Program for Monitoring Operation Regimes of Low-Power Electrical Machines

Sorin Enache*, Ion Vlad* , Monica-Adela Enache*

* University of Craiova/Faculty of Electrical Engineering, Craiova, Romania, senache@em.ucv.ro

***Abstract* – In this paper there are presented details about a program for monitoring steady states and dynamic regimes of low-power electrical machines. The program allows viewing the variation waves of the main electrical quantities, their harmonic content and the relative position of the characteristic phasors. The program advantages are mentioned and there have exemplified some data acquisitions, carried out for a few concrete situations. The main work windows from the Instrument menu are detailed. There have also been presented the results obtained by monitoring the operation of two motors, a three-phase asynchronous motor with single-phase supply and a single-phase asynchronous motor. A part of the conclusions obtained could be mentioned as follows: a) for the case of three-phase asynchronous motor with single-phase supply, we noticed that a voltage increase leads to an increase of the inductive phase shift of the current I_1, the phase shift of the current I_2 (measured on the phase in series with the capacitor) remains practically unchanged, the capacitive phase shift of the current I_3 increases and the distortion degree of the current I_1 decreases; b) for the case of the single-phase asynchronous motor we noticed that in load operation (at rated voltage) a decrease of the phase shift between the current and voltage corresponding to the main winding occurs and the current distortion degree increases when the load increases. The paper ends with conclusions and references.**

Cuvinte cheie: *masini electrice de mica putere, regimuri dinamice, program de monitorizare, analiza armonica, fazori .*

Keywords: *low-power electrical machines, dynamic regimes, monitoring program, harmonic analysis, phasors.*

I. INTRODUCTION

For monitoring operation regimes of electrical machines, especially when it comes to distorting dynamic or steady states, it is necessary to use high sampling frequency data acquisition systems [1], [2], [3].

Their interface, having a facile use, is ensured by monitoring programs.

These programs ensure both data acquisition, their processing and results displaying [4], [5], [6].

The program presented below belongs to this category.

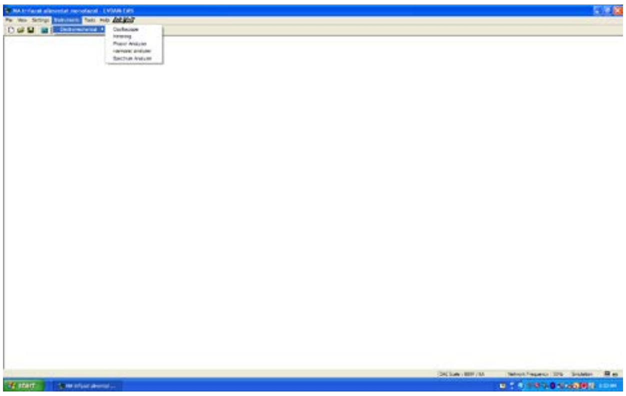
It ensures an adequate use of the test stand detailed in [7], stand used for monitoring the operation of electrical machines rated under 1kW.

II. PROGRAM DESCRIPTION

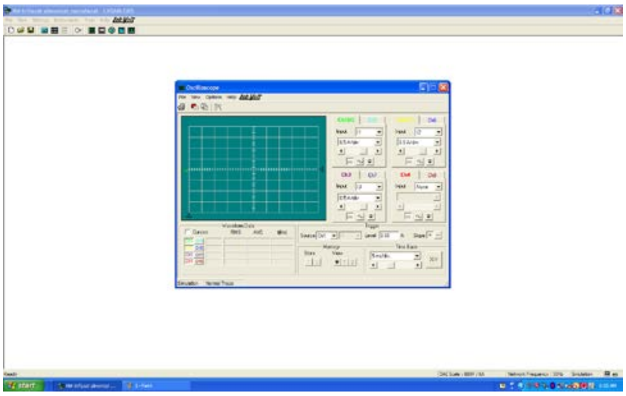
The program is built around a menu displayed in the upper part of the screen.

The main sub-menu of it is "Instruments" (Fig. 1.a).

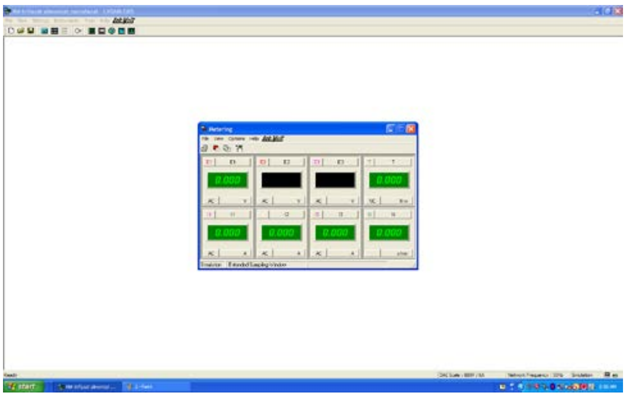
This sub-menu contains five working tools, materialized in five windows: Oscilloscope (Fig. 1.b), Metering (Fig. 1.c), Phasor Analyser (Fig.1.d), Harmonic Analyser (Fig. 1.e) and Spectrum Analyser (Fig. 1.f).



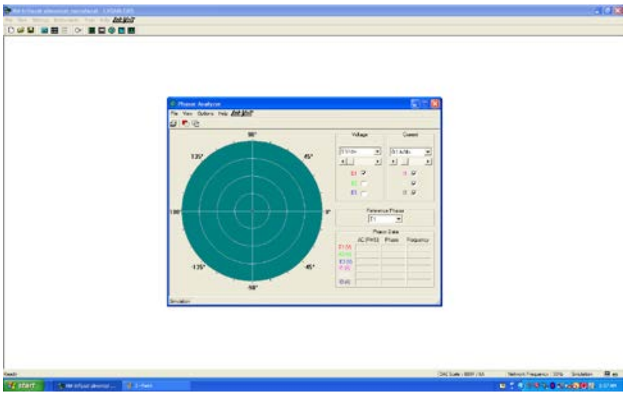
a)



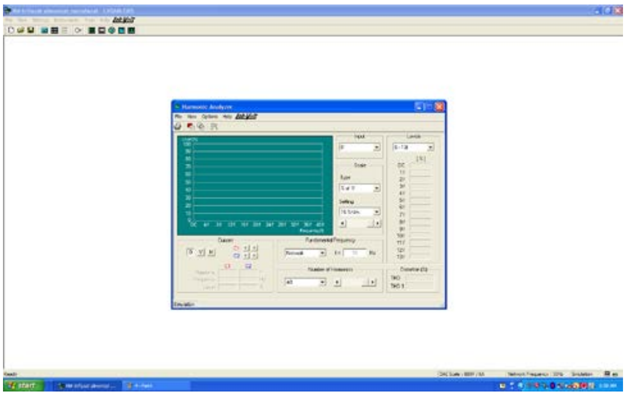
b)



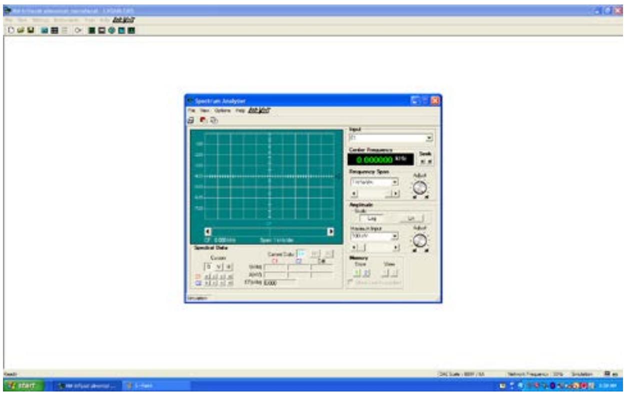
c)



d)



e)



f)

Fig. 1. Windows from the menu "Instruments".

Some examples of using these tools will be presented below.

III. MONITORING EXAMPLES

Two monitoring cases are presented in the following:

A. case of a three-phase asynchronous motor with single-phase supply;

B. case of a single-phase asynchronous motor.

A. For the case of a three-phase asynchronous motor with single-phase supply, from the multitude of tests carried out, there are presented a few of them:

-test at E_1=150 V, C_1=5 μF, M_r=0 Nm;

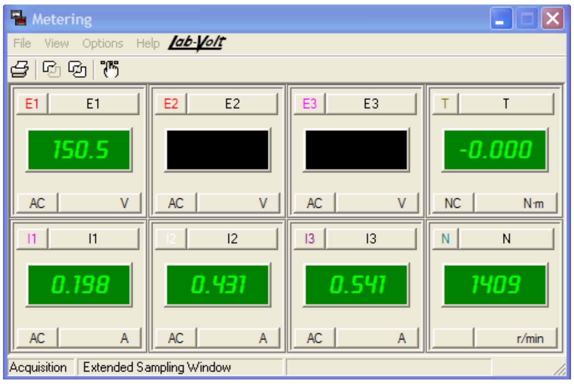
-test at E_1=20 V, C_1=5 μF, M_r=0 Nm.

The notations meaning are presented in [8].

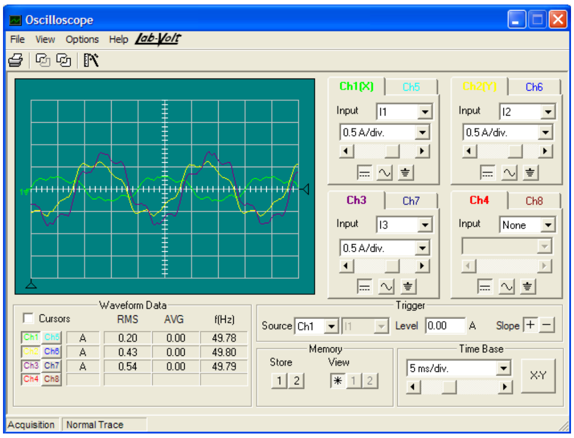
The root-mean-square value of the voltage, E_1, and the resistant torque value can be modified with the test stand [9], [10].

The test from Fig. 2 has been carried out for E_1=150 V, the smallest voltage for which the motor enters the speed (its speed is close to the rated one - 1409 r.p.m). From Fig. 2.a it results that the root-mean-square values of the phase currents are different (I_1=0,198 A, I_2=0,431 A, I_3=0,541 A). Moreover, according to Fig. 2.c, where the voltage E_1 has been chosen as a phase origin, the current I_1 is inductive (φ=-50,7^o) and I_2 (φ=175,5^o) and I_3 (φ=148,3^o) are capacitive.

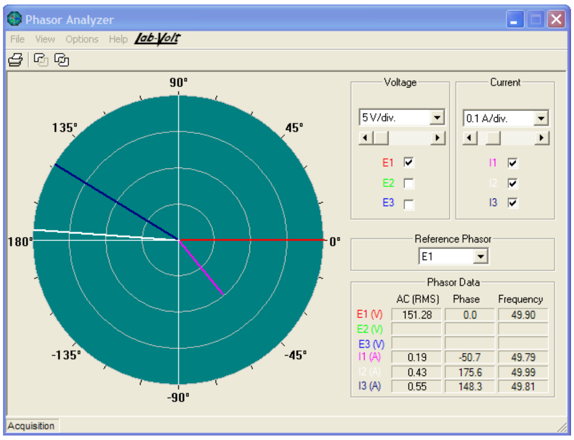
According to Fig. 2. b, d, e and f, the phase currents are deeply distorted (mainly because of the supply source). The current having the highest content of harmonics is I_1 which has THD=24,5.



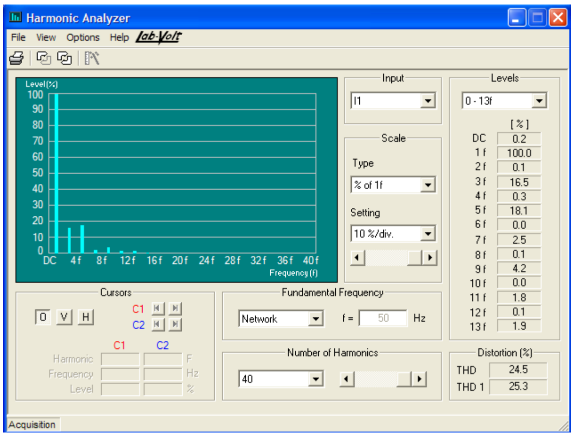
a)



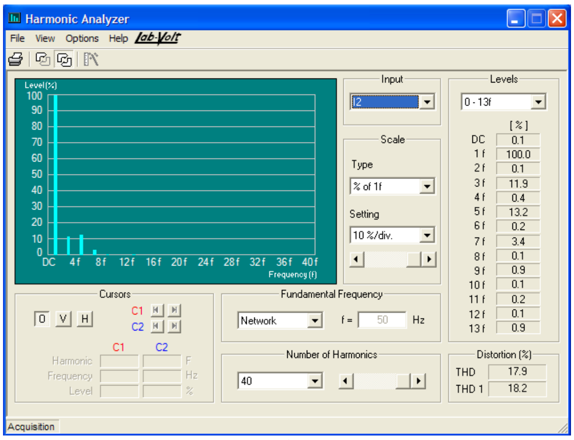
b)



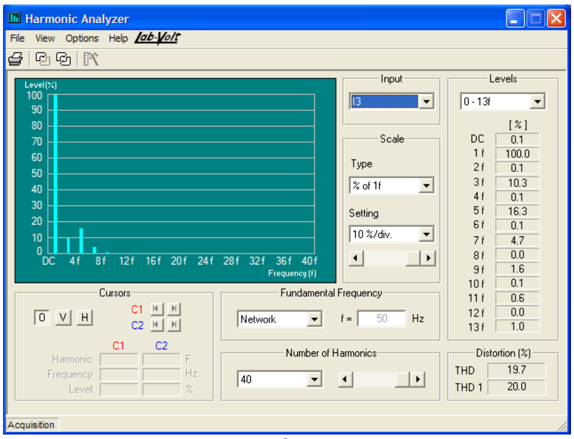
c)



d)



e)



f)

Fig. 2. E_1=150 V, no-load operation, C_1=5 μF.

The case when the supply voltage is the rated one, E_1=220 V, is depicted in Fig.3.

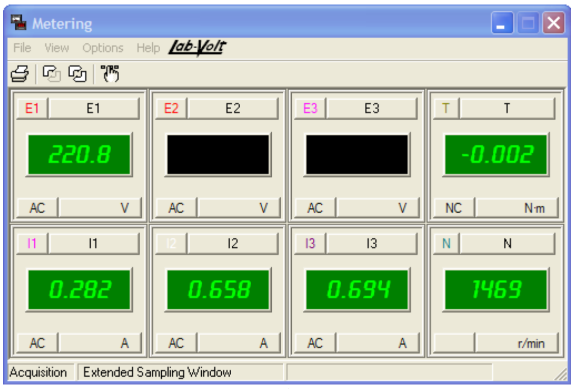
The following modifications can be observed in comparison with the previous situation:

-the inductive phase shift of the current I_1 increases to the value φ=-93,9°;

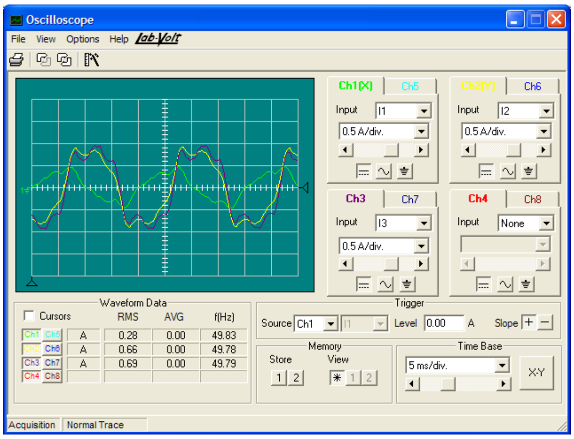
-the phase shift of the current I_2 (measured on the phase in series with the capacitor) remains practically unchanged (φ=175,1°);

-the capacitive phase shift of the current I_3 increases to the value φ=162,3°.

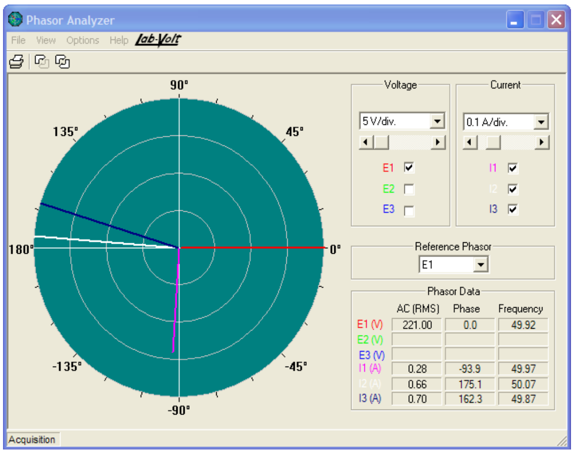
-the distortion degree of the current I_1 decreases to THD=21,7.



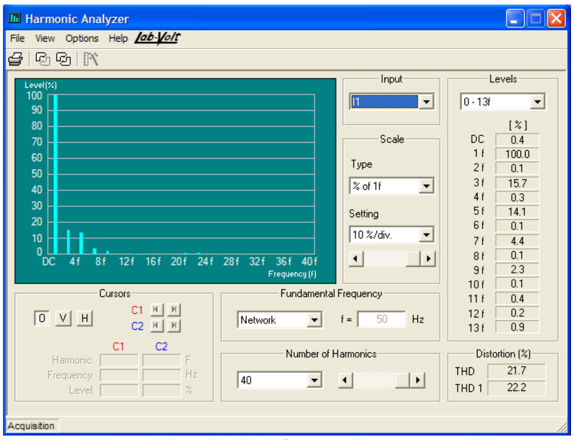
a)



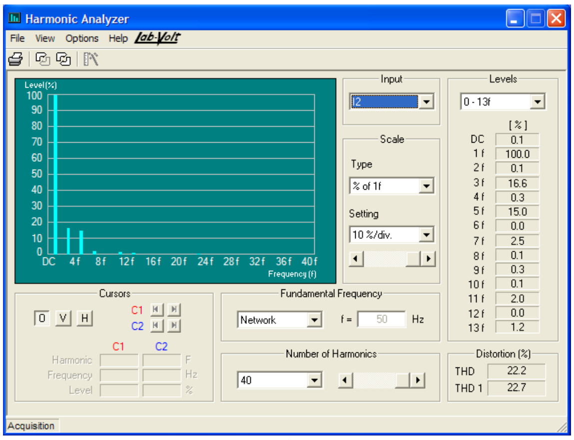
b)



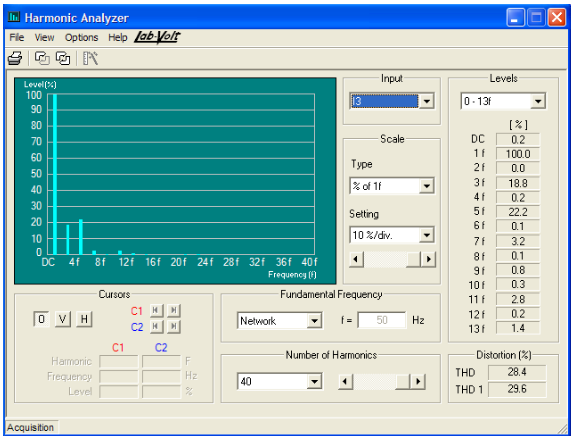
c)



d)



e)



f)

Fig. 3. E_1=220 V, no-load operation, C_1=5μF.

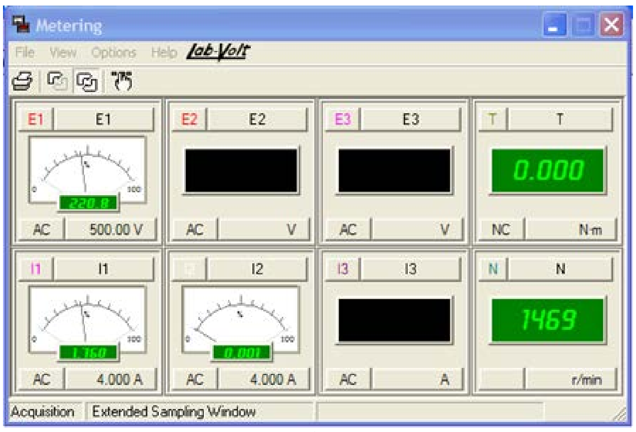
B. For the case of a single-phase asynchronous motor there have been obtained the graphics depicted in Figures 4 and 5.

B1) Operation at the rated voltage (220 V), no-load

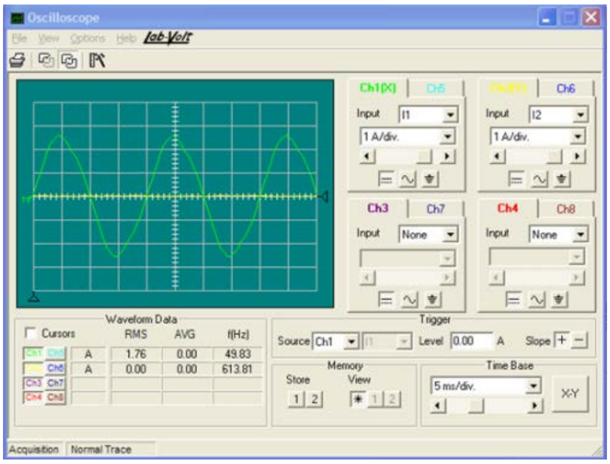
For this case there have been obtained the results presented in Figure 4.

In case of no-load operation at the rated voltage (Fig. 4) it is noticed that the main winding is the only one supplied (Fig. 4 a, b and c).

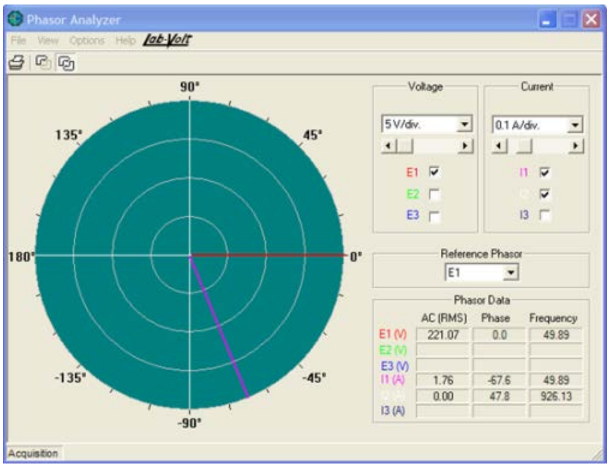
That circuit is mostly inductive, fact confirmed by the phase shift presented in Figure 4.c (67,6 electrical degree).



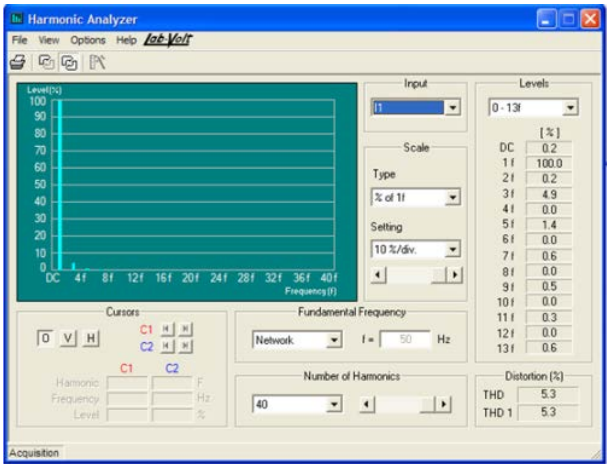
a)



b)



c)



d)

Fig. 4. Characteristics obtained at 220V, no-load.

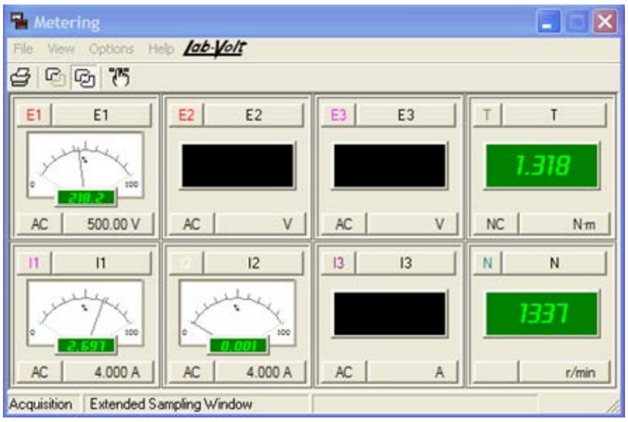
B2) Operation at the voltage supply 220 V and load of 1,3 Nm

The same testing method as in the previous situations has also been used in this case.

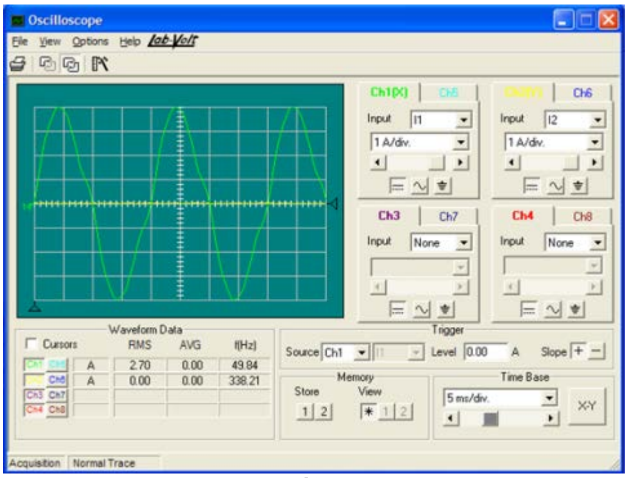
There have been obtained the results detailed in Fig. 5.

As expected, the speed has a slight decrease in case of load operation, because of the „rigid" feature of the motor mechanical characteristic (the speed decreases from 1469 r.p.m, at null resistant torque, down to 1337 r.p.m, at a resistant torque of 1,3 Nm).

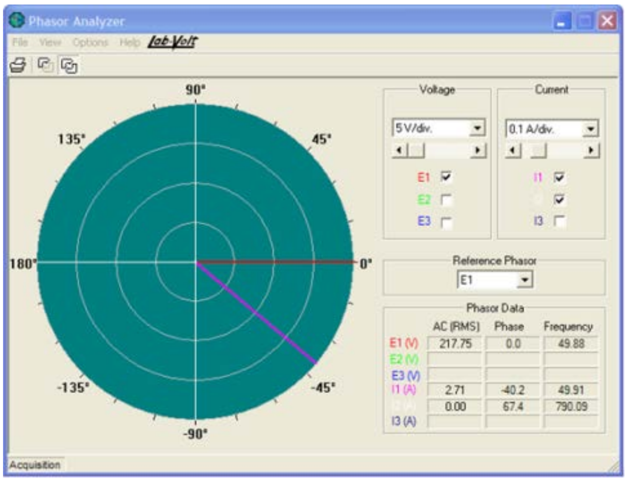
In case of load operation (rated voltage) a decrease of the phase shift between the current and the voltage corresponding to the main winding is observed (the phase shift decreases down to 40,2 electrical degrees as against the value of 67,6 electrical degrees, in case of no-load operation). The distortion degree of the current also increases with the load increase (for the example from the previous figures, the third order harmonic represents 8,5 % as against the value of 4,9 % in case of no-load operation).



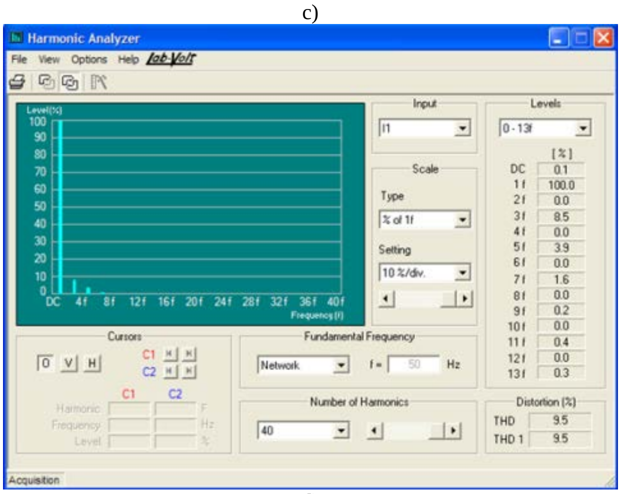
a)



b)



c)



d)

Fig. 5. Characteristics obtained at 220 V, load operation.

IV. Conclusions

The research carried out has revealed the following conclusions:

-the program presented in the paper enable viewing some electrical signals in dynamic regime, their harmonic analysis and the relative position of the characteristic phasors;

-for the case of the three-phase asynchronous motor with single-phase supply, it is noticed that at the voltage increase, the inductive phase shift of the current I_1 increases, the phase shift of the current I_2 (measured on the phase in series with the capacitor) remains practically unchanged, the capacitive phase shift of the current I_3 increases and the distortion degree of the current I_1 decreases;

-for the case of the single-phase asynchronous motor it is noticed that in case of load operation (rated voltage) a decrease of the phase shift between the current and the voltage corresponding to the main winding occurs and the distortion degree of the current increases with the load increase.

A few contributions of the authors could be mentioned:

-the program, the basic structure of which exists, has been improved by the authors of this paper, by adding a module of harmonic analysis of the acquired signals;

-the initial version, functional in an older version of Windows, has been adapted for working in Windows 10.

Source of research funding in this article: Research program of the Electrical Engineering Department financed by the University of Craiova.

Contribution of authors:
First author – 50%
First coauthor – 25%
Second coauthor – 25%

Received on June 08, 2020
Editorial Approval on November 16, 2020

REFERENCES

[1] J. Svarny, L. Pusman, P. Turjanica, M. Sykora, "Data Acquisition Unit for On-Site Diagnostics of Air Compressors", *2020 International Conference on Diagnostics in Electrical Engineering (Diagnostika)*, Pilsen, Czech Republic, 2020.

[2] X. Li, W. An, H. Hu, P. Li, X. Jiang, "Development of data acquisition system for CNC machine tools", *2020 IEEE International Conference on Advances in Electrical Engineering and Computer Applications (AEECA)*, 25-27 Aug. 2020, Dalian, China, 2020.

[3] F. Hamann, G. Mesones, "Development of a hybrid system for automatic identification of brushed direct current motors", *2020 IEEE XXVII International Conference on Electronics, Electrical Engineering and Computing (INTERCON)*, 3-5 Sept. 2020, Lima, Peru, 2020.

[4] D. K. Chaturvedi, S. Iqbal, M. P. Singh, "Condition monitoring of induction motor", *2015 International Conference on Recent Developments in Control, Automation and Power Engineering (RDCAPE)*, 12-13 March 2015, Noida, India, 2015.

[5] B. Adli, P. H. Rusmin, „Vibration Measuring Tools For Rotary Pumping Machine With Accelerometer MEMS Sensor", *2020 FORTEI-International Conference on Electrical Engineering (FORTEI-ICEE)*, 23-24 Sept. 2020, Bandung, Indonesia, 2020.

[6] P. Modesto,T. Estrabis, R. Cordero, "Analysis about the Application of Frequency-Domain Multiplexing in Data Acquisition for Vector Control", *2020 IEEE XXVII International Conference on Electronics, Electrical Engineering and Computing (INTERCON)*, 3-5 Sept. 2020, Lima, Peru, 2020.

[7] M. A. Enache, A. Campeanu, S. Enache, I. Vlad, "Testing Stand for Low-Power Electrical Machines", *International Conference on Applied and Theoretical Electricity ICATE 2018*, Craiova, Romania, 2018.

[8] S. Enache, A, Campeanu, I. Vlad, M,A. Enache, "Aspects Regarding Tests of Three-Phase Asynchronous Motors with Single-Phase Supply", *2019 16th Conference on Electrical Machines, Drives and Power Systems (ELMA)*, Varna, Bulgary, 2019.

[9] ***, Virtual Laboratory and Equipments, User Guide, *Lab-Volt*, 32359-E0, 2017.

[10] ***, Data Acquisition and Management System, User Guide, *Lab-Volt*, 30328-E0, 2017.