

The Design of Remote Analog Electronic Circuit Lab System Based on LabVIEW

Juan WU¹, Xiao HAN¹, Wei LEI², Yi-yi QING² and Chang-yuan LV¹

¹School of Instrument Science and Engineering, Southeast University, Nanjing, China

²Academic Affair Office, Southeast University, Nanjing, China

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Abstract. The paper presents the design and prototype of a remote Analog Electronic Circuit Lab System. The lab system includes local and remote sites, which is built based on B/S (Browser/Server) structure. On local site, the operator can access into the lab website and do circuit designing and simulation. On the remote site, simulated circuit is represented and worked, and the site image as well as the actual parameters is feedback to the operator through network. A lab reservation management function is provided by synthesizing the Web Technology and database. The HTML page generated by virtual simulation and practicality experiments is embedded into the lab management system. After registering, users can log into the experiment and implement the experiment within the prescribed time. The online experiment test showed that the remote lab system proposed in this paper is stable in operation with strong practicability and expandability.

Introduction

Nowadays, experiment course plays an important role in engineering education[1]. However difference specialties have varied constraints to the conduct of lab. Some experiments require complicated and expensive instruments, which could not be supplied to every experimenters. Some of the experiments involving the living culturing, which last for long period, are time-consuming. With the rapid development of virtual instrument, network technology and virtual simulation technology, the remote and virtual laboratories appeared. Previous problems could be partly solved with remote or virtual lab system. As for the remote lab, the experimental facilities could be visited and shared by the remote users utilizing the online interface. It can solve the problems like lacking of special instruments, limited experimental sets and improve effectiveness. The hardware practicality experiment can bring the sense of presence to users, and the experiment result is close to the actual experiment. But it has the trouble on updating and maintaining the equipment[2,3]. Compared with real laboratories, virtual labs usually simulate the experiment procedures on the computer sever. Operator could do some design or parameters adjustment and see the simulated experimental results on the graphic interface. It is relatively safe, visualized and multi-user support[4]. More importantly, it has no physical space occupation and is high efficient. While the shortcoming is that the user can hardly achieve the perceptual knowledge about the operation on the realistic apparatus.

Virtual remote experiment was first put forward by William Wolf, University of Virginia[5]. The remote lab system based on iLab structure was developed by MIT[6]. The whole system was divided into Batched part and Interactive part, respectively for virtual and physical remote experiment. Researchers around the world can visit the laboratory through Internet. Many universities apply iLab pattern in their laboratory, such as University of Southern California[7], Macquarie University[8], University of Essex[9], and The University of Queensland[10]. Virtual lab is the hot point of iLab, such as virtual experiment system based on Flex in Beijing University of Posts and Telecommunications[11], remote lab control system of sports in University of South Australia[12] and the X-ray diffractometer remote experiment system designed by Instrument science and electrical engineering college of Jilin University[13]. Remote lab is more about the teleoperation of material object, such as the remote lab system of mechanical arm designed by

Polytechnic University of Catalonia[14], and the remote teaching system developed by Saga University and Chiba Institute of Technology[15]. iLab brings a lot of convenience on experiment teaching. However, there are still some things can be improved from the following respects: (1) Not strong generality of experiments[16]; (2) Simple experiment subjects; (3) Lack of experimental management system; (4) Lack of creativity in experiments[17].

The analog electronic circuit is one of the basic courses of the electronic engineering major, it has strong theorization and practicability. Therefore, the lab is essential part of the analog electronic circuit course and should be presented simultaneously. To help the students to prepare the lab and review the class, the analog electronic MOOCs are developed at Southeast University. While for the present online courses, which mostly focus on the theoretical part of the online courses. The establishment of the analog electronic circuit remote lab system can effectively utilize the experimental resources, save the investment cost of experiment equipment, and improve students' learning efficiency.

The system designed has the following functions: virtual simulation and real remote operation; remote observation and feedback; online booking and experiment report submitting. Under the virtual simulation mode, the user can regulate any circuit parameters he interested in, and obtain the waveform of data change at any time quantum. Under the hardware practicality mode, users can control the experimental circuit board remotely, run the actual analog experiment circuit, send the key parameter to the experimental circuit board and receive the feedback of result. The rest of the paper are organized as that: The system work flow are presented in Section two. Then the virtual simulation part and remote physical lab are respectively introduced in Section three to six. In addition, the lab reservation management system and real experiment platform are showed in the rest sections.

Scheme for Remote Lab System

The flow chart of the remote lab platform function is shown in Figure 1, which mainly consists of virtual simulation lab system and the hardware practicality lab system. Through the management, the simulation experiment and practicality experiment are released in the form of web page. The content of virtual simulation experiment is generally the same as the practicality experiment, but in different experiment form. With different experiment modes, the user can get the different experiment results so as to further finish the comparison of the experiment results.

Currently there are two main modes for the remote lab system structure: Client/Server (C/S) mode, and Browser/Server (B/S) mode. For later upgrading and maintenance as well as the experimental content expansion and flexibility of the system, this remote lab system is established with the B/S structure. The structure of system network topology is shown in Figure 2.

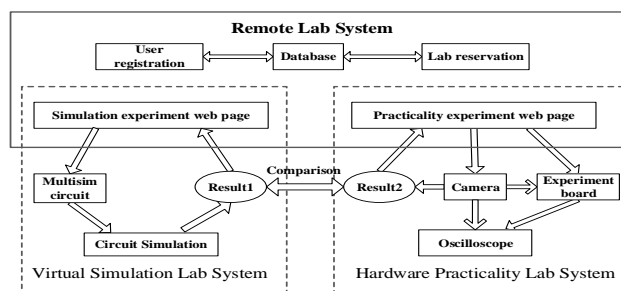


Figure 1. Flow chart for the remote lab platform function.

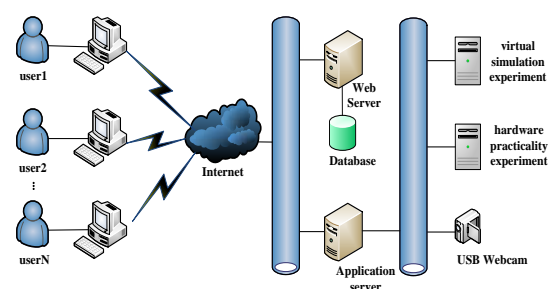


Figure 2. System network topology.

Virtual Simulation Lab System

The remote lab system contains 6 typical analog electronic circuit experiments. It covers the primary of typical circuits in the electronic circuit course, and could certify the rationality of the circuit design by Multisim. For virtual simulation system, LabVIEW and Multisim is used to realize the functions of lab system. The integration is realized by LabVIEW Multisim Connectivity

Toolkit. The simulation experiment panel is shown in Figure 3. Under this system, there are two important functions for experiment study.

Automatic Generation of Experiment Report

Users can record the experiment procedure and obtain the results by experiment report. For this system, it is important to record the simulating experiment results and supplementary information of experiments simultaneously. The function of automatically forming the experiment report is realized by the LabVIEW Report Generation toolkit.

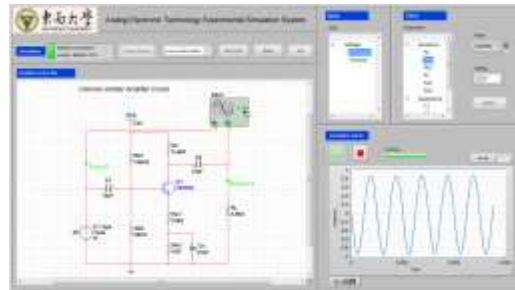


Figure 3. Simulation experiment panel.

Publishing the Virtual Simulation Experiment on Network

This function is helpful for users who have no LabVIEW installed at the client end to run the VI program at the far end through browser. LabVIEW provides a simple method for users to access the remote VI on network. It can be realized by setting the relevant configuration for the LabVIEW Web Server.

Hardware Practicality Lab System

The experiment circuit board provides the real modularized circuit which could be rebuilt and runs the simulated circuit. The hardware itself is an ARM controlled system, and has the functions of experiment circuit selection, key parameter alteration, modular access, experiment result feedback responding to the command from the remote end. The structure diagram for the substance hardware experiment circuit is shown in Figure 4. By using the modular concept, 6 experiment circuits can be designed in the same circuit board.

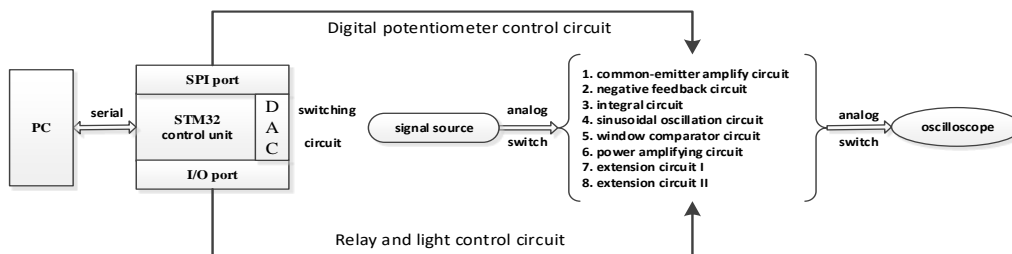


Figure 4. Structure diagram of hardware experiment circuit.

Experiment Circuit Selection

This function can satisfy the various requirements from users. The analog multiplexer is used to finish the experiment circuit switch. It is controlled by the main control unit STM32 which connects the signal source with the certain controlled experiment circuit. This system provides the typical waveform such as sinusoidal wave, triangle wave, square wave. The signal source is adjustable and can be mutually used by the 6 experiment circuits.

Key Parameter Alteration and Function of Modular Access

By changing key parameters, users can obtain different experiment results and have deep understanding of the operating mechanism of the circuit. Resistance value amendment is controlled by digital potentiometer to realize the alteration of parameters. As for upgrading of hardware, modular access need to be applied. It is realized by two interfaces: digital potentiometer control interface and signal source input/output control interface.

Experiment Result Feedback

After finishing experiment, users need to get the feedback of result. The video monitoring system is an key part of the realization of result feedback. The video monitoring system is built based on the NI visual development module. Fig.5 shows that the user on the client end is just using the remote lab system to perform the hardware practicality experiment. Fig.6 shows the scene of remote experiment.

Experiment Reservation Management System

The experiment reservation management system performs the standardized management on the teaching resource of remote experiment. Users in management system are mainly in three roles: administrator, teacher and student. Each user has their own user name and password. Through the management system, administrator takes in charge of user management and daily maintenance; teacher may review the teaching news and upload the experiment teaching materials and assist the student to finish their remote experiment; student can download the experiment course materials, make the experiment reservation and finish the remote experiment course. In order to avoid long-time occupying the experiment resource, the safety of the system operation is improved. The control mechanism on the experiment rights and authorities is provided. Within the specific time period, the experiment can only be accessed to one user and others have no right to access.

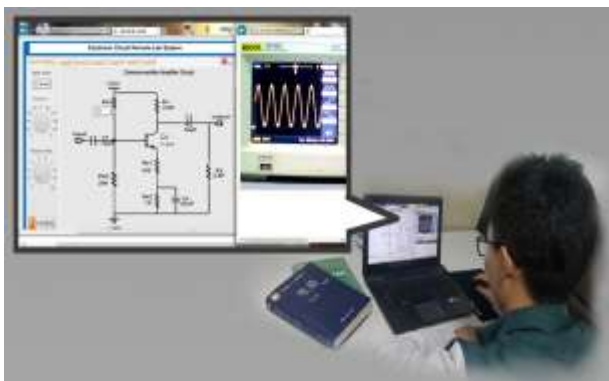


Figure 5. The operation from a user on the client end.

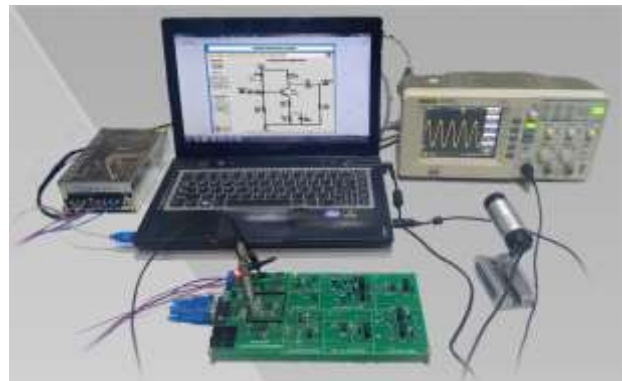


Figure 6. Scene of remote experiment.

Real System Description (an Example of Common-emitter Amplifier Circuit)

After logging in index page, as shown in Fig.7, users enter the experimental system to operate remotely. They can choose to enter the virtual simulation or hardware practicality experiment system and open experiment web page to access control permissions. Under virtual simulation mode, users can load the selected simulation experiment circuit, and modify specific experimental parameters to get the simulation waveform after connecting Multisim successfully. Then the lab report would be generated automatically onsite after filling in the necessary experimental information, which is shown in Fig.8. Under hardware practicality mode, the physical remote experiment page is shown on laptop in Fig.6. Firstly, remote lab user designs the circuit and sets the parameters in the simulating panel. Here, the input waveform control knob and digital potentiometer resistance are adjusted. The simulated wave form is shown right on the graphic interface. Then the send button is clicked to transmit the command and the remote real lab end is

connected. After that, user opens the video monitoring to observe the state of the running experiment circuit as well as the oscilloscope waveform on the remote real lab site.



Figure 7. Index page of remote lab system.



Figure 8. Common-emitter amplifier circuit experiment report.

Conclusions

This system was tested in campus network. It runs well and meets the teaching requirement of the remote experiment. The analog electronic circuit remote lab system designed in this paper has the following advantages: web page accessing, convenient operation, no need to install the complicated client software; inexpensive cost and strong universal property; the reserved experiment expansion interface for both the virtual simulation and substance experiment, the convenience for further integration. The experiment mode combining the virtual and practical situations is beneficial to the optimization of experiment arrangement. Comparing virtual situation with realistic situation, students can realize the difference between the theorization and practicality of the experiment. It provides users with experiment course resources and solution of experiment authorization by constructing the experiment reservation management system. The remote lab could also be applied to other engineering courses, especially to the online courses such as digital electronic circuit and DSP. It helps to improve the learning efficiency of students and save physical space occupation for universities.

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