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Enhancing Training 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 theoretical aspects. Laboratory sessions for measurement by using advanced technologies must be performed. Two implemented tools are presented.
The first one fulfils some requirements: it uses a virtual instrument, will be used in distance learning sections and also includes electromechanical instruments for a better understanding of the system operation.
The last tool, quite different from the previous one, is an electronic power meter, active and reactive, in a wide range of values.

Key-Words: - Training on three-phase system measurements, Electromechanical instruments, Digital instruments, Virtual instruments, Advanced technologies.

1 Introduction

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].
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, which will be an adequate introduction to the power system study. For this reason, an adequate training in the laboratory is needed, in spite of difficulties and also safety risks.
A variety of instruments has been used in the past, such as electromechanical e/o electronic instruments. The settlement of a three-phase measurement station requires a careful choice of adequate components, among them the three-phase load with proper values of the electric quantities, instruments with appropriate ranges, mainly tacking into account the security requirement. Overcoming such drawbacks will provide the students with a deep understanding of many aspects of the power system behaviour.
The impressive improvement of the advanced technologies has deeply modified the teaching requirements, as regards the topics but, more generally, the pedagogical point of view. Indeed, the cultural background of the students is changing, year by year, therefore the hardware, the methodology and the didactic planning of the measurements need to be modified.
Taking into account didactic, technical and economic aspects, some approaches have been recently considered by the authors [4, 5, 6]; for this aim some hardware and software tools have been recently implemented: each tool exhibits different features and didactic relevance.
An attempt to develop advanced experimental techniques has been carried out by the authors. In previous developments they proposed several educational tools, aimed to enhance the effectiveness of the experimental activity in the laboratory. In the progress of the work, advanced technologies have been used, as virtual instrument, implemented in the LabVIEW™ environment, digital acquisition board installed in the PC, a suitable software supervisioning tools and web cam.
A deep study has been performed on the possibility of remotely controlling connected instruments. This approach has provided quite good results, a new hardware/software tool has been therefore carried out [3], 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.

2 A Recent Realization

The didactic usefulness of a recently realized tool can be emphasized with reference to the Fig.1, which represents the image that a remote user can see on the monitor of his PC.
The electric diagram of the three phase system shows the traditional arrangement for symmetrical electric system and balanced load. In the first box the model of the load is included: it consists of three equal impedances in star connection.

The two watt-meters in the Aron configuration and the voltmeter represent the set of electromechanical instruments, also shown in Fig.1.
A virtual instrument has been realized, implemented in LabVIEW™, in order for the undergraduates to understand the use of some advanced technologies.
The software computes the system voltages on the basis of the voltage at the voltage divider, sent at the first input of the data acquisition board (I_1).

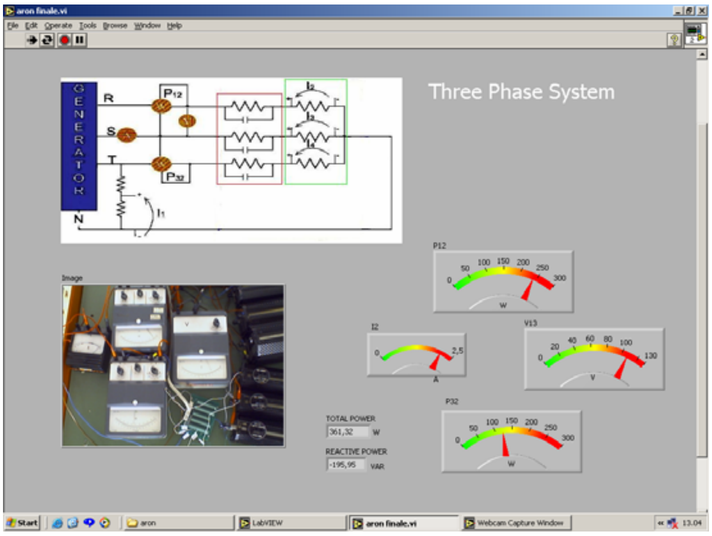

Fig.1: Image of the tool on the remote monitor.

The line currents will be computed from the voltages at the terminals of the three resistors included in the box on the right: these voltages are presented to the inputs (I_2, I_3, I_4) of the DAQ.
The software carries out the various procedures for the realization of the virtual instrument and the results are shown on the same figure. Indeed, the digital virtual instruments on the right appear to be a replica of the other instruments, so the remote user can compare the values displayed by the two sets of instruments.
The opportunity of comparing the characteristics of traditional instruments and the ones of advanced technologies is enabled by the web-cam, located in the lab: it captures the image sent to the remote user, as it can be seen in the left hand site of Fig.1.
Of course, the software computes also the values of both the total active power and the reactive power, which are displayed on the proper boxes.

2.1 Features and Drawbacks of the Tool

The tool exhibits some useful features: first of all, it emphasizes the difference between the traditional apparatus and some advanced technologies. This system gives to the undergraduates a deeper knowledge of the three-phase electric system.
Moreover, additional electronics is needed, because it is quite difficult to adapt the levels of the signals from the real system to the ones received by the data acquisition board.
It should be pointed out that the arrangement and the connections of the various pieces of hardware must be realized very carefully, which will take a long time.
For this reason, the tool has been designed for remote users. Indeed, the system can be user friendly left in the lab, with the personal computer connected to the network.

3 An electronic Power Meter

The last didactic tool is quite different from the previous one: as matter of fact analogical instruments have been disregarded; it is an electronic power meter, active and reactive, in a wide range of values.
The hardware consists of three boards, designed for the conditioning of the input signals, for adapting the level of the signals to the correct level at the input of the micro controller, the last one for programming the micro controller and for managing the communication with the computer.
The software has been implemented by using the "Visual Five", distributed by STMicroElectronics, for programming the micro computer and the LabVIEW™ environment for the virtual instrument.

3.1 Board for signal conditioning

As it is shown in Fig.2, three transformers are used in order to suitably reduce the phase voltages (ready for unbalanced load). This choice depends on the reduced dimensions of these devices. In order to minimize errors, the load on the secondary coil is kept very low.

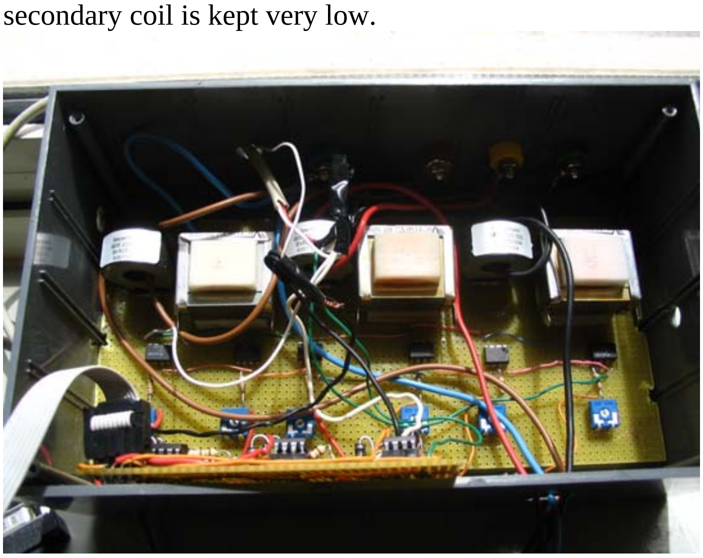

Fig.2: The first board.

Three ammeter transformers are used for conditioning the currents. For impedance decoupling a buffer is used for each bus, therefore the impedance connected to the transformer is very high.

The level of the voltages to be sent to the following board can be carefully regulated by a voltage divider.

3.2 Board for connecting to the micro controller

For the signal to be sent at the inputs of the micro controller some constraints must be overcome. For this reason, in the second board (Fig.3) a configuration based on the operational amplifier has been designed for each bus.

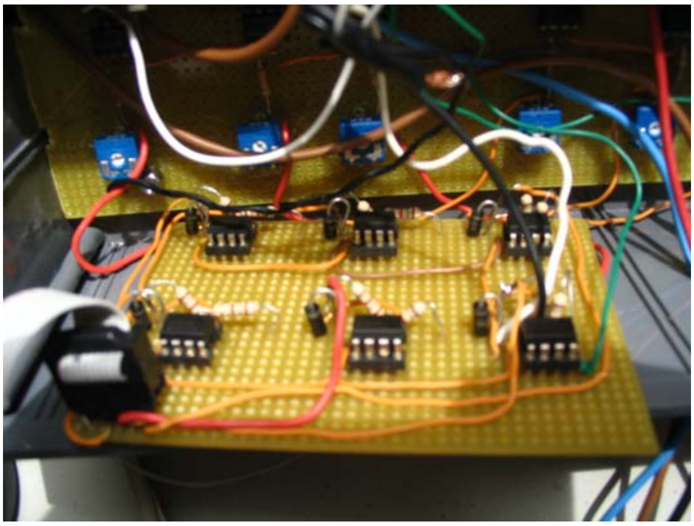

Fig. 3: The second board.

3.3 Micro controller board

On this board the micro controller ST52F513K3B6 has been installed, and also the electronics need for the communication with the PC (Fig.4).

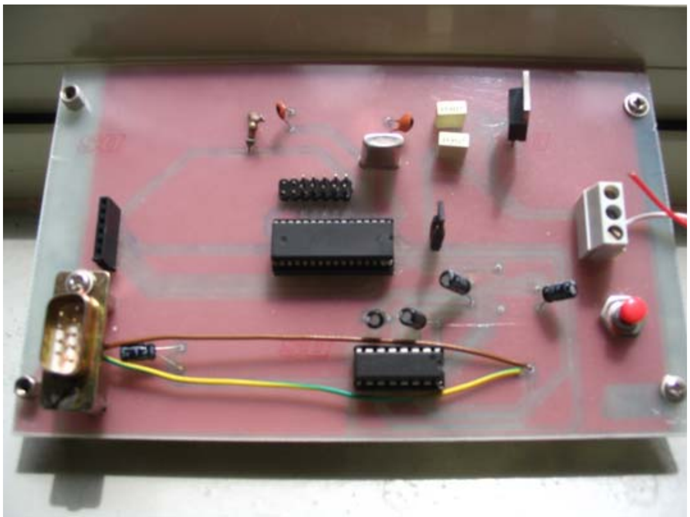

Fig. 4: The micro controller board.

3.4 The software

The implemented software includes the section for programming the micro controller, as well as the section for the realization of the virtual instrument. It enables the user to carry out the management of the measurement sessions and the visualization of the results on the control panel.

4 Results of the test.

The implemented system has been tested is some conditions and a result is shown on Fig. 5. It refers to an unbalanced resistive load.

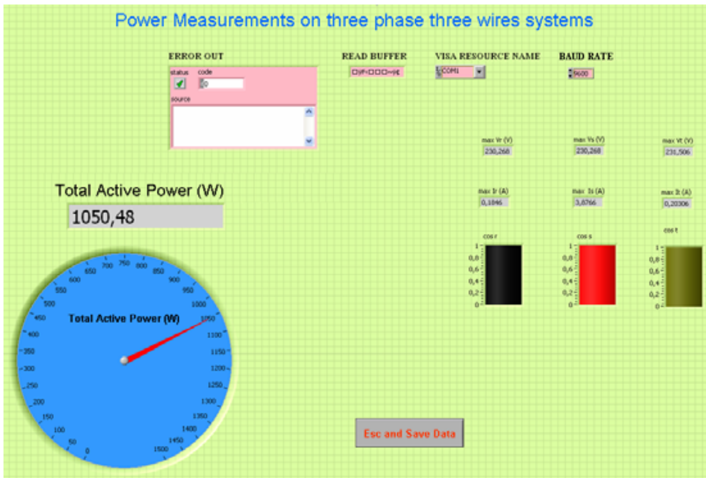

Fig. 5: User interface of a test case.

5 Conclusion

Didactic developments taking into account the technologic improvements are the main purpose of this work. Training on measurements to determine the characteristics of the three-phase electrical system is very useful for undergraduates in order to acquire a deep knowledge of the theoretical aspects. Laboratory sessions for measurement by using advanced technologies must be performed.

Two implemented tools are presented.

The first one fulfils some requirements: it uses a virtual instrument, will be used in distance learning sections and also includes electromechanical instruments for a better understanding of the system operation.

The last tool, quite different from the previous one, is an electronic power meter, active and reactive, in a wide range of values, based on a micro controller and a virtual instruments.

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