MIKE MILLER

The secret life of batteries

A BREAKTHROUGH IN BATTERY MONITORING TECHNOLOGY IS DELIVERING MAJOR BENEFITS ACROSS THE ELECTRIC VEHICLE INDUSTRY, FROM BATTERY MANUFACTURERS AND VEHICLE OEMs TO THE END USERS

Battery management is a complex issue for fleet managers and other end users. For reasons of productivity, safety and cost control, it is essential to know how long the battery life will be, what the state of charge is, how healthy the battery is, and other key aspects of battery functionality. Damage, premature depletion and improper battery maintenance can lead to vehicle downtime or costly battery replacement.

Concerning the science of battery life, Eugene Finger wrote *The Battery Book*. Finger was a Curtis Instruments engineer whose comprehensive analysis of battery functionality became the standard industry reference. His book is still available, and can now be downloaded from the Curtis website.

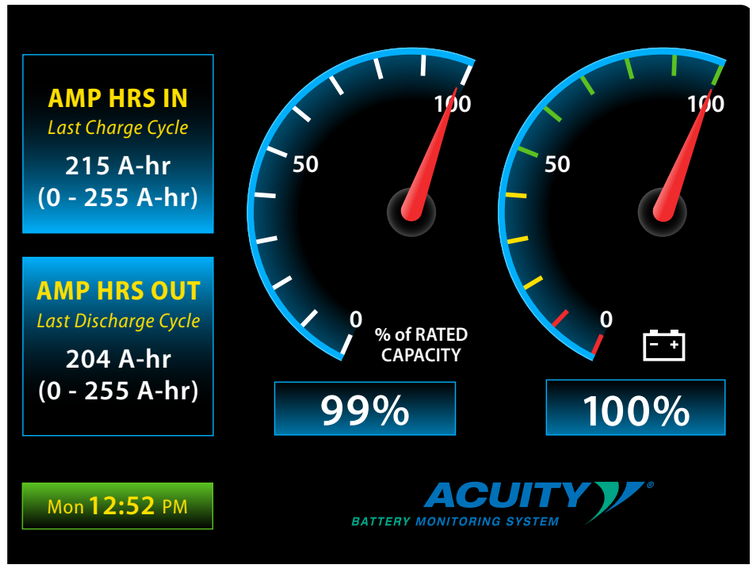
Battery monitoring

Historically, Curtis Instruments – a global leader in integrated systems technology for electric off-highway vehicles – has also been a leader in battery monitoring. Founded in 1960, Curtis patented Battery Discharge Indicators (and coined the term BDI) in the 1970s. However, while these early battery fuel gauges were the state-of-the-art in battery charge measurement, they only indicated discharge.

Early-generation BDIs were mostly used on forklift trucks that typically ran in three shifts. These gauges rode on the vehicle, measuring only the voltage of the battery. The management method was to use the battery almost to the point of depletion, then drive the vehicle to a battery-changing station, where a crane would lift out the drained battery and replace it with a fully charged one. An expensive, awkward and time-consuming system, to say the least.

Finger dreamed of a better solution. He foresaw more accurate measurements and readings by understanding not just the voltage, but also the current of the battery, and what specifically happened during the charge cycle. He realised that if you could measure both current and voltage, and if the device travelled with the battery, then you would achieve the most accurate assessment of the state-of-charge (SOC).

Now Curtis has achieved that goal, and made it affordable for the marketplace. The Acuity battery monitoring system is a revolutionary step in modern vehicle battery monitoring. It is a highly intelligent battery monitor that delivers considerable benefits



Battery information is displayed in real time on the Curtis enGage VII or any other CAN-based display

right across the industry, to battery manufacturers, vehicle OEMs and end users alike.

During the Acuity development process, Curtis engineers sought to fulfil three key value points:

- Provide the highest accuracy SOC information possible, clearly quantifying the amount of energy remaining at any given time;
- Serve as a warranty witness (validating that the battery has or has not been operated within its conditions of warranty);
- Function as a productivity tool, indicating the condition of the battery in addition to SOC.

The new Curtis Acuity mounts directly onto the battery for exact readings of both voltage and current, delivering the most accurate SOC possible. As the industry's most reliable battery monitoring tool, Acuity is a viable warranty witness and productivity tool, providing detailed information on battery life, state of charge, maintenance and abuse incidents. Many decades of battery expertise have enabled its development.

Acuity resolves the ongoing debate between vehicle manufacturers, battery manufacturers and end users as to when battery performance is not as guaranteed. It provides proof positive of compliance or non-compliance within warranty guidelines.

The technology also enables end users to manage their fleets with far more efficiency. They can get the most work out of each charge and each battery; can know in advance what will need replacing, and when; identify abuse patterns that can be rectified; and, in general, achieve more control over fleet performance.

In order to technically solve the problem of a more complex, comprehensive battery reading, a new algorithm was needed. The old maths calculated SOC by integrating the battery voltage over time. As work

The Curtis Acuity device connects directly to the vehicle battery, where it collects and transmits accurate battery state-of-charge and battery-condition information.

was done by the vehicle, the battery voltage decreased and the time that the voltage was below a reference voltage was accumulated, with the resulting SOC being displayed on the gauge.

The new algorithm to calculate a more accurate SOC takes into account multiple charge and discharge scenarios. Acuity calculates SOC by integrating current, voltage and temperature (using an integrated temperature sensor) at multiple discharge rates. It is far more precise than previous algorithms and is what Curtis engineers like to call 'the secret in the sauce'.

Each Acuity device mounts onto the battery, has a unique serial number, and is intended to spend its life on the battery. It provides a full and constantly updated history: how long the battery has been in service, how often it has been charged, and to what level discharged. Any discrepancies in usage are noted. There are about two dozen data points – see box (overleaf) for a sample listing.

Longevity and ease of use

Acuity connects to the vehicle's CANbus system, integrating seamlessly into the Curtis drive system. It also communicates effortlessly with all standard Curtis products and tools, including all enGage displays, all CAN-based motor controllers (including AC), and is accessible with Curtis handheld programmers via Curtis's Vehicle Control Language (VCL).

Installation could hardly be more simple, without any hardware or brackets involved. You basically just put the battery cable through the Acuity current sensor, connect the CAN wires, and tie it into place for plug-and-play performance.

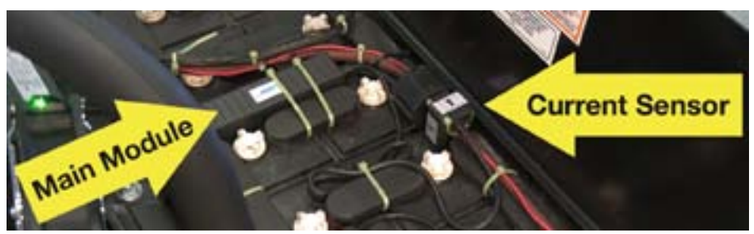
All solid state, Acuity has no moving parts, and is designed to last at least 10 years – the average life cycle of a forklift truck. It is equally at home on golf cars, aerial lifts, sweeper/scrubbers, scissor lifts, etc.

Although the device attaches to the battery and is meant to stay connected for the life of that battery, Acuity is not averse to remarriage. It can be remounted on a new battery if it outlasts its first companion.

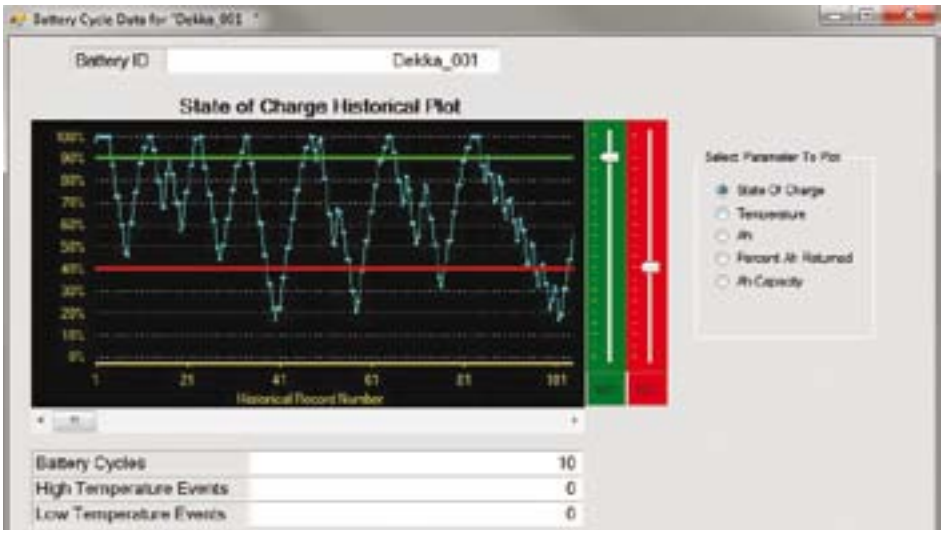
The standard Curtis Acuity system enables users to access battery data from the vehicle's CANbus either via the on-vehicle display or via the handheld programmer or equivalent device using VCL. Once the device is in place, you get information, not just data. Tools to program, read, interpret and apply the information include an on-vehicle display, PC software tools and a handheld programmer connected to the controller.

Rich information

Curtis has created a standalone software program – an optional Acu-Set software kit that greatly enhances this process. The kit consists of software and a dongle which allows the Acuity data to be read by a PC. This proprietary software reads the data and translates it into clearly accessible and actionable information.



ABOVE: **The Curtis Acuity Battery Monitoring System is easy to install. Shown is the Curtis Acuity on the battery of a Class 3 powered pallet truck**



The Acu-Set software translates the Acuity battery data into easy-to-read performance data. It also calculates Percent Rated Capacity (PRC) – the actual energy the battery can deliver as compared to its rated capacity

The Acu-Set tool also allows easy programming of the Acuity, the ability to read instantaneous battery data and store battery data into the PC. Matching Acuity parameters to a specific battery brand and model is easier than ever: most models can be selected from a comprehensive pull-down menu, or a custom battery profile can be manually entered. Reading battery information for productivity, maintenance and warranty witness is extremely simple with this software tool. The user can see instantaneous or historical data of the measured values in comprehensive displays, including in chart format. Fleet managers can easily access the full range of battery data points via wired or wireless means. The Acu-Set software also stores the data collected by the Acuity battery monitoring system.

With battery costs running in the range of US$5,000-7,000, the economical Acuity can very quickly pay for itself by identifying faulty batteries and preventing abuse that shortens battery life. It therefore presents an extremely affordable battery monitoring solution with excellent ROI by saving abuse and forcing warranty terms.

Looking ahead

Curtis Acuity presents the possibility of a new business model: a rental approach to EV usage. Dealers can approach their customers and say: "Only pay for the energy you are using" – similar to paying for mileage on a rental car or truck.

Also to be seen in the near future, a working model of a wireless communications version is now in the Curtis engineering lab. This variation will enable Acuity to communicate via Zigbee, WiFi or Bluetooth. Any time the device is in range of a WiFi hotspot, the operator or manager can access and 'talk to' the vehicle from anywhere in the world. Readings can be made from the fleet manager's office, warehouse or company HQ, supplying vital data for superior battery management and optimal fleet performance. **iVT**

Mike Miller is director of product management, Curtis Instruments, Inc.

Keeping track

Based on Acuity readings, operators can avoid the leading causes of battery damage:

- True accuracy in measuring depletion avoids usage below 80% depth of discharge, the recommended recharge level;
- Because batteries are strongly affected by temperature extremes, Curtis Acuity includes a temperature sensor integrated into the harness.

Acuity provides data – translated by Curtis software into readable information – on the following points:

- Battery voltage;
- Battery current;
- Battery temperature;
- Ampere hours in;
- Ampere hours out;
- State-of-charge (SOC);
- State-of-health;
- Battery serial number;
- Highest voltage measured;
- Lowest voltage measured;
- Highest temperature measured;
- Lowest temperature measured;
- Current measured at highest voltage;
- Current measured at lowest voltage;
- Highest SOC measured;
- Lowest SOC measured;
- Date;
- Time;
- … and more!

The Curtis Acuity monitors the voltage, current and temperature (with integrated temperature sensor) of a battery to determine accurate state-of-charge, battery warranty status and battery productivity

CONTACT
www.curtisinstruments.com
www.evbatterymonitoring.com