UNIVERSITY OF CRAIOVA

FACULTY OF ELECTROMECHANICAL ENGINEERING, ENVIRONMENT AND INDUSTRIAL INFORMATICS

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VIRTUAL MEASUREMENT SYSTEMS USING AT THE TESTING OF ASYNCHRONOUS MOTORS

SUMMARY

SCIENTIFIC REFERENT

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CRAIOVA
2008

CONTENT

KEYWORDS

Asynchronous motor testing, LabVIEW, Virtual Instrument, Virtual Measurement System

SUMMARY

The main objective of this thesis is to solve a practical and current problem, by taking advantage of the new technology. This new trend in testing electrical machines can deliver the technical reports automatically, saving resources and costs.

The new technology has the foundation on graphical software LabVIEW and it is used for interpreting digital measurements and the automation of the technical data by creating technical reports. This permits the replacement of the old analog measurement techniques – which is still in use at some electrical motor testing benches, with the new Virtual Measurement System Bench. This Virtual Measurement System Bench is capable of data acquisition, storage or memorization on different media, visualization of different graphs, printing or distribution of technical reports or analysis on-line or off-line in an automated manner.

This Virtual Measurement System, which is not too complicated but very powerful, would be a very big help for the next domains:

- Electrical machines testing workbenches;
- Electrical machines design laboratories;
- University and colleges' Electrical machines laboratories by its interactive simulations.

The content of the thesis is divided in three parts:

Part 1 (chapter 1, 2, 3) covers general aspects and theory concepts for electrical machines testing and it is an introduction to the Virtual Measurement System.

Part 2 (chapters 4, 5, 6, 7) builds the partial components of the Virtual Measurement System, respectively the virtual measurement instruments.

Part 3 (chapters 8, 9, 10) presents the Virtual Measurement System at work as a hole, exactly as the "resultant' of all the vectors of previous chapters.

The details:

Chapter 1 – covers general aspects related to testing electrical machines. It focuses on types of tests, tests common to all electrical machines, tests dedicated to certain electrical machines; general technical conditions and requirements; contents of a technical test report; new directions in testing electrical machines: open-loop and feed-back control in testing, analysis of motor's circuits, current/frequency response, vibrations, infrared views and ultrasound testing.

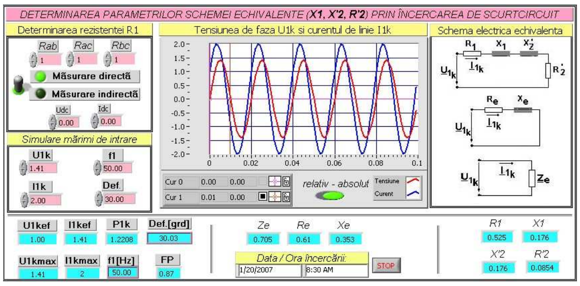
Chapter 2 – presents classical methods of testing electrical machines and introduces the Virtual System methodology with the general architectural schematics. It is focused on the HARDWARE components (for transducers, conditioning, data acquisition, PC calculator) and SOFTWARE components (operating system for the computer, driver for the acquisition and manipulation-calculation of data, graphical presentation, other auxiliary programs and the ones to bring all the components together, virtual instruments with their flexibility and a high degree of integration).

Chapter 3 – is dedicated to the general concepts of electrical machines theory, focusing on the asynchrony motor in steady-state function: functioning equations, electrical schematics for the equivalent circuit, technical parameters. Here the windings motors' parameters are defined : stator resistance R_1, stator leakage reactance X_1, rotor resistance R_2, rational rotor resistance related to stator R_2', rational rotor reactance related to stator X_2', resistance due to ferromagnetic loss stator R_{Fe} or magnetization reactance X_m.

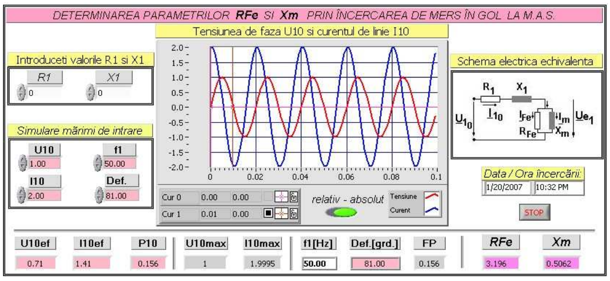
The essential characteristics for the functioning of asynchronous motor are defined as the mechanical, artificial, etc. Also, the characteristics of asynchronous motor are defined as a function of output power P_2. The most important requirements of the SR7246 standard for testing three-phase asynchronous motors are presented here: general technical verification, determination of the windings resistance in DC, no-load testing, short-circuit testing, load testing characteristics, etc. All these will constitute the theoretical foundation for the construction of virtual instruments. These instruments will be built in the next chapters.

Chapter 4 – presents subVI for the determination of the phase shift between two sine waves Voltage and Current, necessary in the calculation of Active Power absorbed by the motor.

Here I will build the virtual instruments used for the measurement of the electrical parameters of the equivalent per-phase schematic: short-circuit and no-load parameters (fig. 1).



a)



b)

Fig. 1 - Frontal panel of the virtual instrument for the determination of equivalent schematic parameters for short-circuit (a) and no-load (b)

The Virtual Measurement System is built using NI-USB-6008 for data acquisition and two LEM transducers, one for voltage and one for current. This system determines the electrical parameters of the per-phase equivalent circuit. Fig. 2 presents the front panel of VI.

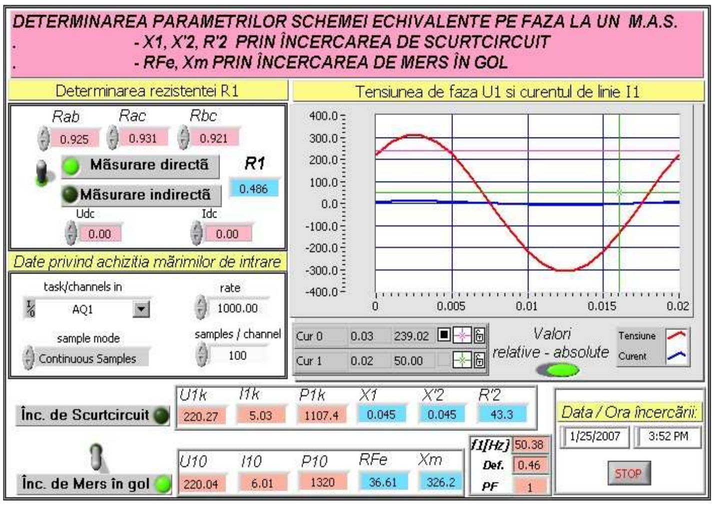


Fig. 2 – VI's Front Panel for parameters determination through real acquisition

Chapter 5 – presents the virtual instruments for creating the functioning characteristics of the asynchronous motor (fig. 3).

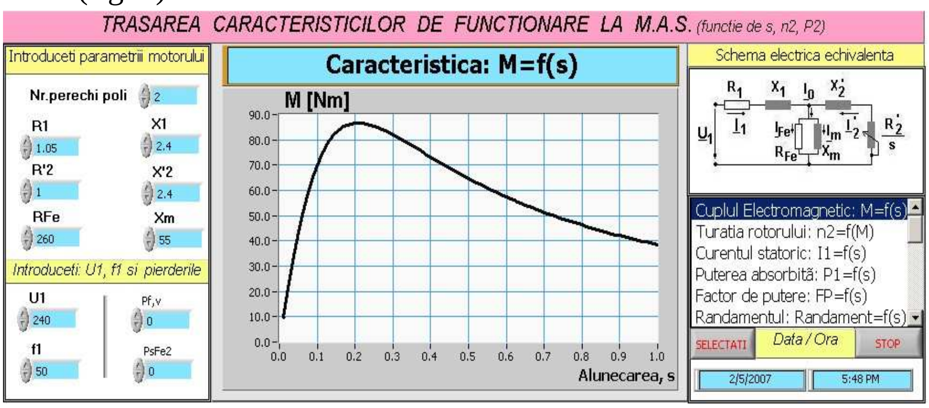


Fig. 3 - VI's Front Panel for Running Characteristics

Some of the virtual instruments are used to compare multi-characteristics graphs. We are able to illustrate how the graph is modified when one or more parameters are changing, such as: changing voltage U_1 (fig. 4a), changing frequency f_1 (fig. 4b), changing rotor resistance R_2 (fig. 4c), changing voltage U_1 or f_1 by keeping the ratio U/f constant (fig. 4d).

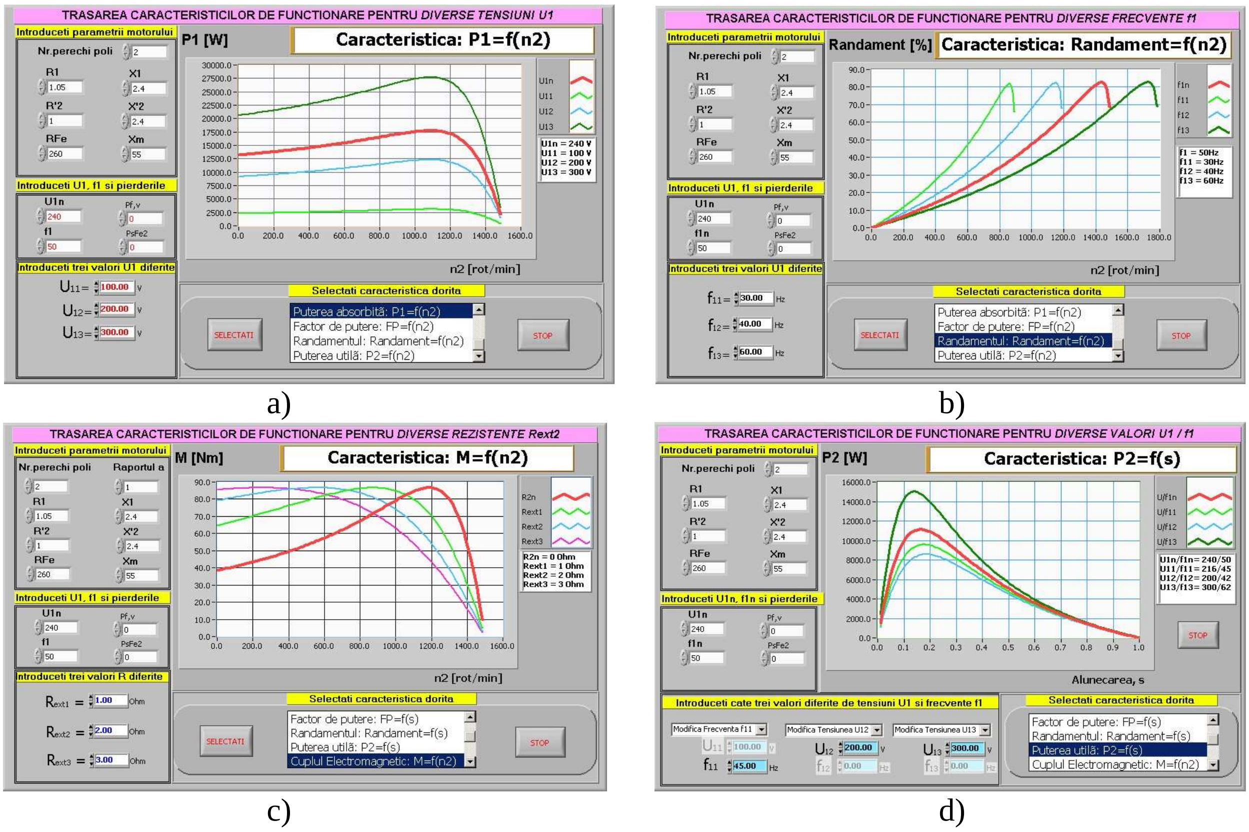


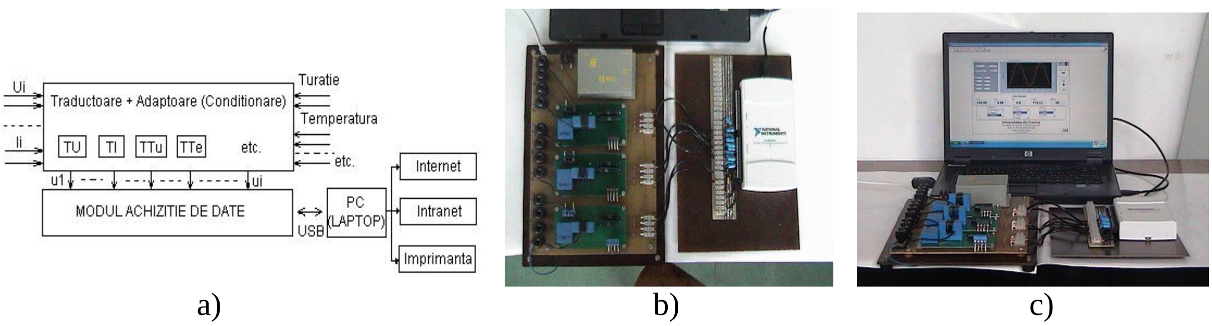
Fig. 4 – Panoul frontal al VI-urilor pentru trasarea prin comparație a caracteristicilor de funcționare

The purpose of building these virtual instruments is double: to familiarize with the design and function of the virtual instruments and to test that the subVI-s built are working properly and without errors so that they could be integrated later in the Virtual Measurement System.

Chapter 6 – is a description of the virtual instruments, which have special functions or for the acquisition of data. You can find the different type of files used to memorize or calculate data (spreadsheet-text, byte stream-binary, datalog) for writing and reading, with their advantages or disadvantages.

Chapter 7 – presents the two versions of the technical report: HTML format – which is seen in a browser, and STANDARD format – which can be sent to a printer. The technical report will be issued with each testing of the electrical machines.

Chapter 8 – covers all necessary details of the Virtual Measurement System created for testing an asynchronous motor with this Hardware: TRANSDUCERS - LEM, conditioning module, acquisition module - NI-USB-6210 and a Laptop (fig. 5).



a) b) c)

Fig. 5 – Hardware components of Virtual Measurement System: a) block schematics, b), c) photo images

The chapter presents also the general structure of the Virtual Measurement System focusing on the Software components, the VI-s introduced in a hierarchical way to be easier to follow the interdependence between them (fig.6).

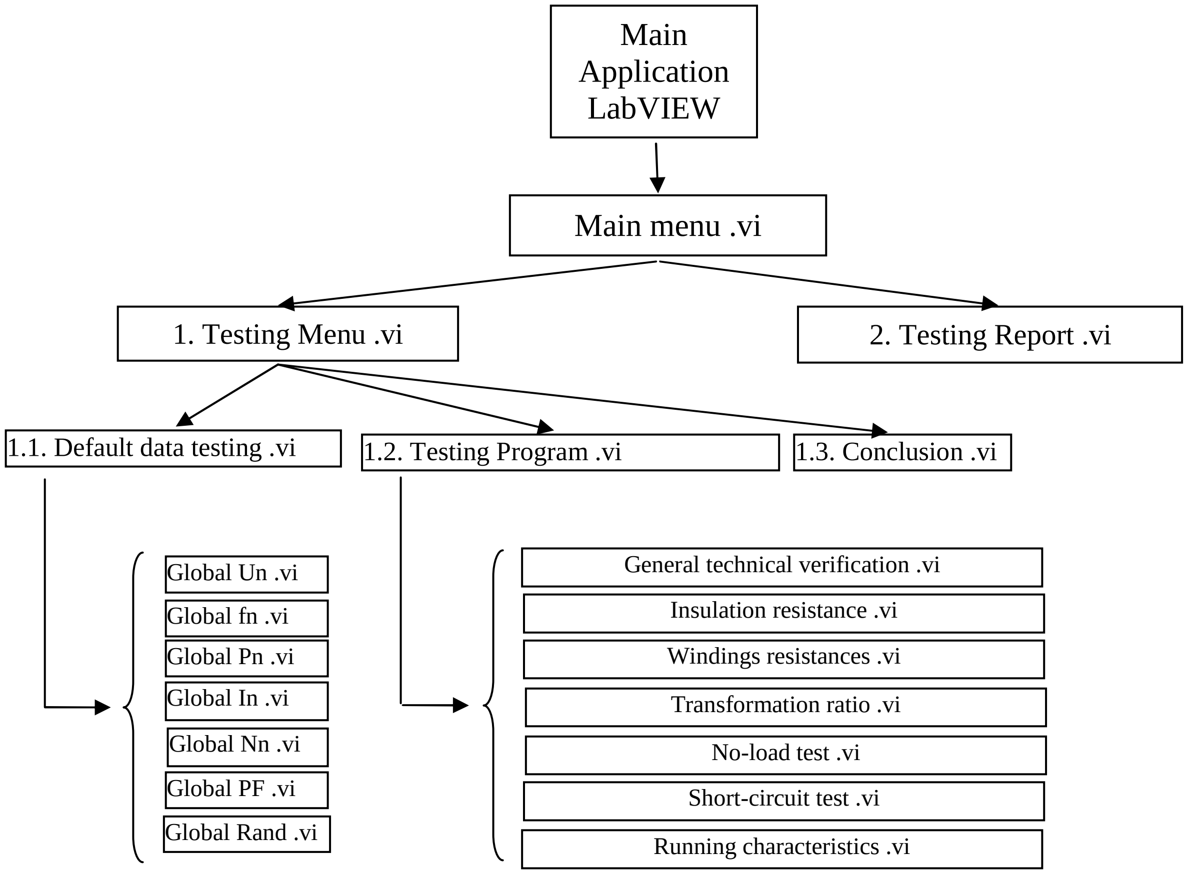


Fig. 6 - General structure of Virtual Measurement used for testing of asynchronous electrical motors

This part covers the front panels, block diagrams and the source code for every VI. Each virtual instrument can work independently (Simulation mode or Real time Acquisition mode) or integrated as part of Virtual Measurement System.

Figure 7 presents the most important VI-s which are part of the Virtual Measurement System:

a) Main menu;
b) Default data for testing;
c) General technical verification;
d)-e) Windings resistance;
f) Test Report;
g) No-load testing;
h) Short-circuit testing;
i) Running characteristics testing.

For comparison, the results of testing the same motor with calibrated instrumentation, carried out by a certified Metrology Laboratory is presented here.

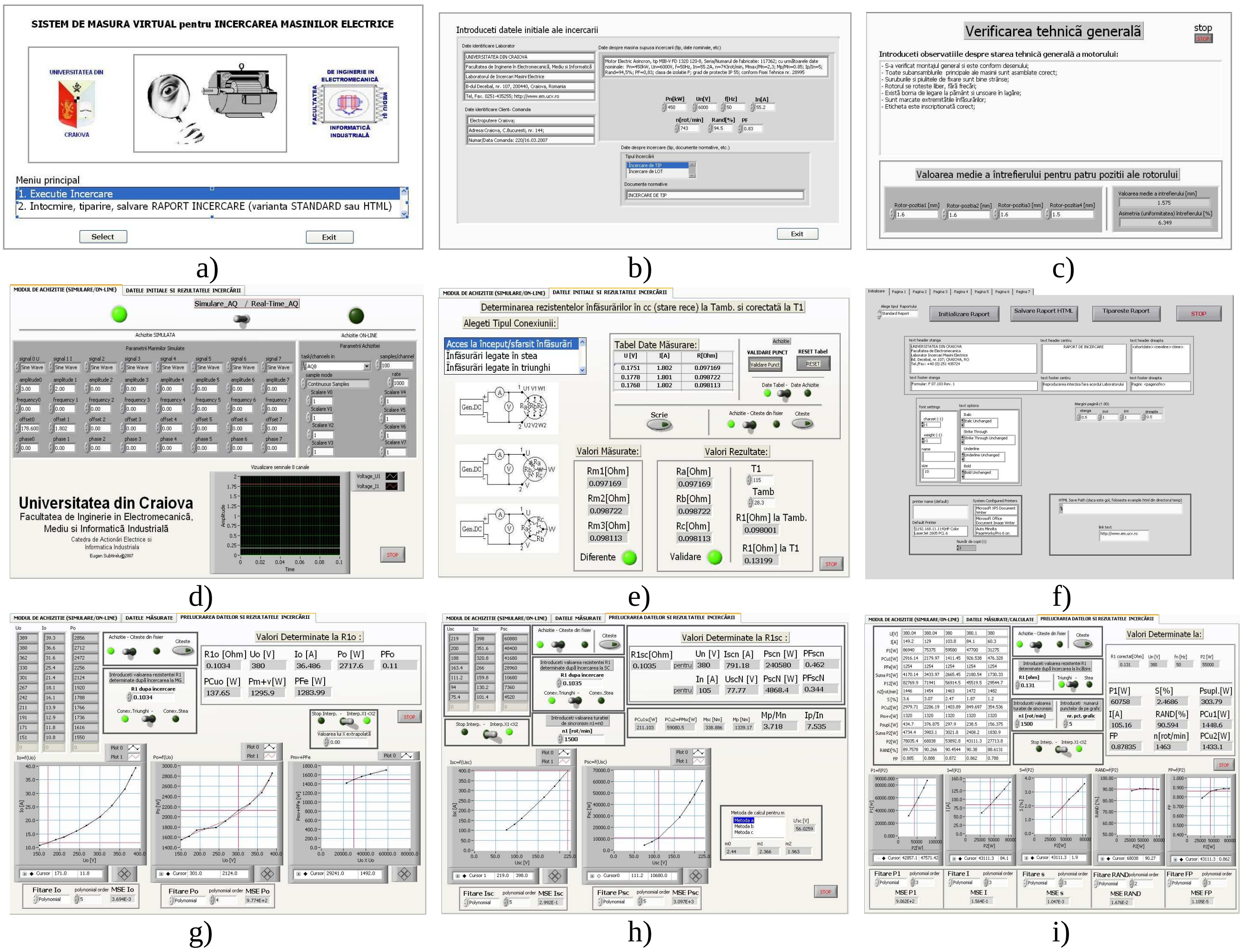


Fig. 7 – Front panel of main VI-s of Virtual Measurement System

Chapter 9 – is at the border of Real-Virtual worlds, by presenting the results of the experiments done through Virtual Measurement System in a real certified testing bench. The six tests were done for a *MIB3 250M 65-4 ; Δ connection; P=55 kW; U=380 V* which is an Asynchronous Motor with short-circuit rotor.

The Simulation function, based on the data supplied from the certification of this motor type, was used to check that the Virtual Measurement System is working properly without errors. The data was presented in a table – spreadsheet format. Every virtual instrument had been used and tested individually and integrated in the Virtual Measurement System. The comparison of the graph and numeric results show that the Virtual Measurement System report and motor certification report are similar.

After verification that data acquisition of Virtual Measurement System is working properly (through Metrological Calibrating) and after the Simulation function verification of Virtual Measurement System, a Real Case was presented by comparing the results delivered by the Virtual Measurement System with the ones supplied by a certified testing bench. In the end, the Virtual Measurement System generated automatically the testing report, which was printed to a printer attached to the system computer.

A comparison between the Virtual Measurements System and Classical results shows that the solution is correct, reliable and compatible.

Chapter 10 – present the personal contributions of author and draws the conclusions of using the Virtual Measurement System in industry and more than that. It is a very competitive, complete, complex and flexible system, ready to move the testing bench in industry to the next generation of equipment, technology and methodology. The future is here!!