A Web-based Virtual Laboratory System For Electronic Circuit Experiments

Dongsik Kim*, and Samjun Seo**

* Division of Information Technology Engineering, Soonchunhyang University, Asan, Korea
(Tel : +82-41-530-1370; E-mail: dongsik@sch.ac.kr)
**Department of Electrical and Electronic Engineering, Anyang University, Anyang, Korea
(Tel : +82-31-467-0874; E-mail: ssj@aycc.anyang.ac.kr)

Abstract: We developed a web-based virtual laboratory system for electronic circuit experiments on the client/ server distributed environment. Through our virtual laboratory, the learners will be capable of learning the concepts and theories related to electronic circuit experiments and how to operate the experimental equipments such as multimeters, function generators, digital oscilloscopes and DC power suppliers.

The proposed virtual laboratory system is composed of four important components: Principle Classroom to explain the concepts and theories of electronic circuit operations, Virtual Experiment Classroom to provide interactive multimedia contents about the syllabus of off-line laboratory class, Assessment Classroom, and Management System. With the aid of the Management System every classroom is organically tied together collaborating to achieve maximum learning efficiency. We have obtained several affirmative effects such as high learning standard, reducing the total experimental hours and the damage rate for experimental equipments.

Keywords: Virtual laboratory, Java Applets for Electronic Circuit experiments, Web-based Education, Flash Animations

1. INTRODUCTION

According to the appearance of various web-based virtual laboratories, the internet applications using multimedia technologies have drawn much interests. This interest is mainly due to the cost of the experimental laboratories at universities with a large number of students. The worldwide web provides new opportunities for distributing all learning materials over the internet.

The worldwide web enables anyone to have easy access to all learning materials over the internet any time. Most of interactive multimedia contents proved to be effective educational assistants. But, this assumes that the multimedia contents are well designed and well managed. Due to the cost of the experimental laboratories at universities with a large number of students, much interest in the web-based virtual laboratory has been drawn. The variance of students' learning abilities also makes difficult for the educators to maintain the quality of educational service. Web-based virtual laboratory system provides new opportunity for solving these problems with paying reasonable cost.

The proposed virtual laboratory system in the area of electronic engineering provides improved learning methods by which the multimedia capabilities of worldwide web can be enhanced. If the learners have access to the virtual laboratory system through a typical web browser such as Internet Explorer, they can make an experiment on basic electronic circuits through simple mouse clicks. Since this interactive virtual laboratory is implemented to describe the actual on-campus laboratory, the learners can obtain similar experimental data through them [1-3].

The proposed virtual laboratory system for electronic circuits is composed of four important components: Principle Classroom, Virtual Experiment Classroom, Assessment Classroom and Management System. Through the virtual laboratory system students can study effectively the concepts and theories related to the engineering experiments and how to operate the equipments such as multimeters, function generators and digital oscilloscopes[4-8].

Our system supports from elementary electrical experiments to advanced electronic experiments included in the curriculum of our engineering college. It has interactive multimedia contents to get the learners exact understanding of the concepts and theories of circuit operation, and the learners can build their own circuits and measure all information about the status of the circuits on virtual space by simple mouse manipulation. Every activity done in the virtual laboratory is recorded on database and provided to the learners as a printout form including experimental information and results. The educators check the printout form turned in to estimate how well the learners understand the experimental contents. Our system provides 4 courses and each course needs one semester[15 weeks]. The implemented virtual laboratory system can be used in stand-alone fashion, but using as assistants of the actual on-campus laboratory class shows more encouraging results.

2. COURSE STRUCTURES

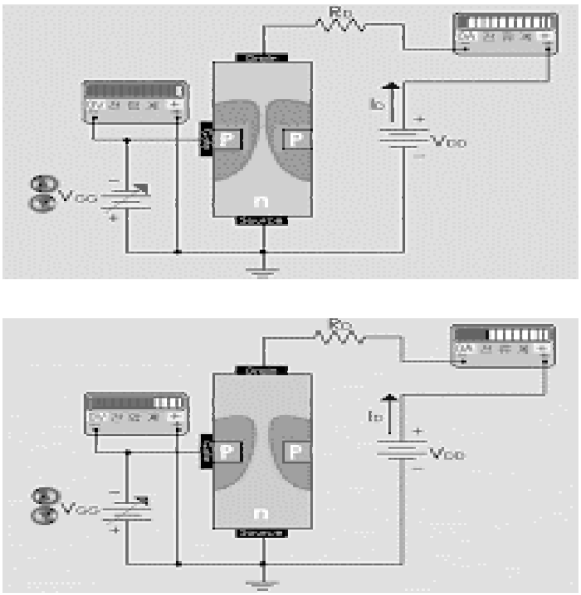
The web-based virtual laboratory needs, in general, various interactive multimedia components such as Java Applets, Flash animations with useful actions, etc. In order to achieve this goal, we suggest that our virtual laboratory include 4 important classrooms for effective experiments on the web. The material in third and fourth courses of our virtual laboratory system is appropriate for advanced courses on electrical and electronic circuit experiments. Each course consists of 15 chapters and each chapter comprises the Principle Classroom to explain the concepts and theories of circuit operations, the Virtual Experiment Classroom which provides interactive multimedia contents to build and test several circuits. The Management System gives the learners and the educators ID and password and provides printout service for all information about experiment done in the Virtual Experiment Classroom.

2.1 Principle Classroom

The Principal Classroom is responsible for making the learners understand the concepts and theories of the circuit operations included in each chapter. Interactive flash animations with creative and intuitive ideas for each subject lead the learners to easily understand them. Fig.1 shows a captured image from the flash animation for half-wave(HW) voltage doubler. Fig.2 shows several important frames from the flash animation for explaining the concepts of JFET characteristic curves. On-line voice presentation and its related texts together with moving images are synchronized for efficient learning process. Because the component is a flash file format, it doesn't need VOD server to provide this service on the web. Fig.3 shows an interactive Java Applet for understanding the key concepts of JFET characteristic curves. In Fig.1, the learners can observe the circuit operation step by step using a step button, which shows how diodes D1 and D2 work together and how capacitors C1 and C2 are charged and discharged. The animation in Fig. 2 is authored to let the learners easily understand relationship between the gate voltage V_{GG} and the drain current I_D. In Fig.3, the learners can easily understand the related concepts to the JFET characteristic curves by increasing/decreasing V_{GG} by mouse manipulations.

2.2 Virtual Experiment Classroom

The Virtual Experiment Classroom provides virtual experimental environment to the learners. Widely used experimental equipments such as oscilloscopes, multimeters, function generators and power supply etc. are implemented by Java Applets. In this classroom, the learners can build circuits for each subject, set the values for each circuit element, and measure voltages or currents etc. using the experimental equipments. When finishing the virtual experiment on the web, the learners can print out the all information related to the experiment which can be used as preliminary report for on-campus laboratory class. For example, Fig. 4 shows a captured image of a Java applet for virtual experiment on JFET transconductance and drain characteristics. The virtual experiment is performed according to the following procedure:



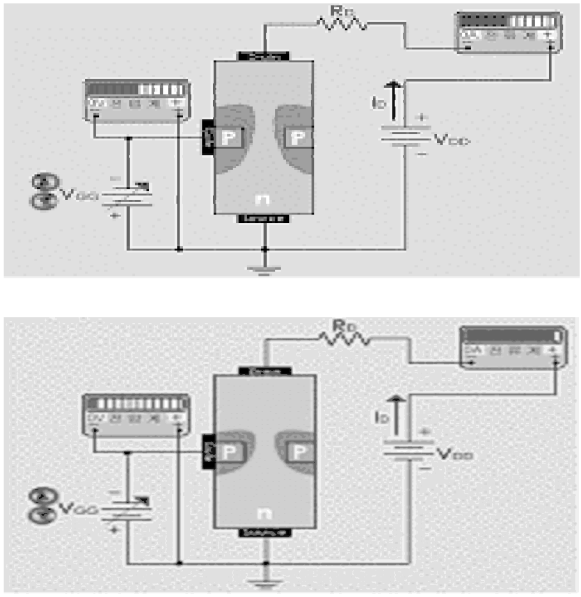


Fig. 2 A Flash Animation for JFET

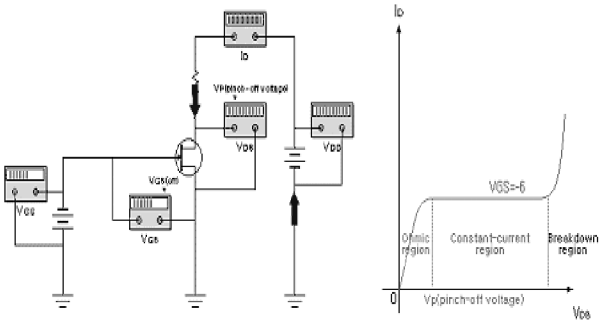


Fig. 3 A Java Applets for JFET Characteristic Curves

Circuit Composition, Applying Input Voltage, Output Measurements, Transmission of Experimental Data and Printout of Preliminary Report as shown in Fig. 5 (a)-(d).

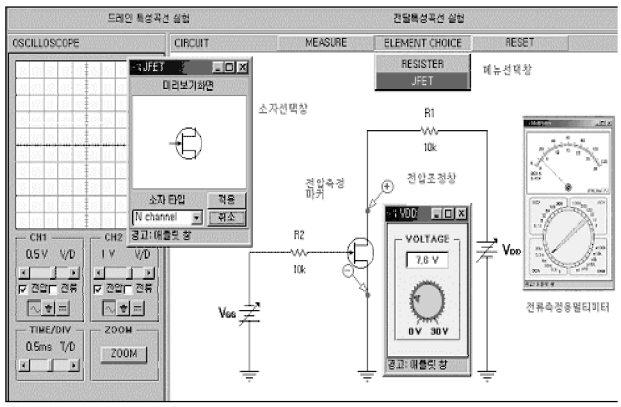


Fig. 4 A Java Applets for Virtual Experiment on JFET

The learners build a given circuit by placing proper circuit elements from ELEMENT CHOICE menu. In this menu, the learner can select circuit elements and change their types or values. In Fig. 4, V_{DD} is set to 7.6[V]. The learners can change the value of DC power supply by double-clicking the DC

power supply symbol. Also, the learners can insert a voltage and/or current markers into the circuit by using MEASURE menu. The learner can also measure several outputs for the various values of Vcc using the oscilloscope.

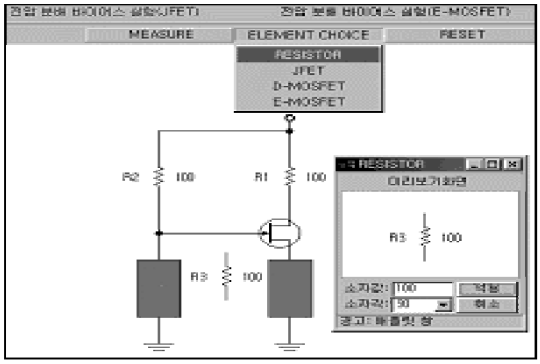


Fig. 5(a) Circuit Composition

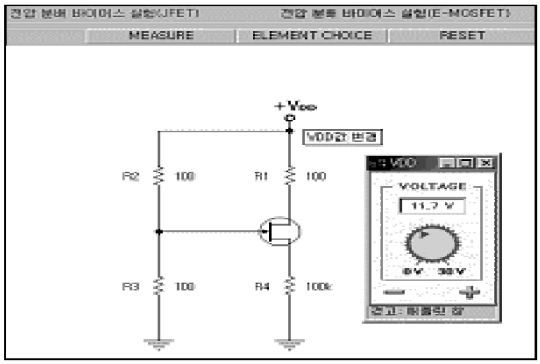


Fig. 5(b) Applying Input Voltage

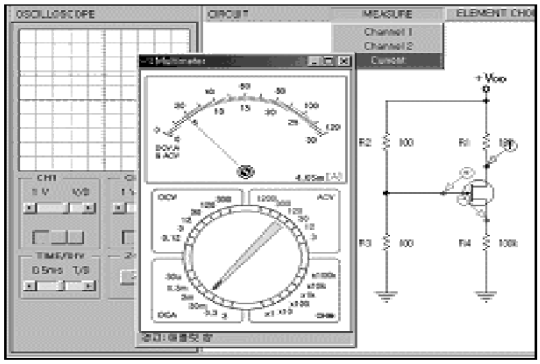


Fig. 5(c) Output Measurements

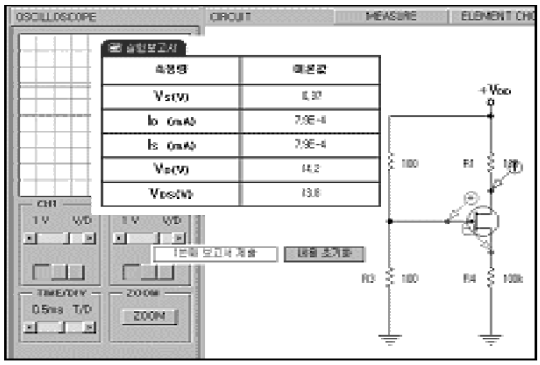


Fig. 5(d) Transmission of Data

2.3 Assessment Classroom

It is very important to provide the educators with useful information about experiments done in virtual laboratory by which the educators evaluate how well the learners are doing. Every activity done in the virtual laboratory is recorded on the database and provided to the learners as a printout form including experimental information and results. The educators check out the printout form turned in to estimate how well the learners understand the experimental process. The management system supports communications between the educators and the learners in the ways mentioned above, and different setups for each learner. Our system based on the client/server architecture uses noncommercial software. Furthermore, simple multiple choices are given to the learners after virtual experiments and the test results are displayed on the message box. According to the test result for each question, if the learners click one of two buttons named as "supplementary study" or "more challenging study", the learners can listen to the voice regarding the related explanations. This assessment process is very essential to increase the learner's academic capability. In Fig. 6, our interactive questioning system is displayed as an example.

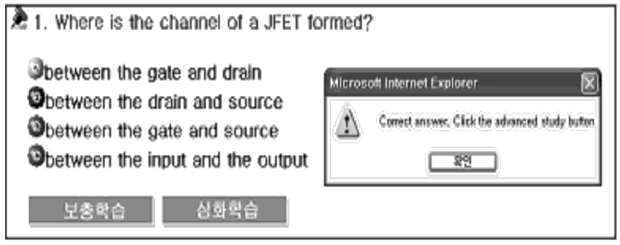


Fig. 6 Our Interactive Questioning System

2.4 Management System

Good instructional development is an iterative process by which the educators and learners perform formative assessments and summative evaluations to continually improve a course. Effective instructors use a variety of means, some formal and others informal, to determine how much and how well their students are learning. In the proposed virtual laboratory system, every activity occurred in the virtual laboratory will be recorded on database and printed out on the preliminary report form. All of this can be achieved by the aid of Management System. The database connectivity is made by Professional HTML Preprocessor(PHP) and the virtual laboratory environment is set up slightly differently for each learner. Our virtual laboratory system, based on client/server architecture, uses none of the commercial software package. Fig. 7 shows database connectivity of the Management System using PHP. Fig. 8 shows a preliminary report form to be printed out after virtual experiment.

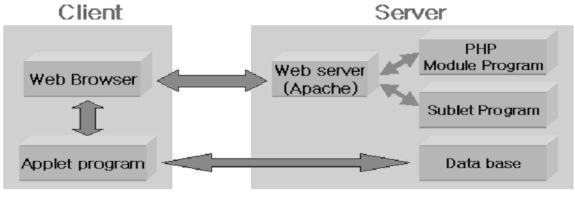


Fig. 7 Database Connectivity of the Management System

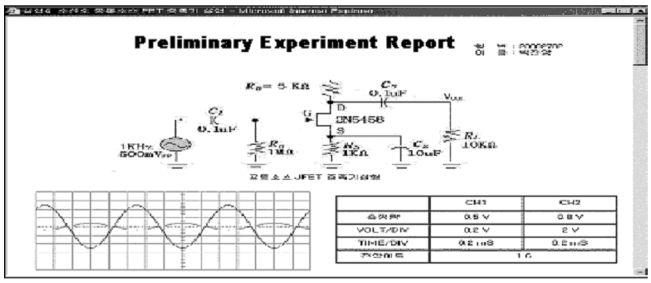


Fig. 8 A preliminary report form after virtual experiment

3. CONCLUSIONS

An efficient virtual laboratory system with creative and interactive multimedia contents is implemented, which can be used to enhance the quality of education in the area of electrical and electronic circuit experiments.

The difficult concepts, principles and theories related to the experiments can be conveyed to the learners effectively by creative multimedia contents and the virtual experimental equipments such as oscilloscopes, multimeters and function generators can be good examples of educational tools.

We have obtained several affirmative effects such as reducing the waste time and labor of both the educators and students, and the damage rate of real equipments, and increasing learning efficiency as well as faculty productivity. The implemented virtual laboratory system can be used in stand-alone fashion, but using as assistants of the actual on-campus laboratory class is recommended. The proposed system is also expected to make a contribution to the activation of internet-based educational systems.

REFERENCES

[1] Dongsik Kim et al," Practical Implementation of A Web-based Virtual Laboratory in the Area of Electrical Engineering," IASTED International Conf. on Computers Advanced Technology in Education, 2001.

[2] J.W. Rickel, "Intelligent Computer-Aided Instruction: A Survey Organized Around System Computers", IEEE Trans. SMC, Vol.19, No.1, pp.40~57, 1989.

[3] Badrul, H. Khan, Web-based Instruction: What is it and Why is it? Web-based Instruction, 1997.

[4] F. Valejo, M.G. Harbour, and H. Gregorio, A Laboratory for Microprocessor Teaching at Different Levels, IEEE Trans. on Education, 32,pp.199-203, 1992.

[5] A.D. Mashall, Developing Hypertext Courseware on the Worldwide Web, Proc. of ED-Media 95: World Conf. on Educational Multimedia and Hypermedia Volume 1, Graz, Austria, pp.418-423, 1995.

[6] Burks Oakley, A Virtual Classroom Approach to Teaching Circuit Analysis, IEEE Trans. on Education, 39, pp.287-296, 1996

[7] A. Ferreo and V. Piuri, A Simulation Tool for Virtual Laboratory Experiments in a WWW Environment., IEEE Trans. on Instrumentation and Measurement, 48(3), pp.741-746,1999.

[8] Burks Oakley, HyperCard Courseware for Introduction to Circuit Analysis, Proc. of ASEE Annual Meeting, pp.496-500.1991.