

Getting Started with Your First Experiment:

Cyclic Charge Discharge

Overview of Cyclic Charge Discharge

The purpose of this test is to apply a constant current to batteries, super capacitors, or electrode materials in order to charge and discharge between defined voltage limits. This will allow you to see how a material or cells capacity, efficiency, and similar parameters are affected as a function of cycle number. The test can be very long depending on the number of cycles you want to test, and the current applied to the cell.

This article will focus on a two electrode Li-Ion coin cell. Three electrode measurements are also possible.

Step-by-Step Set up

1. The instrument should be turned on and idling
2. To make the connections easy, the "Gamry Universal Battery Holder" can be used. You will want to place the positive terminal of the battery to working (left side).
3. Once the battery is securely placed in the holder you can connect the leads from the instrument to the holder. Matching the color leads to the color connector. The black ground lead can be left disconnected. See figure 1.
4. Go into the Framework software and navigate to "Experiment"- "Electrochemical Energy"- "Cyclic Charge Discharge". Page one of the experimental setup screen will open. See figure 2.
 - a. Name your experiment identifier under base file name.
 - b. Include any notes like the type of battery and parameters
 - c. Capacity in A-hr. If known, it can be entered here. An approximate value is suitable.
 - d. Cell Type will be "Full" as the test is on a two-electrode cell. Three-

If connecting to the cell without a holder, the green and blue leads can be connected to the positive terminal, and the red, white, and orange leads to the negative terminal.

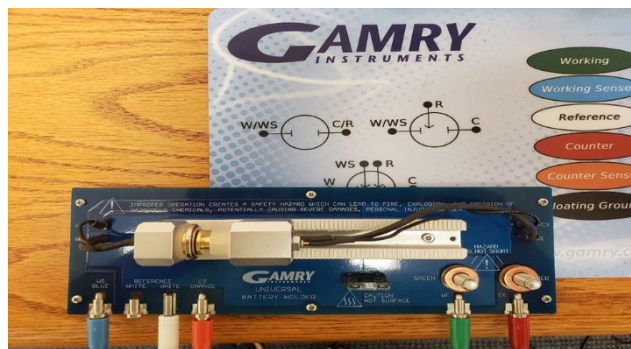


Figure 1- Connections to the Universal Battery Holder for a CCD experiment

electrode cells will use "Half".
 "Both" can be used to measure the half and full cells simultaneously, utilizing a dual electrometer instrument like the Interface 5000.

- e. Save raw data should be checked. If it is left unchecked all the data will be absent.
- f. Working Lead will be set to "Positive".
- g. Cable check should be on to make sure your leads are going to the correct terminals. Click "OK" to bring up the Cable Check dialog box. See figure 3

- 5. After clicking "OK" on the Cable Check, Page 2 of the setup screen will appear. See figure 4
 - a. Number of cycles will be the number of times you wish to charge and discharge the device. One cycle consists of a charge and a discharge step.
 - b. Sample period is how often data points are collected.
 - c. Loop end condition 1 and 2 can stop the experiment if a certain charge time, discharge time, or capacity is reached. In most cases these are set to "None".
 - d. EIS spectrum allows for a spectra to be run following the charge step, discharge step, or both. For brevity, EIS will not be done here but additional information can be found on our Application Notes page
 - e. Charge and Discharge Parameters.
 - i. The options for either charge or discharge mode is constant current, constant load, constant power, and capacitance times N or divided by N (also known as "C" rate).

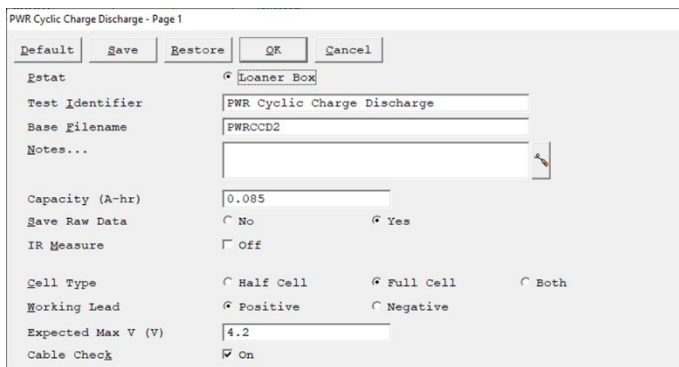


Figure 2- Page one of setup parameters for CCD

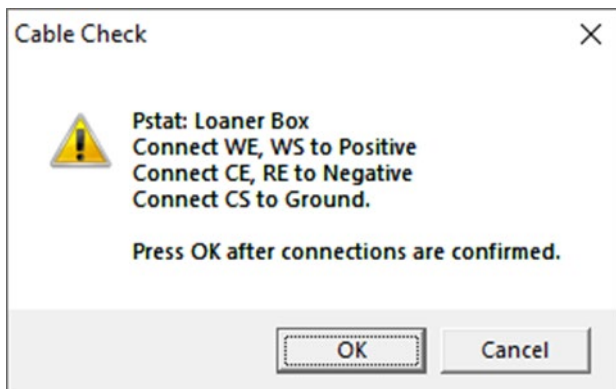


Figure 3- the "Cable Check" dialog box which helps ensure the leads are connected properly based on the Cell Type selected on Page 1 of the setup screen

Each of the modes will decide how to you will apply the a constant to the cell to see how it will handle the constant designed by your experiment. You will be able to decide how long the

charge and discharge will take with a time restraint.

The most common Stop At conditions are defined by a voltage limit. The Discharge limit would be set the lower voltage limit of the cell. The Charge limit would be the upper voltage limit of the cell. For a Li-Ion these limits are usually 3.5V and 4.2V, respectively.

The second stop at is optional but can be used to ensure a temperature limit is not exceeded.

The Voltage Finish is used to potentiostatically hold the cell's voltage at the Stop At limit for a set amount of time, or until the current drops below a set value. This can be used to account for a cell's relaxation post charge or discharge.

- f. Once the parameters are set, click "OK" to begin the cycling.

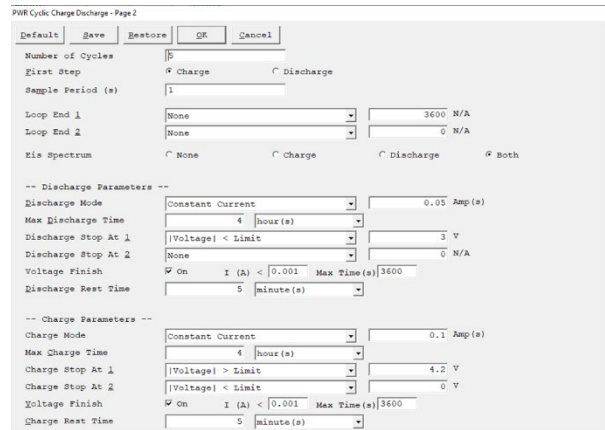


Figure 4- Page 2 of the CCD setup screens. If EIS is not selected, this is the final screen

Cycling Process

The experiment will first measure the open circuit potential and then begin to Charge. The double plot will show the applied current on the upper chart, and the measured voltage on the lower, both as a function of time. Once the Stop At voltage limit is reached the Voltage Finish will occur, followed by the Discharge step. This can be seen in figure 5.

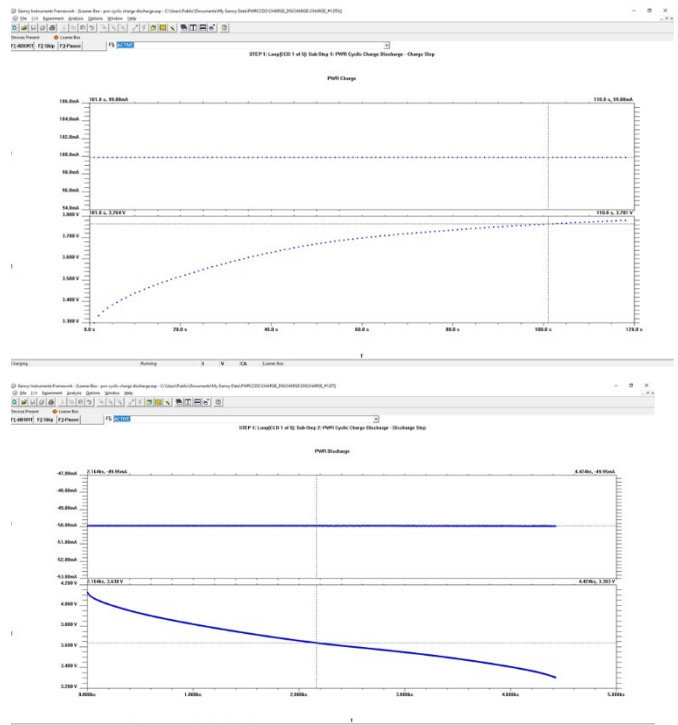


Figure 5- The plots seen during a charge (top) and discharge (bottom) step. This comprises one cycle

When the experiment is done running, 'Experiment done, press "F2-Skip" to continue' will appear in the bottom left status bar. Press the "F2-Skip" button to save and exit.

Performing Analysis

The experimental summary file will be in a folder in the My Gamry Data folder. The raw charge-discharge data will be in a subfolder. The summary file compiles and calculates various parameters, such as capacity, energy, and efficiency, as a function of cycle number. This is useful as an overview of how the cell properties were maintained over the duration of the cycling.

A commonly request plot is an I-V plot showing current and voltage, of all the cycles, plotted against time. To do this, the first step will be to open the Echem Analyst software. From there you will want to click the Open icon. This will take you to C:\Users\WPublic\Documents\WMy Gamry Data. Then click on your cyclic charge discharge folder. Select the subfolder and select all the Charge and Discharge files. Press Open.

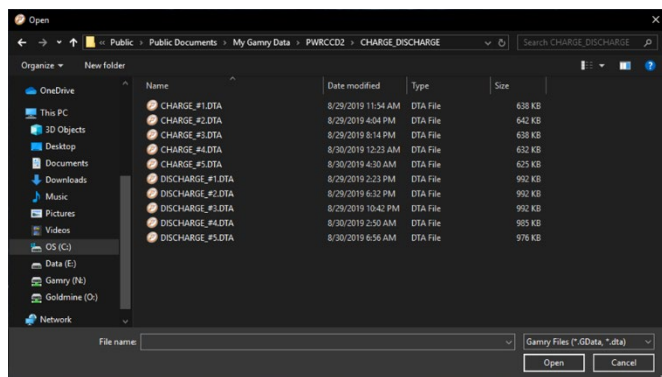


Figure 6- The raw charge and discharge I-V data files. These are contained within a subfolder. The main folder contains the summary file

Then choose the overlay option and it will load the data. Once loaded, you will click the Show Curve

Selector button in the top left of the Analyst screen and select "Real Time" for the x-axis "Vf" (voltage) for the y1-axis, and "Im" (current) for the y2-axis. This will result in the plot as seen in figure 7.



Figure 7- IV plot of the charge and discharge cycles plotted against time. The Show Curve Selector button is selected in the top left of the screen

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