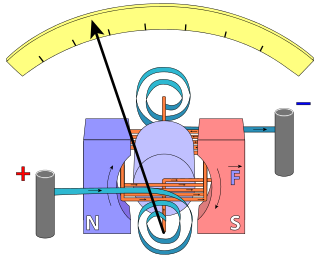
Notes to class before start: take a look at pset (more involved derivation)

Not necessarily HOW a potentiostat works, but how one could build one/visualize

1. Review of IR Circuits

* V=IR
* Kirkoff’s Laws
  + Sum or currents into a junction = 0
  + Sum of potential drops around a loop = 0
* Equivalent Resistance
  + Series
  + Parallel
* Quick practice problem with batter and resistors

1. Definitions
   1. Galvanometer – something that measures the current (also called ammeter)
   2. Potentiometer – something that measures voltage (also called voltmeter)
   3. Galvanostat – applies a current to something
   4. Potentiostat – applied a voltage to something
2. How does a voltmeter work?
   1. Digital voltmeters are what are currently used everywhere (using integrated circuits I won’t get into), but analog voltmeter is a useful exercise
   2. Undergraduate physics!



* 1. Magnetic moment of a coil:
  2. Torque:
  3. Will be balanced by spring (can be the same wire that connects to external circuit)
     1. For a thin steel wire, .
  4. If my magnet is a normal house magnet (refrigerator magnet ~5 mT, so let’s use 100 mT), and I have a current coil with area 0.01 m^2



Surprisingly accurate (and linear!). d’Arsonval and Deprez developed, and with a powerful magnet and delicate spring, original instrument could detect 0.01 mA (Wikipedia).

* 1. Modern-day op-amp or wheatstone circuit
  2. How would I use this to measure voltage instead of current?
     1. By adding a large resistor in series and putting the whole thing parallel to circuit

1. So, assuming we can measure voltage, how would I design a basic galvanostat?
   1. Can apply a known voltage and put your load circuit (cell, battery, etc) in series with a large resistor with both resistors parallel to voltage.

Because , . How much bigger does the resistor need to be than Rload for this to be valid to within 1%?

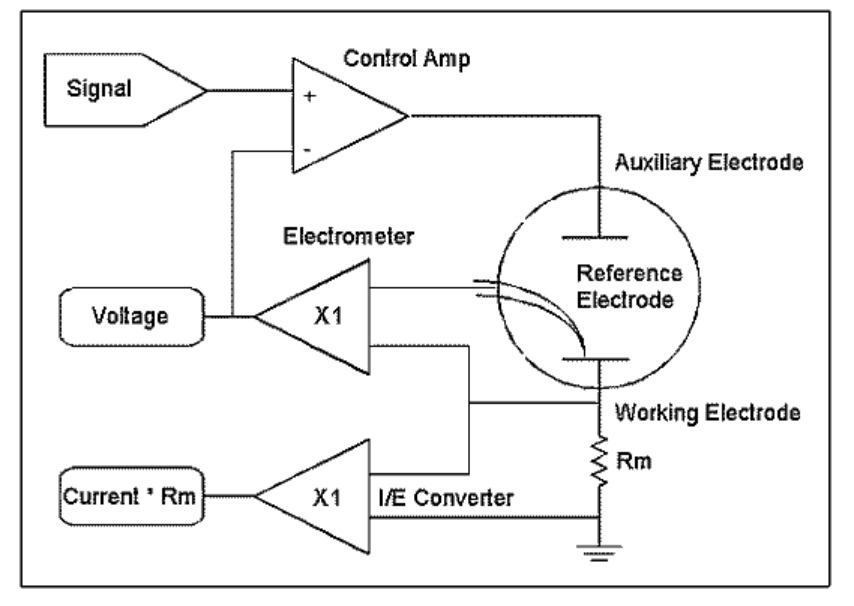
The voltage is a fixed quantity, but we can change the resistor easily enough (manually or through a circuit) to change the applied current. Of course, we don’t know the load resistance necessarily, but we can assume that . Let’s say I want to apply 0.1 mA, 1 mA, and 10 mA to my load. Given our assumption about load resistance, what voltage do I need to apply and what resistors will I use?

V needs to be AT LEAST 100 V!

Rs will be 10000 ohms, 100000 ohms, and 1000000 ohms.

* 1. How would I turn this galvanostat into a potentiostat?
     1. Need to have a known I, but the only way is through what we did above…
     2. Not easy, requires a HIGH voltage and not used at all in practice
     3. For example, if my load resistance is < 100 ohm and I apply 10 mA with 100 V source, then I can vary the load resistance to apply a voltage between 0 and 1 V.
  2. In practice, can measure voltage with circuit easily and work back from there (op-amp)

1. How a potentiostat actually works
   1. Setup: WE, CE (AE), Ref, CA



Source: Gamry

* 1. Electrometer (high impedance, zero current)
     1. Don’t want to get into the details, but there are capacitors and other concerns to make sure electrometer does not interfere with rest of circuit
  2. Current-to-voltage convert (I/E)
     1. Simply measure voltage across known resistance and back out current
  3. Control amplifier
     1. Negative feedback loop
  4. 2 electrode setup and 3 electrode setup
  5. Problem

Demo of homemade potentiostat with 9V battery