Improved Control of Charging Voltage for Li-Ion Battery

Charging potential would be increased by the internal resistive voltage drop.

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The protocol for charging a lithium-ion battery would be modified, according to a proposal, to compensate for the internal voltage drop (charging current × internal resistance of the battery). The essence of the modification is to provide for measurement of the internal voltage drop and to increase the terminal-voltage setting by the amount of the internal voltage drop.

Ordinarily, a lithium-ion battery is charged at constant current until its terminal voltage attains a set value equal to the nominal full-charge potential. The set value is chosen carefully so as not to exceed the lithium-plating potential, because plated lithium in metallic form constitutes a hazard. When the battery is charged at low temperature, the internal voltage drop is considerable because the electrical conductivity of the battery electrolyte is low at low temperature. Charging the battery at high current at any temperature also gives rise to a high internal voltage drop. In some cases, the internal voltage drop can be as high as 1 volt per cell. Because the voltage available for charging is less than the terminal voltage by the amount of the internal voltage drop, the battery is not fully charged (see figure), even when the terminal voltage reaches the set value.

In the modified protocol, the charging current would be periodically interrupted so that the zero-current battery-terminal voltage indicative of the state of charge could be measured. The terminal voltage would also be measured at full charging current. The difference between the full-current and zero-current voltages would equal the internal voltage drop. The set value of terminal voltage would then be increased beyond the nominal full-charge potential by the amount of the internal voltage drop. This adjustment would be performed repeatedly, in real time, so that the voltage setting would track variations in the internal voltage drop to afford full charge without risk of lithium plating. If the charging current and voltage settings were controlled by a computer, then this method of charge control could readily be implemented in software.

This work was done by Gray Creech of Dryden Flight Research Center. Further information is contained in a TSP (see page 1).

Effect of Charging Current on Charge Capacity at Temperature of –20 °C

The Charge Capacity attainable by charging a representative Li-ion battery at constant current decreases with increasing current if the end-of-charge battery-terminal voltage is limited to a nominal full-charge value, because of internal ohmic voltage drop.