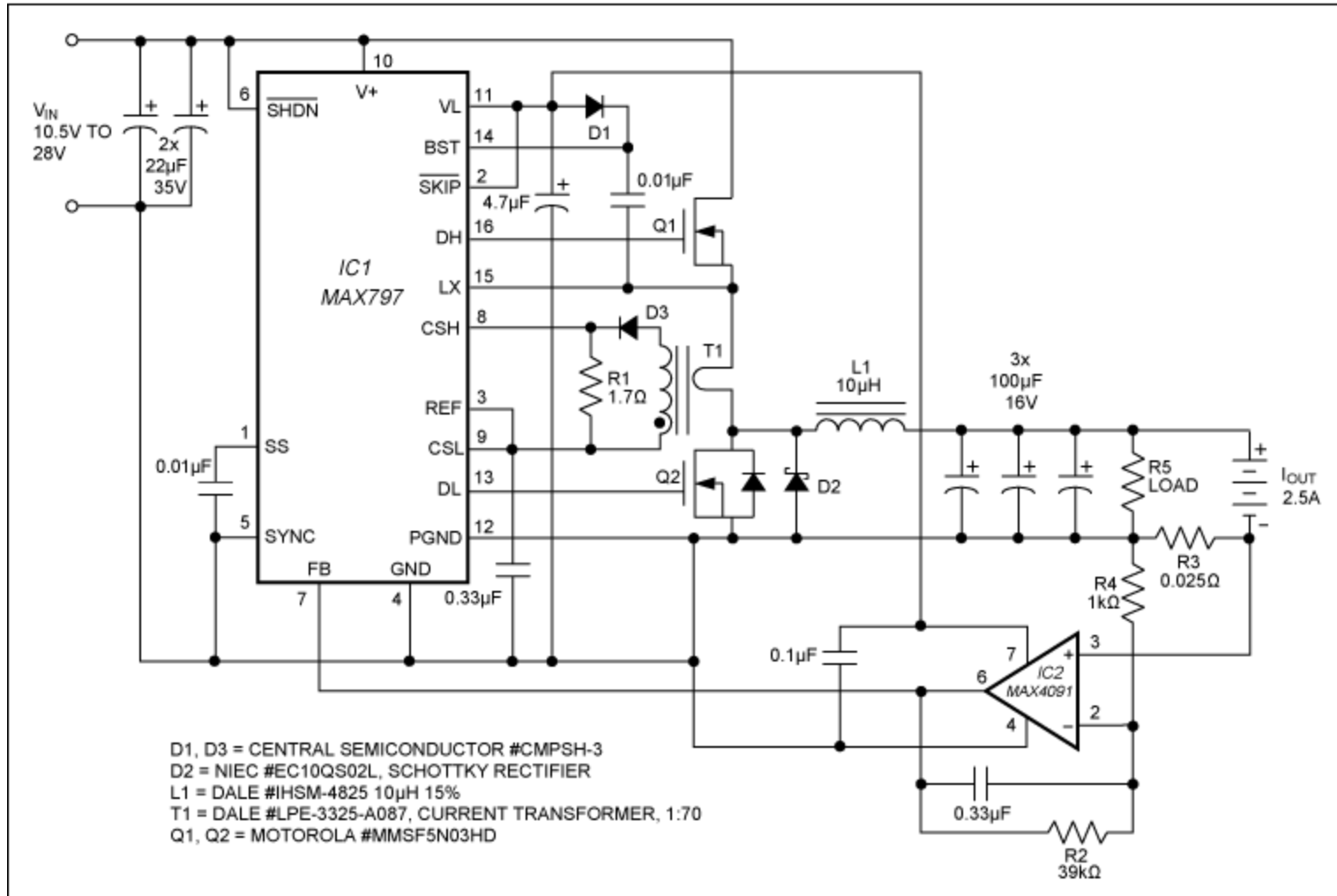
*Figure 1. Modified feedback paths transform this switchmode power-supply circuit for notebook computers into a high-efficiency battery charger.*

IC1 is a buck-mode switching regulator that controls the external power switch, Q1, and the synchronous rectifier, Q2. These n-channel MOSFETs are more efficient than equivalent p-channel types because their on-resistance is lower; therefore they drop less voltage when conducting a given amount of current. IC1 includes a charge pump for generating the positive gate-drive voltage required by Q1.

The battery-charging current develops a voltage across the 25mΩ resistor R3 that is amplified by the op amp and presented as positive-voltage feedback to IC1. This feedback enables the chip to maintain the charging current at 2.5A. While charging, the circuit can also supply current to a separate load, up to a limit set by the current-sense transformer, T1, and sense resistor, R1.

T1 improves efficiency by lowering power dissipation in R1. The transformer turns ratio (1:70) routes only 1/70 of the total battery-plus-load current through R1, creating a feedback voltage that enables IC1 to limit the overall current to a level compatible with the external components.

Efficiency exceeds 96% at the higher output voltages (**Figure 2**). (Lower output voltage produces less output power, so the relatively fixed amount of dissipation associated with Q1, Q2, and IC1 represents a larger percentage of the total.) If you inadvertently disconnect the battery during a charge, $V_{OUT}$ cannot rise to a dangerous level (as it can in a boost-mode topology)

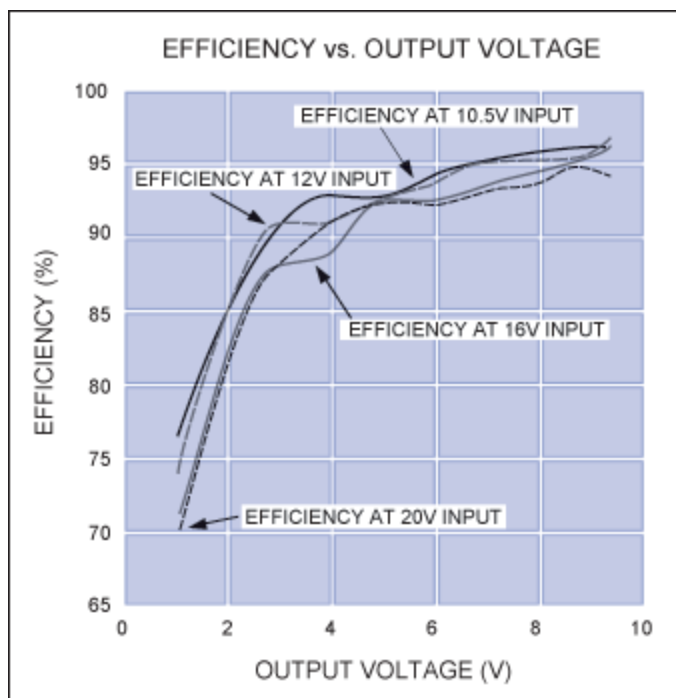because the charger's buck-mode topology limits the maximum output voltage to $V_{IN}$.



Figure 2. Efficiency for the Figure 1 battery charger rises with output voltage.

| Related Parts | | |
|---|---|---|
| MAX4091 | Single/Dual/Quad, Micropower, Single-Supply, Rail-to-Rail Op Amps | Free Samples |
| MAX797 | Step-Down Controllers with Synchronous Rectifier for CPU Power | Free Samples |

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