Gheorghe-Eugen Subtirelu, Mircea Dobriceanu, Adela-Monica Enache, Niculae Boteanu

Monitoring System Dynamic Regimes with Variable Reluctance Synchronous Motors

This paper will present an overview of how can we use a data acquisition (DAQ) device to quickly and easily acquire and present the data of dynamic regimes of variable reluctance synchronous motors. The described monitoring system is built from two principal parts: hardware component (LEMs transducer for measurement voltages and currents, supply voltage, elements for signals conditioning and start command, USB multifunction I/O module); software component based on the industry standard Lab VIEW graphical development environment. The command for synchronization of start acquisition and start motor is on the front panel of data acquisition virtual instrument. The values of data acquisition are displayed numerically and graphically.

Keywords: data acquisition, power system monitoring, voltage measurement

1. Introduction

Often understanding of electrical devices operation involves the study of their steady-state operation; but because the stationary is just a special case of dynamic regime most phenomena encountered in practice are dynamic and transient.

Therefore the functional parameters of dynamic regimes must be known as accurately. This is done by measuring these parameters in real time with proper measuring equipment [1].

Virtual instrumentation is a modern tool for measurement, analysis and control values characteristic of transients phenomena that occur in various situations such as dynamic regimes of electrical machine, apparatus and power systems.

In order to study the dynamic and transient regimes occurring in starting, braking and speed control of electric motor is proposed data acquisition system described below.

2. DAQ aspects of dynamic regimes

In this chapter we will analyze two aspects of acquisition, namely: the problem of interconnection between the signal source and DAQ device and the triggering problem.

As described in [2], the measuring analog signals with data acquisition module is not always as simple as wiring the signal source leads to the DAQ board. In this case the signal produced by adapting and conditioning circuitry associated with LEM transducers is in the form of voltage signal source.

A voltage source can be grouped into one of two categories: grounded and ungrounded or floating; as well, a measurement system can be grouped in two categories: ungrounded or ground-referenced.

Figure 1 shows a grounded signal source measured with a ground-referenced system. The measured voltage (note Vm) is the sum of the signal voltage Vs and the potential difference Vg. The voltage note Vg between the source ground potential and measurement system ground potential causes a current to flow in the interconnection (defined the ground-loop current).
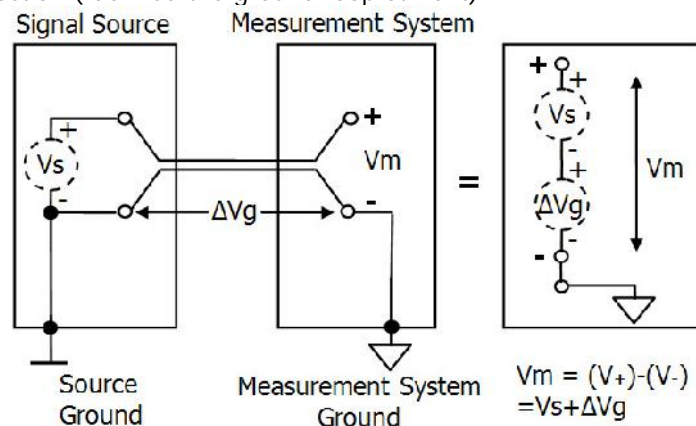

Figure 1. A grounded signal source measured with a ground-referenced system

Ground-loop introduced noise may have two components (AC and DC), thus introducing offset errors as well as noise is in the measurements.

This configuration of measurement system can be used successfully if the signal voltage level are high and the interconnection wiring between the source and measurement device has a low impedance.

A grounded signal source is best measured with a differential measurement system. This is a no referenced measurement system and it shown in Figure 2; any potential difference between references of the source and the measuring device appears as common-mode voltage to the measurement system and is subtracted from the measured signal. [2]

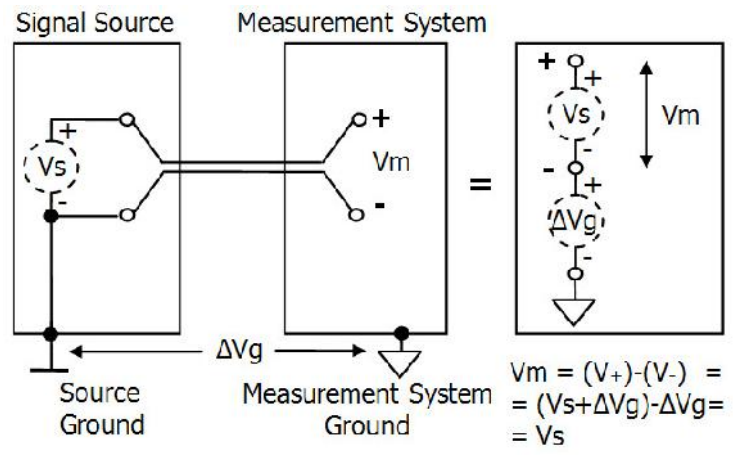Measured signal is applied to the differential input of ungrounded measurement system.

Figure 2. A grounded signal source measured with a differential system

In this case, the measured voltage note Vm is even value of the signal voltage Vs, without any noisy signals.

Also, floating signal source can be measured with differential measurement system. In this case, the care should be taken to ensure that the common-mode voltage level of the signal with respect to the measurement system ground remain in the common-mode input range of the measurement device used.

In order to minimize the input bias current effect of the instrumentation amplifier use two resistors connected between each lead and the measurement system ground. [2] These resistors (bias′ R) are illustrated in Figure 3 (note R1, R2).
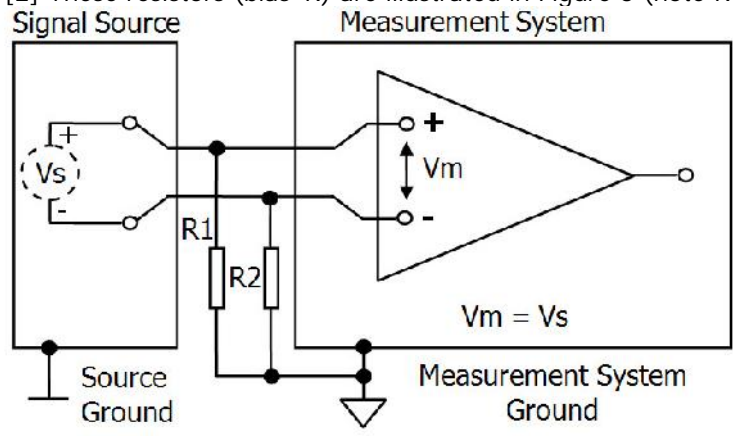

Figure 3. A floating source measured with a differential system

If the input signal Vs (source) is DC-coupled, only one resistor R2 is required.

67

If the source voltage is AC-coupled, two bias resistors (R1=R2) are required to provide return path to ground for bias currents of the instrumentation amplifier. Typically the resistors values are between 10k and 100 k [2].

Usually trigger is the action that is executed automatically when some events occur. In the study of dynamical regimes, triggering allows for an acquisition to begin when a condition is met. With the triggered acquisition we can capture the signal only in the region of interest.

As described in [3], the trigger signals can be classified into digital and analog trigger. Depending on the moment of starting, triggered acquisition applications can be classified as to follows post-triggered and pre-triggered acquisition.

Figure 4 shows the post-triggered acquisition; in this mode, the hardware starts the analog to digital conversion after the start trigger impulse is received.
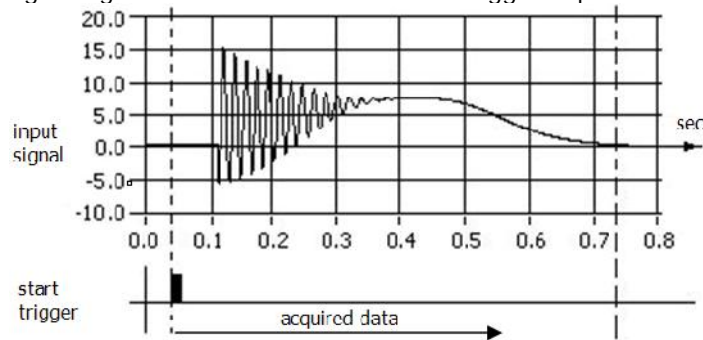
Figure 4. Post-triggered acquisition

If we want to look at the signal before the special event, then it uses the pre-triggered acquisition; this situation is shown below in Figure 5.
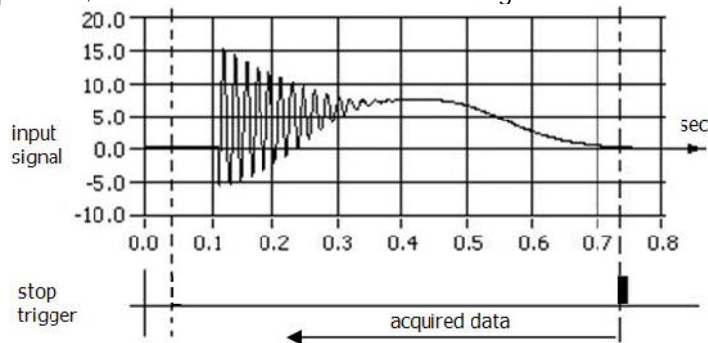
Figure 5. Pre-triggered acquisition

In this case, the hardware starts acquisition before the trigger signal is received . The hardware initiates data acquisition with a software function and stores data in a circular buffer in PC memory.

3. Hardware component of the system

The block diagram of the system is presented in the figure below and his main components are: unit under test (motor, transformer or another equipment) with connection/unconnection device (three phase contactor K3); transducers and conditioning module; DAQ module and computer.
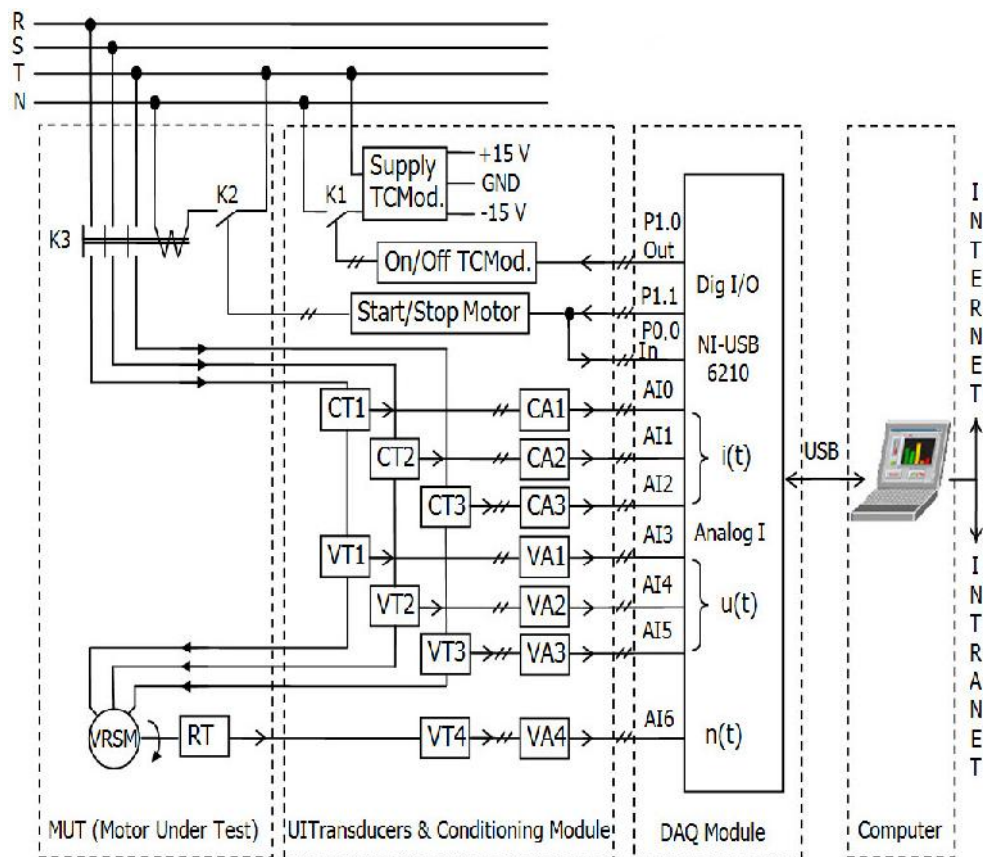

Figure 6. Block diagram of the system

The phase or line supply voltages V1,V2,V3 and the line currents I1,I2,I3 should be measured in real-time by the DAQ module type NI-USB 6210 with 16 analog inputs (16 single ended, 8 differential), 16-bit resolution, 250 kS/s sampling frequency, multifunction digital I/O (4 digital input P0.<0..3> and 4 digital output P1.<0..3>) and the transducers for V-I signal conditioning and isolation purposes with Hall effect (500 V-100 A)-LEM VT1,VT2,VT3 and CT1,CT2,CT3. Non-inductive

69

transducers LEM provide galvanic isolation and a fidelity measuring to those measurements where transient analysis.

To measure motor speed uses a DC tachometer generator (RT) whose output voltage signal is then measured with LEM transducer (VT4).

Blocks CA and VA is adapting and conditioning circuits for currents and voltages measured with transducers. The measured values are applied to six analog inputs of DAQ module (AI0...6). Figure 7 shows all these elements.
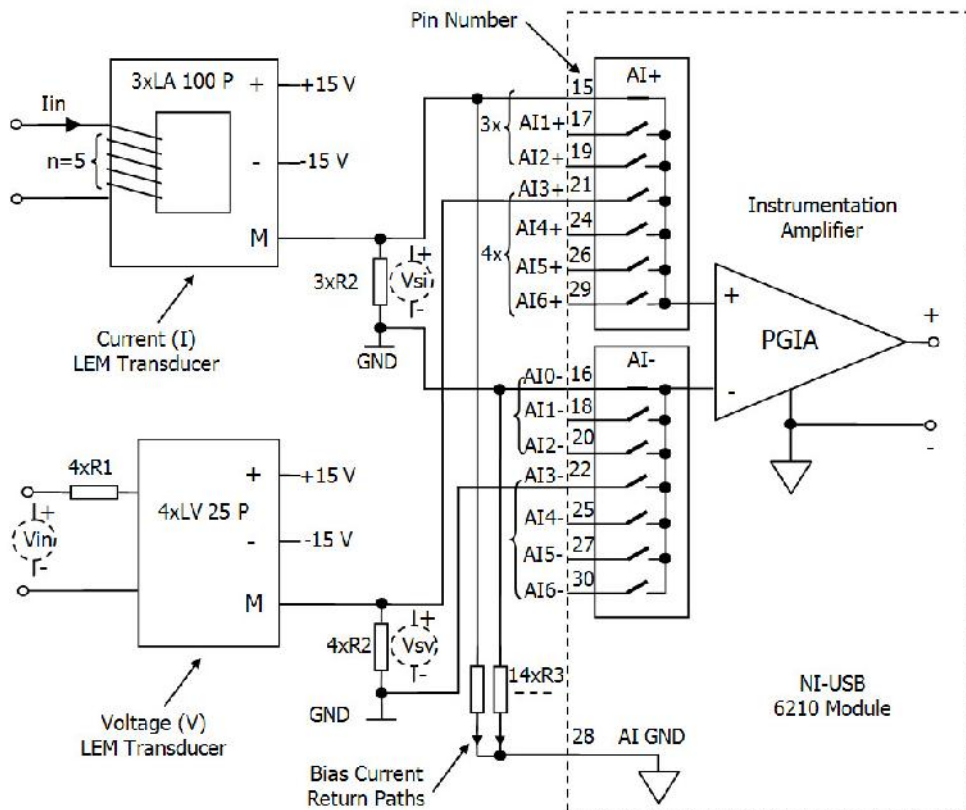

Figure 7. Differential connections for floating signal sources and adapters

In the precedent figure is seen how to connect and power of LEM transducers and their interface with DAQ Module pin out.

Current LEM Transducer dynamic performance is the best with a single bar completely filling the primary hole; for increase the measured current values are given several winding turns (n=5). Primary nominal r.m.s. current is 100 A and secondary nominal r.m.s. current is 50 mA; conversion ratio is 1:2000.

Primary resistor R1 of the voltage LEM Transducer should be calculated so that the nominal voltage had to be measured corresponds to a primary current of

10 mA. Measuring resistances R2 of each transducer are dependent on the values of primary nominal current.

All LEM transducers are powered by a dual source voltage ± 15 V relative to GND; this source is connected to a 220 V by contact of a relay K1. This relay is commanded to power transducers first, before motor start relay K2.

Figure 8 shows the wiring diagram for the power of the two relays K1 and K2; this diagram shows the control system hardware.
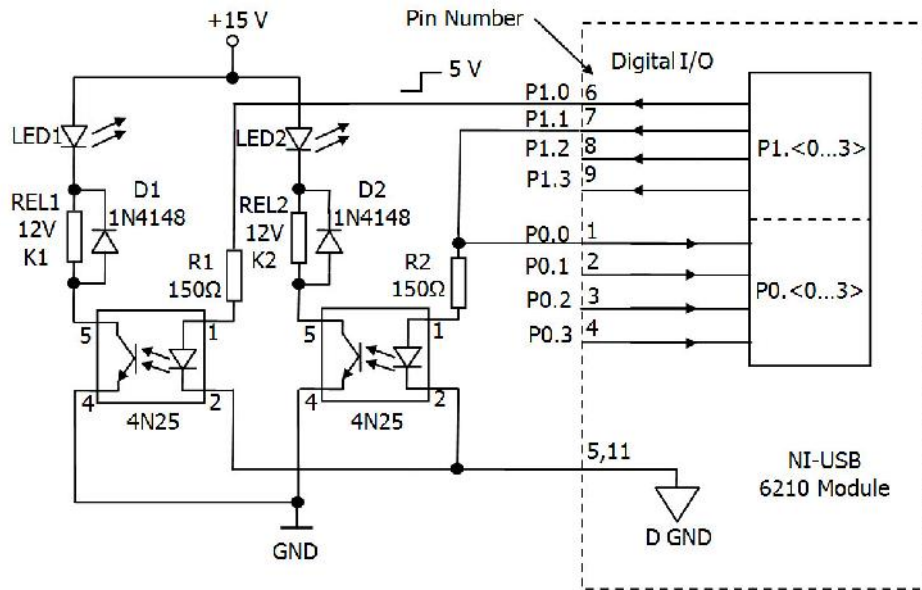

Figure 8. Digital control system

Two relay coils K1 and K2 are supplied with galvanic separation (through optocouplers type 4N25) from digital outputs P1.0 and P1.1 of the 6210 acquisition module.

4. Software component of the system

The software component if our system had Windows XP, LabVIEW version 8.5 and NI-DAQ for Windows 2000/NT/XP installed.

NI-DAQ for communication with 6210 module was used to acquire the data from the system test motor and store it in the memory of PC. LabVIEW takes control and sends the data from memory to the disk. This technique has the advantage of allowing us to have complete control of the data with LabVIEW and the data can be processed as it is being acquired or after acquisition.

In this chapter two types of software component of system are presented.

71

Driver software was used to acquire the data from the system test motor and store it in the memory. NI-DAQmx driver contains an interfaces and functions to easily configure the 6210 acquisition module; they are included in MAX (Measurement & Automation Explorer) with which are selected all configuration parameters of acquisition module.

In the first variant it is used DAQ Assistant to create the virtual instrument of monitoring system. The DAQ Assistant is a graphical interface for configuring tasks. The task is a collection of more channels with: timing settings, triggering settings and other important parameters; in the task we set physical channel associated with the virtual channel. The task will be created with DAQ Assistant from MAX (Measurement & Automation Explorer) or from LabVIEW.

In this case, the Frontal Panel of virtual instrument is presented in figure below.
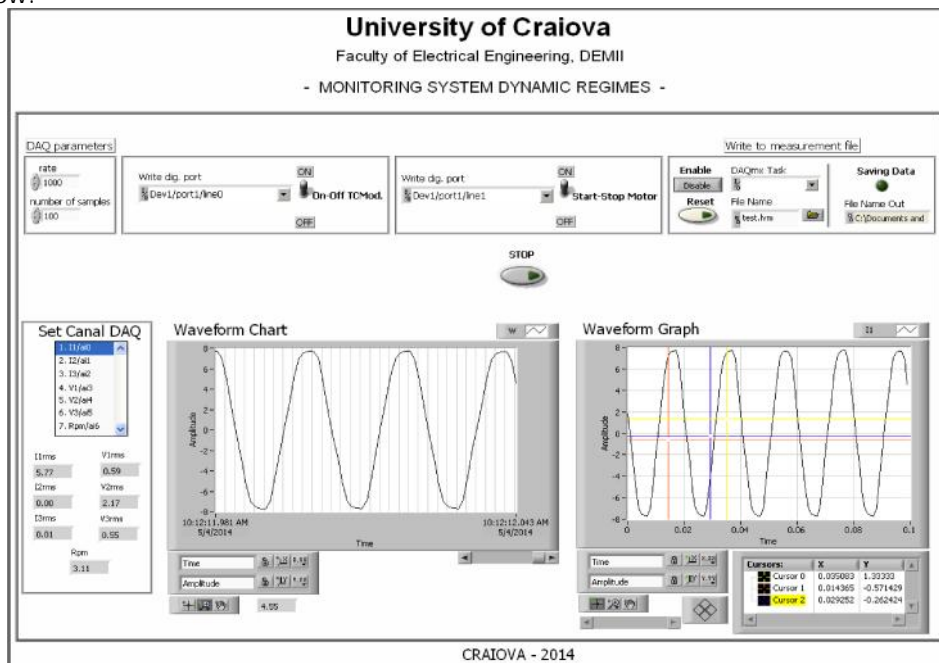

Figure 9. Frontal Panel of system virtual instrument (v1)

Select the Physical Channel to correspond to where the signal is input on the 6210 DAQ device and set DAQ parameters such as number of samples and rate. Power of Transducers Module (TCMod.) and Motor with two switch buttons.

Waveform Graph maps numeric values every time data is sent to it and has no memory of previous data. Waveform Chart keep a history of the data it has been sent; with the scroll bar it is possible to look back through the history.

The Block Diagram of this system is presented in the figure below. We used Express VIs (DAQ Assistant and Write to Measurement File) for decrease develop-

ment time; we must first configure this VIs by double-click on them from the Block Diagram.
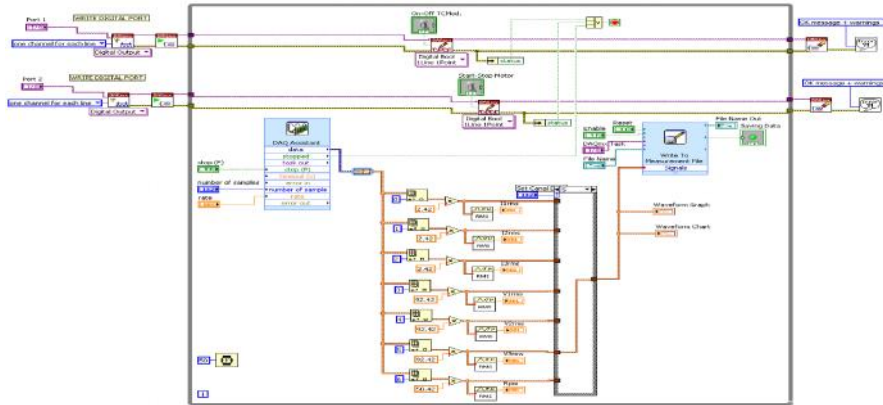

Figure 10. Block Diagram of system virtual instrument

If the acquisition is continuous (Continuous Sample) and Sample Rate is between 10 kS/s and 1 MS/s then NI-DAQmx allocates a 100kS buffer size. Using very large buffers may result in diminished system performance due to excessive reading and writing between memory and the hard disk. If the Sample Mode is set to Finite Samples, NI-DAQmx allocates a buffer equal in size with Samples per Channel.

In the second variant it is used the NI-DAQmx API to do a data acquisition. The timing is set to take a finite number of samples; this number is specified by the Samples per Channel control. The Frontal Panel is presented below.
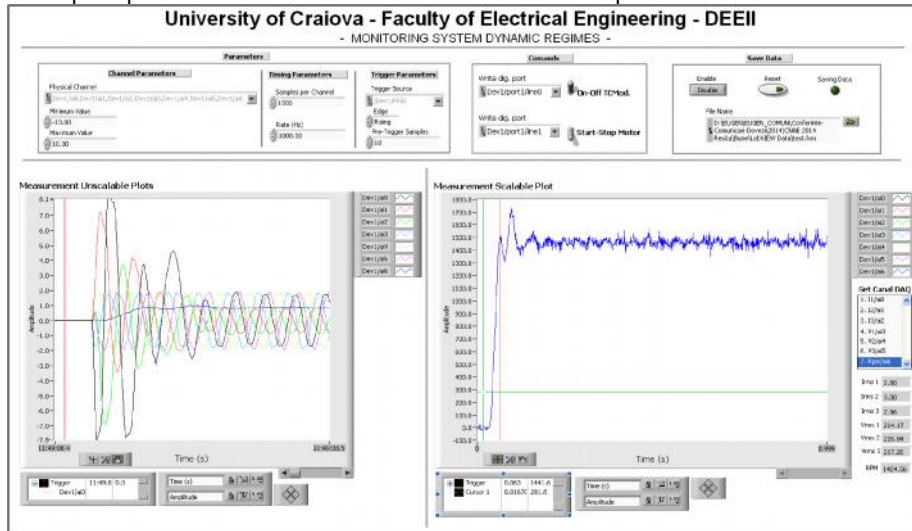

Figure 11. Frontal Panel of system virtual instrument (v2)

73

For better accuracy try to match the Input Ranges to the expected voltage level of the measured signal.

5. Conclusion

This DAQ system demonstrates how to acquire a continues or finite amount of data using an NI-DAQ module and a digital start with reference trigger. The Virtual Instrument displayed the waveform and will be written the data using different options.

References

[1]   Subtirelu E., Dobriceanu M., Virtual Measurement System for study and determination parameters in Asynchronous Motor Test, 19-th International-al Symposium on Power Electronics, Electrical Drives, Automation and Motion – SPEEDAM 2008, June 11-13, 2008, Ischia - ITALY, Proceedings (CD: SEM072), pp.469-474.
[2]   Syed Jaffar Shah, Field Wiring and Noise Consideration for Analog Sig-nals. NI Application Note 025, www.ni.com/white-paper/3344/en/,
      http://www.noise.inf.u-szeged.hu/Online/Sensors/WiringAndNoise.pdf
[3]   Rajesh S. Vaidya, Tips and Techniques in DAQ Triggering. NI Applica-tion Note 129, www.ni.com/white-paper/4329/en/

Addresses:

- S.L. Dr. Eng. Gheorghe-Eugen Subtirelu, University of Craiova, Faculty of Electrical Engineering, Bd. Decebal, nr. 107, 200440, Craiova, esubti-relu@em.ucv.ro; esubtirelu@yahoo.com
- Prof. Dr. Eng. Mircea Dobriceanu, University of Craiova, Faculty of Elec-trical Engineering, Bd. Decebal, nr. 107, 200440, Craiova, mdobricea-nu@em.ucv.ro
- S.L. Dr. Eng. Adela-Monica Enache, University of Craiova, Faculty of Electrical Engineering, Bd. Decebal, nr. 107, 200440, Craiova, me-nache@em.ucv.ro
- Conf. Dr. Eng. Niculae Boteanu, University of Craiova, Faculty of Elec-trical Engineering, Bd. Decebal, nr. 107, Craiova, nboteanu@em.ucv.ro