FINAL REPORT ON PORTABLE POTENTIOSTAT

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BASIC PRINCIPLE OF THE POTENTIOSTAT

A potentiostat is a control and measuring device. In the most common three electrode configuration, a potentiostat will accurately control the potential of the Counter Electrode (CE) against the Working Electrode (WE) so that the potential difference between the working electrode (WE) and the Reference Electrode (RE) is well defined, and correspond to the value specified by the user.

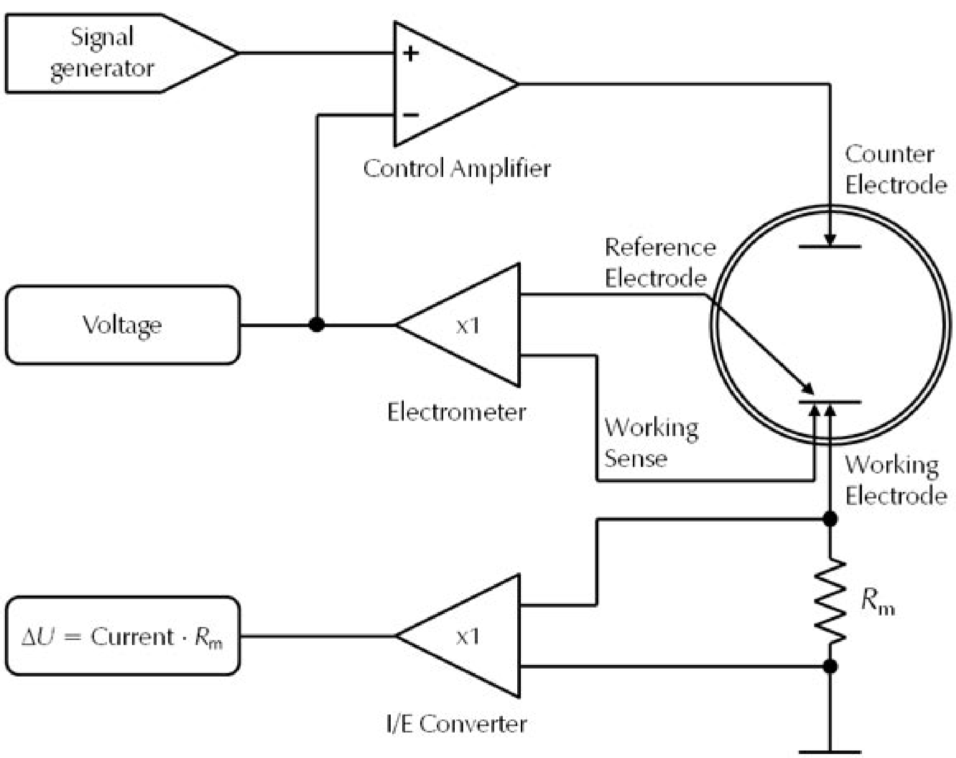
It comprises of an electric circuit which controls the potential across the cell and sensing changes in its resistance, varying accordingly the current supplied to the system: a higher resistance will result in a decreased current, while a lower resistance will result in an increased current, in order to keep the voltage constant as described by Ohm's law.

R = V / I

● I is the output electric current of the potentiostat

● V is the voltage across the Working and Reference electrodes.

● R is the electrical resistance that varies.



CIRCUIT DESIGN

Our potentiostat is a control and measurement device. The computer defines the variables of the experiment such as the starting voltage, the terminating voltage and the sweep rate. Sweep rate is usually defined in mV/sec.

We control the voltage across the Counter Electrode and Reference Electrode. Thus, we need a circuit to convert the digital signals from microcontroller to different voltage levels. Also, since the microcontroller essentially gives us only positive voltages (for a DAC with positive voltage reference) we need to subtract some voltage from the output so that the output covers negative values also.

The current flowing through the Working Electrode is measured and the signal is sent back to the computer where the values are manipulated to get the desired results. The system thus requires Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC) to interface the microcontroller which works on digital signals and voltage control and current measurement circuits which are primarily analog circuits.

Implementation of Blocks

1. Microcontroller

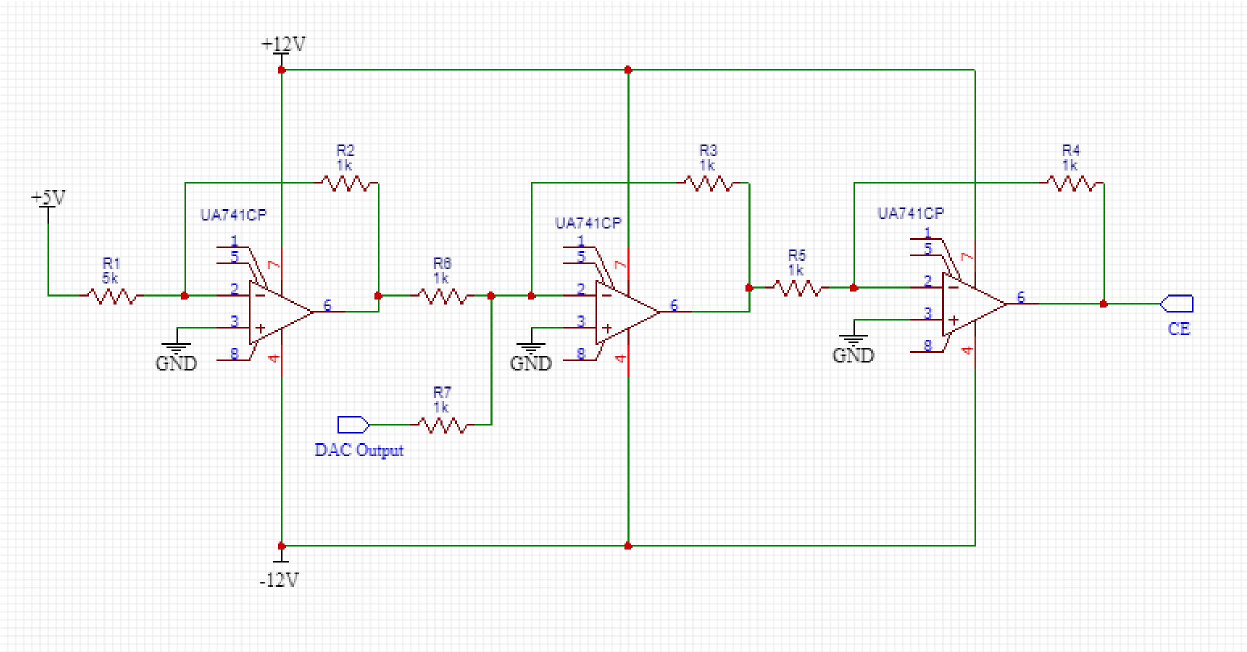
We are using the microcontroller Arduino Mega 2560 for this project as it gives us a lot of flexibility in design and has a lot of accompanying circuits (e.g. SPI and serial communication etc.) already present and also the accompanying resources (shields and libraries) makes it easier to design the system and tinker to choose the best possible solution of the given design problem.

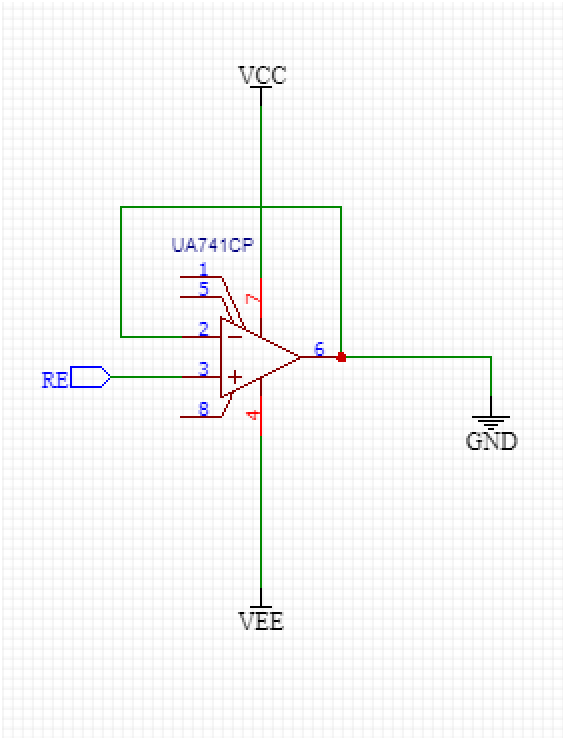
However we can use any other Arduino board like Uno, Mini or Nano with only changes to ports in the code.

2. Voltage Control

We need to convert the Digital signal to an analog value for which we use MCP4725 which is a 12-bit serial Digital to Analog converter which works with SPI. Serial Peripheral Interface (SPI) is an interface bus commonly used to send data between microcontrollers and small peripherals such as shift registers, sensors, and SD cards. It uses separate clock and data lines, along with a select line to choose the device we wish to communicate with. Since the nominal operation voltages of a potentiostat lie between -1V to 1V. We use a as reference for the DAC and subtract 1 V and thus we get a range of -1V to 4V for the voltage applied.

We use a weighted summer for this operation.

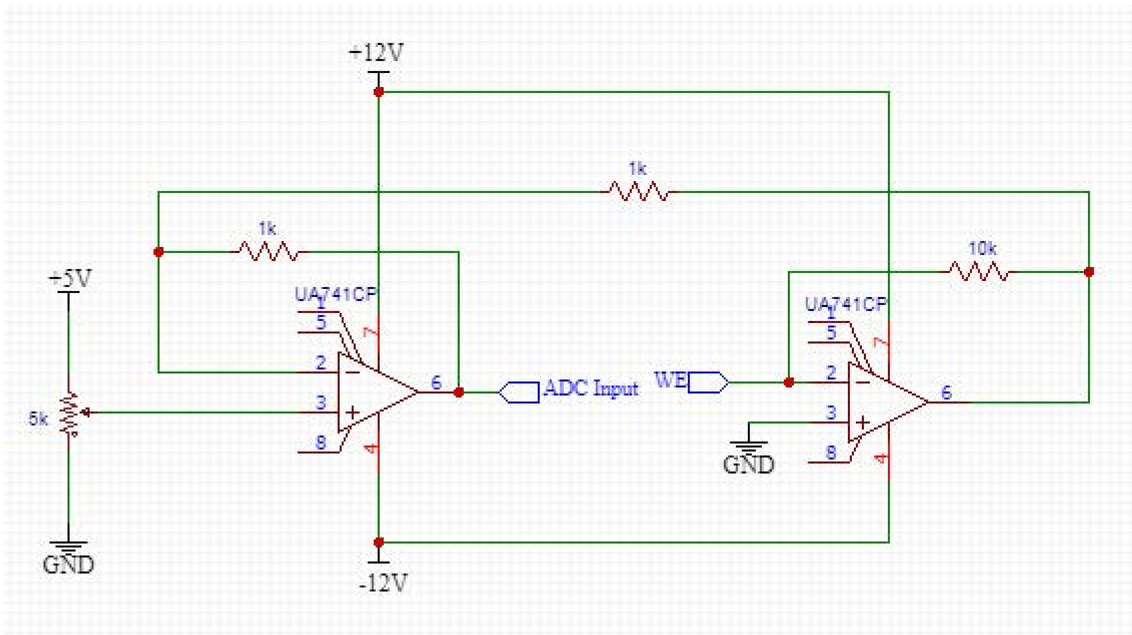




3. Current Measurement

To measure the current, we first need to convert it to a voltage value. For this we use an op amp based current to voltage converter. The voltage value is then read by the Analog to Digital Converter which is already present on the Arduino board. This ADC has a resolution of 10 bits and reference voltage 5V. The value of the voltage may be outside the range of input of the ADC hence we need to add some voltage to it bring it range. This is done using a potentiometer.

The circuit is able to measure the current in the order of **1 micro A.**



4. Computer

To Compute the data in a user-friendly manner. We used PLX-DAQ. It is open source macro for MS-Excel. It allows us to compute the data in a graphical manner.

The data can be sent to computer using USB.

It may also be possible to send data using Bluetooth or Wifi.

5. Voltage Supply

To power the op amps and Arduino board we used two generic 12V DC adaptors.

They are widely available in the market and thus are easy to procure.

Challenges faced During Implementation

The circuit provided earlier did not work. Thus, some of it had to modified and built from scratch.

The code for the microcontroller had to written from scratch to account for cyclic Voltammetry and also to incorporate PLX-DAQ.

The power supplied by USB port to Arduino is not constant and varies from port to port.

Future Scope

The accuracy of the op-amp circuitry can be increased by selecting more precise resistors.

The circuit can be printed on a PCB to further reduce the noise level and make the data more accurate.

PCB will also allow the circuit to be mass produced.

Conclusion

The circuit designed was able to satisfactorily give data within acceptable error range. However the circuit requires more fine tuning and more testing before it is able to manufactured commercially. We can then create small, relatively simple and cheap circuits that can be mass produced at a low cost and used to perform basic electrochemical analysis which can help in noninvasive testing (such as saliva-based glucose testing).