A Study on the Application of EDA Technology in the Design of Virtual Digital Electronic Experiment

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Abstract. Along with the rapid development of computer technology and electronic technology, the traditional digital electronic technology for experiment teaching can hardly meet the development requirements of the times. Therefore, it is essential to introduce Electronic Design Automation (EDA) into digital electronic experiments. From the perspective of EDA technology, the influences of EDA application to digital electronic experiments are analyzed intensively and the design frame and main functional modules for virtual experiment system are put forward, which can provide reference for digital electronic experiment teaching in universities.

Keywords: Electronic Design Automation (EDA) · Digital Electronic Experiment · Virtual experiment system · Functional modules

1 Introduction

As an important course for the major of Electronic Information in universities, Digital Electronic Experiment features both theoretical and practical significance [1]. Its main task is training talents for electronic application. With the development of computer and related technology, the environment for digital electronic experiment teaching in universities is changing continuously so that the teachers and students are faced with new opportunities and challenges [2–4]. Currently, traditional digital electronic experiment teaching can not cater for the development of modern education and even restrain the modernization of education. Therefore, it is essential to reform the traditional teaching methods and contents [5–7]. Electronic Design Automation (EDA) is a new emerging tool of electronic design automation [8]. It is good for changing traditional teaching mode and improving teaching quality of digital electronic experiment to meet the requirement of training innovative talents. Thus, it is an important tool for digital electronic experiment design [9]. This research introduces EDA technology and design procedures in detail and analyzes the merits of bringing EDA technology into digital electronic experiment system in hope of improving teaching effects and develop practical abilities of students.

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2 EDA Technology and Its Design Procedures

2.1 The Concept of EDA Technology

EDA technology has its narrow definition and a broader understanding. Broadly speaking, EDA technology is modern electronic design, while EDA in narrow definition refers to the automatic hardware design which takes computer as the platform and large-scale programmable logic devices as the base and uses EDA software development tool. Dedicated chips ASIC or IES are integrated by the automated design [10]. EDA technology represents the new development trend of electronic design in the new era. Its main characteristic is that designers use computer as the tool to complete the whole design by following top-down design method. Meanwhile, advanced development tools are used to do segmentation, optimization and simulation automatically. This method is called high-level design method of digital logic circuits. This design scheme is convenient for designers to modify corresponding software, forecast design results, improve system design efficiency greatly, shorten product development cycle and reduce system development cost.

2.2 Characteristics of Different EDA Software

Currently, EDA software widely used in China includes EWB, Protel, Multisim, and Matlab etc. EWB was developed by NI in Canada and it was used for electronic circuit simulation. Later, it was updated as Multisim. Multisim provides all kinds of database simulation systems in line with actual electronic equipment and related electronic products for users. It can integrate circuit diagram establishment, simulation analysis and its results as a real experiment platform. It can also print experiment data and schematic diagrams. Multisim is excellent EDA software for circuit design. Protel is a circuit design system with strong functions. It gains a high popularity rate in China. Its function covers drawing circuit schematic diagrams, designing programmable logic devices and generating corresponding charts etc. Learning circuit layout and welding procedures with the software is good for students to improve their abilities of comprehensive designing and practical operation. As an effective engineering computing language, Matlab can be used to do conceptual design and modelling simulation etc. Dynamic modeling simulation tool is a sub-product based on Matlab. It relies on the strong computing function of Matlab, combines the interactive simulation interface and functions, and takes use of virtual equipment to demonstrate simulated dynamic results visually. Thus, it has become one of widely used software package in dynamic modeling and simulation experiments. However, the functions of the software mentioned above are similar but different with their advantages respectively. Multisim has convenient operation interface with which functions for creating circuits and choosing components can be selected directly from the shapes displayed on the screen. On the one hand, it can solve the problems, such as the shortage of components and unqualified specification etc. On the other hand, it can help students know the contents quickly and enhance their understanding on the concepts and principles they learn by various analysis methods included in the software so that it can enhance the innovation ability of the students. Meanwhile, the tool can expand the component database as

much as possible, especially the component models in line with real components, to improve the practicability of the simulated circuits. As an advanced matrix/array language, Matlab has strong functions for design and dynamic modeling. Protel is good for students to make circuit independently and it can enhance hand-on abilities of the students. Therefore, students can select different EDA softwares to do designing.

2.3 Designing Procedures with EDA Technology

From the perspective of designing methods, EDA technology goes through the procedures like hardware designing, debugging, and welding for traditional circuits automatically on computers and it brings fundamental changes to digital electronic design. The process is shown as Fig. 1.

Input: One experiment item is composed of a single source file or several source files and these files can be schematic files or mixed input files etc.

Synthesizing: With EDA software synthesizer, VHDL software is synthesized with the hardware. It is the key point for turning software into hardware circuit. The synthesizer handles the source files in a comprehensive way for a certain product of the supplier FPGA/CPLD. EDA technology can provide good functions for optimization and logic synthesis. It can convert the logic circuit diagram made by the designer into gate level circuits and generate corresponding time series analysis documents or various reports.

Reasonable layout: After the synthesizing, FPGA/CPLD layout/wiring adapter is used to do logical mapping of netlist files to a certain target component, including logical segmentation, optimization and distribution etc. It shall be noticed that the adapted objects after processing shall be in line with the structural details of the components.

Simulation processing: Before downloading the programming, EDA tool is used to make simulation test on the adapted results, i.e. make simulation processing. EDA tool can be used to do simulation tests for different time series and functions. Among these, time series simulation is the simulation processing based on the adapted netlist files and it is the closest one to real object operation. During the simulation procedures, the hardware features of the components shall be taken full consideration. Therefore, the precision of simulation processing with EDA technology is much higher than other methods. Function simulation refers to test simulation on logic functions related to description and it is used to know if the functions meet the requirements of original design.

When the design passes the simulation tests and meets the standards, files generated by adaptation are downloaded through Byteblaster cable to FPGA/CPLD device for real-time hardware debugging and verification. After the above procedures are done, a comprehensive test is done for the whole FPGA or CPLD hardware system to check the operation of the design item in the system. Problems in the design are detected in time for the improvements of the entire experiment.

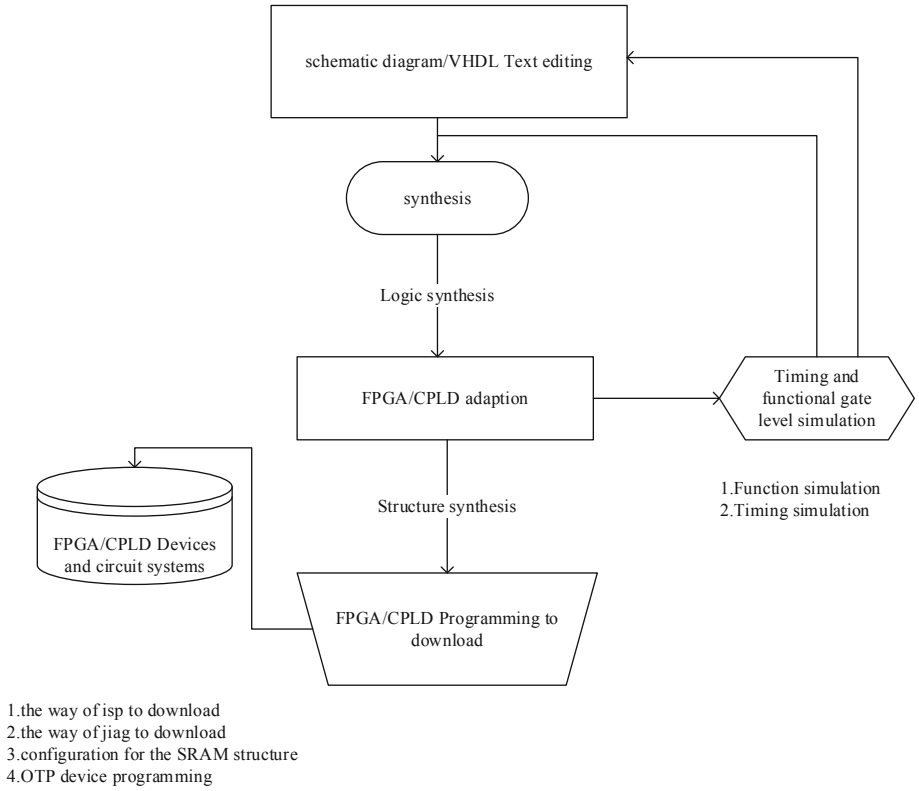

Fig. 1. EDA development and design process

3 Advantages of Using EDA Technology

3.1 It Is Good for Improving Teaching Effects

Using EDA technology in experiment teaching relies mainly on the computer for various operations. Even there are no experiment studies done, related designs can be done smoothly. In addition, all data and files of the experiment can be preserved after the design is done. Using EDA technology in digital electronic experiment can help teachers to solve the problems in traditional experiment teaching. It can not only improve experiment teaching effects, but also enhance the reliability of the experiment. Meanwhile, students can ask questions on the parts they do not understand, or design according to their own thinking without worrying about the device may be damaged. Thus, the experiment teaching effects are improved.

3.2 It Is Good for Improving Develop Practical Abilities of Students

Using EDA technology in digital electronic experiment can facilitate circuit debugging and the development time is shortened. With its advantages, students can understand the key of electronic design intensively. At the same time, students can get better experiment results by taking advantage of this platform. Therefore, it has a positive

impact on stimulating students' interest and enthusiasm in learning, facilitating students to master experimental methods and knowledge, and expanding students' thinking.

4 Design Virtual Experiment System Based on EDA Technology

Traditional digital electronic experiment uses small and medium scale integrated circuits to do experiments and it completes the experiments with wire lapping or test box. However, a lot of problems like poor electrical contact performance, high loss and low efficiency often happen in these experiments. Meanwhile, if such problems happen in experiment teaching, teachers shall waste a lot of time helping students to check errors in wire connection and to remove bugs in techniques or processes. It is a waste of teaching time and it also has a negative influence on students' enthusiasm. Therefore, more and more universities start to develop virtual experiment systems voluntarily to facilitate digital electronic teaching. To analyze from the perspective of experiment content, it can make experiment courses more flexible and teaching tasks to be fulfilled more easily. Besides, the system allows every student to try different ways to do the design so that it is good for students to expand their thinking and their creativity and imagination can be inspired.

4.1 General System Frame

In traditional digital electronic experiment teaching, one device is assigned to one certain student. In fact, preparation for an experiment usually takes a lot of time, while the time for the student to use the equipment for the experiment is limited. To some extent, it is a waste of the experiment resource. Therefore, traditional experiment teaching cannot cater for university development and the reform on digital electronic experiment is an urgent issue which needs solutions. This virtual digital electronic

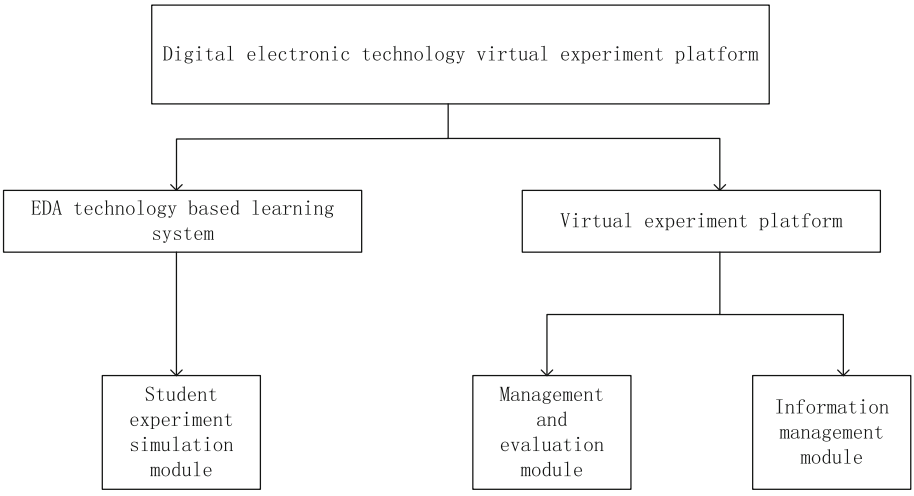

Fig. 2. Virtual experiment platform constructed on EDA technology

experiment system includes two parts, the system and the virtual laboratory. The developing and construction are done with the software Quartusll and Matlab etc. The learning system supports the simulation experiments for the students, while the virtual laboratory is for the developer to do information management, evaluation management and teacher management. The above functions construct a complete virtual experiment teaching system and the structure is shown as Fig. 2.

4.2 Functions of the Modules

Constructing the virtual experiment system is very complicated. To ensure the operation quality and efficiency, the system shall be equipped with suitable network structure. Because the virtual experiment system is developed on the campus network and the scope of application is small. In addition, the system shall be very interactive with real-time responses. To meet the requirements above, this design selects the method of C/S to realize rich interactive effects at the client. According to real experiment teaching process, the design, execution and evaluation of digital electronic experiment, and the characteristics of computer platform, the whole virtual experiment teaching system is divided into three modules, experiment simulation, management and evaluation.

Platform Information Management Module. This module is the reception desk of the virtual experiment teaching system as well as the demonstration part for teaching and management modules. The experiment platform can display if the teaching management works well. This module has the functions of registration, log-on, experiment information management and fault treatment and its key task is managing daily experiment information, such as registration and log-on of students, experiment item downloading, and fault maintenance done by the management etc. Users have to get registered and verify their identity. When doing the registration, users have to fill in their registration information correctly. After the system reviewed the registered information, it will be stored in the database automatically. If the users need to enter the virtual experiment system, they shall enter the correct accounts and passwords. If the account and the passwords are wrong, the system will shift to the interface for re-logon and the experiments can be done on the virtual experiment platform only after the verification is successful.

Basic Learning Module. This module is composed of instrument and theory learning, EDA tool learning and hardware programming learning etc. Among these, EDA learning includes some excellent simulation tools, DSP, QuartusII and Protel etc. It provides good learning and simulation process for digital circuit theory and digital circuit design. Through learning the tools mentioned above, students can improve their abilities of circuit design effectively. As is known to all, the success of virtual experiment system lies in the factors of teaching resources, new technology application and case construction etc. The case construction is the most important factor. When setting up the general teaching plan, new theory and technology shall be considered, the theoretical level and acceptance ability of the students at different stages shall also be considered to improve their learning interest and enthusiasm. Therefore, basic learning module provides complete digital design cases for learners, such as traffic lights control system, data collection system, and camera monitor system etc. This is good for students to know the digital electronic experiment system and to enhance their designing ability.

Student Experiment Simulation Module. This module is composed of several submodules, obtaining information, basic learning, starting and saving virtual experiment and sending experiment results etc. Through virtual laboratory, students obtain the experiment task and related information. After basic learning, they select required EDA tool to do virtual experiment. When the experiment is done, they save the results, such as schematic diagram and program codes etc., and upload their experiment procedures and results for their teacher to check. The module structure is shown as Fig. 3.

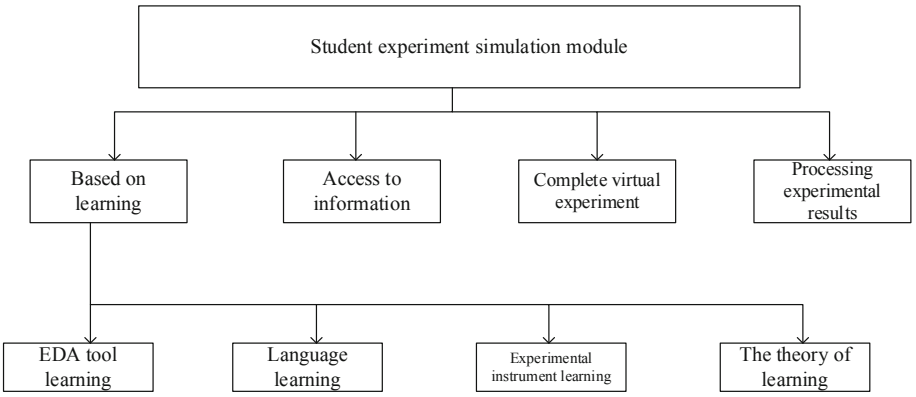

Fig. 3. Main functions of experiment simulation module

Teaching Management and Evaluation. The functions of this module include releasing experiment contents, obtaining experiment items, reviewing experiment items and managing student information etc., as shown in Fig. 4. The teacher displays the experiment contents on the virtual experiment platform according to the teaching task for the students to do corresponding experiments. When the students fulfil the experiments, the teacher gets the uploaded information and gives responses to the students with the review results.

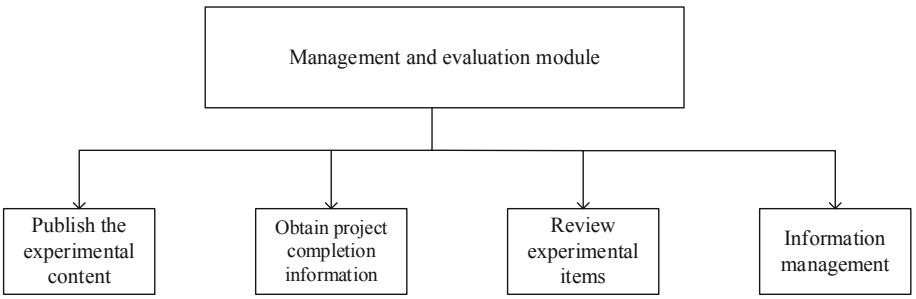

Fig. 4. The structure of teaching management and evaluation module

5 Conclusion

To summarize, virtual digital electronic experiment system is a new mode for experiment teaching. It can provide a humanized, practical and open experimental teaching environment for students and exert positive influence on the improvements of digital electronic experiment teaching. Based on EDA technology, this study analyzes the advantages of EDA technology in digital electronic experiment teaching and puts forward the virtual experiment system and its main function modules constructed with EDA technology in hope of providing some references to digital electronic experiment teaching.

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