Potentiostat Hardware for USB-Style Sensors

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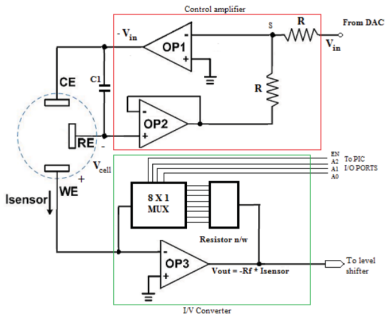


A portable measurement system was assembled using a commercial potentiostat, a custom circuit board, and a 3D-printed enclosure. The system will help demonstrate the portability and simplicity the electrochemical sensors being developed in BioMicroSystems Lab.

Introduction

BioMicroSystems (BMS) Lab is developing point-of-care electrochemical sensors for measuring heavy metal concentrations in environmental samples, such as manganese in lake water [**?**].

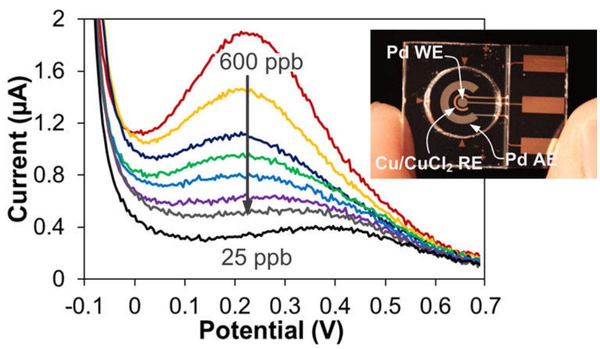


Figure 1: *Measuring Manganese [?]*

Three electrodes are inundated in a sample and a potential is applied between two of the electrodes, while a different pair of two electrodes is used to measure current. At some applied voltage, an oxidation-reduction reaction occurs between the metal of interest and the working electrode surface. Charge is emitted as the metal changing oxidation state; so measuring and integrating the current gives the quantity of metal reagent in the sample.

In a three electrode system, one electrode must be common to both the voltage pair and the current pair, and this is termed the counter electrode. For the other two electrodes (reference and working) to accurately separate voltage and current, they must be virtually grounded by amplifier electronics. A device which drives the virtual ground, sets a potential, and measures resulting current is called a potentiostat.

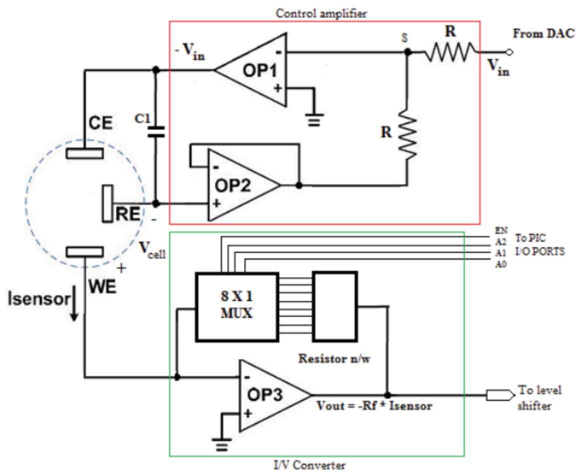
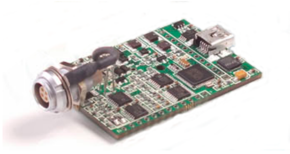
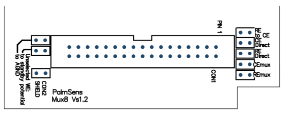


Figure 2: *Op-Amp Potentiostat [?]*

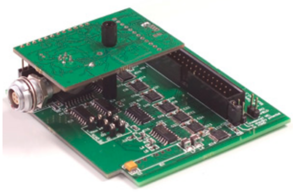
The possible advantages of the point-of-care electrodes being developed by BMS Lab include low cost, portability, measurement speed, and simplicity for non-technical operators. To realize these advantages, a small, portable potentiostat is needed with a simple user interface.



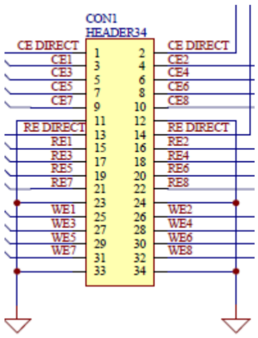
(a) *EmStat Potentiostat*



(b) *Pinout Diagram*

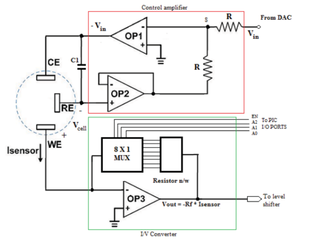


(c) *EmStat with Multiplexer*

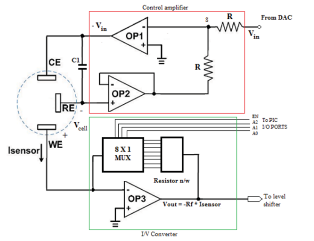


(d) *Pinout Schematic*

Figure 3: *EmStat and Multiplexer from PalmSens [?]*



(a) *Breakout Board*



(b) *PCB Sandwich...tasty*

Figure 4: *Breakout Board for EmStat/MUX*

Method

An OEM potentiostat board measuring only 2" x 1.35" was purchased from PalmSens, called EmStat. Also from PalmSens, a Multiplexer was purchased that allows EmStat to switch between multiple sensors. The EmStat–Multiplexer connection and the external interface towards the sensors are shown in figure 3.

The external interface from the Multiplexer is a standard 0.1" header but the sensors are made to be inserted into a USB receptacle. To make this simple for the end user, a custom breakout board was made to fit in the space between the EmStat and Multiplexer boards.

The breakout board was designed in CadSoft Eagle and the `.brd` file was sent to OSH Park LLC for manufacture. The Eagle project and part libraries used can be found in the directory `PCB_Boards/`. In addition to the manufactured board, the components listed in table 2 are need for assembly.

Table 1: *Breakout Board Components*

Qty.	Component	Man. Part #
4	USB type-A receptacle	292303-1
1	USB mini receptacle	0548190519
1	USB mini plug kit	1734205-1
1	34-pin, 0.1" header	SFH11-PBPC-D17-ST-BK
	hookup wire and heat shrink for USB plug kit	

The x-y coordinates used in aligning the EmStat, Multiplexer, and breakout board are shown in appendix **??**. The schematic diagram for the breakout board and a transparent view from Eagle are inlcuced in appendix **??**.

The packaging was designed in SolidWorks to be 3D-printed in two parts: a base and a lid. In addition to the base and lid, six size #3-48, 1.25" long machine screws and #3-48 tapping equipment are needed for assembly. Instructions for tapping can be found in appendix **??**.

Table 2: *Assembly Components*

Qty.	Component	McMaster Part #
6	3-48, 1.25" socket head cap screws	90044A243
	3-48 tap, tap driver, and spring loaded tap guide	appendix **??**

The design of the packaging was tested and iterated in house using a Makerobt Replicator 2X with ABS filament. Mechanical drawings of the base and lid and a list of revisions are included in appendix **??**.

For printing with MakerBot or an outside printing house, the files `Enclosure_Base.STL` and `Enclosure_Lid.STL` are needed from the `Packaging/` directory. For editing the parts, the SolidWorks files are located in the `Packaging/SolidWorks_Files` subdirectory.

In addition to the potentiostat system, three small sensor interface boards were built. One allows a USB-style sensor to be extended away from the potentiostat system by a USB male-A-to-male-mini cable. Another allows USB-style sensors to be easily connected to the WaveNow potentiostat. The third allows USB-style sensors to be connected to aligator clips for electroplating, etc.

Designs for these three interface boards are included in appendix **??**.

1 Results

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Table 3: *Random table*

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First name	Last Name	Grade
John	Doe	7.5
Richard	Miles	2

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Section 2

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References

[Figueredo and Wolf, 2009] Figueredo, A. J. and Wolf, P. S. A. (2009). Assortative pairing and life history strategy - a cross-cultural study. *Human Nature*, 20:317–330.