Watching Out for You

We increasingly rely on technology to provide us with a feeling of security. Cameras, emergency telephones and safety lighting have a reassuringly high profile, letting us know they are available if needed. Ensuring their availability in an emergency can often demand an infallible power supply, which in turn falls to backup battery. But how do you know your battery backup is infallible?

This problem beleaguers manufacturers of equipment that rely on batteries for emergency power. This is a particularly relevant question for UPS manufacturers, as the sole purpose of UPS systems is to supply electricity in case of a power failure. In these circumstances it is not only imperative to have power, but also to have the power delivered within definite time and supply tolerances.

Most battery backup systems are constructed from a number of valve regulated lead acid (VRLA) cells to create monobloc batteries. Although described as maintenance free, the technology has well-known weaknesses, any one of which can render the battery inefficient or even completely inactive.

Weak, aged, or otherwise “unhealthy” batteries therefore represent a serious hazard in these systems, so it is commonplace to carry out regular maintenance checks on their state of health (SOH) and state of charge (SOC). However regularly these are done, there is still a risk of a battery failure occurring between checks. To eliminate this uncertainty, some companies are turning towards systems that offer constant SOH and SOC monitoring, in-situ.

Continuous Monitoring

While it may sound like a simple solution, continuous monitoring can typically add 50 percent to the cost of a battery, even reaching as much as 70 percent, incurring installation and operation. With such a high cost, it often proves cheaper to replace the batteries before the mean time before failure (MTBF) suggests they have reached their end-of-life. However, like routine maintenance, this too is fraught with uncertainty because environmental conditions affect the MTBF of a battery as well.

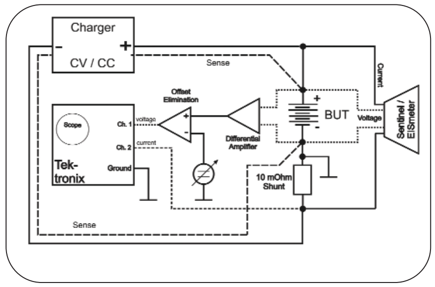
Many manufacturers seek a low cost, continuous monitoring system that provides comprehensive diagnostics of a battery’s SOH and SOC, under all conditions. In March 2007, LEM teamed up with RWTH Aachen University, one of the world’s leading authorities on sealed and vented lead acid batteries diagnostics and management, to set a roadmap for the development of low cost battery monitoring management.

RWTH Aachen University has maintained and furthered a center of excellence that concentrates on the most established and widely selling battery chemistry. The LEM-Aachen partnership is a long term co-operation to research the failure modes of VRLA flooded and gel batteries and to look at the next generation of monitoring and analysis systems, including SOH and SOC.

LEM has continued the development of its solution for continuous monitoring, known as Sentinel. This battery monitoring system derives key electrical parameters under test to determine the ability of the battery to perform in the event of a mains failure by combining accurate temperature with accurate ripple current measurements. A single-chip solution capable of measuring cell voltage, internal temperature and internal impedance, Sentinel offers a level of diagnostic measuring comparable to that offered by much more sophisticated laboratory equipment, but at a cost that does not prohibit its application as a continuous monitoring solution.

In order to develop Sentinel, LEM conducted extensive R&D using the aforementioned lab-based equipment, employing a wide selection of battery makes and brands. In this case, the method being applied and replicated in Sentinel is electrochemical impedance spectroscopy.

It is worth outlining exactly what level of diagnostics this methodology achieves, and how that can help protect the integrity of a battery-based UPS?



Test set-up for the evaluation of the monitoring devices

An Aging Problem

The majority of systems in this class use lead-acid battery technology, a technology that is well known to suffer from degradation in capacity and increase of internal resistance due to aging. Because the technology is so well established, the aging condition is also well understood and can be identified through the detection of several phenomena.

The use of lead-acid batteries in UPS systems is likely to increase. The failure of an individual cell could spell catastrophe for any system employing a UPS. That failure can be predicted, averted and, therefore, cost-effectively rectified long before any collateral damage occurs.

An effect that is particularly common in the aging condition is loss in capacity, due to the use-model of the batteries. In a UPS, batteries are discharged with a high current, which can lead to the growth of large crystals on the electrodes. This can be partly controlled through battery conditioning, but in severe cases it can prove irreversible. If left undetected, the growth of small crystals, or dendrites, can grow together and create short-circuits within the battery. A short-circuit may also result from internal corrosion, where flakes from the terminals drop onto the electrode. Contributors to corrosion include temperature, voltage and local acid concentration, normally affecting the positive terminal. Any of these age-related effects will lead to a loss of battery capacity, or power, and so any kind of diagnostic must be capable of identifying them, in order to take the appropriate action.

RWTH Aachen University used an electrochemical impedance spectroscope (EISmeter) to employ full spectrum measurement, applying a series of sinusoidal waveforms to the battery. The resulting impedance has measured across a spectrum of frequencies between a few mHz and 7.5 kHz. The results, through Fourier analysis, calculates the real and imaginary part of the voltage response for a given frequency. The complex impedance, can be obtained by analyzing the relationship between the voltage response and the excitation current, in amplitude and phase angle.

Trend Analysis

For the purposes of battery diagnosis, it is the relative differences that are of interest. As the measurements are carried out on a continuous basis, it is the trend data that is important. Coupled with temperature and voltage measurement, this can all be carried out using a single integrated circuit.

Sentinel’s single integrated circuit monitoring for VRLA and flooded cells provides measurement for individual cells and monoblocs for internal temperature, voltage and impedance as standard. Each module monitors an individual cell or monobloc, from 2 V to 12 V nominal, reporting over a proprietary communications bus to a battery data logger (BDL).

An integrated temperature sensor provides continuous measurements of individual cell skin temperatures, which enables thermal mapping of the battery. Though its use is an expensive additional service cost, it is essential in the detection of thermal runaway and enables intelligent temperature controlled charging profiles. Not subject to the restrictions of a single ambient sensor, cell skin temperature is more accurate and reliable.

Impedance is known to change in most modes of failure and it remains the most effective method of detecting deterioration of failure in a cell. In order to achieve true readings, it is necessary to test a cell at a current level sufficient to penetrate the surface charge present.

Having a unique True Energy Layer method of impedance measurement, together with a robust test current ensures accurate and repeatable results. The impedance is measured by performing short-duration, mini discharge of the bloc using a square-ware signal at a set frequency for 4.5 seconds.

This action of the single, longer pre-conditioning pulse at the start brings the cell into the right energy layer state before starting to draw measuring pulses. The latter creates a varying cell voltage response, which combined with the reference pulsed current, provides an impedance value.

The impedance test method perturbs only the cell under test. High currents through sections of the battery are not required and DC links are not disturbed by any oscillations. Because the Sentinel itself is powered by the cell being monitored, it is designed to remain in sleep mode for the majority of the time, only waking to take measurements. The wake cycle takes less than 100 mS and is conducted approximately once every five to 10 minutes.

It is also designed for simple installations, through its monolithic design and simplified communications system. Using a proprietary communications bus, each self-contained unit operates autonomously yet can be directly controlled from a central intelligence unit, the BDL.

Having this combination of the single or monobloc measurement units with the accurate information on temperature allows an intelligent analysis of the state of health of the battery. The Sentinel system operates completely automatically, providing cost-effective and reliable monitoring for safety and mission critical applications.

For more information visit: www.lemusa.com.