

# Teaching Digital Voltmeter by Advanced Technologies

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*Abstract:* - In recent years the approach to the theoretical teaching and the practical training of the undergraduate students in the electrical and electronic measurement courses has received great attention, because the fast development of advanced technologies requires continuously updating the way of teaching electrical and electronic measurements. A tool for measurements on three-phase electrical system by using advanced technologies has been already realized in order to enable the students performing the experimental training.

This paper proposes an educational tool for better understanding the operation of the digital voltmeter based on double slope technique, the realization of a virtual instrument in the LabVIEW™ environment and the LabVIEW™ software.

*Key-Words:* - Digital instruments, Advanced technologies, Virtual instruments, LabVIEW™ environment.

## 1 Introduction

Undergraduate students can develop practical training by using driven measurement systems as well as by running simulation software. This approach is very useful for beginners because they can perform a valuable self-training on some theoretical aspects, can acquire a partial knowledge of problems connected with the real-world and hence can test their theoretical background.

The students can carry out experimental training in the lab for short periods because there are various difficult drawbacks, among them:

- the large number of students, arranged in small groups, requires an adequate didactic apparatus with a number of workbenches, equipped with a complete set of instruments;
- the number of available tutors is generally insufficient, which can dramatically reduce the quality level of the training;
- only the most important experimental activities can be carried out in the laboratory, for both the didactic burden and the reduced availability of the laboratory, as well as of the needed complex instruments.

Instrument simulators can therefore be used as a powerful didactic tool in order to verify and improve the theoretical knowledge. Moreover, simulation software can be updated, improved and quite easily modified.

Additionally, it should be taken into account the technological development, which reduces the mean life of an electronic instrument. Updating the set of instruments will drastically increase the cost

of the real-world training.

On the other hands, real experiments carried out by using real electronic components and circuits, on the basis of advanced technologies, “are relevant to more accurate training and to providing a better feeling to students about measurement procedures and measurement system design” [1, 2].

Recently, advanced technologies are widely employed to perform both educational tasks and laboratory sessions: among others, supervised systems, virtual instruments and remote controlled devices have become more and more attractive to overcome many drawbacks of traditional classes. An attempt has been made by the authors to improve the reliability and the availability of the experimental activity, in order to arouse the involvement of the students.

Taking into account the need of enhancing the availability of the laboratory, the perspective of the distance learning has also been investigated: for this purpose, a virtual instrument for the remote control of a set of instruments has been already realised [3].

A hardware/software tool representing a key point in the topic of remote laboratory sessions has been presented: it requires a poor laboratory assistance and reduces the loss of time due to rough inconveniences. Indeed, it consists of a totally PC controlled board, and implements suitable circuits designed for carrying out basic experimental sessions for training of the undergraduates [4].

A particular group of undergraduates includes the students

in the electrical engineering area. Obviously, training on measurements to determine the characteristics of the three-wires three-phase electrical system is very useful for them: 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 acceptable training in the laboratory is needed, in spite of difficulties and, additionally, safety risks. An extended availability of the lab set-up is worthwhile in this case. Therefore, an accurate analysis has already been performed on the possibility of remotely controlling connected instruments, and a complex tool has been realized. It has been recently presented and is synthetically

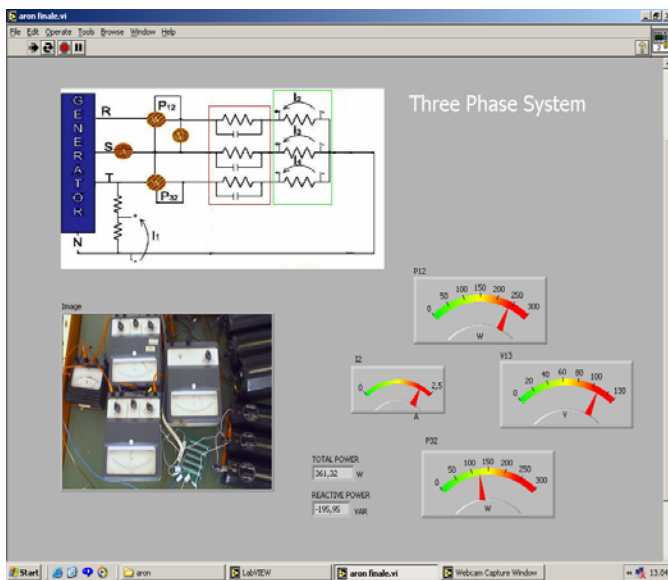


Fig. 1: Image of the tool on the remote monitor.

shown here (fig. 1) in order to emphasize the effectiveness of the use of advanced technologies [5].

The remote user will have the documentation on the various pieces of software realized on purpose, can read a theoretical report, can view the schematic plot of the three phase system, can view the analogic instruments located in the laboratory (on the left hand site of the figure the image acquired by the web-cam located in the lab is shown).

Moreover, the software implemented in LabVIEW™ realizes the virtual instrument and the results are shown on the same figure. It is important to observe that the digital virtual instruments on the right appear to be a replica of the analogic instruments, so the remote user can compare the values displayed by the two sets of instruments, which is a god result of the implemented tool.

The impressive improvement of the advanced technologies has deeply modified the teaching requirements, not only as regards the specific topics but, more generally, the overall pedagogical activity.

Indeed, the cultural background of the students is changing year by year, therefore the didactic planning of the courses in the measurement area, the methodology and also the hardware to be used in the lab, need to be modified.

New instruments are becoming more and more complex, miniature, multipurpose, then it can be difficult teaching “how to use”.

Nevertheless, teaching “how it operates” is very important, at least for basic functional circuits, among them the (A/D, voltage-time) converters, frequency meters, double-slope digital voltmeters.

Moreover, there is an important software, the LabVIEW™ environment, widely used for the implementation of virtual instruments. The undergraduates should learn to use this software.

Teaching activity includes many subjects, therefore an effort is required to optimise technical burden, number and quality of subjects, characteristics of the students and time shortness.

The outlined difficulties can be unlikely overcome in some cases, in particular when the students haven't a good command of the basic elements.

As a meaningful study case, the problem of teaching the digital voltmeter by using advanced technologies has been taken into account. The expectation of this work is to provide clear ideas to the undergraduates and to give a “self-aid” to the students, as an additional private lecture.

The features of the procedure designed and developed in this study are presented in the next sections, as it is shown in fig. 2.

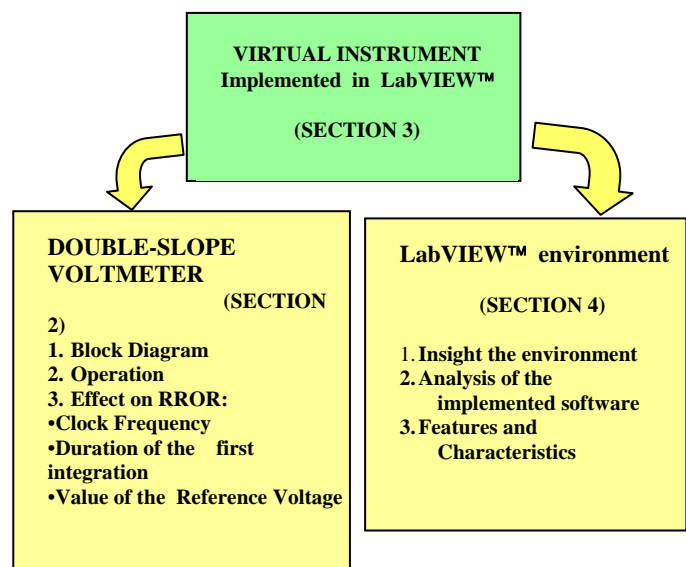


Fig. 2: Features of the implemented procedure.

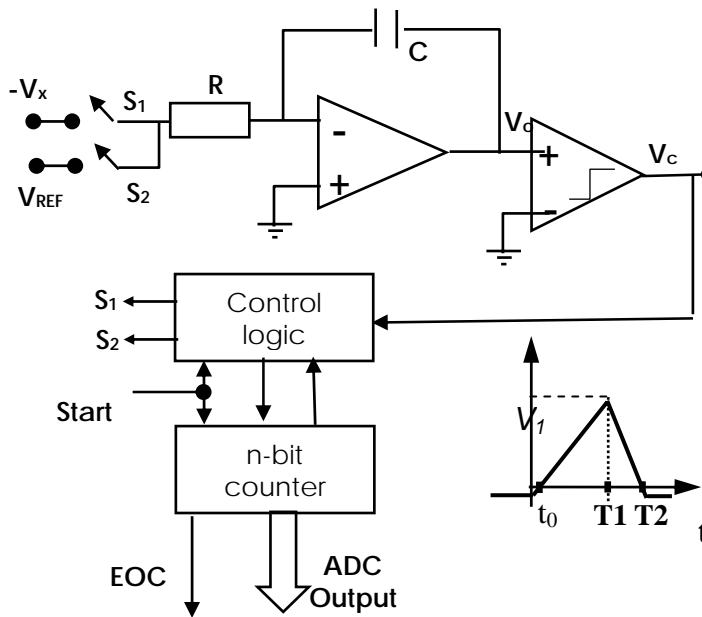


Fig. 3: Block diagram of the double-slope voltmeter.

## 2 The Digital Voltmeter

The central devise of the realized procedure consists of the virtual instrument which works like a digital voltmeter based on the double-slope technique. The simplified block diagram of the voltmeter is shown in fig. 3.

The well known operation is presented to the students during lectures. The virtual instrument, implemented in this work, enables the students to deeply understand the various aspects and the features.

## 3 The Virtual Instrument

The virtual instrument has been developed by a group of undergraduates in Informatics during some guided practical trainings.

Indeed, it works according to the following sequence:

- to start with, the “unknown” value of the voltage will be settled and applied at the input of the integrator;
- the integration of this voltage will be carried out for a fixed time interval;
- than, the reference voltage will be applied at the input terminal of the integrator, therefore the second integration phase will be performed;
- at the end of this step the measured value of the unknown voltage is presented on the display of the virtual instrument.

The front panel of the virtual instrument is shown in fig. 4: the suggestion and instruction sections are noticeable.

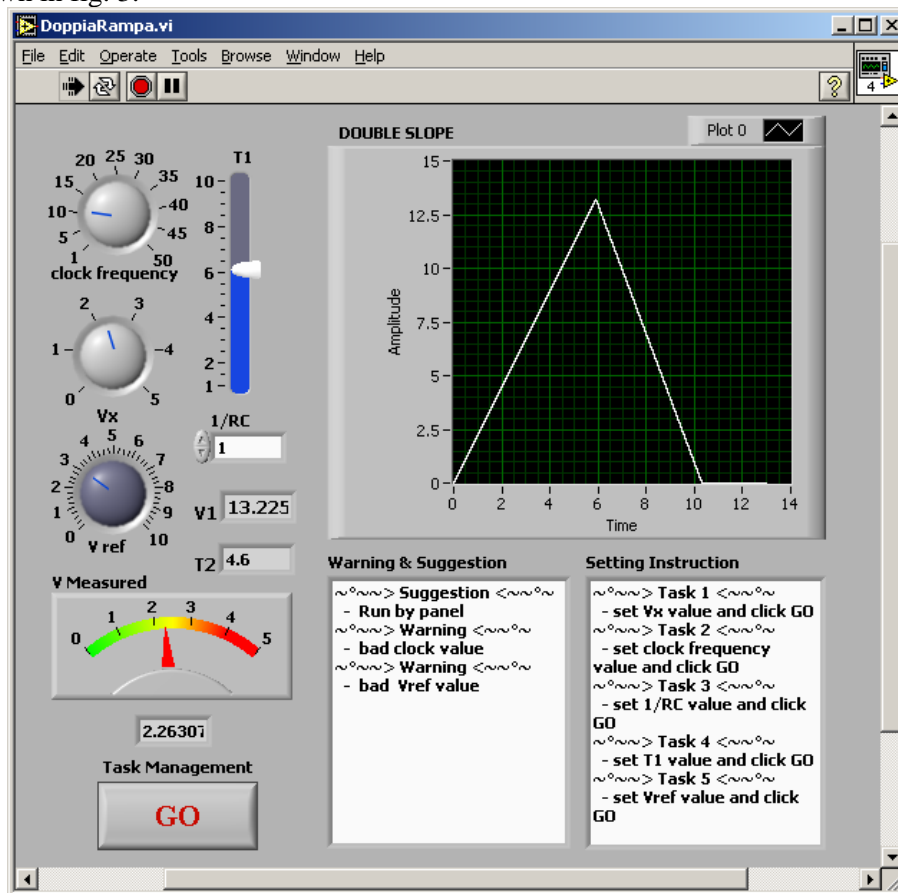


Fig. 4: Front panel of the virtual instrument.

The student can perform many tests, in order to understand the working operations of this virtual instrument.

In particular the student can:

- choose different values of the voltage to be measured;
- vary the time interval of the first integration;
- modify the value of the reference voltage;
- change the frequency of the clock.

These experiments will help the student to understand the operation of the virtual instrument. Therefore the real operation of the digital voltmeter should be clear enough for the user. Indeed, his training is guided by the virtual instruments in a try and verify procedure. The effect of each choice can be immediately examined.

Additionally, the student can find an other on-line help: indeed, he can read a report on the various theoretical aspects under study.

The various functions that can be performed by the implemented tool are emphasized in fig. 5.

The two sections, labelled “warning and suggestion” and “setting instruction” are to be underlined: in fact the student is guided in his training activity, preventing feasible errors.

As far as the error problem is concerned, in this work theoretical considerations can be found in

the report, partially verified on the basis of the obtained values of the measured voltage.

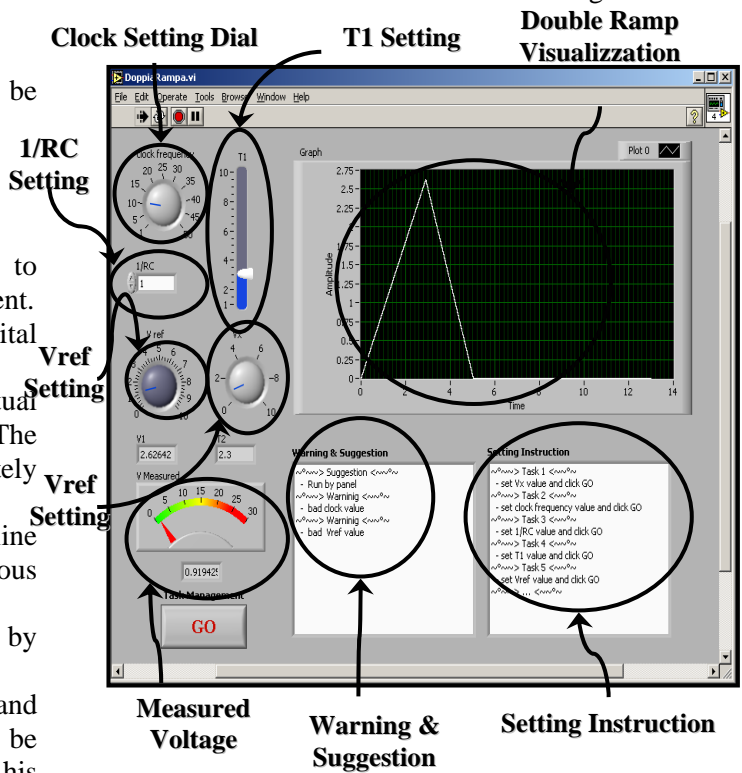


Fig. 5: The functions performed by the virtual instrument.

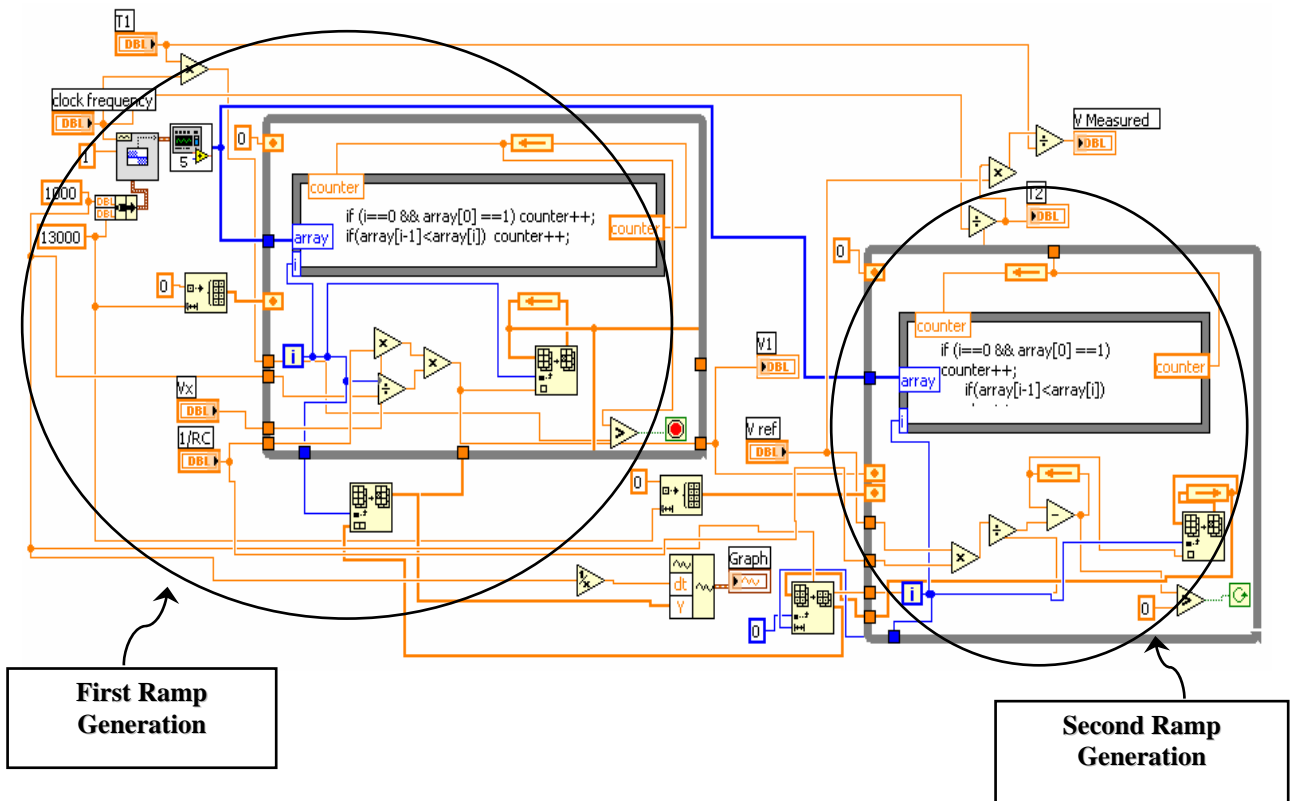


Fig. 6: Block diagram generated by the LabVIEW™.

## 4 The LabVIEW™ environment

It is well known that LabVIEW™ is a general-purpose programming environment; it includes libraries for data acquisition, memorisation and elaboration, for control of programmable instruments, and also functions for program development. It generates programs in the form of block diagrams. Fig. 6 presents the block diagram generated for the implementation of the realized virtual instrument.

In the first approach with LabVIEW™ the undergraduate can analyse this implementation as a study case and can learn how to use some functions. Of course, in case of needs the student can refer to the user manual [6].

As an example, the following considerations can be drawn.

The Block Diagram consists of two main parts:

1. The first slope generation, where a *while loop* is used to allow integration of the unknown voltage. Inside the loop a *formula node* is used to realize a counter to allow stopping of integration after the time interval  $T_1$ , therefore the loop is stopped after the signal integration. This block is controlled by the input parameters  $V_x$ ,  $1/RC$  and  $T_1$ , and gives the obtained output parameter  $V_1$ , that controls the *while loop* of the second slope generation.

2. The second slope generation, controlled by the input parameters  $V_1$  and  $V_{ref}$ , allows integration of reference voltage: the procedure will be stopped when the integrated signal crosses the zero.

To generate the clock a *square waveform generation block* is used, its frequency can be controlled by the *knob* in the *front panel*.

Each block consists of:

- a *while loop*, iterating the instruction set, the stop condition is controlled by a *compare block*;
- a *formula node*, implementing a counter, controlled by the *loop iteration* of the *while loop*;
- a set of *numeric operator* to calculate the integrated voltage at each iteration;
- an *insert to array* to generate the signal to be shown in the *graph indicator* placed in the *front panel*;
- a *compare block*, used to generate the stopping condition.

The two slopes generated in the *while loop* are attached through the *insert to array* block placed out of both loops, and the signal is generated by a *set waveform component* block placed to control the *graph indicator*.

## 5 Conclusion

Didactic developments taking into account the technologic improvements are the main purpose of this work.

An educational tool has been presented. It has been designed for better understanding the operation of the double slope based technique digital voltmeter, on the basis of a virtual instrument, used for training on the operation of the digital voltmeter.

For additional information on digital voltmeters the students can have a look in

<http://en.wikipedia.org/wiki/Voltmeter>

[http://www.facstaff.bucknell.edu/mastascu/eLessons\\_HTML/Interfaces/ConvDVM.html](http://www.facstaff.bucknell.edu/mastascu/eLessons_HTML/Interfaces/ConvDVM.html)

<http://www.hp9825.com/html/dvms.html>

The virtual instrument has been implemented in LabVIEW™ and gives to the undergraduate the opportunity to approach such environment in a study case. The LabView user guide [6] will be helpful for the students.

The proposed procedure will be improved in the future work, mainly taking into account the analysis of the errors.

### References:

- [1] L. Benetazzo, M. Bertocco, F. Ferraris, A. Ferrero, C. Offelli, M. Parvis, V. Piuri, *A Web-Based Distributed Virtual Educational Laboratory*, IEEE Trans. on Inst. and Meas., vol. 49, No. 2, p. 349, 2000.
- [2] F.J. Jimenez-Leube, A. Almendra, C. Gonzalez, J. Sanz-Maudes, *Networked Implementation of an Electrical Measurement Laboratory for First Course Engineering Studies*, IEEE Trans. On Educational, vol.44, N.4, p.377, 2001.
- [3] B. Andò, S. Baglio, N. Pitrone, *Remote Connection for Extended Availability of the Educational Lab*, Proc. of IMEKO World Congress 2001, Budapest, 2000.
- [4] B. Andò, S. Baglio, N. Pitrone, *New Trend in Laboratory Sessions*, Proc. of the 12th IMEKO TC4 International Symposium, Zagreb, 2002.
- [5] S. Baglio, P. Barrera, N. Pitrone, N. Savalli, *Developments on Three-Phase System Measurements by Advanced Technologies*, WSEAS Trans. on Advances in Engineering Education, Issue 2, Vol. 2, April 2005, pp. 127-134.
- [6] LabView user guide, National Instruments [www.ni.com](http://www.ni.com).