Mar 13, 2003

Designing a Pulse Charger for Use With Unregulated Power Supplies

The "Charge Efficiency and Cell Aging Effects of the DS2770 Li+ Pulse Charger vs. Linear Chargers" app note suggests that a current-limited and regulated power supply must be used with a pulse charger like the DS2770. Because the pulse charger does not regulate charging current, the current limit is indeed a requirement. However, by adding a few passive components, the DS2770 can support a variety of current-limited, full-wave rectified, unregulated charge sources.

Operation

When the charge source is connected to the circuit between the CS and PACK- pads, the DS2770 detects the source and begins to charge the cell (following cell prequalification and trickle charging, if necessary). The voltage applied to the V_{CH} pin must not fall below the battery voltage during charging, or the DS2770 assumes the source has been removed and will terminate the charge prematurely. Figure 1 shows possible unregulated charge sources and the modified application circuit to prevent this.

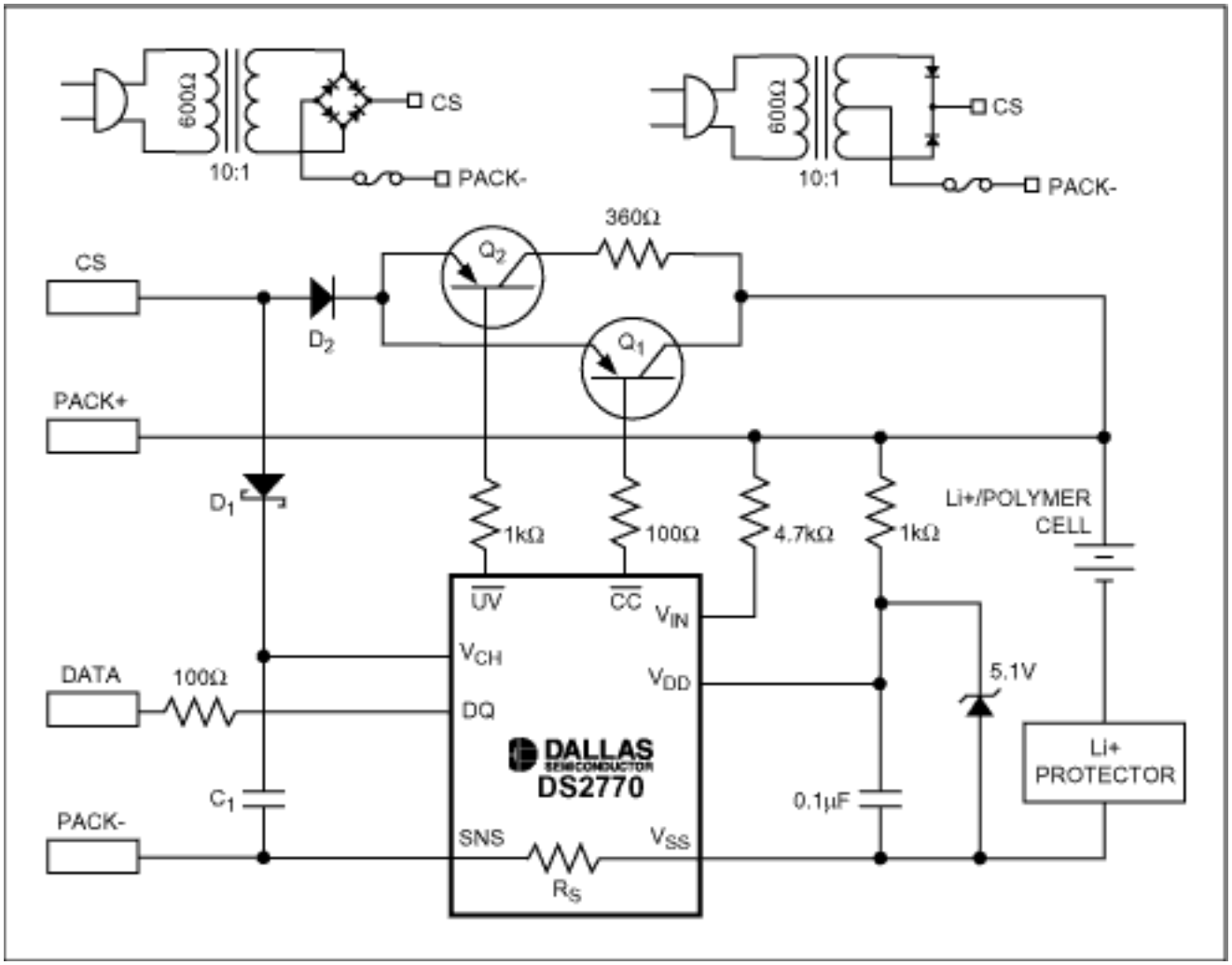

Figure 1. By adding a few passive components, the DS2770 can support a variety of current-limited, full-wave rectified, unregulated charge sources.

Three modifications are required for the application circuit in the DS2770 data sheet to allow for unregulated supplies. Schottky diode D_1 replaces a 150Ω resistor to disallow capacitor C_1 from discharging through the charge source. Junction diode D_2 is added to provide at least 0.5V margin on V_{CH} over V_{DD} and to prevent the battery from discharging through the charge source. Capacitor C_1 exists in the regulated application schematic, but must be made larger to maintain the voltage on V_{CH} for the entire period the charge source is lower than the cell voltage. Design criteria for selecting C_1 follows.

While the source voltage is higher than the cell voltage, charge flows into the cell and the voltage on V_{CH} is forced above the voltage on V_{DD}. While the source is lower than the cell voltage, capacitor C_1 maintains V_{CH} at a level above the cell voltage. Figure 2 shows the relationship between the charge source voltage, V_{CH} pin voltage, and cell voltage during charging.

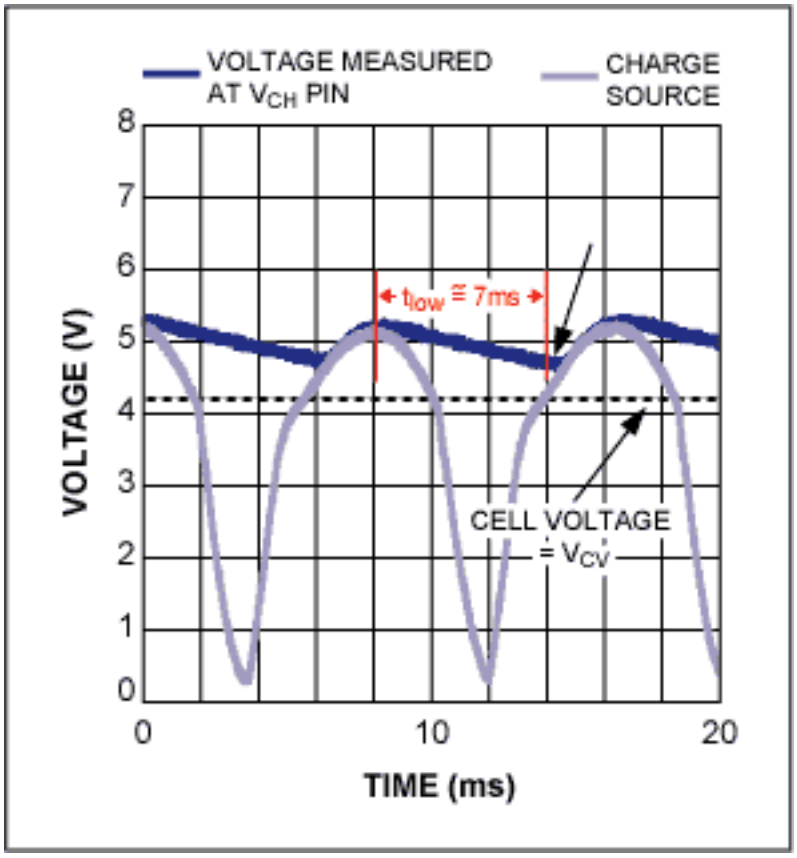

Figure 2. The voltage on the VCH pin must remain above the maximum cell voltage.

Like all pulse chargers, the DS2770 has two distinct phases during the fast-charge process: constant current at the charge-source current limit, and pulse-charge top-off. The primary concern addressed with this circuit is in the constant-current phase when transistor Q_1 is on continuously. This circuit prevents current from pulsing in this phase where constant current is desired. In the pulse-charge top-off phase, the circuit also maintains charging current while Q_1 is on for the pulses, which is approximately 100x the period of a 60Hz full-wave rectified supply (875ms typ for the DS2770). When Q_1 is off during the pulsed phase, C_1 charges up to the open-circuit voltage of the charge source, which is significantly higher than the cell voltage.

Capacitor C1 Calculation

Capacitor C_1 prevents the voltage at the V_{CH} pin from falling below the cell voltage for the duration of the charge source low period (time t_{low} in Figure 2). During this time the 150µA load (data sheet max) through the V_{CH} pin drains C_1. The minimum capacitance value required is derived starting from the standard equation:

$$I = C(dv/dt)$$

where dt is the low period (t_{low}), dV is the voltage difference from the V_{CH} pin to the cell voltage

at the start of t_{low}, and I is the internal load on the V_{CH} pin. To solve for C, the equation can be rewritten as:

$$C_1 \geq I_{VCH}(t_{low} / (V_{D2} + V_{Q1} - V_{D1)})$$

Solving for this example:

$$C_1 \geq 150\mu A \bullet (7ms / (0.7V + 0.2V - 0.2V)) = 1.5\mu F$$

1.5µF is the minimum value for C_1, not considering device tolerances. To ensure proper operation for a specific application, use worst-case tolerances for all components including the tolerance of C_1 itself and the worst-case timing for the width of t_{low}.

Summary

To be used with lower cost, unregulated power supplies, pulse chargers like the DS2770 need very few passive component modifications to the application schematic for regulated supplies. A Schottky diode resistor replaces the charge source sense pin (V_{CH}). Adding a junction diode to the charge path prevents the battery from discharging through the charge source. A larger capacitor on V_{CH} maintains the charge sense voltage at a higher level than the cell voltage for the entire full-wave rectified waveform generated by the charge source. This circuit maintains V_{CH} greater than the cell voltage (V_{CV}) during the charge cycle's constant current phase and the pulsed phase.

EJ46d, March 2003

More Information

DS2770: QuickView -- Full (PDF) Data Sheet -- Free Samples