Circuits monitor and balance large lithium-ion batteries

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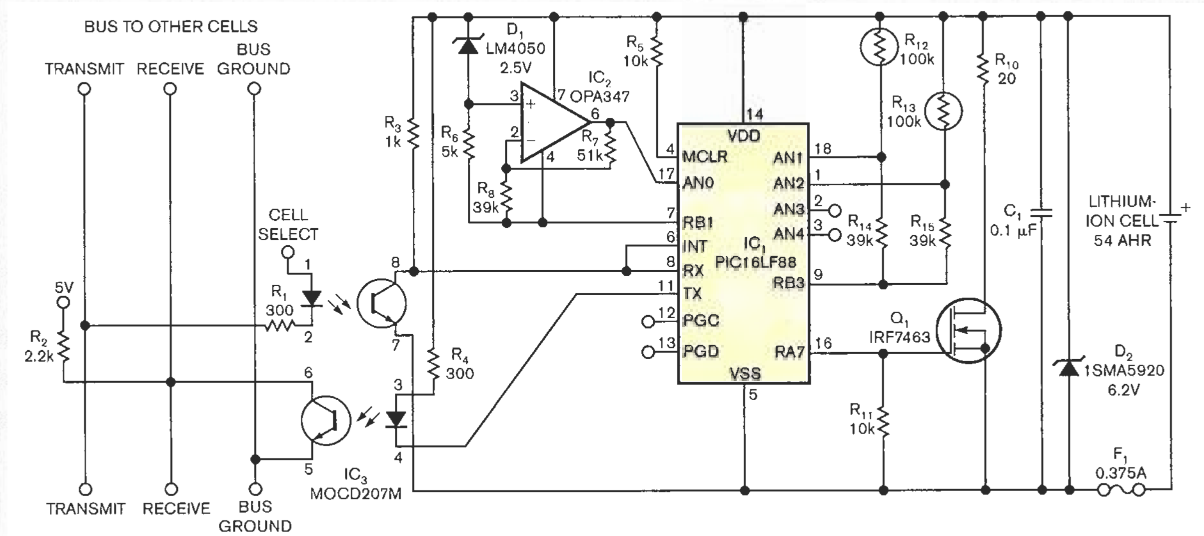
When using rechargeable lithium-ion cells in large batteries, such as those in an electric vehicle, you encounter unique problems. Bus voltages greater than 100V preclude the use of a standard IC for overcharge and overdischarge protection. In addition, because many cells connect in series, small differences in cells' self-discharge rates eventually lead to unequal levels of charge. Therefore, you must correct the cell balance. This Design Idea provides one strategy for protecting and balancing large, high-voltage batteries. The circuit in **Figure 1** monitors



NOTE: R_{12} AND R_{13} ARE VISHAY 232264066104 THERMISTORS.

Figure 1 A microcontroller connects directly to a lithium-ion cell and a battery string to monitor the cell's voltage and temperature. This process shunts current through R_{10} under program control to equalize the cell's self-discharge. Each cell in the battery gets its own monitor. The monitors communicate with a controller through optoisolators.

the voltage of a single lithium-ion cell that connects in series in a battery. The circuit communicates with a supervisor processor. The supervisor monitors all cells in the battery, opens a protection switch in case of a problem, and determines where and when balancing is necessary. This approach easily scales to an arbitrarily high bus voltage.

A PIC16LF88 microcontroller gets power directly from the cell voltage, which ranges from 3 to 4.2V. With no need for voltage regulation, the quiescent current of the entire circuit is less than 1 μA, minimizing self-discharge of the battery. Fuse F_1 and zener D_2 protect the monitor from high voltage in the unlikely event that the cell becomes disconnected from the battery. An optocoupler connects between the cell monitor and an asynchronous serial bus, running at 9600 baud. A cell-select line, driven by the supervisor, selects one cell at a time. The MOCD207M optocoupler has a tightly toleranced current-transfer ratio, so it operates predictably over the possible range of supply voltages. Although the quiescent current of this isolator is near zero, the supervisor can wake up the monitor from sleep at any time by sending a pulse over the serial line.

The monitor measures cell voltage by measuring the fixed voltage of the LM4050 with respect to the unknown supply. Op amp IC_2 scales the signal to achieve 3-mV resolution using the microcontroller's built-in 10-bit ADC. The reference, op amp, and gain error introduce voltage offsets, which you can calibrate in software. The remaining error arises from temperature variation of these parameters. R_7 and R_8 use a temperature coefficient of 25 ppm/°C. The resulting accuracy of the voltmeter is ±7.5 mV over 0 to 50°C. By biasing the reference from a digital output, the voltmeter draws current only when necessary. The same trick biases several thermistors, which measure the temperature of the monitored cell.

This cell monitor can balance an overcharged cell by shunting 200 mA through R_2. Although the shunt current is smaller than the battery's maximum discharge current of 12A, it is more than enough current to balance the differential self-discharge of series-connected cells. EDN