

# Application of FPGA in teaching reform of digital electronic basic experiment

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**Abstract:** Digital electronic basic experiment is an experimental course which emphasizes the combination of theory and practice. Because the traditional verification experiment can not meet the development requirement of students for engineering practice, teaching reform is imperative. This paper introduces the technology of FPGA into the experimental system, and uses the technology based on FPGA to carry out experimental development. Because the technology of FPGA itself is based on the technology of engineering application, its simulation technology can simulate the actual work of the product very well. By introducing the technology of FPGA and combining with design examples, students can not only have a deep understanding of theoretical knowledge, but also stimulate innovative consciousness and improve engineering ability.

## 1. Introduction

With the rapid development of computer technology, digital circuit[1] is more and more widely used in signal processing, and its advantages are more and more prominent, which puts forward higher and higher requirements for class teaching and design experiment. The digital electronic basic experiment[2] is a basic experiment course which mainly studies the analysis and design of logic gates, integrated devices and circuit, and emphasizes the combination of theory and practice. As the key of higher education reform is not only to improve the quality of teaching, but also to cultivate innovative talents, the previous teaching mainly focuses on verification experiment, which can not improve the comprehensive of practical ability, nor adapt to the actual development of digital circuits. The teaching of digital electronic basic experiment is not only an important way to cultivate practical ability of testing, analysis and design, but also an important way to cultivate innovative spirit. It is necessary to consolidate theoretical basis and strengthen practical ability.

Because the digital electronic experiment should be closely integrated with daily life, such as digital clock, traffic lights, transponders and so on, innovative experiments such as automobile flash taillights, robot path-finding experiments need to be added. In order to achieve this goal, we can use the FPGA technology[3-4] as a tool to reform the existing experimental courses. This paper introduces the important role of FPGA technology in the experimental teaching reform[5-7] of digital electronic. Students can not only master and use FPGA to design digital circuits skillfully, but also enter the state of “electronic designer” in a short time.

## 2. Related theoretical analysis

### 2.1 FPGA technology

In the past, the students majoring in electrical engineering seldom had the opportunity to participate in practical engineering design when they were studying professional courses, and their theoretical knowledge was difficult to relate to the actual engineering products. The digital electronic basic experiment mainly introduces the principle and verification experiment. Although students can directly use such as Multisim and other software to verify, after all these software only can simulate the algorithm or model simulation. Field-Programmable Gate Array (FPGA), is a product developed on the basis of programmable devices such as PAL and GAL. The FPGA technology is based on the technology of engineering application. The simulation technology of FPGA can simulate the actual

work of the product very well, especially the timing simulation technology. It passes the programming of the timing simulation on the computer and can be directly applied to the project without any modification. The integration of design, verification and simulation can perfectly combine theory with engineering practice. Figure 1 shows the development and design process of the FPGA.

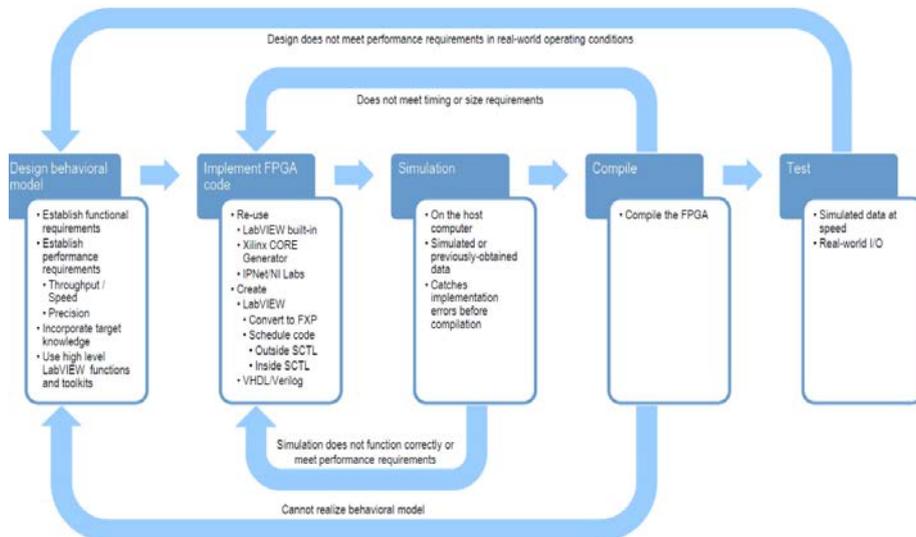


Figure 1. FPGA design flow

## 2.2 Problems in digital electronic basic experiment

At present, the traditional experiment box is still used in the digital electronic technology experiment class, Most of the experiments are verification experiment. A large number of connections are needed in the slightly complicated experiments. It is very easy to make mistakes, and the signal attenuation caused by a large number of connections also affects the results of the experiment. Because the reasons of the limitation of equipment and other objective, it is impossible to carry out innovative experimental design, which hinders the cultivation thinking in experiments. The drift of the parameters leads to the increase of the errors in the experimental results and the analysis of the experimental errors, which is contrary to the intention of the experimental verification.

## 3. Teaching reform of digital electronic basic experiment

### 3.1 Thoughts on teaching reform

Based on the above situation, according to the principle of digital electronic basic experiment from shallow to deep and gradually improving, the teaching reform should be divided into three stages: basic experiment, design experiment and system-level experiment, and different teaching methods should be designed according to different experimental levels. The basic experiment is the verification experiment, which mainly verifies the basic theory, so that students can master the basic operation means, measurement and calculation, statistics and other experimental methods. In the experiment, the teacher participates in the whole experiment process, through the basic experiment, cultivates the basic literacy and good experimental consciousness, and lays a solid foundation for the design experiment. Designing experiments include design experiments for functions such as digital clocks, traffic lights and transponders, and innovative experiments such as automobile flash taillights and robot path-finding experiments.

### 3.2 The introduction of hardware description language in classroom teaching

First of all, the teaching content reform of digital electronic basic experiment is carried out. The digital electronic basic experiment is divided into two courses (Digital Logic Circuit experiment and Digital Electronic Circuit experiment). In the Digital Logic Circuit experiment, we still mainly

discuss the analysis and design of combinational circuit and sequential logic circuit, so that students can learn the basic knowledge of digital electronic technology. In addition to explaining the basic working principle of gate circuit, the generation and shaping of pulse signal, semiconductor memory and the basis of A/D, D/A, the part of Digital Electronic Circuit experiment adds the explanations of 10-hour or so of FPGA technology. In the teaching content of FPGA technology, this paper briefly introduces the basic concept, development process, hardware description language and development environment of FPGA. This is mainly about the notes of the hardware description language.

Hardware Description Language (HDL) is an important part of FPGA technology. Hardware Description Language (HDL) is mainly used to write design files and build circuit models in PLD. VHDL and Verilog HDL are the two most commonly used hardware description languages. These two hardware description languages adopt the language form and description style of the general computer high level language. As most college students have opened the C language course before learning the course of “Digital Electronic Technology”, students have a certain ability of C language programming. Therefore, in the teaching of theory course, it is not the norm and format of the language that should be emphasized, but several important features different from other high-level programming languages. The following are introduced separately. Instruct students to write HDL statements with parallel and delayed concepts. Hardware Description Language (HDL) describes the logic function, circuit structure and connection form of electronic system by means of software programming, so there must be some hardware features such as parallel and delay.

### **3.3 The introduction of FPGA technology in teaching reform**

In the process of practice teaching, it introduces the development software and process of a programmable logic device by using multimedia teaching environment, including input, compile, emulate and download test of design files, so that students can understand the process of developing FPGA technology. Quartus II is a professional software developed by Altera to develop programmable logic devices. It is a verification and innovation software. In practice teaching, teachers can take Quartus II software as an example to explain the design process of FPGA.

The introduction of FPGA technology should be linked to this profession to better serve the purpose of professional services. Digital electronic basic experiment as a professional basic experiment course, its basic theoretical knowledge, analysis methods and design will lay a good theoretical foundation for the follow-up professional courses. In the introduction of FPGA technology, through the introduction of professional related examples, to better achieve the purpose of professional basic experiment courses for professional services. Secondly, the basic modules of digital and electrical experiments, including voter, full adder, LED lattice display, LED digital tube, gate circuit keying modulation, counter, timer, frequency divider, memory, BCD code adder, parallel multiplier, color lamp controller, pulse generator, A/D and D/A converter, have exceeded the experimental platform. The experimental range can be completely replaced by the application of FPGA technology, and further familiar with the design environment of FPGA. The graphical editing method of ISE software can be used to stimulate the interest and motivation of the students.

## **4. Conclusion**

The technology of FPGA is widely used in recent years. The application of new technology in teaching experiment depends not only on the characteristics of the combination of hardware and software of the FPGA itself, but also on the innovative way of experimental teaching of digital electronic technology. Strengthen teaching means, promote the training of teaching quality and ability, and improve the level of experimental teaching. Efficiency and quality play an important role in cultivating practical ability of students, innovative consciousness and innovative ability.

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