May 21, 2003

App Note 2044: Simple Current Limiter for DS2770-Based Chargers

This application note presents to the user a current limit circuit that can be added to the DS2770 Li+/NiMH charger IC and battery monitor reference design which is found in the DS2770 datasheet. It is intended for use when the charge source is a low-impedance regulated power bus and it can provide an accuracy of about ±20%. A current limiter circuit is presented, as well as methods to be used for component value selection.

Overview

This application note presents a simple, low-cost current limit circuit that can be added to the DS2770 charger IC and monitor reference design (See Dallas Semiconductor *Application Note 201*). This circuit is recommended when the charge source is a low-impedance regulated power bus, such as a 5.0V system power bus or USB bus.

The accuracy of the current limit is about ±20% and is suitable for preventing battery or bus overloads in the majority of applications.

The Current Limit Circuit

When added to the DS2770 Li+ or NIMH charger reference design (App Note 201), the circuit in Figure 1 will limit the fast charge current to approximately 500mA.

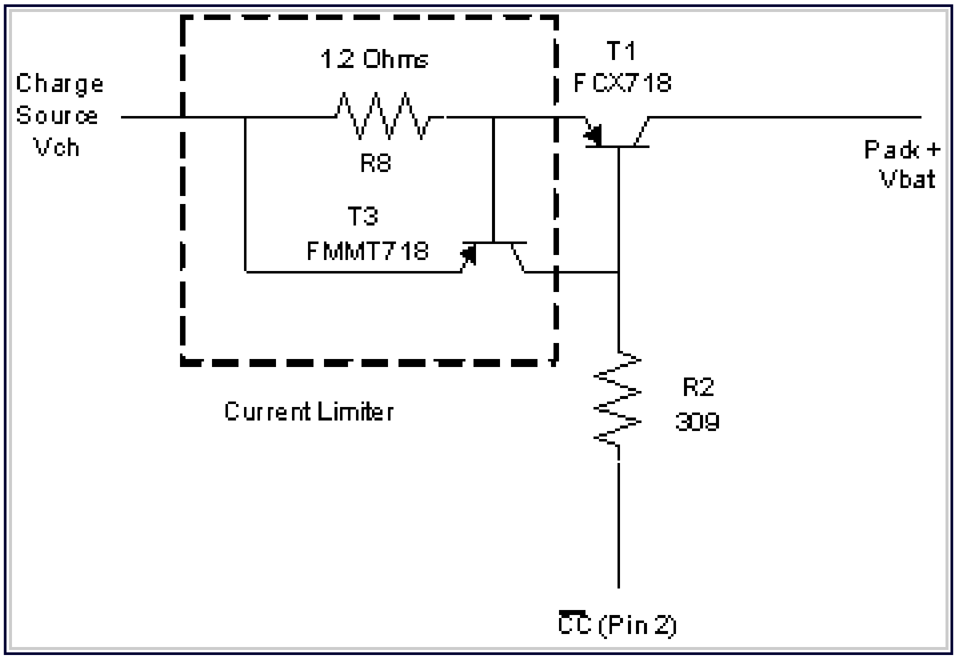

Figure 1. Simple current limiter for DS2770-based chargers.

When the charging current approaches 500mA, the voltage across R8 becomes high enough to bias T3 on, and base current is diverted from T1. The delivered current is limited to approximately V_{BE}/R8. Bipolar transistor V_{BE} is typically 0.7V, with a dependency on temperature, current, and lot variations. Manufacturer's data sheets should be consulted when calculating current limit tolerances.

Calculating Base Drive Resistor for T1

Adding the current limiter introduces a small change in the bias condition of T1. To guarantee saturation at maximum load, it is necessary to recalculate the value of R2 from Application Note 201:

1) $R2 = [V_{CH(MIN)} - R8*I_{MAX} - V_{BE(T1)}]*\beta_{T1} / I_{MAX} - R_{CC}$

Where $V_{CH(MIN)}$ is the minimum input voltage from the charge source, typically 4.5V for a 5.0V bus. I_{MAX} is the maximum charging current. $V_{BE(T1)}$ is the saturated base-emitter voltage of T1 at maximum load current and R_{CC} is the 200Ω internal resistance of the /CC driver (Pin 2) of the DS2270. β_{T1} is the worstcase minimum gain of T1.

Assuming R8 is 1.2Ω, minimum charge source voltage of 4.5V, maximum load current of 600mA, saturated base emiter voltage of 0.7V, and a gain of 100, the calculated value for R2 is 313Ω. The closest 1% resistor value that guarantees sufficient base current is 309 Ohms.

Calculating Power Dissipations

Typical ambient temperature conditions for the intended applications are in the range of 15° C to 40° C. R8 and T3 should be sized accordingly to the end equipment derating guidelines.

2) $P_{R8} = (I_{MAX})^2 * R8$

3) $P_{T1} = (V_{CHMAX} - V_{BE(T3)} - V_{BATMIN}) * I_{MAX}$

For 600mA, and a value of 1.2Ω, R8 must safely handle 432mW. The minimum battery voltage is set by the Fast-Charge threshold of 3.0V. For a typical 5.0V bus, the maximum voltage is 5.5V. T1 will dissipate 1.08W. Manufacturer's data sheets should be consulted for layout guidance and device thermal impedance.

Peak Charging at Low V_{CH}

At low input (V_{CH}) voltage and high battery voltage, T1 saturates and the current is limited by R8:

4) $I_{CH} = (V_{CH} - V_{CE(SAT)} - V_{BAT})/R8$

Figure 2 shows measured data for a typical I_{CH} versus V_{CH} curve with a battery voltage of 4.23V. Data were taken using a battery emulator. This effect should be considered when estimating charge times at low V_{CH}.

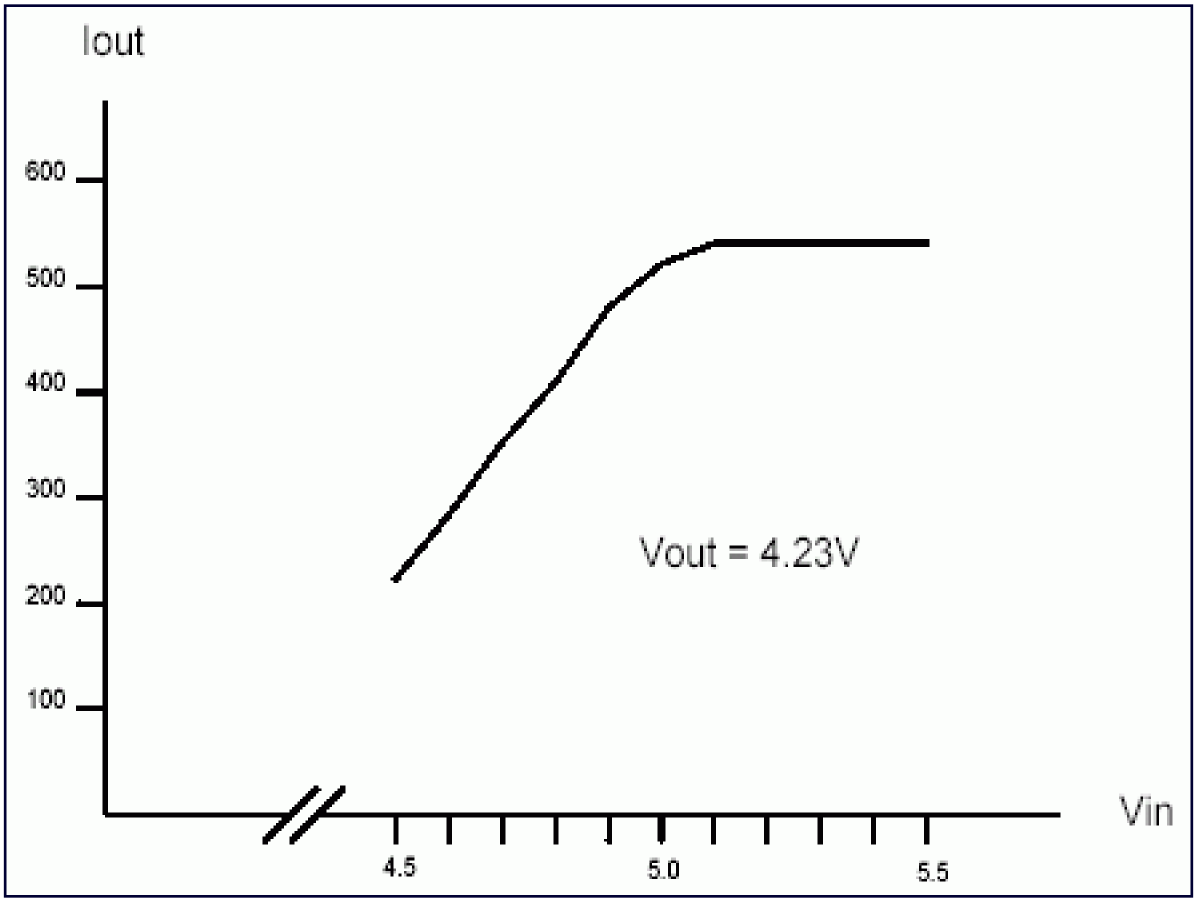

Figure 2. Current limit versus input voltage (V_{CH}).

Conclusion

This is a simple, effective, low-cost method for limiting charging currents for the DS2770. The circuit in Figure 1 typically limits at ~550mA and is recommended for end equipment intended for home or office environments.

More Information

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