Versatile Current Source Safely and Quickly Charges Everything from Large Capacitors to Batteries – Design Note 405

David Ng

Introduction

The LT®3750 is a current mode flyback controller optimized to easily and efficiently provide a controlled current to charge just about any capacitive energy storage device. The LT3750's simple but flexible feature set allows it to handle a wide variety of charging needs. These include large high voltage capacitors for professional photoflash equipment and emergency beacons, small capacitors that are charged and discharged thousands of times a second, and batteries for long term energy needs.

Safe, Small and Flexible

All of the control and feedback functions of the LT3750 are referred to the charger's input. The target voltage is set by just two resistors in a simple, low voltage network that monitors the flyback voltage of the transformer. When charging a capacitor to a high voltage, there is no need to connect any components to the hazardously high output potential. The charging current is a triangle wave whose amplitude is set by an external sense resistor and the flyback transformer turns ratio.

The LT3750 operates in boundary mode, at the edge of continuous and discontinuous conduction, which significantly reduces switching losses. This in turn allows for high frequency operation, and a correspondingly small flyback transformer size. The LT3750 is itself tiny, available in a 10-lead MSOP package.

The LT3750 is also compatible with a wide range of control circuitry. It is equipped with a simple interface consisting of a CHARGE command input bit and an open-drain $\overline{\text{DONE}}$ status flag. Both of these signals are compatible with most digital systems, yet tolerate voltages as high as 24V. The LT3750 operates from 3V to 24V DC.

Simple Strobe Capacitor Charger

Figure 1 shows a LT3750 circuit that charges a 400µF strobe capacitor to 300V. This capacitor and voltage combination is typical of professional photoflash systems, security devices and automotive light strobes. The target voltage is set by the two resistors R2 and
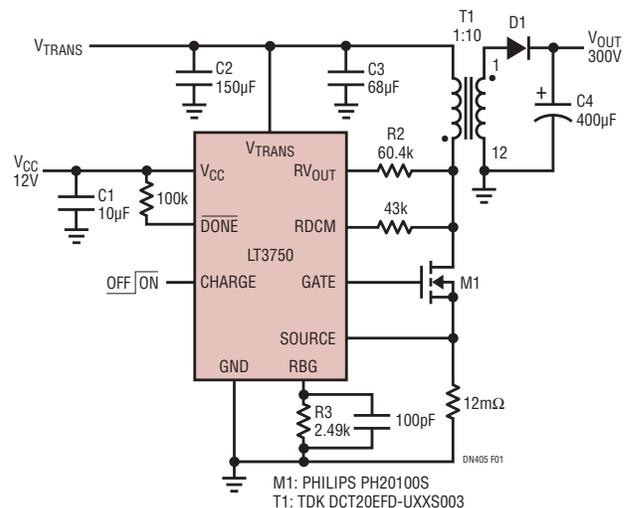
Figure 1. LT3750 Circuit Charges 400µF Capacitor to 300V. DANGER HIGH VOLTAGE—OPERATION BY HIGH VOLTAGE TRAINED PERSONNEL ONLY

R3, which together monitor the MOSFET drain voltage. This voltage, when referenced to the input rail, is directly proportional to the output potential while power is being transferred to the output capacitor. The LT3750 compares this to an internal reference and terminates the charge cycle when the output has reached the desired target voltage, after which the LT3750 sets the $\overline{\text{DONE}}$ bit to signal the system microcontroller that the charge cycle is complete.

As shown in Figure 2, the LT3750 charges the 400µF to 300V in about 0.92 seconds when the circuit is powered from a 12V source. Note that the output current amplitude is constant throughout the charge cycle.

Charge Small Capacitors Fast

Many devices need to provide energy to a transducer multiple times per second, such as diagnostic equipment and device testers. Figure 3 shows that, for the same circuit
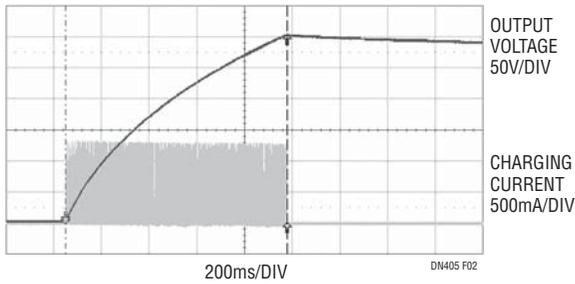
Figure 2. LT3750 Charges 400µF to 300V in 0.92 Seconds
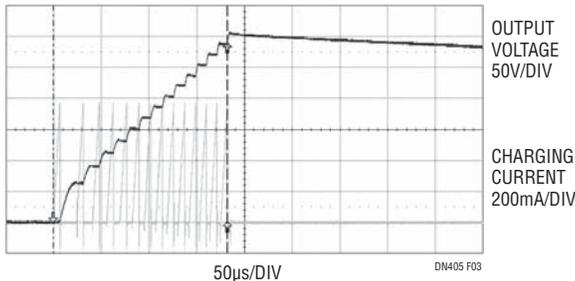
Figure 3. LT3750 Charges 0.1µF to 300V in 180µs

as in Figure 1, the LT3750 is capable of charging a 0.1µF capacitor to 300V in just 180µs. The only change in the circuit is the replacement of the 400µF output cap with one that is much smaller. The performance of the circuit is essentially the same, other than the charge time. As

far as the output device is concerned, the LT3750 circuit is a current source.

Charge Batteries Too

Another type of system that needs a controlled current source is a fast charger for a lead-acid battery. A fast charger for a lead-acid battery differs from the capacitor charging applications in that it needs to charge at high current, but at a much lower voltage. Figure 4 shows a circuit that charges at 6A until the lead-acid battery potential reaches the 14V float voltage. Again, the circuit is remarkably similar to the previous two designs—the transformer turns ratio is now 1:1 and the R2 set resistor has been changed to set the target float voltage to 14V. Other float voltages may be accommodated by simply changing R2 to the appropriate value.

When the battery voltage reaches 14V, the LT3750 sets the $\overline{DONE}$ bit. This can then be used to signal the system microcontroller, which can then enter a "trickle-charge" mode by setting the CHARGE bit at a fixed, low frequency interval.

Conclusion

The LT3750 is an easy-to-use controller that is ideal for applications where there is a need to charge an energy storage device to a predetermined target voltage. Its unique architecture allows it to be used in just about any application where a controlled current source is needed, with almost no limitation on the output voltage.
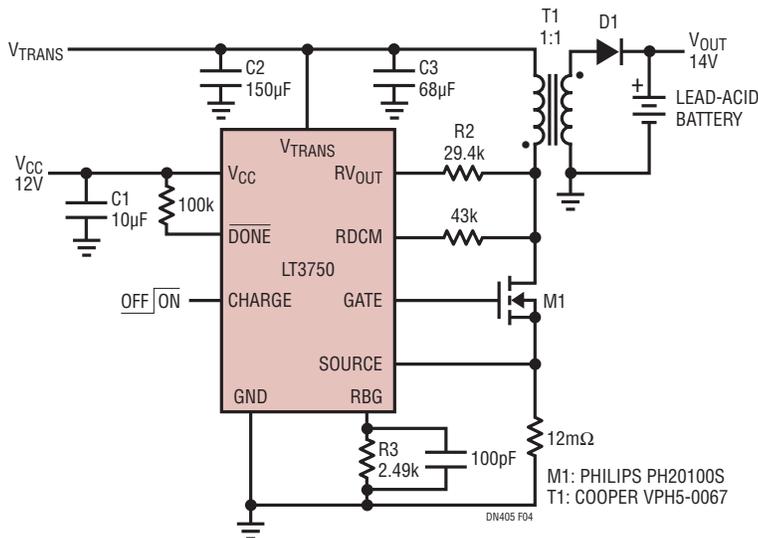
Figure 4. LT3750 Battery Charger with Microcontroller Interface for Variable Current Charging