Proceedings of 2nd International Conference on Information Technology Based Higher Education and Training, Kumamoto, Japan
July 4-6, 2001

Development of Distance Real Laboratory System

Kazutake Kozono, Hidenori Akiyama and Naoyuki Shimomura[1]
Graduate School of Science and Technology, Kumamoto University
Department of Electrical and Electronic Engineering, Tokushima University[1]
kazutake@educ.kumamoto-u.ac.jp, akiyama@eecs.kumamoto-u.ac.jp,
simomura@ee.tokushima-u.ac.jp

Abstract

Over the last few years, the Internet has been increasingly used for education and research purposes. In particular, many colleges and universities have begun to offer distance learning classes by using the World Wide Web. Although distance learning offers many advantages, the distance real laboratory is not realized. In this paper the design process of developing the distance real laboratory system is described. This distance real laboratory system is called Advanced Learning and EXperimental system (ALEX). This system consists of three parts, ALEX server, ALEX management server, and ALEX client. ALEX server is connected to the experimental circuits using GP-IB board and the A/D converter board, which control experimental devices and acquisition of experimental data. These experimental circuit and devices are taken by CCD controlled camera. ALEX management server can manage several ALEX servers and ALEX clients via the Internet. ALEX client is able to control the experimental circuits and the CCD controlled camera on ALEX server. As one example, we built a single line experimental system relating to the pulsed power technology.

1. Introduction

Distance education using Internet and another information technologies has been increasingly becoming very popular. The use of hypertext and multimedia in engineering education has grown rapidly in the 1990s [1]. The emergence of the Web in the mid-1990s has added new opportunities for using text, audio and video materials in the education. Computer networks are widely used as a delivery medium in engineering education. Many colleges and universities have begun to offer distance learning classes by using the World Wide Web. Although distance learning offers many advantages, it does not provide the traditional face-to-face experiences in the classroom. Figure 1 shows the schematic configuration of distance education that is consisted of three regions.

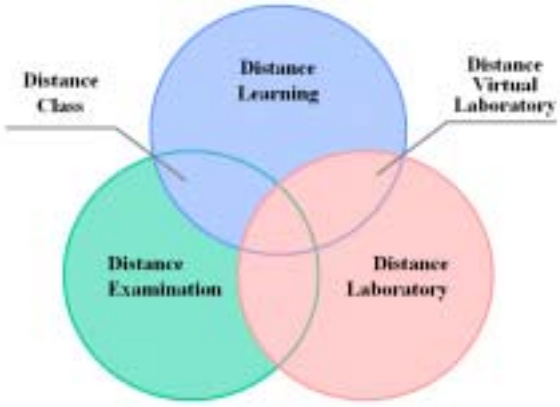


Figure 1. The schematic configuration of Distance Education

Distance learning and distance examination have been developed already by various systems [2-5]. Advancement in the field of distance laboratory is slower than those of distance learning and distance examination [6-7]. Therefore, construction of the distance laboratory regions should be realized as soon as possible. The development of Internet based distance laboratory is necessary in order to realize a distance education for students of engineering and sciences [8]. Our group has been trying to develop a distance real laboratory system on the junior level in the department of electrical and computer engineering at Kumamoto University. The Advanced Learning and EXperimental system (ALEX) has been constructed, and applied to the experiments of pulsed power technology [9]. This paper describes the distance real laboratory and the constructions of distance real laboratory system.

2. Concept of Distance Real Laboratory

Distance laboratory is one of the important components in three part of distance education as shown in Fig. 1. Advantages of distance laboratory are shown:

- The efficient use of laboratory equipments;
- Experimental courses by using computers;
- To provide a flexible curriculum;

At present, specific problems are as follows:

- Complex of a system structure and difficulty of an equipment control;
- A little laboratory component for the distance laboratory;
- Unknown education effects to distance laboratory.

Figure 2 shows a relationship among real laboratory, distance real laboratory and virtual laboratory.

Figure 2. Relationship among Real Laboratory, Distance Real Laboratory and Virtual Laboratory

Distance real laboratory is between virtual laboratory and real laboratory. Each system has various advantages of its own as follows.

- Distance Real Laboratory:
  - Acquisition of data based on real phenomena;
  - Measurement results which do not coincide with theoretical values;
  - Access to the apparatus from out of campus;
  - To share the equipment by several institutions.
- Virtual Laboratory:
  - No equipments, therefore cost down
  - Flexibility of experimental subjects by changing software
- Real Laboratory:
  - Control and connection of equipments with their hands.

The aim of our group is to develop the distance real laboratory system.

3. Development of Distance Real Laboratory

Our group has been constructing ALEX, Advanced Learning and EXperimental system, as a means to incorporate the distance real laboratory. The ALEX is an environment of the distance education integrating all three aspects, the distance examination, the distance learning and the distance laboratory. Characteristics of the distance laboratory in the ALEX are as follows:

- The monitoring system using a controllable Charged Coupled Device (CCD) camera;
- Distance control system of experimental equipments;
- Transmission of the experimental data;
- Establishment of Bulletin Board System (BBS) for discussion.

The ALEX system for the distance real laboratory consists of three parts that are experimental servers, an management server and clients. Each role and the relation are shown in Figure 3.

Figure 3. The ALEX for Distance Real Laboratory

The experimental server and equipments are shown in Figure 4. The experimental server includes various extended boards. These boards acquire various data and control the experimental equipments. The roles of Relay board (aISA-R47, Adtek Company) are to turn on-off switch of the equipment and the experimental circuit. The GP-IB board (HP 82350E, Hewlett and Packard Company) controls the experimental equipments such as Oscilloscope, Digital Multi Meter and Power supply, and also acquires the experimental results. An A/D converter board (aPCI-A35, Adtek Company) acquires the value of voltage from the experimental circuit. The data obtained from an experimental circuit are changed from the analog to digital signals by the A/D converter board, and then the digital signals are sent to the experimental server. A video capture board (Canopus Company) acquires the data of movie from the controllable camera (VC-C3, Canon Company) using RS-232C port. The direction, the zoom and the focus of the CCD camera, connected with the server via an RS-232C, can be controlled remotely. The video signal with a National Television System Committer (NTSC) form from the CCD camera is sent to the experimental server through a video capture board. The Ethernet Board is used for connecting to the Internet.

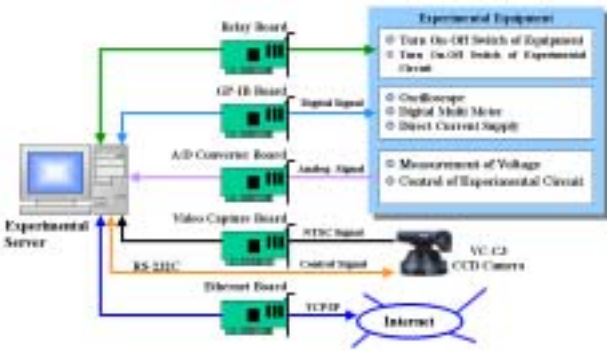


Figure 4. The experimental server and equipments

A distributed circuit has been frequently used to generate a pulsed power. Figure 5 shows a schematic

circuit of a single line using the distributed constant circuit. A voltage source (HP 6612C, Hewlett and Packard Company) charges the single line, which behaves as a capacitor for a slow charging voltage. After completing the charging of the single line, the closing switch SW is turned on.

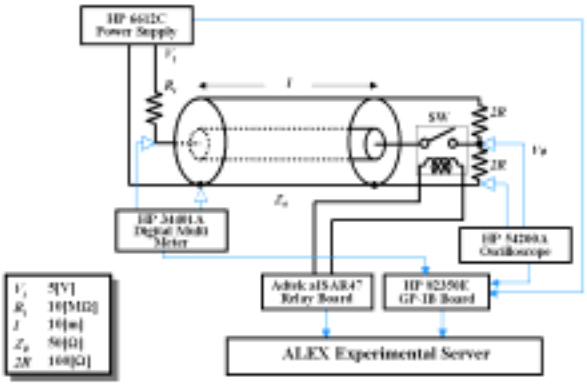


Figure 5. The Single Line to produce the pulsed Power

Figure 6 shows a photograph of experimental equipments. The experimental equipments consist of the oscilloscope, the digital multi meter, the power supply, and the single line circuit.

Figure 6. Photograph of experimental equipments

The results of the development are shown in Figures 7-9. The ALEX client executes the experiment from a distant place. Students are able to do the experiment from the distant place via the network. The capture screen of the ALEX client is shown in Figure 7. The experimental state is displayed with the rate of 2 frames per second (fps) and the resolution of 320x200 pixels. The students are able to control the pan, tilt and zoom of the camera by the button operation on the screen. Moreover, this server has various functions to show the textbook, to control the experimental equipments and to discuss each other using BBS. The capture screen of the ALEX experimental server is shown in Figure 8. The functions of the experimental server are to control the experimental equipments and the CCD camera, to record the experimental logs and to manage the clients. The capture screen of the ALEX management server is shown in Figure 9. This server monitors the several experimental servers and manages the clients.

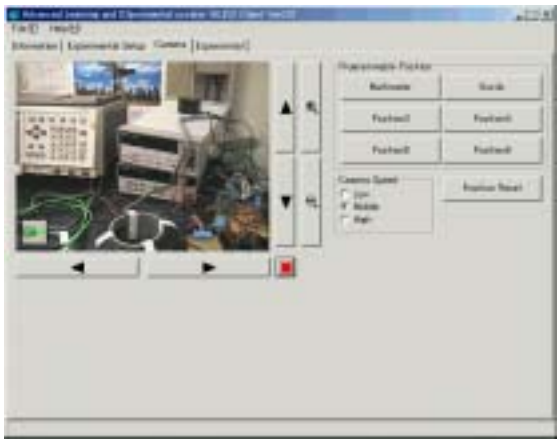


Figure 7. The capture screen of the ALEX client

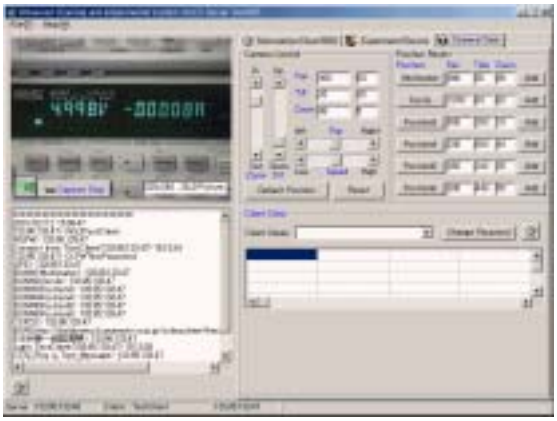
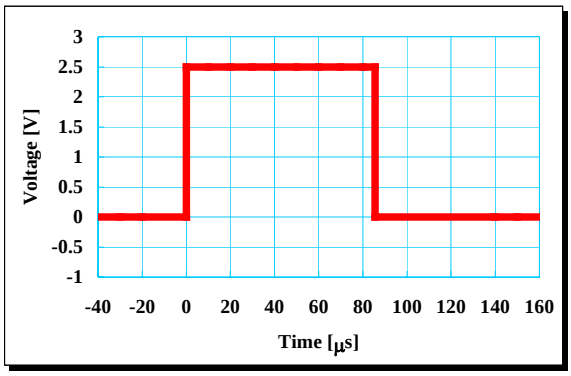


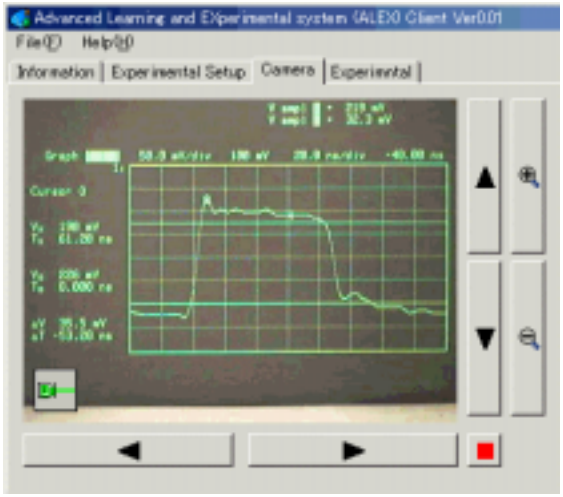
Figure 8. The capture screen of the ALEX experimental server

Figure 9. The capture screen of the ALEX management server

Figure 10 shows the theoretical waveform of the single line circuit at the load (a) and the client capture screen of waveform (b). The voltage becomes half of the charging voltage of the single line, and the pulse width becomes two times of l/v, where l and v are the length of the single line and the velocity of wave in the single line. Since $v=1/(\mu\varepsilon)^{0.5}$, the pulse width increases with increasing ε. The pulse width is 85ms from the theoretical waveform.



(a)



(b)

Figure 10. The calculated waveform of Single Line circuit (a) and the client capture screen of waveform (b)

The waveform in (a) is a little different from the one in (b). These differences between results using the ideal theory and the distance real laboratory are very important for students to learn the real phenomena. This system is sufficient to be used at the usual junior laboratory level.

4. Conclusion

By using this system, the various contents of distance real laboratory can be made flexibly and widely. It becomes possible for students to understand the experimental scene by using a controllable CCD camera. At present, this system has a little content of the distance real laboratory. Our group is trying to develop and increase the experimental subjects using the ALEX system and also to use the ALEX system on a junior level laboratory.

References

[1] Hannu Markkanen, "Network Based Project Learning In Engineering Education," 29th ASEE/IEEE Frontiers in Education Conference, 13a2-18, November 10-13, 1999.

[2] Dale A. Harris, Andy DiPaolo, “Advancing Asynchronous Distance Education Using High-Speed Networks”, IEEE TRANSACTIONS ON EDUCATION, VOL. 39, NO.3, AUGUST 1996

[3] Gwo-Jen Hwang, "A Tutoring Strategy Supporting System for Distance Learning on Computer Networks," IEEE TRANSACTIONS ON EDUCATION, VOL. 41, NO.1, pp.343, NOVEMBER 1998.

[4] Thomas G. Cleaver, Robert L. Toole "Design of a Web-Based Education Environment," 29th ASEE/IEEE Frontiers in Education Conference, 12a3-1-5, November 10-13, 1999.

[5] J. C. Burguillo, L. Anido, M. Llamas and M.J. Fernandez, “Internet-based Distance Education. Past, Present and the Future,” International Conference on Information Technology Based Higher Education and Training, pp132-137, Istanbul, Turkey, July 3-5, 2000.

[6] Denise Consonni, Antonio Carlos Seara, "A Modern Approach to Teaching Basic Experimental Electricity and Electronics," IEEE TRANSACTIONS ON EDUCATION, VOL. 44, pp5-15, FEBRUARY 2001.

[7] Ahmet Bugra Koku, Okyay Kaynak, "An Internet-Assisted Experimental Environment Suitable for the Reinforcement of Undergrauate Teaching of Advanced Control Techniques," IEEE TRANSACTIONS ON EDUCATION, VOL. 44, pp24-28, FEBRUARY 2001.

[8] Kazutake Kozono, Hidenori Akiyama, Tomoaki Ikegami, and Naoyuki Shimomura, "Distance Real Laboratory using Internet at Kumamoto University," International Conference on Information Technology Based Higher Education and Training, pp.264-267, Istanbul, Turkey, July 3-5, 2000.

[9] Masanori Hara, Hidenori Akiyama, “High Voltage Pulsed Power Engineering,” IN JAPANESE, Morikita Shuppan Company, April 1991 (ISBN 4-627-74140-5), pp.6, 169-170, 196.