Digital Design Lab 2

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**Abstract**

The purpose of this lab was to become familiar with using the Quartus II software to create digital logic gates and connect them to hardware such as the FPGA board. In this lab, Quartus was used to set up a NOR logic gate. After the logic gate was made, the FPGA (Alterra DE2) board was connected to the computer and used to test it. The FPGA board successfully lit up only when both buttons were pressed (indicating 0s), which is consistent with the truth table for a NOR gate.

**Introduction**

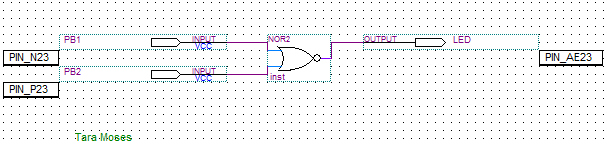
Quartus II is software that allows the user to create logic circuits and connect them to hardware. It works by letting the user drag and drop basic logic gates such as NOR, AND, OR, etc. The software offers various forms of these logic gates, each having a different number of inputs. After the logic circuit has been made, the user can rename each input (e.g. “switch 1”, “button 2”) and output (e.g. “LED”) to make the circuit easier to understand. Each input and output is then assigned to a certain point on the FPGA board so that the logic circuit can be tested.

This lab was designed to familiarize the student with using Quartus to make and test logic circuits. In this lab, a basic logic circuit was created using a 2-input NOR gate. The circuit was created, and the FPGA board was used to test it. The board was expected to light up (indicating a 0 on the truth table) when both buttons corresponding to the logic circuit inputs were pressed (indicating 0s as well). This outcome matched the truth table for a NOR gate.

**Design and Implementation**

For this lab, a 2-input NOR gate was arranged in Quartus. A new project was created and a 2-input NOR gate was selected and attached to the schematic window. After the NOR gate was added, two input pins were added to the left of the NOR gate. In similar fashion, an output pin was added to the right of the NOR gate. The inputs and output were connected to the NOR gate using the Orthogonal Node Tool to the left of the schematic. The input pins were renamed PB1 and PB2, referring to the buttons on the FPGA board. The output pin was renamed to LED, referring to the LED light on the board.

After the block diagram of the logic circuit was finished, the project was compiled to check for errors. The input and output pins were then assigned to parts of the FPGA board. The output LED pin was assigned to PIN\_AE23, which corresponded to LED0 on the board. PB1 was assigned to PIN\_N23, and PB2 was assigned to PIN\_P23. These corresponded to buttons KEY1 and KEY2 on the board. The schematic can be seen in Figure 1 below.



**Figure 1**: schematic of a NOR logic circuit with pin assignments.

The program was compiled again, and the FPGA board was plugged into the computer using a USB cord. The FPGA board was also plugged into the wall and turned on. The FPGA was programmed by selecting the project file and USB-Blaster in the Hardware Setup menu. The program was then tested using the board. Each button corresponded to a 1 when not pressed and 0 when pressed. The LED corresponded to a 1 when lit up and 0 when dark. According to the truth table for a NOR gate shown in Table 1 below, the LED was supposed to light up only when both buttons were pressed.

|  |  |  |
| --- | --- | --- |
| PB1 | PB2 | LED (NOR output) |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

**Table 1**: truth table for NOR gate.

**Results**

The LED only lit up when both buttons were pressed, indicating that the logic circuit was correctly built. The lab took about thirty minutes to complete.

**Conclusion**

The lab was designed to give students a hands-on experience with Quartus II and building logic circuits. Using Quantus, a NOR logic circuit was created and assigned to be tested using an FPGA board. In the future, this FPGA board could be used to test much more complicated logic circuits.