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By Nirwan Syarif

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Multichannel Data Aquisition System for Monitoring Supercapacitor Module and Cells

Nirwan Syarif[1]*, Assaidah[2]
[1]Department of Chemistry, Faculty Mathematics and Natural Science, Universitas Sriwijaya, Indonesia
[2]Department of Physics, Faculty Mathematics and Natural Science, Universitas Sriwijaya, Indonesia
*Corresponding author, e-mail: nnsyarif@gmail.com

Abstract

The monitoring system is needed to observe changes in the voltage of supercapacitor module and cells so that their performance can be assessed. A multichannel data acquisition system was needed to implement because a module of supercapacitor consists of several individual cells. The system can be implemented in a computer program using data acquisition board and computer programming. The computer program acts as computer and user interface was created by using Labview symbolic programming software, while the data acquisition board was Labjack. The test showed that the monitoring system can receive eight channel of input signal (voltage) of the module and cells simultaneously. The voltage of the module which has a wider range, 0-20 volts, rather than the normal input, 0 to 2.44 volts, can be overcome by adding a voltage divider circuit.

Keywords: *Supercapacitor, Labview, Labjack, DAQ, Programming, Instrumentation*

1. Introduction

Data acquisition is a process used to collect information to document or analyze some phenomena [1]. A simple example of data acquisition system is logging the temperature of an oven on a piece of paper. As technology move forward, this type of process has been simplified and made more accurate, versatile and reliable through electronic equipment [2]. A multichannel from single data acquisition system has been built which is connected to a computer in the same way as any other equipment for example scanner and printer [3], [4]. This system can be used to monitoring special events, tasks and devices, just like as in supercapacitor module and its cells [5].

Supercapacitor (SC) has become important device as power support in electric vehicles or and in renewable energy systems [6]. SC has longer life time and faster in charge time compare to battery [7]. However, module with two or more SCs suffered imbalanced voltage distribution [8, 9]. Some SCs will have an overvoltage that will be associated with the decrease of the lifetime. For the other SCs, the maximum voltage will be undervoltage therefore the energy storage in SCs will not be at its maximum level. A SC with a low capacitance has shorter charging time and, thus, reaches its maximum voltage faster than SC with high capacitance. This situation is unacceptable, because it would cause damage to the module. To avoid damaging, voltage equalization/stabilization component have to be employed in each cells [10]. The other problem is in the making of the electrode, the precursors are derived from various carbon materials so that the SC has a diverse electrical properties [11]. Considering the two problems, therefore, a multichannel monitoring system is needed in efforts to study the properties of SC cell or to develop module of SC with maximum performance.

The application of supercapacitor is mostly affected by capacitance, voltage and internal resistance in both alternating and direct current. These factors can give a robust valuation of electrochemical supercapacitor performance. In many cases, it would be more important to know characteristic of individual supercapacitor in various operative conditions and various electrical/electronic devices. A simple data acquisition system can be used in order to study supercapacitor character. The basic needs for build acquisition system in supercapacitor application are multi-channel monitoring, automatic control, high accuracy, fast data processing [12].

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The monitoring system was implemented through the computer, and the obtained data are stored in the computer memory, plotted on the screen and recorded on the disk as a file. The file data are available for offline processing. The main part of the monitoring system is data acquisition board, i.e. Labjack. Information about the applications of Labjack in acquiring data can be found in some papers [13-15] That can be received signal as voltage, i.e. 0 – 2.44 volt with 4 – 100 mA of current.

The complexity of the method demands the setup a simultaneous control or monitoring of various devices, and much time must also be devoted to post-data treatment and analysis. The development of this method for its application as a standard tool in electrochemical research and development, Therefore, LabVIEW was used to overcome these difficulties and needs. LabVIEW is a general purpose programming environment with high level programming languange [16] and has been established in electrochemical research as a control, data acquisition and analysis software [17]. In this paper, we present a description of the construction of multichannel monitoring system to investigate the supercapacitor cells and module using LabVIEW. The setup allows the data acquisition board, Labjack to be probed simultaneously charge and discharge rate of supercapacitor.

2. Research Method

2.1. Hardware description

Intel Pentium i3 PC was used for monitoring interface and part of data acquisition system. Synchronizing between digital and analog signal was provided by DAQ board (Labjack U3-LV). The DAQ board can be interfaced to PC by using USB hub providing multiple I/O channels, i.e. 8 flexible I/O (digital input, digital output, or analog input), 4 digital I/O channels, 2 counter/timers channels and 2 channels 10-Bit analog outputs. The circuit works at low–level current signal ranging from 4 to 100mA and low voltage ranging from 0 to 2.44 volt.

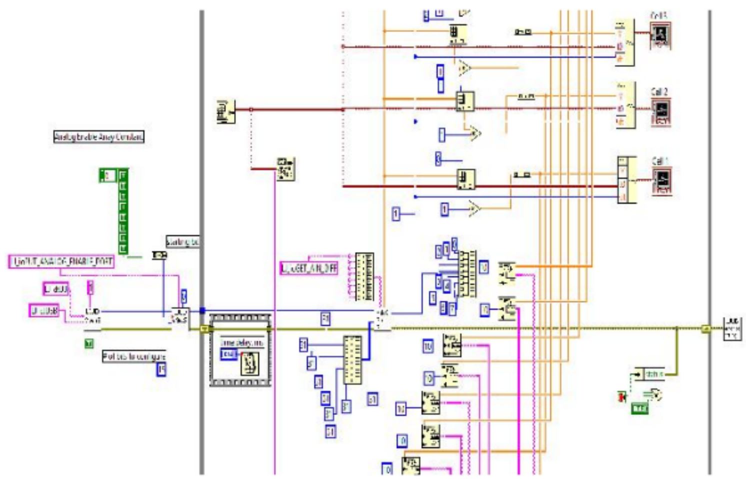

Figure 1. The Interface Programming for Monitoring Voltage of SC Module and Cells that acquired by using Labjack Data Acquisition Board

2.2. Software Description

The software platform for predicted measurement methods was National Instruments LabVIEW 8.5 package, which is regarded as a high standard in the area of modern virtual instruments. LabVIEW is based on the principles of virtual instruments with the graphical user interface. Graphical user interface has two windows (a) Front panel for process control and monitoring (b) Application diagram (block 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. As an example, the Block Diagrams as well as Front Panels has been showed for the characteristic electrochemical methods. The data acquisition program allows adjusting the values of the operation parameters, i.e. reading speed, plotting the voltage and saving the data.

3. Results and Analysis

In designing the system, the monitoring interface was made in such way to resemble the actual user-friendly instrument. The programs interface designed to do the following: 1) initialize USB communication port as the input voltage of the power supply; 2) read the data from the power supply, SC module and cells; 3) featured the data presentation in graphical form; 4) set the sampling time; 6) store the data from the measurements in .ssv (space separator value) format. Figure 1 and 2 show the program and the interface were used to acquire the data.

Monitoring system for supercapacitor data acquisition is a very important factor to solve the task of system optimization for particular application. The main feature of the supercapacitor data acquisition system is necessity to the numerous measurement signals. This is because the supercapacitors are passive components that do not create their own signals, which can be perceptible by sensors. In fact the supercapacitor data acquisition system should create the independent influences on each data acquisition channel and then collect the individual responses from each supercapacitor.

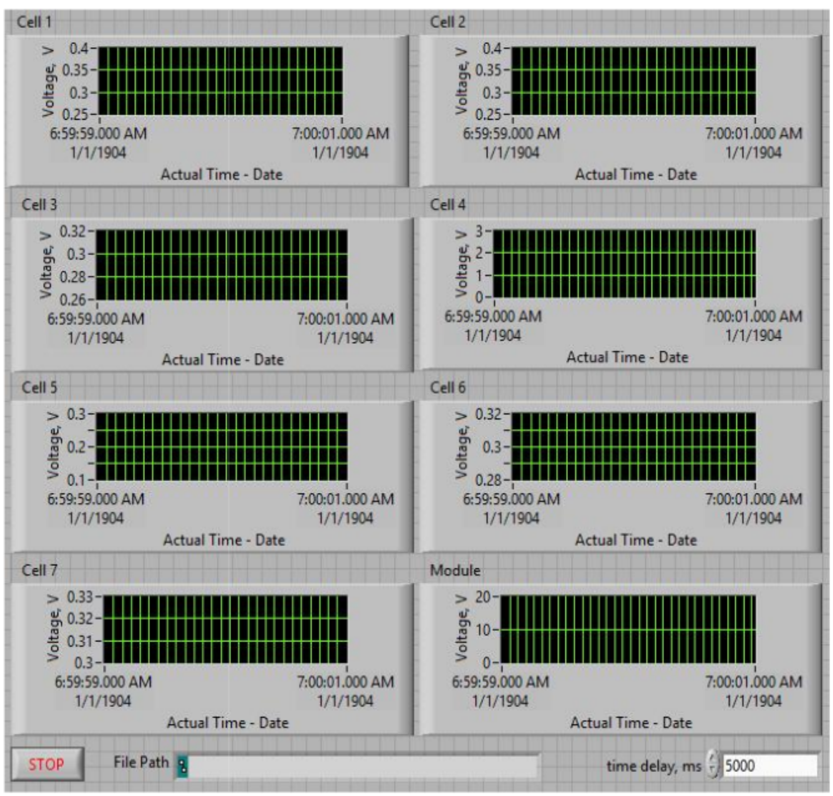

Figure 2. Screenshot of Program Interface for Monitoring Voltage Input from SC Module and Cells

One of special problem in developing and applying SC is complexity of making the module from SC cells and it is much harder to connect SCs compare than batteries because of the characteristics of electrode precursors [18]. In general, individual cell of SC has bias voltage about 2.5 volts since the power supply gives 25 volt to simulate the factual voltage to the module. Therefore, it needs serial and parallel connection in order to match with given voltage. The module needs extra components in order to work best and to have longer lifetime. In the other hand, the normal input range for a low voltage channel on the U3 is about 0-2.44 volts. The easiest way to handle larger voltages is often by using voltage divider circuit (Figure 3), which is a two channel buffered divider module that plugs into the U3 screw-terminals.This divider is easily implemented by putting a resistor (R1) in series with the signal wire, and placing a second resistor (R2) from the AIN (analog) terminal to a GND (ground) terminal. To maintain specified analog input performance, R1 should not exceed the values specified in Labjack manual, so R1 can generally be fixed at the max recommended value and R2 can be adjusted for the desired attenuation.The divide by 2 configuration where R1 = R2 = 10 kohm (max source impedance limit for low-voltage channels), presents a 20 kohm load to the source, meaning that a 5 volt signal will have to be able to source/sink up to +250 μA. Some signal sources might require a load with higher resistance, in which case a buffer should be used. Labjack is then ready for use in monitoring the data from the SC module.

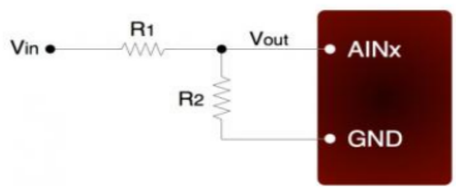

Figure 3. Voltage Divider Circuit for Reading 0 – 20 volts Input from SC Module and Cells

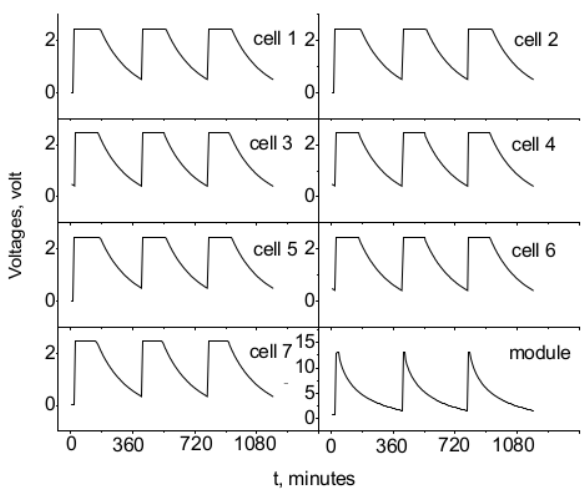

Figure 4. Receiving Actual Data while Charging Discharging Process in Cells and Module

Labjack digital input test was done by receiving saw tooth signal from the signal generator. The output signal generator which was on the probe connected to the Labjack seven analog input ports AIN0-AIN6. The other one input port was gain ten times to give simulated data of 20 volts. After the output of the signal generator was monitored by Labjack, then in

LabVIEW to record digital data that has been issued by the signal generator.The provision of digital data will be compared to LabVIEW between a given frequency signal generator with a frequency that is captured by LabVIEW. From digital input test results will be obtained Labjack digital input with a maximum frequency of how that can be acquired by Labjack this alternative. Testing was done by giving the variation frequency of the signal box to Labjack and displayed by LabVIEW, given the variation was 1Hz and above. The results showed that the monitoring system was done well in monitoring eight giving signals (voltages). Figure 4 shows the input test of monitoring test.

All these logged data are recorded in the tabular form also which can be seen when log button is clicked. The data can be recorded in csv or txt format. Following parameters are recorded with actual date and time, seven channels for cells voltage, one channel for module voltage. The update rate of these data depends upon the time set in milliseconds. The content and structure of data log file can be is shown in Figure 5.

0	12/5/2015	6:46:19 PM	0.004526	0.004239	0.471007	0.471592	0.004733	0.471805	0.01468	0.857915
5	12/5/2015	6:46:23 PM	0.004526	0.00366	0.444727	0.444793	0.004687	0.445439	0.004526	0.831635
10	12/5/2015	6:46:29 PM	2.448624	2.448403	0.418446	0.418907	2.449382	0.419195	0.004526	0.811924
15	12/5/2015	6:46:35 PM	2.448624	2.44764	2.448624	2.448718	2.448752	2.449585	2.448624	12.89444
20	12/5/2015	6:46:41 PM	2.448624	2.448093	2.448624	2.448716	2.448684	2.448788	2.448624	12.97328
25	12/5/2015	6:46:47 PM	2.448624	2.448129	2.448624	2.449031	2.448687	2.449664	2.448624	13.00614
30	12/5/2015	6:46:53 PM	2.448624	2.448075	2.448624	2.448877	2.448992	2.448983	2.448624	11.60669
35	12/5/2015	6:46:59 PM	2.448624	2.447941	2.448624	2.449117	2.44937	2.450096	2.448624	10.66716
40	12/5/2015	6:47:05 PM	2.448624	2.447753	2.448624	2.44904	2.449482	2.449796	2.448624	9.964153
45	12/5/2015	6:47:11 PM	2.448624	2.447703	2.448624	2.44935	2.449089	2.449483	2.448624	9.353128
50	12/5/2015	6:47:17 PM	2.448624	2.447847	2.448624	2.448839	2.449408	2.449628	2.448624	8.820945

Figure 5. The content and structure of data log file generated by the monitoring software

The logged data can be analyzed and represented in different forms. In the similar way graphical representation of other logged parameters are also displayed like current with time, array voltage data versus time, discharging versus time. Figure 6 shows graphical representation of module and cell voltage versus time.

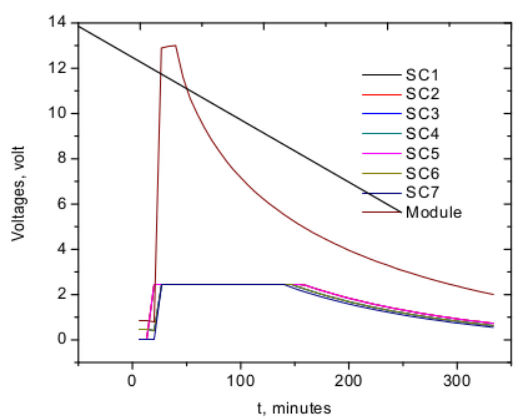

Figure 6. Representation of voltage changes as function of time in SC module and each cells during charging discharging process

It is clear that the implemented system can do the acquisition task. The use of low cost data aqcusition system will facilitate the spread of the measurements both cells and module, thus allowing recognized individual SC as part of solar panel and wind power generation.

4. Conclusion

Monitoring system for supercapacitor data acquisition is a very important factor to solve the task of system optimization for particular application. This paper has presented a description of the construction of multichannel monitoring system to investigate supercapacitor cells and module using Labjack data acquisition board and LabVIEW programming language. Developed multichannel monitoring system was successfully used to evaluate voltage changes in supercapacitor module and cells.

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