DESCRIPTION

Demonstration circuit 531 is a complete pulse battery charger designed to charge one Lithium-Ion cell. DC531 features the LTC4052 Li-Ion pulse charger with internal MOSFET suitable for charging at a maximum current of 1A.

Other Features include:

❑ Preset float voltage of 4.2V ±1%

❑ Constant Current set by wall adapter current limit

❑ Over current protection

❑ 3-hour charge termination timer. This timer can be set for other time periods through a capacitor change. For instance, you may want to use a much shorter period (on the order of 30 seconds) when evaluating the board with a battery simulator instead of a Li-Ion battery.

❑ Trickle charge for deeply discharged batteries

❑ Auto recharge when battery voltage drops below 4.05.

❑ Low battery drain current when the input supply is removed

❑ Input Power OK LED indicator (ACPR)

❑ C/10 Charge LED indicator (CHRG)

Small surface mount components are used to minimize board space and height with the circuitry occupying approximately 0.15 square inches of board space with a height of 0.054 inches (1.4mm).

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

Table 1. Performance Summary

PARAMETER	VALUE
Input Voltage Range	4.5V to 10V
Output Voltage V_{BAT}	4.2V ±1%
Output Current I_{BAT} (constant current mode)	Up to 1A (determined by input supply current limit)
Output Current I_{BAT} (trickle current mode)	24mA ±40%
C/10 CHRG LED Threshold Level	10% Duty Cycle
Trickle Charge Threshold Voltage	2.45V
Battery Drain Current with V_{IN} Removed	1µA

QUICK START PROCEDURE

Demonstration circuit 531 is easy to set up to evaluate the performance of the LTC4052. Refer to Figure 1 for proper measurement equipment setup and follow the procedure below:

1. Before connecting the input power supply to the demo board, adjust the power supply current limit to 1A. Adjust the output voltage to 0V and then connect the power supply to the Vin and GND pins of the demo board.

2. Set the battery simulator to 0V, and then connect it to the BAT and GND pins.

3. Connect the digital voltmeters as shown in the setup diagram to measure the input voltage V_{IN}, charger voltage (VBAT) and the charge current (IBAT).

4. Begin increasing the input voltage to 6V and keep the battery simulator power supply at 0V. Both LEDs (CHRG and ACPR) should have come on at approximately 2V, and the charge current should be approximately 24mA. **This is the trickle charge mode for a deeply discharged battery.** Typically, a battery that has not been charged for a long time.

5. Starting from 0V, slowly increase the battery simulator power supply (VBAT), observing the charger's output voltage on the DVM. When the charger's output voltage exceeds approximately 2.5V, the charger will suddenly enter the Constant current portion of the charge cycle resulting in an abrupt increase in charge

current (IBAT) to the current limit of the input power supply. **This is the constant current mode.**

6. Continue to slowly increase the battery simulator power supply until the charge current pulsing begins. Approximately 3 seconds after the pulsing stops, the CHRG LED turns off and stays latched off.

   NOTE: When an actual battery is used, the battery voltage rises much slower than the battery simulator, resulting in a very gradual decrease in pulse duty cycle. When the duty cycle drops to 10%, the CHRG LED goes off, though there is still 40µA flowing through the LED.

   When the timer ends (3 hours for a 0.1µF timing capacitor) the charge cycle ends and the CHRG pin becomes high impedance. Connecting a new battery or cycling the input power turns on the CHRG LED, starting a new charge cycle. A new charge cycle also begins if the battery voltage drops below 4.05V, though the CHRG LED is not on.

   When the charger is in the pulse mode, the DVM reading appears to exceed the 4.2V Li-Ion float voltage. This is because when the charger is pulsing, the LTC4052 monitors the charger's output voltage when the charge current is not flowing. Because of the battery and pack protection ESR, wiring and connector resistance, the charger's output voltage will exceed the 4.2V float voltage when the charge current is flowing.

   Figure 2 shows typical waveforms when the battery is near the end of the charge cycle. The charger output voltage, when charge current is flowing, approaches 4.260V. The 60mV overvoltage is due to the (measured) 60mΩ resistance of the internal ESR of the battery simulator power supply and associated wiring, and the 1A of charge current. The pulsing stops when the lower portion of the charger voltage exceeds 4.200V ±1% or the timer ends the charge cycle.

7. After the timer has timed out, slowly decrease the battery simulator power supply. At approximately 4.05V the charge current resumes and a new charge cycle begins. **This is the Recharge Threshold Voltage.**

   NOTE: For evaluation purposes, the time can be decreased from the programmed 3 hours to approximately 30 seconds by reducing the timer capacitor (C4) from 0.1µF to 270pF
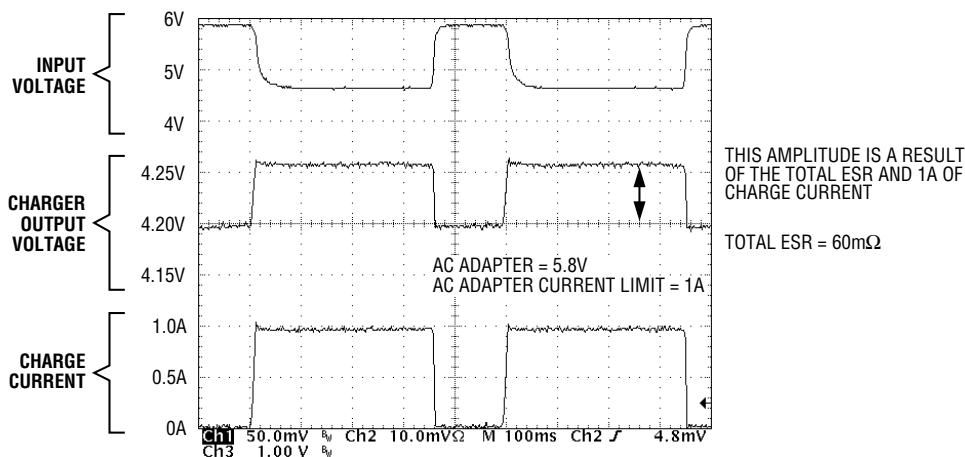
8. To verify battery drain current, remove the input supply voltage. The ammeter that was reading charge current now reads the battery drain current. A typical value is less than 1µA.

9. To verify the overcurrent protection feature, adjust the battery simulator power supply to approximately 3.5V. Increase the current limit of the input power supply to approximately 2.5A. When the charge current reaches the overcurrent threshold of approximately 1.9A, the charge current immediately stops, waits for 640ms, then rises again, resulting in short pulses of current at approximately 1.6Hz. These short pulses of current represent an average current of approximately 1% of the overcurrent level of 1.9A. Figure 3 shows the waveforms.
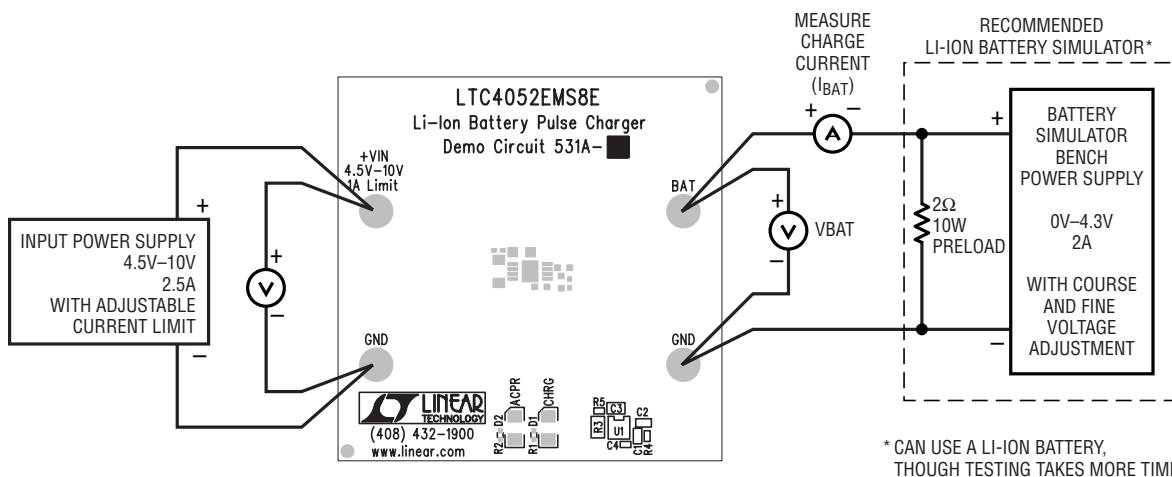
Figure 1. Proper Measurement Equipment Setup

NOTE: Although it would take more time, this charger can also be evaluated using a rechargeable Li-Ion battery in place of the battery simulator pictured here. If you use an actual battery, keep the DC resistance between the charger and the battery to a minimum, as this will affect the charge current in the constant voltage mode.
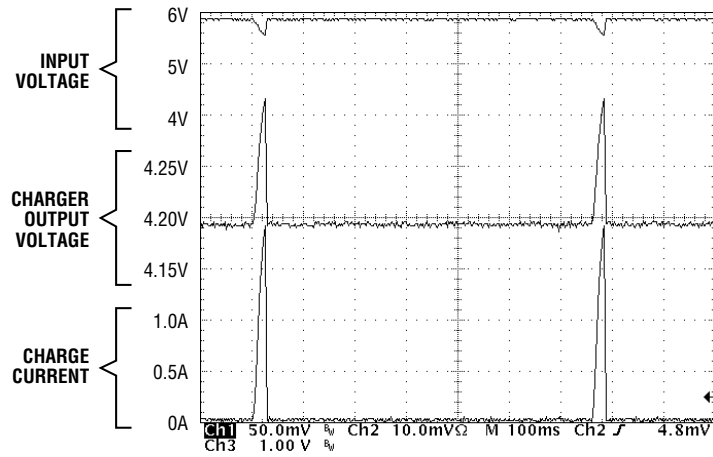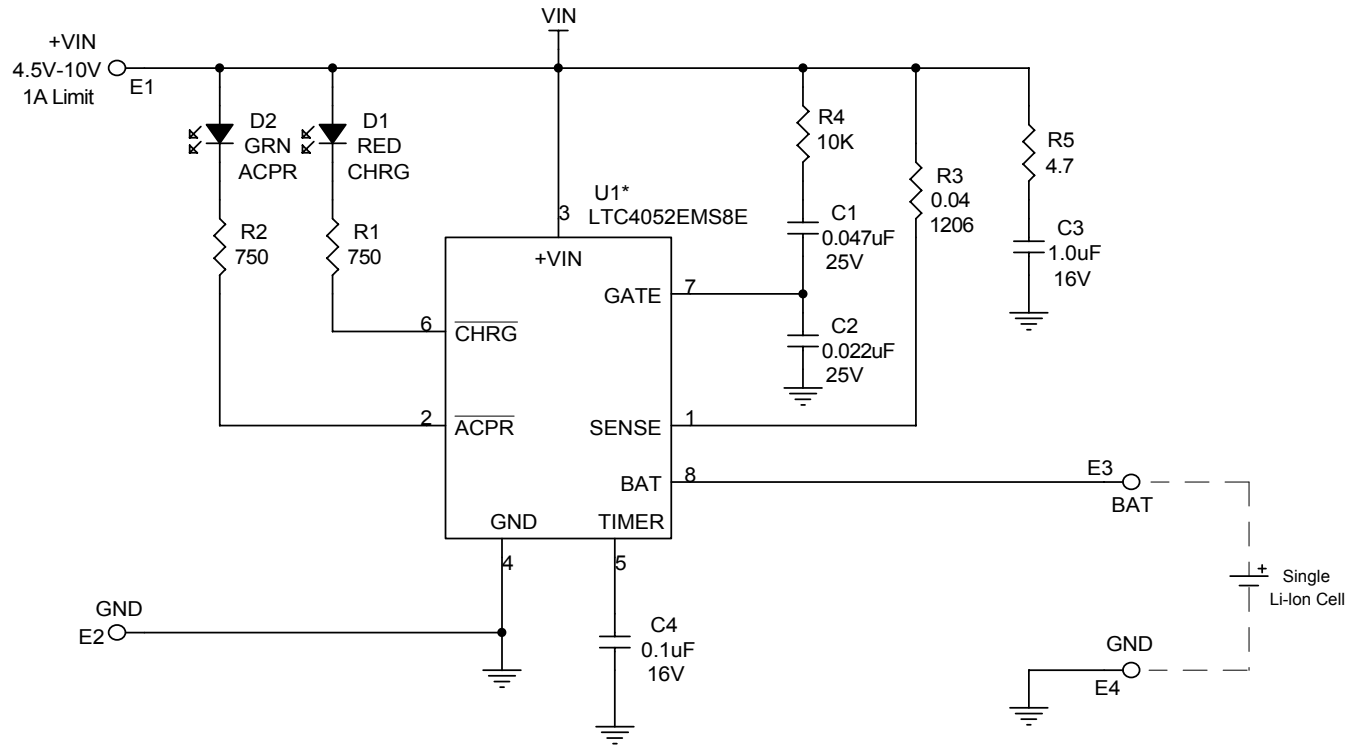

Figure 2. End of Charging Cycle

Figure 3. Overcurrent Protection

VIN

+VIN
4.5V-10V
1A Limit   E1

D2
GRN
ACPR

D1
RED
CHRG

R2
750

R1
750

U1*
LTC4052EMS8E
3

+VIN

6 $\overline{CHRG}$

GATE 7

2 $\overline{ACPR}$

SENSE 1

BAT 8

GND   TIMER
4   5

R4
10K

C1
0.047uF
25V

C2
0.022uF
25V

R3
0.04
1206

R5
4.7

C3
1.0uF
16V

E3
BAT

+ Single
Li-Ion Cell

GND
E2

C4
0.1uF
16V

GND
E4

* VERSION TABLE

VERSION	Battery Voltages	U1
DC531A-A	4.2V	LTC4052EMS8E-4.2