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APPLICATION NOTE 4520

Charging Lithium Batteries with a Nonstandard Termination Voltage

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Abstract: By adding a dual op amp and some other components to a lithium-battery-charger IC, you can adjust the charging voltage to any level within the range for standard lithium batteries (3.6V to 4.2V).

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Lithium batteries have been produced over the years by many manufacturers, and they have settled into a fairly standard product—one with a maximum charge voltage of 4.2V ±1%. As a result, most of the ICs currently available for charging lithium batteries are designed to charge at 4.2V, with a tight tolerance of ±1%.

In the past few years, however, a different lithium-battery technology has reached the market, offering higher power density, accepting much higher charge and discharge rates than standard batteries, and featuring various charge-termination voltages. This design idea modifies the application circuit of a standard, high-end IC charger to provide a different termination voltage and higher current rate, while maintaining all the charger's original features.

The battery to be charged in this case is type ANR26650m1, manufactured by A123 Systems. It accepts a standard charge mode at 3A (1.3C), and can be fast-charged at 10A (4.34C) with a charge-termination voltage of 3.6V. Thus, it represents the battery types whose termination voltages range between 4.2V and 3.6V. The circuit of **Figure 1** is a modification of the application circuit for an IC designed to charge from one to four 4.2V lithium cells (MAX1737). By adding a micropower dual op amp (MAX4163) and some resistors, this modification allows you to charge 3.6V cells.

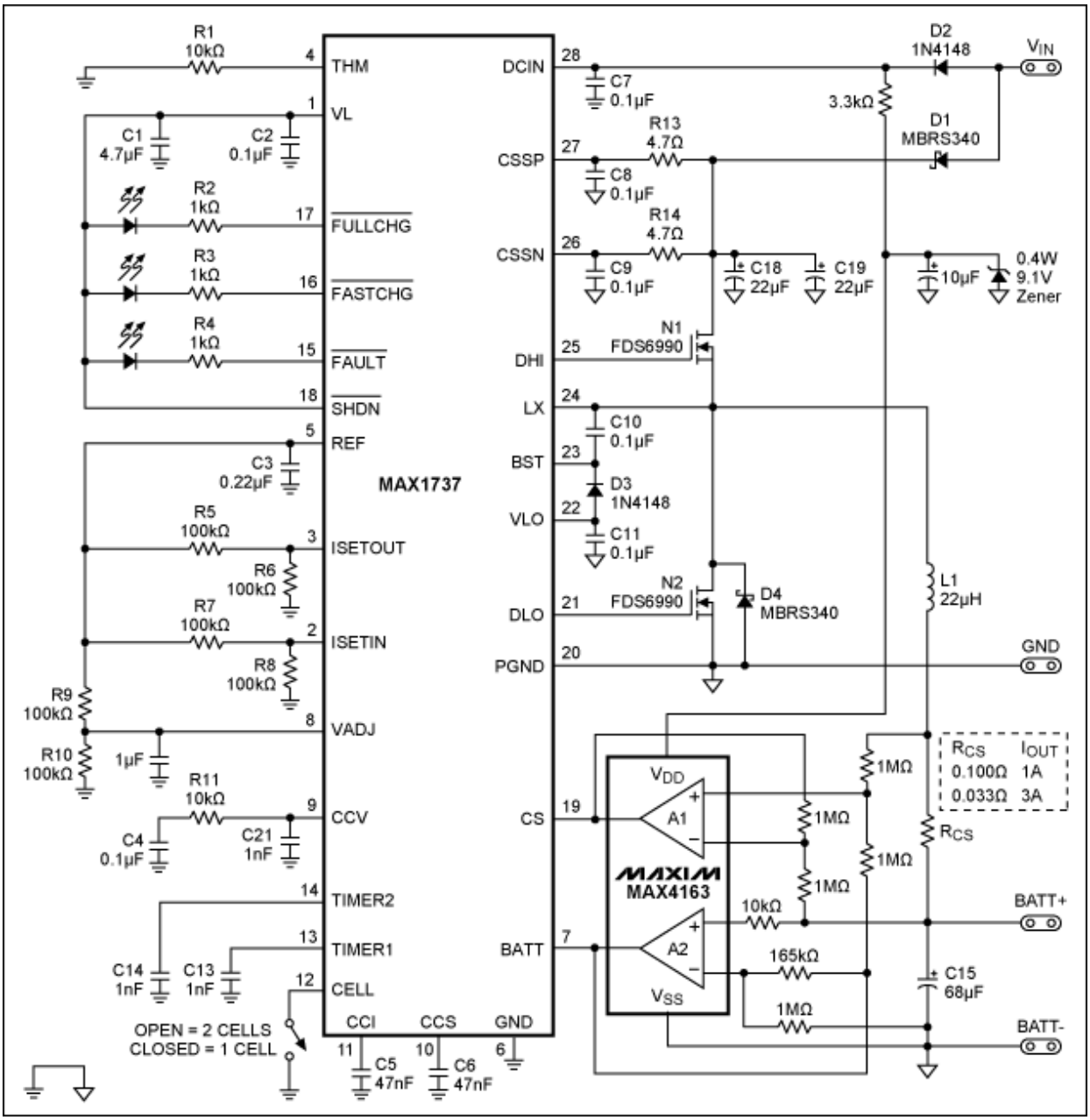

Figure 1. The dual op amp and associated external components shown enable this lithium-battery charger to accept the new lower-voltage lithium batteries.

The modification also changes the current-sense resistor value (R_{CS}), thereby increasing the charge-current limit to that accepted by the A123 Systems battery in a standard charge (3A). The power components N1, N2, D1, D4, and L1 are suitable for charging currents up to 3A.

For currents above 3A, the external switches N1–N2 should be rated for higher drain current but a similar drain voltage. They should not produce much more total switching charge than do those suggested in the MAX1737 data sheet. The maximum current rating for diodes D1 and D4 should also be increased, if charging currents are to exceed 3A.

The MAX1737 charger is internally set to switch from constant current mode (CC) to constant voltage

mode (CV) at 4.2V ±0.8%. The MAX4163 dual op amp is configured to modify that threshold. Amplifier A2 is connected as a noninverting amplifier with gain of 1.16, and therefore produces 4.2V when its input is 3.6V. The A2 output connects to the charger's BATT terminal (normally used to sense the battery voltage), so the charger now switches from CC to CV at a battery voltage of 3.6V.

The A2 input connects to the positive terminal of the battery to be charged. If the resistors associated with A2 have 1% tolerance, the termination-voltage error is 3.62V -1.1%/+1.2%. With better-tolerance resistors, this error can approach that of the charger (0.8%). You can also obtain better accuracy using the charger's VADJ function (pin 8).

Amplifier A1 is configured as a differential amplifier with gain of one. Its reference (the voltage assumed by the output when the differential input voltage is zero) is the A2 output. A1's output connects to the charger's CS terminal. (The IC senses charging current as the voltage difference between BATT and CS.) When the drop across R_{CS} is zero, the difference between BATT and CS is also zero. A1's differential inputs connect across R_{CS}. Thus, the voltage across them is repeated by the gain-of-one circuit as the voltage difference between terminals BATT and CS, as the IC requires. With the ISETOUT terminal set at $½V_{REF}$, the battery charges to a CV of 3.6V/cell, with a charging current of $0.100V/R_{CS}$ delivered at the A1 output.

The other parameter affected by these modifications of the charger's sense inputs is the voltage at which full charge is allowed to begin (2.5V/cell for this charger, when unmodified). Amplifier A2 scales down this voltage (to 2.14V) by the same factor as that applied to the CC/CV switchover voltage. When a battery voltage less than 2.14V is connected, the charger goes into a prequalification mode, in which it charges at 1/10 the I_{OUT} setting until the voltage rises above 2.14V. It then applies the full charging rate.

The dual op amp's maximum supply voltage imposes a limit of two on the maximum number of cells this circuit can charge. **Figure 2** shows the V/I charging curve obtained using the modified circuit of Figure 1. Full data sheets and other info on the MAX1737 and MAX4163 can be found at www.maximintegrated.com.

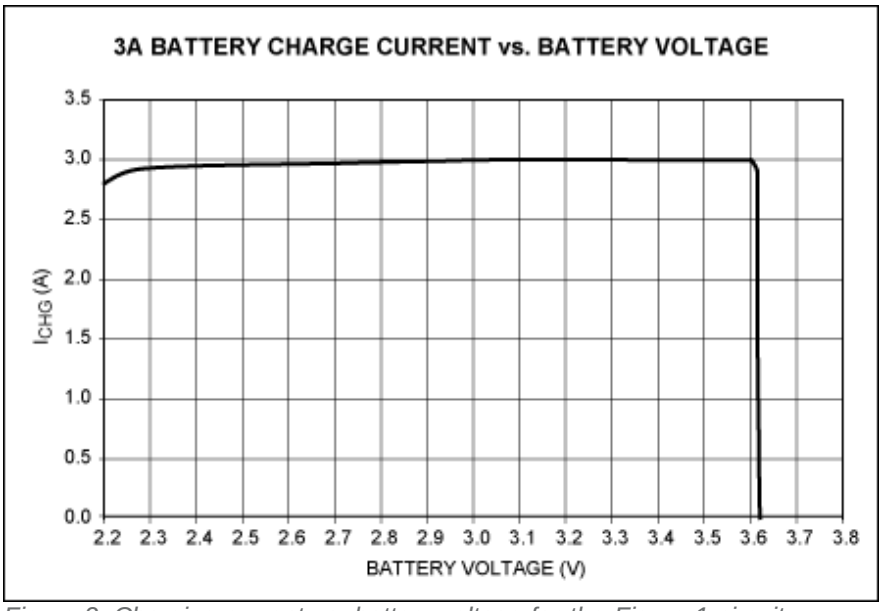

Figure 2. Charging current vs. battery voltage for the Figure 1 circuit.

Related Parts		
MAX1737	Stand-Alone Switch-Mode Lithium-Ion Battery-Charger	Free Samples

	Controller	
MAX4163	SOT23, Micropower, Single-Supply, Rail-to-Rail I/O Op Amps	Free Samples

More Information
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