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Development of HDL Modules for E-Learning

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***Abstract*: The challenges faced by an entrant of an undergraduate course or any individual who has interest in learning Digital logic and design is in perceptive the essentials of Combinational and Sequential Circuits. To overcome the challenge, a module was introduced to enhance the learning in Combinational and Sequential circuits. To improve the performance of learners, there was a need to improvise their understanding the concepts of Digital logic; hence this activity was designed and implemented. The e-learning module was design with help of Xilinx ISE and Visual Studio 2017. This e-learning tool was applied in designing structured learning experiences and it was targeted to enhance understand the fundamentals of Digital Logic. Learners were encouraged to study online videos given on YouTube. This paper will describe how any Digital circuit can be taught with the integration of different tools such as Xilinx, Visual Basic & FPGA in a simple video which can inculcate concepts in the mind of the learners which was thought to be difficult by the instructor. Xilinx will act as a platform to write software programs for OR gate (in this case) and perform behavioral analysis on it. Visual Basic will be useful when it comes to checking different outputs for different cases by the learner. The programs will be uploaded on the FPGA board to check the real time analysis.**

***Keywords*: Xilinx, Modules, e-learning**

1. Introduction

Teaching means a purposeful and pre-planned activity aimed at providing opportunities to facilitate and accelerate learning and systems development. Learning is a process for achieving knowledge, skills and the ability to make decisions and performance that ultimately leads to a change in their behavior. At the same time, with the rapid changes and the development of new information technology techniques and skills and their impact on the way of life, the education process, which is one of the fundamental pillars of society, is also changing. With intercommunal communication and the emergence of different needs and innovation, people entered a period called the information era. Increasing and strong tendencies to e- learning show the various advantages of this method in comparison with traditional teaching methods. Many educational psychologists also believe that learning should be organized in such a way that each learner is engaged in learning activities based on his or her ability. In this regard, it should be noted that e learning is an individual training where learners are able to achieve educational goals based on their own talents and, in fact, they learn how to learn, and this is one of the educational goals, because learning continues throughout life. So, in this paper, we review the effectiveness of e-learning when it is implemented in Engineering curriculum to teach students one of the courses named Digital circuits and Design and its effect when it is combined with traditional learning. Digital Circuits have evolved from simple 4-5 gates to more than thousands of transistor devices. When it comes to devices consisting of 4-5 gates it could be easily tested on the breadboard whereas it is difficult and impractical to mount thousands of devices and test it using the breadboard. Hardware descriptive language offers a platform for testing the behavior and logic of complex circuits. Designers no longer had to place gates manually for the construction of digital circuits. You could describe complex circuits in terms of functionality and data flow at an abstract level by designing these circuits in HDLs. The logical synthesis tools would implement the specified gate and gate interconnections functionality. HDLs are also used to simulate system boards, interconnected buses, FPGAs and PALs (Programmable Array Logic).

Verilog also introduces modules concept. The basic building block in Verilog is a module. A module can be an element or a collection of design blocks at a lower level. Elements are typically grouped into modules to provide common functionality that is used in many design locations. A module gives the higher-level block the necessary functionality through its port interface (inputs and outputs) but hides the internal implementation. This enables the designer to modify the internal modules without affecting the remainder of the design.

2. Literature survey

Learning digital logics and performing hardware simulation go hand in hand. But these methods do not work when you ought to learn complex circuitry on the bulky laboratory equipment and you might also go wrong with the practical values. With the emergence of computer, hardware simulation could be performed using software which made it possible to evaluate hardware components without fabricating them; however, few of them possess the right combination of simplicity and user empowerment. This is where the perfect combination of Verilog Language & Xilinx ISE fit in. Verilog language is comparatively easier to digest than its predecessor-VHDL thanks to the basic C language taught at Educational institutes. This will help us as a tool to inculcate digital logic in the minds of learners. Many students, having learned other programming languages such as C, can usually modify a program until it performs the required function. With VERILOG this may not be a good option. Students should be kept in mind that VERILOG is NOT a programming language,

it is used to describe the behavior and property of the digital hardware, thus while writing VERILOG module, they should always have a clue of what kind of hardware can be generated or what type of hardware they are designing. Being able to put this statement into practice would require substantial practices and experiences.

In today's technological era, e-learning is finding its root in almost every sector for learning, because of its benefits over the traditional methods, still there is a need to find an e-learning solution for digital logic and circuits. These benefits of e-learning could be enhanced when e-learning emerges with the traditional learning methods thereby generating a perfect platform for learning Digital circuits.

The module can be designed with the help of Xilinx and Visual Studio 2017. This website contains animated videos of various topics from subject, which includes basic concepts of Physics, Electrical Engineering and introduction to Basic Electrical Engineering laboratory.

- To comprehend the concepts of Digital circuits through Animated Video.
- To provide students with opportunities for self-assessment.

Also, learners using traditional methods learn only theory point of view and for practical and real time approach they need to spend a lot of time in it, so for practical understanding a proper hardware system must be there which will not consume much time as well.

3. Methodology

A. *Problem definition*

The world is moving towards digitization & automation, but the employees are not well versed with the upcoming technology. It takes time to assimilate to the updated technology. In a fast-moving market where time is money it is important that they learn everything in a short amount of time. Usually, the person takes 2-3 courses in order to build the basics of trending technologies. And completion of single course usually takes 5-6 months which consumes a lot of time. This is where our paper comes to picture wherein we are designing circuits with their visual representation using Verilog and FPGA which will help them to understand complex circuit. Learning Digital logics is also very important as is forms the base of many subjects such as VLSI, IoT, Computer Hardware, etc. Simply mugging up all the concepts won't do the trick of remembering them for lifetime. As the learners will see the circuits working in real life their concepts will be clear.

B. *Course module*

The information and data gathered regarding the previous implementation, operation; future scope of the above-mentioned topics from the literature survey. With the help of these data, we have designed an e-learning module for learning complex digital circuits using visual representation, hardware; software implementation using FPGA and Verilog respectively. Further, the division of the digital logic into four sections that is, Combinational circuits, Sequential circuits, FSM (Finite State Machine), Microprocessor. The Verilog function of the mentioned circuits on the Xilinx IDE software was identified. Then all the circuits were coded on Xilinx using Verilog language to test its behaviour and logic verification. Then real time analysis of the chosen circuit was done on the FPGA hardware board. After this, designing of the GUI was done using Visual Studio 2017 to visualise the functioning of the GATE, which will show the proper output when different inputs are applied. Then a video has been made combining all the steps which has been performed earlier. Similarly, all the other combinational circuits, and other circuits will be developed in a module.

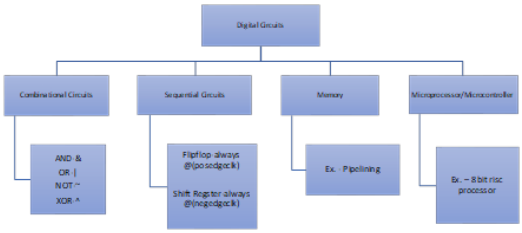

Fig. 1. Course module

4. Results and Discussion

The main aim of our paper was to develop logic related to the circuits such that the learner can remember it for lifetime. It was a big challenge for us as it was difficult to convey knowledge in such a way that it should be unique as well as eye-catching. We found our solution in day to day real life examples.

One of them was a two-keyhole lock that is used in bank lockers which can be opened only when both the keys are inserted simultaneously. This example functions in a similar analogy of an And Gate operation.

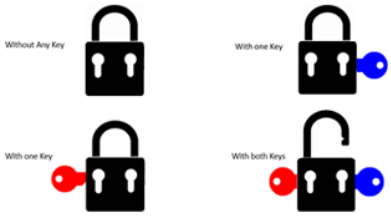

Fig. 2. Snippet of Video of And Gate

Moving Further we have explained how the And gate can be programmed using Verilog on the Xilinx ISE. As the Verilog programming is based on C language which is taught in most of the schools and colleges.

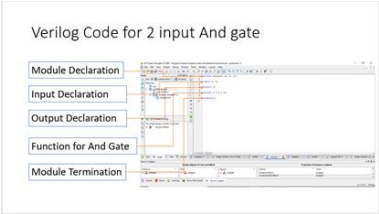

Fig. 3. Snippet from video VERILOG

In the next slide we will be explaining about the output obtained after the Verilog program coding. This will help in studying the output waveforms of the Digital device as well as assess Truth table of that device.

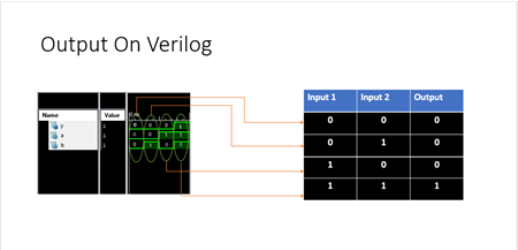

Fig. 4. Video snippet of Verilog output

Further we showed them how the circuit will look in a RTL schematic which is important in understanding the flow of data from and through different modules. Here as and gate is a basic circuit we can only see 2 inputs and one output.

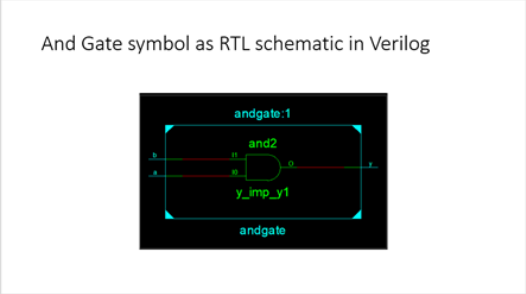

Fig. 5. And gate symbol as RTL schematic in Verilog

Finally, we ended the video stating the applications of the device.

5. Conclusion

This paper primarily intends to develop the logic-based understanding of the Digital logic. These e-learning modules can be referred by any beginner who wants to learn about digital logic, its operations, functions and application or anyone who wants to learn about latest technologies like IoT, embedded systems, VLSI, etc. in short span of time. The module strategy of the courses can be used to improve the interest and knowledge of students. Some people don't understand the idea of digital logic at the beginning, but they can understand the idea because of online support. These modules have been designed in such a way that it covers basics of digital logic in a very exciting way and the understanding becomes much better with the help of explanation of output waveforms and truth table. Usually the person undergoing graduate courses takes up to 3-4 courses to cover the digital logic and each course requires 5-6 months to complete. So, it becomes time constraint i.e., people take too much time for completion of digital logic in this time bound world. So, these modules cover each and every topic in a limited time frame i.e., up to 15-20 minutes. As this paper consists of e-learning modules, it will be available at free of cost and all the topics is covered in short span time, unlike traditional learning methods. While learning digital logic, people will also learn Verilog functions and commands which is not include in the curriculum.

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