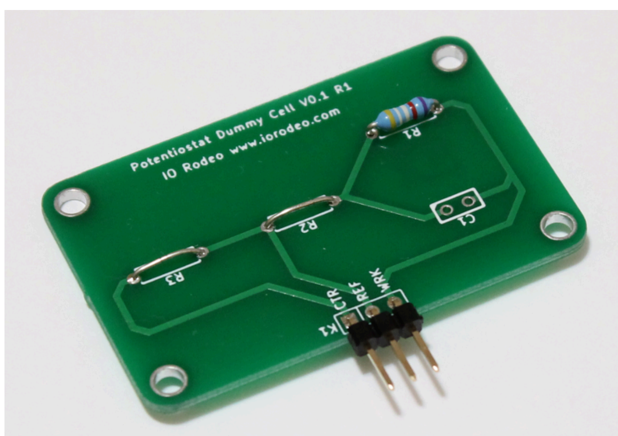
Cheapstat calibration with the potentiostat dummy cell

The Cheapstat potentiostat returns measured current values as raw unitless integers read from the ADC (analog to digital converter) at the output of the transimpedance amplifier (current to voltage converter). These integer values are proportional to the current flowing into the working electrode. You will need to convert these unitless integer values to current measurements using a calibration. While it is possible to do a first principles calculation using the values of the feedback resistor in the transimpedance amplifier it is generally better to just do a simple calibration using a dummy cell consisting of a single resistor of known value R.

The basic idea is to connect the counter and reference electrodes to one side of the resistor and the working electrode to the other side. You then slowly sweep the voltage across the resistor through a range of values - e.g. via a cyclic voltammetry test. Because the resistance of R is known you can calculate the current i(t) flowing through the resistor for each voltage v(t) in the test using Ohm's law as follows i(t) = v(t)/R. At the same time you have the measured current values in the form of the sampled ADC integer values n(t). To get the calibration you can perform a linear fit between the measured ADC integers n(t) and the known current values i(t).

We recently designed a potentiostat dummy cell which can be easily used to perform this calibration. In its simplest configuration it has a single resistor in position R1 where counter and reference electrodes are connected to one end of the resistor (a 50K resistor is shown below) and the working electrode is connected to the other end. In this configuration the potentiostat can be used to set-up a voltage across the resistor while measuring the current passing through it - as in the calibration procedure outlined above. In other configurations the dummy cell can be used for different tests and demonstrations.



When performing the calibration test make sure to select an appropriate resistor. You want to generate currents which span the measurement range (for current), but which do not go outside of it. The cheapstat has two user selectable current measurement ranges ± 10μA and ± 50μA. The value of the resistor R and the maximum/minimum voltage values Vmax, Vmin in the voltage sweep can be used to calculate the maximum/minimum currents which will occur during the test Imax, Imin as follows: Imax = Vmax/R and Imin = Vmin/R. Select R, Vmax and Vmin so that the current during the test stays within the current measurement range. If you go outside of the current range you will get clipping (or saturation) of the output which will show up as a flat spot in your calibration data.

More about the ADC Integer

The ADC integer is basically the measurement of the current flowing through into the working electrode. More specifically it is a measurement of the voltage output from the transimpedance amplifier (current to voltage converter). It is important to note that this value does not have any units and we need to apply a scaling to convert it to either voltage or current.

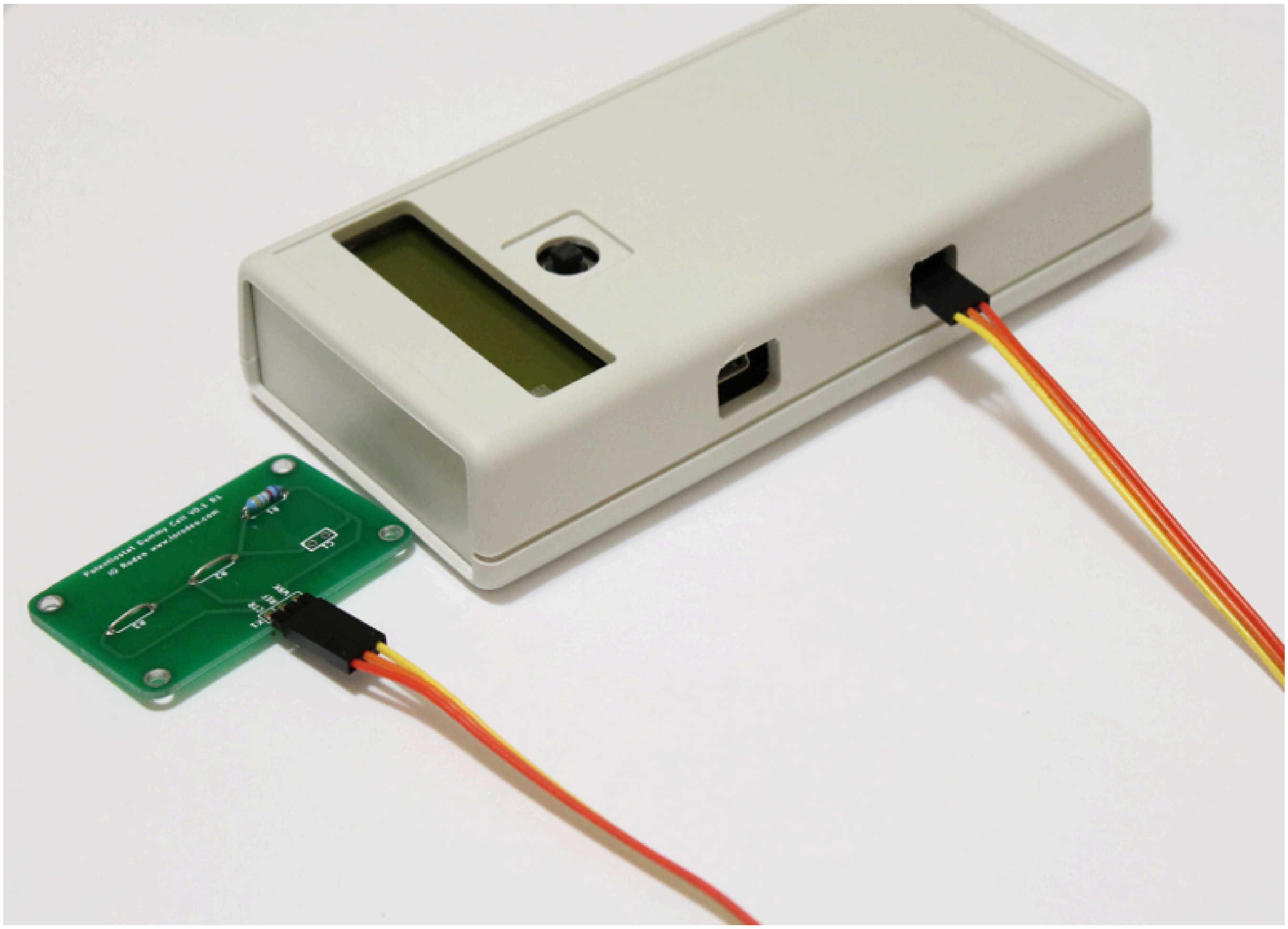
Example calibration: cyclic voltammetry with a 50K dummy cell

Cheapstat set-up:

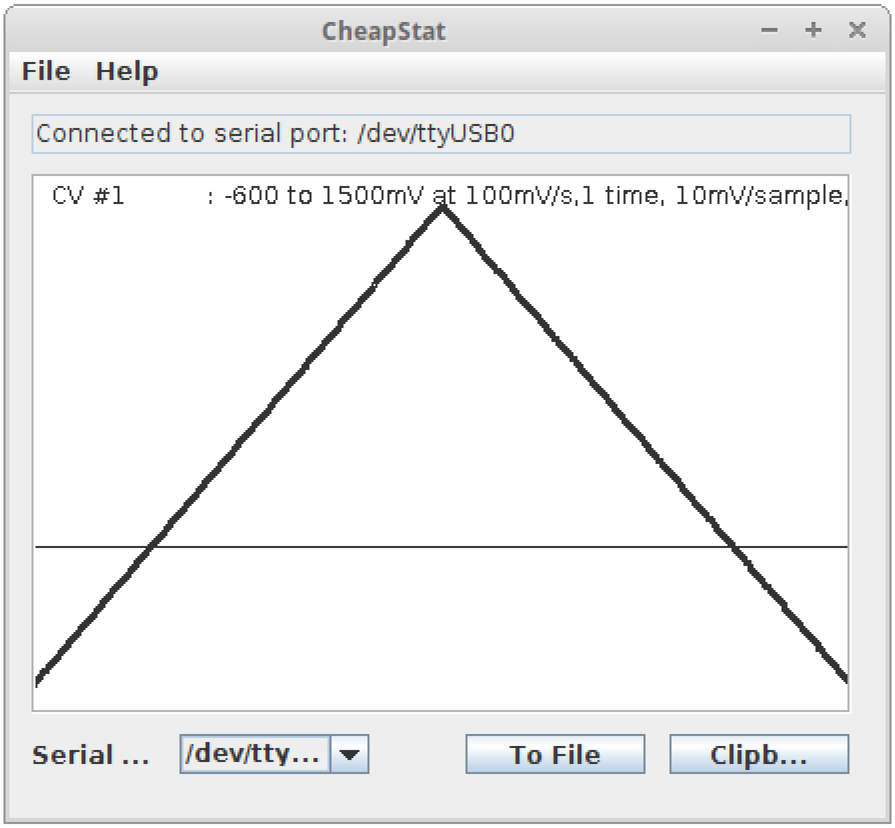
- Current range setting: ± 50 μA[1]
- Start: - 600 mV
- Stop: 1500 mV
- Slope: 100 mV/s
- Sample Rate: 10 mV/sample
- Cycles: 1

Connect the dummy cell with a 50K precision resistor to the potentiostat using a 3 wire connector cable.

[1] This needs to be done at least once for each of the two current range setting: ± 10 μA and ± 50 μA.



Run the experiment on the Cheapstat. Example is shown below.



Save the data to clipboard and paste into a spreadsheet. You will need to do some data conversion before you can plot the data.

Getting the calibration

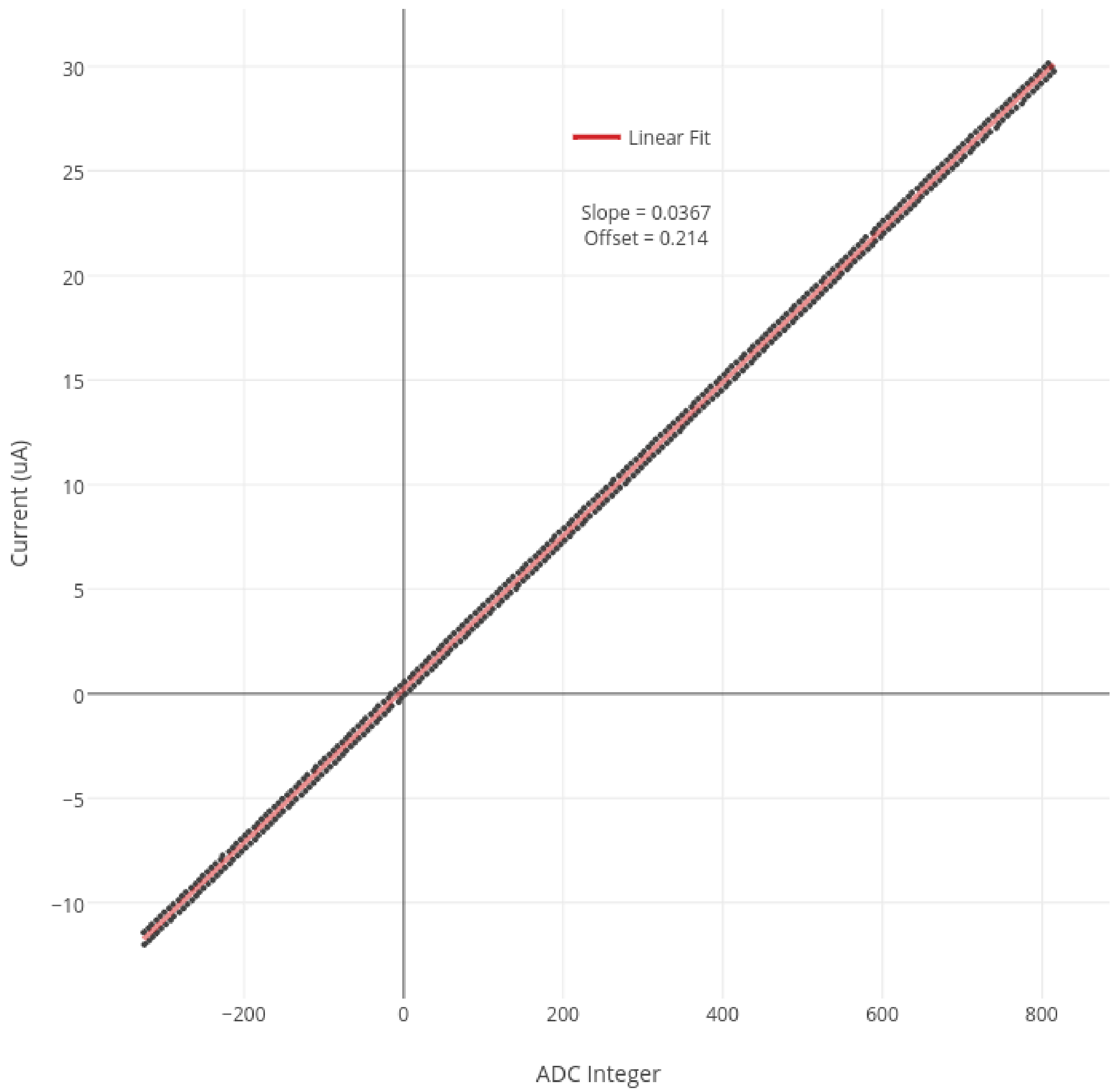
In your spreadsheet you will have two columns of data. Column 1 is the voltage applied across the resistor (mV) and Column 2 is the measured ADC integer which is proportional to the current flowing through the resistor.

The first step is going to be to convert the data in Column 1 from voltage (mV) to current (μA). We can use Ohm's Law here because we know the voltage across the resistor and the resistance (50K in this example) we can calculate the current flowing through the resistor (I=V/R).

To data in column 1:

- Divide by 1,000 to convert mV to V
- Divide by R to calculate the current (A) (In this example R = 50,000)
- Finally, multiply by 10^6 to convert to μA

Next, plot your data with ADC Int on the x-axis and the newly converted current (µA) on the y-axis.



Get the slope and offset values. We used [Plotly](#) to generate this graph and to get the slope and offset values.

From the linear fit shown above:
Slope, m = 0.0367
Offset, b = 0.214

Using the calibration to data collected with the Cheapstat

To convert the ADC Ints to current values use y = mx + b where

y = current (μA) you wish to compute
x = measured ADC integer values
m and b are the slope and offset calculated using the procedure above

e.g. Current (μA) = 0.0367 x ADC Int + 0.214

Apply this calibration to the data in Column 2 to convert the ADC Ints to current in μA.