Q: What are the differences between and advantages of the 850/890 Fuel Cell Test System with the 880/881 FRA and the 885 Fuel Cell P/GSTAT with the EIS option?

A: The electronic load used in Scribner's fuel cell test systems (850, 855, 890, 890ZV) can be furnished with Scribner's 880/881 Frequency Response Analyzer (FRA), a.k.a., impedance analyzer. An FRA is required to perform Electrochemical Impedance Spectroscopy (EIS) and High Frequency Resistance (HFR) measurements (HFR is an impedance-based method for measurement of the ohmic resistance of the fuel cell). Both EIS and HFR operate in conjunction with 850/890 load but, importantly, only when the cell is an energy producing device (*e.g.*, H_2 Anode and Air/O_2 Cathode) and under load (*i.e.*, current I > 0 Amp). This has the advantage that the cell's impedance can be characterized at various operating conditions and at DC currents near the limit of the load (10s to 100s of Amps, depending on the load size). Characterization of the cell's impedance as a function of current density is critical for the evaluation of the magnitude and relative magnitude of the sources of impedance within the cell (activation, ohmic and mass transport). These sources of cell polarization have different relative magnitudes at different current densities and are a function of operating conditions (temperature, RH, reactant flow or stoichiometry, pressure, etc.).

However, because a load cannot source energy into the cell, EIS and HFR cannot be performed using the 850/890's load at Open Circuit Voltage (OCV) or when the cell is in a "diagnostic" mode, such as under H_2/N_2, N_2/N_2 or Air/Air conditions, *i.e.*, the fuel cell is not an energy producing device under these conditions.

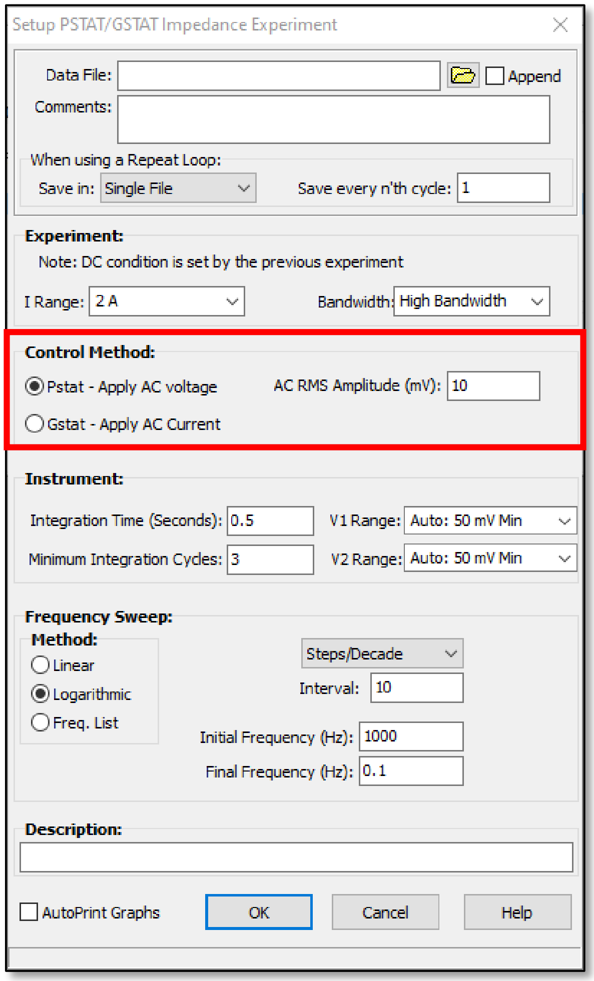
Scribner's latest model of the 885 Fuel Cell P/GSTAT has an option for EIS. Because the 885 is a potentiostat / galvanostat, it can perform EIS measurements under conditions that the 850/890 load + FRA cannot. For example, the 885 P/GSTAT can perform EIS at OCV as well as when the cell is in a "diagnostic" mode, the most common of which is measurement of the catalyst layer proton resistance under H_2 / N_2 [1-3]. In the latter case, the cell is in a "driven" mode and the P/GSTAT is sourcing energy into the cell in order to perform the EIS measurement.

An electronic load cannot source energy to a cell, it can only sink energy from an energy producing device, such as a fuel cell operating as a fuel cell or a discharging battery. By the same logic, the 850/890 load + 881 FRA are unable to conduct EIS measurements at OCV because in order to do so, it would have to source energy into the cell to polarize it above OCV. That is, during half of the imposed AC waveform, the load would be driving the cell above OCV and during the other half of the AC waveform, it would be pulling the cell below OCV. The load can do the latter but not the former. In contrast, a potentiostat / galvanostat such as the 885 can both source energy to and sink energy from the device under test.

Another potential advantage of performing EIS with the 885 P/GSTAT is the smaller current ranges of the instrument in comparison to the load: the 885 P/GSTAT has current ranges of 0.02/0.2/2 A (or 0.05/0.5/5 A) whereas the 850 current ranges are 5/25/50 or 10/50/100 A. By using the lower current ranges of the P/GSTAT one can obtain improved current accuracy and therefore improved EIS spectra at small DC currents, *i.e.*, near OCV.

As shown in the image below, with the 885 P/GSTAT, one has the option of performing voltage-based or current-based EIS measurements.

It should also be noted that HFR is not currently supported for the 885 P/GSTAT.



References

1. Makharia, R., *et al.* "Measurement of Catalyst Layer Electrolyte Resistance in PEFCs Using Electrochemical Impedance Spectroscopy" *J. Electrochem. Soc.* **152** A970 (2005).
2. Liu, Y. *et. al.* "Proton Conduction in PEM Fuel Cell Cathodes: Effects of Electrode Thickness and Ionomer Equivalent Weight" *J. Electrochem. Soc.* **157** B1154 (2010).
3. Liu, Y. *et. al.* "Effects of Catalyst Carbon Support on Proton Conduction and Cathode Performance in PEM Fuel Cells" *J. Electrochem. Soc.* **158** B614 (2011).