DEVELOPMENT OF A VIRTUAL INSTRUMENT APPLIED TO HEAVY METAL DETECTION IN WATER

Juliana Lopes Cardoso[1] and Marcelo Bariatto Andrade Fontes [1,2]

[1]Faculdade de Tecnologia de São Paulo - FATEC-SP,
Praça Cel. Fernando Prestes, 30 – Bom Retiro 01124-060
[2]Laboratório de Sistemas Integráveis (LSI) -EPUSP
São Paulo, SP, Brasil, 05508-900

ABSTRACT

In this paper we present the development of a virtual instrument (VI) using the software LabVIEW[TM] to detect electrochemically heavy metals, meanly mercury and lead. The electrochemical detection of the ionized metal is based on applying specific waveforms potential and record theirs output, through a potentiostat circuit. Using LabVIEW[TM] we could develop two VI's that fill the requirements of input signal and record the results. The first VI builds the waveform with high and low values and a percent of quiet time and send it to the potentiostat circuit. The second VI plots the output waveform and keeps up those values in a file.

1. INTRODUCTION

Potentiostats are amplifiers that control the voltage between two electrodes, commonly immersed in liquids, one called work electrode and other called reference electrode [1]. We can find either circuits with two electrodes, work and reference electrodes, or three electrodes, where an auxiliary electrode is used. Potentiostats determines experimentally polarization waveforms of elements in a solution. The potentiostat allows us to range, anodically or cathodically, the solution potential in respect to reference electrode. For each voltage value applied on input, the result is a current that the potentiostat supplies. The element concentration is proportional to the detected current. This potential will be applied and controlled by a Virtual Instrument (VI) built in LabVIEW[TM]. [2]

2. ELECTROCHEMICAL DETECTION

The electrochemical detection of heavy metals starts with a process called "pre-concentration", where the electrode is held at a cathodic potential (reduction) so that metal ions from the solution are reduced at the electrode surface, concentrating on it, as indicated in Figure 1(a) [3]. As long is the concentration time as higher is the reduced material, making this a compromising step. Next, the potential is scanned in the anodic direction to re-oxidize the metal concentrated on the electrode, process called stripping. This causes a current peak at specific reduction potential of the ion and it is proportional to the concentration of the ions in the solution, Figure 1(a). Increasing the specific ion concentration causes an intensification of the reduction peak. Finally a calibration curve can be obtained from the peak current or from the area under the reduction curve, Figure 1(b).
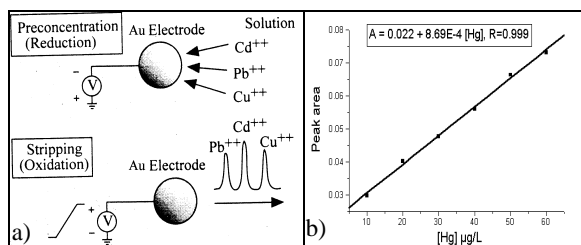

Figure 1 – Electrochemical detection of heavy metals.

3. VIRTUAL INSTRUMENT DEVELOPMENT

LabVIEW[TM] is a graphical programming language that uses icons instead of lines of text to create applications. In LabVIEW[TM], we were able to build a user interface by using a set of tools and objects. The user interface is known as the front panel. In a block diagram, we add code using graphical representation of functions to control the front panel objectives. [4]

3.1. Potential Controller

This VI was developed to produce some waveforms. Those waveforms are sent to the potentiostat input by a plug-in data acquisition (DAQ) board.

This front panel is built with seven digital controls, two Boolean controls, one knob, and one waveform graph, figure 2.

Digital controls are interactive inputs of values. The types of values, which should be defined before run this VI, are indicated on label of each digital control. There is a data range limiting some values of digital controls. The VI will ignore a value out of range. Digital control values are necessary to define the values of the waveform chosen. Boolean controls are inputs of logic values. They work as a power button, which stop the VI, and a positive/negative waveform start control, which indicate what value, high or low limit, will be used first.
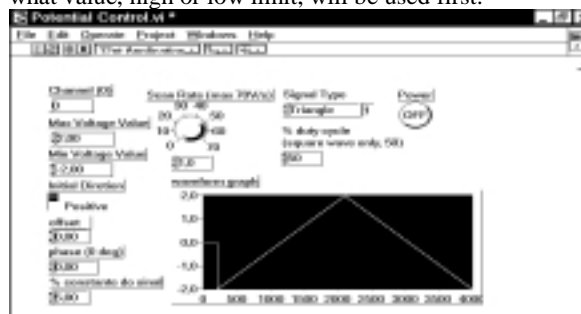

Figure 2 – Potential controller front panel.

A knob is a kind of digital control where a value can be defined by moving its indicator. It is used to indicate the scan rate value. The quantity of calculated points and the number of points sent to the DAQ board controls the Scan Rate.

The waveform calculated is plotted in the waveform graph.

3.2. Output Signal

This front panel is composed of maximum and minimum voltage limiters, numeric indicators, and a scan rate, figure 3. The output signal potentiostat circuit is indicated in waveform graph Ch1.

The input signal circuit, from signal generators or from the potential controller VI, is showed at Ch0. Ch 1/0 show both input and output signals. XY graph show Ch1 values in Y-axis and Ch0 in X-axis. Therefore, it is possible to plot current versus voltage to voltammetry analyze, figure 4.

Figure 3 – Multi-plotter VI

A special characteristic of this VI, is the possibility to save the values of the plotted waveforms in a .TXT file. The file has values of time, in milliseconds, the values of the input and output signals. The input signal value will appear only if the VI were able to catch it.
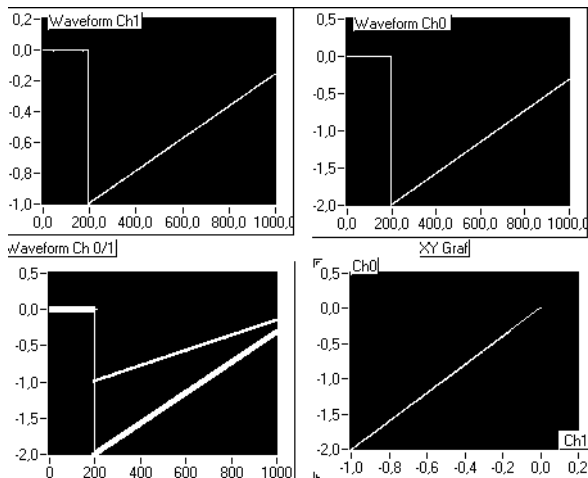

Figure 4 - Multi-plotter VI of output and input signal

4. RESULTS AND DISCUSSION

The potential controller VI waveform was analyzed using an oscilloscope. The signal of the potential controller VI has low frequency and is limited between +10 V and -10 V. The voltage limitation is caused because of the DAQ board. The frequency limitation is related to calculus speed and maximum scans per second (max 1000 scans/sec) of the output. Therefore, the best output signal definition is for low values of scan rate.

The frequency and voltage necessary to analyze a solution are low, allowing this VI for voltametric analyzes.

The Multi-Plot VI also has limitations of voltage (+10 V and -10 V), and a scan range of 1000 scans/sec because of the DAQ board. This VI are useful for any analyze that needs to show both input and output signals simultaneity and XY graph.

5. CONCLUSION

We presented two Virtual Instruments projected to apply a potential in a potentiostat and to analyze its output signal to detect heavy metals in water.

The first VI are able to calculate three kinds of waveforms: square, triangle, and sawtooth. These waveforms correspond to three voltametric analyzes. This VI builds the waveform, with a high and low values and a percent of quiet time and send it to the potentiostat.

The last VI plots the potentiostat output waveform and keeps those values in a file. The VI has four waveform graphs that show the potentiostat output and input signals, together (in the same waveform graph), in separated waveform graphs, and in a XY graph. Save signal values allow a posterior study of that waveform and to plot it in any other graph program.

6. ACKNOWLEDGMENT

7. REFERENCES

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