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System for Monitoring Asynchronous Motors Powered at Variable Voltage

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Abstract – **This paper presents some experimental aspects related to the operation of asynchronous motors powered at variable voltage. A modern system for actuation of low-power asynchronous motors is presented, equipped with a voltage and frequency converter. Also, a data acquisition system is presented, with a sampling frequency of up to 100 kHz, supervised by an acquisition program that allows the visualization of the variations of the main characteristic sizes of the motor. The program contains both graphic interfaces developed by the manufacturer and by the authors of the paper. This program solves, among other things, an electromagnetic compatibility problem. The experimental tests carried out with the help of this system (in permanent non-sinusoidal regime at various power supply frequencies) are detailed. Technical details of the main system components are provided. The tests are accompanied by photos taken during the experiments and many original explanatory graphics. The authors' contributions are mainly in the software area. Thus, in the original program, a series of windows for harmonic analysis and visualization of the characteristic phasors of the analyzed electrical quantities were implemented. The paper ends with the main conclusions resulting from the completion of the study and with a representative bibliography.**

Cuvinte cheie: *motor asincron, convertor de tensiune, sistem de achizitii de date, program de monitorizare, analiza armonica.*

Keywords: *asynchronous motor, voltage converter, data acquisition system, monitoring program, harmonic analysis.*

I. INTRODUCTION

In practice, there are many situations that require adjusting the speed of asynchronous motors.

Among these, the most used are those that use voltage and frequency converters, or only voltage converters, which are the subject of an impressive number of papers published at prestigious conferences [1], [2], [3].

Dedicated data acquisition systems [4], [5], [6], with high sampling frequencies, can be used to monitor them.

The present paper belongs to this field.

A modern monitoring system for low-power electric machines is presented, with an application for an asynchronous motor with short-circuited rotor fed from a variable voltage source [7], [8].

A graphic interface that solves, among other things, an electromagnetic compatibility problem is detailed.

II. TEST STAND

The test stand used (sampling rates 100 kHz) was presented in detail in the paper [9].

From the multitude of blocks available, to complete the detailed research in this paper, the blocks from figures 1-5 were used.

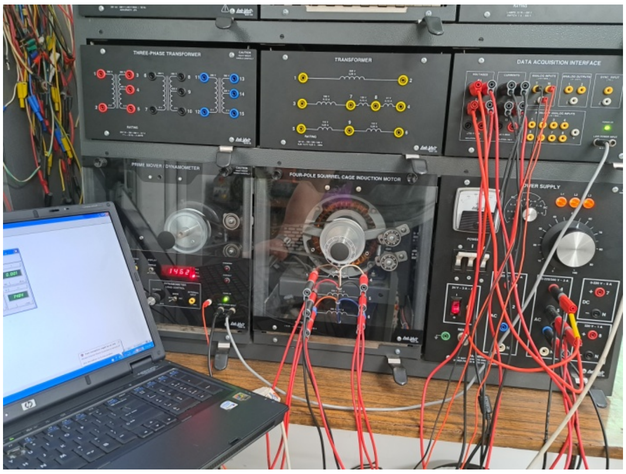


Fig. 1. Overview.

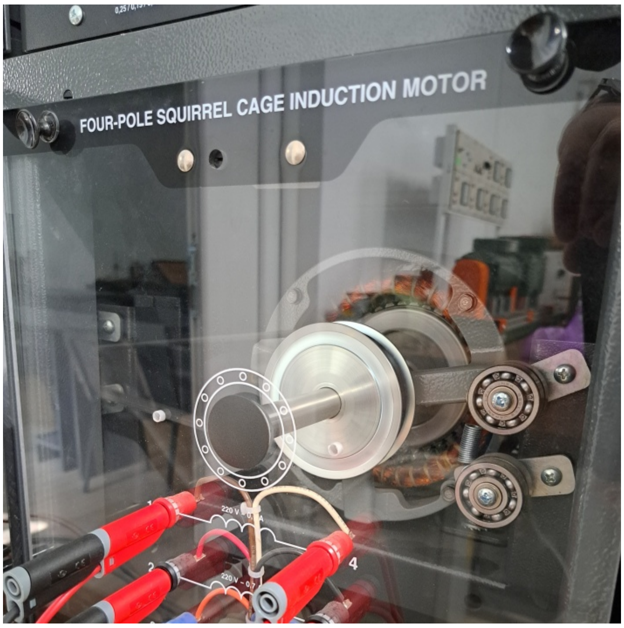


Fig. 2. Asynchronous Motor block.

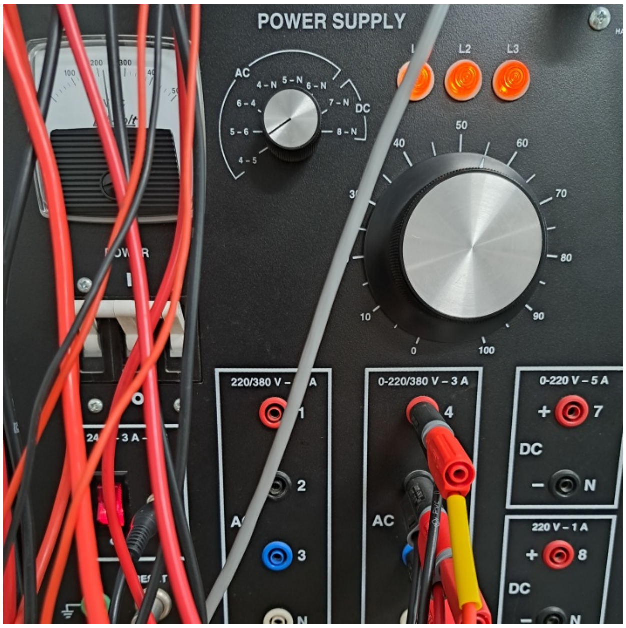


Fig. 3. Power Supply block.

Fig. 4. Dynamometer block.

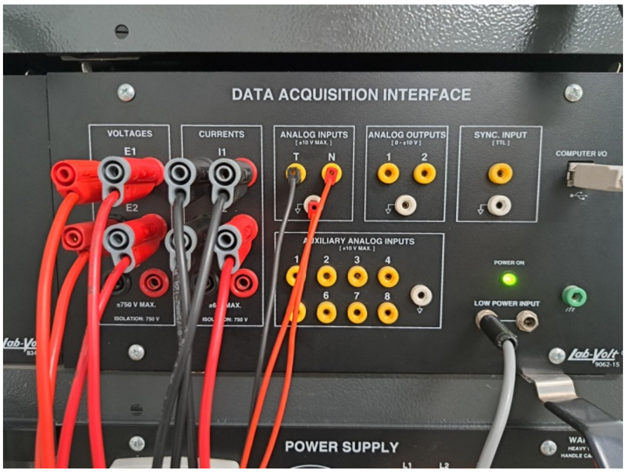


Fig. 5. The Data Acquisition Interface block.

III. Assembly Diagram and Monitoring Windows

To carry out the experiments, the mounting scheme from figure 6 was used.

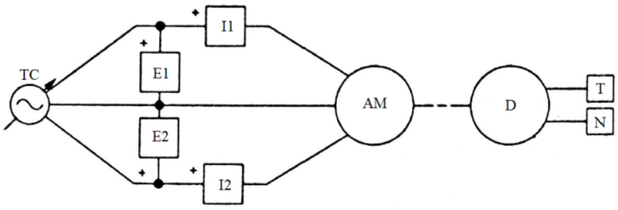


Fig. 6. Mounting scheme.

The meanings of the notations are the following:
- AM – asynchronous motor;
- D – dynamometer;
- TC – voltage converter;
- E1, E2 – voltage transducers;
- I1, I2 – current transducers;
- T – torque transducer;
- N – speed transducer.

The system includes a monitoring program [10], with visualization and analysis windows also made by the authors. The most important windows are included in figure 7 (Metering, Phasor Analyser, Harmonic Analyzer and Spectrum Analyzer).

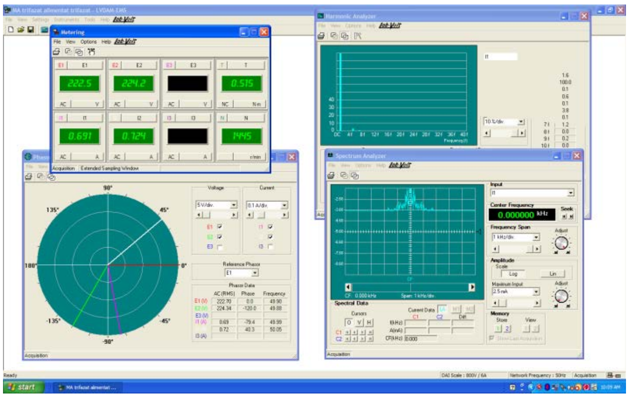


Fig. 7. The most important windows of the program.

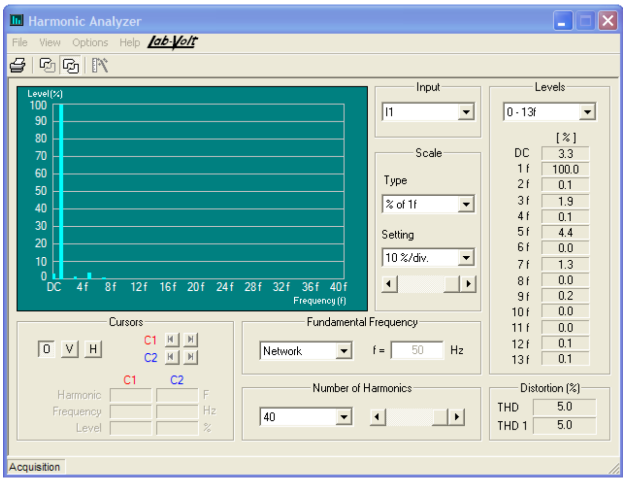
Of these, the last three will be detailed for the practical situations considered relevant for the current research.

IV. Experimental Determinations

With the help of the previously detailed assembly, a series of tests were carried out, considered relevant.

Three line voltages were preferred:
- 380 V (0 Nm and 1 Nm);
- 300 V (0 Nm and 1 Nm);
- 220 V (0 Nm and 1 Nm).

The graphic representations obtained are shown in figures 8, 9, 10, 11, 12 and 13.



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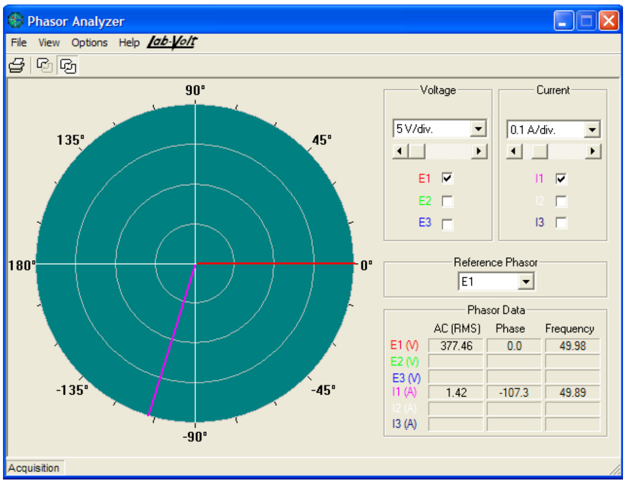

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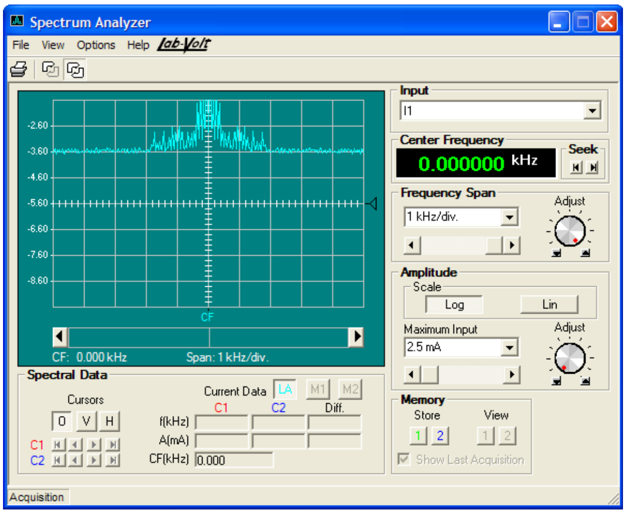

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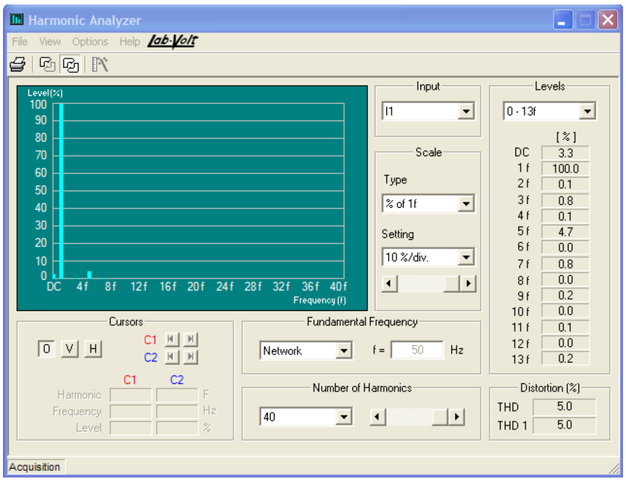
Fig. 8. Representations obtained at 380 V, 0 Nm.



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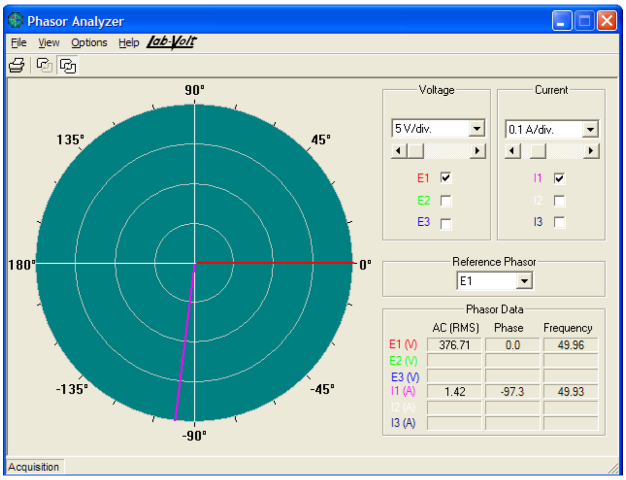

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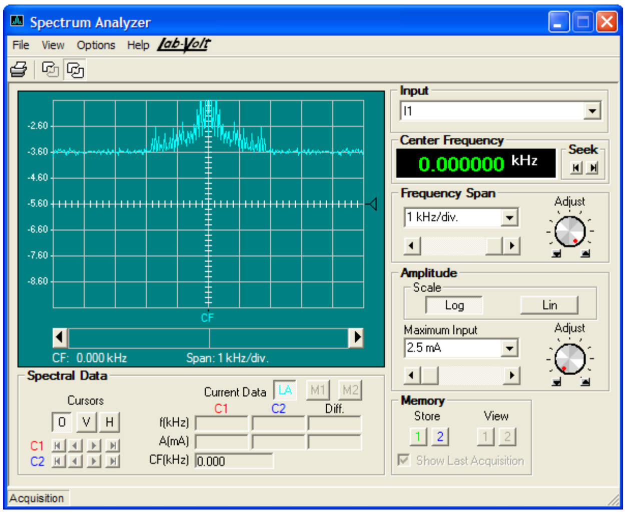

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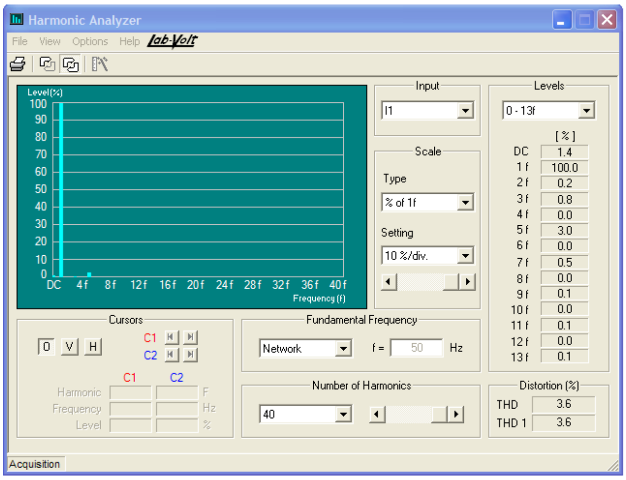
Fig. 9. Representations obtained at 380 V, 1 Nm.



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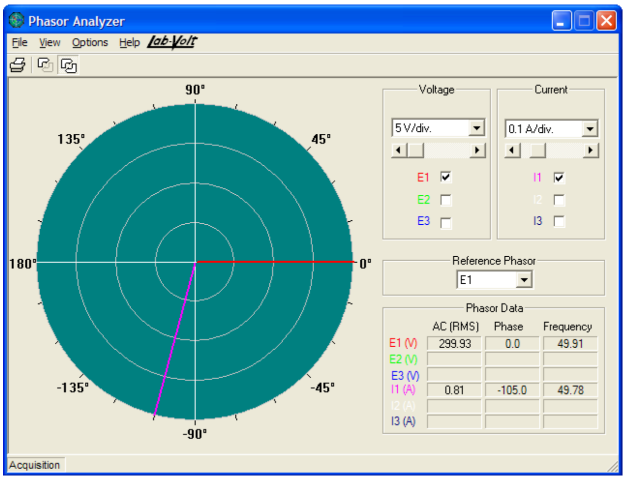

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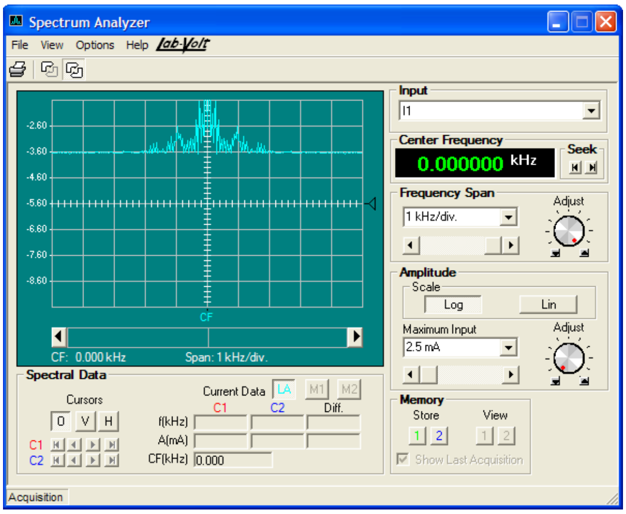

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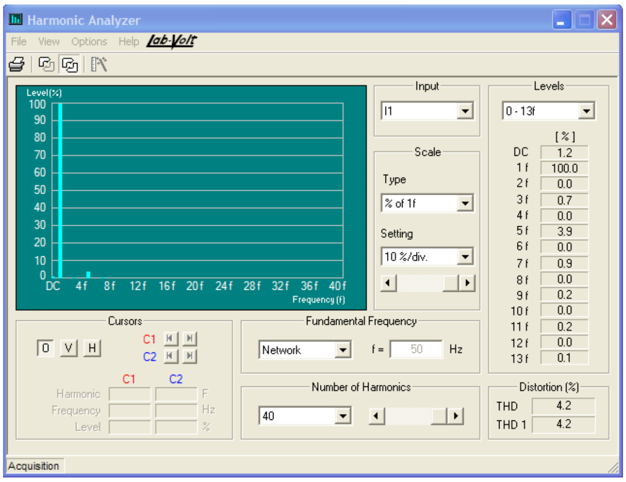
Fig. 10. Representations obtained at 300 V, 0 Nm.



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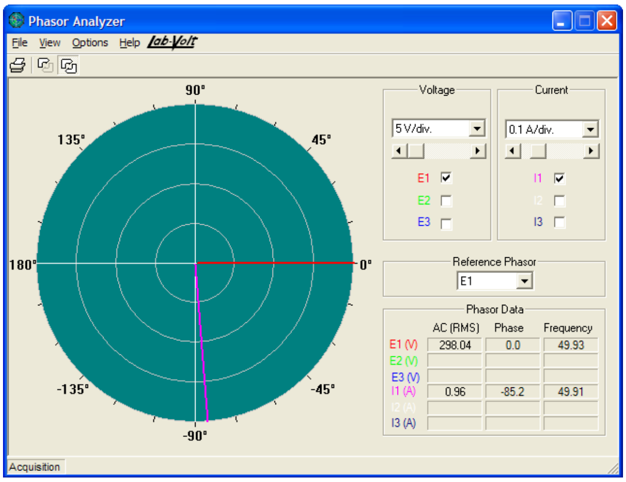

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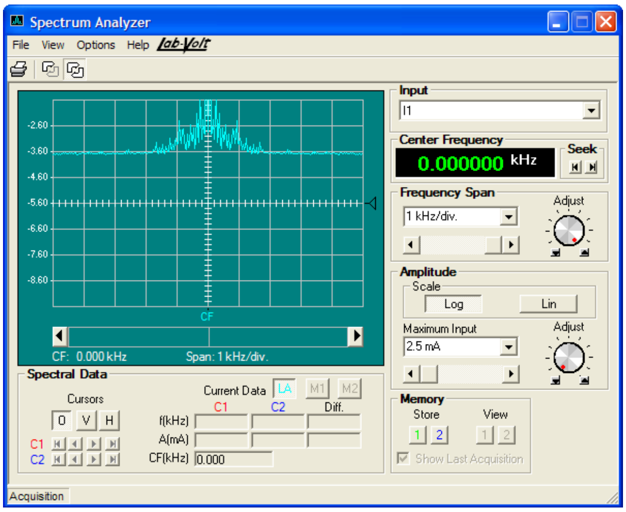

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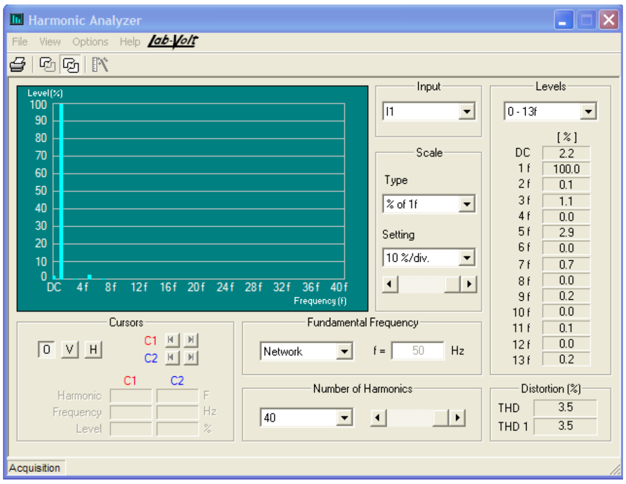
Fig. 11. Representations obtained at 300 V, 1 Nm.



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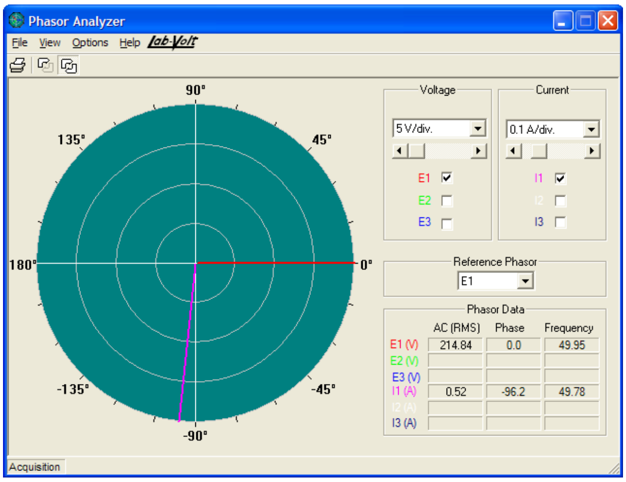

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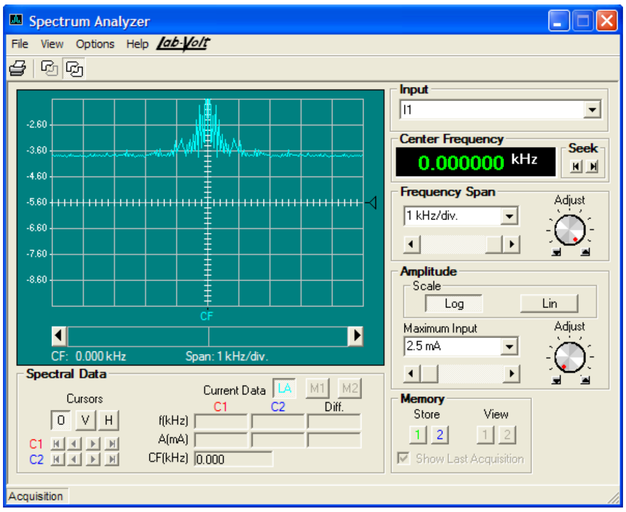

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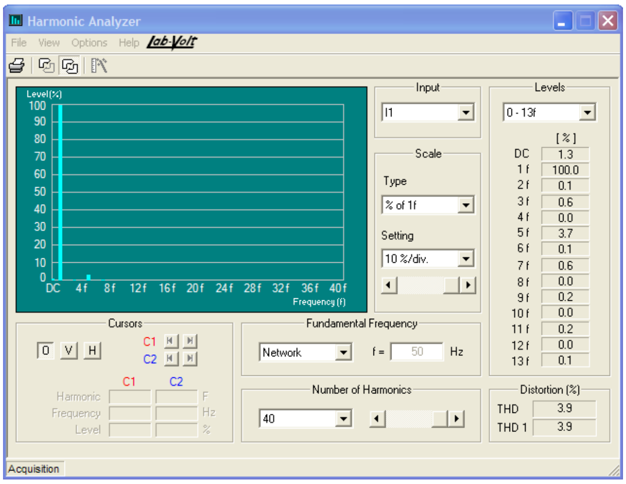
Fig. 12. Representations obtained at 220 V, 0 Nm.



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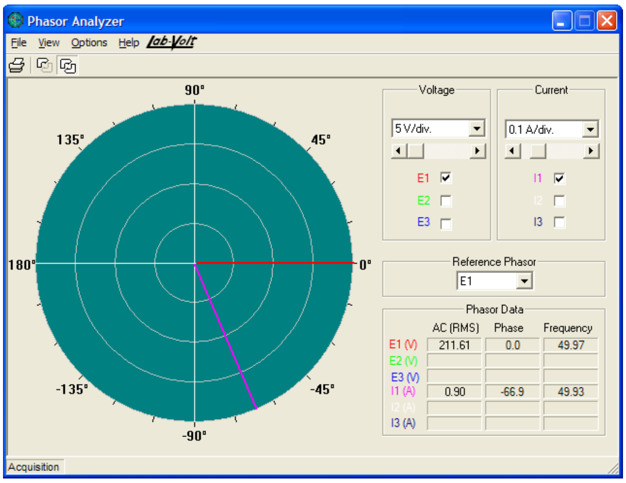

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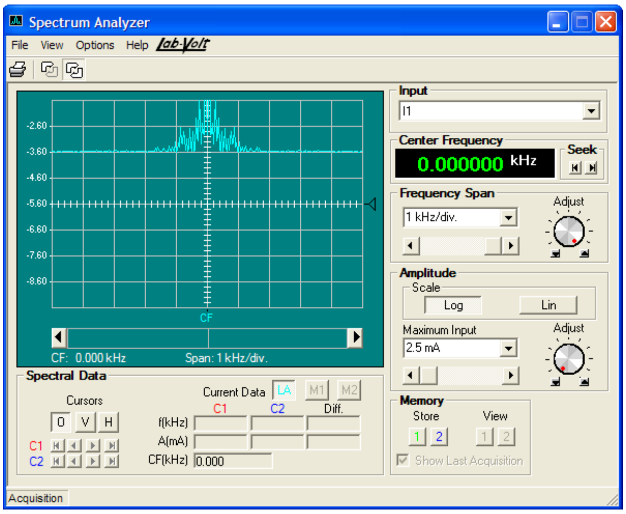

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Fig. 13. Representations obtained at 220 V, 1 Nm.

To facilitate the analysis of these representations, Table I was completed.

TABLE I.
CENTRALIZING DATA

Voltage [V]	Couple [Nm]	Harm. 3 [%]	Harm. 5 [%]	Harm. 7 [%]	The phase [o]
380	0	1,9	4,4	1 ,3	107,3
	1	0,8	4,7	0,8	97,3
300	0	0,8	3,0	0,5	105,0
	1	0,7	3,9	0,3	85,2
220	0	1,1	2,9	0,7	96,2
	1	0,6	3,7	0,6	66,9

V. CONCLUSIONS

The paper is an application of the use of a data acquisition and visualization program used on an actuation system with an asynchronous motor and variable voltage source.

Among the important contributions made by the authors in the paper, it should be stated that they added to the existing monitoring program, several modules for calculation and visualization of the phase shift angle of the phasors and harmonic analysis of non-sinusoidal quantities.

The program can be used in many practical situations (the paper presents a particular case considered to be representative).

Following the analyzes performed, according to Figures 8-13 and Table I, for the proposed application, the following conclusions were obtained:

- the current absorbed by the motor has a relatively important content of odd harmonics, in which the 5th order harmonic predominates;

- the importance of this harmonic increases as the load increases, regardless of the voltage value;

- for the other odd harmonics (the cases of the 3rd and 7th order harmonics were exemplified), as the load increases, their importance decreases;

- the phase shift angle between the current and the line voltage (obviously inductive), decreases when the load increases;

- the spectral analysis of the current highlights the important content of odd harmonics.

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Contribution of authors:
First author – 40%
First coauthor – 30%
Second coauthor – 30%.

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REFERENCES

[1] C. Kang, F. Liu, “The design of material winding system based on tension control”, *2021 IEEE 16th International Conference on Nano/Micro Engineered and Molecular Systems (NEMS)*, 2022.

[2] B Tejaswini; E. Sheeba Percis, “Supremacy of Power Electronic Technologies and their Applications in Modern Operating Converters in Smart Grid”, *2022 6th International Conference on Electronics, Communication and Aerospace Technology*, 2022.

[3] H. Bouregba, M. Hachemi, S. Mekhilef, A. Ratni: “FFT analysis-based P&O with IC for 100 kW two stage grid-connected PV system: Comparative study”, *2022 19th International Multi-Conference on Systems, Signals & Devices (SSD)*, 2022.

[4] P. Deka, S. Deka, R. Kishore Roy,T. Bezboruah, “Development Of Weight Measurement System Based On Bend Sensor And Linear Compression Spring”, *2023 4th International Conference on Computing and Communication Systems (I3CS)*, 2023.

[5] H. Wu, Y. Liu, S. Ni, G. Cheng, X. Hu, “LossDetection: Real-Time Packet Loss Monitoring System for Sampled Traffic Data”, *IEEE Transactions on Network and Service Management*, Vol. 20, Issue 1, 2023.

[6] M. Holub, O. Andrs, V. Stepanek, J. Kroupa, R. Huzlik, J. Tuma, J. Kovar, T. Marada, F. Bradac, “Experimental study of operational data collection from CNC machine tools for advanced analysis”, *2022 20th International Conference on Mechatronics - Mechatronika (ME)*, 2022.

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

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

[9] S. Enache, A. Campeanu, I. Vlad, M. A. Enache, “Contributions Regarding Monitoring of Universal Fractional-Horsepower Commutator Motors”, *Annals of Faculty of Engineering Hunedoara - International Journal of Engineering*, Tome XX [2022], Fascicule 4 [November], ISSN 1584-2665, pp. 175-178.

[10] S. Enache, I. Vlad, M. A. Enache, “Program for Monitoring Operation Regimes of Low-Power Electrical Machines”, *Annals of the University of Craiova*, Electrical Engineering series, No. 44, Issue 1, 2020, ISSN 1842-4805, pp. 55-60.