

## DESCRIPTION

Demonstration circuit 973 is a complete constant-current, constant-voltage battery charger for one 4.2V Lithium-Ion battery. The LTC®4069EDC used in this demo circuit is packaged in a tiny 2 X 2 mm DFN package and features an internal P-Channel power MOSFET with a unique thermal feedback loop that reduces the output current under high ambient temperature and/or high power dissipation conditions. This feature allows the charger to provide higher charge currents under normal conditions and still provide safe charging under abnormal conditions such as high ambient temperature, high input voltage or low battery voltage.

The preset float voltage is 4.2V with  $\pm 0.6\%$  accuracy. Charge current is programmed for 750mA although lower currents are easily programmed using a single external resistor from the PROG terminal to ground. This terminal (PROG) also allows the charge current to be monitored. An NTC terminal is provided for sensing battery temperature by using a thermistor located near the battery. Two jumpers on the board are used for shutdown and selecting the external thermistor function.

A 4.5 hour timer provides charge termination with a shorter time period for a recharge cycle. Undervoltage lockout, low-battery charge conditioning (trickle

charge) and soft-start to limit inrush current are featured.

An LED indicates several charger conditions. When the LED is solid ON, charge current is flowing and is greater than 10% of the programmed current level. When the charge current drops below 10%, indicating a near full charge condition, the LED turns off. A pulsing LED indicates fault conditions. Pulsing at a 2Hz rate with a 80% ON duty cycle indicates that the trickle charge time has run out with the battery voltage not exceeding 2.9V, indicating a defective battery. When replacing the battery, the charger requires a reset by momentarily floating the PROG pin or toggling the input voltage. Pulsing at a 2Hz rate with a 20% ON duty cycle indicates a battery out of temperature range condition. The temperature fault does not require a reset.

The 6-Pin 2mm x 2mm DFN thermally enhanced package features an exposed bottom-side metal pad for soldering to the PC board for increased power dissipation. Small surface mount components are used minimizing board space and height.

**Design files for this circuit board are available. Call the LTC factory.**

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**Table 1. Typical Specifications (25°C)**

Input Voltage Range $V_{IN}$	3.75 to 7V (upper range limited by PC board power dissipation)
Input UnderVoltage Lockout	3.6V $\pm 6\%$
Output Float Voltage $V_{BAT}$ (constant voltage mode)	4.2V $\pm 0.6\%$
Output Current $I_{BAT}$ (constant current mode)	750mA $\pm 5\%$
PROG Terminal Current Monitor Output	1V $\pm 5\%$ @ Full Current
Charge Termination Timer	4.5 Hours $\pm 30\%$
Recharge Termination Timer	2.25 Hours $\pm 30\%$
CHRG LED Indicator (C/10 Threshold)	75mA, $\pm 10\%$
CHRG LED Indicator (Fault Flash Rate)	2Hz (typ)

## QUICK START PROCEDURE

The charger can be evaluated using an actual Lithium Ion battery or a battery simulator. The battery simulator is faster because all battery state-of-charge conditions can be quickly simulated.

A battery simulator consists of an adjustable power supply with a load resistor across the power supply output. The resistor value is selected that will provide approximately 800mA when the power supply is set for 2.8V. The power supply must provide at least 1.3A when adjusted for 4.2V. For this battery simulator, a 3.5 Ohm, 10 Watt power resistor connected to the output of a 0 to 5V, 1.5A bench supply will work fine. The power supply can now sink and source current, similar to a battery, and by changing the power supply voltage, any battery state-of-charge condition can be quickly simulated. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

1. Set jumpers JP1 & JP2 to the left position. With the input power supply and battery simulator power supply adjusted to 0V, connect the input power supply and the battery simulator power supply to the demoboard as shown in Figure 1. If desired, an ammeter or 100m $\Omega$  current sense resistor can be placed between the BAT terminal and the positive terminal of the battery simulator to measure charge current. Connect a 4½

digit DVM to the BAT and GND terminals to measure battery voltage and a DVM to the PROG and GND terminals to monitor the LTC4069 program pin voltage which is proportional to charge current.

2. Begin increasing the input supply voltage, up to 5V. As the voltage passes through approximately 3.8V (which is the **undervoltage lockout threshold**), the CHRG LED will turn on and the preconditioning **trickle charge** of 75mA will begin flowing. Observe the voltage reading of 100mV on DVM 3 indicating a 10% charge current.
3. Adjust the battery simulator power supply to 3V. At the **trickle charge threshold** of approximately 2.9V (as measured on DVM 1), the charge current will abruptly increase to the **programmed constant current** of 750mA (75mV on DVM 2). DVM 3 will measure 1.0V indicating 100% charge current.
4. Continue slowly increasing the battery simulator power supply, thus simulating the Li-Ion battery accepting charge. As the battery simulator approaches the float voltage of 4.200V, the charge

# QUICK START GUIDE FOR DEMONSTRATION CIRCUIT 973

## SINGLE CELL LI-ION BATTERY CHARGER WITH NTC

current will begin to drop. This is the **constant voltage portion of the charge cycle**. It is important to keep the DC resistance between the charger output and the battery to a minimum, otherwise the charge current will begin dropping much sooner. When the charger is in the constant voltage portion of the charge cycle, small changes in the simulator power supply voltage will result in relatively large changes in charge current.

- Continue slowly increasing the battery simulator power supply until the charge current drops to approximately 75mA (10% of the programmed value). When the charge current drops below this value, the **CHRG LED will go OFF** indicating a near full charge condition (about 94% charge level). Continue increasing the simulator voltage until the charge current drops to approximately 5 or 10mA, then read the **battery float voltage on DVM 1**. The charge cycle will continue until the **4.5 hour timer ends the charge cycle** with the battery at the 100% charge level.

- After the charge cycle has ended, if the battery voltage drops approximately 100mV, a **re-charge cycle** will begin. For a recharge cycle, the time period is shortened to 2.25 hours.
- To verify the **shutdown mode**, remove jumper JP1. Observe the charge current dropping to 0mA and the CHRG LED turning off.
- To verify the **thermistor function**, remove jumper JP2. Observe the charge current dropping to 0mA and the CHRG LED pulsing at a 2Hz rate with a 20% ON duty cycle. A resistor substitution box may also be used to simulate a thermistor temperature. The LED will begin flashing for thermistor values less than approximately 54k (40°C), or greater than approximately 326k (0°C). Thermistor data taken from curve 1 of the Vishay/Dale Thermistor Conversion Table, document number 33011.

See **LTC4069 Data Sheet for additional information**.

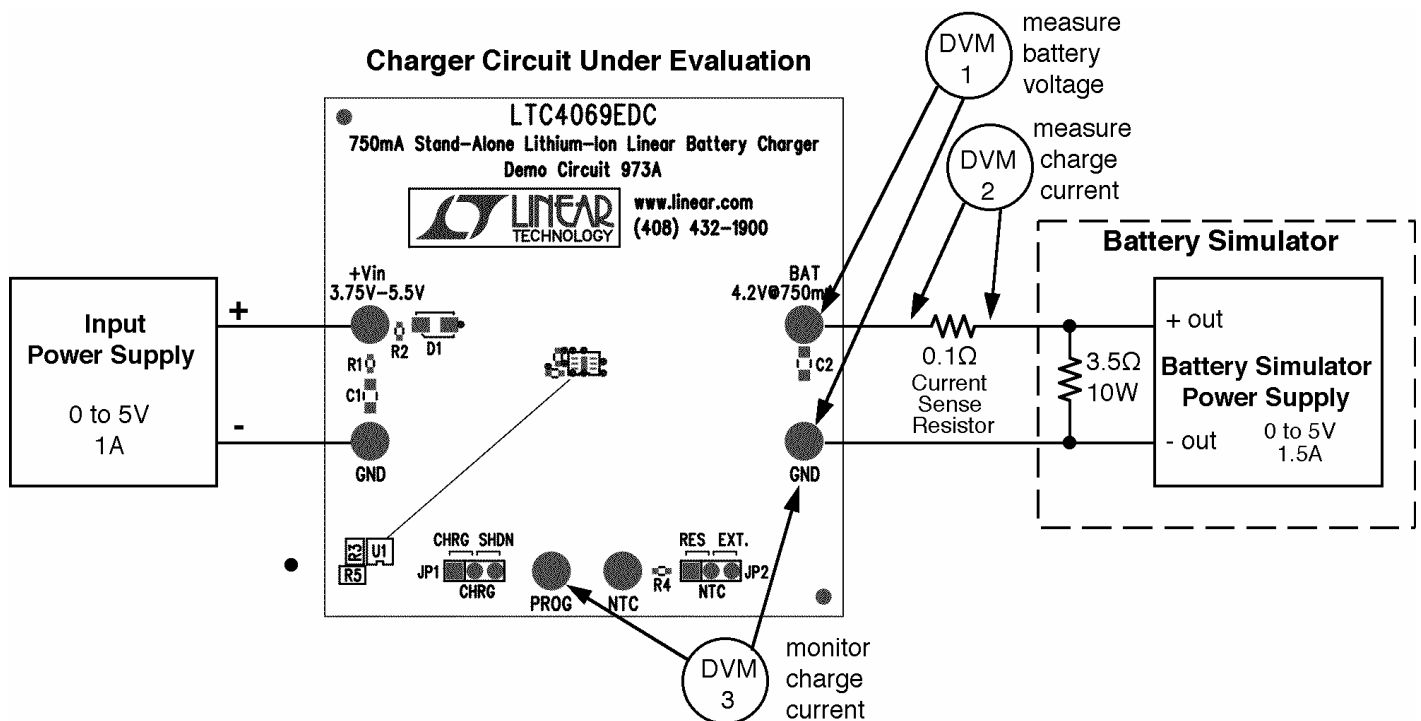
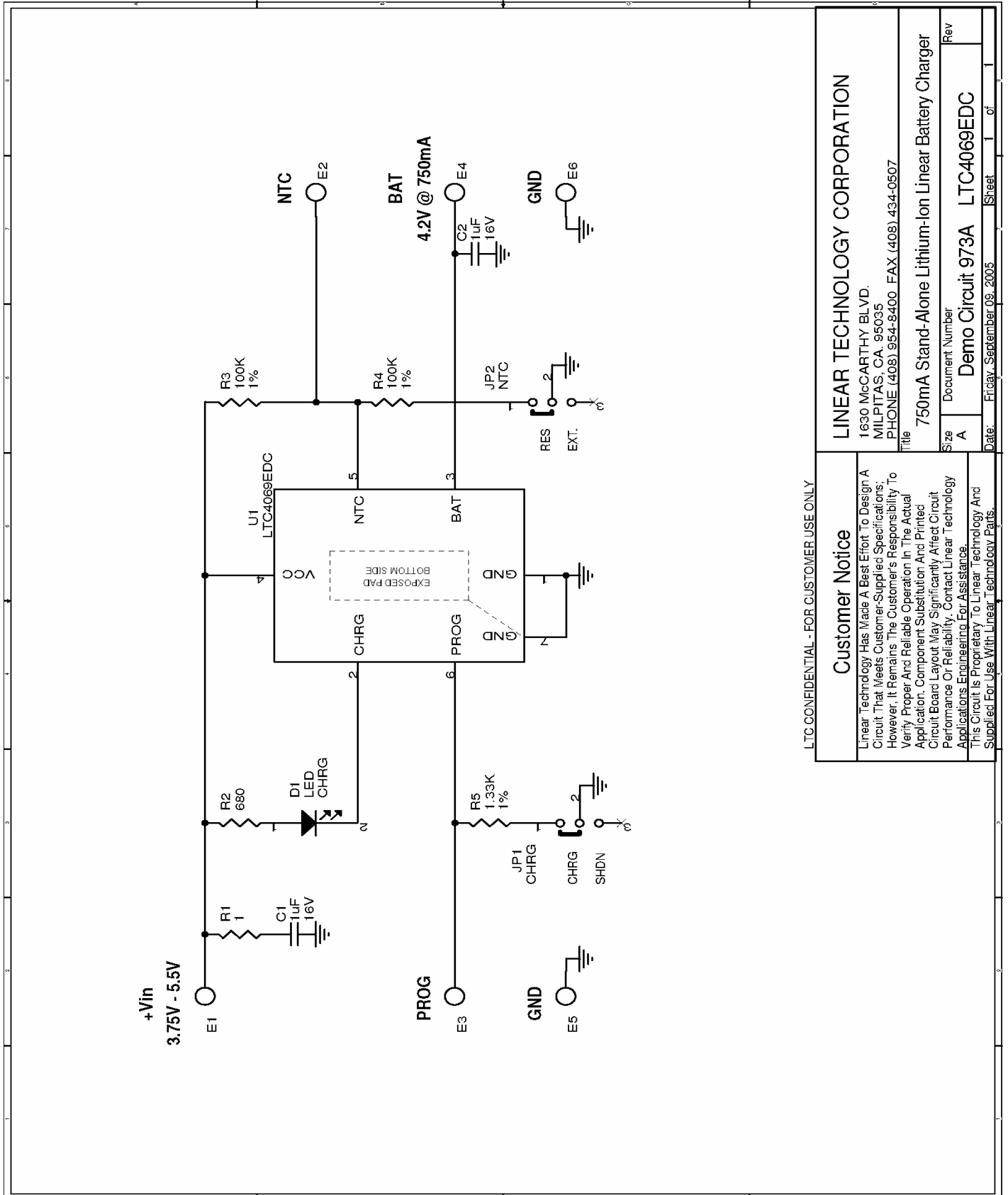


Figure 1. Demonstration Board Hookup Diagram

# QUICK START GUIDE FOR DEMONSTRATION CIRCUIT 973 SINGLE CELL LI-ION BATTERY CHARGER WITH NTC



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## Customer Notice

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Title: 750mA Stand-Alone Lithium-Ion Linear Battery Charger

Size: Document Number  
A Demo Circuit 973A LTC4069EDC

Date: Friday, September 08, 2005 Sheet 1 of 1