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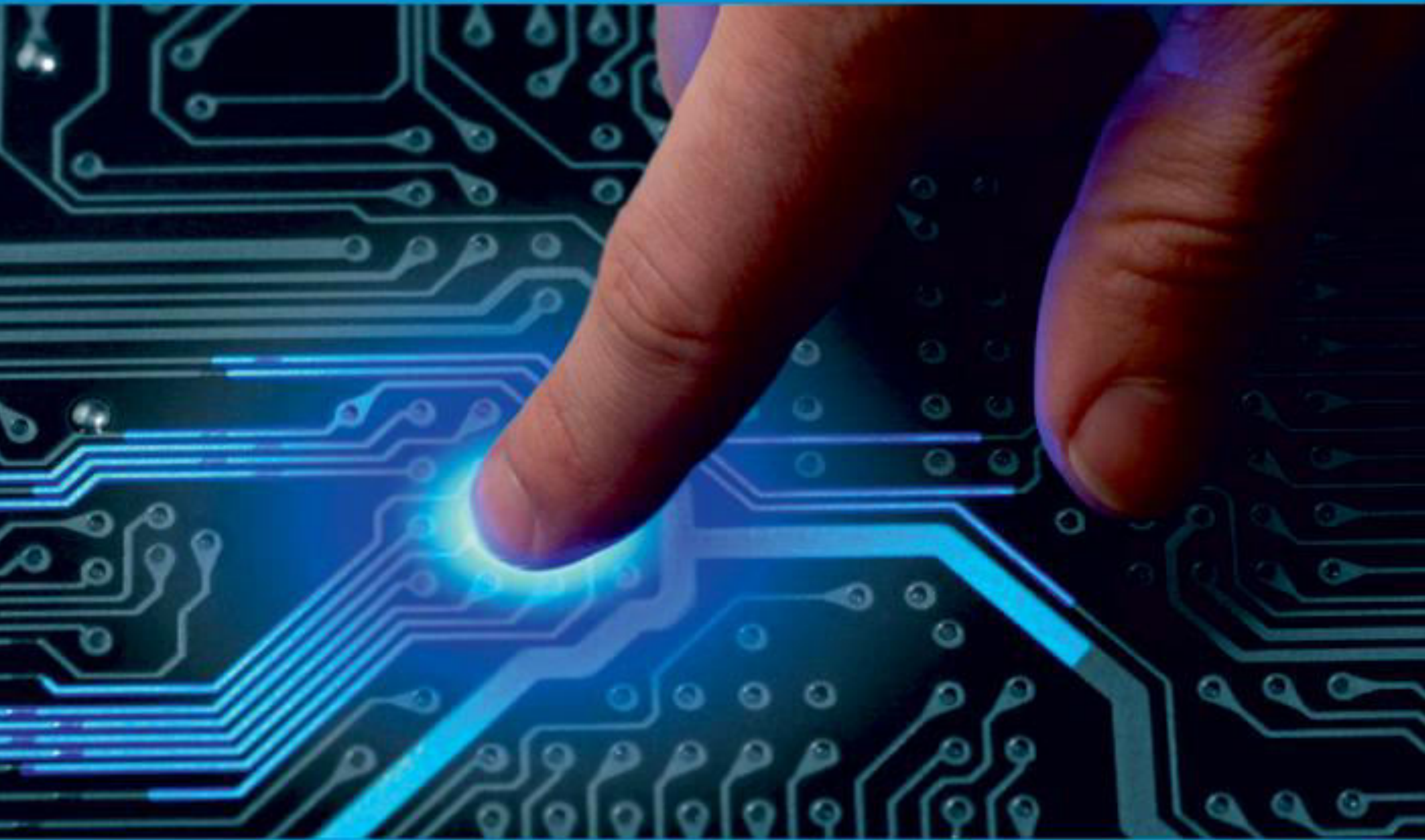

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Digital Logic Gates Implementation using FPGA and Embedded Systems

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ABSTRACT: This study looks at the latest uses of embedded systems and Very Large Scale Integration (VLSI), particularly Arduino and the DE10-Lite board to construct digital gates. The goal of the study is to verify the results of each platform. Platforms like Arduino are emphasized for embedded systems, with flexibility, resource limitations, and affordability being assessed. Performance, re-configurability, and flexibility of the DE10-Lite FPGA board are evaluated, with a particular emphasis on parallelism. The comparison provides insights into the appropriateness of Arduino and the DE10-Lite board for various digital gate implementations by taking into account criteria like scalability, application situations, and simplicity of use. The results seek to add to the continuing conversation on digital gate implementations by assisting researchers, engineers, and educators in choosing the best platform given particular project needs and goals.

KEYWORDS: Logic gates, CMOS, VLSI, Keil, Verilog, Arduino, Embedded System, Quartus Prime, FPGA.

I. INTRODUCTION

The use of digital gates is a key area of focus in the quickly changing fields of embedded systems and Very Large Scale Integration (VLSI). The platforms like Arduino, VHDL, Keil, and Verilog are discussed in his review paper. Digital gates are important components in digital communication and new technology they are essential block of micro-controllers and micro-processors.

Our review is primarily focused on the technologies like Arduino, VHDL, Keil, and Verilog and their practical implementation to solve real life problem and to get more precise to the calculated answers. It is very difficult to design digital gates because of wide number of operating technology so it is necessary to take decision wisely. We will examine the nuances of digital gate design techniques in relation to the Verilog, VHDL, Arduino, and Keil platforms during this review. Through a careful examination of the performance characteristics and design details, we hope that our review gives you the liberty to choose the platform correctly for your application. We hope that our comparative research will provide insightful information to the larger field of digital gate design, enabling wise choices and promoting progress in VLSI and embedded systems.

Embedded system is the system which incorporates with system hardware and software program it is the combination of hardware and software. VLSI is the technology which stands for Very Large Scale Integration. It is usually based on hardware. It uses millions of transistors to work. It consists of many micro controller and processors which uses many systems function

There are 7 basic gates which consist of AND, OR, NOT, NAND, NOR, EX-OR, EX-NOR. These gates are fundamental of digital electronics; these are generated to test the pulses provided. These gates are used in many microprocessors and controller and these gates can be generated by using VLSI and Embedded system. [7] [8] [9]

II. LITERATURE REVIEW

This paper compares and contrasts every fundamental logic gate using various design philosophies. [1] This paper provides the functionality of basic gates through simulation using LED and switches controlling them by Arduino. [2] [6] This paper proposes a four transistor NAND gate utilizing 32nm CMOS technology and demonstrates that any gate or VLSI can be constructed with four transistors (NAND). [3] This paper describes the digital logic trainer's hardware architecture and software implementation. Multisim was used to complete the simulation findings for the logic gate segment. [4] In this paper the detailed information about at-mega is given and Arduino ATMEGA-328 microcontroller has been programmed for various Logic gates. [5]

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III. TESTING

We have tested all of the logic gates on Arduino as well as on DE10-Lite FPGA (with Verilog) along with simulation using testbenches on Intel Quartus Prime software. We have verified that the output is same as the truth table.

1] NOT Gate: The NOT gate, also known as an inverter, is an electronic circuit that generates an inverted version of its inputs toward its output. The inverted output, known as NOT A, is shown as A' or A with a bar on top, for instance, if the input variable is A. A single bit can be entered into and output from this gate.

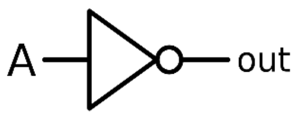

Fig. 1. NOT GATE

TABLE I. NOT GATE TRUTH TABLE

NOT Gate	
INPUT	***OUTPUT***
A	***Y***
0	1
1	0

2] AND Gate: An electronic circuit known as an AND gate produces a HIGH output only when all of the inputs are HIGH; otherwise, the output is maintained in the LOW state. An AND operation is shown by a dot.

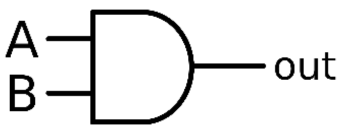

Fig. 2. AND GATE

TABLE II. AND GATE TRUTH TABLE

AND Gate		
INPUTS		***OUTPUT***
A	***B***	***Y***
0	0	0
0	1	0
1	0	0
1	1	1

3] OR Gate: An electronic circuit known as an OR gate produces a HIGH output only when at least one of its inputs remain HIGH.

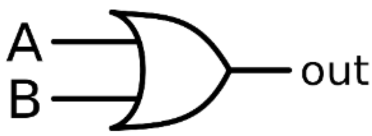

Fig. 3. OR GATE

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TABLE III. OR GATE TRUTH TABLE

OR Gate		
INPUTS		*OUTPUT*
A	*B*	*Y*
0	0	0
0	1	1
1	0	1
1	1	1

4] NAND Gate: This is a NOT-AND gate, which is the opposite of an AND gate and is equivalent to an AND gate preceding a NOT gate. If at least one of the inputs are LOW, then all of the NAND gates' outputs are HIGH. An AND gate with a little bubble on the output is represented by the symbol. Inversion is represented by the little bubble.

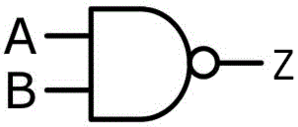

Fig. 4. NAND GATE

TABLE IV. NAND GATE TRUTH TABLE

NAND Gate		
INPUTS		*OUTPUT*
A	*B*	*Y*
0	0	1
0	1	1
1	0	1
1	1	0

5] NOR Gate: This is a NOT-OR gate, which is the opposite of an OR gate and is equivalent to an OR gate preceding a NOT gate. If at least one of the inputs are HIGH, then all of the NOR gates' outputs are LOW. An OR gate with a little bubble on the output is represented by the symbol. Inversion is represented by the little bubble.

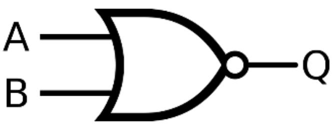

Fig. 5. NOR GATE

TABLE V. NOR GATE TRUTH TABLE

NOR Gate		
INPUTS		*OUTPUT*
A	*B*	*Y*
0	0	1
0	1	0
1	0	0
1	1	0

6] EX-OR: This is an exclusive OR gate, which symbolizes the inequality between the inputs. If one input is HIGH and the other is LOW, the gate's output is HIGH. It has two inputs and one output, and it is frequently used in circuits. In symbolic representation, the OR gate is surrounded by an arc.

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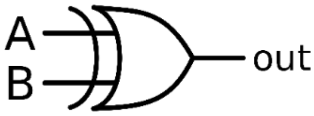

Fig. 6. EX-OR GATE

TABLE VI. EX-OR GATE TRUTH TABLE

EX- OR Gate		
INPUTS		*OUTPUT*
A	*B*	*Y*
0	0	0
0	1	1
1	0	1
1	1	0

7] EX-NOR: This is an exclusive NOR gate, which symbolizes the equality between the inputs. If both the inputs are LOW or HIGH, the gate's output is high. It has two inputs and one output, and it is frequently used in circuits. In symbolic representation, the NOR gate is surrounded by an arc.

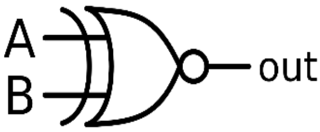

Fig. 7. EX-NOR GATE

TABLE VII. EX-NOR GATE TRUTH TABLE

EX-NOR Gate		
INPUTS		*OUTPUT*
A	*B*	*Y*
0	0	1
0	1	0
1	0	0
1	1	1

IV. RESULTS

The logic gates implemented over Arduino UNO (Embedded System) and DE10-Lite (FPGA) gave accurate results as per the truth table. Implementation of "AND" gate over Arduino UNO and DE10-Lite FPGA has been showed below. The simulation over Quartus Prime has been performed on a Windows 11 system with 12th Gen Intel Core i5 Processor with 16GB RAM.

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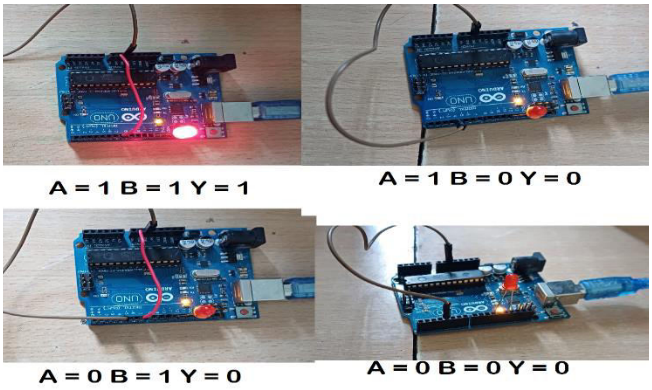

Fig. 8. Implementation on Arduino UNO

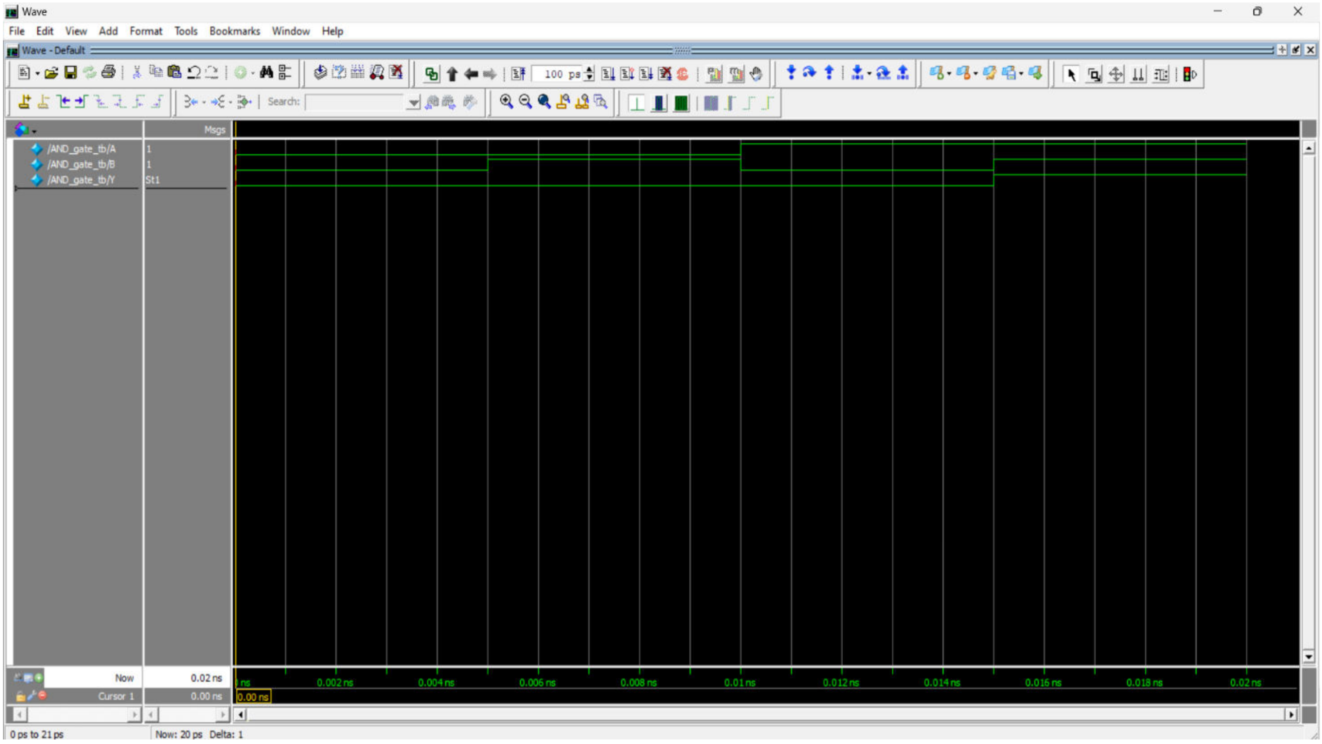

Fig. 9. Verilog RTL Simulation

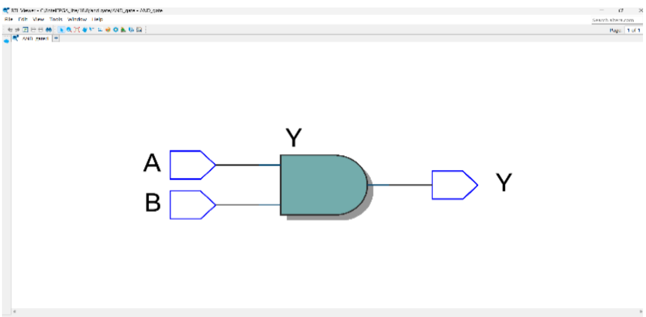

Fig. 10. Verilog RTL

Fig. 11. Implementation on DE 10 LITE INTEL FPGA

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V. CONCLUSION

Finally, our studies conclude by concentrating on the usage of FPGA and embedded systems for the development of digital logic gates, with a focus on platforms like Arduino and DE10-Lite. The paper investigates the challenges of creating digital logic gates in the quickly developing domains of embedded systems and VLSI. Our goal is to offer insightful information that will help decision-makers select the best platform for certain applications by comparing performance metrics and design elements. This work advances the field of digital gate design, enabling informed decision-making and advancing the domains of VLSI and embedded systems.

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