Demonstration Guide

analytical measurement solutions

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DC cell analysis techniques; Ohmic drop measurements

Demonstration Expt: DG01

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Introduction

Energy storage devices such as batteries, fuel cells and supercapacitors characteristically are low impedance devices (typically < 100mOhms cell impedance). However, ohmic losses arising from effects such as solution resistance, memory effects in rechargeable batteries and deterioration of components during the lifetime of the cell severely reduce the electrical performance of the cell. Research scientists attempt to quantify these effects using current-interrupt or current reversal techniques during charge / dicharge cycling. The technique involves interrupting (or reversing) the DC current supplied to or from the cell and measuring the instantaneous changes in cell voltage which are attributed to ohmic losses within the cell. The technique assumes a simple model for the cell of an equivalent series resistance (ESR) in series with interfacial impedance represented by capacitance, resistance and diffusion elements. When the current is interrupted (or reversed), the voltage across the ESR immediately changes while the voltage across the other elements is maintained for a while due to cell capacitance. The key requirement for accurate measurement of ohmic loss is to measure voltage and current as soon as possible after the current is interrupted (or reversed). The 1470E provides measurement rates of up to 10,000 samples per second which is ideal for this measurement (many test systems are only able to measure at a much lower rate). Having measured the voltage and current just before and just after the current step, it is then easy to calculate the ohmic loss from [change in voltage / change in current].
This guide demonstrates how to capture data at varying acquistion rates so as to optimize the experimental setup allowing the scientist to evaluate ohmic losses effieciently and with a high degree of accuracy and reproducibility.

Equipment

Solartron 1470E multi-channel potentiostat, battery demonstration test box

Connections

Connect coloured cables from channel 1 to their corresponding connections on the test box.

Software Setup

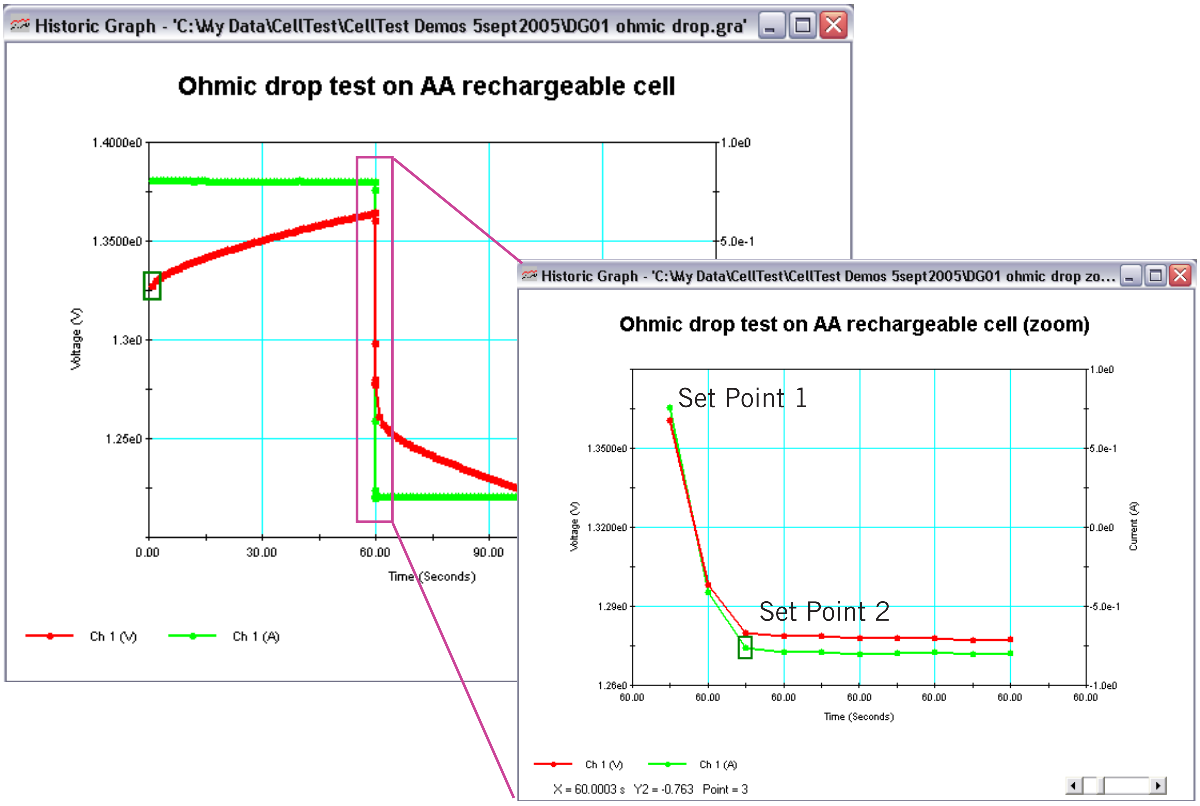
The table below highlights the necessary input experimental parameters.

Schedule Editor

Step	Parameter	Setting	Comment
Step 1	i) Mode ii) DC level iii) Sample rate iv) Step duration v) Current range	i) Current control ii) +0.8A iii) 1 point / second iv) 60 seconds v) 5A	charge the cell and capture data at low rate
Step 2 Same as step 1 except:	ii) DC level iii) Capture rate iv) Step Duration	ii) -0.8A iii) 10,000 points / second iv) 1 millisecond	discharge the cell and capture date at very high rate for a very short period to obtain accurate ohmic drop data
Step 3 Same as step 1 except:	ii) DC level -0.8A	ii) -0.8A	continue discharge of the cell while capturing data at low rate. Fixed current range used throughout

Notes on Setup

It is not necessary, nor is it desirable, to acquire data at high capture rate for the whole duration of the experiment since this can quickly fill a disk drive with useless data. The data that is of most interest occurs immediately before and after the current interrupt (or reversal) step and it is this period of the experiment where high data capture rates are required. Hence the data capture rates were setup in the 'Measurements' page in the 'Schedule Step Settings' window to reflect this requirement. Fixed current range is used throughout the test to ensure that the range is correct immediately after the step so that no high-speed data is lost during the important step phase of the test.
A loop can easily be added to repeat this charge / discharge / ohmic drop sequence to examine how the ohmic drop changes as the cell becomes exhausted and eventually fails.



Data Presentation and Analysis

When the data from this experiment is first shown (by double clicking on the data file in the project tree) a graph showing the whole charge / discharge curve is seen. The main area of interest on this curve is the point just before and just after the current reversal. This can be zoomed into by clicking (using the mouse button) on the graph at one corner of the area of interest and dragging the mouse while holding the button until the required zoom area is selected. The button is then released to zoom the graph. This procedure may be repeated several times to zoom precisely into the area of interest, as shown above. In order to achieve accurate ohmic drop measurements, it is very important to measure the voltage as soon as possible after the current is reversed and the CellTest system's high-speed data capture rate allows this to be easily achieved as can be seen in the zoomed graph display showing data points at intervals of 100microseconds (10,000 samples per second).

The CellTest software calculates ohmic drop by using two reference cursors. First move the graph cursor to the point just before the step in current, right click on the mouse and select "calculation -> Set point 1". Then select the point just after the step, right click and select "calculation -> Set point 2". Finally right click again and select "Calculation -> Calculate Ohmic Drop".

In the example shown above, the rapid change in cell voltage at the current interrupt is attributed to ohmic losses within the cell and was measured to be in the order of 53mOhms.

Conclusions

The high data capture rate and ease of selecting the appropriate measurement speed makes the CellTest system the ideal choice for the determination of ohmic losses for battery, fuel cell and supercapacitor development. An alternative measurement method for obtaining the ESR is impedance analysis and that method is also supported by the CellTest system.