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USE OF MODERN IT IN THE STUDY OF RESONANCE IN A PARALLEL *RLC* CIRCUIT

BY

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Abstract. The paper presents a case study regarding the use of virtual laboratory techniques for implementing a practical experiment in the electric domain using the LabVIEW graphical programming language. The experiments deals with “The study of resonance in an alternating current parallel *RLC* circuit”, where the student will have to observe the parameter variations in the given circuit for different functioning phases and also to draw conclusions about the errors that appear in such a circuit and about the technical applications of the resonance.

Key words: apple-view; browser Web; resonance.

1. Introduction

The recent evolution in the computer-based instruments that made their interconnection relatively easy is opening the way to the realization of virtual didactic laboratories that can be accessed over the network, virtually removing all drawbacks of the laboratories (Kocijancic & O’Sullivan, 2002; Chirico & Scapolla, 1998).

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The first attempts in the implementation of virtual laboratories were generally confined to the simulation of the most common instruments (like oscilloscopes, DMMs, spectral analysers, etc.), as shown, for instance by Ferrero & Piuri (1999).

These solutions, though effective in getting the students accustomed with the instruments, cannot provide them with the skills that only the direct contact with real instruments and experiments can give.

More recently, several solutions have been implemented in order to provide the access to real instruments and real test benches through a remote connection (Bertocco & Ferraris, 1998; Fortino & Grimaldi, 1997; Fortino & Nigro, 2000). The quick evolution that the computing systems and software applications have undergone in the last few years made most of the presently available applications obsolete in at least one among the following key points: implementation cost, maintenance cost, security, flexibility, portability, communication burden (Arpaia *et al.*, 1996).

On the other hand, the most recent development of Labview language and the Java Native Interface (JNI) has provided a very efficient tool for answering to all above requirements. Labview is a platform independent language that ensures the highest level of portability and has specifically been developed for the implementation of secure distributed systems (Arpaia *et al.*, 2000)

In what follows an application of virtual laboratory type simulated for the study of resonance in an alternating current parallel RLC circuit is described, which allows the user to follow the parameter variation of such a circuit, parameters that cause resonance, the losses that occur in these measurements, the way voltage varies in the three modes of operation, resulting conclusions that will highlight both the reception of the application and the understanding of the parallel RLC circuit functioning. At the end of the application, the user has the task to say which are the domains in which the resonance could be applied.

The application is designed to be accessed remotely *via* a Web browser (Benetazzo, 2000), containing all the elements of a real application, starting with theoretical considerations and ending with the experimental data processing.

The measurement laboratory to be accessed remotely is realized around the server (Bertocco & Ferraris, 1998), that is equipped with a suitable interface toward the field signals (digital board, analog-to-digital and digital-to-analog conversion board) and the instruments.

The remote lab is accessed by the remote clients as a Web page and the data flow inside the server is organized as shown in Fig. 1.

The client accesses the server through a single URL (Uniform Resource Locator) address, which activates the Web server application. Apache open source Web server has been used to develop the Web server.

All static Web pages, associated with the lab presentation, experiment selection, documentation and help are managed by this Web server.

When the experiment selection static page is opened, the available experiments can be accessed by selecting the corresponding link.

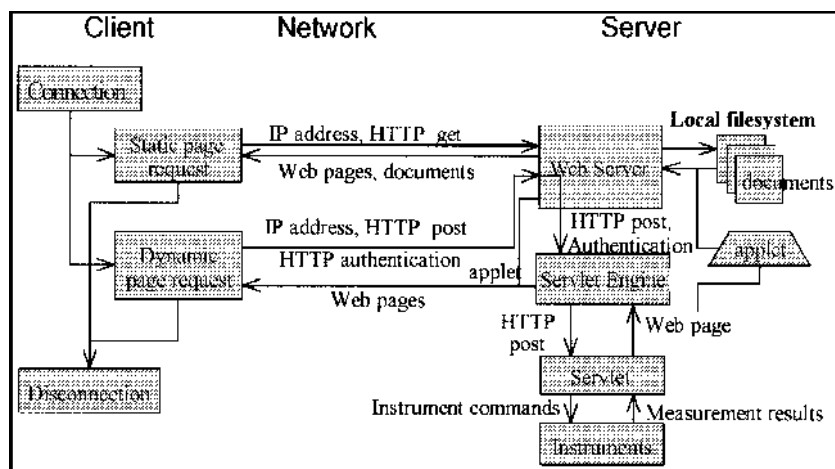


Fig. 1 – Data flow in the client–server architecture employed to implement the laboratory.

The paper describes an application of virtual laboratory type simulated for the study of resonance in an alternating current parallel RLC circuit consisting of a resistor, an inductor, and a capacitor, connected in parallel.

The application allows the user to observe the parameter variation of such a circuit, parameters that generate resonance, the losses that occur in these measurements, the way the voltage varies in the three modes of operation, resulting conclusions that will highlight both the reception of the application and the understanding of the parallel RLC circuit operation.

2. Structure of the Laboratory Work

The modern information technology enables the study in a simulated environment of the variation of the electronic components parameters, in our case the inductance of a coil and the capacity of a condenser in an alternating current parallel circuit; the phenomena related to this component are shaped by mathematical relationships implemented in the Labview programming environment.

2.1 Considerations Concerning the Work

In Fig. 2 the laboratory architecture is represented where the work on resonance study in a parallel RLC circuit can be simulated.

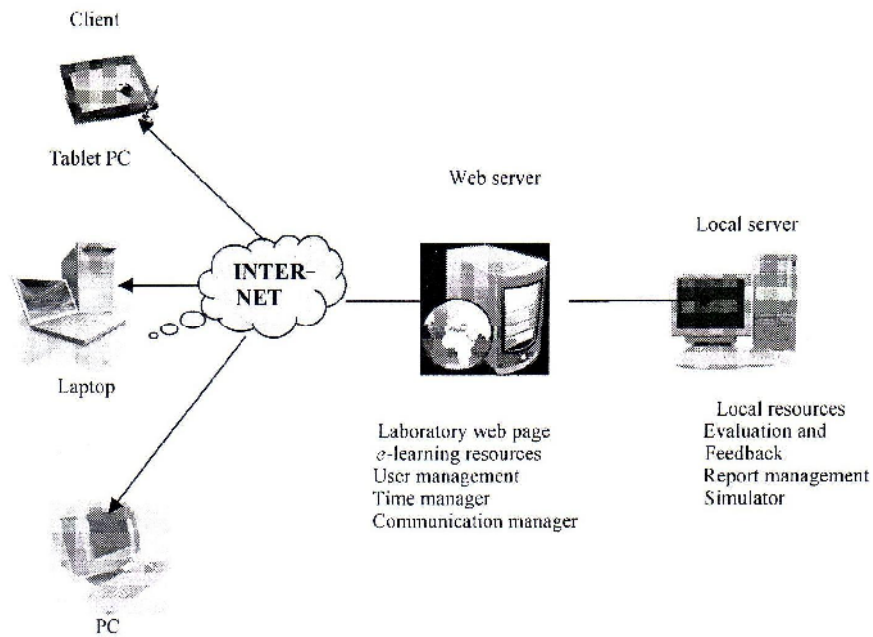


Fig. 2 – The architecture of the laboratory where the work runs.

VIRTUAL LABORATORY FOR ELECTRIC PROFILE

HOME CONTACT

[DC measurements](#)

[Measurement of electrical quantities in an AC circuit](#)

[Diode characteristics](#)

[Operational amplifier](#)

[Inductive transducers](#)

[DC Engine characteristics](#)

VIRTUAL LAB

Virtual Labs offer web-based interactive experiences aiming at increasing students' level of understanding concerning the general principles involved in the experiments. They can also be used to simulate inaccessible devices to replace hazardous working environments or to provide a visual image of some very complex calculations.

Undoubtedly, Virtual Labs are one of the great achievements of the twentieth century, showing a rapid spread far and having a huge growth potential in the future, and maybe in a few years reaching an indispensable necessity in research and education.

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Fig. 3 – The general Web page.

The work is implemented on the local server where the simulator runs. On the same server the work page runs as shown in Fig. 3.

On the local server, there is both the database where the teacher gets the processed data from the work and the evaluation test. The teacher will grade each part of the work according to the difficulty level and the final mark is written down in the user database that runs on the web server. On the same server, the web page of the work runs.

On the server, there are also other resources of the *e-learning* platform. The web server has three main functions

- a) user management (UM);
- b) laboratory timetable management (TM);
- c) tutor communication management (CM).

The web page of the work contains the following elements:

1. Theoretical considerations.
2. Arrangement and requirements.
3. Practical application.
4. Final report.
5. Knowledge testing.

1. The *theoretical considerations* include references about the study of functioning of an alternating current parallel *RLC* circuit in conditions of resonance. This file type is hypertext; it contains references to reference resources on the Internet or in the application database and it stays open throughout the entire work.

2. The second section contains both *the arrangement* (Fig. 4) that will be used in the practical application implemented in LabVIEW and *the requirements* for this work. The file for them is hypertext and contains references to the database of the application and possibly to other necessary reference resources for task solving.

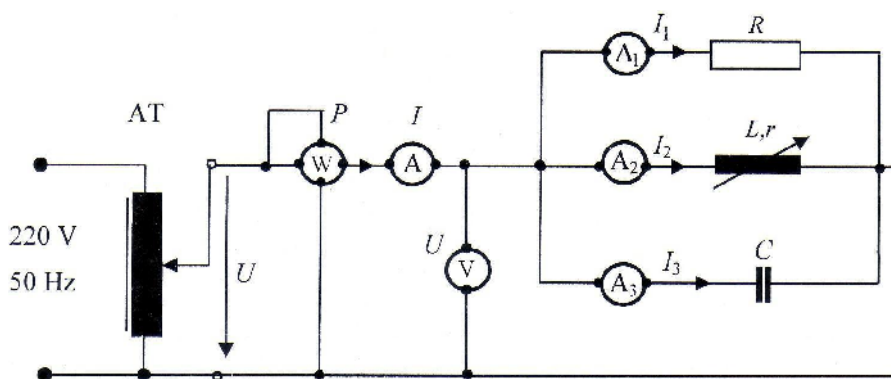


Fig. 4 – Experimental arrangement.

3. *The practical application* is the centre of the virtual laboratory work where the user accesses an application of the applet type shaped in LabVIEW.

The front panel and the block diagram of the practical application developed as virtual instruments in LabVIEW are presented in Figs. 5 and 6.

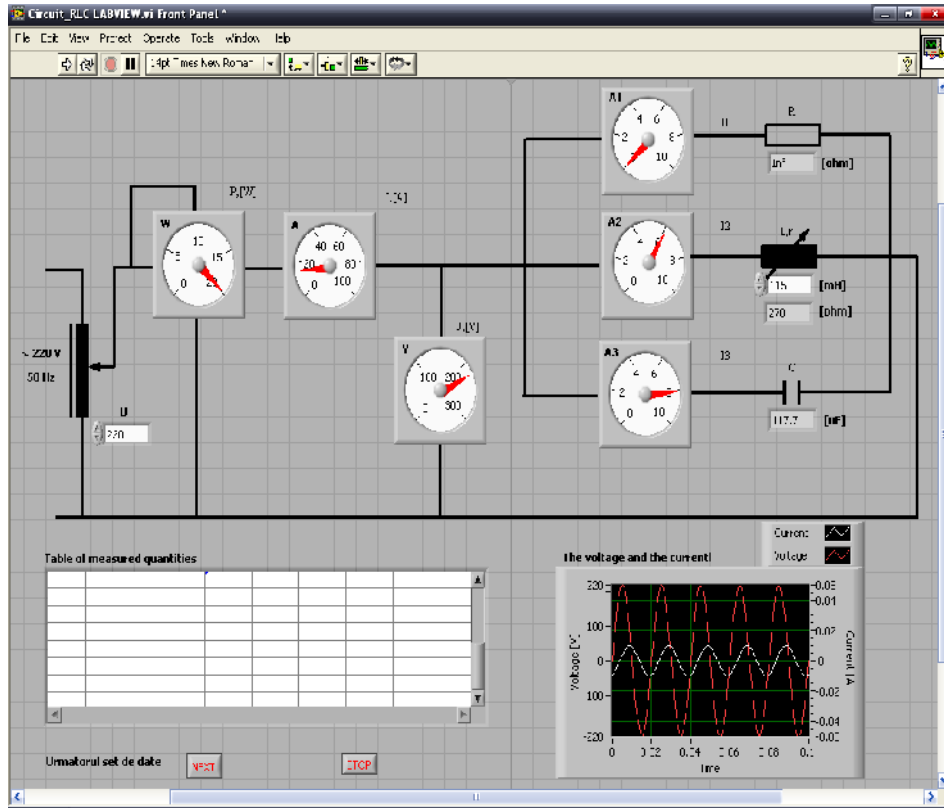


Fig. 5. – The practical application of the work "The study of resonance in an AC parallel RLC circuit"

The front panel of the virtual instrument shown in Fig. 5 contains the arrangement for a parallel RLC circuit, a series of controls through which the user provides data to the instrument, a table where the measurement results are introduced and also the results of some measurement calculations. On the same panel one can see the NEXT button that offers the user the possibility to run the program as many times as he/she wishes, the obtained experimental data being shown on the front panel. The dependence between the voltage and the current is represented in the graph that is also shown on the front panel.

The functions implemented by the main instrument are achieved in two sequences, namely in a first stage there is the reading of the user input and the GPIB (General Purpose Interface Bus) control of the function generator and in the second, represented graphically in Fig. 6, the acquisition of experimental data, their digital processing and reporting the results take place.

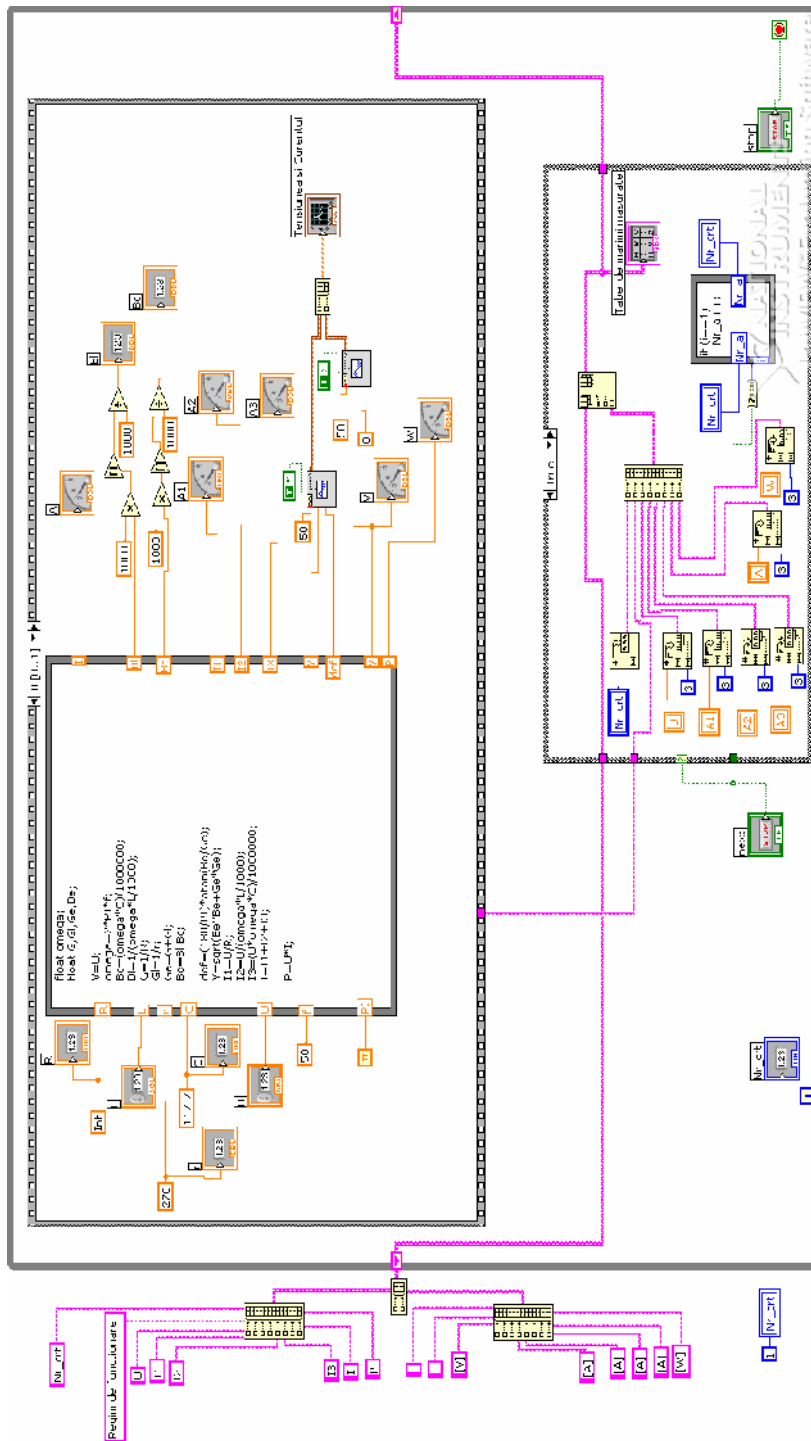


Fig. 6 – The diagram of connections of the main instrument.

The diagram of connections (DL) contains the source code of the virtual instrument. Every object on the PF has a correspondent on the graphically representation, which is called *terminal*.

The software component of the application has the following functions:

- a) it manages the user interface;
- b) it calculates the required measurements;
- c) it shows the calculation results in tables;
- d) it ensures the selection of the two measures for drawing the graph.

The diagram of connections of the main instrument includes a series of structures that perform the above functions, structures that interconnects with other nodes in the diagram of the instrument and are automatically executed when all input data are available, providing the output results. They are used to repeat blocks of code or to make conditioned codes in a certain order. In order to make the diagram for this application, several types of structures were used: formulas node (a structure used for calculating the output data), *For* type structure (used for gathering the necessary points for $u(t)$, $i(t)$ graphical representations – for the output tunnels the self-indexation is maintained), *While* type structure (used to obtain the continuous running of the application until it receives the logical value ordering to stop functioning – this value is transmitted to the structure terminal when operating a control in the user interface), *Case* type structures (used to control the conditioned functioning of some sequences of the application). The Sequence-type inner structure offers the possibility to run the program in a certain preferred order.

4. The *final report* is a Word file in which the student fills a series of available tables with the data and interprets the results of the work. The report obligatorily contains the conclusions on measurement precision and the influence factors. The report is downloaded from the Web page, filled in and then sent to the tutor by *e-mail*.

5. The final test is a series of questions both from the theoretical part and the experiment. It is a multiple choice test with one correct answer. The result is immediately supplied by the management program of the user tests, which is automatically transmitted to the tutor, who takes it into account when assessing the final grade of the work, the student receiving this grade by *e-mail*.

3. Results and Conclusions

Taking into account that the virtual laboratory is very often used for simulating works both for technical and other school subjects in the secondary education, it was decided that a questionnaire should be given to a group of 50 teachers from different technical high schools in the Iaşi county. The teachers had to answer 10 questions received by Internet concerning the evaluation of the simulated works, the efficiency of this evaluation, the degree of correctness, etc. The results were received and introduced in a table. Here are the items of the questionnaire:

1. Evaluation of the simulated work *versus* evaluation of the practical

work.

2. Exclusion of errors in marking works.
3. Correspondence between evaluation items and objectives.
4. The evaluation techniques are objective and have a high degree of

fidelity.

5. The ratio between the assessment scale and the learning contents.
6. Easily obtaining a good mark with minimum effort.
7. The efficiency of the educational act according to the evaluation

results.

8. The way the evaluation results are transmitted.
9. Evaluating a large number of elements in a short amount of time.
10. Suggestions, opinions.

The teachers had to assess each question on a scale from 1 to 5, where 1 is the lowest level and 5, the highest.

In Table 1 we can see the number of answers for each question and the corresponding percentage and in Fig. 7 we can see the diagrams that show the percentage for each question with its five levels.

Table 1

Answer level	Question number								
	1	2	3	4	5	6	7	8	9
1	5 (10%)	0 (0%)	14 (28%)	19 (38%)	10 (20%)	0 (0%)	14 (28%)	0 (0%)	0 (0%)
2	4 (8%)	3 (6%)	2 (4%)	2 (4%)	15 (30%)	3 (6%)	6 (12%)	3 (6%)	4 (8%)
3	4 (8%)	2 (4%)	2 (4%)	4 (8%)	0 (0%)	7 (14%)	0 (0%)	5 (10%)	2 (4%)
4	7 (14%)	5 (10%)	4 (8%)	5 (10%)	7 (14%)	11 (22%)	6 (12%)	4 (8%)	8 (16%)
5	30 (60%)	40 (80%)	28 (56%)	20 (40%)	18 (36%)	29 (58%)	24 (48%)	38 (76%)	36 (72%)

By analysing the answers it was found that the evaluation of the simulated works is for the 70% of the interviewed (4 and 5) a simple and efficient way of evaluating students, and therefore it can be said that most of the teachers frequently use simulation instead of practical applications.

When it comes to errors appearing in grading, it was noticed that over 90% of the interviewed considered that evaluating simulated works involves little errors taking into consideration that the test results and the report are filled in directly on the computer and sent to the tutor by *e-mail*, thus eliminating the possibility of lost or modified data, of influencing the marks for the other school subjects or of disfunctions in grading the works.

As regards the correspondence between the evaluation items and the objectives, the interviewed considered that this correspondence applies both to the simulated works and to the practical ones, which is a compulsory condition.

The used techniques for the evaluations of simulated works and practical applications have a high degree of objectivity, meaning that the assessor doesn't distort the objective data on which the evaluation is based, fidelity and application, and this can be seen in the almost equal percentages (40% and 38%) for the two types of evaluation.

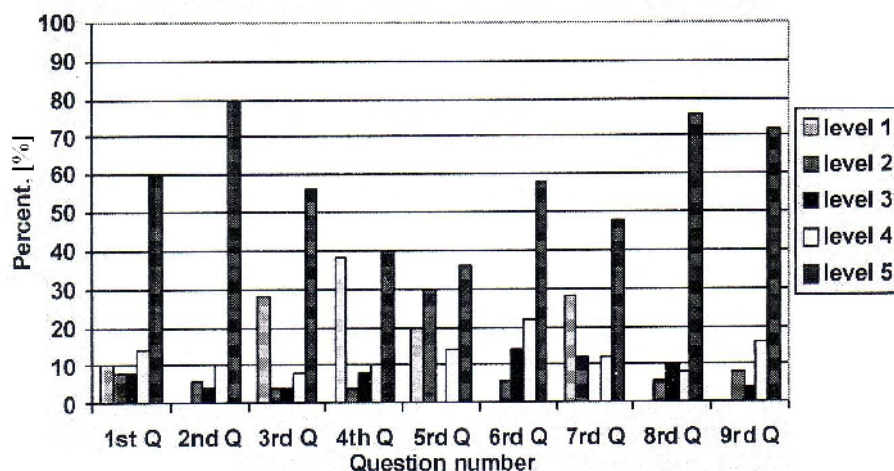


Fig. 7 – The diagrams for each question with its five levels.

As for the scale of the evaluated contents in a simulation, half of the respondents considered that for the practical application students need more skills and knowledge to be successfully evaluated, and therefore, when evaluating a practical work, we can verify a larger amount of knowledge acquired during the educational process.

It is clear that a good mark can be more easily obtained by taking a simulated test, and this is confirmed by the percentage of 70% , in comparison with the practical application where the student needs *prior* acquired knowledge, skills in order to solve the tasks. The simulated works have on the Web page all the theoretical considerations that concern the work and the Websites where the student can find any information in order to solve the tasks. The user must know how to use a computer and not necessarily have *prior* knowledge of the matter.

As concerns the efficiency of the educational process, about 40% of the respondents consider that the efficiency is more visible in the evaluation of the practical applications because, besides getting intellectual skills, the student can get a series of skills and abilities and 60% consider that the efficiency of the educational process is seen in the very good results in the evaluation and this can be achieved by evaluating a simulated work.

Information about the evaluation results is done easier when the work is simulated, the tutor (in this case, the teacher) analyses the results received from each student by *e-mail*, grades the work and immediately sends the final mark to

the user, and the preference for this type of evaluation is obviously shown in the 76% percentage of the respondents.

Given the amount of assessed information in relation with the amount of time, about 80% respondents consider that the evaluation of a simulated work is done faster, with better results and the amount of evaluated information is quite large.

4. Conclusions

This paper, an application of simulated virtual laboratory (Ferrero, 1998) meaning to study the resonance of a parallel RLC circuit, specific to the students from the technical high school, electric profile, is designed in the LabVIEW development environment, having the possibility to be remotely accessed *via* a Web browser, contains all the elements of a real application starting with the theoretical considerations and ending with experimental data processing. This paper presented on a Web page as an applet (Benetazzo, 2000) offers the user the opportunity to use easily accessible, modern IT.

REFERENCES

- Arpaia P., Baccigalupi A., Cennamo F., Daponte P., *A Measurement Laboratory on Geographic Network for Remote Test Experiments*. IEEE Trans. Instrum. Meas., **49**, 10, 992-997 (2000).
- Arpaia P., Cennamo F., Daponte P., Savastano M., *A Distributed Laboratory Based on Object-Oriented Systems*. Measurement, **19**, 207-215, Brussels (1996).
- Benetazzo L., Bertocco M., Ferrarsi F., Ferrero A., *A Web-Based Distributed Virtual Educational Laboratory*. IEEE Trans. Inst. Meas., **49**, 2, 349-355 (2000).
- Bertocco M., Ferraris F., Offelli C., Parvis M., *A Client-Server Architecture for Distributed Measurement Systems*. IEEE Trans. Instrum. Meas., **47**, 10, 1143-1148 (1998).
- Chirico M., Scapolla A.M., Bagnasco A., *A New and Open Model to Share Laboratories on the Internet*. IEEE Trans. on Instrum. a. Measur., **54**, 3 (2005).
- Davoli F., Maryni P., Perrando M., Zappatore S., *A General Framework for Networked Multimedia Applications Enabling Access to Laboratory Equipment: The LABNET Project Experience*. Proc. Internat. Conf. on Inform. Technol: Coding a. Comp., Las Vegas, 2001, 359-365.
- Ferrero A., Piuri V., *A Simulation Tool for Virtual Laboratory Experiments in a WWW Environment*. Proc. IMTC98, St. Paul, USA, MN, May 1998, 102-107.
- Fortino G., Grimaldi D., Nigro L., *Distributed Measurement Patterns Based on Java and WebTools*. Proc. IEEE Autotestcon, Anaheim, CA, USA, 1997, 624-628.
- Fortino G., Nigro L., *A Measurement On-Demand Service for Access and Delivery Process Acquisition Data*. Proc. 17th IEEE IMTC, New York, USA, 661-666, 2000.
- Kocijancic S., O'Sullivan C., *Integrating Virtual and True Laboratory in Science and Technology Education*. 32nd ASEE/IEEE Frontiers in Education Conf., Boston, USA, 2002.

UTILIZAREA TEHNOLOGIEI INFORMATICE MODERNE PENTRU STUDIUL REZONANȚEI CIRCUITULUI *RLC*-PARALEL

(Rezumat)

Aplicația prezentată, după conceptul de laborator virtual, utilizând mediul de programare LabVIEW, reprezintă un model de aplicație a unei lecții de laborator din domeniul electric. Prin intermediul acestor aplicații utilizatorii au posibilitatea de a acumula experiențe interactive, bazate pe Web, care urmăresc creșterea nivelului de înțelegere în ceea ce privește principiile generale implicate în experimentele simulate. Pentru evaluarea prestației elevului, în urma parcurgerii unei astfel de aplicații, se urmărește dacă au fost atinse toate cerințele și dobândite toate competențele ce au fost impuse pentru o astfel de lucrare, nota finală acordată de tutore reprezentând media dintre nota la test și cea obținută la raportul final trimis profesorului prin *e-mail*, nota pe care elevul o primește prin *e-mail* în cel mai scurt timp de la finalizarea lucrării.