Monitoring Batteries Improves UPS Reliability

Systems from mobile telecommunications to data centres must operate with minimal downtime, making the reliability of the electrical mains supply a key concern. Uninterruptable power supplies (UPSs), which provide back-up power in the event of mains failure, are therefore widely used to ensure critical electronic systems continue to function normally in the event that the mains power goes down. Sentinel III; a set of components for a battery monitoring addresses the needs of UPS OEMs and battery providers. These components are used to create a simple to install and intuitive solution for continuous battery monitoring within mission critical installations. **Loic Moreau, LEM SA, Geneva, Switzerland**

Although other technologies, such as flywheels, can be used, most UPSs use batteries to store energy. Batteries provide significant capacity and are able to deliver power almost instantaneously. If the UPS is to operate reliably, it is essential that the batteries are not only fully charged, but also in good condition.

High influence on UPS performance

Battery cells have a limited lifetime, which can be shortened considerably if the environmental conditions - particularly temperature - are outside the optimum range. In most installations cells are replaced at a fixed interval based upon the warranty - typically every five years. This approach is imperfect: batteries operated outside of the expected environmental conditions can fail sooner, whilst well maintained batteries might have a longer lifetime.

Modern UPSs are required to deliver high power levels, and therefore many cells are required. In large strings, a failure in a single cell can cause the whole string to fail. Large and medium UPSs will implement redundancy to ensure that a string failing does not result in the entire UPS failing. Whilst the UPS will continue to operate, the peak current that can be delivered and the time for which the system can run using the UPS will both be reduced. Furthermore a failed cell can damage the other blocks in the string, reducing their lifetime.

Battery monitoring and maintenance represents a significant cost associated with running UPSs. Typically an engineer visits the site on a regular basis - perhaps monthly - to measure the electrical characteristics of the cells in the system. Typically the voltage of the cell will be measured, identify cells operating out of range, which will then be replaced. Output voltage is not always a good predictor of

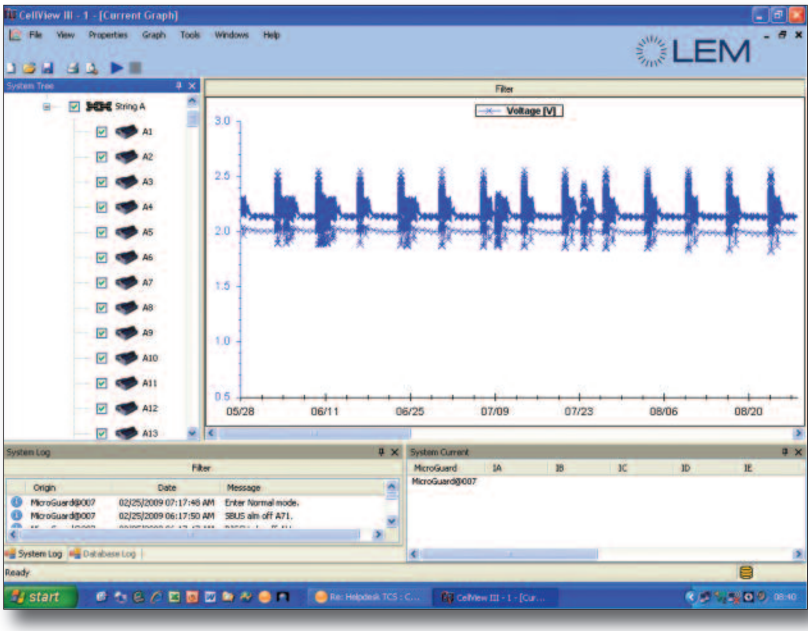


Figure 1: Battery cell output voltage

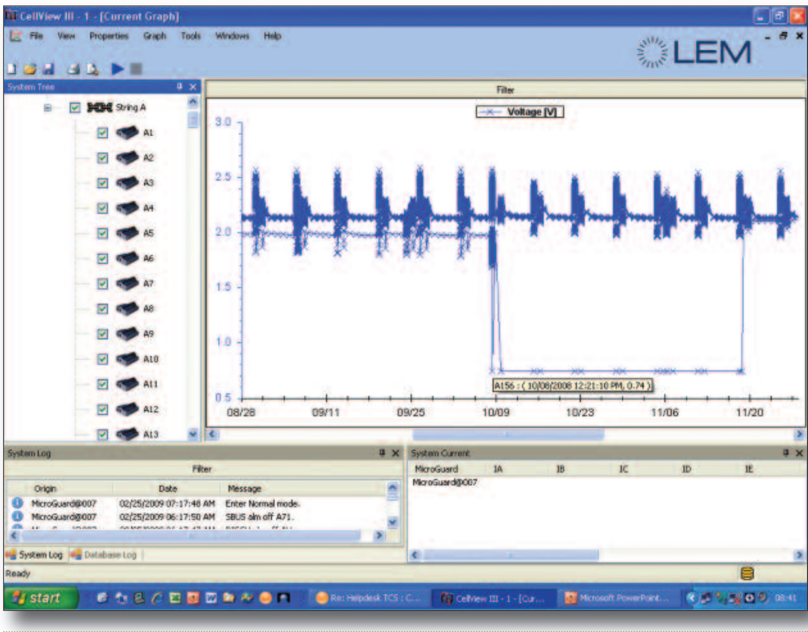


Figure 2: Cell failure

failure, so cells may fail in between these regular visits, require an additional service.

Permanent monitoring of batteries not only reduces cost by reducing the time for an engineer to physically check the state of each of the batteries, making their site visits more efficient, but also allows for preventative maintenance. By identifying potential failures, cells can be swapped out during routine visits, ensuring greater reliability and removing the need for emergency engineer visits.

Monitoring a large UPS

LEM used the Sentinel (see Sidebar) battery monitoring system to measure the cells in a broadcast facility with an 800kVA UPS. Figure 1 shows the output voltages of a number of cells in one of the strings. In this case each string had 200 monoblocks, delivering around 440V. There is considerable variation in the voltage, which is due to incorrect configuration of the battery conditioning, which is discussed later in this article.

The graph clearly shows one cell is delivering 2V, rather than the nominal 2.2V. Although the block is producing a lower voltage than expected, the difference is relatively small, and is stable. This behaviour is typical, making the use of output voltage as an indicator of impeding failure is unreliable, as the voltages can be remain within thresholds and therefore alarms are not triggered.

In this case, the battery monitoring system was being used to assess the effectiveness of the scheduled maintenance approach, and not to warn of potential problems. As no action was taken, Figure 2 shows that on 9th October (10/9) the cell fails catastrophically. Note that prior to the cell voltage dropping to 0.7V, the voltage of the faulty block remains constant, giving no indication that the block is about to fail. The voltage returns to normal on 19th November when the cell was replaced.

The output voltage is not a good predictor of likely failure, as there was no change in its value prior to the failure of the cell. Another characteristic of the cell - impedance - is a much better indicator as Figure 3 shows. This graph illustrates the impedance rising in June, and by the start of July the value has increased by more than 20%. A trend is easy to detect: measuring impedance could have identified the problem three months before the cell failed. If the customer used the impedance data, the cell could have been replaced during regular preventative maintenance before its deterioration caused the failure.

Permanent monitoring provides other useful information that can help increase

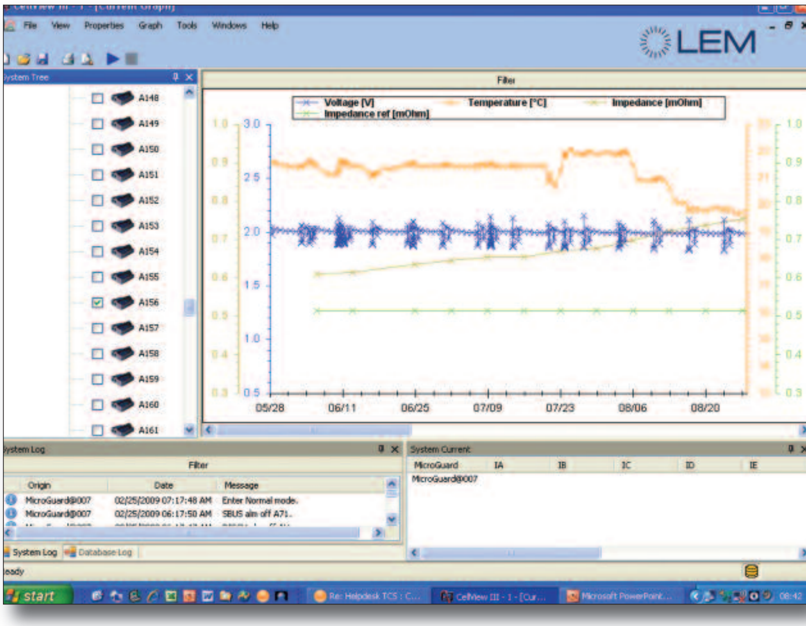


Figure 3: Cell impedance predicts failure

UPS reliability. For the example in Figure 1 it is clear that there are plenty of charge/discharge cycles (shown by the spikes on the voltage trace). Although all batteries need to undergo conditioning the battery discharge is much too frequent, with 4-5 discharges per month. Whilst some battery conditioning lengthens life, too many discharge cycles will reduce the lifetime: a normal configuration will cycle only two or three times per year. Typically cells have a guaranteed lifetime of 20-50 cycles. In the case we are considering the batteries would have exceeded this in just a few months, and a strategy of replacing batteries every five years would mean that the cells would undergo several times more discharge cycles than they were designed to endure.

The frequent charge/discharge cycles at this site were caused by the installer leaving the UPS in a commissioning mode that cycles the battery charge frequently to allow testing - a surprisingly common mistake that can drastically shorten the lifetime of the batteries. Erroneous configurations will not be obvious to engineers during their visits to the site - continuous automatic monitoring, however, makes the problem obvious.

Another cause of shortened battery lifetime is high temperature. Even a small increase in temperature increases the rate of the unwanted chemical reactions in the battery that ultimately cause it to fail. Typically battery manufacturers quote lifetimes at 20°C. Figure 4 shows the ambient temperature in this system varying

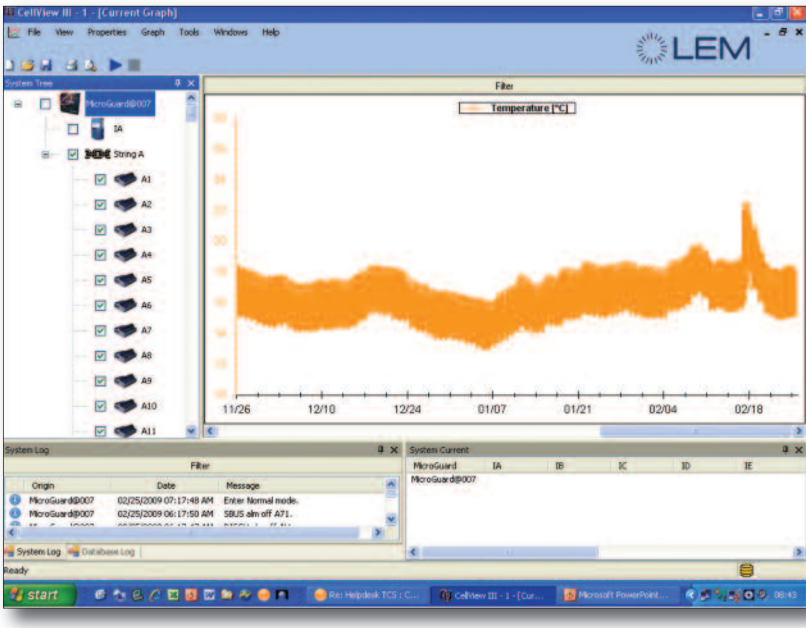


Figure 4: Temperature monitoring

with time, and at one point reaching 22°C. The air conditioning failed to maintain the temperature within an acceptable range, which will result in a reduction in battery life. Furthermore the increased temperature may void the battery manufacturer's warranty.

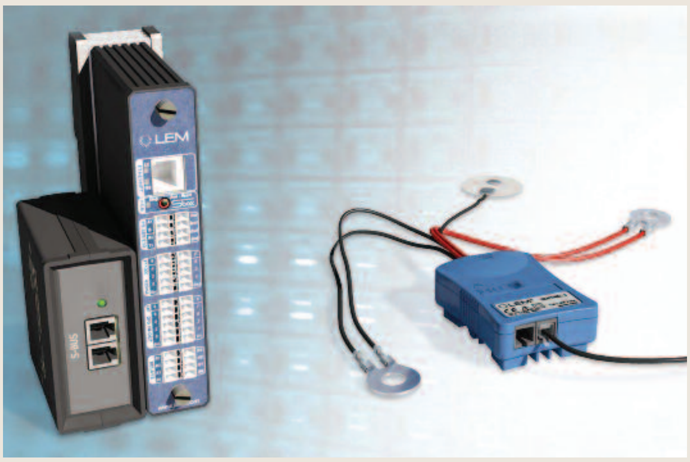
Conclusion

Permanent battery monitoring offers many advantages, beyond the reduction in cost by making site visits by engineers more efficient. In this example automatic monitoring of the impedance of the battery would have identified a failing cell three months before the cell became faulty. Continuous monitoring also makes identifying UPS configuration problems simple: particularly incorrect charge/discharge frequency that can dramatically reduce battery life. Monitoring measures ambient conditions, ensuring that lifetime is not reduced because of high temperatures. Monitoring maximises the life of the cells, reducing the risk of failure and saving money by ensuring that strings do not need to be replaced prematurely, as well as ensuring early detection of deteriorating cells, often allowing replacement before the string goes down. Although critical systems such as UPSs are usually not the first target for cost savings, it is important that users switch to permanent monitoring as it both cuts cost and increases reliability.

Sentinel III Battery Monitoring Components

The Sentinel solution comprises transducers, data loggers and software components to create a standby battery monitoring solution (SBM). In order to extend the functionality of the existing Sentinel, LEM has developed the S-Box; a data logger featuring an embedded webserver, which enables administrators to monitor installations remotely. The state-of-the art measurement and data logging features include bloc, string and battery voltage measurement, Bloc temperature and impedance measurement, discharge performance and discharge/charge current. The S-Box also measures ambient temperature, a key factor affecting battery life.

The Sentinel transducer is designed to reduce installation time, offering DIN-rail mounting and an external temperature patch. Users can set up an alarm for each of the parameters measured by the transducers connected to the S-Box. As well as instant alarms the S-Box can also provide a weekly report to the administrator, containing all daily measurements and critical system information.



Components of Sentinel III battery monitoring system