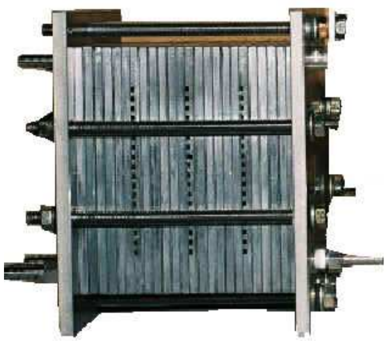

I/V characterization of a fuel cell stack: DC measurements at high current densities

The operational behaviour of a fuel cell stack is usually evaluated by determining the polarization and power density curves of the cell. These curves provide a quick characterization of the stack performance and an assessment of its optimal operating conditions (temperature, humidity, electrocatalyst, ion-exchange membrane).

Most fuel cell stacks operate at currents far higher than 1 A, while most potentiostats are limited to 1 or 2 A. With the Autolab PGSTAT302N, the maximum measured current is 2 A, and it can be expanded up to 20 A by the use of the Booster20A. Nevertheless, even 20 A is not enough to study a large fuel cell stack.

To bypass this limitation, an electronic load can be used in combination with the Autolab. While the electronic load draws the current from the cell, the Autolab measures the electromotive force of the cell.

The voltage of a fuel cell stack is equal to the sum of the individual cell voltages in the stack, and can reach values higher than 10 V, which is outside of the measurable range of most potentiostats. For the PGSTAT302N, an optional voltage divider is available, which allows measurements of stack potential up to 100 V (Order code: VOLT.MULT). The use of the voltage divider has been illustrated in a battery related application note (see application note #46).

Choice of the electronic load

For the experiments presented in this application note we have used four Chroma series 63030 electronic loads in parallel. Each load module is capable of sinking a current of 60 A, which means that a total of 240 A discharge current can be achieved. The maximum voltage was 60 V. One of the loads was set as the master while the three others were operating as slave units.

The experiments described can also be performed in combination with many other commercially available loads.

Connections between Autolab and Load

The connection between the Autolab PGSTAT302N and the electronic load modules requires the Electronic Load Interface (Order code: LOAD.INT). The use of this interface has been illustrated in the previous fuel cell related application notes (see application notes #35 and #39).

Experimental conditions

The electronic loads used in these experiments have a combined maximum current of 240 A, and a voltage range of 0-60 V. Measurements were performed on 14 PEMFC (Polymer Electrolyte Membrane Fuel Cell) stack with dispersed Pt as a catalyst on both the anode and the cathode. The fuel cell was operated on humidified H_2/Air at 50℃. Each fuel cell has a surface area of 200 cm².

The polarization curves were obtained using an Autolab PGSTAT302N in combination with the NOVA software. The electronic load was used to draw predefined currents from the fuel cell stack. The electromotive force of the stack was measured using the differential electrometer of the PGSTAT302N in combination with the voltage divider. The measured value was automatically corrected for the division in the software.

The load was operated in Constant Current (CC) while the Autolab PGSTAT302N was operated in potentiostatic mode. The procedure used in the NOVA software was designed to measure the potential of the stack during 30 seconds, using an interval time of 10 ms, for each value of the current drawn from the stack. The value of the discharge current was controlled by the software directly. The values varied between 0 and 170 A.

Experimental results

The potential was measured continuously, while increasingly large current values, up to 170 A, were drawn from the fuel cell stack.

Figure 1 shows the discharge current and measured potential profiles during time.

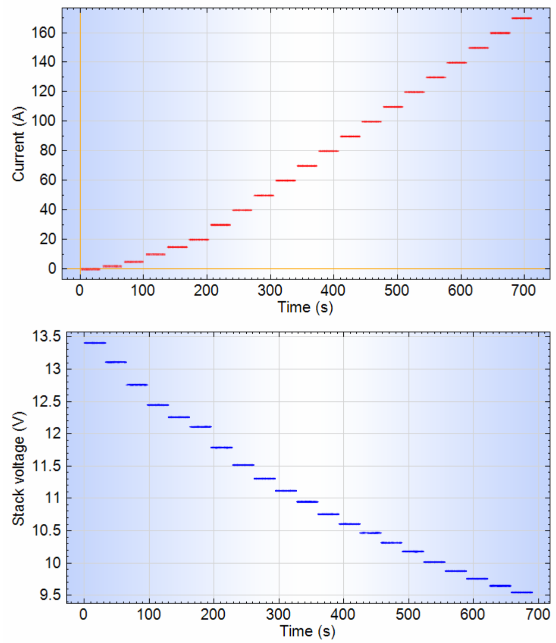

Figure 1 – Discharge current (red) and measured potential (blue) profiles

The total measurement time was about 700 seconds. After the measurements, the NOVA software was used to build the complete polarization curve and the power density curve, using the measured potential values and the applied discharge current values.

Figure 2 shows the polarization curve obtained for the 14 cell fuel stack.

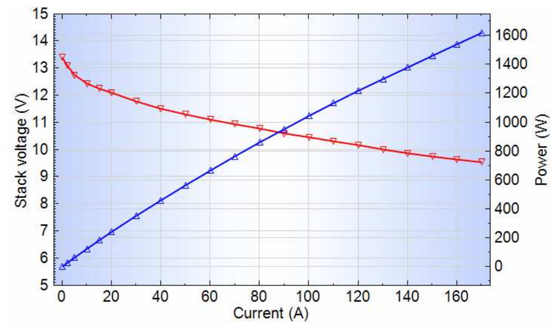

Figure 2 – Polarization curve (red) and power density curve (blue) obtained from the experimental current and potential values

Using this experimental setup, it was possible to compare the performance of different fuel cell assemblies. Figure 3 shows a comparison of two different stacks, operating in the same experimental conditions.

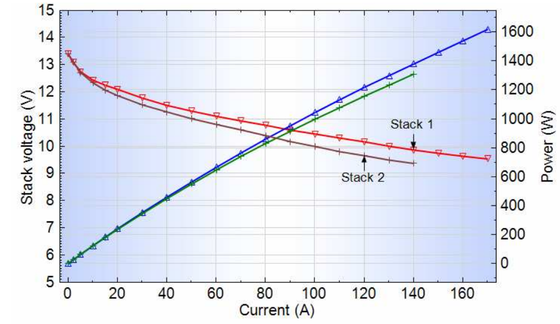

Figure 3 – Direct comparison of the fuel cell stack performance (Stack 1, red I/V curve, blue power density curve vs. Stack 2, brown I/V curve, green power density curve)

Conclusions

The measurements presented in this application note demonstrate the combination of the Autolab PGSTAT302N with a high-power electronic load. The full polarization curve of a large stack could be measured using this experimental setup.

The electronic load, in combination with the PGSTAT302N, was used to sink currents higher than 2 A while the voltage divider allowed the PGSTAT302N to measure stack potentials greater than 10 V.