Eliminate VRLA Battery Failures in Telecom Outside Plants And Maximize In-Service Life

Bob Williams – President
Sea Air Land Technologies, Inc.
Marathon, Fl
www.salt-systems.com

The VRLA Paradox

The valve regulated battery (VRLA) has been of principal concern to the telecom industry when used in the outside plant environment. Although this "stationary battery" was conceived and engineered to be used in climate-controlled environments, it has become the battery of choice in outside plant applications. The use of "flooded" batteries just wasn't practical in this application, principally due to corrosive fumes, hydrogen buildup and frequent maintenance.

Unfortunately, this environment introduces some factors that may undermine the projected service life of these batteries, principally temperature and charge regulation. In many cases, even a conservative battery replacement program does not prevent a significant number of premature failures occurring in cabinets, which experience seasonal high temperatures. VRLA batteries begin stressing at around 90°F, but it is not unusual to see internal cabinet temperatures during a North American summer exceeding 130°F. Knowing that severe temperature extremes place hardship on the performance and life expectancy of VRLA Batteries, users are faced with the challenge of trying to detect when a battery is going to fail prior to the problem becoming catastrophic in nature.

Regional Study

This Case Study involves about 600 Digital Line Carrier (DLC) cabinets, (manufactured by Lucent, Reltec, Nortel and Siemens) in the Florida area. These DLC cabinets typically utilize rectifiers with constant voltage regulation, some featuring temperature compensation. All rely heavily on field maintenance as a means of staying ahead of the VRLA battery attrition rate in the outside plant environment.

This study area has the highest incidence of convective lightning activity in North America, so the customer has a heightened awareness of their reliance on VRLA batteries, in that they experience a high number of power disruptions during the summer months. This can create logistical difficulties in prioritizing generators, especially after the VRLA temperatures, frequently in excess of 120°F, have stressed the batteries.

A battery replacement program of every 24 calendar months is usually the solution of choice. Unfortunately, this approach is costly and still does not pre-empt the VRLA failures that can occur in less than a 24-month duty cycle. Nor does it allow for the full in service life of batteries in low stress environments (DLCs which are usually shaded) that can extend beyond 36 months.

Background

Investigation into the use of battery analysis using "internal ohmic measurements," "string current monitoring," "block voltage," and "mid-point monitoring", found these technologies to be better suited for their Central Office and UPS applications. Where individual cell replacement is warranted, there is justification of a higher cost of more sophisticated monitoring equipment and administration of data trending. However, for the outside plant VRLA batteries, the consensus at this time is that "load testing" remains the only proven way to determine a battery string's status in terms of its projected life curve. The economics of this approach is even more compelling in light of the general practice of replacing the complete VRLA battery string in a DLC cabinet, versus individual cell replacements typical to the larger stationary battery market.

At this time most other non-load testing battery analysis methods require an understanding of the specific philosophy employed by each of these methods. Measurements may change when comparing different model batteries. The pass/no pass criteria for these measurements may be highly subjective. Manufacturers may not accept some of these methodologies for warranty replacement. On the other hand, load testing is a concept well understood and accepted by both application engineers and field technicians. More importantly, this approach has now been fully automated, allowing a large network of cabinets to be precisely administered through a single host computer. This requires only one full time technician to compile the data, respond to alarms and manage the host computer.

This case study focuses on the results of the subject's investment in remote monitoring with programmed "load testing" to determine to what extent it increases both the reliability and actual in-service life of VRLA batteries.

Case Study Requirements

For its DLC cabinets, the subject telecom company required a remote monitoring device for outside plant battery systems that could provide automated load testing. Some required functional specifications to qualify for the company's "standards number" included the following:

- Ability to provide an automated load test with user defined pass/fail set points
- Means for telemetry to the host computer
- Alarm relay contacts to interface directly to existing cabinet alarm infrastructure
- Remote scheduling of battery tests and other user definable functions
- Real time display via computer interface or unit LCD display of Volts, Amps, Amp Hours, Temperature and alarm condition
- Remote or field access to data logs on Volts, Amps, Temperature and last Load Test
- Oscilloscope mode showing AC ripple component graph on computer
- Non-invasive monitoring, including Hall effect current sensing
- Fail safe alarm defaults and conditional pre-test requirements

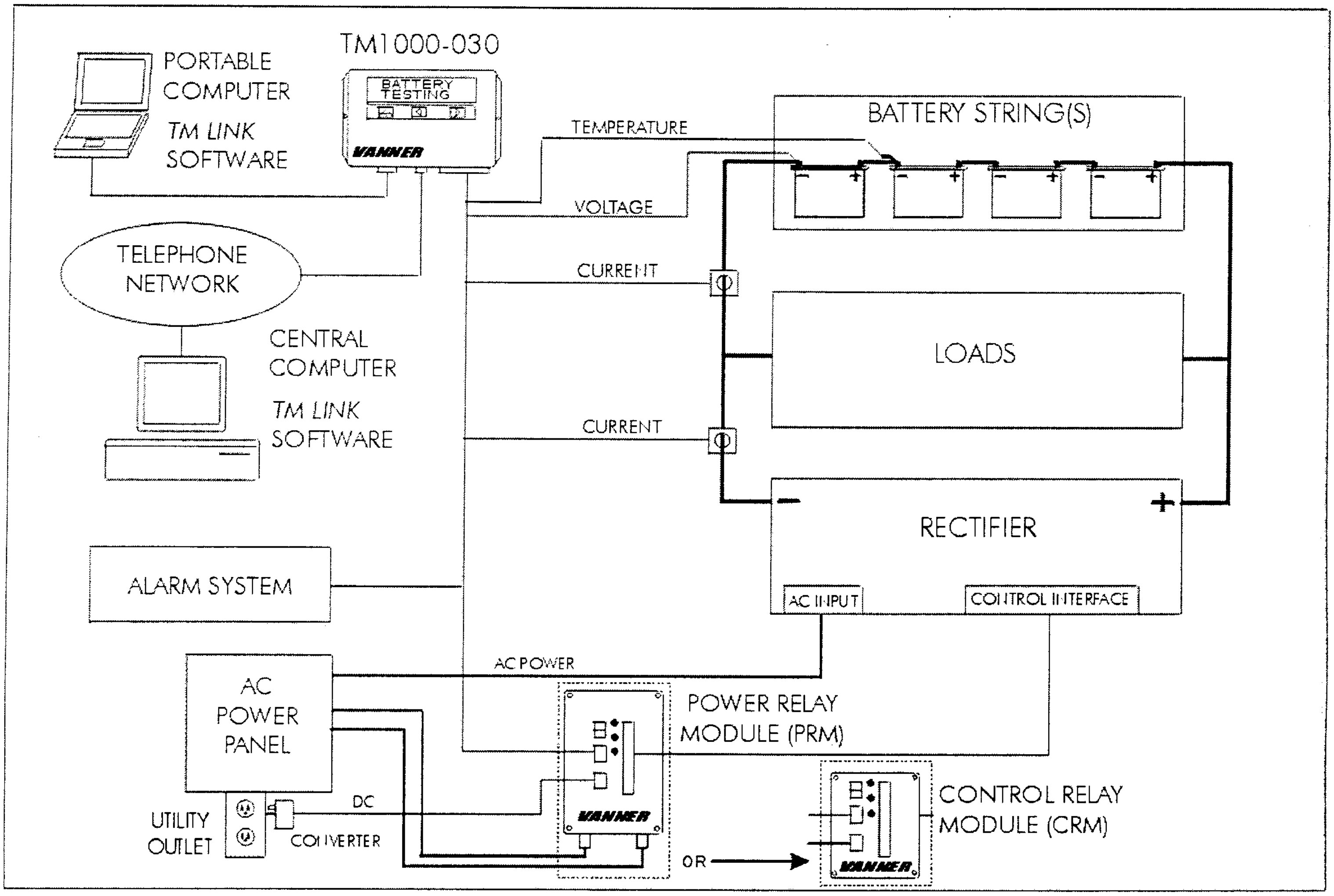

Figure 1 - Outside Plant Monitoring System Configuration

Test Procedure

The monitor chosen for this application was the SALT TM1000 Battery Systems Monitor manufactured by Vanner Power Group. Two test configurations are available for the TM1000. One allows the TM1000 to conduct a discharge analysis to at least 50% of the battery string's original capacity with a pass/fail based on the calculated amp hour capacity (this method is currently being tested in Bell South DLC cabinets). The second test configuration (as used in this case study) provides a pass/fail limit based on the string voltage under load after 10% of the battery capacity (amp hours) is delivered. The test window is limited to a one-hour period (more recently extended to two hours). This configuration requires that each type DLC cabinet be assessed on the overall amp hour capacity of the VRLA batteries when new, and then factor in an acceptable floor voltage after delivering 10% of the over all rated capacity (see diagram 2.0).

A test is manually initiated after the installation of the TM1000 monitor is complete while the technician is on the DLC cabinet site. This benchmarks the condition of the batteries. If the batteries are proven to be inadequate they are replaced. If, on the other hand, they are deemed acceptable, an automatic test is programmed to occur every 28 days in the same fashion. Typically the battery test is programmed to occur during the maintenance window between midnight and six a.m.. Daily administration of the host computer is essential to confirm that the information from monitors is being properly received and posted.

The Test

When the 28-day interval arrives the TM1000 checks for these conditions prior to allowing for a test:
- Batteries must be above 52 volts DC.
- Batteries must not be in discharge.
- Temperature is greater than 45° F.
- Monitor must have detected "full battery" from last discharge recovery.

If these conditions are not met the TM1000 posts a "not testing" message with the host computer. If these conditions are met the test will commence by removing the charge source. Depending on the type of rectifier, this is accomplished by the TM1000's activating the rectifier's TR (temporary release) input on the rectifier or by powering a relay that breaks AC power to the rectifier. (see figure 3)

In an effort to keep cost and complexity to a minimum it was decided to use the cabinet's s natural load (usually between 16 and 18 amps @ 48 volts) to load the battery string. Establishing conservative pass/fail conditions puts the burden on having to possibly review a few marginal test failures, not VRLA battery reliability. The alternative approach is to conduct the test with a constant load management device as part of the system to maintain a fixed discharge rate. This, and allowing a deeper discharge test to 20% would gain additional resolution, but not necessarily improve functionality.

If at any time during the test the voltage drops to 47 volts, the rectifiers are automatically brought back on line and a "Test Fail" is posted with the host computer. If after 10 minutes into the test the batteries have not recovered from the Coup de Fouet above 49 volts a "Test Fail" is posted with the host computer. Otherwise, the test is run for the remaining test time window, originally one hour (now two hours).
If the 10% amp hour capacity (user defined) is delivered prior to hitting the floor voltage (user defined) the test passes. The load test is always logged with a five-second-sample rate. (see figure 3)

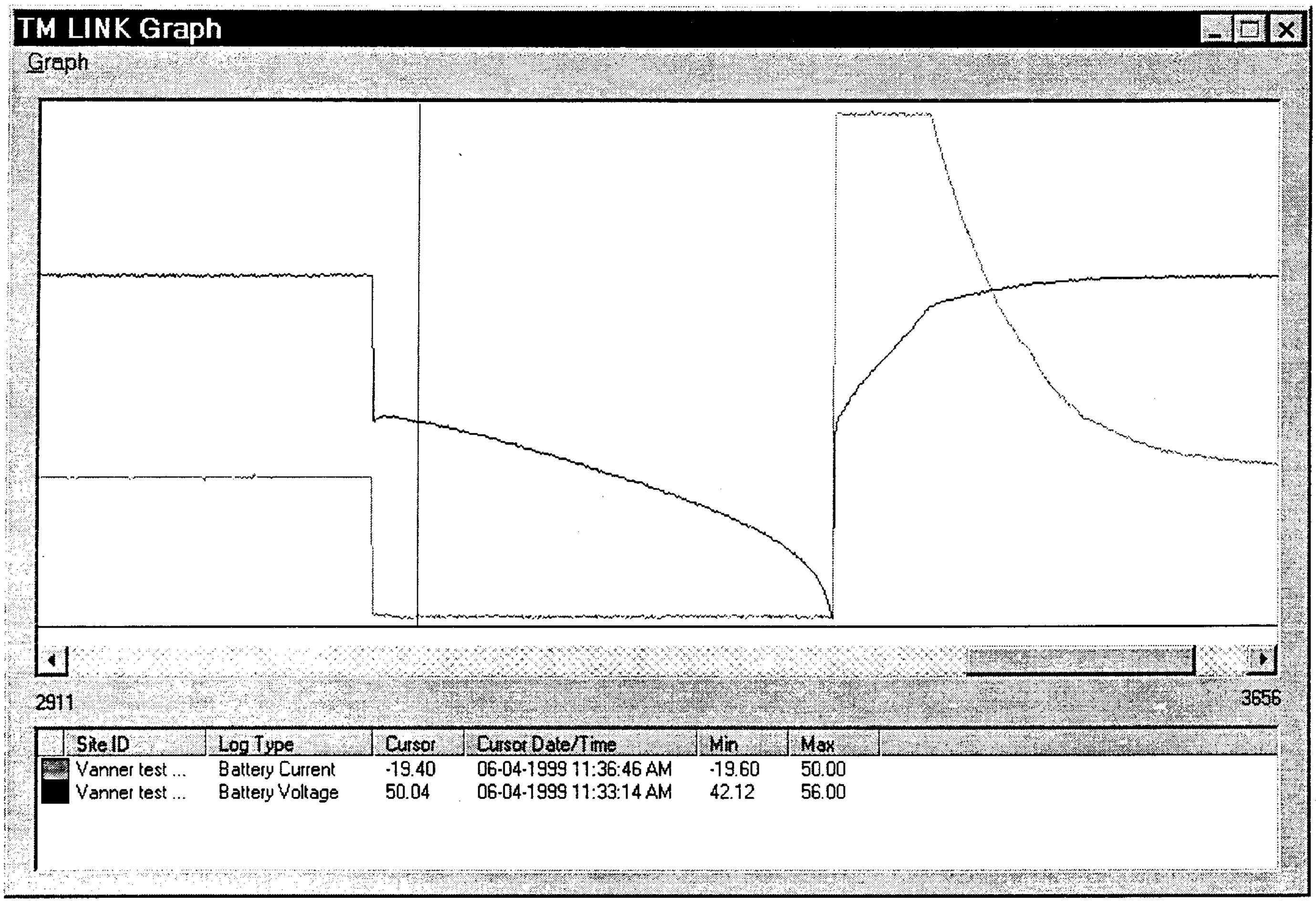

Figure 2 – Voltage and current data log showing 9.25 hour discharge of one 48 volt, 160 amphour battery string (@ 77°F) down to 42 volts. The vertical cursor is located at the one hour data point where the case study auto-load tests are stopped. The discharge is reasonably linear to 45 volts.

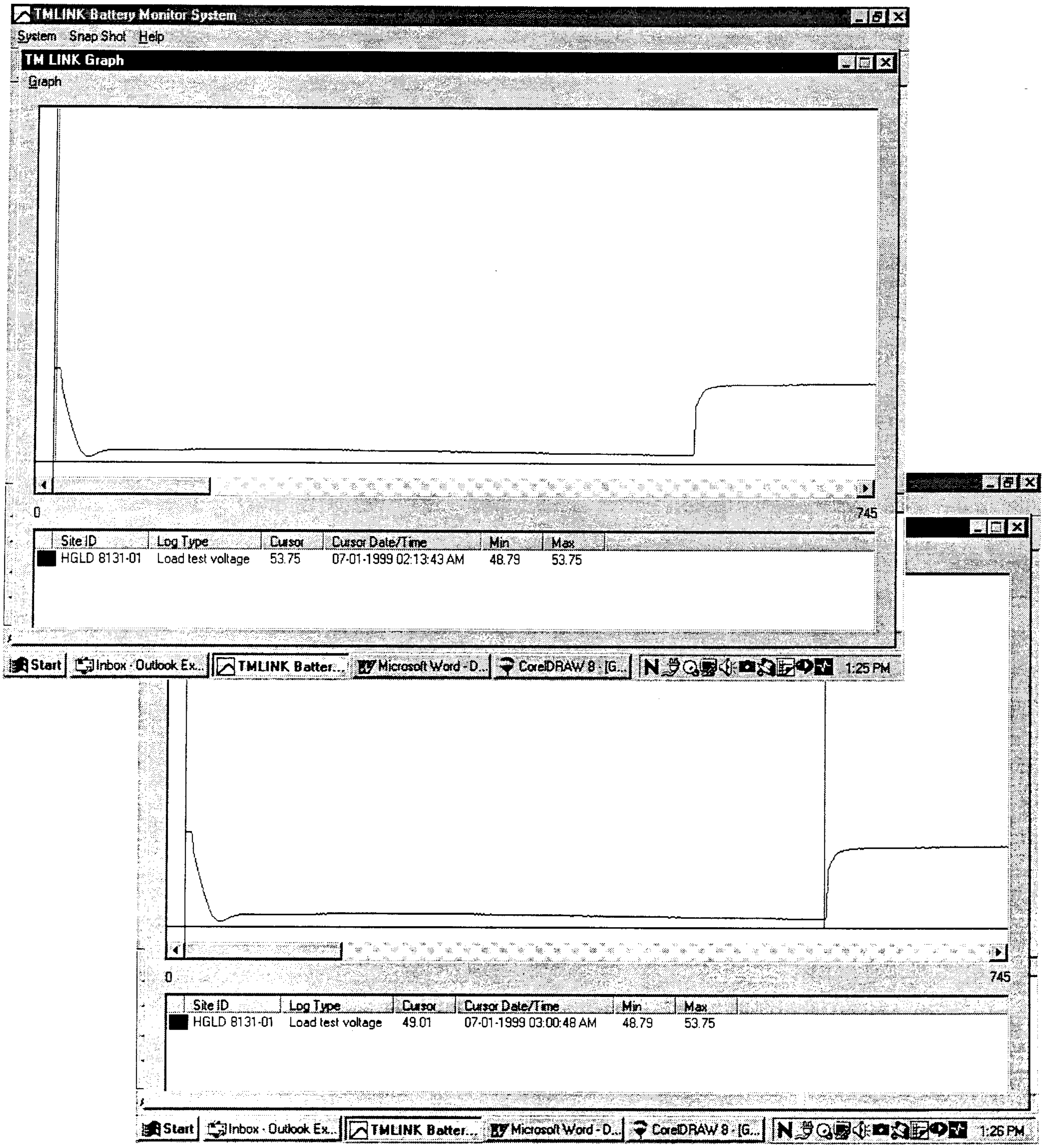

Figure 3 – Auto test voltage log retrieved from a DLC. The top view shows cursor marking the initial data point. The bottom view shows cursor marking the last data point. The monitor reported this to the host computer as a failed test because it reached the set floor voltage (49 volts) in less

than the one hour limit. If, during the test period, the voltage had not descended to 49 volts, it would have still needed to deliver 10% of the battery strings amphour rating before passing the test.

The TM1000 Monitor measures electrical values of the remote site's battery-based electrical system. These measured parameters are set up in the configuration procedure. The parameters, such as battery voltage and current, rectifier voltage and current, and battery temperature, can be stored in three memory locations (see figure 4). A fourth memory location is used to store the results of the battery capacity test. The user has the ability to select the measured parameter, the sample interval (one to 32,766 seconds per sample), and set the memory accumulator to fill and stop accumulating or continue accumulating when full with the oldest data discarded.

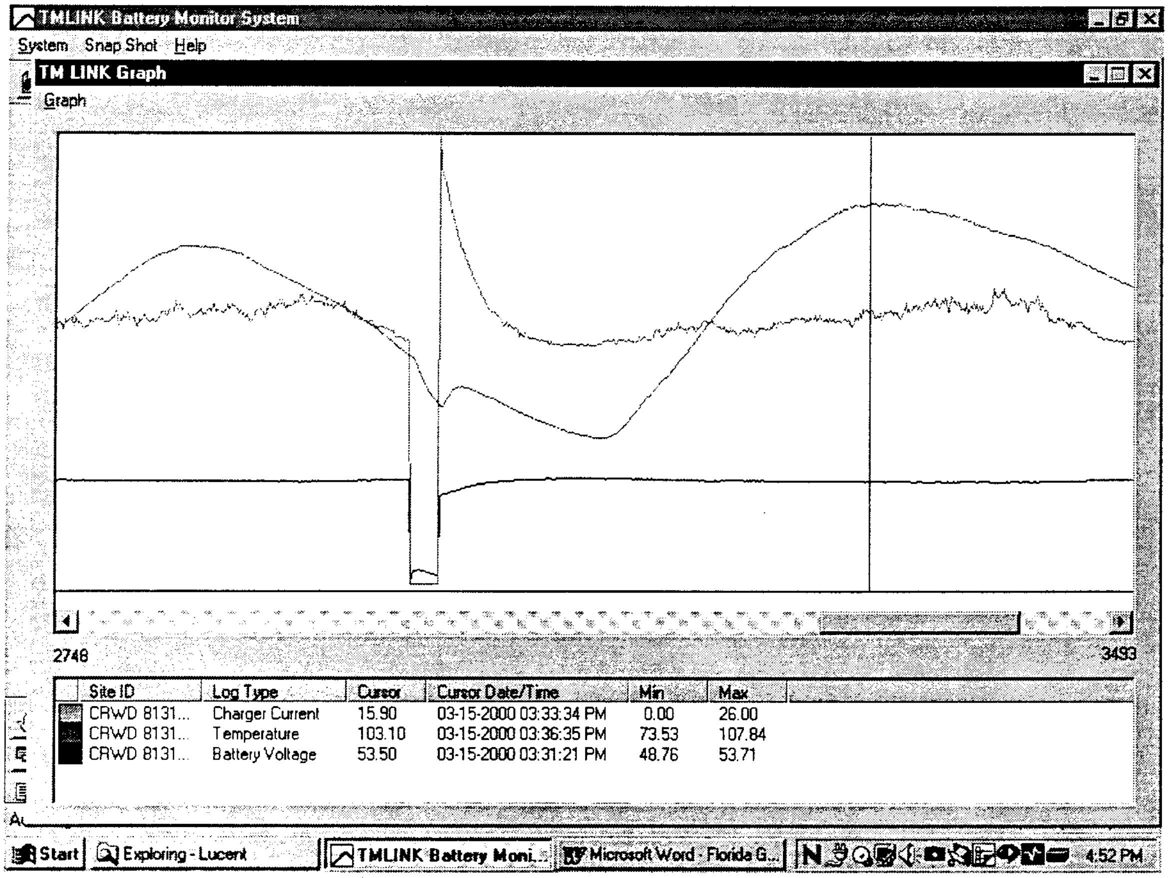

Figure 4 – These 3 continuos data logs (180 second sample rate) are from the same DLC depicted in figure 3. Battery temperature, current and voltage. Note the deflection caused by the auto-test. Note the cursor data point showing a high temperature of 103°F in early March.

Results

Deficient battery strings are replaced during the monitor installation if the initial on-site start up load test fails. During the 36-month study period up to the end of 1999, over 7200 automated tests were conducted. Once load testing commenced, there was not a single incident of a DLC outage relating to failed battery strings over this three year period. Load testing has shown to date that 78% VRLA Battery strings are lasting an average 32 months. Since this report the average battery life is now expected to be above 36 months. A significant percentage of sites are expected to have batteries in service beyond 48 months.

Conclusion

This Case Study's principal objectives, increased VRLA battery reliability and extended in-service life were met. The funding decision for this or a similar system must reflect other cost savings as well, including the extension of the average in-service battery's life to 36 months, while avoiding blanket replacements. In addition, savings in man-hours are realized in modifying the 6-month interval battery maintenance. This subject's budget case took into consideration the cost of deployment and the need for an administrator (30 hours per week for approximately 1000 sites) to respond to alarms, compile and evaluate data and record keeping. The benefits of this, or similar system, can be summed up from the following case study results:

- Automatic battery testing has effectively eliminated system outages caused by failed batteries.
- Real time information from a DLC in alarm (e.g. commercial power outage) helps prioritize the situation and determine the best response.
- Programmable alarms for current; voltage; temperature and battery capacity provide a backup for existing alarm infrastructure.
- Historical data logs are a valuable tool in the investigation of system outages and product performance.
- Test Results indicate that battery capacity begins to degenerate several months before loss of adequate reserve time, allowing for a pro-active battery replacement program that can use budgeted dollars more effectively.
- Automated battery capacity testing greatly reduces the frequency of man-hour routines in the field.
- Data collected by this type of monitoring allows for evaluation of the performance and reliability of power related products with greater credibility.
- Evidence that placing VRLA batteries through periodic shallow discharge improves battery health.

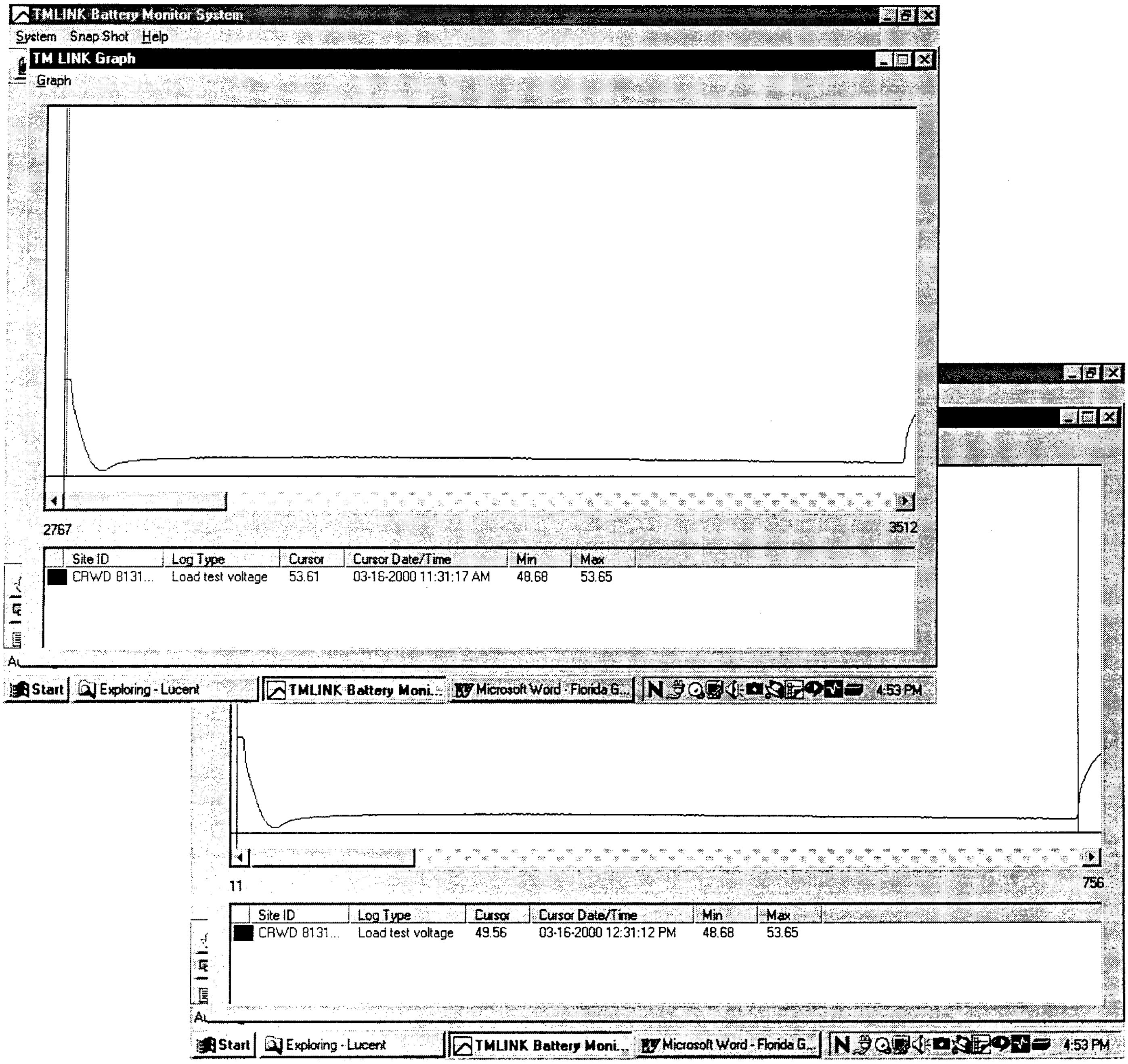

Figure 5 – Auto test voltage log from a DLC that passed the test criteria.

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C:\Program Files\TMLINK\BART 05.txt

BART 8131-5                08/02/1999               03:12 PM

-----------------------------------------------------------------

BATTERY         53.7 Volts       -0.5 Amps        140 Amp Hrs
CHARGER         54.0 Volts       14.6 Amps        32700 Amp Hrs

TEMP. F.        104.2 Degrees F.

POWER SUP       11.7 Volts

-----------------------------------------------------------------
Next Battery Test: 08/29/1999 @ 12:56 AM
Test Status       : Not testing and no errors
Start Volts       : 53.76
End Volts         : 49.91
Start Capacity    : 140
End Capacity      : 126
Test Length       : 1
Min. Battery Cap: 15
Test Cycle        : 28
Low Voltage       : 49.00
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Figure 6 – Down load snap shot of the set up configuration with in a deployed monitor.

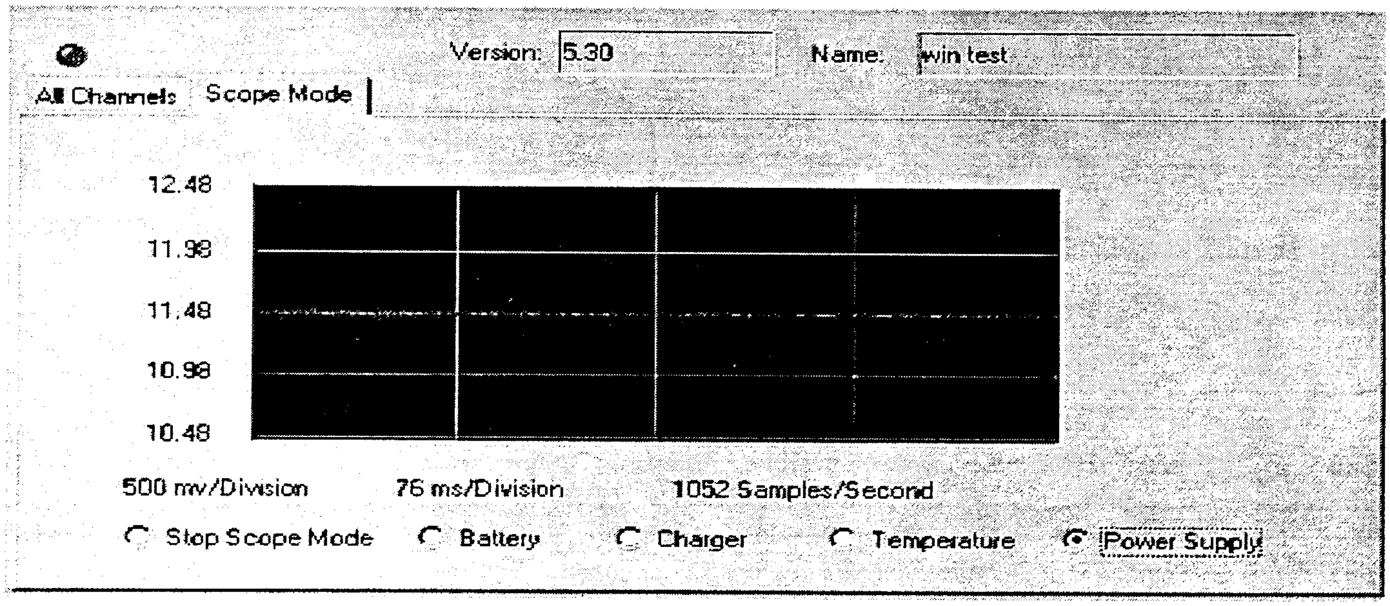

Figure 7 – Oscilloscope mode providing AC ripple measurements in DLC from host computer.