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Approaching E_Learning on Three-Phase System Measurements

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Abstract: - Training on measurements to determine the characteristics of the three-phase electrical system is very useful for a deep knowledge of the various theoretical aspects, in the different load conditions. The use of advanced technologies are suitable to obtain many advantages: the values of the various parameters can be detected and/or computed, presented on the user friendly interface and stored in a file.
By using advanced technologies a laboratory session for measurements on three-phase systems has been realised. A user-friendly virtual instrument enables the student attending an electric measurement course (or any other operator) to perform the experiment. The software that has been realised for this work consists of a virtual instrument, implemented in the LabVIEW™ environment: it can be easily improved. A digital acquisition board installed in the PC and software managed acquires the values of the voltages and the currents used by the software, which computes the active power and the reactive power. The web cam gives an overview on the details of the system adopted and enhances the "presence feeling" to the far user.

Key-Words: Laboratory sessions, Three-phase system measurements, Electromechanical instruments, Digital instruments, Virtual instruments, Advanced technologies, Training issues.

1 Introduction

The dramatic improvement of the advanced technologies has deeply modified the teaching requirements, particularly as regards the topics, but more generally from the pedagogical point of view. Indeed, the cultural background of the students is changing, year by year, also the hardware and the methodology of the measurements have been modified.
On the other hand, the already emphasized problems are still unsolved: in particular, the large number of students, arranged in small teams, would require a didactic apparatus with a number of workbenches, equipped with complete sets of instruments; moreover, the always insufficient number of tutors can dramatically reduce the quality level of the experimental training; finally, the students cannot spend enough time in the laboratory activities, for both the didactic burden and the reduced availability of the laboratory. As far as electrical engineering is concerned, the drastic modification in the area of electrical measurements are to be considered.
A partial solution to the previous problems can be the following one: undergraduate students can carry out some practical training by using driven measurement systems as well as by running simulation software. Indeed, instrument simulators can be a powerful didactic tool.
Nevertheless, it has been recognized that real experiments with real electric and electronic component and circuits, carried out by using advanced instrumentation, are relevant to more accurate training and to provide a better feeling to students about measurement procedures and measurement system design [1, 2].
Overcoming the outlined difficulties requires adopting suitable approaches. An attempt to develop advanced experimental techniques has been carried out by the authors. In previous works they proposed several educational tools, aimed to enhance the effectiveness of the experimental activity in the laboratory. A deep study has been performed on the possibility of remotely controlling connected instruments [3]. This approach has provided quite good results, a new hardware/software tool has been therefore carried out [4], which supplies the students with some tutorial assistance and, moreover, reduces the time loss due to rough troubles and represents a key point for future remote laboratory sessions.
For undergraduates in the electrical engineering area training on measurements to determine the characteristics of the three-wires three-phase electrical system is very useful: indeed, they can acquire a deep knowledge of the various theoretical aspects in the different load conditions.
Taking into account didactic, technical and economic aspects, some approaches have been recently considered by the authors [5, 6]: in the next sections a review will emphasize the advantages as well as the drawbacks of the realized tools. In the last section an improved variant of the previous tools is shown: it has been designed with the purpose of enhancing the educational performances in a

good balance between both traditional and advanced technologies.

2 The First Implemented System

In this first approach a laboratory session has been realised in order to carry out measurements on three-phase systems. In Fig. 1 is shown the used hardware, which consists of a reduced voltage and current laboratory model.

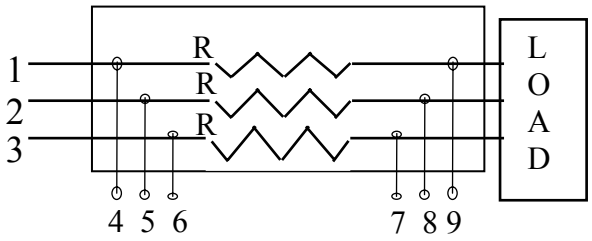
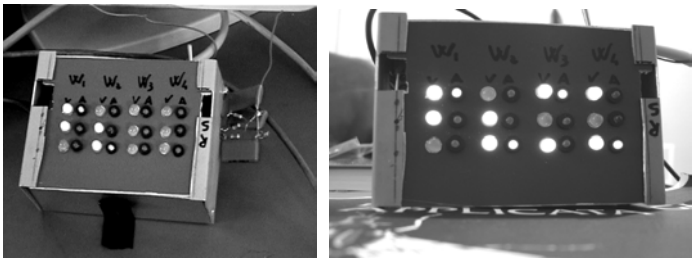


Fig. 1: The laboratory model

The user can chose the load in order to realise either a balanced star connection or an unbalanced load, for seek of generality [5].

Fig. 2 a) emphasizes, for each phase, the running acquisition of the voltages and the currents and the computation of the powers that could be measured by analog watt meters. In this case the laboratory model consists of a balanced load, located outside the box, therefore the Aron's method is used.

Fig. 2 b) emphasizes the running acquisition of the voltages and the currents and the computation of the powers that could be measured by analog watt meters in case of unbalanced load: indeed, the four watt meters method is needed for a complete knowledge of the unbalanced load three phase system.



a) b)

Fig. 2: The box and the lab model of the load

The implemented software consists of an user-friendly virtual instrument implemented in the LabVIEW™ environment. It is running on the personal computer and enables the user performing the management of the experimental training.

A digital acquisition board installed in the PC acquires the values of the voltages and the currents that will be used by the software, in order to compute the total active power as well as the reactive power.

The software computes the line currents from the voltages at the terminals of the R resistors of suitable values, on the basis of the characteristics of the used data acquisition board. The resistors in Fig. 1 are put in a box, in order to simplify the connection to the data acquisition board. Some indicators on the box show the actions that are carrying out by the software.

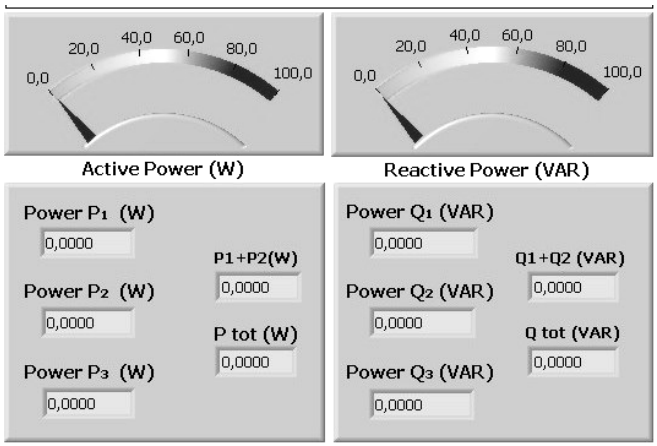
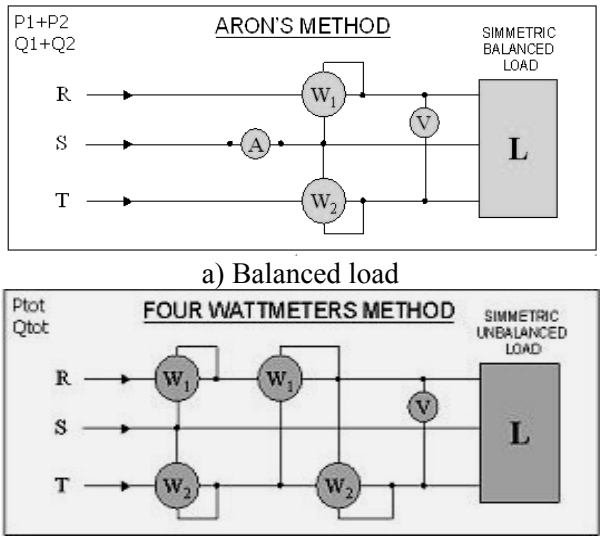


Fig. 3: Virtual instruments on the configuration panel

On the user-friendly interface the virtual instruments are shown in Fig. 3, where also the individual results are presented.

According to the configuration of the load, chosen by the user, the corresponding electric circuit is focused (Fig. 4).



a) Balanced load

b) Unbalanced load

Fig. 4: Electric circuits

In the perspective of using the realised tool for a distance learning project, a web cam located in the lab has been already used, in order to give an overview of the system adopted and to enhance the "presence feeling", which can be very important for far users.

Fig. 5 emphasizes the overall system and the result of this improvement.

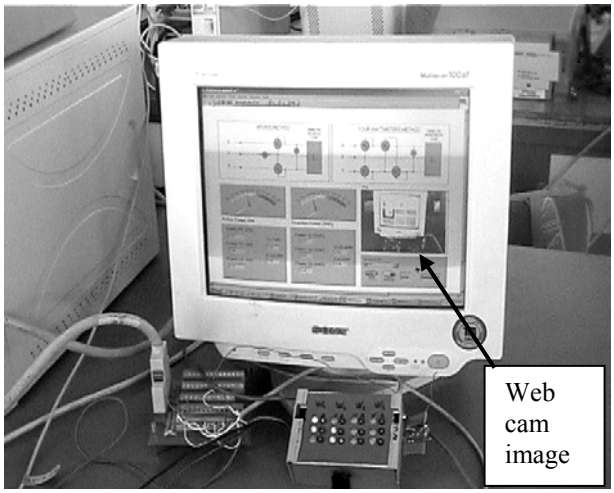


Fig. 5: The overall system

3 The Second Implemented System

This second hybrid hardware solution is based on the use of analog and digital circuitry, exploiting the sound board [6]. Three independent transformers are adopted in order to reduce the level of the signals to the one compatible with the following analog circuitry. Moreover, voltage followers separate this stage from the section in which the signals are multiplexed and then provided to the Sound Board.

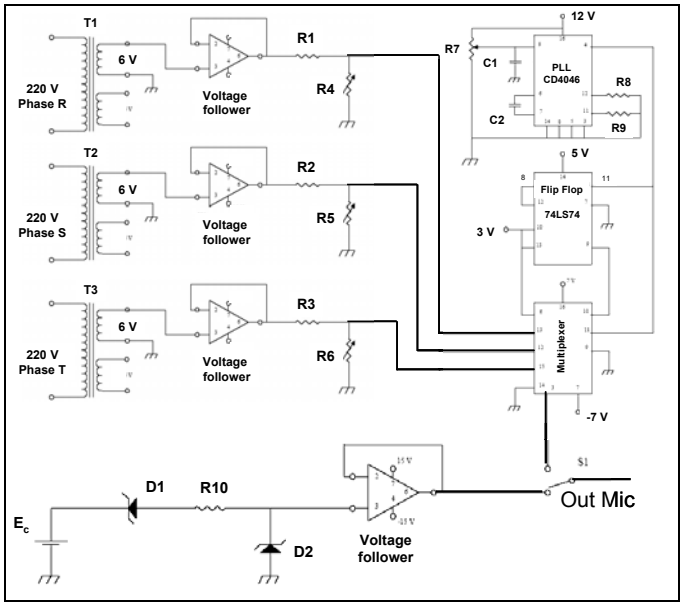


Fig. 6: Hardware architecture of the portable module

In this system the digital hardware is therefore reduced to an Analog to Digital converter, while software is a bit more complex, because there is a need of demultiplexing sound-board signals after acquisition. This function is performed through suitable cyclic software procedures, starting from a software trigger value.

The PLL (CD4046) has been used to provide the driving signal of the multiplexer together with a D-type flip flop, as shown in Fig. 6.

At the beginning of each measurement, to avoid damages at the sound board, a hardware calibration procedure must be performed, by regulating the input microphone volume; the voltage reference level is provided by zener diodes.

The voltage transformers have been characterized and their contribute to the uncertainty has been evaluated. Therefore the calculations of the active and the reactive powers inherent to the analysed system can be easily addressed.

4 Features of the Implemented Systems

The tools have been designed in order to fulfil the following requirements:

- simplicity, indeed they are user friendly, can be easily implemented and consists of simple hardware;
- reliability, because in a future realization they will be used in distance learning sessions;
- safety, as they are used for analysing low voltage laboratory systems;
- interest, because the students must be involved by using advanced technologies.

For a better understanding of the system operation, normally the tools will include electromechanical instruments. Indeed, the values acquired by the automatic acquisition technique can be compared with the ones that will be measured by the analog instruments, in spite of the drawback due to the small values of the voltages in the lab model.

Data acquisition boards, much more costly than sound boards, offer advantages in conceiving a conditioning circuit and consequently in obtaining a full digital signal processing. On the other hand, the operating range is limited, due to the requirements of the digital components. The configuration based on Sound Boards gives the opportunity to perform important part of Electrical Measurement laboratory activity with a portable low cost instrument without limitations in the operating range.

The use of advanced technologies is well acknowledged by the undergraduates, which is the most important feature of the implemented tools.

5 The last Implemented System

Measurements on three-phase electrical systems require an accurate training with real components and suitable values of the voltages and the currents for a deep knowledge of the various theoretical aspects. The didactic requirement is

the main reason for the implementation of the following system.
A particular attention has been paid to an impressive choice of the lab components.
The chosen load, shown in Fig. 7, consists of a balanced three-phase impedance presented in Fig. 8.

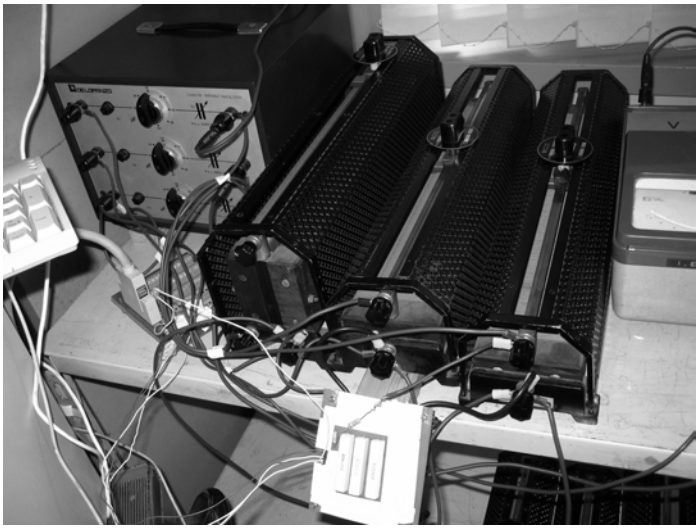


Fig. 7: The three-phase load

On each line an RC circuit of usual values of the parameters has been adopted.
The used analog instruments are shown on the circuit in Fig. 8 and a real view is presented in Fig. 9. The two watt meters are connected in Aron configuration and the last independent quantity is measured by the voltmeter. The ammeter enables the choice of the current range of the watt meters.

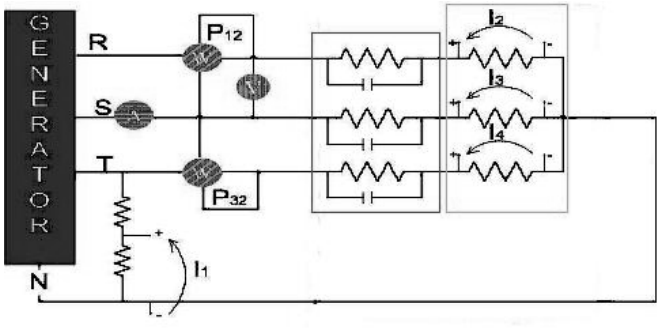


Fig. 8: Scheme of the hardware

The software that has been implemented in LabVIEW™ performs a set of operations in order to realize the virtual instruments and the user-friendly interface, according to the scheme presented in Fig. 10.
The line currents are computed on the basis of the detected voltages across the resistors of comparable small values, on account of the characteristics of the acquisition board.
The voltages of the system are computed on the basis of the detected voltage across the voltage divider.

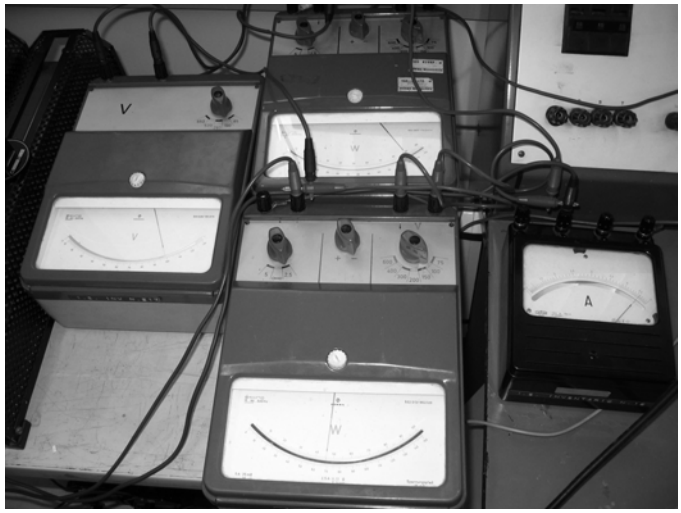


Fig. 9: The analog instruments

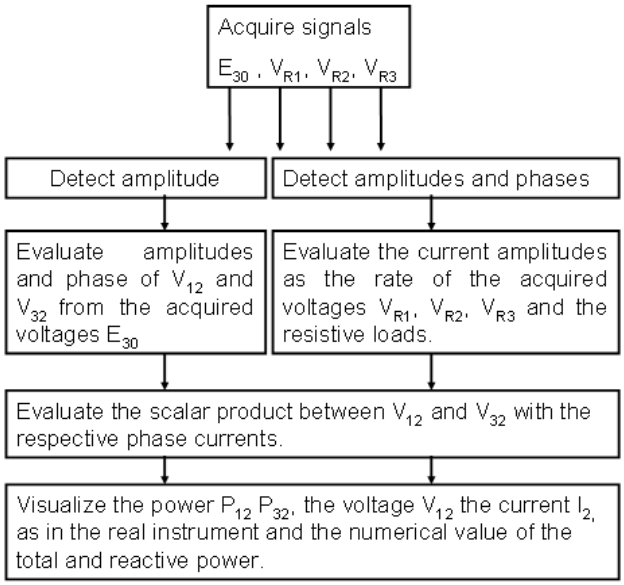


Fig. 10: The implemented software

Some tests have been performed and the results are very promising, in the sense that the realized system will meet the agreement of the undergraduates, which will be the final test!, because didactic effectiveness is the key point of this work.
This training session has been designed for far users: mainly for safety reasons, because the values of the electrical quantities are the usual ones, therefore tutors are needed in the lab. A web cam has been used, because in this case it is very important to give an overview on the details of the system adopted and to enhance the “presence feeling”. Also this test has been performed. The monitor of the PC of the far user shows the image of Fig. 11.

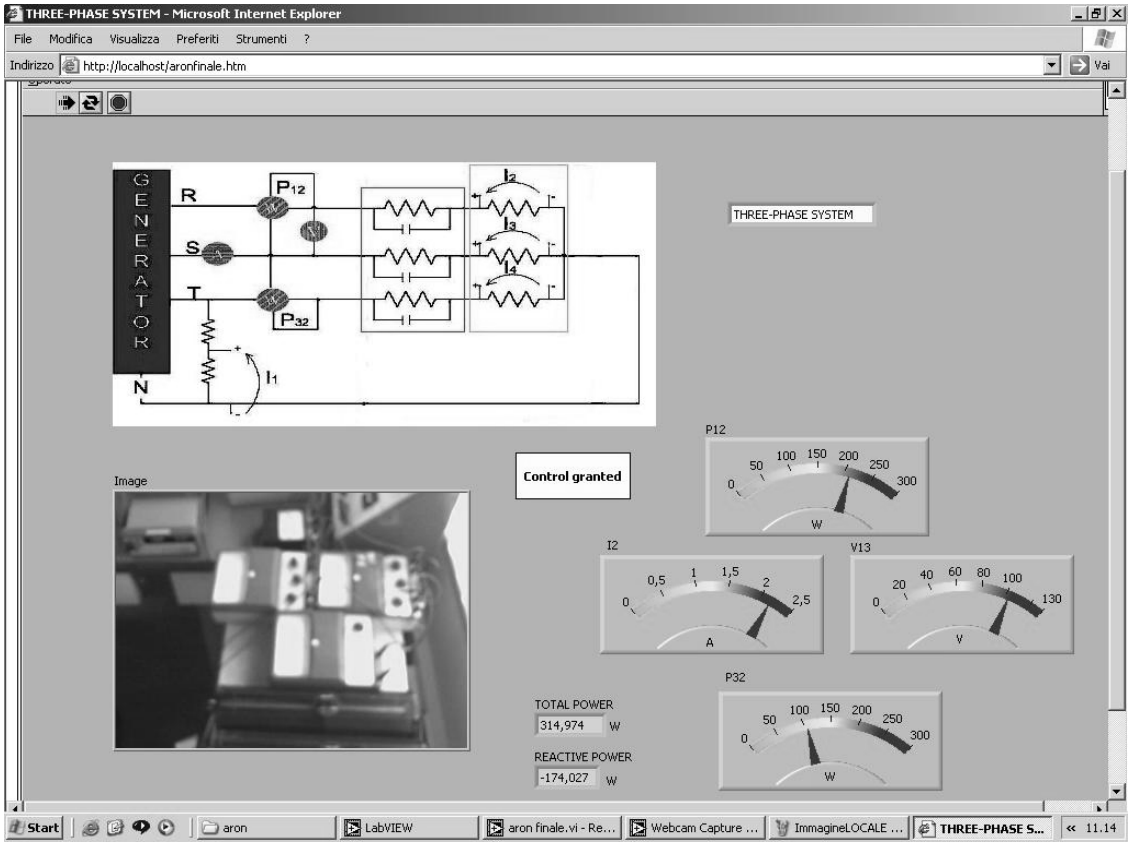


Fig. 11: Image observed by the far user

The image captured by the web cam isn't clear enough, indeed analog and virtual instruments give the "same" values. In this implementation the errors are completely neglected (!).

3 Conclusion

As far as theoretical aspects connected with the power system behaviour are concerned, training on measurements to determine the characteristics of the three-phase electrical system is very useful for a deep knowledge.

By using advanced technologies a laboratory session for measurements on three-phase systems has been realised. The tool fulfil the following requirements: it is user friendly; it will be used in distance learning sections; the students will be strongly involved by using advanced technologies

The tool will include also electromechanical instruments for a better understanding of the system operation. Indeed, the values acquired by the automatic acquisition technique can be compared with the ones that can be obtained from the analog instruments. In this work the precision level of the results is not considered.

In a future development of the tool such lack will be overcome.

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