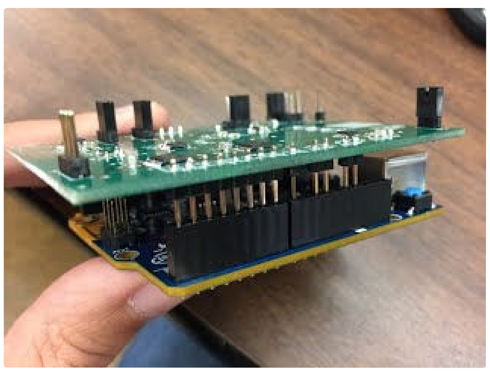
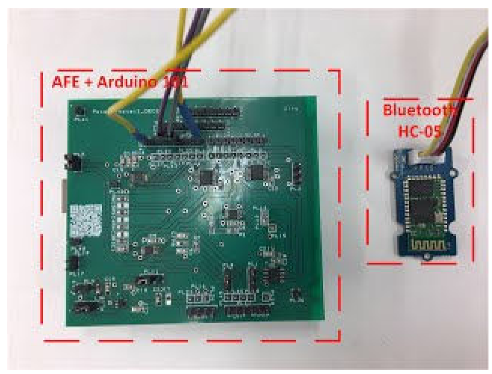
The CaseStat: A Low-Cost Wireless Open-Source Potentiostat

This page contains enough information for you to build your own CaseStat, a low-cost wireless potentiostat for electrochemistry experiments designed by researchers in the Integrated Circuits and Sensor Physics Lab at Case Western Reserve University. If you decide to use the instrument for your own research, please cite the following publication:

- Jifu Liang, David Ariando, Yingying Wang, Jonathan Strobl, Daniel Scherson, Kenneth Loparo, Soumyajit Mandal, "A Wireless, Portable, and Inexpensive Open-Source Potentiostat", presented in the poster session at the *68th Annual Meeting of the International Society of Electrochemistry* in Providence, RI, USA.



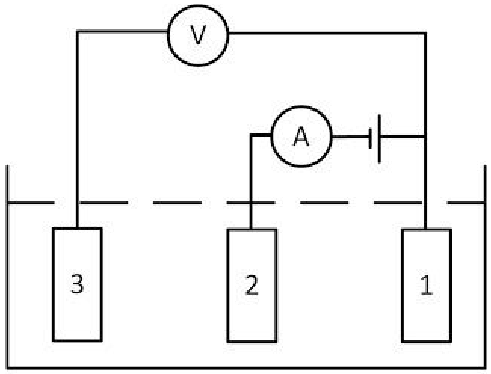


Motivation

The detection and quantitation of trace components in complex samples is essential for a wide range of applications, including biological threat detection, quality control, and disease diagnosis. Therefore, a number of sensitive and reliable analytical electrochemical sensors have been designed and used to test analyte concentrations. However, factors such as the need for extensive sample preparation, limited selectivity, non-portability, and high instrumentation costs reduce the efficacy of these devices. The CaseStat is a miniaturized, low-power, and autonomous electrochemical sensor designed to overcome these limitations.

Three-electrode measurements and the potentiostat

Electrochemical sensors typically utilize three-electrode measurement techniques and interface with software through a potentiostat. A potentiostat is the electronic hardware required to control the three-electrode cell and run most electroanalytical experiments. Three-electrode systems contain a working electrode, reference electrode, and counter (auxiliary) electrode, as shown in the following figure. The working electrode applies the desired potential to the electrolyte in a controlled way and facilitates the transfer of charge to and from the analyte. The reference electrode acts as a reference that measures and controls the working electrode's potential and at no point does it pass any current. The auxiliary electrode passes all the current needed to balance the current observed at the working electrode. If a voltammetry algorithm is utilized, information about an analyte can be obtained by measuring the current as the potential between the working electrode and the reference electrode is varied.



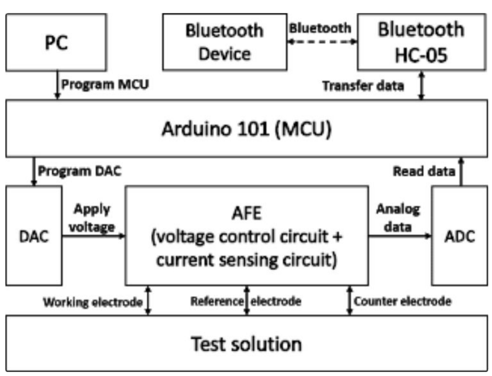
A three electrode system: (1) working electrode, (2) counter electrode, and (3) reference electrode.

Block diagram

The CheapStat contains the following modules: A custom analog front-end (AFE) including a digital-to-analog converter (DAC) and an analog-to-digital converter (ADC); a low-cost commercial microcontroller board (Arudino 101); and a wireless module (Bluetooth HC-05 board).

How it works: The Arduino is pre-programmed by the PC, and also needs to be programmed by the user to set up customized voltammetry parameters through Bluetooth. Then, arbitrary digital samples generated by the Arduino are sent to the DAC through a serial peripheral interface bus (SPI), which then converts them to the analog output voltage waveforms required for voltammetry. A low-noise transimpedance amplifier in the AFE senses the current in the analyte as the voltage between reference and working electrode varies. The sensed voltage is amplified, digitized by the ADC, sent to the Arduino over SPI, and finally wirelessly transferred to another Bluetooth device.

- PC: used to pre-program the microcontroller (MCU).
- Arduino 101 board: MCU, used to program DAC/ADC and control the Bluetooth HC-05 module.
- Bluetooth HC-05: Used to read the command data from another Bluetooth device and send the experimental data to it through regular Bluetooth.
- DAC: used to control the voltage across the test solution.
- ADC: used to digitize the signal from analog front-end (AFE) and transfer digital data to MCU.
- AFE: used to sense the current in the tested solution. Three electrode voltammetry system is utilized here.



Hardware and components

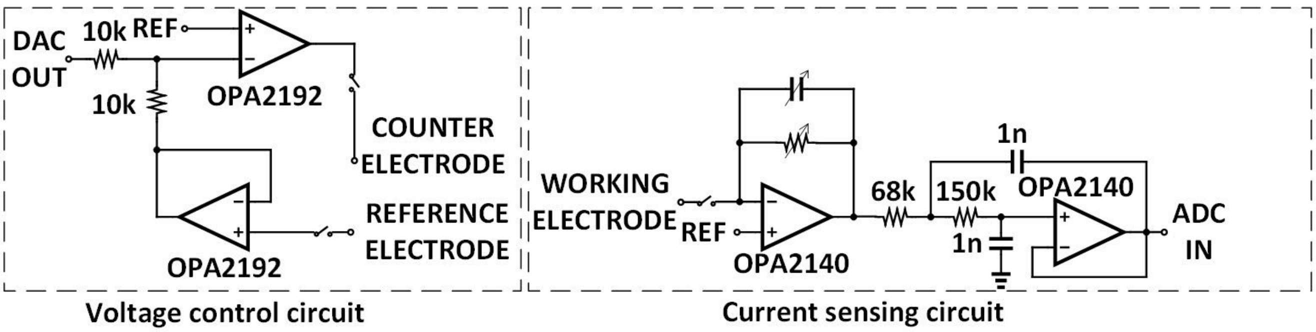
Arduino 101: Arduino 101
Bluetooth HC-05: Bluetooth board
AFE PCB component list: Component_list_excel

PCB design

The PCB of the analog front-end was designed using PCB Aritst, which can be downloaded from here:
PCB_Artist_Download

PCB design file:
PCB_File

Schematic of the AFE:



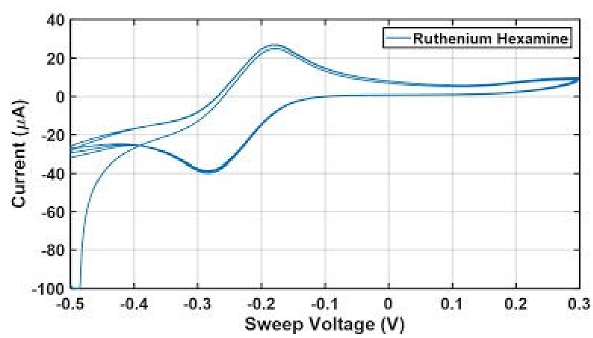
Programming

Matlab code to set up CV parameters and receive data through Bluetooth:
matlab_code

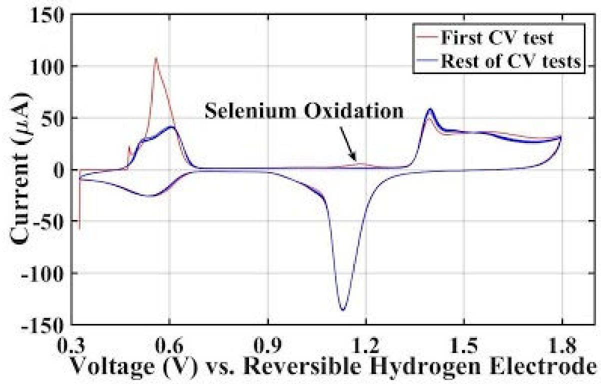
Arduino 101 Code:
Arduino_Code

Typical experimental results

Experiment 1. Ruthenium hexamine
Experimental detection of 2 mM ruthenium hexamine by using a screen-printed electrode, 0.1 M KCl supporting electrolyte, 50 mV/sec slope, 3 mV/sample sampling rate, and -500 mV to 300 mV cyclic voltammetry (CV) range.



Experiment 2. Selenite
Experimental detection of 50 nM selenite by using anodic stripping voltammetry (ASV) with a gold rotating disk working electrode, 1.2 mM $Cu(ClO_4)_2$ concentration, 0.1 M $HClO_4$ supporting electrolyte, 0.1 V/s CV sweep rate, and 1500 rpm electrode rotation rate. The working electrode potential is held at 0.325 V for 560 seconds before doing the CV tests.



Contact information

In case of any questions, please contact Jifu Liang (jxl1265@case.edu).

Comments

You do not have permission to add comments.