EFFECTIVE COMPUTER SYSTEM FOR TESTING SUPERCAPACITORS

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The paper gives a brief overview of the developed simple and affordable computer-controlled system for testing electrochemical elements including supercapacitors. The means for the system embodiment and the main parameters of it are described. The realization of principal hardware blocks of the system and the software for it are shown. An example of implementation of the cyclic voltammetry method using the developed system is given.

Key words: supercapacitor, LabVIEW, data acquisition, cyclic voltammetry.

Introduction

There are a number of methods for testing electrochemical elements, which can be also used for testing supercapacitors [1—3], however the commercially available equipment for this purpose is excessively complicated and too expensive, while many research laboratories often need simple and cheap devices providing standard tests.

Therefore, the aim of this work is to develop a simple and affordable computer-controlled system of this kind, which makes it possible to implement the most common testing methods and has sufficient characteristics and handy user application.

Means for implementing the system

Measurement and control system for signal generation and monitoring the response of electrochemical element is developed using PC and LabVIEW software package. The hardware part also includes commercial AD-DA converter and an external interface for analog signal processing.

AD-DA conversion

For the purposes of measurement and control, commercially available data acquisition card (NI6009) was chosen. The most important features of the card are:

— the number of input analog channels (AI) 8 (single ended);
— the number of output analog channels (AO) 2;
— I/O voltage range ±5 V;
— AD convertor resolution 14 bit;
— DA convertor resolution 12 bit.

Measuring interface

For the purposes of voltage and current tests of electrochemical system, the circuit was designed (Fig. 1) with the following characteristics:

— two voltage inputs with ± 5 V range,
— one measurement current output with ± 5 A range,
— one voltage output ± 5V for input current ± 5A,
— one voltage output for monitoring referent potential,
— resistance input of referent electrode is greater than 1012 Ω,

— three outputs for electrodes for electrochemical cell with manual selection:
  · voltage of ± 5 V range
  · current of ± 5 A range.

Using the laboratory 5½ digit instrument PRIMA B7-21A (voltmeter + ammeter) and PRIMA B7-38 (voltmeter) the system (individual modules and general assembly) was calibrated for the selected range, then the whole system was tested and tuned using the accompanying software. The offset and gain constants were reduced to the input constants of the LabVIEW application. The other checks (temperature stability, immunity to interference, etc.) were also carried out. The interface and the entire system showed stable behavior, while the measurement error was less than 0.2%, depending on conditions.

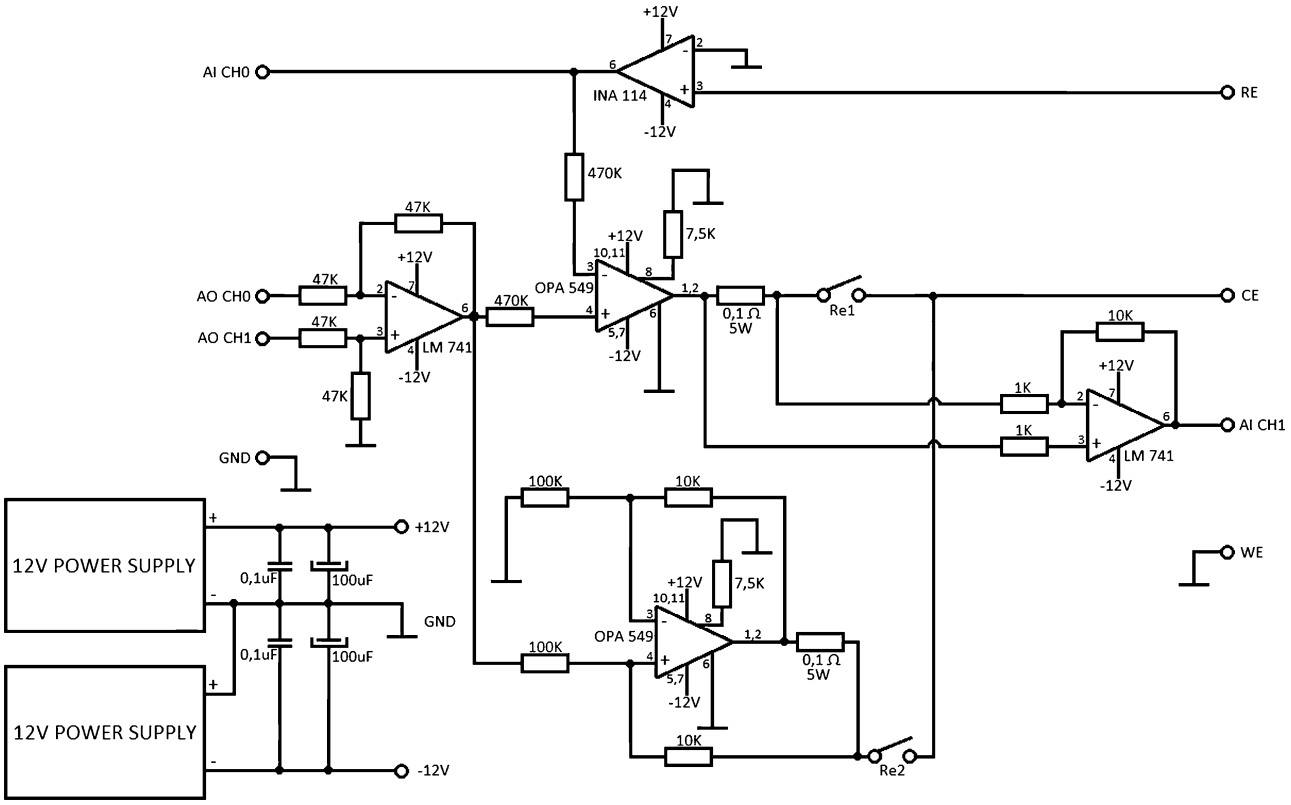

Fig. 1. The circuit of the measuring interface

Since the device is developed for measuring small voltages and currents, during assembling and installing of the whole system, special care was taken with shielding, grounding, filtration and positioning of the parts. Therefore, the system is well grounded, the interface modules are packed in a metal box, and the device and the cell are connected using special measuring shielded conductors.

Software

As a platform for writing user applications, LabVIEW package (National Instruments) [4, 5], which is a kind of standard among modern virtual instruments, was chosen. For connection with the AD-DA converter and the outside world, NI Collection driver that comes with the converter NI 6009 was used. The installation of these two packages and AD-DA converter provides a powerful development system for measurement, control and signal processing (virtual instruments). LabVIEW is based on the principle of virtual instruments with graphical user interface.

The applications were developed for potentiostatic and galvanostatic methods, cyclic voltammetry and measuring the open circuit potential. An example of described applications for cyclic voltammetry is shown in Fig. 2.

Cyclic Voltammetry

In this method, current measurement is performed using the channel AI CH1, while channels A0 CH0 and CH1 are used for setting the output voltage (Fig. 1). The voltage intensity is set on the virtual instrument panel. Regulated power supply with output current of 5A is solved as a part of the external interface.

Minimum and maximum potentials and the voltage increase in time are set by control E_{min}, E_{max} and dE/dt, from which the actual value of the output voltage is calculated according to the following equations:

$$E = k \cdot t + E_{min} \text{ for } t \le t_1, \quad (1)$$

$$E = -k \cdot t + 2E_{max} - E_{min} \text{ for } t > t_1, \quad (2)$$

where E — actual voltage value;
t — time;
$k = dE/dt$ — specified voltage increase rate;
$t_1 = (E_{max} - E_{min})/k$ — duration of voltage increase;
E_{min}, E_{max} — minimum and maximum voltage values.

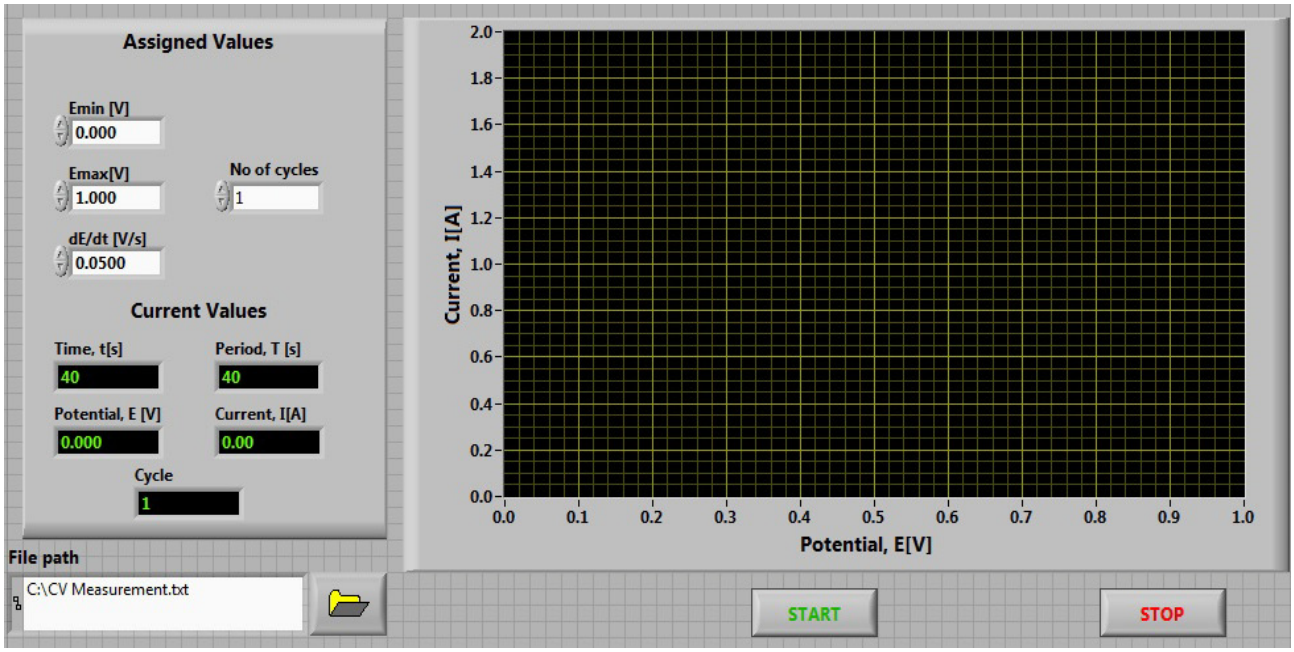

Fig. 2. Application for cyclic voltammetry

Conclusions

The developed computer-controlled system for testing supercapacitors has high-resolution measuring interface and handy user application based on LabVIEW package. The device is simple and affordable, while being able to implement the most common testing methods. Therefore, it may be useful for carrying out the study of electrochemical elements including supercapacitors, and is recommended for research laboratories of educational and scientific institutions.

This investigation was funded by the Ministry of Education, Science and Technological Development of Republic of Serbia under the projects ON 172060 for the period 2011-2017.

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Ефективна комп'ютерна система для тестування суперконденсаторів

Стаття представляє стислий огляд розробленої простої та доступної системи з комп'ютерним керуванням для тестування електрохімічних елементів, в тому числі суперконденсаторів. Описані засоби для побудови системи та її основні параметри. Показане виконання ключових блоків пристрою, а також програмного забезпечення для нього. Наведено приклад реалізації методу циклічної вольтамперометрії з використанням розробленої системи.

Ключові слова: суперконденсатор, LabVIEW, збір даних, циклічна вольтамперометрія.
