Universal Dummy Cell 3

Operator's Manual

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Introduction

The Universal Dummy Cell 3 (UDC 32) is a printed circuit board used for calibration and troubleshooting of a Gamry potentiostat. It has 3 "test cells" equipped with terminals, arranged around the boarders of the printed circuit board.

The terminals are marked with labels corresponding to the leads on a Gamry Cell Cable. The FAS2 has fewer cell leads than a PCI4 or Reference 600, so some terminals will have no connection to an FAS2.

This document applies to the UDC 3, engineered to work with Gamry's PCI4 family of potentiostats and the newer Reference 600 Potentiostat. The UDC3 is clearly labeled with the text "Universal Dummy Cell 3" written diagonally across its printed circuit card.

AC calibration of a Reference 600 Potentiostat should always be done using a UDC3. Stray capacitance on an older UDC2 will cause significant phase errors at 1 MHz.

Calibration

The calibration circuit is a 2 kΩ precision resistor (with some protection components). It is accurate to better than 1 Ω. Because potentiostats are not perfectly accurate, its value measured with a Gamry potentiostat is typically between 1.994 kΩ and 2.006 kΩ.

Very early revision UDCs had a 100 Ω resistor in the calibration circuit. PCI4 family potentiostats and the Reference 600 require a 2 kΩ resistor. 100 Ω Universal Dummy Cells (shipped before May 2003) will not calibrate a PCI4 family potentiostat or a Reference 600 to its full accuracy.

AC calibration of a Reference 600 Potentiostat should always be done using a UDC3. Stray capacitance on an older UDC2 will cause significant phase errors at 1 MHz.

You can also use the calibration circuit to test for proper operation of your potentiostat. Use any technique. The current at any potential should be given by Ohm's law, I = E/R. At 1 Volt, the current should be 500 μA.

More specifically, we recommend you use one of these techniques if you have concerns about your potentiostat's health:

- DC105   Polarization Resistance
- EIS300   Potentiostatic EIS
- PHE200   Cyclic Voltammetry

EIS

The EIS Dummy Cell is a Randle's cell (as described in Gamry's Help system). If you have a license for Gamry's EIS300 Electrochemical Impedance Spectroscopy software, you can record this cell's EIS spectrum to check your system's EIS operation.

Figure 1, a circuit diagram of the EIS cell is shown below. Figure 2 is a typical spectrum of the cell in Bode format.

A visual examination of the spectrum is usually sufficient to determine if your EIS system is working. Most system malfunctions totally prevent recording of the spectrum or cause gross errors that dramatically change the shape of the curve.

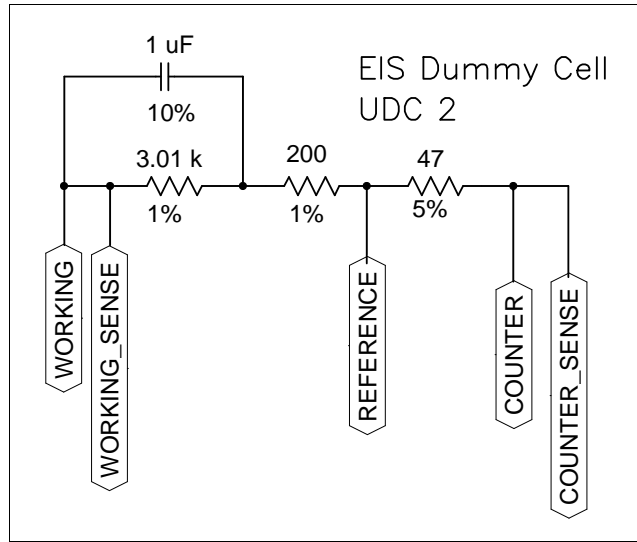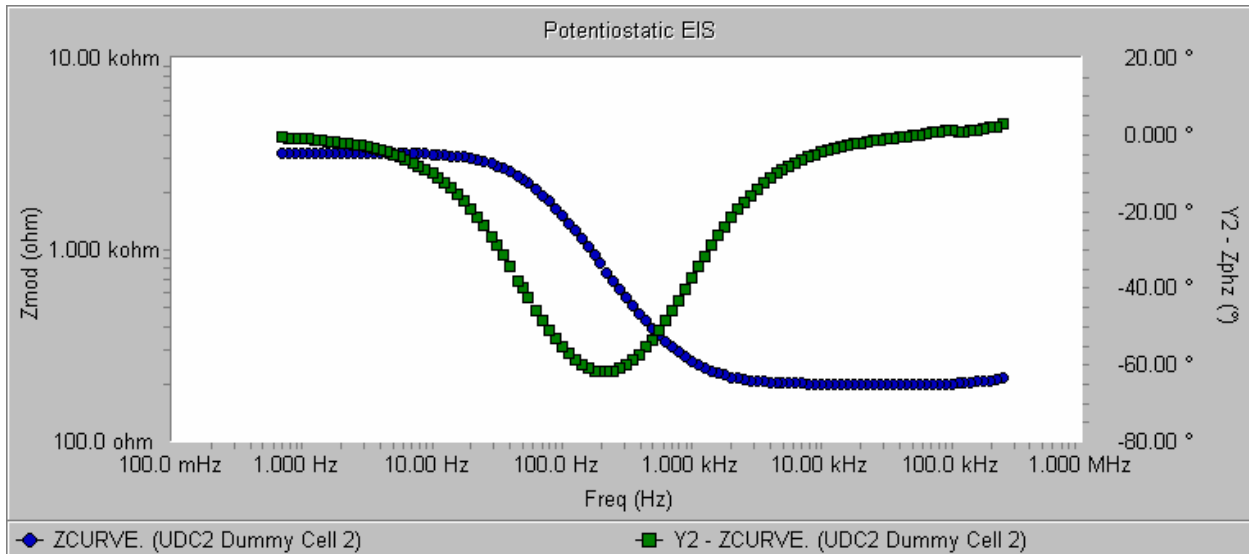**Figure 1**
EIS Dummy Cell Schematic Diagram

Figure 2
**Bode Plot of EIS Dummy Cell Spectrum**

If you want a numerical confirmation of the system's performance, fit the dummy cell's spectrum to the Randle's model in the EChem Analyst.   The calculated values should be between:

R_p 2.95 kΩ -- and -- 3.07 kΩ

R_u 196 Ω -- and -- 204 Ω

C_f 0.90 μF – and – 1.10 μF

DC Corrosion

The UDC 2's DC Corrosion circuit simulates current versus voltage behavior of an ideal corrosion cell. A voltage scan on this cell, with current range auto-ranging enabled, is particularly useful when testing potentiostat operation because almost all current ranges will be used during the scan.

Figure 3
DC Corrosion Dummy Cell Schematic Diagram
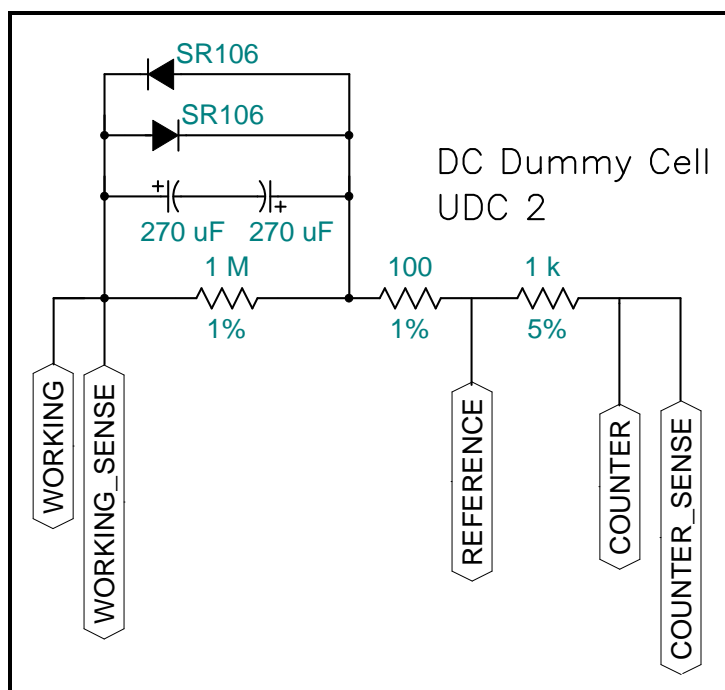
The circuit diagram of the DC Corrosion cell is shown in Figure 3.
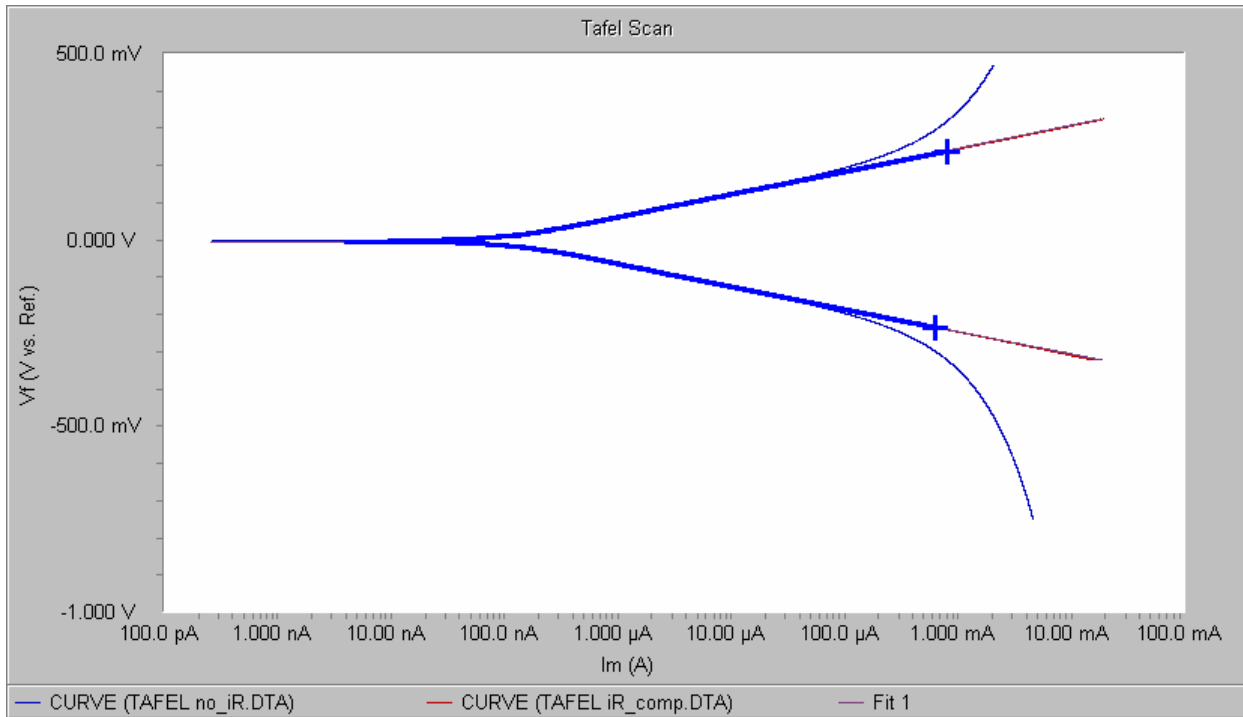
Current through a Schottky diode is proportional to the logarithm of the applied voltage, modeling a kinetically controlled electrochemical process. Unfortunately a Schottky diode based dummy cell does not model corrosion perfectly. A corroding electrode has a non-zero I_{corr} (corrosion current) while I_{corr} is essentially zero for this test cell.

You must have a license for Gamry's DC105 software to fully utilize this cell. You can run the CHECK105 script provided with the DC105 application.

If you want to test your system using a standard DC105 technique, we recommend using the Tafel technique. Your scan should be slow (0.50 mV/sec) and should use a Sample Period of 0.5 second per point.

This cell gives acceptable log I versus E linearity for potentials ± 175 mV of E_{corr} (zero volts on this cell). Current interrupt iR compensation during the scan expands the linear region to ± 300 mV but adds noise to the data.

A Tafel fit of a typical scan (both with and without iR compensation) can be seen below. Both the anodic and cathodic Tafel constants were calculated to be between 60 and 70 mV per decade. The calculated corrosion rate is quite small (about 10^{-3} mm/year) because of the very small I_{corr} (about 10^{-10} Amps/cm^2).

Tafel Scan

500.0 mV

0.000 V

Vf (V vs. Ref.)

-500.0 mV

-1.000 V

100.0 pA 1.000 nA 10.00 nA 100.0 nA 1.000 µA 10.00 µA 100.0 µA 1.000 mA 10.00 mA 100.0 mA

Im (A)

— CURVE (TAFEL no_iR.DTA) — CURVE (TAFEL iR_comp.DTA) — Fit 1

Note that the Schottky diodes used to produce the linear log current versus potential behavior have a fairly high variability. Both the current at zero volts and the slope of the log current versus potential plot vary significantly diode to diode.

For this reason, you should use the results obtained with the DC Corrosion Test cell with some caution. The shape of the Tafel curve is important, but the values obtained in a Tafel fit are not.