Charge-Control Unit for Testing Lithium-Ion Cells

This unit is useful for testing any non-aerospace battery cells.

John H. Glenn Research Center, Cleveland, Ohio

A charge-control unit was developed as part of a program to validate Li-ion cells packaged together in batteries for aerospace use. The lithium-ion cell charge-control unit will be useful to anyone who performs testing of battery cells for aerospace and non-aerospace uses and to anyone who manufacturers battery test equipment. This technology reduces the quantity of costly power supplies and independent channels that are needed for test programs in which multiple cells are tested. The cost savings that were achieved in a test program are shown in Figure 1. Battery test equipment manufacturers can integrate the technology into their battery test equipment as a method to manage charging of multiple cells in series.

The unit manages a complex scheme that is required for charging Li-ion cells electrically connected in series. The unit makes it possible to evaluate cells together as a pack using a single primary test channel, while also making it possible to charge each cell individually. Hence, inherent cell-to-cell variations in a series string of cells can be addressed, and yet the cost of testing is reduced substantially below the cost of testing each cell as a separate entity.

In the original aerospace application, life-test data on Li-ion cells is critical in order to assess their performances and capabilities relevant to NASA missions and exploration goals. For example, for many NASA missions that involve flight in low orbits around the Earth, batteries are required to endure more than 30,000 charge/discharge cycles, and Li-ion batteries are relatively new to this type of application. The scheme required for charging Li-ion cells is more complex than that typically required for charging the alkaline cells that the Li-ion cells may supplant. This scheme includes the establishment and enforcement of strict cell voltage limits to ensure safe, long operation.

So that this requirement could be addressed in laboratory testing, the present charge-control unit was developed to manage the current through each

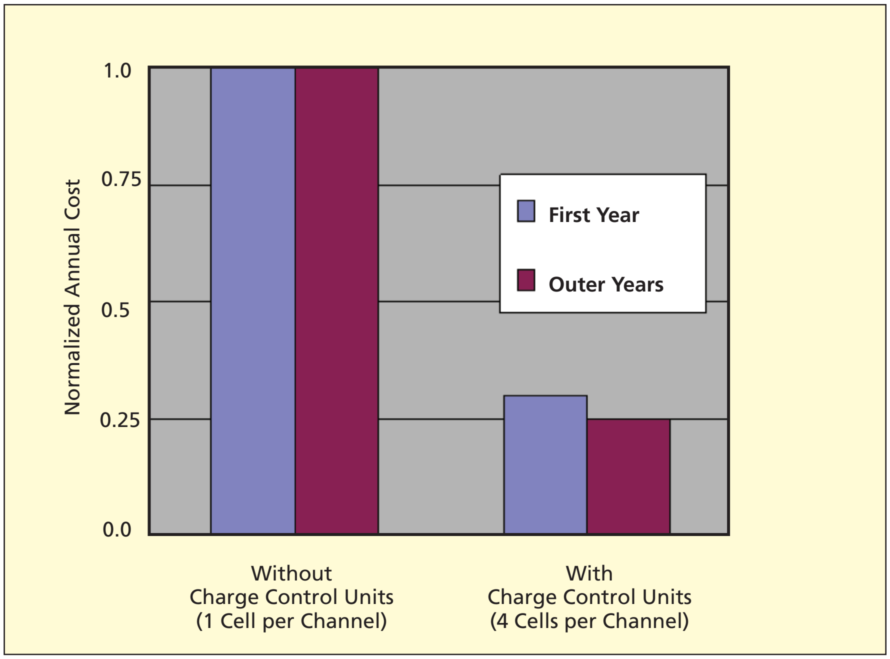


Figure 1. A **Comparison of the Annual Costs** of a three-year battery cell test program is shown without charge control units and with charge control units (escalation is neglected). The first year costs include the capital cost of the charge control units.

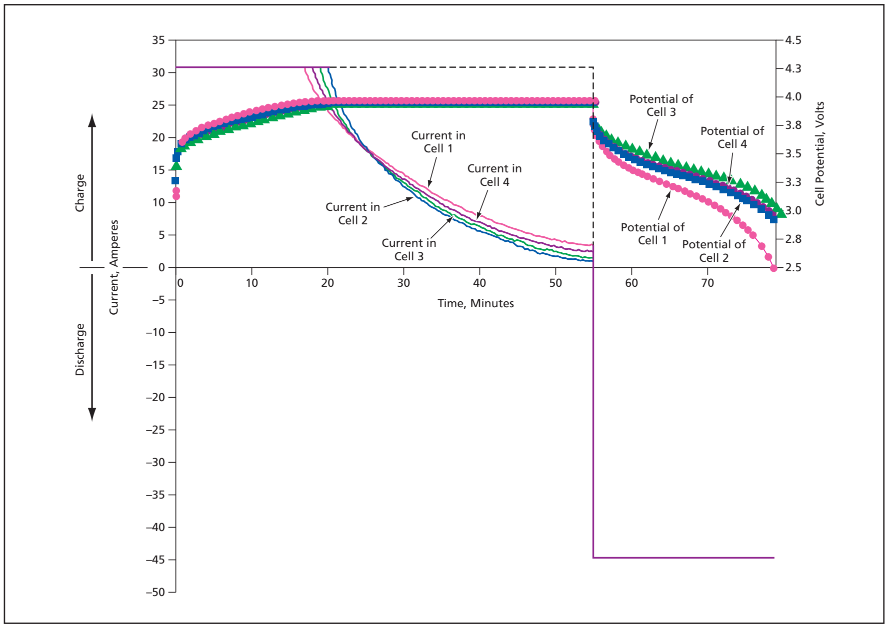


Figure 2. **These Current and Voltage Plots** represent measurements on four series-connected, unmatched Li-ion cells that were charged by use of the present charge-control unit for 55 minutes, then discharged.

cell once the voltage of the cell reaches the established limit. By use of this unit, multiple Li-ion cells connected in series within a battery pack can be charged from a single current source, and yet the charging of each cell is controlled independently of the other cells. More specifically, by use of this unit:

- Each cell in the series string is charged at full current until the cell voltage reaches the limit;
- Once the voltage of a given cell reaches the limit, the voltage is held at that limit and the current through that cell is tapered off so that the cell continues to gain some charge without becoming overcharged; and
- Even after some cells have reached voltage limit, other cells that are at lower states of charge continue to be charged at full current until they reach the voltage limit (see Figure 2).

The unit consists of electronic circuits and thermal-management devices housed in a common package. It also includes isolated annunciators to signal when the cells are being actively bypassed. These annunciators can be used by external charge managers or can be connected in series to signal that all cells have reached maximum charge. The charge-control circuitry for each cell amounts to regulator circuitry and is powered by that cell, eliminating the need for an external power source or controller. A 110-VAC source of electricity is required to power the thermal-management portion of the unit. A small direct-current source can be used to supply power for an annunciator signal, if desired.

This work was done by Concha M. Reid, Michelle A. Manzo, and Robert M. Button of Glenn Research Center and Russel Gemeiner of QSS Group, Inc. Further information is contained in a TSP (see page 1).

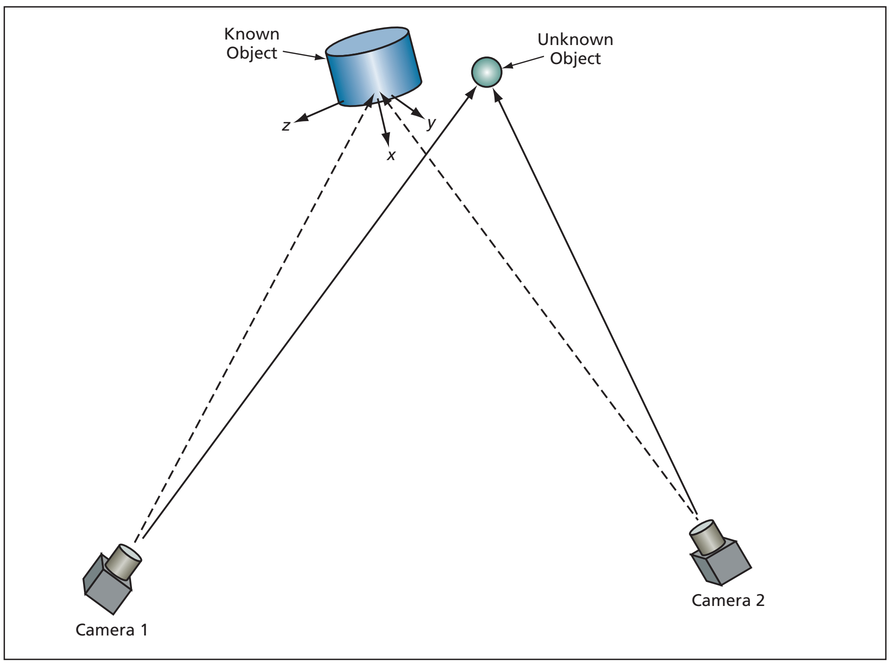
Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17703-1.

Measuring Positions of Objects Using Two or More Cameras

This method could determine the causes of accidents.

John F. Kennedy Space Center, Florida

An improved method of computing positions of objects from digitized images acquired by two or more cameras (see figure) has been developed for use in tracking debris shed by a spacecraft during and shortly after launch. The method is also readily adaptable to such applications as (1) tracking moving and possibly interacting objects in other settings in order to determine causes of accidents and (2) measuring positions of stationary objects, as in surveying. Images acquired by cameras fixed to the ground and/or cameras mounted on tracking telescopes can be used in this method.



Two Cameras Are Aimed at a pair of possibly moving objects, at least one of which is known. The positions and orientations of the cameras relative to the known object need not be known initially: instead, they are determined by means of photogrammetric computations.

In this method, processing of image data starts with creation of detailed computer-aided design (CAD) models of the objects to be tracked. By rotating, translating, resizing, and overlaying the models with digitized camera images, parameters that characterize the position and orientation of the camera can be determined. The final position error depends on how well the centroids of the objects in the images are measured; how accurately the centroids are interpolated for synchronization of cameras; and how effectively matches are made to determine rotation, scaling, and translation parameters.

The method involves use of the perspective camera model (also denoted the point camera model), which is one of several mathematical models developed over the years to represent the relationships between external coordinates of objects and the coordinates of the objects as they appear on the image plane in a camera. The point camera model is implemented in a commercially available software system for three-dimensional graphics and animation used in television, film, industrial design, architecture, and medical imaging.

The method also involves extensive use of the affine camera model, in which the distance from the camera to an object (or to a small feature on an object) is assumed to be much greater than the size of the object (or feature), resulting in a truly two-dimensional image. Using a technique common in photogrammetry as practiced in aerial surveying, depth information is obtained from a combination of image data acquired from two or more cameras. Synchronized image data from two or more cameras are combined