ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering
Tome IV (Year 2011). ISSN 2067-3809

[1.] Zoran STEVIĆ, [2.] Mirjana RAJČIĆ-VUJASINOVIĆ, [3.] Dubravka NIKOLOVSKI, [4.] Sanja BUGARINOVIĆ, [5.] Dejan ANTIĆ

HARDWARE AND SOFTWARE OF A SYSTEM FOR ELECTRO-CHEMICAL AND BIO-ELECTRO-CHEMICAL INVESTIGATIONS

ABSTRACT:
Electrochemical investigation methods are widely used for characterization of different kinds of materials and live tissue, as well as of the processes in systems where the electrochemical reactions take part. One such system for electrochemical researches based on PC and LabVIEW software package was developed and described in the paper. An overview of standard electrochemical methods, such as potential measurements, chronopotentiometry, chronoamperometry, cyclic voltammetry and EIS, but also of new methods, is given. For signal generation and recording of the response of investigated electrochemical cell, a measurement and control system was developed, based on a PC. The rest of the hardware consists of a commercially available AD-DA converter and an external interface for analog signal processing. The software platform for desired measurement methods is LabVIEW package. The developed system was adjusted, tested and compared with other commercially available systems.

KEYWORDS:
Electrochemical Measurements, Bioelectrochemistry, Measurement system, LabVIEW, Hardware, Software

INTRODUCTION

Electrochemical investigation methods are widely used for characterization of different kinds of materials and live tissue, as well as of the processes in systems where the electrochemical reactions take part [1, 2]. There is a series of well known methods, but some new methods from electrotechnic area have been introduced. So, first of all it was given an overview of the standard electrochemical methods and parameters, beginning with potential measurement and simple methods such as chronopotentiometry and chronoampermetry, till electrochemical impendance spectroscopy. The last named method is adapted for systems containing large capacitancies, that became actual with appearance of electrochemical supercapacitors. New methods are Dirack voltage excitation and Dirack current excitation. Measurement system described here is a new, updated version of previously developed one by the same authors at Technical faculty in Bor [3]. The system is assigned for electrochemical laboratories at faculties and institutes where it could replace expensive and/or old measurement equipment, rising work comfort and quality of obtained results at a higher level.

HARDWARE

For signal generation and data acquisition it was developed a measuring and control system based on PC Pentium 4. Beside PC, hardware consists of ADDA converter and external interface for analog signals conditioning [4-6]. ADDA conversion is performed using commercially available converter NI 6251 from National Instruments. National Instruments M series high-speed multifunction data acquisition (DAQ) devices are optimized for superior accuracy at fast sampling rates. They have an onboard NI-PGIA2 amplifier designed for fast settling times and high scanning rates, ensuring 16-bit accuracy even when measuring all channels at maximum speeds. All high speed devices have a minimum of 16 analog inputs, 24 digital I/O lines, seven programmable input ranges, analog and digital triggering, and two counter/timers [7].

Measurement interface designed for the needs of the electrochemical investigations by controlled current or voltage excitation have the next characteristics:

- *two control voltage inputs ±10 V,*
- *one measuring current input ± 100 mA.*
- *one voltage output ±10 V for input current of ± 100 mA,*

- *one voltage input for the reference potential recording,*
- *the reference electrode input resistance higher then 10^{12} Ω,*
- *one the three-electrode output for electrochemical cell with the next possibilities:*
  - *voltage range ± 5 V with the possibility of superimposing the small signal in the range of ±10 mV,*
  - *current range ± 100 mA.*

Figure 1 presents the photograph of the electrochemical measurement system, and figure 2 presents the block diagram of the interface.

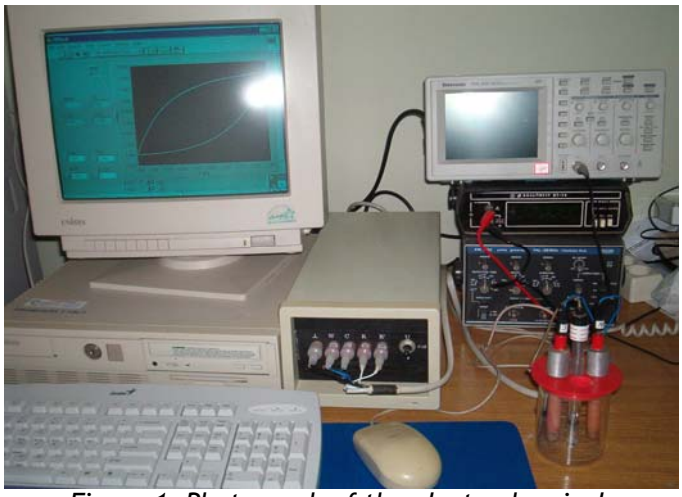

Figure 1. Photograph of the electrochemical measurement system

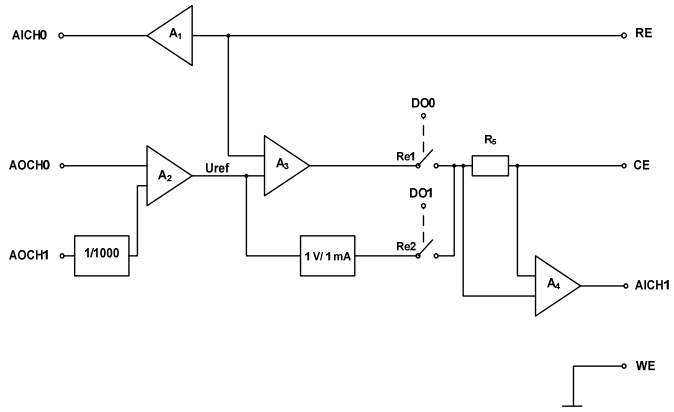

Figure 2. The block diagram of the interface

SOFTWARE

The software platform for predicted measurement methods was National Instruments LabVIEW package, which is regarded as a high standard in the area of modern virtual instruments [8]. LabVIEW is based on the principles of virtual instruments with the graphical user interface. Graphical user interface has two windows:

- *control panel for process control and monitoring,*
- *application diagram which presents used virtual instruments, relations between them, the course of signals and error detection.*

In LabVIEW, one builds a user interface by using a set of tools and objects. The user interface is known as the front panel. One then add code using graphical representations of functions to control the front panel objects. The block diagram contains this code.

Figures 3, 4, 5 and 6 presents control panels for galvanostatic method, potentiostatic method, cyclic voltammetry and electrochemical impedance spectroscopy, respectively.

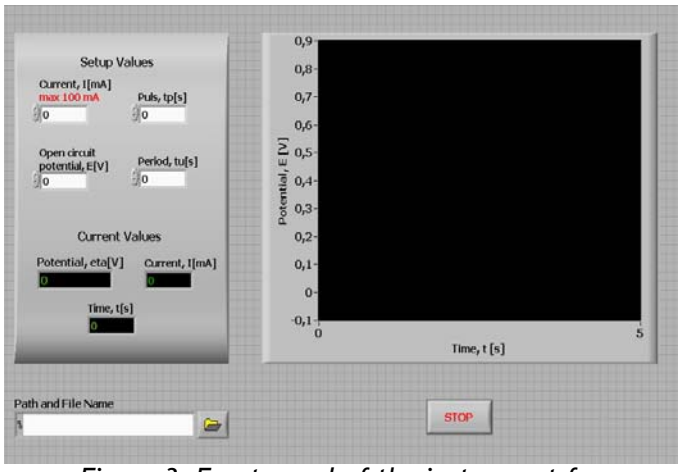

Figure 3. Front panel of the instrument for galvanostatic method

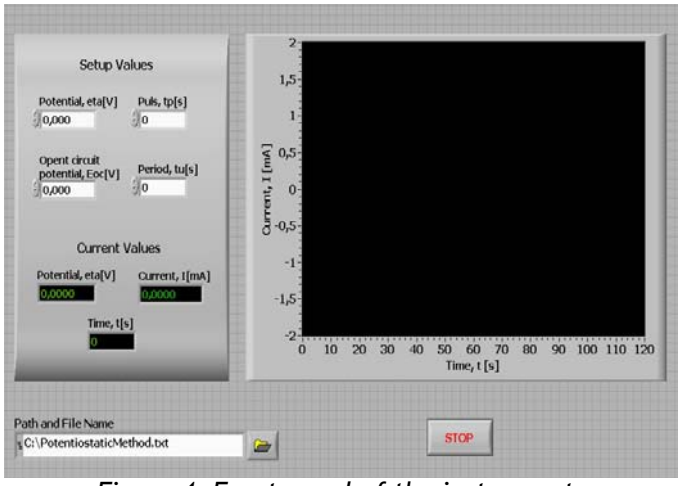

Figure 4. Front panel of the instruments for potentiostatic method

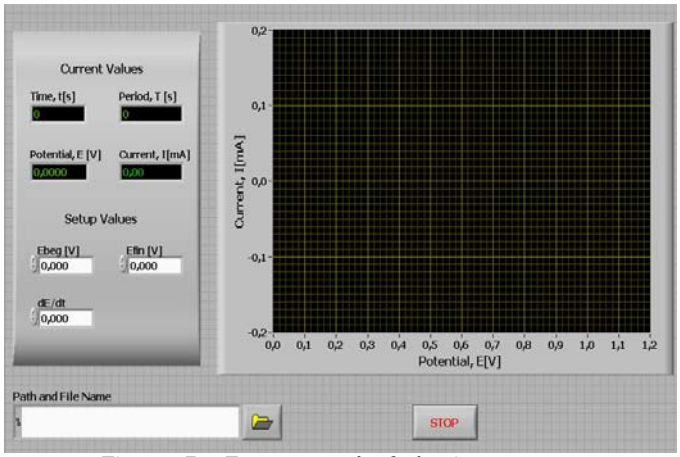

Figure 5. Front panel of the instrument for cyclic voltammetry

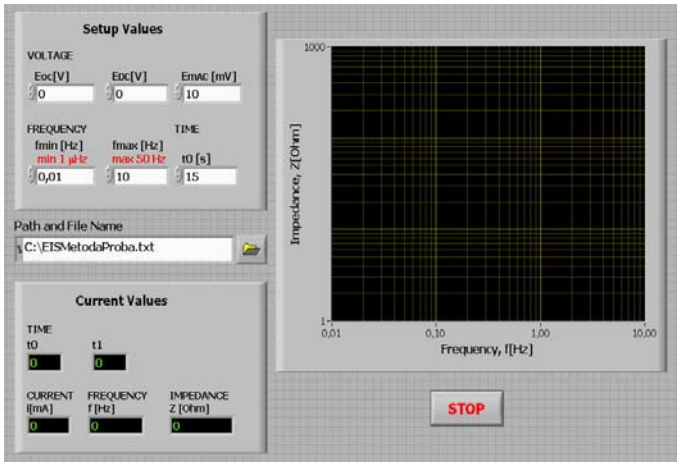

Figure 6. Front panel of the instruments for electrochemical impedance spectroscopy

EVALUATION AND CONLUSION

The system is calibrated using high accurate measurement instruments predicted for laboratory instruments adjusting (PRIMA B7-21A, PRIMA B7-38 and PHILIPS 5712). Measurement error less than 0.5 % in all ranges is achieved. The results obtained using this system are compared with those obtained in the same conditions using commercial galvanostat-potentiostat AMEL 551, and also with the results obtained by simulation in ORCAD software package. Excellent agreement of compared data can be seen.

ACKNOWLEDGMENT

This work was financially supported by Ministry of Science and Technological Development of Republic of Serbia (Project No. 172060).

REFERENCES

[1.] F. SCHOLZ, Electroanalytical methods: guid to experiments and application, Web reference: http://www.chemweb.com/arforms?fid=31.
[2.] I.L. SKRYABIN, G. EVANS, D. FROST, G. VOGELMAN, J.M. BELL, Testing and control issues in large area electrochromic films and devices, Electrochimica Acta 44 (1999) 3203-3209
[3.] Z. STEVIC, M. RAJCIC-VUJASINOVIC, Chemical Industry, 61,1 (2007)1-6
[4.] R.J. BOZEMAN, System of memorizing maximum values, US Patent No: 5539402
[5.] M. RAJČIĆ-VUJASINOVIĆ, Z. STANKOVIĆ, Z. STEVIĆ, The consideration of the electrical circuit analogous to the copper or coppersulfide/electrolyte interfaces based on the time transient analysis, Elektrokhimiya 35, 3 (1999) 347- 354
[6.] X. ANDRIEU, L. JOSSET, Bifunctional electrode for an electrochemical cell or a supercapacitor and a method of producing it. Patent: Accumulateurs Fixes et de Traction S A SAFT FR, US Patent No: 5811205
[7.] www.ni.com/products
[8.] National Instruments, LabVIEW development guidelines, NI Corporation, 2006

AUTHORS & AFFILIATION

[1.] Zoran STEVIĆ,
[2.] Mirjana RAJČIĆ-VUJASINOVIĆ,
[3.] Dubravka NIKOLOVSKI,
[4.] Sanja BUGARINOVIĆ,
[5.] Dejan ANTIĆ

[1,2,5.] UNIVERSITY OF BELGRADE, TECHNICAL FACULTY IN BOR, SERBIA,
[3.] INSTITUTE OF PUBLIC HEALTH PANCEVO, SERBIA
[4.] RESEARCH-SCHOLAR OF THE MINISTRY OF SCIENCE AND TECHNOLOGICAL DEVELOPMENT, UNIVERSITY OF BELGRADE, TECHNICAL FACULTY IN BOR, SERBIA

ACTA TECHNICA CORVINIENSIS
– BULLETIN of ENGINEERING
ISSN: 2067-3809 [CD-Rom, online]