Simple test setup performs functional testing of linear, single-cell lithium chargers

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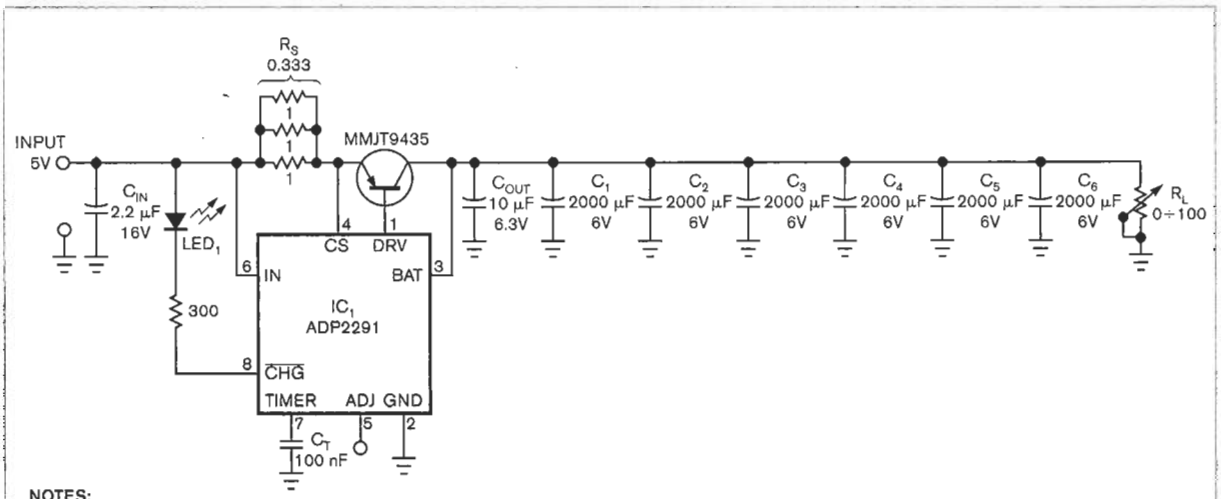
Most currently available battery chargers are switched-mode types. Yet, a niche application exists for modern lithium-ion, single-cell linear-IC chargers, which have per-cell voltage of 4.2V. Further, the 5V-dc supplies, which are convenient for supplying single lithium-cell chargers, are ubiquitous. A linear charger charges the lithium cell from the 5V supply voltage at an efficiency, η, of approximately 4.2V/5V, or 84%. Although this value is ideal, the practical value is somewhat lower because of the power consumption of the charger's control circuitry. However, its efficiency is comparable with that of the switched-mode chargers. Linear chargers also provide some additional



NOTES:
C_{IN} AND C_{OUT} ARE TANTALUM-CHIP CAPACITORS.
C_1 THROUGH C_6 ARE ALUMINUM-FOIL CAPACITORS.
C_T IS A CERAMIC-CHIP CAPACITOR.
LED_1 IS A 0805-SIZE, RED-CHIP LED.

Figure 1 A handful of off-the-shelf components allows you to qualitatively and quantitatively check the operation of a linear lithium single-cell charger.

benefits. They produce almost no EMI (electromagnetic interference), they require no inductors, and they require fewer capacitors than do switched-mode chargers.

The test setup in **Figure 1** employs IC_1, an Analog Devices (www.analog.com) ADP2291 for a lithium-cell linear charger. The device comes in 3×3-mm LFCSPs and QFN packages. The otherwise-welcome small dimensions of this IC pose an inspection problem. After soldering in the IC, you must perform a functional test of the charging circuit. You cannot rely on a visual inspection of solder joints, which are 0.5 mm apart.

In the charger circuit in **Figure 1**, for testing purposes, a bank of electrolytic capacitors substitutes for the lithium cell, dramatically reducing the charging interval and cutting the test time to seconds. Additionally, charging a capacitor has a well-defined course, and you can easily delete all previous charging and discharging by metallically short-circuiting the capacitor.

Also, a linear charger allows you to discharge the capacitor to 0V, which a lithium cell does not. After powering-on the circuit, you should momentarily light and then dim the LED annunciator to ensure that the charger is properly functioning. You estimate the time that the LED is on using the following **equation**:

$$t_{LEDON} \approx C\left(\frac{V_T}{I_{PR}} + \frac{V_{OUT} - V_T}{10I_{PR}}\right) = \frac{C}{I_{PR}}(9V_T + 1V_{OUT}),$$

where V_T is 2.8V, the threshold value of output voltage at which the charger enters its fast-charging mode; C is the total capacitance of the bank of capacitors that connect to output; I_{PR} is the precharge current; and V_{OUT} is 4.2V, the nominal output voltage at the end of the charging. The charge-current level is about 10 times that of the precharge mode. This condition occurs when you leave the ADJ (adjust) pin of the IC open. The first term in the parentheses of the **equation** corresponds to the precharge interval, and the second one expresses the charge interval. For a total capacitance of 0.012F, the precharge current is 46.5 mA, and the on-time of the LED is approximately 0.76 sec.

You can determine the value of the output threshold voltage by slowly turning the rotor of the variable-load resistor, R_L, from the minimum value of resistance until the LED dims. At that instant, you stop the rotor movement by disconnecting one end of the load resistor and measuring its value with an ohmmeter. The value of precharge current is then the output voltage divided by the measured value of the load resistor and the output voltage, or 4.2V. For the values of components in the **figure**, the experimentally determined value of a 44.4-mA precharge current is consistent with the typical value of 45 mA when the value of the current-sensing resistor is 0.33Ω (**Reference 1**).

You can measure the value of the threshold output voltage, V_T, as follows: Turn the rotor of the load resistor from minimum value of resistance while measuring the output voltage of the charger with a voltmeter. When the output voltage increases to about 2.6V, slowly proceed until the output abruptly changes to 4.2V. Using this method, you can determine the threshold voltage to be 2.75V. EDN

REFERENCE

1 "Compact, 1.5 A Linear Charger for Single-Cell Li+ Battery," ADP2291, Analog Devices, 2005, www.analog.com/en/prod/0%2C2877%2CADP2291%2C00.html.