Volt-Ammeter Method introducing Principles and developing Technologies to undergraduates

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Abstract: - To face the pressing need of updating the teaching work making use of advanced instruments both hardware and software and to stimulate the interest in the students attending the lectures the use of different teaching techniques is necessary. To cope with this new wave the authors are trying to introduce new hardware and software tools to enable the teacher to show to the students in an alternative and practice way the theoretical constructs explained during the lecture. In this paper the experimental activity on the volt-ammeter method has been completely renewed and a LabVIEW® based tool is presented.

Key-Words: - Volt-ammeter method, Advanced technology, Virtual Instrument, LabVIEW®, Digital multimeter, Experimental training.

1 Introduction

As an introduction to the course of Electric and Electronic measurements, the lecturer should familiarize the undergraduates with some peculiarities of this theoretical and experimental course, among them:

- the experimental aspects are essential;
- a deep knowledge of the working principle and then features of a variety of instruments is needed;
- an exhaustive understanding of the involved phenomena is required;
- an intensive training in the laboratory is determining;
- the real meaning of the “models” should be clear.

In order to rapidly get the undergraduates to take an interest in measurements, the authors experienced to give the first lectures on the volt-ammeter method for measuring resistances in direct current. Indeed, many different activities are involved, both theoretical and experimental ones.

The theoretical problems can be summarized as follows:

- definition of direct and indirect method;
- characteristics of the real instruments adopted: it is useful in this case the use of electromechanical instruments, in order to give some references on the interaction between the magnetic field and the electric current;
- analysis of a class of errors, known as the systematic errors: using electromechanical instruments the loading error can be easily understood by the undergraduates; the definition of the random error and the evaluation of the precision level can be easily performed.

An effective training activity will accomplish the teaching task: indeed, the students will be able to check the level of their knowledge.

The dramatic development of the technology requires updating the teaching work, which involves using different teaching techniques, advanced instruments, complex equipments, and also high-level software, distance learning [1-5].

Taking into account these pressing needs, the authors are trying to introduce new hardware and software [6-8], in various areas: three-Phase System Measurements, digital devices, by using Virtual Instruments (implemented in LabVIEW®) and microprocessors.

In this paper the experimental activity on the volt-ammeter method has been completely renewed. A small group of students in informatics has been asked for the realization of a tool, which has been designed during guided sessions. The prototype has been improved and will be presented in the next sections.

2 The implementation of the Volt-Ammeter method as a LabVIEW® based application

In the past years researchers of Department of Electric and Electronic Engineering of the University of Catania have demonstrated to retain of importance the didactic aspect and the innovation in the teaching activity to stimulate the interest in the students attending the lectures. To this purpose among their chief research activity they have always covered these aspects directly involving the
students themselves. An example of software tools developed with this intention is discussed in the sequel. During the course on electronic measures for computer sciences engineering the students have developed two stand-alone LabVIEW® based applications implementing the volt-ammeter method. The first application permits to simulate the method of measurement together with the instrumentation enabling the possibility to choose analogue or digital instruments. The application will change its representation of the measures according with the previous choice. The other application instead, permits to interface the PC on which it is running with two real instruments (in particular two HP34401A multimeters), to measure the voltage and the current respectively, via the GPIB (IEEE488) bus. The two applications have been joined to form a single package enabling the teacher to show to the students in an alternative and practice way the theoretical constructs explained during the lecture. The students on the other part have the possibility to put in practice learning by doing. In this manner they have the possibility to interface with various concepts and problems such as the setting of a real instrument to evaluate the required measure, the development of a PC based instrument together with the LabVIEW® integrated development environment [9], the design and implementation of a resistive electronic circuit.

To permits the user to choose between the two possible applications a simple GUI, shown in Fig.1, has been included. The block diagram implementing the GUI as been reported in the same figure; essentially it consist of a event structure that waits for an event to happen, in particular the event it waits is the selection, by the user, of one of the two radiobutton on the front panel. As a consequence of the selection an event is issued and handled by the event structure calling and opening the proper front panel. Fig.2 shows the experimental setup with the PC on which the software tool is running and the hardware circuit to implement the volt-ammeter method.

![Fig. 2. The experimental setup with the PC on which the software tool is running and the hardware circuit to implement the volt-ammeter method.](image)

2.1 The simulated Volt-Ammeter section

Selecting the simulated volt-ammeter method the GUI shown in Fig. 3 will appears. It can be subdivided in two parts. In the left part the user can set the insertion of the instruments in the circuit (the two possible insertions, shown in figure 4a and b, have been indicated as Conf.1 and Conf.2) and all the circuital properties such as the input voltage, the unknown resistance value together with its maximum power dissipation. Depending on the user setting the software evaluates the power dissipation and in case of limits exceeding a warning advice will be issued by a led indicator. Moreover depending on the resistance value the software suggests the optimal circuital insertion of the instruments.

The other two tabs, shown in Fig.5a and 5b, permit the user to choice to represent the voltage and the current measures in an analogue or a numeric format; in other words the user can carry out the choice of an analogue or digital instrument. The user can set the accuracy class and the full scale for both the voltmeter and the ammeter; moreover,
when the digital instrumentation has been chosen it is possible to set the number of digits to use for the representation of the measured quantities. In the right section of the GUI (in Fig.3) the relative and absolute error on the voltage and the current measure are shown together with the evaluated resistance value. The deterministic and the statistical model to evaluate the uncertainty in the resistance evaluation process have been implemented.

2.2 The GPIB Volt-Ammeter section

This other tool permits to interface the PC on which it is running with two real instruments (in particular two HP34401A multimeters), to measure the voltage and the current respectively, via the GPIB (IEEE488) bus. The front panel shown in Fig.6 will appear when this tool is selected from the initial GUI. Only the essential information are represented in it; the user can choose the insertion (Conf.1 and Conf.2, whose circuital schematization are shown on the front panel for the sake of clarity) of the hard instruments to perform the measures and set the correct full scale, the full scale of the instruments will be automatically switched to the selected one.

The block diagram implementing the applicative is reported in Fig. 7a. It consists of a main flat sequence structure repeatedly executed by the external while loop. The flat sequence structure consists of sub diagrams, or frames, that execute sequentially from left to right ensuring a well defined data flow. In particular in the block diagram shown in Fig. 7a the flat sequence consists of three frames which will be explained in the following. The first frame is associated to the application parameter setting. It permits to select the configuration (Conf.1 and Conf.2) in which the two multimeters have been inserted in the circuit, to set the GPIB addresses for the voltmeter and the ammeter (the two multimeters) and to set the voltage and current full scale for the two instruments by two knob controls. The selected full scale determines the uncertainty (or accuracy) of the instruments whose values are indicated in the related manuals and reported in the two case structures linked to the two knobs together with the selected full scale. This latter value is converted in a string format and passed to the next frames.

Fig. 3. The simulated Volt-Ammeter method GUI.

Fig. 4. Circuital schematization of the two possible insertions of the instruments: Conf.1 (a) and Conf.2 (b).
The next frame is devoted to the communication with the instruments: the voltmeter and the ammeter. Two stacked sequence structure consisting, each of them, of two subdiagrams executed sequentially, are enclosed in it. In the first frame the first subdiagram is shown while the second subdiagram is shown in the second frame. Essentially the first subdiagram of both the two frames sends a query to the multimeter having the specified GPIB address to require the measure of the voltage and current respectively. The communication with the instruments is implemented by two dedicated GPIB blocks. A first block, named “GPIB Write”, permits to send a query to the instrument: it require the specification of the GPIB address of the instrument and the string representing the command to execute using the SCPI (Standard Commands for Programmable Instruments). The second block named “GPIB Read” enable us to read the result of the command execution reading a specified number of bytes from the device having the indicated GPIB address. The command execution is monitored by the error out blocks which give information on the status of the communication. The last frame elaborates the data coming from the previous frames and shows the results. A subVI implementing the voltammeter method is used. Its block diagram has been reported in Fig.7b. It performs the data computation in order to estimate the resistance value taking in account the selected instruments insertion, the uncertainties and the auto-dissipation error.
3 Conclusions

The dramatic development of the technology requires updating the teaching work, which involves using different teaching techniques, advanced instruments, complex equipments, and also high-level software and distance learning. To overcome these pressing needs and to stimulate the interest in the students attending the lectures the authors are trying to introduce new hardware and software.

In this paper the experimental activity on the volt-ammeter method has been completely renewed and a LabVIEW® based tool has been presented. A future version of this tool will enable users to remotely perform the training via the internet network.

References: