The Study of Electrical Resistance Measurement Methods using Virtual Instruments

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Abstract: - Measurement and automation technology were changed once the National Instruments company introduced the concept of virtual instruments, using the graphical programming LabVIEW (Laboratory Virtual Instrument Engineering Workbench). LabVIEW, originally developed for the measurement and automation technology, has been advancing more and more as an alternative to conventional programming languages. This graphical programming represents crucial reading and work for instructors, scientists, students, hardware and software developers, and decision-makers in research, academia and industry [10,12]. This article presents theoretical considerations regarding electrical resistance measurement in D.C. circuits and applications for their study and analysis using the LabVIEW graphical programming. By combining the meta-cognitive strategies with interactive work procedures, by the efficient use of the computer in the simulation of certain phenomena specific for the diverse scientific disciplines, the academic staff builds increasingly motivating learning experiences, stimulating the students to progress increasingly faster in their learning, providing them with the necessary framework for an authentic, sequential learning, resulting in flexible acquisitions, able to be transferred and valorized in different theoretical and practical contexts.

Key-Words: - LabVIEW, virtual instruments, competences, academic learning, computer-assisted training

1 Introduction

Computer-aided teaching tools have turned out to be an indispensable element of both classroom lectures and laboratory experiments. The application of market-ready mathematical and database programming software for teaching engineering course outline is well appreciated.

This paper presents the utilization of *LabVIEW* Laboratory Virtual Instrument Engineering Workbench in the study of measuring methods for electrical resistance.

In the areas of engineering education due to various shortcomings of the traditional laboratories, virtual laboratories have appeared as a potential alternative to traditional laboratories [16].

For more than 10 years, LabVIEW has revolutionized the way engineers and scientists in industry, government, and academia approach measurement and automation. Leveraging PCs and commercial technologies, virtual instrumentation increases productivity and lowers costs for test, control, and design applications through easy-to-integrate software, such as NI LabVIEW, and modular measurement and control hardware for PXI, PCI, USB, and Ethernet. With virtual instrumentation, engineers use graphical programming software to create user-defined solutions that meet their specific needs, which is a great alternative to proprietary, fixed functionality traditional instruments. Additionally, virtual instrumentation capitalizes on the ever-increasing performance of personal computers. For example, in test, measurement, and control, engineers have used virtual instrumentation to downsize automated test equipment (ATE) while experiencing up to a 10 times increase in productivity gains at a fraction of the cost of traditional instrument solutions. Because LabVIEW has the flexibility of a programming language combined with built-in tools designed specifically for test, measurement, and control, you can create applications that range from simple temperature monitoring to sophisticated simulation and control systems. No matter what your project is, LabVIEW has the tools necessary to make you successful quickly [10,12,17].

Virtual instrumentation is applicable in many different types of applications, starting from design to prototyping and deployment. The LabVIEW platform provides specific tools and models to solve specific applications ranging from designing signal processing algorithms to making voltage measurements and can target any number of platforms from the desktop to embedded devices – with an intuitive, powerful graphical paradigm.

It is indispensable to emphasize the engineering education curriculum with computer-aided teaching tools that are interactive as well as educational, in order to keep sustainable interest in the learning process for the students. For these reasons LabVIEW, a graphical programming language was introduced to initiate the modifications in teaching methodology.

LabVIEW is a graphical programming language that shares some aspects with traditional non-graphical programming languages (C, Pascal etc.) and some aspects of hardware definition languages (VHDL, Verilog). Namely, it combines the generality and power of traditional programming data structures such as loops, if-then branches, and arithmetic operators with the ability of hardware definition languages to perform simultaneously multiple tasks.

2 Generality

We are now witnesses of a process of radical change of the world we live in, a process going on so fast that it is sometimes hard for us to recognize yesterday's world in the world of today. Knowledge, globalization and IT represent basic coordinates of the contemporary society.

The exponential development of the new informational and communicational technologies has created the premises of the post-industrial society, where the classical raw matter diminishes its importance, being replaced more and more by knowledge, the economic life depending to an overwhelming extent on it.

Change and competition have become features of nowadays society, imposing on all levels of our existence, from the macro social one to the one of the professional organizations and finally to the individual one, attitudes characterized by dynamism, flexibility, openness, innovations and rapidity in the assimilation of the technological progress. In this context, the "intellectual capital" enters in competition on the "markets of knowledge", creating new horizons of demand concerning the products of education.

In such a dynamic context, education can no longer remain inert, but must take on this change despite the traditionalism, the rigidity and the routinely style often manifested by the teaching staff.

Modern education should assume the development of the learner's autonomy, so that the differences between the world of education/of the university/of the didactic process and the real (social, professional) world may be significantly reduced.

Universities, the main trainers that begin the formation of experts, of professionals who will exercise their roles in different activity domains, must experiment the change, beginning with the way finalities (goals) are projected (in terms of competences) and ending with the remodeling of the evaluative processes. All these need to happen while ensuring a high-quality educational process, because only a high-quality academic education can represent the guarantee of social progress and also of the individual progress of each internal beneficiary.

The mission of higher education is, according to the *Quality guide in higher education* (the CALISRO project), that of answering the individual's specific educational and professional training needs and the community's social and economic needs [2]. Such a goal cannot be accomplished but to the extent to which these needs are satisfied at a high standard of quality, allowing both the individual and the society to perform in an environment characterized by competition and dynamism.

In this context, the change, the modernization of the educational process that is taking places in higher education no longer remain simple desires, declarative needs but also responsibilities that we need to assume.

The present study starts from the premise that to satisfy the requests and expectations of the academic education's beneficiaries it is necessary to conceive and to organize a student-centered didactic approach, promoting interactive didactic strategies, the new information and communication technologies, computer-assisted training etc.

So, as professor I. Neacsu demonstrated, the academic learning environment must allow and be characterized by:

• a intelligent and professionalized organization of knowledge;

• a regulation of the strategies of communication in agreement with the knowledge of the students' social, cognitive, emotional and spiritual needs, expressed in the lookout for the sense of the study, in interrogations, in hypotheses, in direct or mediated interactivities;

• the increase of the student's relation with the object of his learning/study, which must become deeper, more synthetic, more diverse, more integrative, more applied and oriented towards public transparency ;

• introduction of new components in the independent academic learning paradigm [13].

In this way is promoted a culture of independent academic learning, which has become not just a component, but also a standard for the quality of: the training processes and its products (students, graduates), the satisfaction, effectiveness, efficacy and competitiveness of the university.

So, we need a change of paradigm – from the model of the teacher who teaches the student we must move on to the model of the student who learns from the teacher, becoming active, learning in interaction with the others, acting, experimenting, formulating problems, hypotheses, elaborating solutions, trying, investigating, and above all, actually doing what the teacher would only teach him/her to do. The academic staff no longer has only the mission to provide informational messages, to provide the students with ready-made knowledge, its main responsibility being that of creating an attractive, interesting, motivating, efficient educational environment, by projecting didactic strategies within which they valorize the new technologies, computer-assisted training, learning through discovery and cooperation, simulation, etc., allowing the student to build his/her own knowledge and to train/develop those competences that will recommend him/her as a future specialist, with expertise in his/her domain.

The issue of competences has actually been one of the most approached and analyzed lately, generating a new model of curricular projection focused on the final acquisitions of learning and on the practical dimension of the student's personality [5].

M. Savu-Cristescu [15] has analyzed the effects produced by the orientation towards the model of curricular projection centered on "competences":

- moving away from the former focus of the traditional model of curriculum, where the structure was given by themes/contents that were supposed to be covered in a number of hours and which practically meant a focus on teaching (on the teacher) and on the assimilation of knowledge;
- focusing mainly on learning, which is no longer understood as a simple assimilation of knowledge, but as formation of capacities and attitudes;
- elaborating and introducing in the analytical programs the main – professional and transversal – competences, ensuring in this way a connection between the curriculum and the evaluation.

The competence-centered model generates in this way a higher efficiency of the teaching-learning-evaluation processes.

Competence is defined as a "mix of <<savoir-faire>> and <<savoir-être>> allowing the adequate realization of a role, of a function or of an activity" [7]. Competence, as a synthetic educational result, is hard to obtain and also to assess. "It is obtained through intensely formative learning-teaching and is also evaluated formatively" [15], which supposes going through the trajectory teaching-learning-evaluation-self-evaluation, both on the level of the teacher's activity and especially of the student's activity.

Competence is identified by the philosopher H. Dreyfus as a stage in the paradigm "expert - novice". If the behaviors of the "experts" and those of the "novices" are carefully observed, mentions the quoted author, a significant qualitative distance is noticed between the ways how the problems they have to solve are approached and then dealt with by the two categories. The traditional perspective on the cognitive strategies used by experts to solve a problem points out that they start from the deep knowledge of the particular situations, complex but concrete (in the didactic process – learning situations) and then gradually get to formulate the higher order rules, the general principles or laws that could be applied after understanding the new situations.

In the academic type of learning, the students' level of development (the stage of their abstract, formal thinking) obliges us to look at the acquiring of "savoir-faire" in the opposite order, which means "the passage from abstract rules to particular cases" [9].

Competence once formed/acquired gives the student the possibility to plan his intervention, which means a way to treat, to order, to organize the action hypotheses, namely to pass to the decisional stage, through the more or less efficient interiorization of certain rules. This stage represents the debut of the expertise and is characterized by the subject's personal engagement in the failure or the success in relation to the aim he/she set himself/herself. The moment when he/she faces difficulties in reaching a goal, the competent executer feels responsible for the result of his/her choice, which also involves him/her emotionally. Only a positive result will satisfy the subject, as he/she has the powerful memory of the situations that he/she managed to solve correctly, and failures are not easily forgotten either.

Familiarized with increasingly successful experiences, the student becomes competent, which signifies that he/she has appropriated the action rules associated to the almost unconscious perception of the most pertinent features of the given situation, leading to the automation of the answers. On a higher level, the experience gets amplified and the subject retains it in numerous configurations, which increases his/her ability to solve it. The situation is perceived as a whole, and its "indicators" orient the expert towards the choice of the "routines" that he/she executes automatically. In this last stage, the "competence on the level of expertise", the situation to be solved is evaluated based on a few pertinent indicators that the brain discriminates in record time; what defines the expert's behavior is an evaluation based on the automatized comparison of the situation with the class of already encountered previous situations.

The informatization of the educational system, one of the main directions of modernization, allows the organization of learning experiences at the end of which the students will develop a series of cognitive, instrumental-applicative, and meta-cognitive competences.

By combining the meta-cognitive strategies with interactive work procedures, by the efficient use of the computer in the simulation of certain phenomena specific for the diverse scientific disciplines, the academic staff builds increasingly motivating learning experiences, stimulating the students to progress increasingly faster in their learning, providing them with the necessary framework for an authentic, sequential learning, resulting in flexible acquisitions, able to be transferred and valorized in different theoretical and practical contexts. By means of the didactic strategies based on action, application, research, simulation and experimentation is assured the development and the valorization of the students' cognitive, affective and actional resources, and they are allowed to actually do what they were only supposed to learn to do.

In this context, computer-assisted training represents, with all the risks involved if it is not adequately sized and used, a way of carrying out the teaching-learning process actually helping to:

- present the contents in an interactive and interdisciplinary way;
- exercise the formation of certain abilities;
- consolidate knowledge through repetition;
- simulate certain phenomena, processes, real actions;
- provide cognitive and actional models;
- stimulate motivation, curiosity and interest;
- evaluate knowledge, follow progresses;
- develop certain capacities and aptitudes;
- offer supplementary learning [14].

Beyond these functions, the computer is a training instrument appreciated by both the students and the teachers, as it allows the realization of differentiated and individualized teaching-learning approaches, respecting the students' different learning rhythms and styles, valorizing their resources and making them responsible concerning the results of their own learning.

In relation with teaching and learning, the assessment, especially the formative one, is an instrument for the regulation of the competence training process. This regulation supposes actions of remedy, being a "pedagogical device" by means of which the students are provided with new learning activities allowing them to diagnose, to fill their gaps of knowledge and to correct their errors. The regulation as action/set of actions exerted from the outside is gradually converted in self-regulation, according to the external feedback principle which generates the internal feedback, the self-control realized on the behavioral level.

Both of the partners of the educational act, the teacher and the student, constitute two distinct informational levels, each one giving and offering information, receiving and transforming it, adopting personal decisions concerning the orientation of the subsequent actions favoring the obtaining of the awaited results.

The feed-back acts as a tool able to change the own behaviour,having beneffic effects on the two partners involved in the process and on their commune action.

The adjustment is a process that allows the system to maintain its balance (stabilization adjustment) or to evolve to a superior level (development adjustment). Therefore, the focus is on the role of the evaluation as a "central processor", "the brain" of the didactic activity. Using specific methods and techniques, the assessor collects the information, processes and interprets it depending on the efficiency criteria, taking decisions which will help improve the aim, his activity and its results.

Analyzing the relations between teaching, learning and evaluation from the evolutionary perspective, one can notice significant changes which turn the evaluation into a special activity, whose amelioration function has been improved, in the same time as the control function has been diminished.

Focusing on the coordination of the modern evaluation, C. Cucos insists on the necessary distance between this process and the "classical" control of knowledge, or the assessment which is "traditional and is conceived as a way to perfection, presuming a global strategy of the educational process. The evaluation finds its meaning only when "it is confronted with the demand to provide the assessor with tools to adjust the learning." [6].

Therefore, the adjustment becomes the essential activity of the student. To adjust means to interfere into a system in order to improve it by the proper usage of the information. The adjustment is the whole process of improving, aiming at the best function. Here appears the paradigm feed-back-adjustment, built around the concepts of purpose-information-adjustment, the evaluation being a help for the learning process. The student takes an active part in the learning process, being placed on the trajectory: anticipated domination of the demarche in all its complexity-accomplishment-self-evaluation-self-adjustment.

In this process, the teacher must take three objectives into consideration, which are considered as criteria for his decisions: the conditions of the process (the resources), the procedures (processes) and the product, since the behavior of the students cannot be reduced only to the result, but the problem is far bigger, comprising the whole process leading to that result. Consequently, it is necessary for the teacher to inform the student not only on the criteria for evaluating the products, the results, the performances, but also the procedures which allowed him to obtain the results.

The term of "basis for the orientation of the action" can be helpful at this point. Galperin (1966) defined it as a ramified system of representations of the action and of its product, of the properties of the departure points and of the gradual transformations, of all the information which serve the subject in order to perform the action. He states that if the subject needs knowledge about the means that bring to the accomplishment of the purpose, in order to elaborate a rational basis of orientation, this is not enough. "If we want to guarantee the accomplishment of a purpose, based on a fully orientated ground, we need to provide the learner knowledge about each purpose, but we also need to improve his ability to analyze the purpose and make his own basis" [11].

Even if we cannot speak about a direct external adjustment of the process, being individual and unnoticeable, the teacher can perform an indirect action over the self-adjustment of the learner, starting with his own referentially and the information he receives.

The evaluation is not only "a look", but also "an act of listening", an "attention" to the other. In order to make the student to realize his own adjustment, he needs models of operations, of strategies, acting as interfaces between the procedures and the processes. All these models will help him in the process.

The student would have such a much easier life if the teacher explained his expectations, and defined the processes of understanding. Therefore the subject could use them, test them on his own cognitive and practical-active functions and also give feed-back to the evaluator.

The adjustment and self-adjustment would work here both ways. During the didactic process both partners get the role of external adjuster for the other, by valorizing the communication forms of teaching-learning-evaluating.

Then, the complex process of teaching -learning-evaluating-self-evaluating-self-adjustment become part of a continuum of acts in correlation and interaction.

Consequently, the knowledge and the use of the regulation-self-regulation mechanisms of the specific activity of the two partners in the didactic act constitute prerequisites for the improvement of the performances in learning, which in the situation under analysis represent specific competences for the theme approached in education.

Associated and even resulting from the accentuation of the formative side of education, the competences, both as "targets" and as "results", highlight more obviously the role of the teaching-learning processes, as perspectives of training and development, and of the assessment processes correlated to them, as perspectives for their memorization and consolidation.

At the same time, by means of computer simulations, the students are faced with diverse problems they can encounter in their daily life as well, becoming fully involved in solving them, using the best of their creativity, decisional capacity, resolving abilities or critical intelligence.

The gap between the academic world and its environment disappears in this way, and the students develop solid professional and transversal competences that they can easily transfer, later on, to their socio-professional environment.

Now, we will describe an interactive application realized in the Electrical and Electronic Measurement laboratory and later on we will prove its efficiency and its positive impact on learning, by presenting the data obtained following the micro-research we carried out.

In technique is necessary to measure different types of electrical resistance, often meet is: linear resistance, nonlinear resistance, parametric resistance, and dynamic resistance, resistance in D.C. or A.C. The difficulties in making of measurement methods and resource less are amplified by very large measurement range. It must assure contact resistance measurement $(10^{-8} - 10^{-7}\,\Omega)$ also of an isolation resistance $(10^{17} - 10^{18}\,\Omega)$. For every range, any measurement methods are specific, pursuing elimination of parasite resistance influence. From these above mentioned, it results that the measurement methods of electrical resistance have to be very varied and the choice of any method depends on the size order for resistance and on the accuracy with which is desired for the obtained result. The resistance can be measured by direct, indirect, comparative, bridges methods. In alternative current the resistivity for receiver is not constant, it varies with reversed stress, because the absorbed active power is modified with frequency, due to the existence of film effect, the proximity effect, the loses through back-set as well as hysterezis.

3 Direct methods – measurements with ohmmeter

Ohmmeters are used at electrical resistance measurements in very large range of values (Ω…MΩ) also at circuits continuity test. Their accuracy is low but the needs of measurement / rapid troubleshooting of circuits. There are frequently meet in multimeter structure and rarely as individual device (for high resistance measurement).

Analogical ohmmeter directly indicates the value of resistance measured with removal of a pointer in front of a graduated scale. Measurement is based at evaluation of the current that runs through the measuring resistance and the device scheme has to contain the magneto-electric instrument indicator, continuous power supply (battery, generator dc), resistors for protection and magneto-electric instrument for measuring change intervals.

Ohmmeters with serial scheme are the most spread, being used for the measurement of resistance in range $10-10^6\Omega$. Electrical scheme for the device is presented in figure 1. Power supply provides the voltage U, R_0 resistance is making null adjustment of the instrument magneto-electric (U not stabilized) and $R_1 \ldots R_n$ resistance are used for measuring the change interval ohmmeter.

Considering all switches open, the deviation of the instrument has the expression:

$$\alpha = \frac{U}{C_i} \frac{1}{R_0 + R_i + R_X} \tag{1}$$

Where the static characteristic $\alpha = f(R_X)$ has the hyperbolic character and the scale is non-uniform and reverse. The maximum deviation is obtaining for $R_X = 0$ (The switch K is closed):

$$\alpha_{\max} = \frac{U}{C_i} \frac{1}{R_0 + R_i} \tag{2}$$

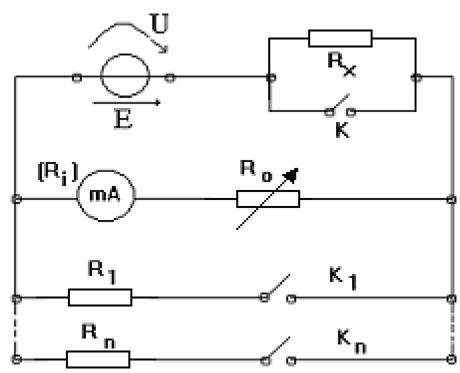

Fig. 1. Serial ohmmeter - diagram.

And minimum deviation is obtaining for $R_X \to \infty$, having the value $\alpha_{\min} = 0$.

Graduated scale device is reversed, the deviation $\alpha = 0$ corresponds to $R_X \to \infty$ and deviation $\alpha = \alpha_{\max}$ corresponds to $R_X = 0$. The adjustment at $\alpha = 0$ is made by variation of R_0 with K switch closed. The change of measurement range is made by introduction in circuit of one of $R_1 \ldots R_n$ resistance.

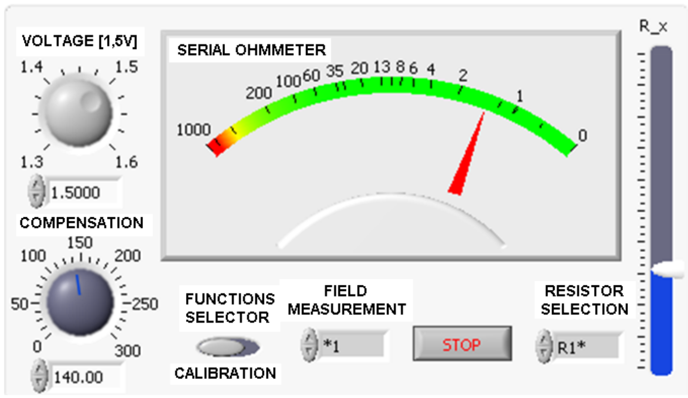

Fig. 2. Serial ohmmeter –LabVIEW application, front panel

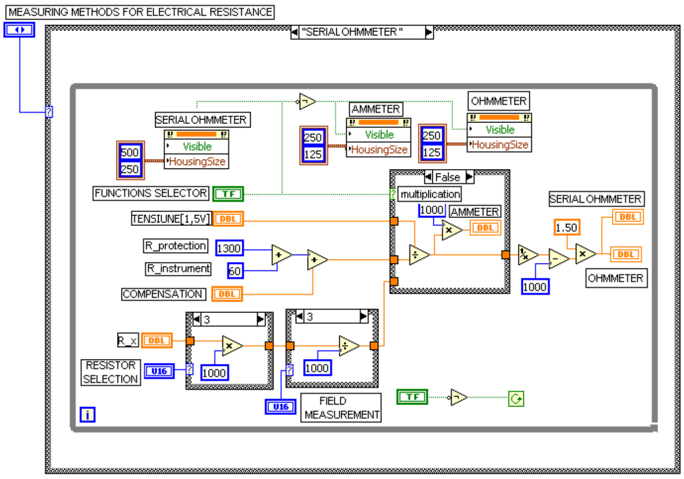

Fig. 3. Serial ohmmeter –LabVIEW application, block diagram

Graduated scale device is reversed, the corresponding deviation and the corresponding deviation.

For ohmmeter error calculation it must, considering that instrument magneto-electric device have a certain report error, conforming to accuracy class:

$$\varepsilon_{rI} = \frac{\Delta I}{I_{\max}} = \frac{\Delta\alpha}{\alpha_{\max}} \tag{1}$$

Because:

$$\Delta\alpha = \left| \frac{\partial\alpha}{\partial R_X} \Delta R_X \right| \tag{2}$$

Results:

$$\Delta\alpha = \alpha_{\max} \frac{R_0 + R_i}{(R_0 + R_i + R_X)^2} \Delta R_X \tag{3}$$

And relative error for resisting measure has the following expression:

$$\varepsilon_{rR_X} = \frac{\Delta R_X}{R_X} = \varepsilon_{rI}\,\frac{(R_0 + R_i + R_X)^2}{(R_0 + R_i)R_X} \tag{4}$$

The minimum of the error is obtaining for $R_X = R_0 + R_i$, so at the middle of the scale and has the value:

$$(\varepsilon_{rR_X})_{\min} = 4\varepsilon_{rI} \tag{5}$$

To extremity the error goes to the infinite. As result, for the measurement error of a resistance with serial ohmmeter to be smaller is necessary the choice of a measurement range so that the reading to be made in central area of a scale.

4 Indirect methods

4.1. Substitution method

Substitution method consists in unknown resistance comparison R_X with a known resistance R_e through ammeter or voltmeter. In figure 4 is indicated the measurement schemes, unknown resistance putted in parallel with a precision adjustable resistance R_e with a known value. The method involves two successive measurements, the resistance for measure R_X being replaced with resistance R_e, which is adjusted until the same indication of the device for both positions of switch K is obtained. The value for measurement resistance is equal with adjusted R_e resistance.

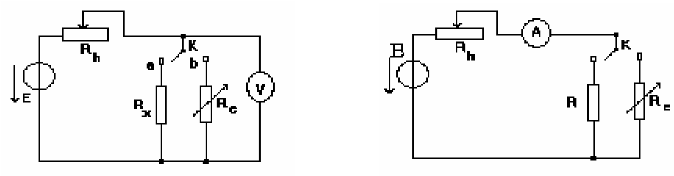

Fig. 4. Substitution method using: voltmeter, ammeter.

4.2. Indirect method of ammeter and voltmeter

The determination of resistance through this method is based by Ohm's law: $R_X = U_X / I_X$ It is necessary to be measured the voltage at the resistor terminals and inside current, then the resistance is calculated. After connecting mode of a voltmeter, it can be used upstream or downstream assembly.

In upstream assembly the result is:

$$R_X = \frac{U - U_A}{I} = \frac{U}{I} - R_A \tag{6}$$

If the unknown resistance is calculated only from both devices indications, without considering the internal resistance of ammeter, it is as a systematic error:

$$\frac{\Delta R_X}{R_X} = \frac{\frac{U}{I} - \left(\frac{U}{I} - R_A\right)}{R_X} = \frac{R_A}{R_X} \tag{7}$$

The error decreasing imposes condition such as $R_X \rangle\rangle R_A$, so the upstream assembly is used for big resistance measurements.

Using the right term, the relative error limit is:

$$\frac{\Delta R_X}{R_X}(\%) = \left(\frac{\Delta U}{U} + \frac{\Delta I}{I}\right)\left(1 + \frac{R_A}{R_X}\right)100 \tag{8}$$

Where:

$$\frac{\Delta U}{U} = \frac{c_V U_{\max}}{100} \tag{9}$$

$$\frac{\Delta I}{I} = \frac{c_A I_{\max}}{100} \tag{10}$$

represent the relative errors of the using devices.

For the upstream assembly:

$$R_X = \frac{U}{I - I_V} = \frac{U}{I - \frac{U}{R_V}} \tag{11}$$

The same for upstream assembly, the systematic error is:

$$\frac{\Delta R_X}{R_X} = \frac{\frac{R_X R_V}{R_X + R_V} - R_X}{R_X} = -\frac{1}{1 + \frac{R_V}{R_X}} \tag{12}$$

As that error to be small it is necessary to $R_X \langle\langle R_V$, so the upstream assembly is used for small resistance measurement. The relative error limit is:

$$\frac{\Delta R_X}{R_X}(\%) = \left(\frac{\Delta U}{U} + \frac{\Delta I}{I}\right)\left(1 + \frac{R_X}{R_V}\right)100 \tag{13}$$

Tacking into consideration some theoretical aspects an application has been made. This application gives the possibility for method analysis, having the following facilities: measurement range selecting at ammeter and voltmeter, the accuracy class of the devices selecting, tension and current change for measurement of different values resistance, measurement method selecting and specifying which method has to be used as well as the error calculation.

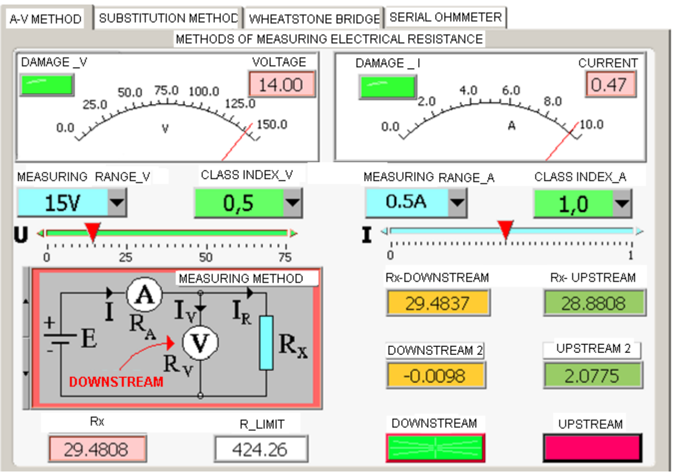

Fig. 5. Electric resistance measurement with ammeter and voltmeter LabVIEW application

The observations at that measurement method are:

- the errors are percentages so the method does not have a high accuracy;
- for minimal limit errors, at the resistance measurement with ammeter having the R_A resistance and with a voltmeter having the resistance R_V, it was chosen the assembly:

- upstream, if $R_X \langle \sqrt{R_A R_V}$
- downstream, if $R_X \rangle \sqrt{R_A R_V}$

- it is the only applicable to nonlinear resistance method (arc, incandescence lamps, discharge in gas pipes, semiconductors etc) also at internal resistance measurement of direct current sources.

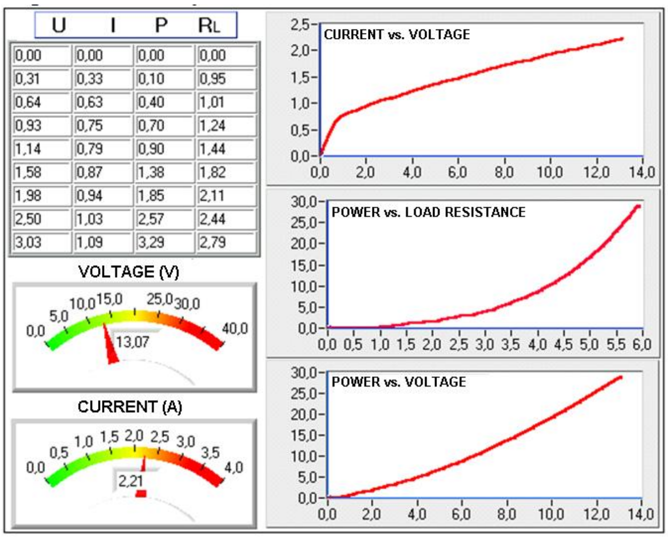

Fig. 6. The determination of not linear resistors characteristics – LabVIEW application

For example, figure 6 presents measurement and determination of electrical lamp with incandescence characteristics for the cars, using an acquisition date system made with PCI 6023 XE.

4.3. Link methods for electric resistance measurement - Wheatstone in well-balanced regime

The measurement method principle of the unknown resistance X consist in equalization of the Wheatstone through resistance R variation, the equalization moment is relieved by galvanometer indicator $I_G = 0$.

In this situation the C and D points have the same potential:

$$U_{CD} = 0 \rightarrow aI_1 = bI_2 \quad \text{and} \quad XI_1 = RI_2 \tag{14}$$

Result the equation which lead to unknown resistance calculation:

$$X = R\frac{a}{b} \tag{15}$$

Conforming with this result it can be built Wheatstone with:

- $R = \text{constant}$ and $a/b = \text{variable}$;
- $a/b = \text{constant}$ and $R = \text{variable}$, this type being the most used.

Because R have a discreet variation, the R_e value can't be obtained and it is reached two closed values, R_1 and R_2 corresponding for left and right by-pass to zero position.

In that situation R_e it is approximate by interpolation resistance:

$$R_i = \frac{R_1\alpha_1 + R_2\alpha_2}{\alpha_1 + \alpha_2} \tag{16}$$

Principle electrical scheme is presented in figure 7, and the LabVIEW application in figure 8.

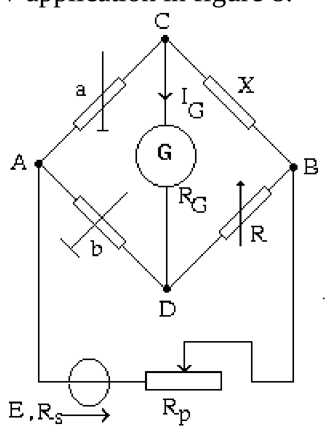

Fig. 7. Wheatstone bridge

a,b – Wheatstone resistance (1,10,100,1000)Ω;
R - resistance decade 10 x(0,1+1+10+100+1000)Ω;
X – resistance for measurement ;
R_G – galvanometer resistance;
R_S – internal resistance of source;
E - voltage of electric source;
Rp - protection resistance.

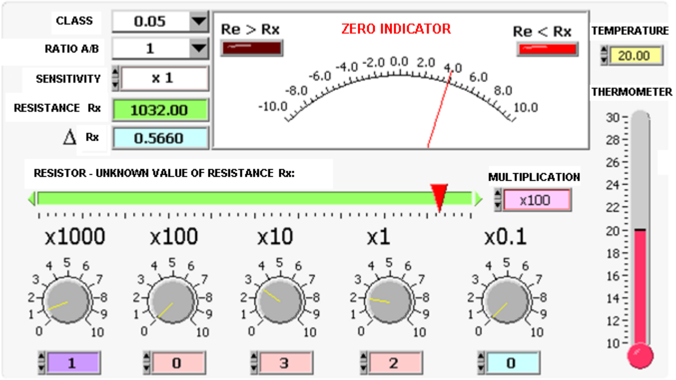

Fig. 8. Wheatstone bridge – front panel

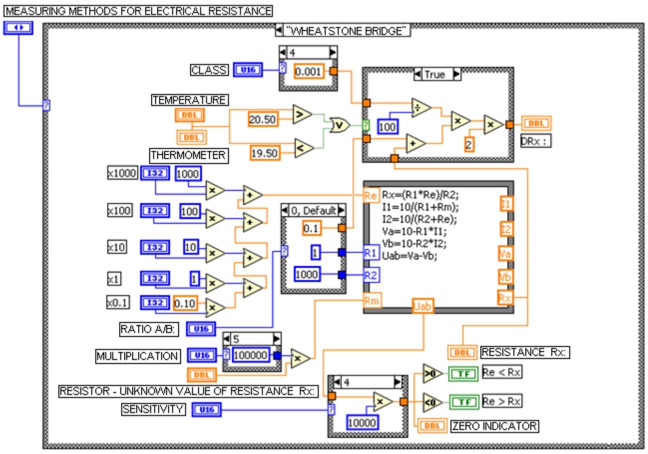

Fig. 9. Wheatstone bridge – block diagram

The application is made for measurement of unknown resistance having the facilities: resistors values selection R_1, R_2 (10; 100; 1000Ω) which give the possibility to increase the accuracy of Wheatstone; sensibility change (*1; *10; *100; *1000); the decade resistor utilization 0 ÷ 11111,0; utilization of the null analogical pointer; logic signalling of the result of comparison between unknown resistance with standard resistance.

5 Pedagogical researches

To analyze the efficiency of the computer assisted training and, respectively, of the interactive applications used in the Electrical and Electronics Measurements (MEE) laboratory, we have made a pedagogical micro research that aims the following objectives:
- the identification of the efficiency grade of the interactive applications used in MEE;
- the analysis of the advantages of using interactive applications in MEE laboratory activities;
- to point out the role of the interactive application have for the learning of the notions specific to this matter and for the development of some professional competences and cross- competences.

The general hypothesis of this research is the following:

If, in the laboratory activities, the teachers will use the interactive applications, then the students will develop in a good measure some professional competences and cross- competences, and the learning process will be more efficient. Students have different levels of motivation, different attitudes about learning. Students have different approaches to learning and different intellectual level [4].

The research was done using a sample of 140 students from the second and the third year of Electrical Engineering Faculty, "Valahia" University of Targoviste.

The research instrument used was a questionnaire with fifteen items, but five items are important for our study. Each item refers to some important aspects of using the interactive applications in Electrical and Electronics Measurements laboratory activities.

Through the first item of the questionnaire, the students are requested to appreciate the efficiency of the interactive applications used in the MEE laboratory activities, on a scale of 5 to 1, where 5 is maximum efficiency and 1 is minimum efficiency.

Inside our sampling, the percentage distribution of the students' answers to this item was made so: 34% from the students appreciate with 5 the efficiency of using the interactive applications, 46% with 4 and 20% with 3.

The second item of the research instrument requires to the students to make a hierarchy of the advantages of using the interactive applications in the laboratory activities. So, on the first place of the hierarchy, the students place the development of an efficient learning style (42%), the explanation and good interpretation of the theoretical models of the matter (26%), the effective identification of the important information (16%), efficiently carrying out of the proposed tasks trough adequate applications of the cognitive acquisitions in different educational contexts (10%), the application of some problem-solving models adapted to the context (6%). Learning efficiency increases when theory is accompanied by practical application on algorithm and concept [17].

To the third item, which refers to the faciliting the learning of the important notions specific to the matter through the virtual tools, 90% from the students answer affirmative and bring some arguments to sustain their answers?

The students from the sample consider that the virtual instruments permit them to form a real imagine of the studied notions and to form some retentive representations; virtual instruments facilitate a fast understanding of the delivered contents; its provide a easy retention of the essential knowledge; virtual instruments represent a good way to combine the theory with practice and its have an important contribution to the development of an efficient learning style.

The fourth item of the questionnaire requested to the students to appreciate the contribution of the virtual instruments used in the Electrical and Electronics Measurements laboratory activities to the development of some instrumental-applicative competences specific to the MEE. The percentage distribution of the students answers are: in a very good measure (38%), in a good measure (44%), in a moderate measure (18%), in a small measure (0%), in a very small measure (0%).

The last item, which is important for our research refers to the identification of the advantages of the computer simulation of real life phenomena. The main advantages mentioned by questionated students were: the creation of some learning situations, similar to the real ones, which allow the explanation of complex actions, the observation of the components and their functionality (30%), faster learning of technical skills (20%), tracking, in real-time, the changes that occur in the variables values (20%), verification of data which may be required in authentic context of action (15%), eliminating the risks of accidents and damage the equipment (15%).

6 Conclusions

Using of LabVIEW, the analysis and the study of the electric resistance measurement methods in D.C. is assured. This analysis is based on the presented theoretical reason, being very useful in lab application. The made applications allow the input parameters change by means of the specific control elements, the choice of measurement method and determination of nonlinear resistors characteristic. The dramatic development of the technology requires updating the teaching work, which involves using different teaching techniques, advances instruments, complex equipments, and also high level software and distance learning. [1]

After analyzing, processing and interpreting the data obtained in this microresearch, we can express some general conclusions about the opportunity of using interactive applications in laboratory activities and also about their efficiency:

- most of the students consider that using those interactive applications is good and efficient;
- the development of an efficient learning style is the most important advantage of using the interactive applications;
- in the opinions of the questioned students, the virtual instruments facilitate the authentic understanding of the notions specific to the matter and the development of some instrumental-applicative, cognitive and metacognitive competences, which are results, but also objectives for a efficient learning process.

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