

# The Design Concept of a Virtual Experiment Teaching Platform for Digital Logic Based on LabVIEW

Kunliang Xu

<sup>1</sup>*School Of Computer Science And Engineering of Qujing Normal University, QuJing, 655011, China  
422078334@163.com*

## Abstract

*This article introduces a design concept of a virtual experiment teaching platform for digital logic and provides a systematic and comprehensive design scheme and selected module design schemes. This experiment teaching platform not only assists classroom teaching where the teacher can create a hi-tech atmosphere, but also offers exercises and tests for students' self-learning after class. A stimulus for students in learning and experimenting, the platform enriches teaching approaches and methods and enhances teaching quality. This brand-new teaching platform is a break-through in the transformation of education.*

**Keywords:** *teaching digital logic; virtual experiment; LabVIEW*

## 1. Introduction

Digital logic, a professional foundation course for computer and other related majors, is closely connected in theory and practice. Its theory is both abstract and detailed; its approaches are flexible and varied [1]. With the rapid development of electronic information technology [2], digital system is becoming ever larger and its logical relations are getting more complex—a situation that poses new requirements for the teaching of this course. It requires students to not only master the basic knowledge and theory about digital logic system analysis and design, but also focus on the transition from parts and details to whole and abstractness, so as to establish a systematic concept and lay a solid foundation for further courses including principles of computer composition, microcomputer interface technology and its application.

Traditional digital logic teaching has been carried out in labs using specific hardware facilities and equipment, which not only requires large amounts of costs in previous purchasing, but also causes easy loss and high maintenance costs. It has become an urgent need for the teaching of computer major in many universities and colleges to use limited lab teaching resources for students to have adequate conditions for practice and knowledge consolidation, as well as the construction of their ability to solve real life problems and innovation [3].

This research has developed a virtual experiment teaching platform for digital logic based on LabVIEW software in order to improve teaching effects, save teaching costs and reduce risks due to mis-operation when using facilities [4-5]. Using the design tool graphical user interface (GUI) of VI [6-7], this platform combines teaching with experiments and can be used to aid experiment teaching, class demonstrations, as well as self-learning and experiment previewing for students after class. This empirical research shows that this virtual experiment teaching platform is conducive to students'

perceptual knowledge and consolidation of the theoretical knowledge of digital logic, as well as the enrichment of teaching approaches and efficiency [8-12].

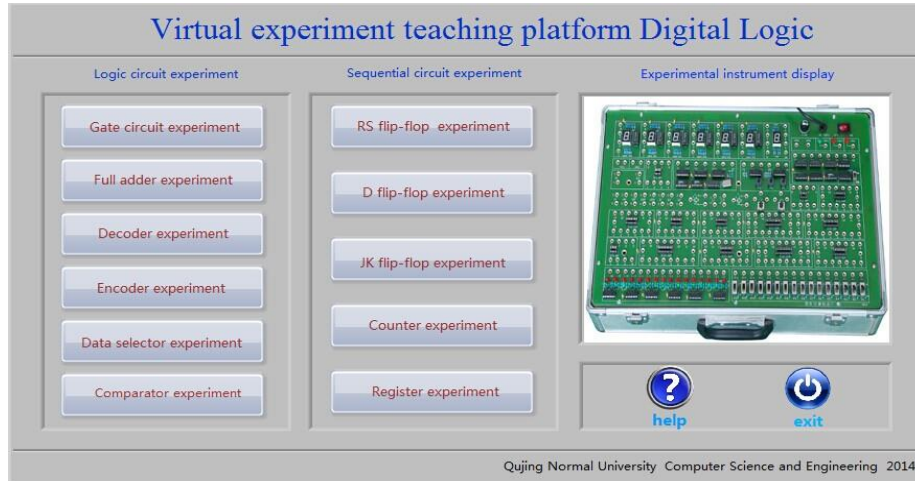
## **2. Introduction of LabVIEW Development Tool**

LabVIEW programming environment boasts of many advantages: the structured programming does not require much code-writing; it uses familiar terms, icons and concepts; it provides numerous clear icons, expandable function libraries and subroutine libraries. Using it, program design and function can be quite easy; principle research, design, testing and equipment system implementation can be far more efficient. Therefore, with LabVIEW, virtual platform designing can be much less work-load and lower costs [6]. LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a powerful graphical virtual instrument development environment, widely accepted by industries and research institutions in automobiles, semiconductors, aviation and aerospace, transportation, telecommunication and biological medicine, etc. As a typical graphical programming language (G language), its development environment combines the high performance and flexibility of graphical programming formulas with the high-tech and configuration targeted at testing, measurement and automated control. It provides the necessary development tools for various applications including data collection, instrument control, measurement, analysis and data display, etc [6].

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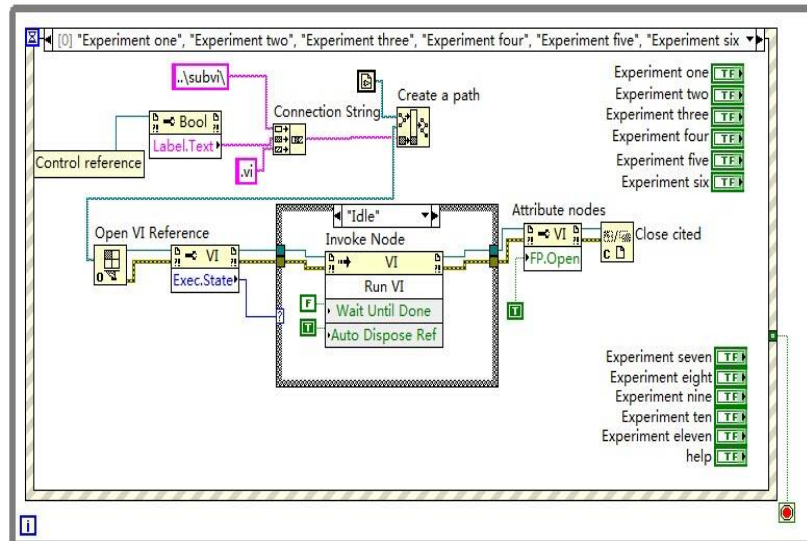
## **3. Structure Design of the Virtual Experiment Teaching Platform**

LabVIEW has more than 600 internally integrated analytic functions, used for the analysis and applications of signal generation, frequency analysis, mathematical calculation, digital signal processing, etc [6-7]. This paper makes full use of the internal functions and designs the corresponding virtual experiment platform according to the content and requirements of the experiment. The front panel of the main interface is shown in Figure 1. The main interface is constituted by three parts: the logic circuit, the sequential circuits and experimental instrument display, where in the logic circuit includes basic gate circuit, full adder, decoder, encoder, data selector and comparator; the sequential logic circuit is made up of RS flip-flop, D flip-flop, JK flip-flop, counter, register experiment, totaling 11 major sub form modules[13]. The corresponding sub forms can be started by clicking on the main interface button. The experimental instrument display is to show the typical instrument of digital Logic laboratory by animation dynamic display. One of instrument pictures is shown.



**Figure 1. The Front Panel of the Virtual Experiment Teaching Platform**

In the main interface in the diagram, the conditional structure is used to control program exit; the event structure is used to select among experimental projects; after choosing a certain experimental project, the sub-form can be started by calling the sub VI. This process involves functions of the creation of path, the attribute node, opening VI reference, calling nodes, closing reference etc. The specific program chart is shown in Figure 2.



**Figure 2. The Program Chart of the Virtual Experiment Teaching Platform**

## 4. Case Introduction for the Virtual Experiment Teaching Platform

This part is focused on a detailed description of the design process of the gate circuit and RS flip-flop experiments.

### 4.1. Gate Circuit Experiment Design

Gate is the basic unit circuit to implement the digital system. Understanding the internal structure, working principle and the external characteristics of gate circuit is necessary for analyzing and designing the digital logic circuit. Therefore, this experiment sets several basic experiment of gate circuits projects, including and, or, xnor, xor and not. The experimental interface is shown in Figure 3. Toggle switch A and B in the gate circuit experiment (below the interface), and the results can be shown in the output F. In the process of experiment, the verification can be done using truth table of the gate circuit (above the interface), so as to understand the working principle of gate circuit.

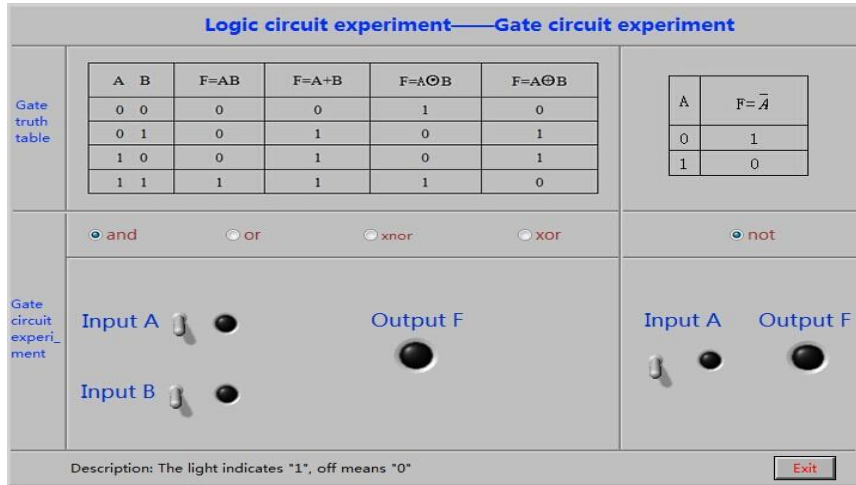


Figure 3. The Front Panel of the Gate Circuit Experiment

The program chart of gate circuit experiment is shown in Figure 4. In the interface, the 3 Boolean vertical control switches are the input of the logical operation, and the 2 Boolean LEDs are used to display the results of logic operations. Among them, operations and, or, xor and xnor use the Boolean radio button. Set the button number 4 to carry out the operation selection, and use conditional structures for distinction. Boolean logic controls are added in each branch. The program chart of “and” branch operation is shown here.

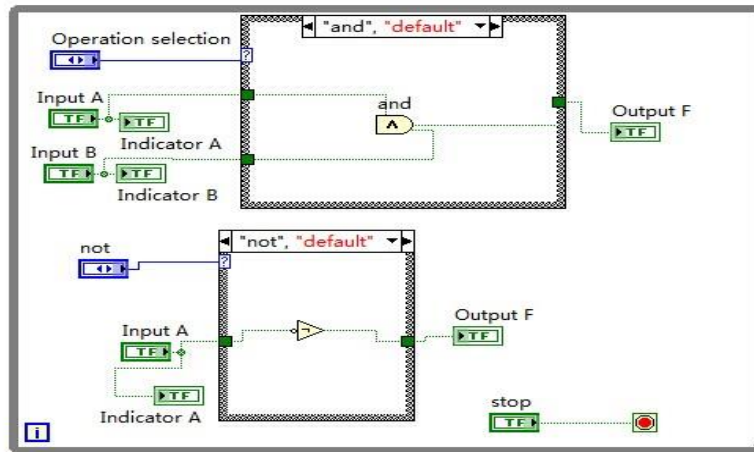


Figure 4. Program Chart of Gate Circuit Experimental

## 4.2. The RS Flip-flop Experiment Design

The interface and result of RS flip-flop experiment operation is shown in figure 5. Choose the experiment content on the main interface; by clicking on the button R and S on the virtual operating panel, student can set the clock frequency and duty ratio; observe the Q waveform of dynamic output of the RS flip-flop; make contrast with the RS flip-flop function truth table and experimental results of the RS flip-flop for learning and summarizing the logic functions of RS flip-flop. The whole experiment learning process is vivid and entertaining, allowing students to better understand the function of RS flip-flop. Figure 6 shows the program chart of sub VI for simulation experiment on the RS flip-flop.

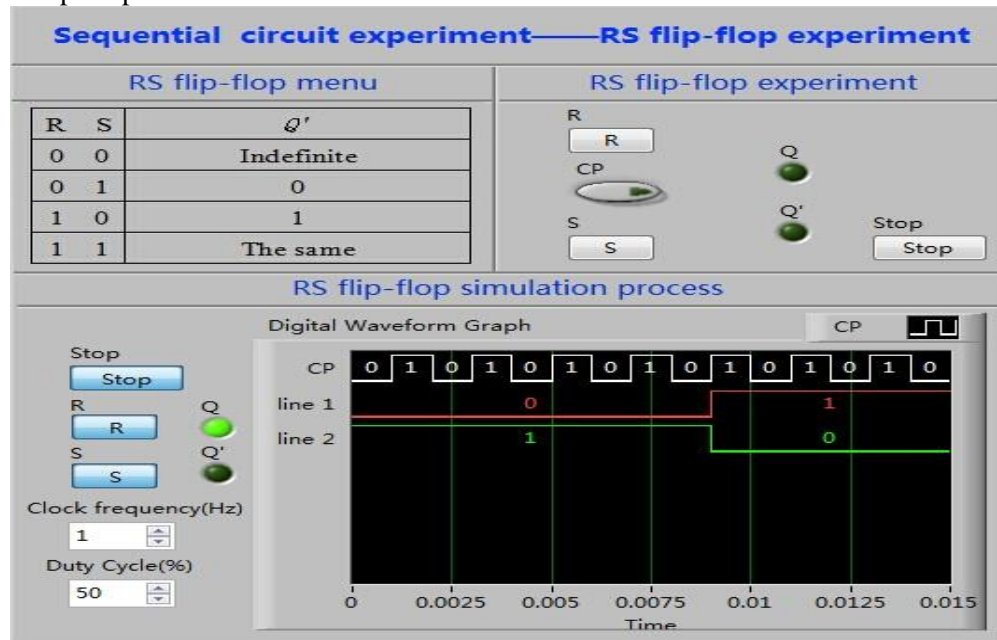


Figure 5. The Front Panel of RS Flip-flop Experiment

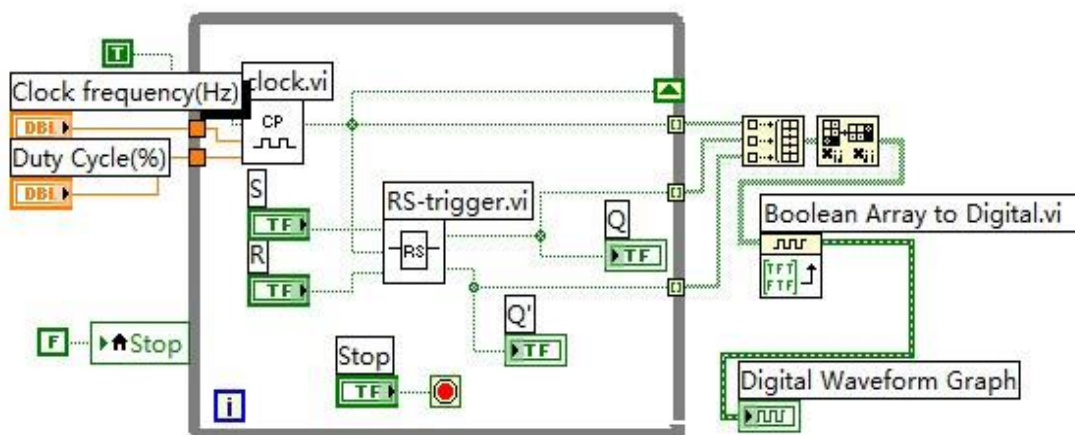


Figure 6. Sub VI Program Chart of RS Flip-flop Simulation Experiment

## 5. Conclusion

This paper has given a detailed introduction to the development of a virtual experiment teaching platform for digital logic. Although this platform is mainly developed for this course, it can be also adapted to the teaching design of other subjects. Using the virtual demonstration experiment designed by LabVIEW [14-15] in digital logic teaching possess the following advantages: (1) The graphical user interface allows users to complete the experiment with a click of the mouse on the switches and a tap of input data. Students can understand the analytical methods and treatment results of the digital logic circuits and better grasp the theories they have learned. They are also able to see directly the dynamic changes of experiment results caused by different inputs. (2) Applying the design of virtual equipment in teaching not only helps teachers create a hi-tech atmosphere, but also offers motivates students to make experiments. The brand-new teaching platform enriches teaching methods and approaches and enhances teaching quality. (3) The limits of time and space of traditional experiment models are broken, for students can preview before experiment using the virtual platform, reducing their blindness when actually conducting the experiment. All in all, applying the virtual experiment based on LabVIEW in digital logic course teaching not only assists in class teaching, but also serves virtual experiment platform for students to do after-class exercise on experiments, so as to enhance their understanding of the theories and their practical abilities as well as their overall quality.

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## Author



**Kunliang Xu**, He received his M.Sc. in Computer (2006) from Yunnan University. Since 2006 he is a teacher of Computer Science and Engineering department of Qujing Normal University. His current research interests include different aspects of Electronic circuit design, computer software and virtual instruments.

