

Teaching Digital Devices by using Virtual Instruments

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Abstract - In recent years the approach to theoretical teaching and 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. As far as digital instruments are concerned, only a theoretical support is generally supplied. It is very important to deeply understand the operation of the basic digital instruments, the frequency meter and the dual-slope voltmeter. This task can be achieved by the approach suggested in this paper: indeed, an educational tool has been realized; it consists on flexible virtual instruments developed in the LabVIEW™ environment. In this way, features and performances of the instruments can be carefully analysed by the students.

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

I. Introduction

The undergraduate students can perform experimental training in the lab for short time, due to various severe difficulties, among them:

- because of their large number, the students are suitably grouped, which requires an adequate experimental apparatus with a number of workbenches, equipped with a complete set of instruments;
- the number of available tutors is generally insufficient, consequently the quality level and the availability of the lab can be dramatically reduced;
- for both the didactic burden and the reduced availability of the laboratory, only the most important experimental activities can be usually carried out in the laboratory.

The 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 self-training, can acquire a limited hands-on experience with some problems correlated with the real-world experiments and hence they can test their acquired theoretical knowledge.

The technological development reduces the mean life of the electronic instruments, therefore updating the experimental apparatus will drastically increase the cost of the real-world training.

Anyway, real experiments carried out by using real electronic components and circuits are relevant to more accurate training [1].

In the last years, an attempt has been made by the authors to improve the availability of the experimental activity and to stimulate the interest of the students, therefore they tried to widely employ advanced methodologies (supervised systems, virtual instruments and also remotely controlled devices) to perform both educational tasks and laboratory sessions.

On the perspective of distance learning, a virtual instrument for the remote control of a set of instruments has been already realised [2]. A tool for remote laboratory sessions has been presented: it consists of a totally PC controlled board and requires a poor laboratory assistance and reduces the loss of time due to roughly inconvenient. It includes the panel for the configuration of the software for the remote control of the developed board [3]. In fig. 1 the blocks of the realized system are shown.

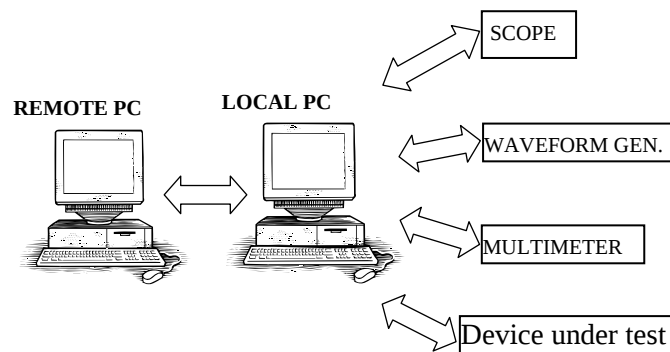


Fig. 1: Tool for remote measurements.

A suitable approach to the digital technology is very important for the undergraduates in the electrical engineering area: for these students it is very useful training on measurements to determine the characteristics of the three-phase electrical system; indeed, they can acquire a deep knowledge of the various theoretical aspects in the different load conditions, as an introduction to the power system analysis. For this reason, an extended availability of the lab set-up for an useful training is needed. Therefore, a complex tool has been realized for remotely controlling connected instruments. It has been recently presented and the front panel is shown in fig. 2. It emphasizes the extended use of advanced technologies [4].

The software has been implemented in LabVIEW™ and realizes the virtual instrument, which computes the electric quantities on the basis of the data collected by the data acquisition board.

The remote user can have an outlook to the traditional analogic instruments located in the laboratory (as shown in the figure acquired by the web-cam) and can analyse the solutions adopted for connecting the analogic instruments with the digital world.

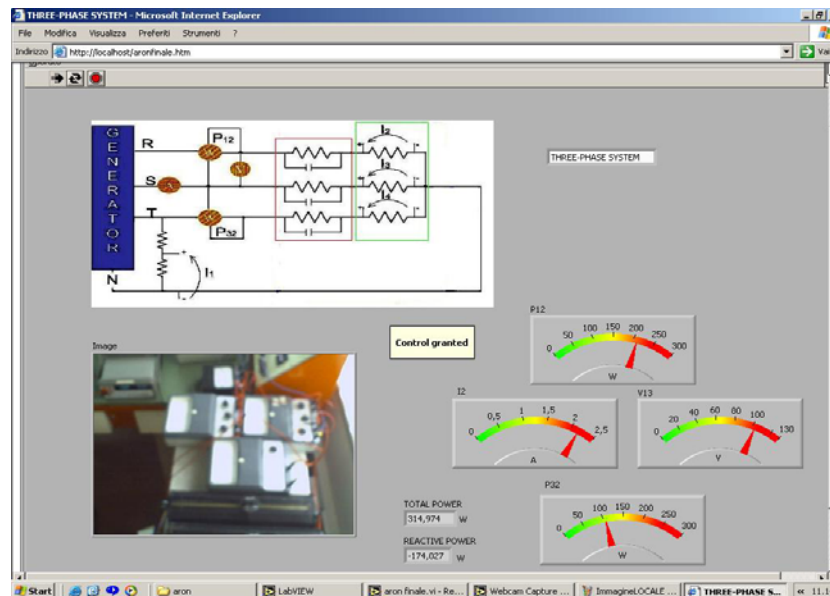


Fig. 2: The front panel observed by the remote user; the image of the web-cam shows the instruments located in the lab.

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

Indeed, year by year the cultural background of the students is changing, 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 complex, miniature, multipurpose, then it can be difficult teaching “how to use” them, nevertheless, it is more important teaching “how it operates”, at least as it regards some basic circuits, among them the frequency meter and the double-slope digital voltmeter.

In the internet a theoretical dossier is available [5], but it isn’t adequate to deeply understand the operation.

Moreover, the undergraduates should learn to use the LabVIEW™ environment, very useful for implementing virtual instruments.

In this paper the problem of teaching the operation of the frequency meter as well as of the digital voltmeter by using advanced technologies has been taken into account and the expectation is to provide the undergraduates with helpful tools for training on the operation of these digital instruments.

Some features of the procedure designed and developed are presented in the next sections.

II. The Basic Digital Instruments

The first device considered in this paper is the frequency meter: its simplified block diagram is shown in fig. 3.

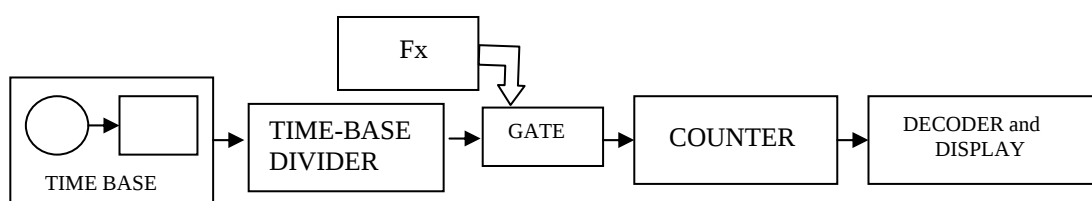


Fig. 3: Block diagram of the frequency meter.

The second device taken into account is the digital voltmeter based on the double-slope technique. The simplified block diagram of the voltmeter is shown in fig. 4.

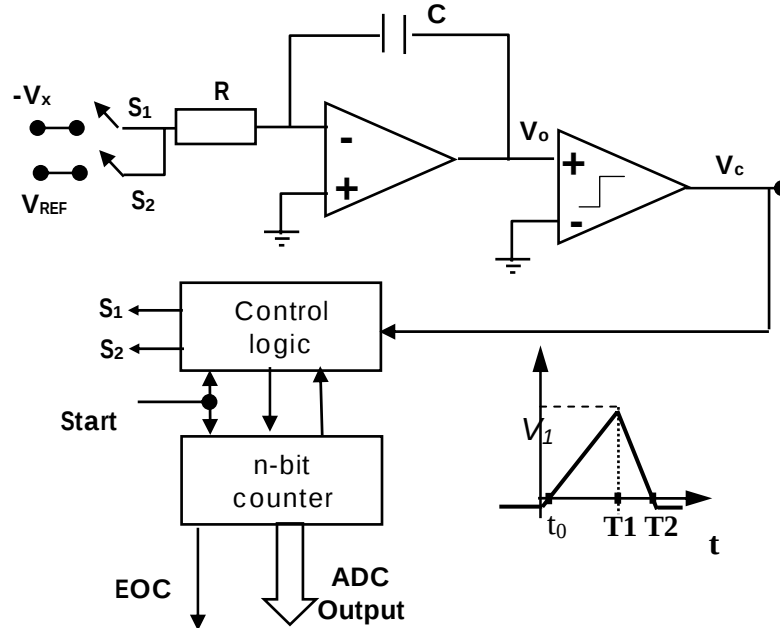


Fig. 4: Block diagram of the double-slope voltmeter.

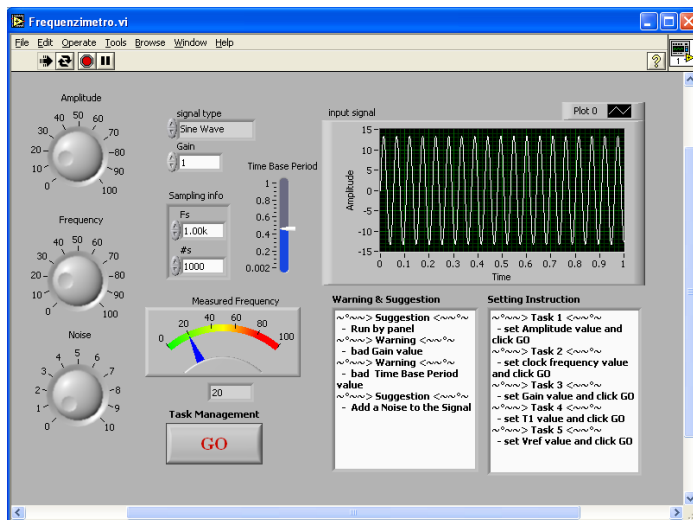
III. The Virtual Instruments

The realized tool includes two virtual instruments in the LabVIEW™ environment, designed in order to provide the students with a smart simulation apparatus which allows to highlight the effect of different choices of the values of the electric quantities, characterising the behaviour of the real instruments.

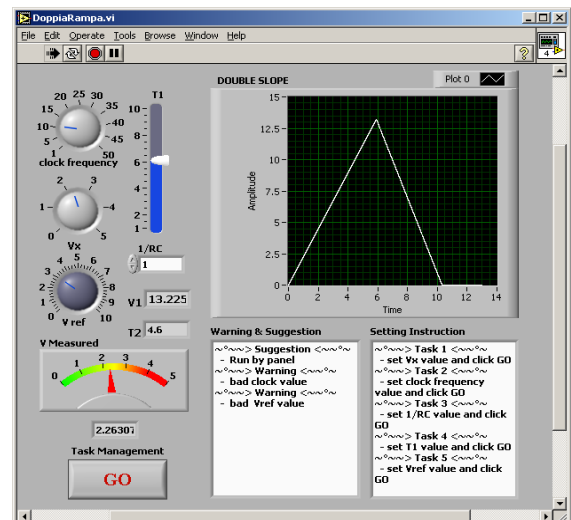
The front panels of the two virtual instruments are shown in fig. 5.

At the beginning of the training the user chooses the “unknown” values of the frequency and of the voltage, respectively.

Training up in the frequency meter virtual instrument, the user can settle on the frequency of the time-base and the number of decade dividers. He can understand the effect of changing these values, according to the theoretical statements. During the practice, the user will be supported by the software: indeed, two sections have been implemented and are shown on the front panel, the “Warning and Suggestion” section and the “Setting Instruction” section.



(a)



(b)

Fig. 5: Front panels of a) the frequency meter and b) the voltmeter.

As far as the double-slope digital voltmeter is concerned, it is well known that the values of the following quantities characterise the features of the real instrument: the clock frequency, the time interval of the first integration, the time constant of the Miller integrator, the reference voltage for performing the second integration.

In order to understand the working operation of the instrument, the student can choose different values for each of the previous quantities and can test the effect of his choice.

Moreover, his training is guided by the virtual instrument in a try and verify procedure. The two sections, labelled “warning and suggestion” and “setting instruction” will guide the student in his training activity. Additionally, the student can find an other on-line help: indeed, he can read a report on the various theoretical aspects under study.

IV. The LabVIEW™ environment

As it is known, LabVIEW™ is a general-purpose programming environment; it includes libraries for data acquisition, memorisation and elaboration, for control of programmable instruments, and functions for program development. Programs are generated in form of block diagrams. As an example, the Block Diagram of the double-slope digital voltmeter is shown in fig. 6.

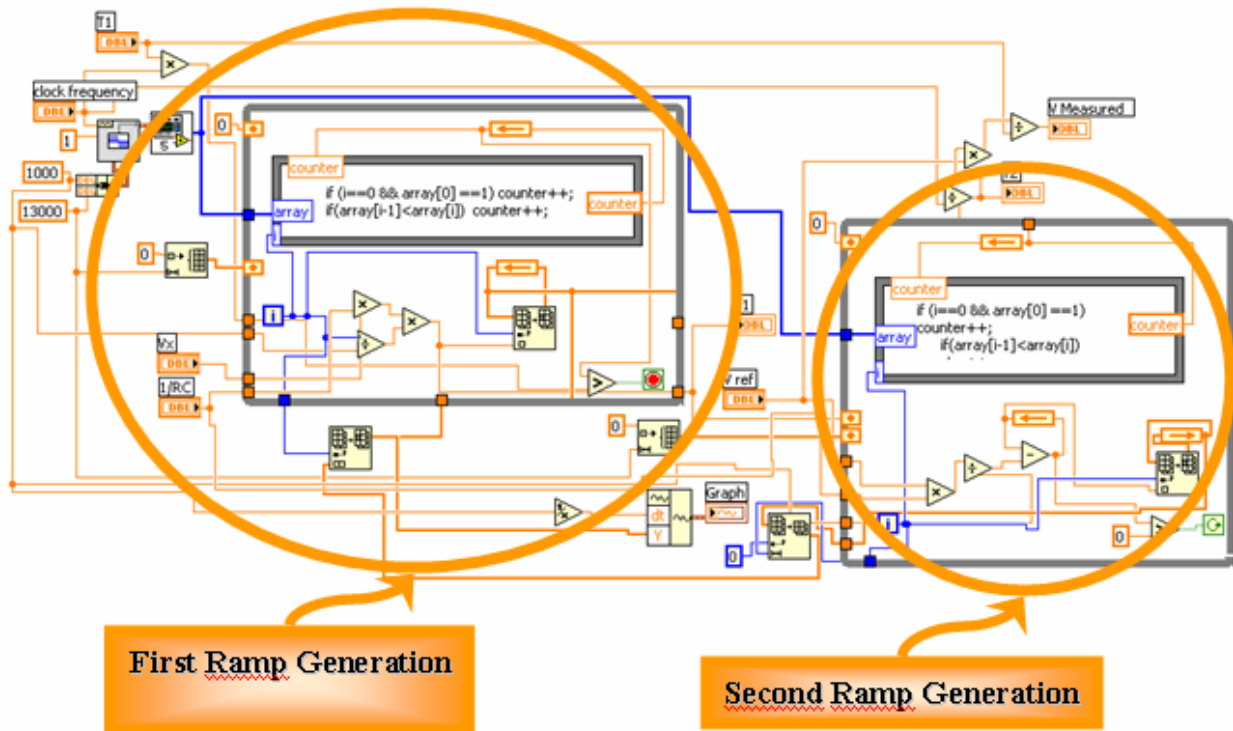


Fig. 6: Block Diagram of the digital voltmeter.

The undergraduate should learn the characteristics and the main instructions of this software: as a first approach with LabVIEW™ he can analyse some pieces of programs already implemented and therefore he will be able to directly use some functions. Of course, the user can refer to the LabVIEW™ user guide[6] in order to improve his knowledge.

The analysis of the previous block diagram emphasizes the following considerations: indeed, it 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 T1, therefore the loop is stopped after the signal integration. This block is controlled by the input parameters Vx, 1/RC and T1, and gives the obtained output parameter V1, that controls the second slope generation *while loop*.
2. The second slope generation, controlled by the input parameters V1 and Vref, allows integration of the reference voltage and stops the procedure when the value of the integrated signal becomes 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 show 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*.

V. Conclusions

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

An educational tool has been presented, mainly oriented to experimental training of undergraduates in the area of electrical engineering; it has been designed for better understanding the operation of the basic digital instruments (the frequency meter and the double slope based technique digital voltmeter) on the basis of virtual instruments, used for training on the operation of those devices. The virtual instruments have been implemented in LabVIEW™. The analysis of the implemented programs can also give to the undergraduate the opportunity to approach such environment in a study case.

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