There are vital rules to consider when connecting potentiostat channels to multi-cell electrochemical systems like battery stacks or fuel cells

Batteries, fuel cells, supercapacitors, and other electrochemical devices are often large collections of much smaller cells. These cells are combined in a multi-cell configuration to provide higher capacity and power output than they otherwise could supply if each cell were simply used individually. When conducting research or maintenance on such systems, it is vital to understand how to properly isolate and measure the performance of these individual cells to identify problem areas. Using potentiostats in a multichannel mode is an effective way to investigate isolated areas of the entire battery pack or fuel cell stack. There are two basic multi-cell connection configurations we will discuss here: 1) a *Serial Connection* scheme and 2) a *Parallel Connection* scheme.

Serial Connection

In a serial connection, the negative terminal of an electrode pair is connected to the positive terminal of an adjacent electrode pair. The total voltage is the sum of voltages of each cell pair within the series. But, the current flowing through each cell in the series has the same magnitude and direction. Because of this, the cells connected in series should only be run in a galvanostatic mode. Galvanostatic mode means that current is the variable being controlled by the potentiostat.

A recommended configuration is shown below to test electrochemical devices in series with any of our Squidstat potentiostats. In this configuration, the entire stack of cells is controlled by Squidstat channel 1 in galvanostatic mode. Squidstat channels 2 and 3 should be run only in open circuit mode.
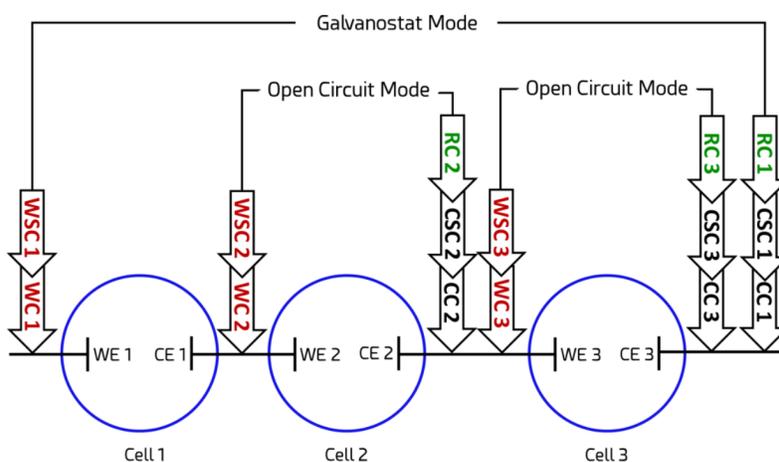

Figure 1. Schematic for connecting multiple channels to cells in series. In the above example, channel 1 is controlling the whole stack with galvanostatic or current-controlled experiments. Channels 2 and 3 are running open circuit potential experiments. In this way, voltage drop across each cell can be measured. (WE: working electrode, CE: counter electrode, RE: reference electrode, WSC: working electrode sense clip, WC: working electrode clip, RC: reference electrode clip, CSC: counter electrode sense clip, and CC: counter electrode clip)

In serial connections, users must be careful that the total voltage of the combined stack of cells does not exceed the voltage limit of the Squidstat running the experiment. The maximum controlled voltage limit of all Squidstat potentiostats currently available as of August 2020 is ±10 V. New Squidstat hardware is currently in development to go to 80 V or higher. Please contact us to learn more.

At a glance, it might seem like channels 2 and 3 can also be run in galvanostatic mode by setting the same current across the cell 2 and 3. This would be erroneous because the CCs can be at different potentials and will interfere with the feedback control of each channel. Therefore, only one of the potentiostats, Squidstat 1, can be controlling the current.

Parallel Connection

In a parallel connection, terminals of all cells with the same sign are connected to each other. The voltage across each cell is the same, and equal to the total voltage of the stack. But, the total current is the sum of all the currents from each cell. In such a configuration, users might be interested in finding out the current flowing through each cell. At a glance, it might look like this can be achieved by setting the same potential across each cell and then measuring the current. However, this would be wrong because the current flowing in one cell will affect the current flowing in another cell. This interferes with the feedback control of each potentiostat channel. Therefore, it is not possible to run cells connected in parallel with multiple channels even in potentiostatic mode without interference.

A recommended configuration is shown below to test multiple cells connected in parallel with a single potentiostat channel controlling the whole configuration. In this setup, the channel can be run both in potentiostatic or galvanostatic modes. Users must be careful not to exceed the total current limit of the Squidstat they are using.
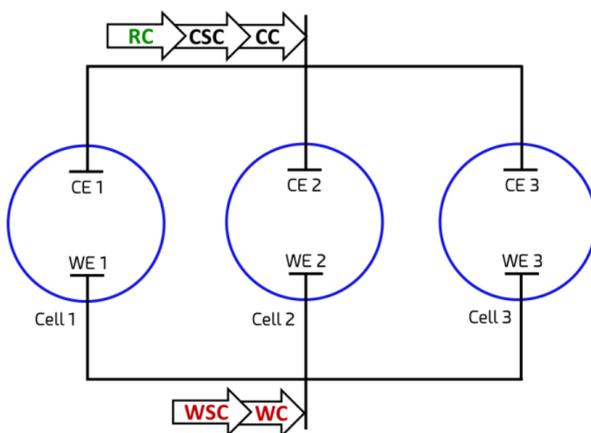

Figure 2. *Schematic for connecting multiple channels to cells in parallel. It is not possible to find current flowing through each cell by running them in potentiostatic mode because current from one cell will try to flow through the other cell. (WE: working electrode, CE: counter electrode, RE: reference electrode, WSC: working electrode sense clip, WC: working electrode clip, RC: reference electrode clip, CSC: counter electrode sense clip, and CC: counter electrode clip)*