

# Low Cost Data Acquisition Setup for Electrical Machines Laboratory

Ciprian Sorandaru, Sorin Musuroi

*“POLITEHNICA” University of Timisoara, ROMANIA, Faculty of Electrical Engineering  
Bd. Vasile Parvan nr. 2, Dept. MAUE, Tel/Fax: +40 256 403452  
e-mail: ciprian.sorandaru@et.upt.ro*

**Abstract-** This paper describes the hardware and the software for data acquisition parameters, which is used in the Electrical Machines Laboratory. The hardware consists in a LEM board and a low cost data acquisition module. The main software is developed in LabVIEW. A simple Matlab sample is also presented.

## I. Introduction

DAQ hardware without software is of little use and without proper controls the hardware can be very difficult to program. The purpose of having appropriate software is the following:

- Acquire data at specified sampling rate
- Acquire data in the background while processing in foreground
- Stream data to and from disk
- Integrate different DAQ boards in a computer and use various functions of a DAQ board from a single user interface.

In the figure 1 a complete DAQ system with LabVIEW is shown. The driver software is a lower level driver that interfaces LabVIEW software with the DAQ boards.

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where the flow of data determines execution. In LabVIEW, you build a user interface by using a set of tools and objects.

As a user of LabVIEW one does not have to worry about configuration and control of components within DAQ boards. LabVIEW identifies each board by a device number and therefore one can have as many devices as many as the computer can accept on their expansion slots. LabVIEW can also combine and display inputs from various sources like inputs from serial and parallel port, data acquisition boards, and GPIB boards on a single interface as shown in the figure below.

LabVIEW is programmed with set of icons that represents controls and functions, available in the menu of the software. Such a programming is called visual programming and National Instruments calls it G. The user interface which is called a VI consists of two parts: a front panel and a block-diagram. This is similar to that of an instrument where a front panel is used for an input, output controls, and to display the data whereas the circuit resides on the circuit board. Similarly you can bring the buttons, indicators and graphing and display functions on the front panel.

One can configure a VI to include functions and graphs that are fully customizable. When data acquisition is performed, the software needs to know the following information:

- Device number
- Channel that is being used
- Sampling Rate

Often LabVIEW is used to perform system simulations, since it contains many commonly used filter, digital signal processing, and statistical functions. LabVIEW compiles almost as fast as C or Matlab and therefore one can perform complete simulation within a VI. In addition to data input output, LabVIEW can access serial ports, parallel ports and GPIB cards to read data from instruments that have a GPIB interface.

## II. Hardware setup

The data acquisition system which use the software developed in the electrical machines laboratory and which is described in this paper consists in:

- a PC equipped with a low cost data acquisition board from National Instruments and LabVIEW software
- an 6 channels interface board built with voltage and current transducers.

The block diagram of the data acquisition system is a classic one, presented by National Instruments (Figure 1).

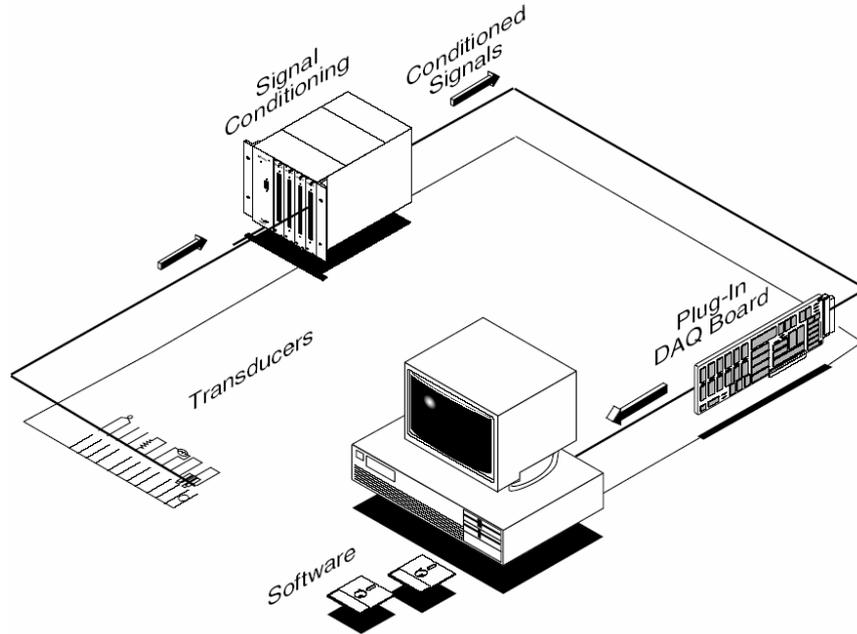


Figure 1. Scheme of a data acquisition system [5]

Generally, a DAQ board can perform a variety of functions—*analog-to-digital (A/D) conversion, digital-to-analog (D/A) conversion, digital input/output (I/O), and counter/timer operations.* Each board supports different data acquisition and signal generation speeds. For the DAQ board used in this system, only analog inputs channels are considered.

When measuring analog signals with a DAQ board, you must consider the following factors that affect the digitized signal quality: *mode (single-ended and differential inputs), resolution, range, sampling rate, accuracy, and noise.*

There are two ways to configure the analog inputs: *single-ended and differential.*

Single-ended inputs are all referenced to a common ground point. Use these inputs when the input signals are high level (greater than 1 V), the leads from the signal source to the analog input hardware are short (less than 15 ft.), and all input signals share a common ground reference. If the signals do not meet these criteria, use differential inputs. In this system, the analog-inputs are configured as single-ended.

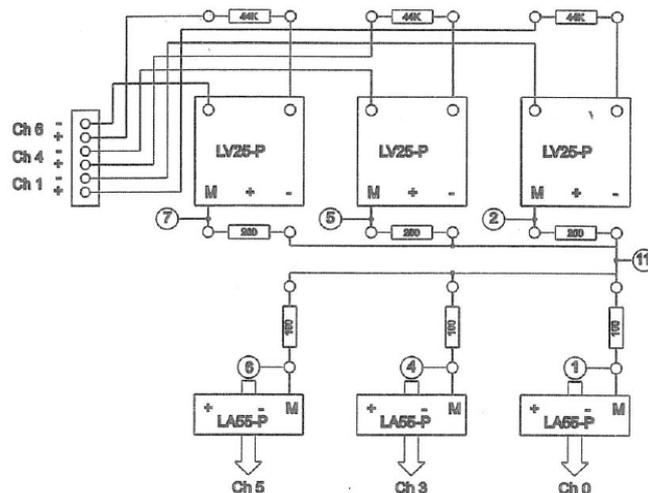


Figure 2. The block diagram of the signal conditioning module



Figure 3. Top and inside view of the NI USB-6009 data acquisition module

Figure 2 presents the block diagram of the signal conditioning module. Mainly, it consists in three current transducers and three voltage transducers, calibrated for the desired range of current and voltage respectively. The data acquisition which is used in this experimental setup is a low-cost one, which is presented in figure 3.

After the installation and testing of the USB-6009 module, it must be configured in MAX. One has to create *tasks* for the analog input and the analog output operations. A task represents the configuration of the signal input or signal output operation to be executed by the I/O device. Creating tasks is a general feature of the MAX utility. In general, a task can contain one or more *global or local virtual channels*, and one such virtual channel is based on one *physical channel*. The MAX test panel is presented in figure 4.

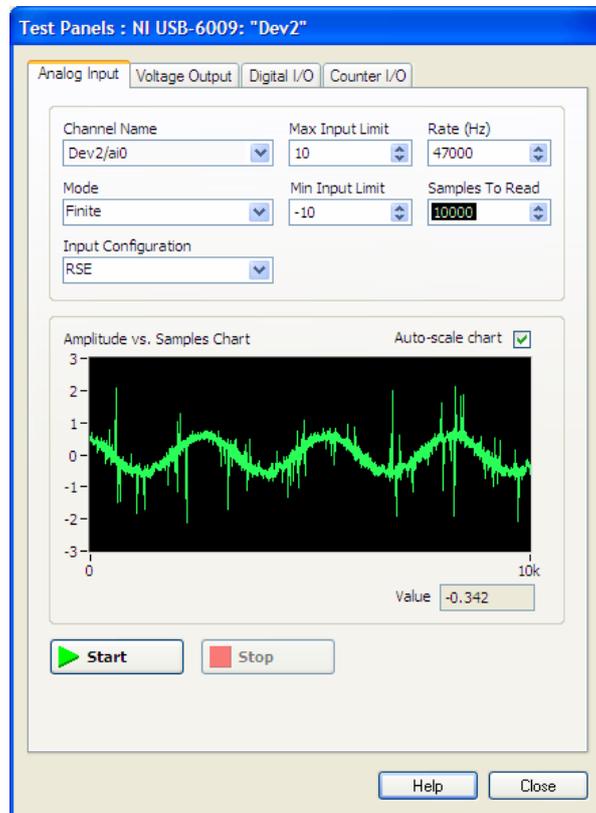


Figure 4. The MAX test panel

Using this setup, three currents and three voltages can be acquired.

### III. LabVIEW software description

The software which is presented in this paragraph is performed in LabVIEW. Figure 5 presents the main front panel of the described software. As can be seen, the software can operate in two different modes: simulation and acquisition. For each of these two modes, single acquisition and continuous acquisition is possible.

In the simulation mode, the user can impose his own parameters regarding the peak voltage ( $U_{max}$ ), frequency, currents ( $I_{e1}$ ,  $I_{e2}$ ), speed and excitation voltage ( $U_{ex}$ ). Also the program allows to the user to impose a noise which adds to all signals. The noise is set as percent from the ideal signal.

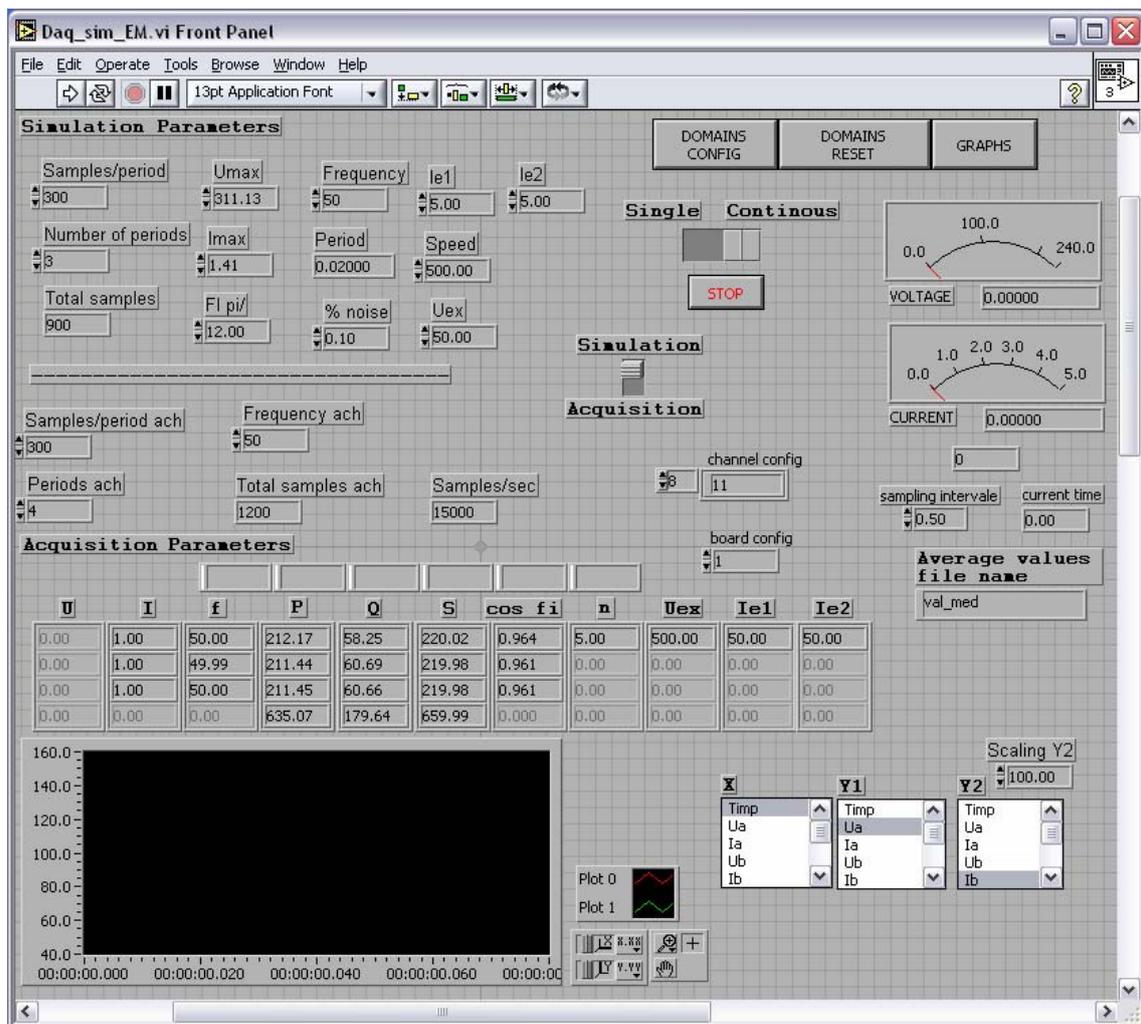


Figure 5. The main front panel of the LabVIEW data acquisition software

### IV. Matlab software example

One of the advantages of the most National Instruments boards is this that they can be also used with the Matlab software. This is an advantage because the students are not obliged to know LabVIEW programming. A simple sample of such a program, written in Matlab is presented below:

```

ai=analoginput('nidaq','Dev2');
addchannel(ai,0:2);
x=10000;
set(ai,'SampleRate',10000);
set(ai,'SamplesPerTrigger',x);
start(ai);
data=getdata(ai);

for i=1:x
    data1(i,1)=data(i,1);
    data2(i,1)=data(i,2);
    data3(i,1)=data(i,3);
end

a=1.39;

for i=1:x
    data2(i,1)=(a+data(i,2))*1370;
    data1(i,1)=(a+data(i,1))*5;
    data3(i,1)=(a+data(i,3))*80;
end

subplot(3,1,1); plot(data1)
subplot(3,1,2); plot(data2)
subplot(3,1,3); plot(data3)
delete(ai);
clear (ai);

```

This program acquires three parameters: current, speed and voltage for a period of one second, from an asynchronous machine fed by a voltage source inverter. The results for the transient starting process are presented in figure 6.

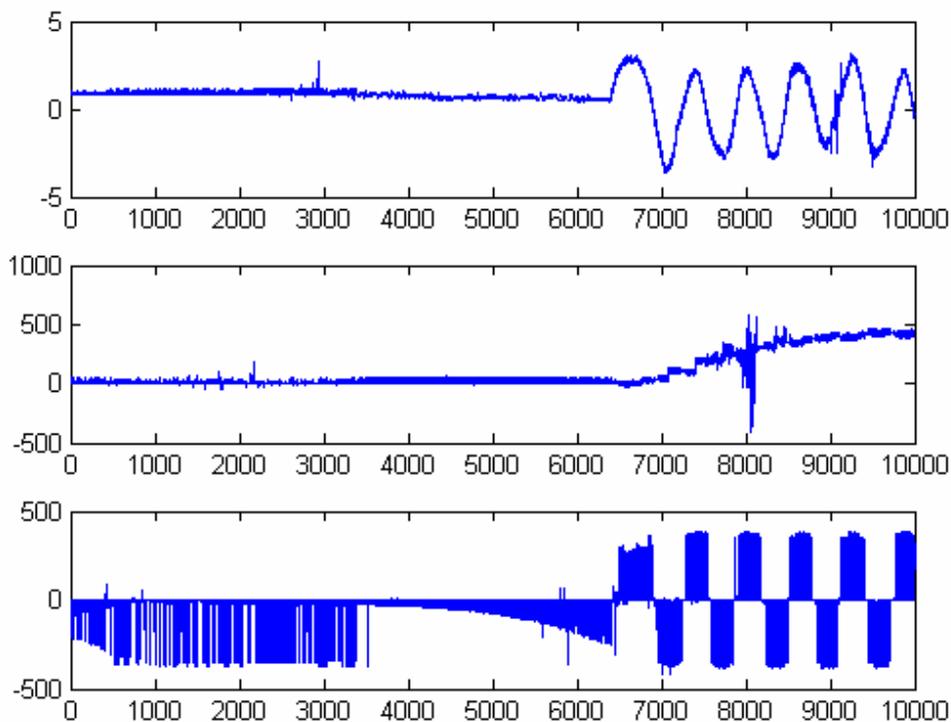


Figure 6. The starting of an asynchronous machine recorded by the Matlab software

## V. Conclusions

This purpose of this experimental setup in association with the appropriate LabVIEW/Matlab software presented in this paper is especially destined to be used for testing of electrical machines. This software is useful for the Electrical Machines Laboratory in University, and also for industrial use, in Electrical Machines factory.

The simulation feature which is included in the main LabVIEW program is also useful for the student's practices. The facilities in the simulation mode are the same as in acquisition mode.

There are the possibilities to continuous develop this software, to be adapted to various transducer boards and to calculate and display various parameters.

## References

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