



Current Interrupt Charging Algorithm

Extending Deep Cycle Life of Valve-Regulated Lead Acid Batteries

Transportation FOR THE 21ST CENTURY

ENERGY EFFICIENCY AND RENEWABLE ENERGY

OFFICE OF TRANSPORTATION TECHNOLOGIES



Background

The performance and lifecycle costs of battery electric vehicles (BEVs) and hybrid electric vehicles (HEVs) are closely tied to their energy storage systems. The nickel-metal hydride (NiMH) battery has been the recent battery of choice for these vehicles because of its high specific energy and long cycle life. However, NiMH batteries are expensive, and researchers have looked for methods of extending the cycle life of less costly valve-regulated lead acid (VRLA) batteries in order to make them competitive with NiMH systems. VRLA units are also suitable for high-volume production methods, and their recyclability makes them environmentally sustainable. An improvement in their deep cycle life by a factor of three or four would make them practical for use in transportation systems.

The National Renewable Energy Laboratory (NREL), with support from the Department of Energy's Office of Transportation Technologies, has developed an award-winning "current-interrupt technique" that extends the life of a lead acid battery by a factor of four. NREL worked in partnership with Recombination Technologies and Optima Batteries, Inc., to achieve this success. In 2001, the three organizations were awarded an R&D 100 Award from *Research and Development Magazine* for their accomplishments.

The Technology

Researchers used the following working hypothesis in approaching their problem:

There are two reasons why a VRLA battery reaches its end-of-life prematurely when subjected to a conventional constant current/voltage charge: (1) insufficient recharge at the negative plate, and (2) interference with recharge of the negative

plate by the "oxygen cycle" or recombination reactions, which cause oxidation of sulfuric acid into sulfate.

The new technique involves applying a current to the battery for 5 seconds, overcharging it slightly, then interrupting the current for 5 seconds to cool the battery and prevent its going into the oxygen recombination phase. Tests on a pack of 24 Optima yellow-top batteries verified that the VRLA battery can sustain 700 deep discharge cycles with this method, four times more than when it is charged with a standard constant current/voltage system. The research team hopes to eliminate the battery management system, further lowering the cost of producing and using this battery.

Commercialization

Auto manufacturers and charging companies have recognized the significance of the new technology for electric and hybrid electric vehicles. As the vehicles become more reliable and cost-efficient, they will attract a greater consumer following.

Charging companies have expressed interest in incorporating the technology in various chargers and controllers. The Ford Motor Company has tested current-interrupt charging for its potential use in its BEV and HEV programs, and has observed significant improvement in the performance and life of the traction batteries when using variants of this charge regime. The company's latest generation of BEV battery controllers has been designed to accept current-interrupt algorithms similar to those developed by NREL and Recombination Technologies. Ford sees lead acid batteries as the most likely near-term solution to energy storage, and believes the breakthrough technology of current-interrupt charging will enable large-scale deployment of electric vehicles.

Success Story

Benefits

- The current-interrupt technique extended deep cycle life of Optima lead acid battery module to 700 deep discharge cycles (4 times better than using standard constant current/voltage charging).
- High inrush currents prevent the loss of capacity in the negative plates of valve-regulated lead acid batteries.



Optima battery pack used to test cycle life

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