

## V-I CHARACTERISTIC CURVE PLOTTER FOR POTENTIOSTAT

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### ABSTRACT

We use potentiostat for measuring characteristics of various materials, or to observe current values according to changing voltage values. The current and the potential cannot be controlled simultaneously, and we must choose which experimental variable is to be controlled. In voltammetry, the potential of an electrode is the controlled variable while the current is the observed variable. As voltammetric methods are more popular than galvanostatic methods, the focus of this work is on voltammetry. This project describes the way that readings are obtained from a potentiostat. It is developed for doing potentiometric work in an easy way. The PIC18F452 was used to Read the output signal from the potentiostat and to process data. Produced data were sent to the computer through a Transistor-Transistor-Logic (TTL) module. The input data to the computer from the TTL module was processed by a computer program written in Java programming language and a comma separated values (CSV) file was generated as the final output of the system. Using the D-plot software the voltage vs. current graph can be plotted manually.

**Keywords:** potentiostat, V-I plotter

### 1. INTRODUCTION

Most students in an instrumental analysis course are already familiar with basic electrochemical concepts as taught to them in a high school or introductory college level chemistry course. They have already been exposed to half reactions, formal potentials, reference electrodes, the Nernst equation, free energy calculations, and simple dual electrode cells. Most of the calculations that students have performed in these early courses deal with the subject of potentiometric.

The basic function of a potentiostat is to maintain the potential of a working electrode (WE) at a desired fixed value or to control that potential under a defined functional variation with respect to a reference electrode (RE).

This potential should be maintained or controlled regardless of any fluctuations of electrolytic current, solution resistance, temperature, or other factors. The potential ( $V_{WE-RE}$ ) of WE is measured against RE when RE is placed very near to WE via an apparatus such as a lugging capillary. A desired potential is preset into the potential control circuit.  $V_{WE-RE}$  is then read and balanced against this preset potential. The difference or error signal is fed back into the control amplifier. The resultant control signal varies the output of the power amplifier (counter electrode, CE) as necessary to maintain the preset potential. Because of the extremely high input impedance (more than  $10^{11}$  ohms) of the electrometer, which is built in to sense the potential of the reference electrode(RE), essentially no current is drawn through RE, and its potential remains stable.

The principle function of a potentiostat is to control potential and measure current. The conventional three-electrode potentiostat is connected to the working, reference, and auxiliary electrodes immersed in the test solution. It controls the potential of the working electrode with respect to the reference electrode while simultaneously measuring the current flowing between the working electrode and the auxiliary electrode. Note that the potentiostat's internal feedback circuits prevent all but a very small current from flowing between the working and reference electrodes.

The potential of working electrode is maintained independently of the other and with respect to the reference electrode. Only an insignificant current flows through the reference electrode. Because the very basis of voltammetry is the control of electrode potential, a function generator is required to provide the potential sweep or pulse sequence to be applied to the working electrode. Most modern potentiostats include a built-in sweep and/or pulse generator, and those which are interfaced to a computer usually rely on the computer to generate the desired waveform. But those modern potentiostat devices are very expensive. An external function generator can also be used by connecting its output to an input on the potentiostat. This latter option is used with potentiostats that have no internal sweep/pulse generator or whenever highly specialized waveforms are required.

The voltage and the current signals can be obtained from the potentiostat as its basic output signals. The PIC18F452 was used to Read those output signal from the potentiostat and to analog to digital conversion. Produced data were sent to the computer through a Transistor-Transistor-Logic (TTL) module. The input data to the computer from the TTL module was processed by a computer program written in Java programming language and a comma separated values (CSV) file was generated as the final output of the system. Using the D-plot software the voltage vs. current graph can be plotted manually. Developed system can be controlled by two push button by selecting auto and manual operations. LCD display was used to show the produced data.

## 2. EXPERIMENTAL

### 2.1 Data Acquisition unit

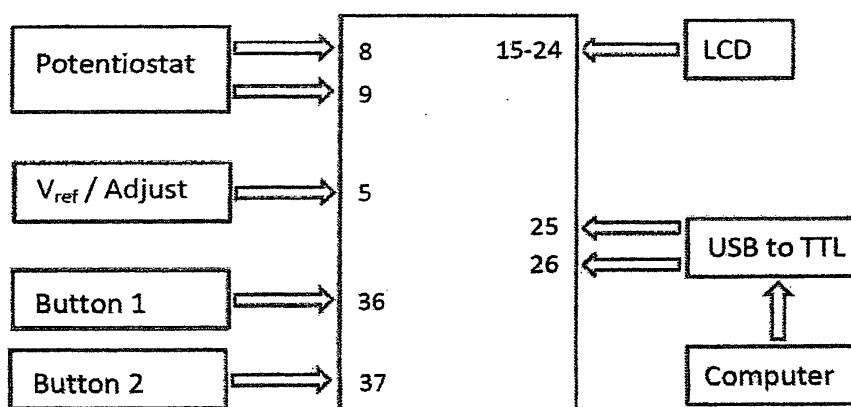


Figure 1: Functional block diagram of the system

PIC microcontroller is used here to convert analogue voltage to digital. The potentiostat output pins are connected to pin number 8 and 9 of the PIC. Then the analogue values are compare with the reference voltage that was given by user. Here I used reference voltage to increase the resolution of the final output. Reference voltage is connected to pin number 5 of the PIC. Finally the digitalized values are send via 25 and 26 pin of the PIC to USB to TTL module. The calculation used in the PIC microcontroller to calculate voltage value are below.

$$\text{Reference Voltage (V}_{\text{ref}}) = \text{Analogue reading of the pin 5}/1023 \dots \dots \dots (1)$$

$$\text{Input Voltage (V)} = (\text{Analogue reading} /1023) * \text{V}_{\text{ref}} \dots \dots \dots (2)$$

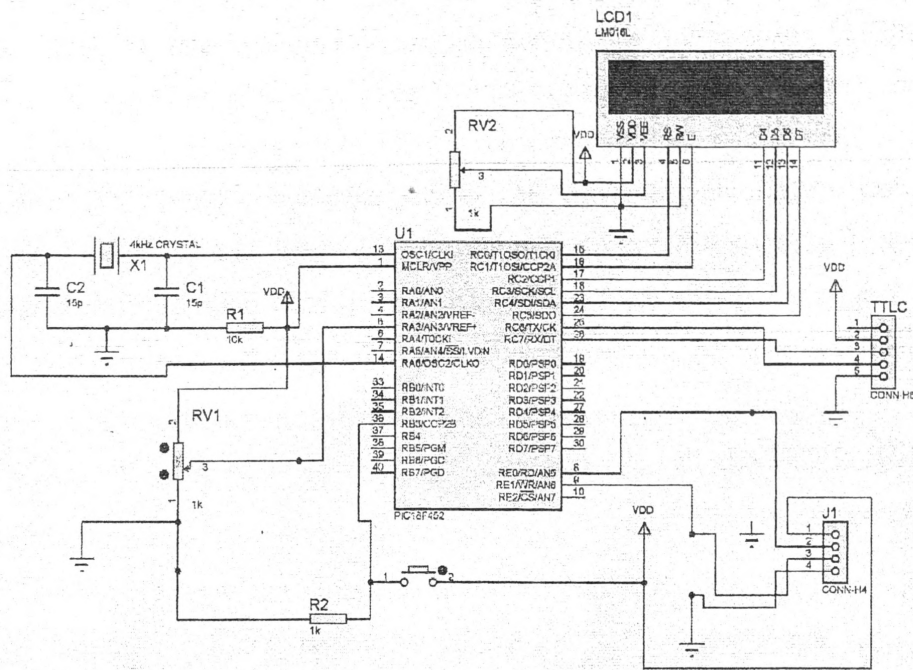


Figure 2: Design of the system

## 2.2 Programming the PIC 18F452

A simple program was written in microC compiler for proper analog to digital conversion (ADC) and to send RX/TX data serial to USB-to-TTL converter module. The program was compiled to make HEX file. The generated HEX file was programmed to the PIC 18F452 microcontroller using PICKIT2 programmer. Flow chart of the PIC program is shown in figure 3.

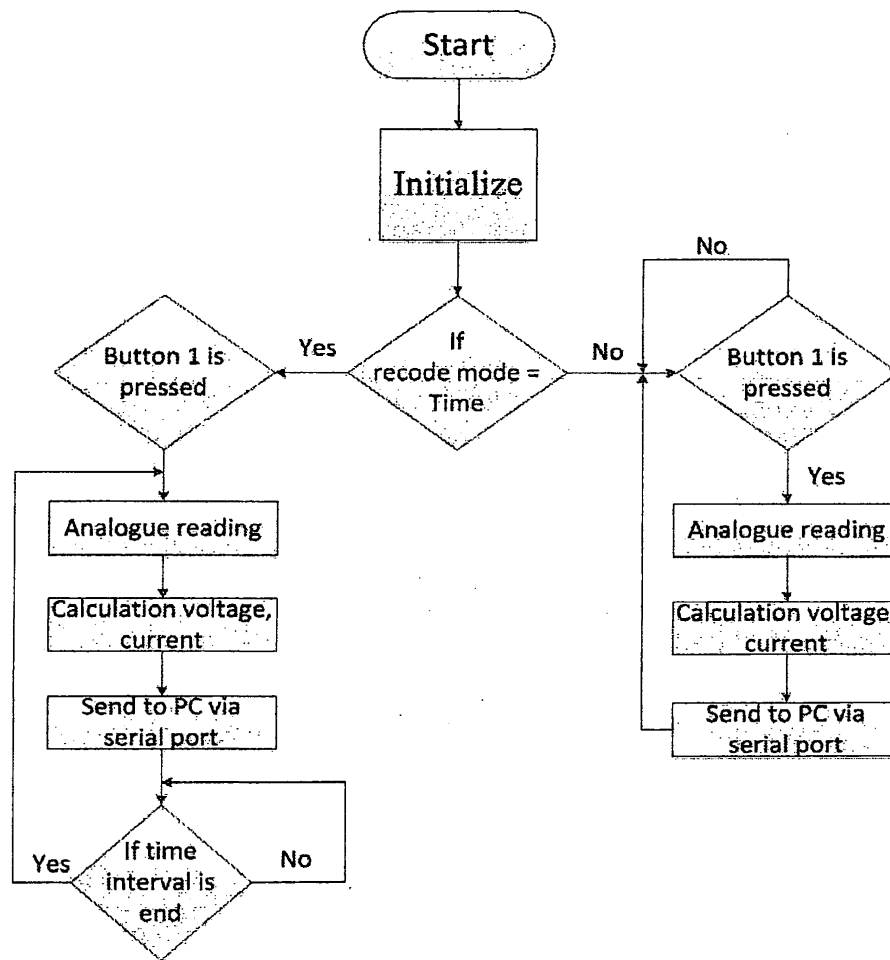


Figure 3: Flow chart of the PIC program

### 3. RESULTS AND DISCUSSION

The features of cost effectiveness, better data acquisition and compatibility with PCs and laptops were prioritized. This system has been design using PIC18F452 microcontroller for monitoring the varying signals. Microcontroller send the data to PC or laptop and by using program that convert the data in to text file which contains x y coordinates separately. The processed data are collected to a comma separated values (CSV) file for each predefined time intervals. These time intervals can be changed to 100ms, 200ms, 300ms, 400ms, 500ms and 1s.

The accuracy of the system is about 90% when considering the ADC. An observed VI characteristic graph is shown in figure 4.

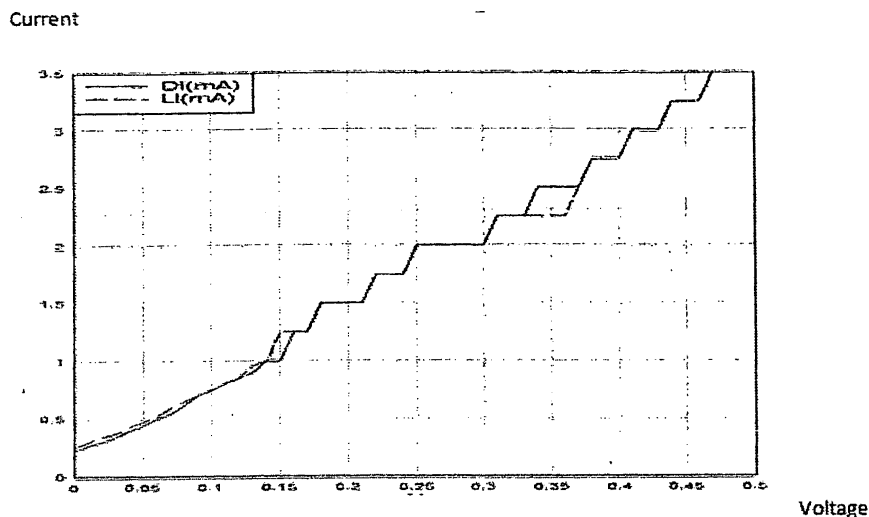


Figure 4: Observed VI characteristic graph

Time variations provided is not much accurate since there is no direct way to generate accurate time delays. ADC is not accurate since the ADC was done only using a PIC18F452 microcontroller. The developed system can be future improved by using self-calibration ADC integrated circuit like ADC1241. Another drawback of the system is VI characteristics on negative voltages cannot be observed using the developed system.

#### 4. CONCLUSION

The design is a low cost, simple and compatible to PCs and laptops, as USB port is very common these days. This will be very useful in research and practical laboratories when acquisition of number of observation is high. Also help to measuring, monitoring and graphical representation of data. It can also be developed with more feathers.

#### ACKNOWLEDGEMENTS

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#### REFERENCES

- [1]. <http://www.bio-logic.info/assets/app%20notes/Application%20note%204.pdf>
- [2]. Microchip Technology, PIC18FXX2 Data Sheet, Microchip Technology, 2006.

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