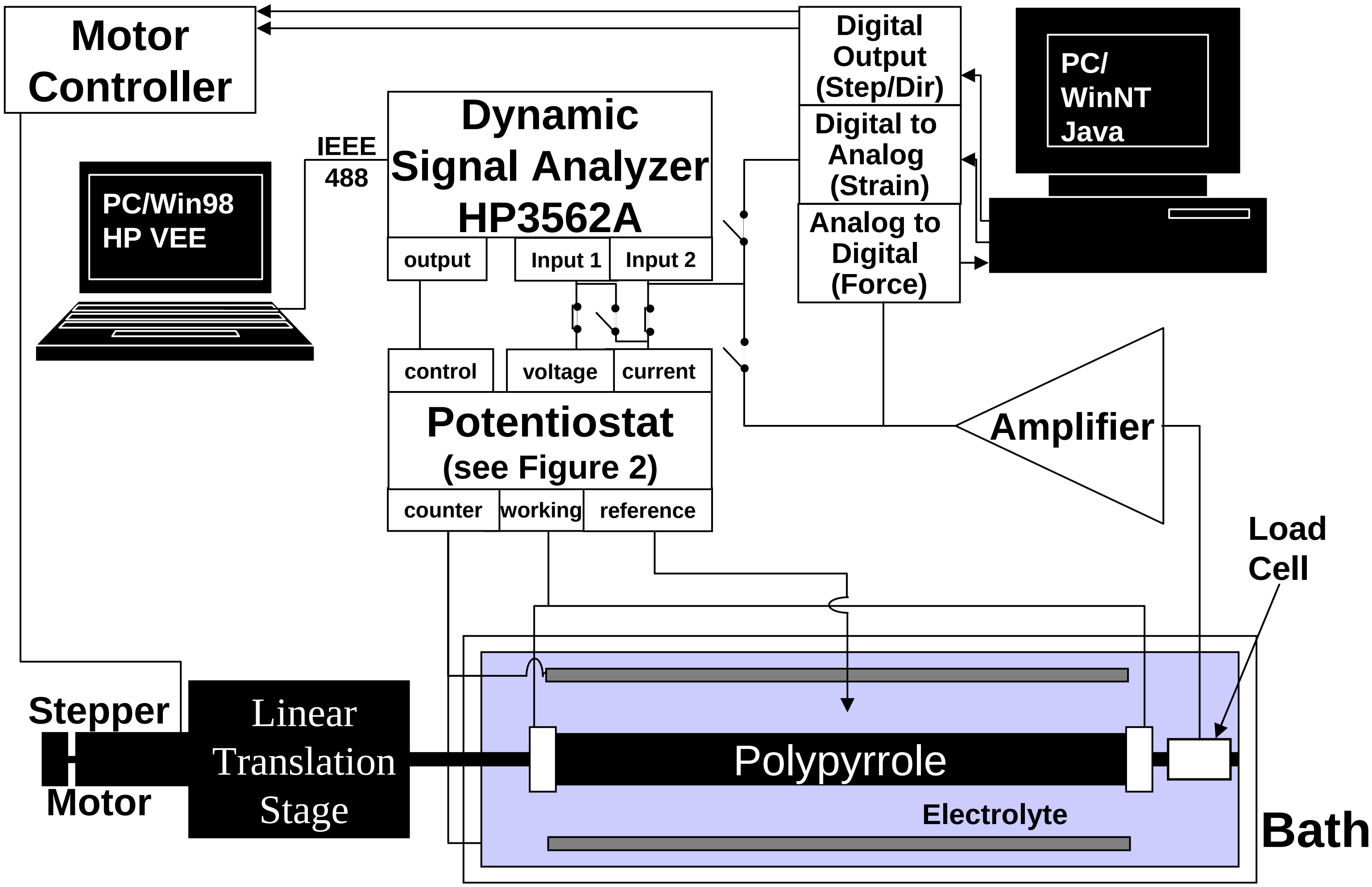

Figure 1: Diagram of the experimental apparatus for measuring polypyrrole admittance. Strain to current and stress to current are measured by switching connections to the DSA.

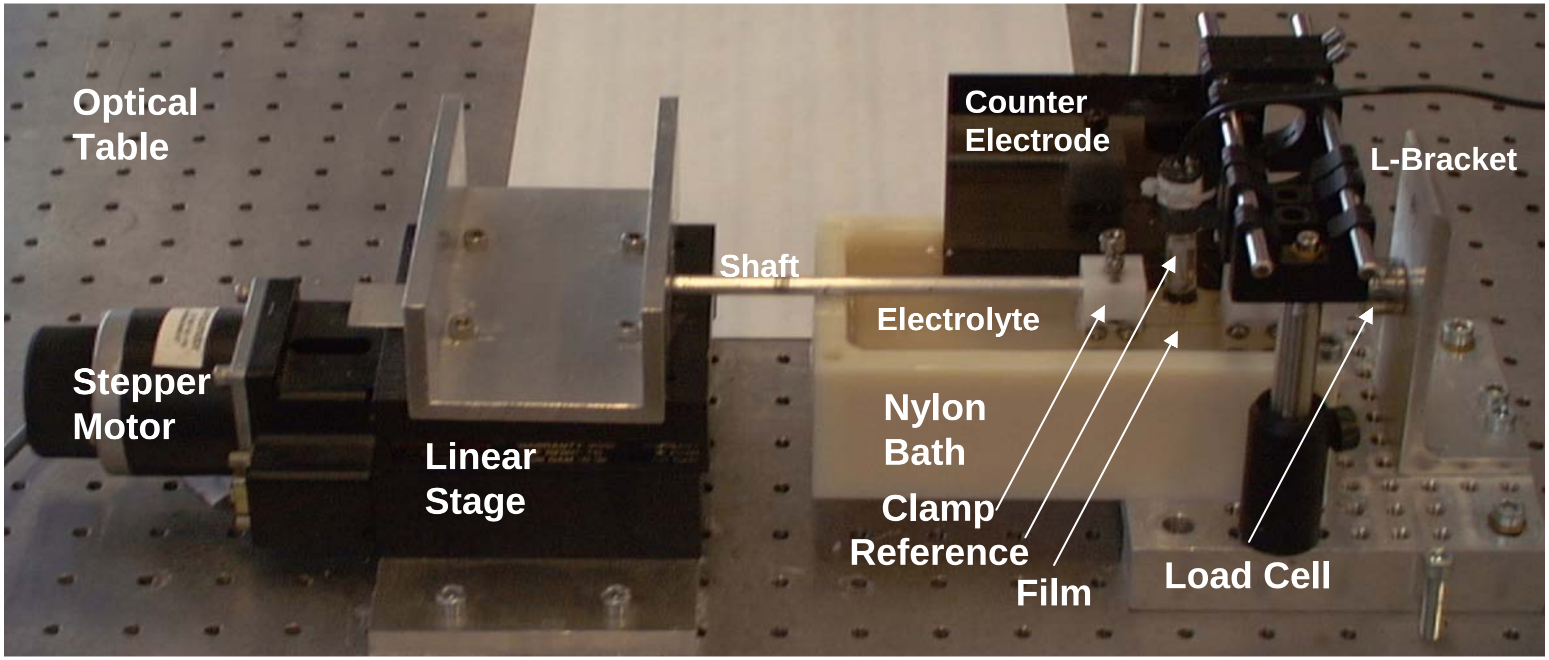

Figure 2a: A photograph of the bath in which electrical and mechanical tests of polypyrrole films are performed, and of the stepper motor and linear stage used to apply displacements to the film. A second counter electrode, placed symmetrically about the film relative to the first, is not shown.

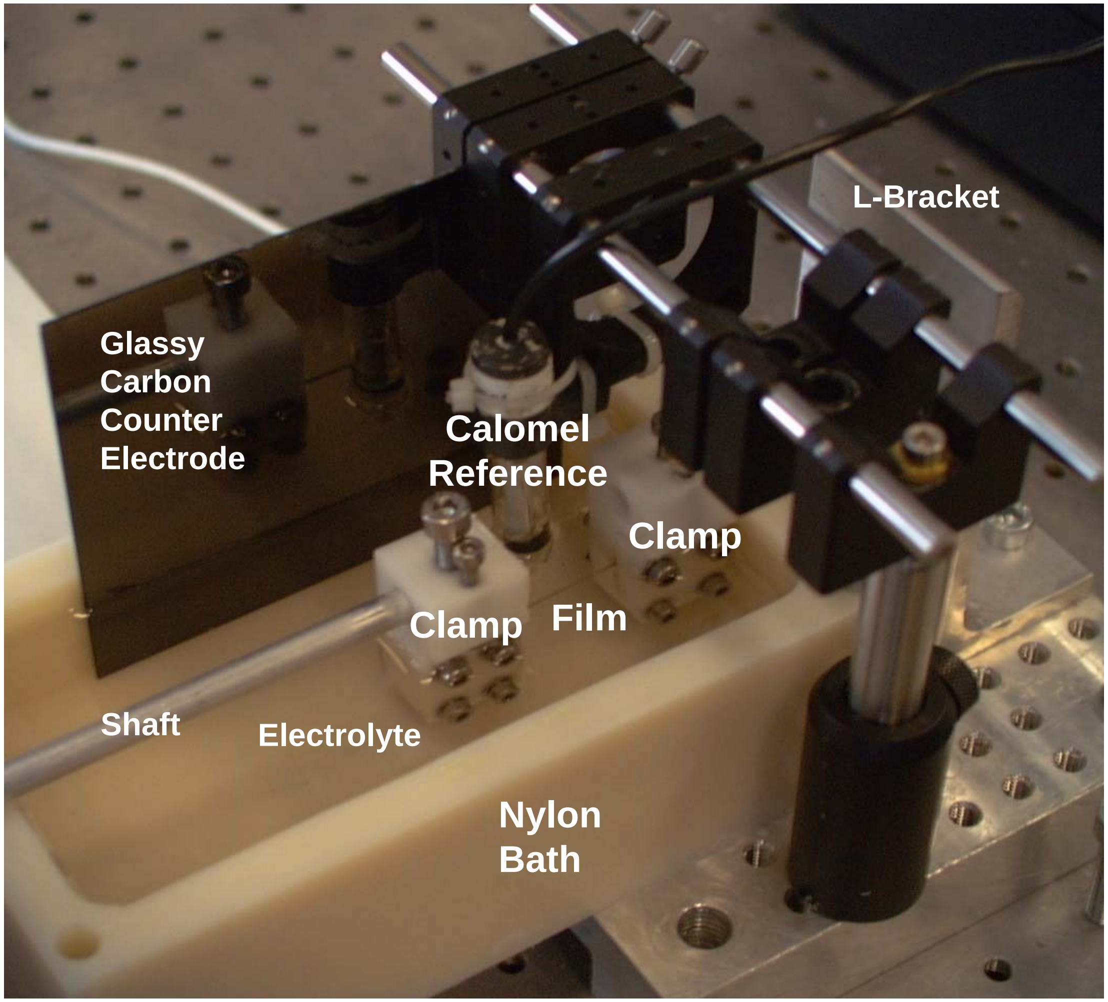

Figure 2b: A closer view of the bath, showing the positioning of the clamps, the reference electrode and the film. A second identical counter electrode on the near side of the film has been removed.

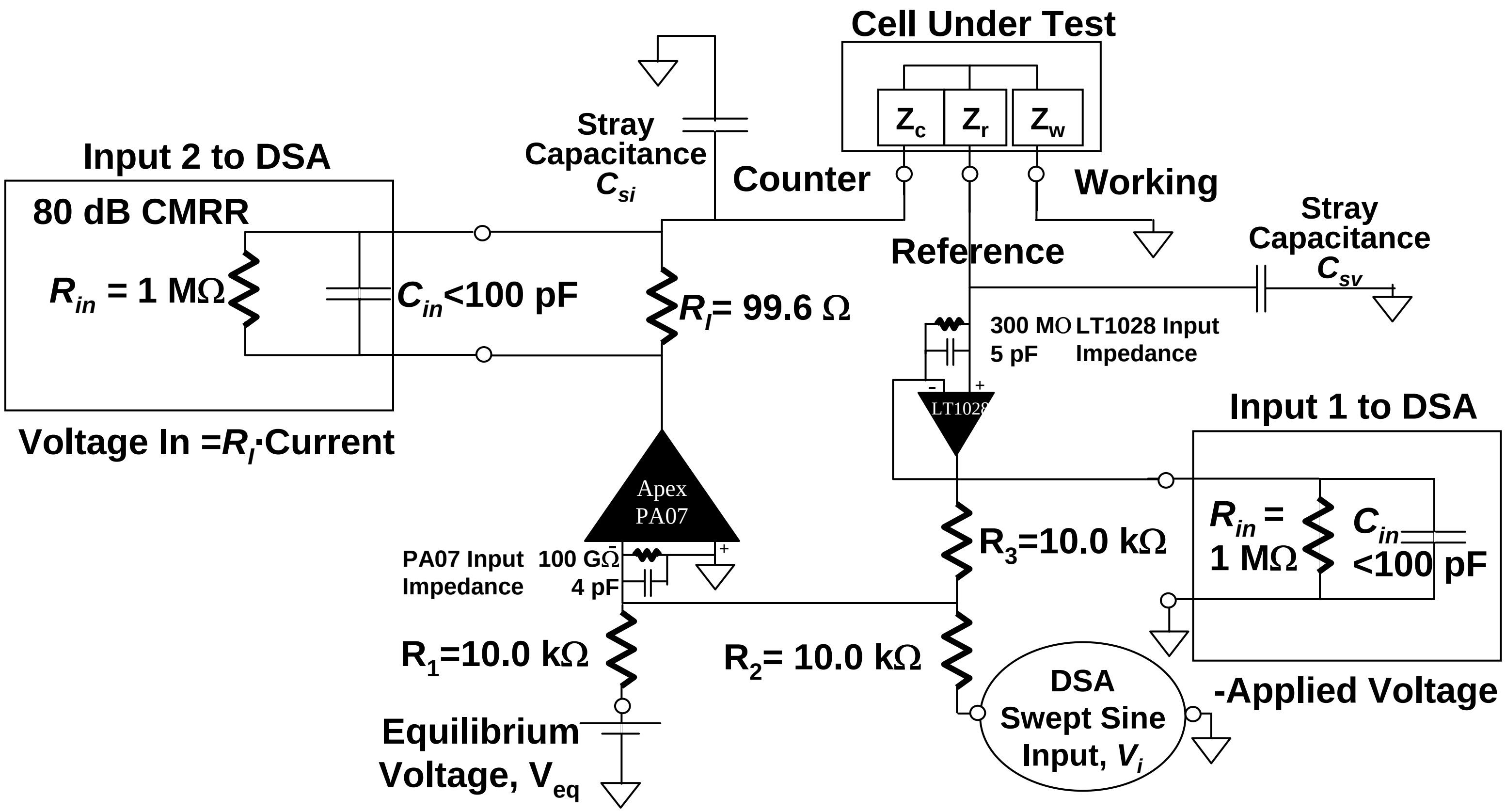

Figure 3: Diagram of the potentiostat circuit with the HP3542A DSA (dynamic signal analyzer) connected. The open circles represent inputs and outputs to the potentiostat. The DSA input impedances and some of the parasitic capacitances are shown. CMRR is the Common Mode Rejection Ratio of the DSA inputs. The admittance is the ratio of amplitudes of Input 2 to Input 1multiplied by exp(i*phase difference)

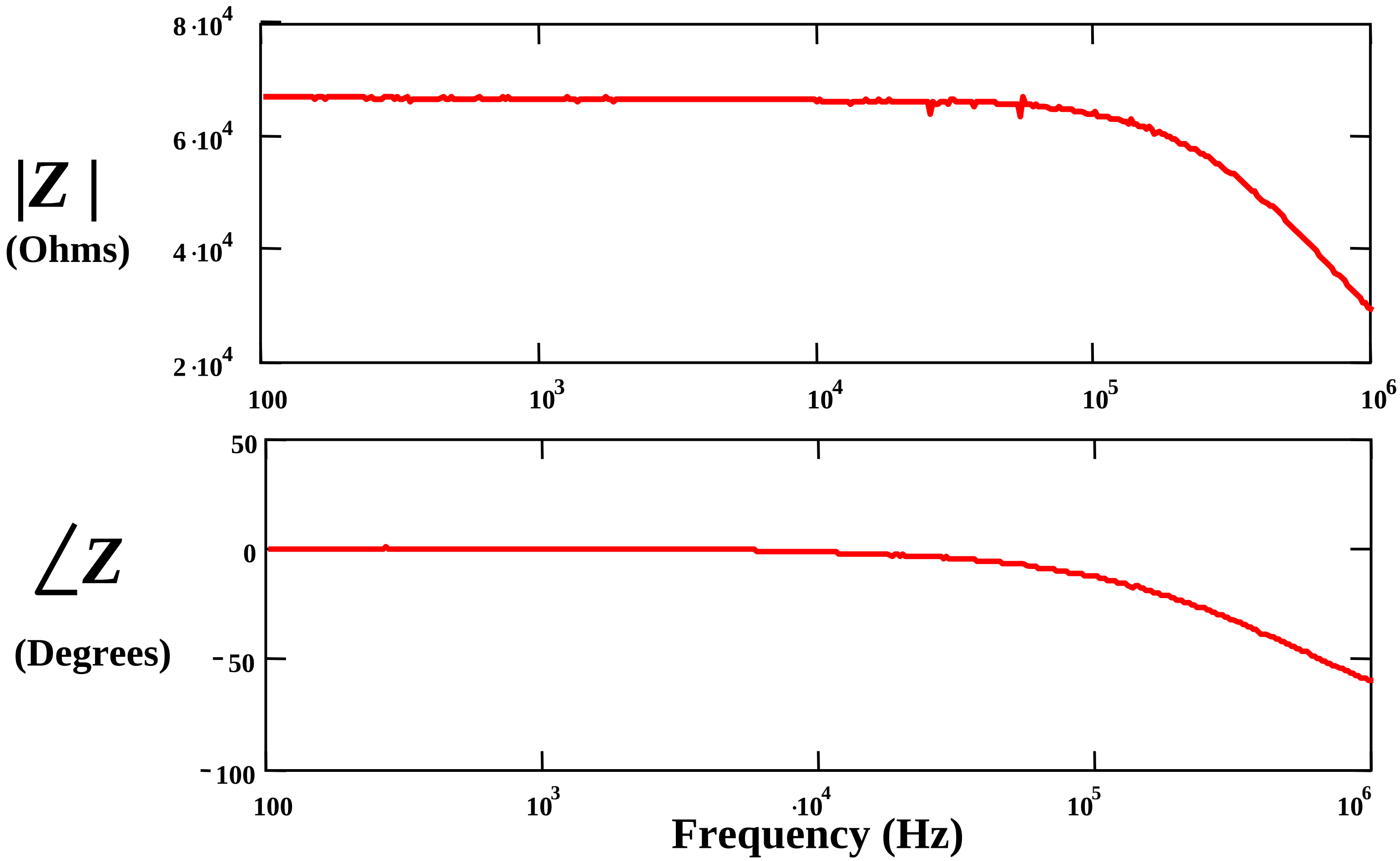

Figure 4: Impedance of a Ag/$AgClO_4$ reference electrode. A 10 mV applied potential is used to measure the impedance against a 50x50 mm stainless steel electrode placed 10 mm from the reference tip, and all immersed in 0.3 M tetraethylammonium hexafluorophosphate in propylene carbonate.

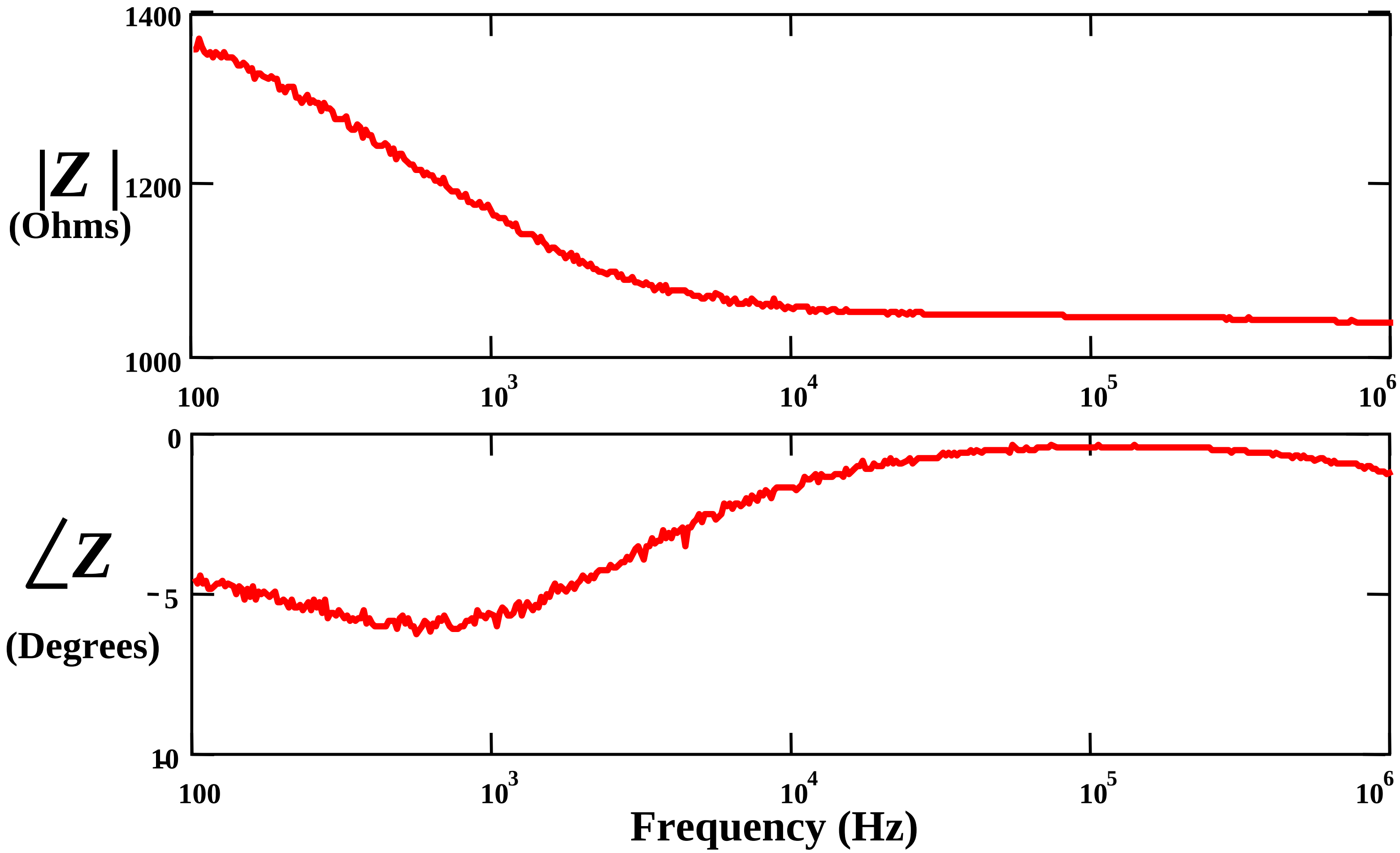

Figure 5: Impedance of a calomel reference electrode. A 10 mV applied potential is used to measure the impedance against a 50x50 mm stainless steel electrode placed 10 mm from the reference tip, and all immersed in 0.3 M tetraethylammonium hexafluorophosphate in propylene carbonate.

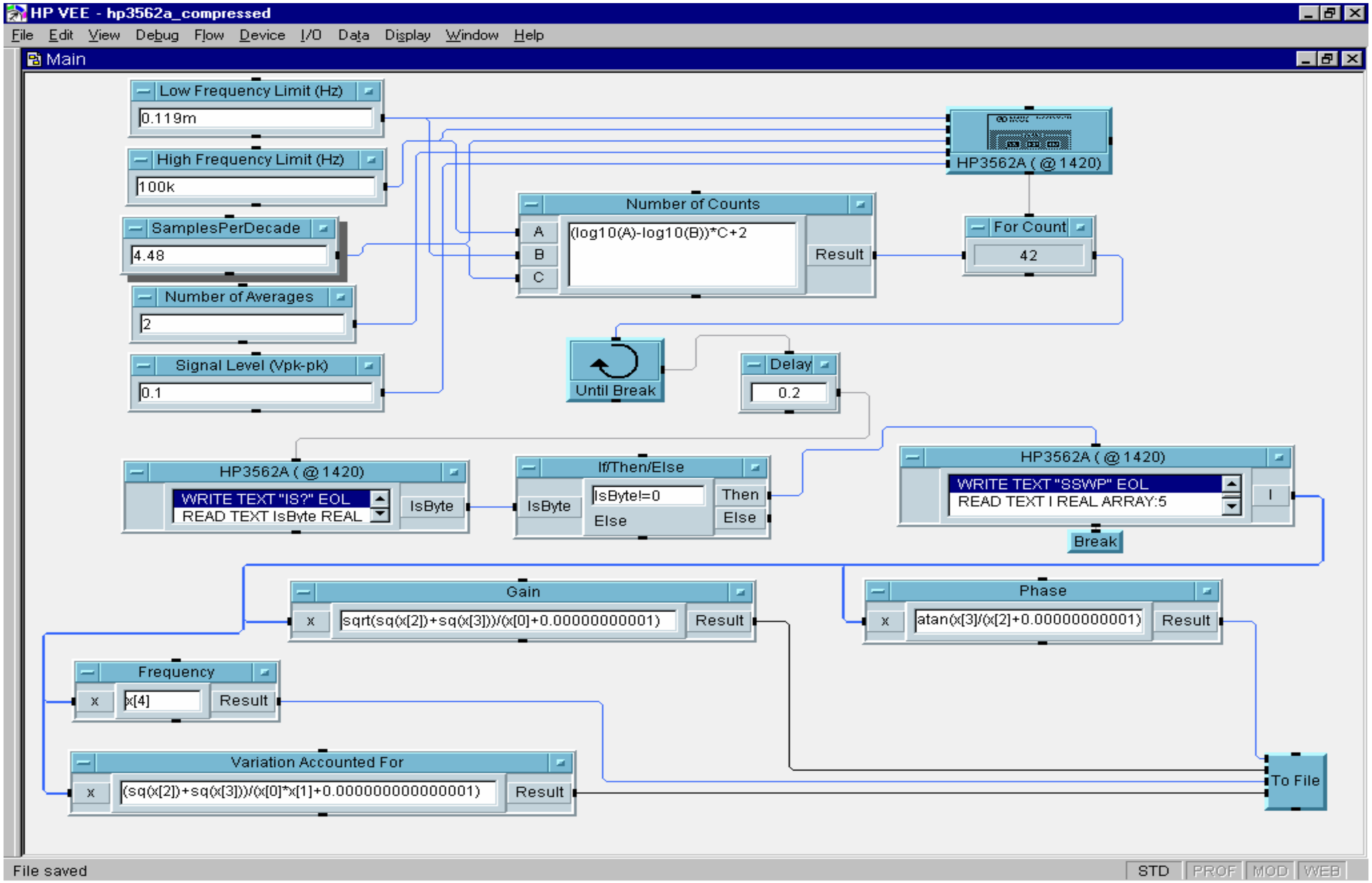

Figure 6: The HP VEE program used to control the dynamic signal analyzer, acquire data, and compute gain, phase and variation accounted for.

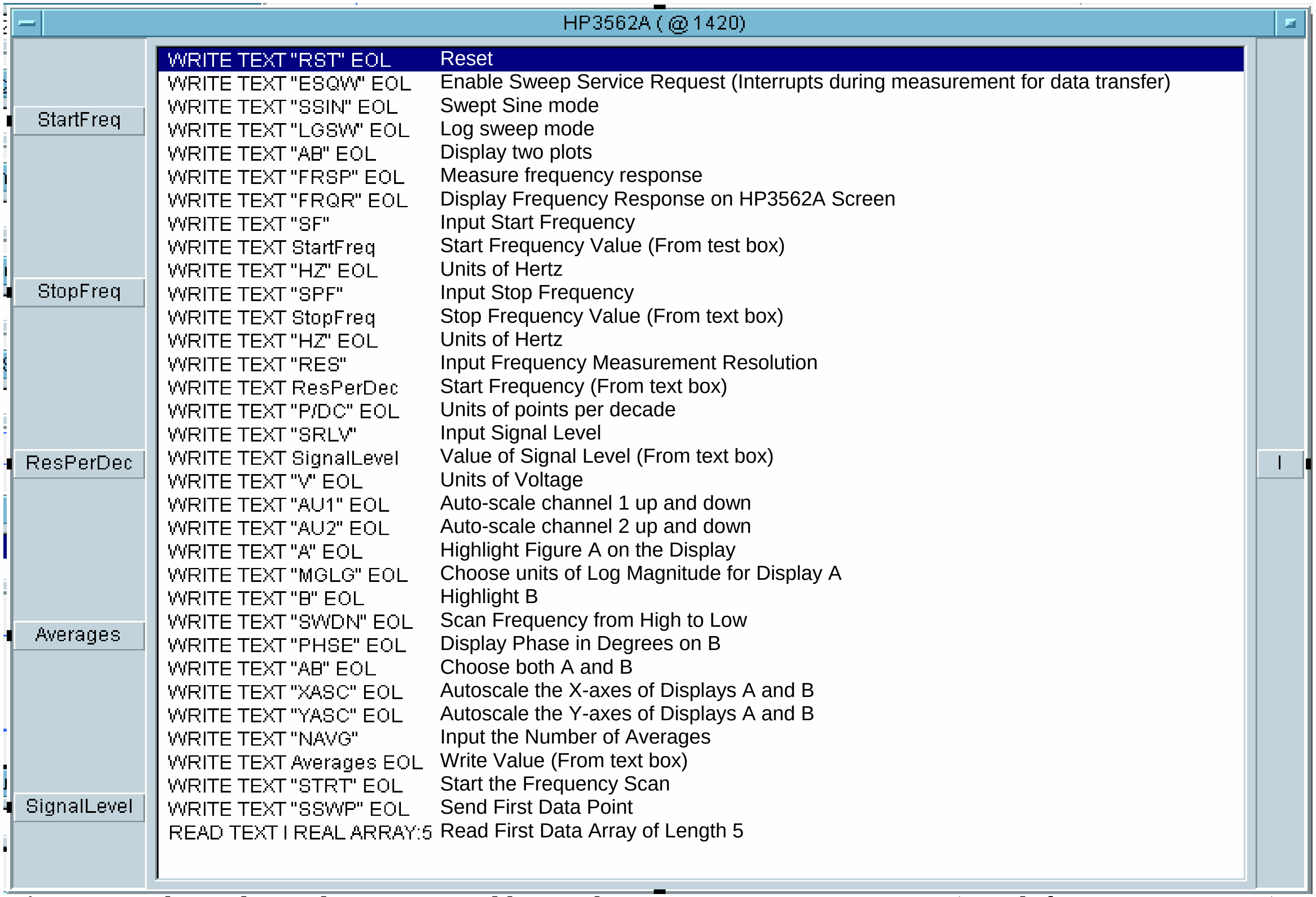

Figure 7: The code used to set-up and begin the HP3562A measurement. (Top left icon in Figure 6).

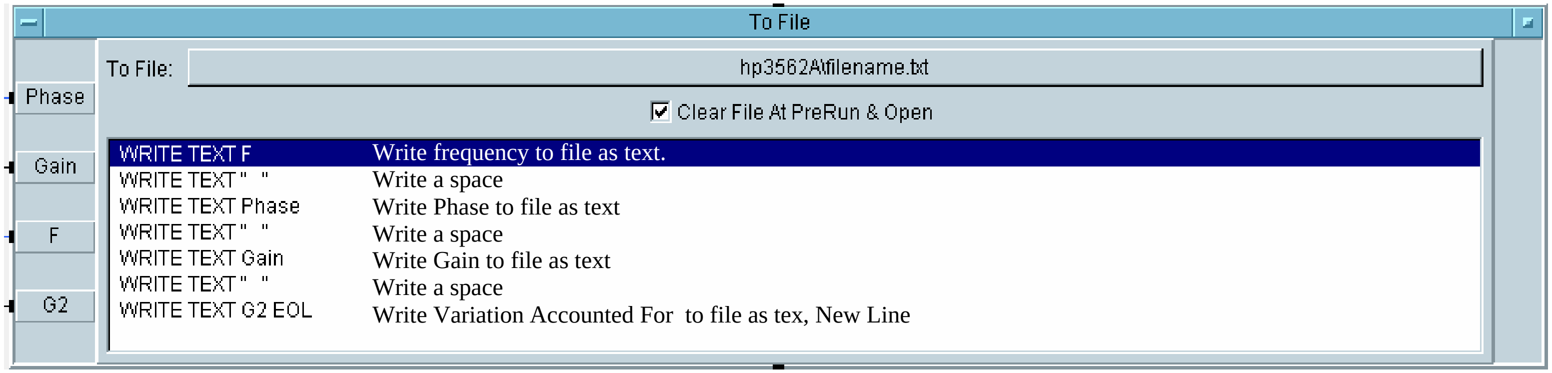

Figure 8: The code used to write frequency, gain, phase and variation accounted for to file in HP VEE.

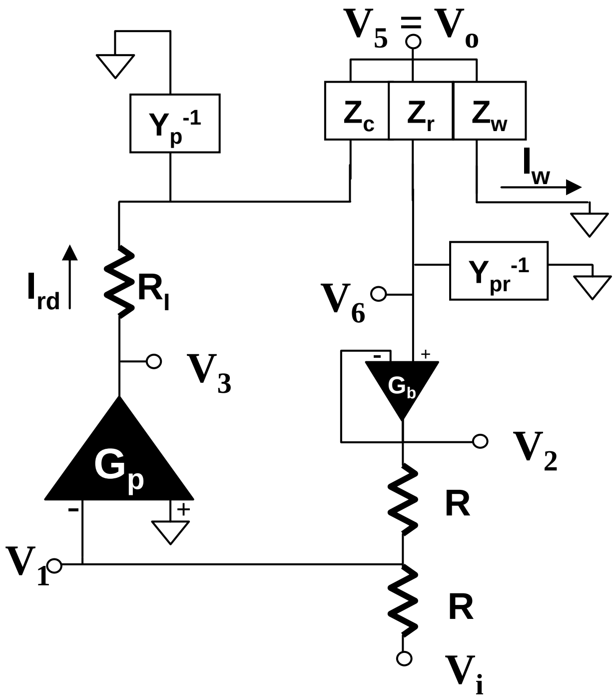

Figure 9: Equations describing the effects of parasitic admittances and finite operational amplifier gains on potentiostat output. The circuit diagram at left defines the variables employed.

$$V2(f) := \frac{-Gb(f)\cdot Zw(f)\cdot Gp(f)\cdot Vi}{(A(f)\cdot Yp(f) + B(f))\cdot Ypr(f) + C(f)\cdot Yp(f) + 2\cdot(Zw(f) + Zc(f) + Ri)\cdot(1 + Gb(f)) + Zw(f)\cdot Gp(f)\cdot Gb(f)}$$

$$V3(f) := -Gp(f)\cdot\frac{(Vi + V2(f))}{2}$$

$$A(f) := 2\cdot(Zw(f)\cdot Ri\cdot Zc(f) + Zc(f)\cdot Ri\cdot Zr(f) + Zr(f)\cdot Zw(f)\cdot Ri)\cdot(1 + Gb(f))$$

$$B(f) := 2\cdot(Zw(f)\cdot Ri + Ri\cdot Zr(f) + Zc(f)\cdot Zr(f) + Zc(f)\cdot Zw(f) + Zw(f)\cdot Zr(f))\cdot(1 + Gb(f))$$

$$V6(f) := V2(f)\cdot\frac{(1 + Gb(f))}{Gb(f)}$$

$$C(f) := [2\cdot(Zw(f) + Zc(f))\cdot Ri\cdot(1 + Gb(f))]$$

$$Ird(f) := \frac{(Zw(f) + Zr(f))\cdot(1 + Gb(f))}{[Gb(f)\cdot(1 + Ri\cdot Yp(f))\cdot Zw(f)]}\cdot V2(f)\cdot Ypr(f) + \frac{[2\cdot V2(f)\cdot(1 + Gb(f)) - Gp(f)\cdot Yp(f)\cdot Zw(f)\cdot Gb(f)\cdot(Vi + V2(f))]}{[2\cdot Gb(f)\cdot(1 + Ri\cdot Yp(f))\cdot Zw(f)]}$$

$$Iw(f) := \frac{V5(f)}{Zw(f)}$$

$$V5(f) := V3(f) - Ird(f)\cdot Ri - \left[Ird(f) - \left[-Gp(f)\cdot\frac{(Vi + V2(f))}{2} - Ird(f)\cdot Ri\right]\cdot Yp(f)\right]\cdot Zc(f)$$

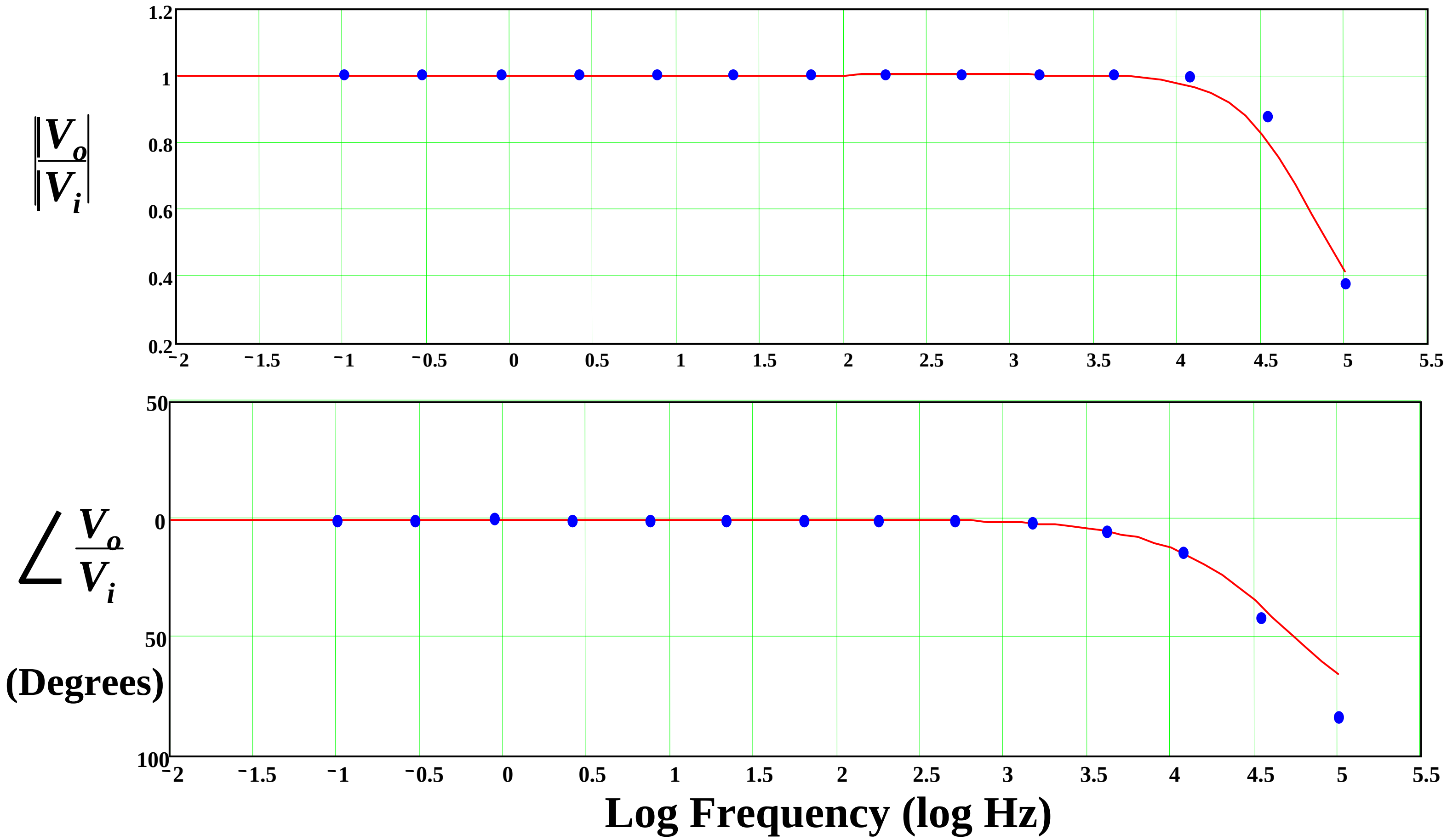

Figure 10: Ratio of actual output potential by the potentiostat to command input. The blue dots indicate measured values, while the red line is the response predicted using the equations in Figure 9, which account for the finite gains of the operational amplifiers used in the potentiostat, and for parasitic impedances.

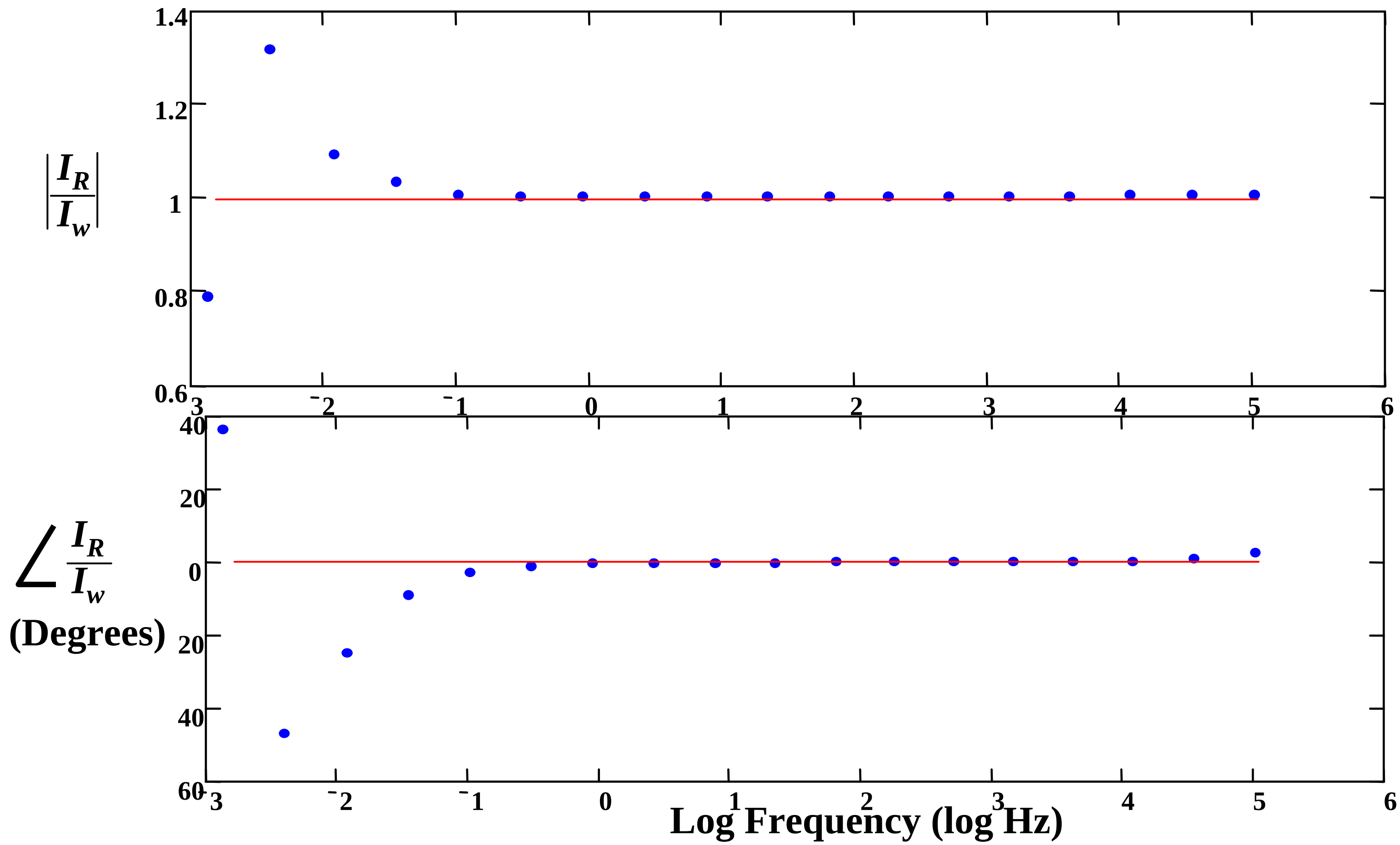

Figure 11: Ratio of current, I_{rd}, measured across R_i, to actual current, I_w, across the working electrode (Figure 9) impedance, Z_w. The blue dots indicate measured values, while the red line is the predicted response. The currents are equal until 100 mHz, at which point finite common mode rejection of the DSA affects measured currents, as discussed in Section 9.2.4.2.4, and accounted for in Figure 12.

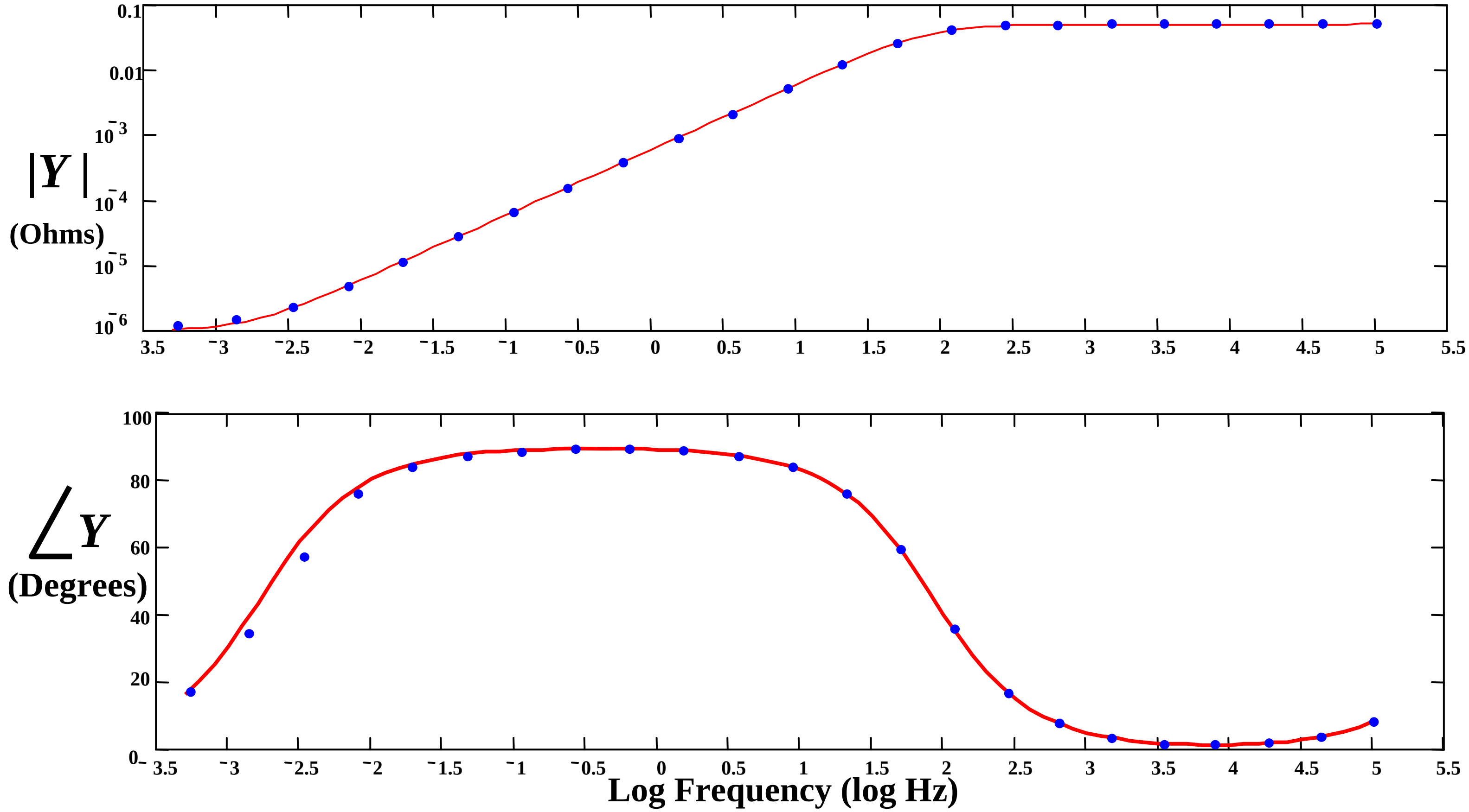

Figure 12: Measured and predicted admittance from an *RC* test circuit (R=20.1 Ω, C=94.6 μF). The blue dots indicate measured admittance values, while the red line is the predicted response, which accounts for the finite gains of the operational amplifiers used in the potentiostat, and parasitic impedances, using the equations in Figure 9, and additionally the finite common mode rejection of the Dynamic Signal Analyzer.

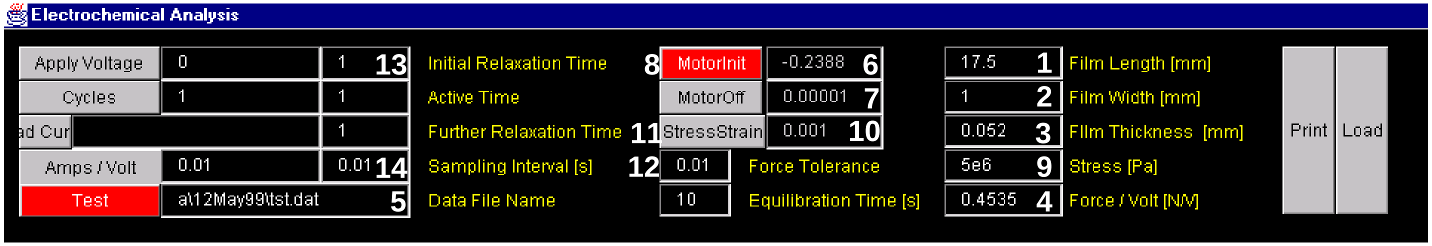

Figure 13: Image of the Java user interface used to set film length, run stress/strain experiments, and maintain isotonic conditions.