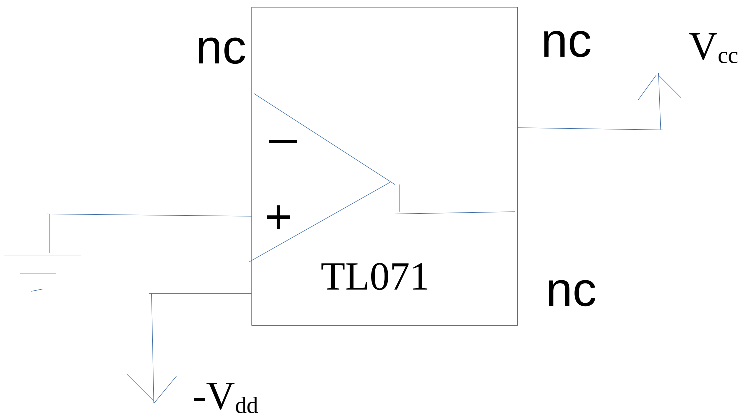
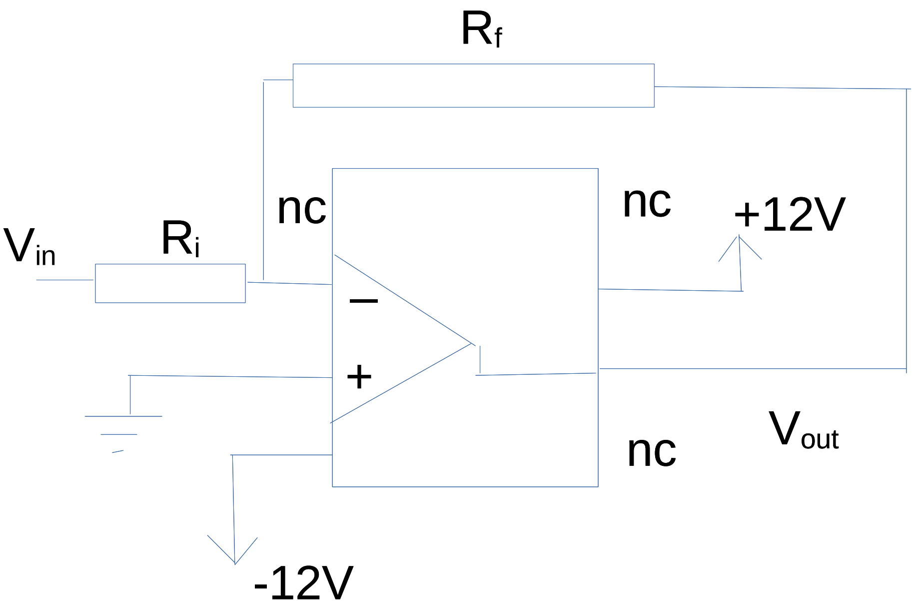
Introduction

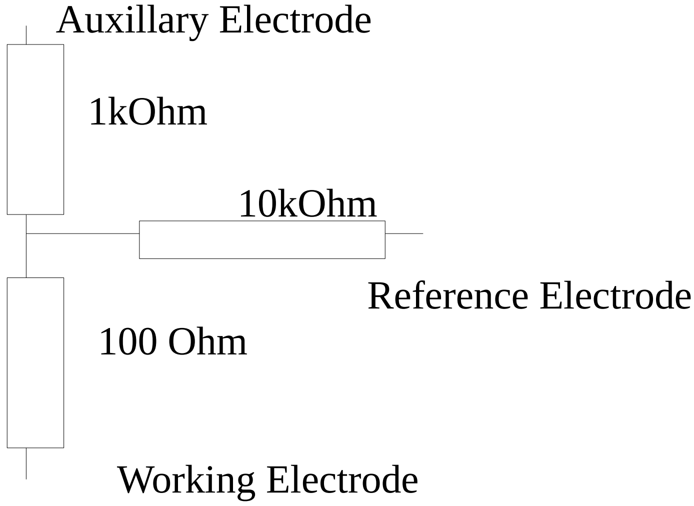
If you know how transistors (tr’s) and Operational Amplifiers (OA’s) work the chapter on Semiconductor Intelligence (SI) can be safely omitted. If you have no idea how these components relate to instrumentation and you feel an impediment due to this ignorance then SI could be meaningful reading. This chapter (SI) answers the question of how a tr works. A single tr as an analog audio amplifier or as a digital switch is understood.
Things get more complicated and quite beautiful when more than 1 tr is used , all in orchestration. OA’s are made up of about 14 tr’s but we do not go into the electrodynamics of the tr arrangement that would constitute the OA. Instead in the ch Electrochemistry as we explain the OA i.t.o. a formula that governs the Voltage output as a function of the Voltage input(s) we rely on the basis that every (different) almost standard configuration of OA works on the same basic principle. That is to minimize the difference between the non-inverting + input and the – inverting input. Also note that the input impedance at + and – is assumed to be infinite implying that these inputs draw no current. The OA then computes the output taking all this into account on the smallest time scale.



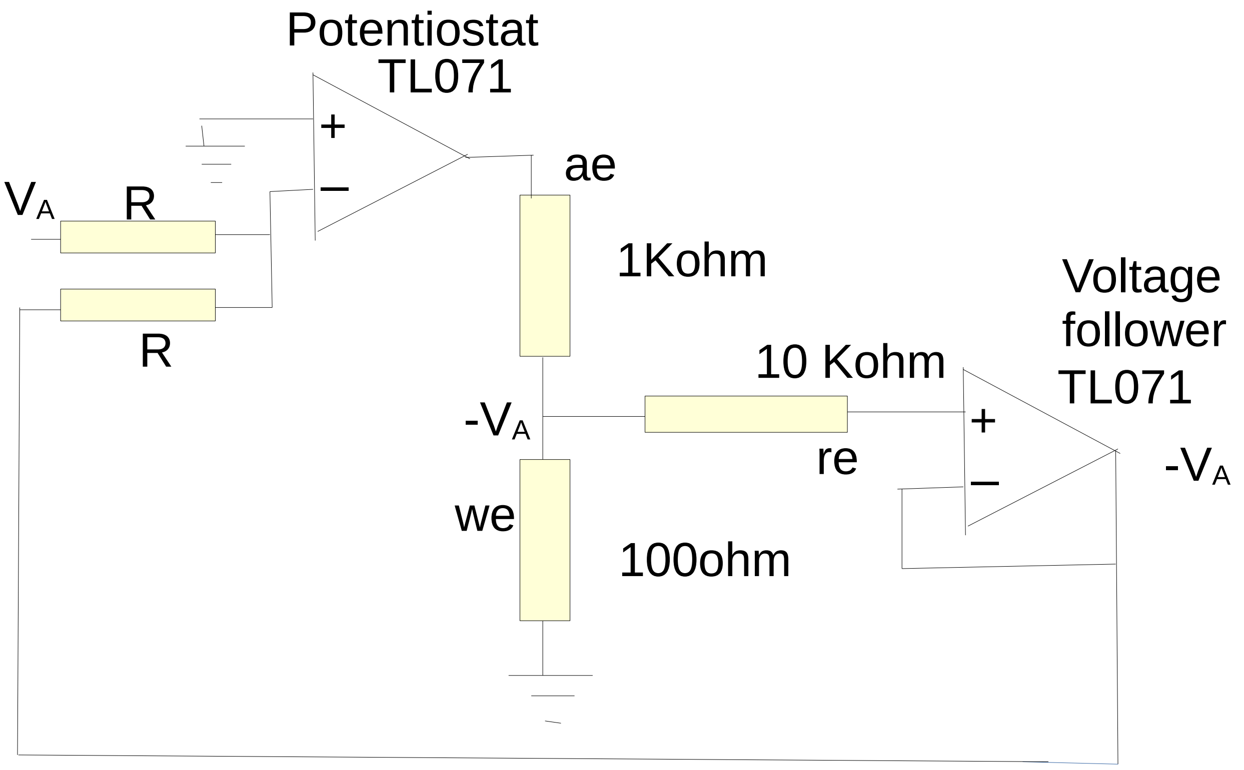
With + at earth the – terminal aims at becoming what is known as a ‘virtual earth’. The OA computes to reduce the sum of all inputs to the – terminal to zero.For this feedback is required.Inversion plays a role too.
Briefly then in preview the inverting amplifier is as below:



Input current from V_{in} to the – terminal is $I_{in} = V_{in} / R_i$ (Ohms Law)
So for the virtual earth at the – terminal the current from V_{out} must be $-I_{in}$.
So $V_{out} = -I_{in} * R_f$ but $I_{in} = V_{in} / R_i$
So $V_{out} = -V_{in} * R_f / R_i$
$R_f > R_i$ makes an inverting amplifier
$R_f < R_i$ acts in division
while $R_f = R_i$ is just plain unity gain inversion.
The potentiostat used in 3 electrode system Electrochemistry to maintain a certain measureable potential at the working electrode (we) is like the inverting amplifier except the potentiostat takes its feedback from the we.
The "Test Cell" used to simulate a real electrochemical cell in linear scan Electrochemistry is as below:

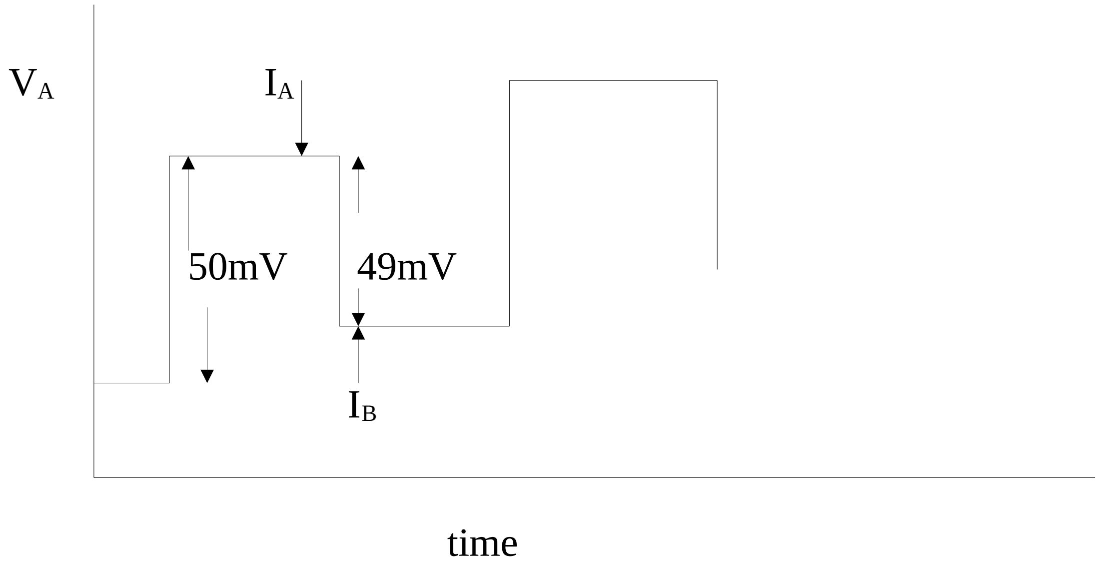


The Potentiostat and Voltage follower are depicted below running a Test Cell :

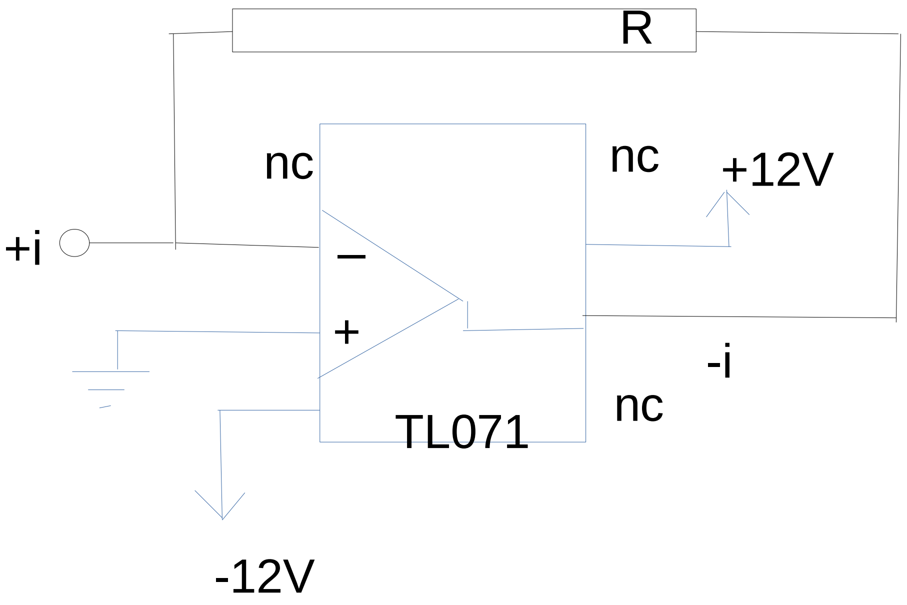


The voltage follower simply follows the voltage at the we with high impedance thus minimal interference. Impedance is really resistance. The Potentiostat operates or computes till the sum of currents entering the – terminal add up to zero. That virtual earth again since the + terminal is hard wired earth. The same action as in the inverting amplifier except most importantly the feedback is from the we.The we has been potentiostatted to $-V_A$ volts by the V_A volts applied by external circuitry not shown here. The reference electrode is effectively just a conductor.It is non- polarisable and later on we discuss how the constant potential contributed by the re is taken account of.

Other than the potentiostat there are no other peculiarities behind our Square Wave Voltammeter -SWV-design .Central is the Digital Analog Convertor -DAC-and we use one of the 2 DAC's provided by the USB6008.This is a Data Aquisition interfacing peripheral and it plugs into the USB port. The action in our SWV design is to write 50mV to the DAC feeding the auxillary electrode as the pulse then take a reading of the voltage then after the charging current has decayed take a reading of current related voltage $I_{A,}$ subtract 49mV and take another reading of current related voltage-I_B Then plot I_A -I_B against V_A

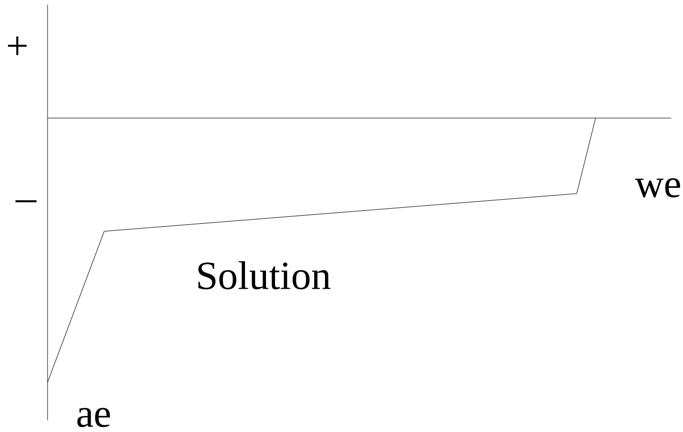


This procedure is executed at every tick of the TimerTick event procedure in the Visual Basic program controlling the USB6008 peripheral.
A step and resolution of 1mV and a pulse of 50Mv till a programmable limit is reached. The design is quite simple. Only one quad op Amp the TL074 and the voltage controlled oscillator of a 4046 phase lock loop with a period fixed at 1.2uS are required to complete provision made by the USB6008.That is 1 DAC and 2 Analog voltage input channels, P(0,0) to switch the oscillator on and off and PFIO for the oscillator 4046 output into the USB6008.
The current follower we eventually use is:

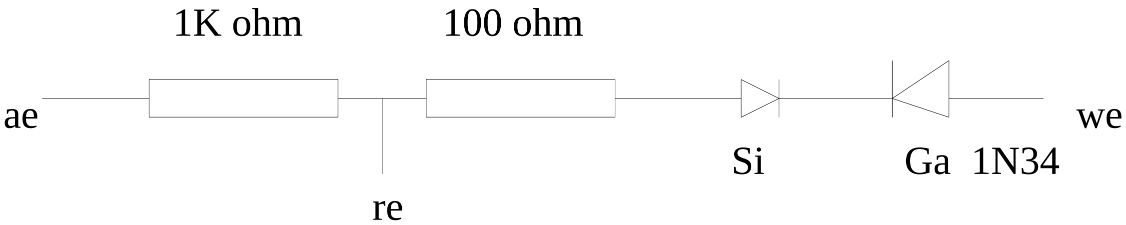


R= resistance in ohms

Here feedback forces current out to equal -i Amp and V_{out} = - i *R volts. This current follower ensures positive current for oxidation. For oxidation the ae must be negative. See below



Here we see how polarising the electrochemical cell by a negative ae results in a positive we for oxidation.The bulk solution is charged and the we is posive wrt this charge.
A peak is produced on the Test Cell described below when the SWV stimulant waveform is applied at the ae.



When you can observe such a peak you will know your machine is working