Development of A Prototype for Electrical Engineering Remote Laboratories Via Internet

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Introduction

This paper summarizes the initial effort to implement a framework for developing a prototype for remote Electrical Engineering Laboratories via Internet. It presents a complete explanation and description of the entire development process including the integration of the different software tools used. The developed prototype can be seen as a first step of an initiative to develop an integrated Introductory Electrical Engineering Laboratory using state of the art computer technology tools and new developments in instructional technologies. This initiative has been driven by the concern of the changes that the educational process has to implement in order to satisfy the labor force requirements for the next millenium. The proposed remote laboratories will be used as an additional teaching tool to undergraduate/graduate Electrical Engineering courses and as a virtual laboratory for distance learning programs.

The software tools being used to implement this application are based on software packages provided by National Instruments Inc.. Both, LabView and the Internet Toolkit are the two main software tools being used in the developing stage. A set of appropriate user interfaces, Web pages, and LabView VI's can all be integrated to implement virtual laboratories. A complete test to verify the prototype reliability will be performed. A complete evaluation of the actual developed laboratory will also be performed and the results will be presented at the conference.

General Design Concept

The design concept is based on instructional technology and computer technology synergy. An instructional design framework has been considered which includes learning objectives, learning-teaching activities, subject contents, and a criterion reference test for each course experiment, all of them supported by up to date hardware/software tools. The design concept consists of the following elements: Instructional Technology, Computer Technology, Block Diagram, Tools applied for the implementation, and Hardware available for the implementation.

Instructional Technology

This prototype was designed based on an operational and functional approach. The final user would be supported through the system to pursue the course objectives: from low level to high level skills, including critical thinking. Pedagogical features are the mechanisms to reach these objectives. However, instructional design framework based on the computer as a vehicle to acquire knowledge might be a tough resource. Furthermore, when this learning process is accomplished without an assistance to supervise it and orient it, might loss the reliability of educational technology resources. As an alternate experience, in this project there were applied basic concepts of instructional design to overcome these drawbacks in teaching and learning methods. The main concept was organized at two levels:

a) Conceptual learning model for this type of virtual laboratories, and

b) Particular learning models oriented to specific course-works (experiment), as a direct application of the general conceptual model.

General Conceptual Learning Model.

The main purpose here is to provide information about the courses curricular organization.

On an instructional design framework, the model includes an explanation about the instructional components, which will help the student to accomplish his/her educational goals. Such instructional components will be stated in terms of:

- What the student is going to be able to perform (learning objective),
- How the goal will be attained (learning activities),
- What topics will support the learning activities (contents), and
- How the student performance should be assessed according to learning objectives (evaluation).

Under this conceptual model, every virtual laboratory or experiment should answer these issues for every work session. A particular description for every work session includes theoretical framework, elements for solving problems, instruments, process, and results related to the virtual experiment. They are the basic materials where the previous issues have to be presented. Designers of this kind of learning process have to keep in mind the previous four issues.

Main Web Page.

The Main Web page includes a structure of folders where different text files are kept with pre-defined file paths. These paths point to specific laboratories and/or courses where virtual experiments are performed by the remote student. The organization of the complete set of web pages is based on complete monitoring, administration, and control of the resources required for carrying out remote laboratories via Internet. The overall system monitors the remote users, administers computer resources and laboratory/course development, and controls system access for security purposes. Thus, the main web page environment on the server has to have sufficient capabilities to handle files and system users in an efficient manner.

Figure 1 shows the designed folder structure, which can be expanded with additional directories to include new laboratories or courses.

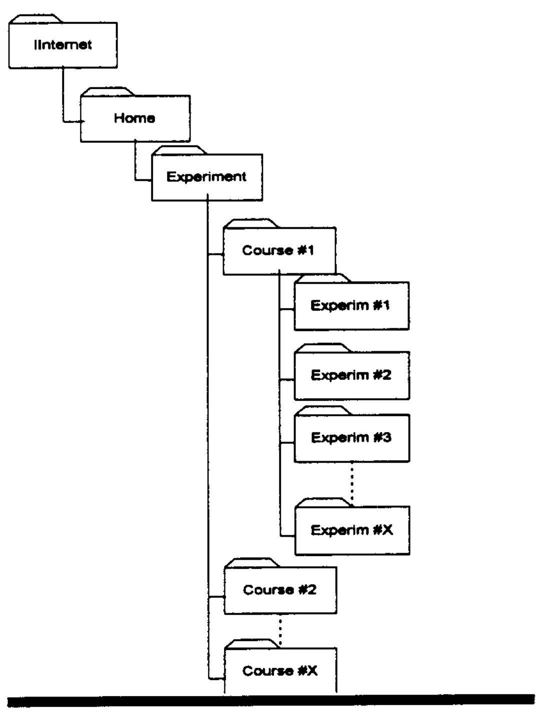


Figure 1. Folder Structure on WEB Server

Virtual Experiment Pages

In the virtual experiment pages, the complete course contents, in the form of standard text, and supported with hypertext are included. The hypertext being used is based on referenced textbooks and written material with previous application on actual electrical engineering laboratories. Due to the nature of laboratories write-ups, the virtual experiment page is particular large and it includes all the standard components required for a comprehensive laboratory manual. Laboratory procedures, Virtual labs, graphs, formulas, and related discussions are being prepared in different pages as a tutorial, where final users would submit via Internet using standard web page environment. Every experiment consists of a pre-lab and a post laboratory. Presently, the required support to the pre-labs within the remote laboratories are being developed by virtual experiments within LabView. Designs of the experiments on LabView, are implemented on standalone environment. These experiments are tested and designed to include all the requirements to achieve the pre-laboratory objectives successfully. For every experiment on Virtual Lab Page, the following conditions have to be achieved: provisions on the web pages to encode and decode information, required protocols to manipulate data and results from the LabView (virtual instruments programs or vi's) to Internet, tuned procedures, and real time tests, etc.

Laboratory Experiments.

Once, a final user acquires the required basic knowledge in a particular experiment, he or she will have the necessary tools to perform real experiments. The improved achievement by the users with the combination of experiments on web pages, and the real experiments can be followed up by an evaluation strategy already stated within the instructional design.

Developed Laboratory Evaluation

An entire evaluation of the actual developed laboratory is being conducted at two levels. Expert judgement as a main evaluation technique will be applied in three different areas. First, subject content expert opinions in order for verifying the content quality. Second, instructional design expert opinions in order to verify how well the instructional components work, and finally, a computer system expert opinion to judge how reliable and efficient is the integration of the different computerized tools for remote educational purposes. In addition, the remote users (students), also are being asked to complete a survey related to the areas above mentioned. The survey is a fifteen-item questionnaire. The first twelve items have to be completed by students by using a five-point rating scale, and the last three items have to be answer as open questions. The following chart shows the questionnaire framework.

Area	Aspects	Item #
Subject content	• Quality • Organization • Pertinence • Sufficiency	1-4
Pedagogical	• Learning action • Execution • Performance level • Feedback • Learning style	5-8
Technical	• Quality • Friendliness	9-11
Overall		12
Open questions		13-15

Illustration of a Virtual Experiment Design

The procedure below shows an example of the first basic experiment developed, which consists of a simple resistive circuit where the Ohm's law concept is used. The complete set of developed experiments and the results of the different evaluations will also be presented at the conference presentation.

Ohm's Law

Ohm's Law states that the voltage across many types of conducting materials is directly proportional to the current flowing through the material, $v=Ri$ where the constant of proportionality R is called resistance. (Hayt & Kemmerly)

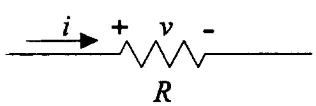


Figure 2. A Resistor

Web Design Interface

There are four methods to establish an interface between Web Page (HTML) and a Virtual Instrument (VI) within LabView and they are:

1. - CGI Environmental Variables. It performs a CGI call.

2. - CGI Call With Single Parameter (GET). It just passes a single parameter to a CGI VI as part of the URL.

3. - CGI Call With Multiple Parameters (GET). It passes multiple parameters to a CGI VI as part of the URL.

4. - CGI Call With Multiple Parameters (POST). It passes multiple parameters to a CGI as part of the content, generates an HTML document with the contents of the request. The POST method is used in this project as the CGI application to process an HTML form using a CGI VI. Figure 3 shows the POST.vi.

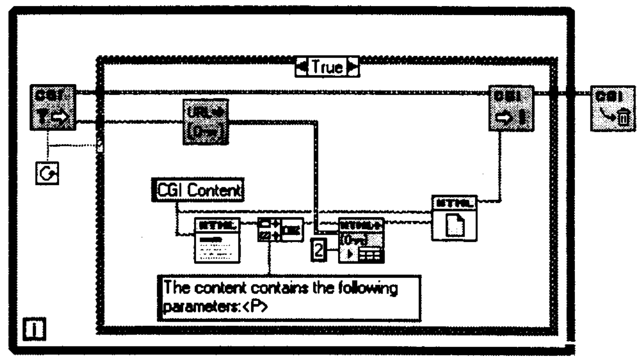
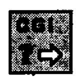


Figure 3. POST vi

An explanation for each element (VI) shown in figure 3 is presented below:

CGI Read Request.



What this icon does is just wait timeout seconds for a request before timing out. If a request arrives, the calling VI can use its content and the associated environmental variables to build an appropriate reply that must be returned with a call to the CGI Write Reply VI.

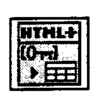
CGI Parse URL-Encoded Parameters String.

This element returns the contents of an URL-encoded parameter list string in a Keyed Array. This VI can be used to parse the QUERY_STRING environmental variable or the contents of an HTML form (POST) request.

HTML Heading.

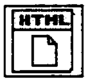
This element constructs a heading tag <H1...H6> for the specified heading.

HTML+ Keyed Array To Table.



This element constructs HTML code to describe a table constructed from the contents of a Keyed Array.

HTML Document.



This element builds an HTML 3.2 document with the title specified by document title and contents specified by document body.

CGI Write Reply.

This element writes a reply to the HTTP connections specified by CGI connection info.

CGI Release.

This element informs the server that the CGI has finished processing requests and can be unloaded from memory.

VI "Ohm's Law"

The VI "Ohm's Law" is represented simply by some elements that allows to make the calculations of current through the circuit, Voltage in each resistor, and the power dissipated by all the circuit components using the Ohm's Law and the power equation. Figure 4 shows the "Ohm's Law". VI

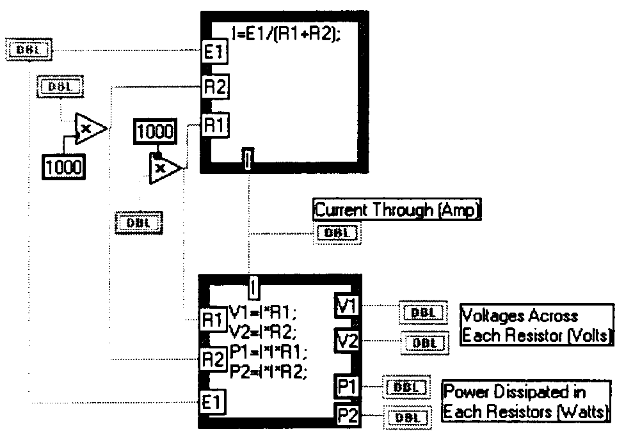


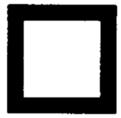
Figure 4. "Ohm's Law". VI

The Ohm's Law VI was developed using standard LabView elements. A brief explanation of each one of these elements is presented below.

Multiply

This element returns the product of the inputs and these inputs may be x and y, where they can be scalar numbers, arrays or clusters of numbers, etc.

Formula Node



The Formula Node is a resizable box. Instead of containing a sub-diagram, however, the Formula Node contains one or more formula statements delimited by a semicolon. Formula statements use syntax similar to most text-based programming languages for arithmetic expressions.

Other Elements shown in the figure represent simply indicators, controllers and constant displays.

Virtual Instrument

The Virtual Instrument is a combination of the VI's mentioned above (VI POST and VI Ohm's Law). The virtual instrument used in this example, called Labotatory1.vi, is shown in figure 5. Noticed that the VI is a combination of the two VI's. This VI can be divided in four main parts: Data, Conversion, Evaluation, and Output.

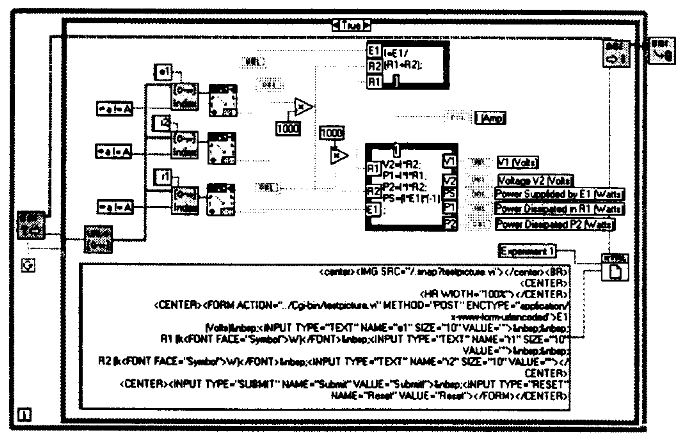


Figure 5. Virtual Instrument

The Data section is integrated by the two VI's (CGI Read Request and CGI Parse and URL-Encoded Parameters String.) and they have the function of getting and decoding the contest that comes into the VI POST. When the variables get to the Index VI (Keyed Array Index) and its returns the value of the element identified by key (pink box). After this step, the variables are scanned and transformed by the element Scan from String, which has the function of scanning the input string and converts it according to the format string. Once the variables have been decoded and transformed in its respective format, they are evaluated in the Ohm's Law VI generating the Voltages, Powers and currents before defined. As a final step, the results of the Ohm's Law evaluation will be located in a HTML VI with the designed format to be displayed in the Front Panel of the Laboratory1.vi (Output Part) following which is shown in figure 7.

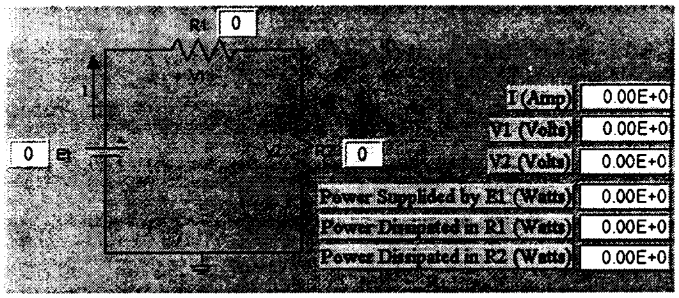


Figure 7. Displayed Panel

In the front Panel of Laboratory1.vi, the following variables are displayed: Current, Voltages V1 and V2, Power dissipated by R1 and R2, and the Power supplied by E1. All the calculations of these variables are based on the circuit shown in Laboratory1.vi.

Experiment Test

The developed user-friendly interface allows the user to submit the variable's values in the small boxes shown in figure 8. Once these values are submitted the Virtual Instrument is called, evaluated, and shown with the results displayed back to the user.

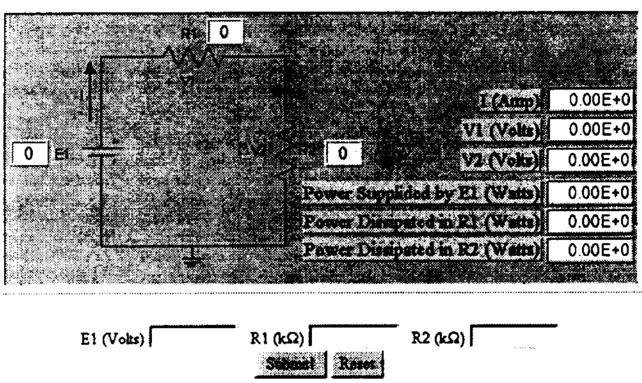


Figure 8. User Interface

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