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COMMERCIAL FEATURE

BATTERIES FOR METERING APPLICATIONS
VOLTAGE LOSS AND HOW TO OVERCOME IT

By Dr Thomas Dittrich

Commercial lithium batteries have been available in the market since the late 1970s and Tadiran has been one of the leading manufacturers since then. While these batteries were first mainly used for memory back-up applications and were designed for a 10 year battery life, recent metering applications are much more demanding. A battery life of 15 or 20 years is more and more often required and the batteries must handle high current pulses to operate valves and communication modules. One obstacle is the build-up of voltage losses in a lithium battery during long term application. A good way to overcome it is with parallel connection of a small capacitor with high charge content, such as Tadiran’s HLC.

PROVEN 20 YEARS BATTERY LIFE

3.6 V lithium thionyl chloride batteries are the preferred power source for stand alone metering applications. This is due to both the high voltage level and the large energy content of this technology.

It was previously reported that Tadiran AA cells have operated safely for more than 20 years in AMR devices. Electronic gas meters, however, have relatively high current draws, typically in the range of 50 to 200 µA. Therefore, D-size cells with a nominal capacity of 19 Ah would be required to reach a battery life of 10 or 20 years.

The nominal capacity of a cell is determined by its total amount of lithium and thionyl chloride. Predicting the expected operating life merely from the cell’s nominal capacity, however, can be misleading as the available capacity is also affected by the internal self-discharge rate and by impedance growth during discharge. Since the volume of active ingredients is limited by the size of the cell, nominal capacity values often do not vary substantially between different brands of the same electrochemical system. Moreover, quick laboratory tests are not suitable to determine the decisive properties of long term batteries. Such tests include accelerated ageing by temperature increase, studies of the passivation (voltage delay) behaviour, and even sophisticated methods like microcalorimetry, yielding an estimation of self discharge rates. These methods allow for a qualitative comparison of certain properties of batteries manufactured under different conditions. However, they are not sufficient for a precise prediction of battery life under various application conditions.

DATABASE ALLOWS RELIABLE PREDICTIONS

Tadiran has access to decades of real time discharge tests with various cell types, including the XOL type suitable for 20 year operating life. These data allow for reliable prediction of battery life under real application conditions. Figure 1 shows an example where a D-size cell of Tadiran’s XOL series, suitable for eXtended Operating Life, is discharged under various loads, resulting in between 10 to 20+ years of battery life.

In order to allow for prediction of battery life under real conditions, it is also necessary to consider the effect of voltage loss being caused by an increase of internal resistance when substantial current pulses are applied to the battery. This effect is demonstrated in Figure 2, where a D-size cell was discharged under a continuous load of ~50 µA and short pulses of 150 mA.

The battery is able to deliver this current at a voltage level of 3 V at least for a period of 2 years. From the low average current draw of 50 µA, one would be misled to assume that the battery could continue to deliver these pulse currents for more than 10 or 20 years. However, after 2 years, the voltage level under pulse load starts to decline reaching as low as 1.5 V after 5 years. At this voltage level, most applications would stop to work and the battery would be considered as discharged. However, it is not, as can be seen from the red curve showing the battery voltage under background load. It stays at 3.6 V, even after 5 and 10 years. Connecting Tadiran’s Hybrid Layer Capacitor (HLC) in parallel solves the problem. The HLC maintains its low internal resistance throughout the remaining battery life. Meanwhile, the test has been continued and battery life has reached more than 14 years. The pulse voltage stayed above 3.4 V during this time period.

Figure 1 – Long term test D-cell @ RT under various continuous loads (test is being continued)

Figure 2 – Long term pulse test D-cell @ RT, 68 kΩ background load (~50 µA), pulses 150 mA
HYBRID LAYER CAPACITOR COMPENSATES VOLTAGE LOSSES

The HLC was introduced more than 10 years ago. Its technology is based on electrodes comprising lithium intercalation compounds. In comparison to lithium ion batteries, the HLC has an improved sealing system (laser welding, glass-to-metal feed through), improved temperature behaviour (−40 °C to +85 °C) and decreased leakage current (approximately 10 times less than lithium ion batteries). Each of these improvements is necessary to make the HLC suitable for 20+ years of operation in conjunction with a primary lithium battery. Table 1 shows important properties of different sizes of HLC available today.

A typical stand-alone metering application is an electronic gas meter with an electrical valve for prepayment functions and a low power radio for bidirectional communications, optionally including a meter with an electrical valve for prepayment functions and a low power radio module with an electrical valve for prepayment functions. Table 2 shows the battery relevant data of such an application.

MODULAR DESIGN

As can be seen from Table 1, Tadiran’s HLCs cover a wide span of capacities, ranging from 30 As to 560 As. Each of them can be combined with one or more primary high energy cells, ranging from the ½ AA size with a nominal capacity of 1.2 Ah to DD size with 35 Ah nominal capacity. This modularity offers tailored solutions for many applications with very diverse requirements regarding the maximum power capability, energy content, voltage level and temperature range of the power supply. The HLC-1550 with a current capability of 5,000 mA at room temperature is suitable for GSM communication modules where the peak current is usually between 1.5 A and 2.5 A. It has enough performance reserve to accept cold temperatures.

<table>
<thead>
<tr>
<th>Model</th>
<th>Max. capacity</th>
<th>Discharge end voltage (V)</th>
<th>Size (mm)</th>
<th>Max. pulse current (mA)</th>
<th>Cell impedance (mΩ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLC-1550</td>
<td>560 As (155 mAh)</td>
<td>2.5</td>
<td>Ø 15 × 50</td>
<td>5000</td>
<td>&lt;100</td>
</tr>
<tr>
<td>HLC-1530</td>
<td>250 As (70 mAh)</td>
<td>2.5</td>
<td>Ø 15 × 30</td>
<td>3000</td>
<td>&lt;140</td>
</tr>
<tr>
<td>HLC-1520</td>
<td>140 As (39 mAh)</td>
<td>2.5</td>
<td>Ø 15 × 20</td>
<td>2000</td>
<td>&lt;250</td>
</tr>
<tr>
<td>HLC-1020</td>
<td>45 As (12 mAh)</td>
<td>2.5</td>
<td>Ø 10 × 20</td>
<td>750</td>
<td>&lt;400</td>
</tr>
<tr>
<td>HLC-1020L</td>
<td>30 As (8 mAh)</td>
<td>2.5</td>
<td>Ø 10 × 20</td>
<td>500</td>
<td>&lt;600</td>
</tr>
</tbody>
</table>

Table 1 – Characteristics of different HLC sizes

Figure 3 shows the results: the red curve represents the cell after 15 years on 100 µA. During the 30 mA pulse, voltage drops below 2.5 V due to the voltage loss caused by impedance growth. The green curve represents the cell and HLC. The voltage loss is completely compensated by the HLC. Voltage stays well above the minimum requirement of 2.9 V.

Figure 4 – PulsesPlus battery combining an HLC-1520 and a D-size XOL cell in a waterproof resin package

CUSTOMIZED PACKAGE

The HLC-1520 is the best solution for medium range radio modules where current peaks are between 500 mA and 1,000 mA and temperatures are moderate. A typical example for such an application is a water meter with a radio module for remote meter reading from a distance between 20 and 2,000 m. A PulsesPlus battery usually combines an HLC and a high energy primary battery in a shrink sleeved package. However, customized solutions are possible, such as the one shown in Figure 4, where an HLC-1520 and a D-size cell are moulded under resin and form a waterproof battery pack.


ABOUT THE AUTHOR:
Thomas Dittrich studied physics and physical chemistry at the Bonn University in Germany. He joined Sonnenschein in 1988. As manager of Quality Assurance, he led Sonnenschein Lithium GmbH to ISO 9001 certification in 1993. Since 2002, he has been Manager of Applications Engineering. In 2006, Sonnenschein Lithium changed its name to Tadiran Batteries.

ABOUT THE COMPANY:
Tadiran Batteries is a leader in the development of lithium batteries for industrial use. Its technology is well established for more than 30 years. Tadiran Batteries are suitable where utility meters require a single long term stand alone power source, even if it has to supply high pulse currents for a GSM module.

www.tadiranbatteries.de