Design of Electronic Virtual Experiment System Based on LabVIEW

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Abstract: For traditional experimental equipment, there are no experimental simulation functions and assistant experimental teaching functions in experimental teaching. A set of virtual experiment system for electronics department was designed by LabVIEW, including the synchronous binary counter virtual experiment and spectrum analyzer virtual instrument. The experimental system possesses distinctive features, such as openness, expansion, interaction, digital, network, module, economy, etc. It is a new experimental teaching method and development direction of experimental teaching innovation, and it will effectively promote teaching concepts and teaching technology. The reform of the model is conducive to improve the teaching conditions and the level of experimental teaching. It is the dominant direction of the reform of hardware experimental teaching based on traditional instruments in colleges and universities.

1. Introduction

With the continuous development and deepening of China's college education, and gradually emphasizing the cultivation of students' practical ability, practical teaching has become a crucial link in college education. With the deepening of theory and practice, the experiment occupies a very important position in the teaching of electronic information experiments and is an essential part of teaching activities. Many courses in electronic information are based on experimental courses.

Experiments can enhance students’ interest in learning, deepen their understanding of theoretical knowledge, and develop practical hands-on skills, curriculum design skills, the ability to find problems in practicing, analyzing problems, and solving problems, as well as innovative exploration capabilities and collaborative spirit. Therefore, schools can only speed up students' understanding of the theoretical knowledge and applied technologies they have learned through adequate validation experiments and comprehensive design experiments. Experiments are electronic information technology as an emerging autonomous industry. Its development is very rapid, and the technology is updated very quickly. As a result, college courses, especially experimental courses, tend to lag behind the progress of technology, and can not meet the needs of experimental teaching. Moreover, the domestic colleges and universities, its traditional experimental equipment in the experimental teaching...
exposed a variety of drawbacks, such as, there is no experimental simulation function and auxiliary experimental teaching and other functions. Therefore, it is an indispensable goal to develop a virtual simulation experiment teaching system that is advancing with the times to teach students in order to improve their ability to work and innovate.

Based on the analysis of traditional experimental teaching methods, this article explores the use of virtual instrument simulation technology in electronic experimental teaching. Using LabVIEW development platform to design a set of low-cost, high-yield, and easy-to-elevate electronic teaching virtual simulation experiments.

2. Laboratory Virtual Instrument Engineering Workbench

Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is a graphical programming language-based development environment developed by National Instruments (NI) Corporation. This programming language is similar to VC language and VB language. But unlike them, they use a text programming language, and LabVIEW uses a graphical programming language. For LabVIEW, the program is a block diagram design format and is a powerful virtual development tool. NI's research on LabVIEW has made NI a recognized authority in the field of virtual instrumentation. LabVIEW provides a large number of controls that look and feel similar to traditional instruments. You can connect and manipulate data using wired connections when you create a user interface.

3. The design of the virtual experiment system

The electronic virtual experiment system based on LabVIEW includes virtual instruments and virtual experiments. The virtual instrument is a visual graphical programming language and platform to create a graphical soft panel on a computer screen to replace the conventional traditional instrument panel. Soft panels have knobs, switches, indicator lights, and other control components similar to actual instruments. It makes full use of the powerful data processing capabilities of the computer system. With the support of basic hardware, the user completes functions such as signal acquisition and control, signal analysis and processing, storage, display and output of measurement results through mouse or keyboard operation soft panels. The combination of software and hardware to achieve the various functions of traditional instruments. The virtual instrument can flexibly define the function of the instrument according to its own needs. A combination of different functional modules can constitute multiple instruments without being limited by the specific functions provided by the instrument manufacturer; it can be easily connected to networks, peripherals, and other applications. You can also use the network for multi-user data sharing; full use of the computer's storage capabilities, so that virtual instruments have almost unlimited data recording capacity; software-based architecture also greatly saves development and maintenance costs. The virtual experiment is a simulation experiment of the basic courses of electronic information and professional courses (such as circuit basis, digital circuit, analog circuit, signal and system, communication principle and digital signal processing, etc.). There are many formulas in electronic information specialty courses, which are computationally intensive and abstract in concept and difficult to understand. Students are more difficult to learn. By introducing LabVIEW software into experimental teaching and building a virtual experiment platform, some abstract concepts can be transformed into images. With vivid and intuitive graphics and examples, students through simulation experiments have made it easier to understand the theoretical knowledge of obscure and easy-to-learn courses, and effectively stimulated students' interest in learning curriculum knowledge so as to deepen their understanding of abstract concepts and improve their presentation. Problems, analysis of problems, and ability to solve problems, in an experimental way, really overcome a major problem in teaching from theory to practice. Figure 1 shows the structure of the virtual experiment system. The experimental platform includes the experiment login, administrator interface, and student interface. The student platform includes some instruments commonly used in the laboratory, such as signal generators, oscilloscopes, and spectrum analyzers; Each experimental project module in the experiment is an independent experimental subsystem that can complete specific experimental content.
4. Virtual Instruments and Virtual Experiments Examples of Spectrum Analyzer

The synchronous binary counter experiment subsystem in the spectrum analyzer and digital circuit course in virtual instrument were taken as an example to introduce the basic idea of developing electronic virtual experiment system with LabVIEW.

The spectrum analyzer is a common instrument commonly used in experimental teaching. It aims at the use of the spectrum analyzer that students need to master in the university experiment course. This paper uses the signal processing module integrated in the virtual instrument software LabVIEW to design a conventional spectrum analyzer. Functionally matched virtual spectrum analyzer. The instrument can not only observe the spectrum of conventional signals such as sine wave, triangle wave, sawtooth wave and square wave, but also can perform spectrum analysis on any signal collected by the lower unit. Figure 2 and Figure 3 are the front panel and block diagram of the virtual spectrum analyzer. The user can select the basic signal type, frequency, amplitude, phase, square wave duty cycle, sampling frequency, and sampling point number from the front panel. Some of these parameters can be adjusted via the rotary knob, or they can be entered numerically and have corresponding digits display, in addition to the output signal to save and print functions. In the block diagram, the event structure, the While Loop structure, and the Case condition structure are used to complete the response of running, saving, printing, exiting, and Panel Close 5 events. Among them, the main event subroutines vi, Real FFT.vi and other functions are used to complete the fast Fourier transform of the selected basic signal; the main event of the save event is File Dialog.vi (select signal save path), Functions such as Open/Create/Replace.vi (determining the signal save file name) and Write File.vi etc. complete the signal storage function; the print event needs to call the Invoke Node Print Panel To Printer to complete the printing function; the exit event needs to call Current VI's Close FP and Close Reference in the Path, Open VI Reference, and Invoke Node complete the process of closing the front panel and stopping the run after obtaining the current running program path.
5. Virtual Instruments and Virtual Experiments Examples of Synchronous binary counter

According to the calculation rule of binary addition, when a multi-bit binary number increases by one, if the rest of the bits below the i-th bit are all 1, the bit will be flipped by the influence of the low-order carry, and the lowest bit will always be flipped. According to the function, it can be realized by using a T flip-flop, because when the T flip-flop satisfies the input terminal \( T=1 \), each clock state is flipped once, and when \( T=0 \), the state is maintained. It is only necessary to consider the time delay of each T-flip-flop, so that the \( Ti \) of the flipping is \( =1 \), and \( Ti=0 \) should not be flipped. The deduced logic expression is

\[
\text{Q} = Q_{i-1} \cdot Q_{i-2} \cdots Q_1 \cdot Q_0,
\]

each bit state logic below the i-th bit is input to the i-th T flip-flop input \( Ti \). The highest-order carry-side expression is the output equation for the logical sum of all states \( C = Q_4 \cdot Q_{i+1} \cdots Q_1 \cdot Q_0 \).

According to the needs of the synchronous binary counter, select the five Boolean output indicators Round LED (\( Q_3, Q_2, Q_1, Q_0, C \)) and the corresponding five 8-bit integer digital display.
keys required in the front panel Controls Palette, Numeric Indicator. Two Numeric Control control keys complete the setting of the clock frequency and duty cycle parameters. Digital Waveform Graph displays five groups of waveforms; Three control buttons Labeled Square Button are used to complete the run, exit and information help functions. Use Tools Palette With the related functions in the Controls Palette, the front panel is made to bring the front panel closer to the real instrument. The manufactured front panel is shown in Figure 4. The main program design of the synchronous binary counter is shown in Fig. 5. The entire block diagram mainly calls the loop structure (While and For), sequence structure (Frequency Sequence Structure) and event structure (Event Structure), and places the sequence structure in the For loop. In the structure, add four events: Run, Exit, Help, and Panel Close in the event structure. The function of synchronous binary counters and how to use them are described in the help event. In the exit event structure, closing the front panel using Current VI’s Path, Open VI Reference, Invoke Node, and Close Reference also ends the entire program.

Finally, the special explanation is that since the Escape, Run, and Help keys are bound to the F4, F5, and F6 shortcuts, respectively, you need to select Advanced→Key Navigation...→Key Assignment in the right-click shortcut menu of the corresponding key. The corresponding shortcut function key.

Figure 4. Synchronous binary counter front panel

Figure 5. Program for Synchronizing Binary counters
6. Concluding remarks

This article starts from the theory, combines practical scientific theory practice, makes a comprehensive study on the structure and framework of the virtual laboratory, and on this basis uses the LabVIEW software platform to build a simulation electronic virtual experimental system. The experimental system combines the actual experimental needs, mainly for the design of basic signal processing experiments in higher education, such as various waveform generators, digital filters, phase-frequency response of signals, etc., and some important experiments in the field of electronic experiments. Perform simulation design, specifically branch current method, nodal voltage method, trigger, decoder, modem, differentiator and so on. This is a new attempt in experimental teaching. It can not only improve the level of student's program design, but also solve practical problems in the course of teaching and improve the quality of teaching.

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