Cutler-Hammer

Improving Life of Parallel Connected Battery Strings

Application Note

General Description

Telecommunication batteries are typically paralleled to provide additional capacity and reliability and operate in a mode called “float” service (remaining fully charged for the majority of its life).

Since batteries age and deteriorate at different rates, at some time after installation, one or more individual batteries in the string will have lower capacity (ability to power the load) compared to the other batteries in the string. Should the battery be called to supply power, the string with the reduced capacity battery will provide a lower output voltage compared to the other parallel strings.

Since the other batteries in the string have a higher terminal voltage, those other batteries provide the majority of the current to the load. A particular problem called “thermal runaway” occurs when the reduced capacity string begins to consume power rather than source power.

Even without thermal runaway, imbalances in charging current between strings mean that some batteries are overcharged in the attempt to fully charge all batteries. Chronic overcharging can damage a battery and reduce its capacity.

To compensate for these problems, most telecommunication companies replace the batteries on an accelerated schedule, some after as few as 50 charge/use cycles. While manufacturer data states that a battery should provide 400 charge/use cycles under optimal conditions, few companies see any benefit of “pushing the envelope” since the cost of replacement batteries is far less than the aggravation of having a failed battery string.

New Solution

By separating each battery string such that each is charged separately, we can more evenly balance the charging current and achieve a longer battery life, closer to the manufacturers ratings. In addition, since each battery string cannot reverse feed another battery string, the problem of thermal runaway is eliminated.

This design uses a lower cost solution than supplying separate rectifier/ chargers for each battery string. Instead, we propose using a single charger, but providing separate regulated outputs for each battery string.

For example:
600A rectifier, 1 output (traditional design)

600A rectifier, n outputs, each rated 1/n of the output (e.g. 4 outputs = 150A per output)

Note that while the diode mounted in series with each battery string does introduces cost, additional voltage drop and another point of failure, all three issues can be shown to be surmountable problems.

Possible Concerns

Cost

The cost of installing a shunt with an embedded Schottky diode is far less expensive than the cost of even one battery string. As this system permits additional battery capacity and results in at least one less battery change out, the ROI is very high.

Voltage Drop

Battery system output voltage varies based on remaining battery capacity. The voltage is higher when the battery is charged and is floating and is lower when energy is being consumed and the remaining battery capacity is decreasing. Battery manufacturers set limits on the minimum allowable cell voltage that a battery may reach under load. In addition, battery manufacturers set maximum allowable cell voltages that may be endured during charging.

These limits are coordinated with the requirements of the equipment connected to this battery system. In particular, the system will be designed to shut off current draw from the battery system when the battery system voltage drops below a particular limit.

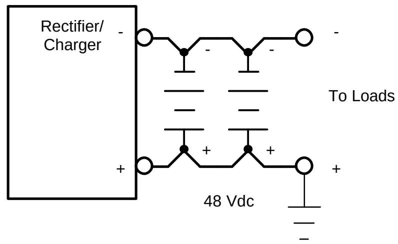

Figure 1: The traditional connection of one rectifier (battery charger) with a group of batteries. The rectifier provides current to supply the load plus charge the batteries.

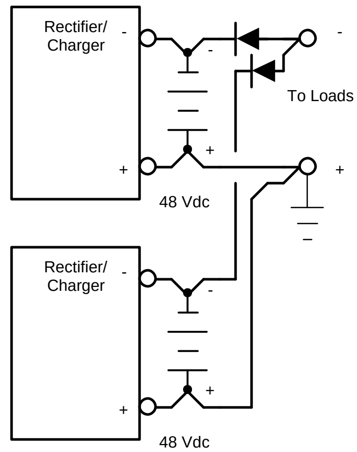

Figure 2: The traditional method of balancing the charge across a group of batteries to provide separate rectifiers for each battery string.

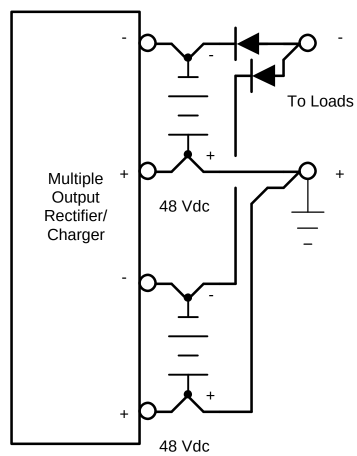

Figure 3: A rectifier/charger with multiple outputs provides better value since a common incoming step-down transformer and rectifier is utilized for all outputs. Not having to duplicate transformers and rectifiers save cost.

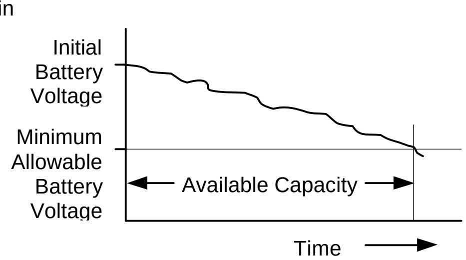

Figure 4: Relationship between voltage drop and battery capacity. The minimum allowable voltage is established by the battery manufacturer.

Drawing additional current from the battery system when the battery voltage is below this lower limit can cause damage to the battery.

The amount of time that the battery system can maintain acceptable voltage while under load is called "capacity".

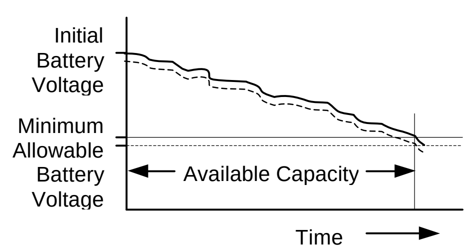

Figure 5: Same diagram as Figure 1, except 0.7 Vdc drop from series connected blocking diode on each battery string. The underlying battery capacity remains unchanged as long as the logic is programmed to consume power to 0.7 Vdc below the previous Minimum Allowable Battery Voltage level.

Additional Point of Failure
A diode is not a controlled device. It has only two modes of failures, failed open or failed shorted. As this is a single PN junction device, the failed open mode can only occur if the PN junction is vaporized, in effect acting as a fuse. However, even if it did, it would provide the same protection that battery string fusing would provide. With a properly sized diode, a downstream fault would be cleared by the Battery Distribution Fuse Bay (BDFB), resulting in continued operation to the balance of the BDFB loads.

If the diode failed shorted, the system would revert to the same mode of operation as is done today.

Financial
Battery strings are costly maintenance items, not only in terms of the cost of the replacement battery and the labor to install, but also the loss of revenue should a battery unexpectedly fail and cause downtime or facilities damage.

Papers presented at Intelec 2002 claim that proper charge balancing across each battery can effectively double its life. The technique described in this paper would result in less frequent battery replacement by improving the battery capacity due to improved charge management.

Since replacement batteries are far more costly (both in initial and disposal costs) than supplying a rectifier with multiple outputs, this solution is a good value proposition for a customer with multiple parallel battery strings.