Recording bio-signals generated by plants

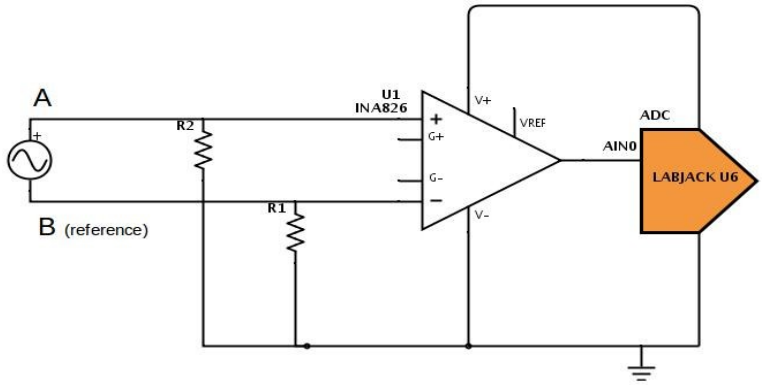
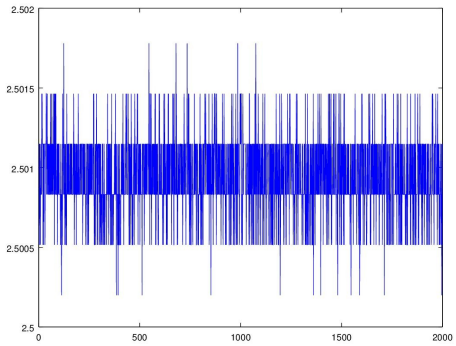


figure 1: A Reference Architecture

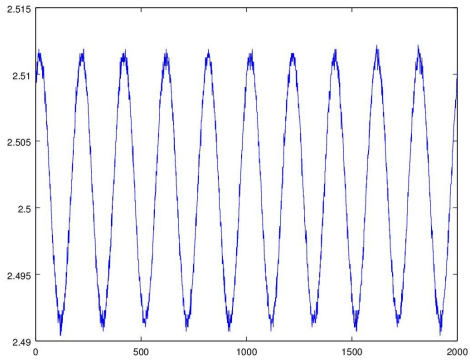
The main goal is to measure the variation of a signal in the plant at point A with respect to a reference in the plant at point B. The signal generated by the plant is simulated by a function generator that outputs a sine function at 10Hz and +/- 10mV, 1Mohm of output impedance. Notice that the ground of the function generator is not “directly” connected to the ground of the DAQ because the DAQ is powered by the battery of the PC and is is thus isolated from the GND of the function generator. In other words, the signal generated by the plant is an ungrounded signal source (see [2] and 3.4.9 Measuring ungrounded signal sources in [3])

If R1 and R2 are infinite, namely there is no connection between the GND and the electrodes, the two inputs are not referenced (see Floating Voltages in [5]) and thus “... an in amp cannot measure floating voltages. This includes anything that is not referenced to ground ...”.

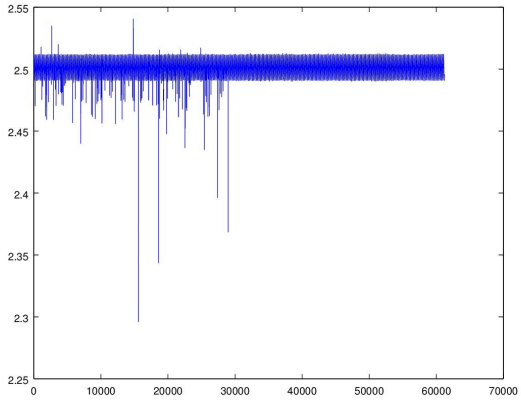
Indeed, the signal observed by the DAQ is shown in figure



If we now use two resistors of 10Mohm, the signal observed by the DAQ is shown in the following figure

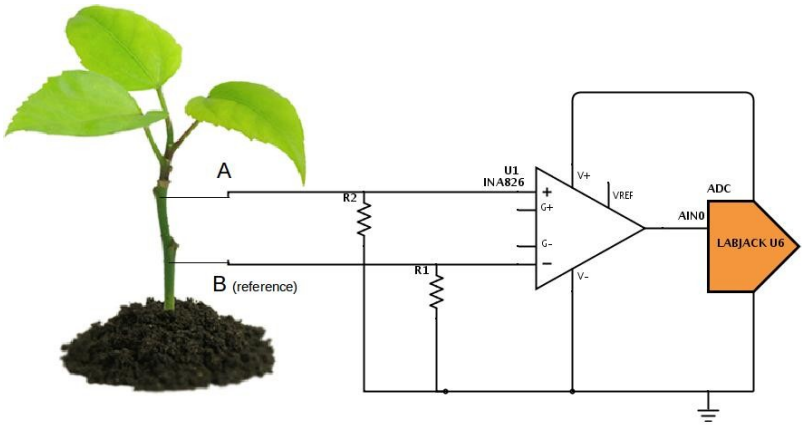


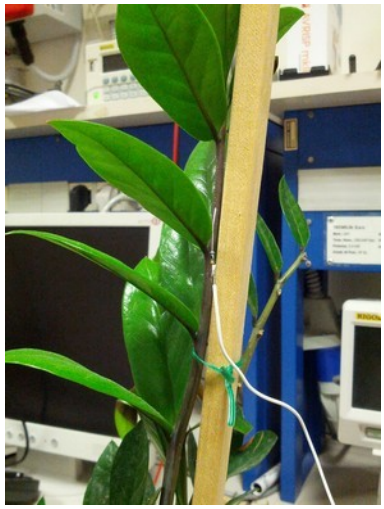
A similar behavior, is obtained also if only a single branch is connected to the ground. Finally notice that when the DAQ is connected to the powerline, there is some significant noise introduced as can be observed in the following figure in which the powerline is disconnected approximately at sample 30000



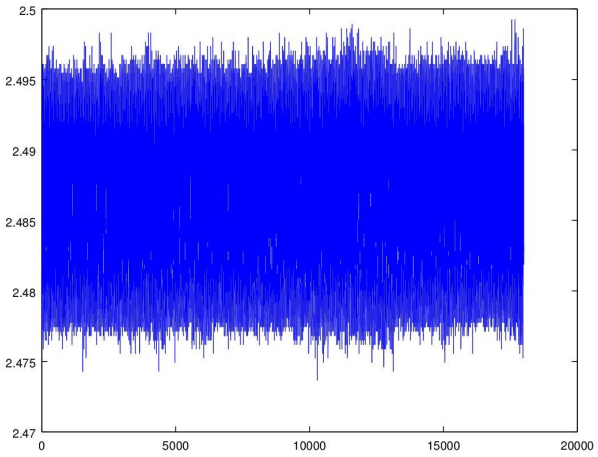
Expreiments on Plants

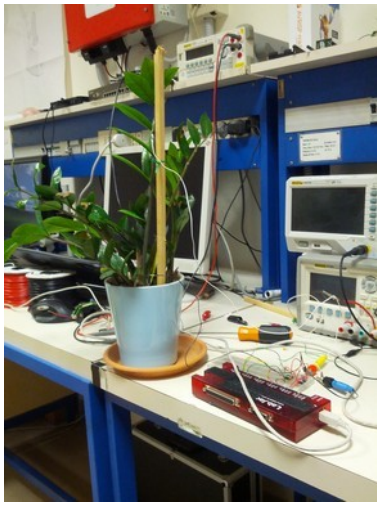
We are now ready to plug two needle electrodes for EMG into the plant.



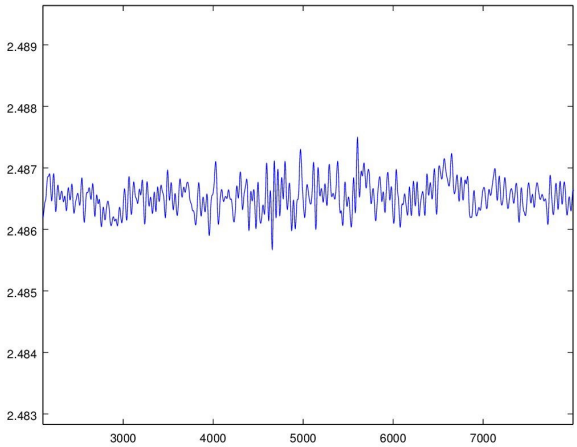


A short segment of the obtained trace is shown in the following figure



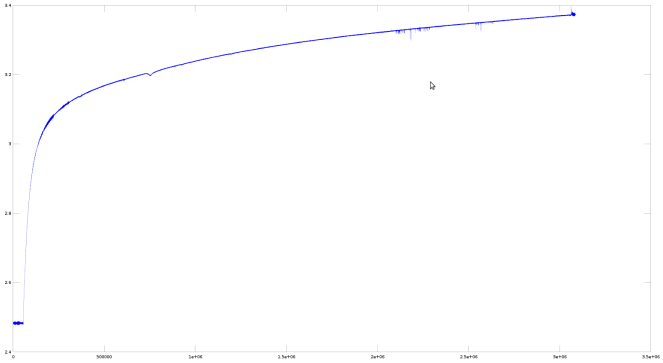


An FFT of this signal, shows a peak at 50HZ as expected. Removing this component with a notch filter and applying a low pass filter at 100Hz (all filters are software post-processing) produces the following result



The signal amplitude is less then 1mV, giving us some hope to capture the effects of some kind of stimulation that according to [1] is of the order of tens of millivolts.

Notice that if during an experiment we remove R2, the amplifier slwly saturate as shown in the following picture no the right. The same behavior is obtained if you start the experiment without R2



This experiment seems to suggest that the impedance of the plant is relatively high and thus a couple of resistors in both + and – branch are necessary

On the reference electrodes [chapter 5 of 4]

"... the reference electrode was assumed to be at some distant site (from the active electrode recording the plant activity) that doesn't pick up any (plant) activity ..."

"As the (plant) signals near the active electrode changed, it was assumed that this would influence the voltage near at the active site but no at the reference site."

The no-Switzerland principle. There is no electrically neutral site (on the plant)

References

[1] Stanković, B., Witters, D. L., Zawadzki, T. and Davies, E. (1998), Action potentials and variation potentials in sunflower: An analysis of their relationships and distinguishing characteristics. Physiologia Plantarum, 103: 51–58. doi: 10.1034/j.1399-3054.1998.1030107.x
[2] http://www.ni.com/white-paper/3394/en/
[3] *Practical Data Acquisition for Instrumentation and Control SystemsIDC Technology* (*Paperback*) by John Park.
[4] An introduction to the Event-Related Potential Technique. S. J. Luck
[5] http://www.planetanalog.com/document.asp?doc_id=527518