NAND/NOR Logic Gate Equivalent Training Tool Project Proposal

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Table of Contents

1.0 Introduction

1.1 Objective: It can be difficult to learn circuit equivalents going from a design using ANDs, ORs, and NOT gates to a design using only NAND or only NOR gates. As a proposed solution to simplify the learning process of translating to NAND/NOR equivalent circuits, our goal is to design a learning board that will be split into two halves: one half will only allow the use of ANDs ORs and NOTs to build an original circuit and the other half will allow only the use of NANDs or NORs to build the equivalent circuit. All gates will be represented by small pieces, instead of IC chips, to take out any necessary base knowledge of IC chips. Each halve will output to a truth table based on the circuit built. The two truth table outputs will be compared to each other to see if the two circuits built are logically equivalent; if the two circuits are equivalent a green LED will light up, and if not a red LED will light up. Also, the NAND/NOR side of the circuit will tell the user if the correct number of gates are being used based on the most simplified version.

1.2 Background: In beginner Electrical and Computer Engineering courses, students are tasked with learning how to design basic circuits using TTL gates and then implementing those designs on breadboards. In the beginning these circuit designs are completed with AND, OR, and NOT gates. The use of many types of gates creates an inefficiency in design since an unnecessary amount of IC chips must be used. To reduce the number of IC chips, NAND or NOR gates are used to replace all of the AND, OR, and NOT gates. The circuits can now be built out of entirely NAND or NOR gates, thus reducing the total number of IC chips. A problem that many introductory students encounter with this conversion is the use of IC chips, whether it be reading their datasheets or making sure power is supplied. Our design uses simple pieces that represent the gates to avoid the need for the user to understand IC chips. Taking focus off of the IC chips allows for the user to focus on finding the NAND/NOR equivalent.

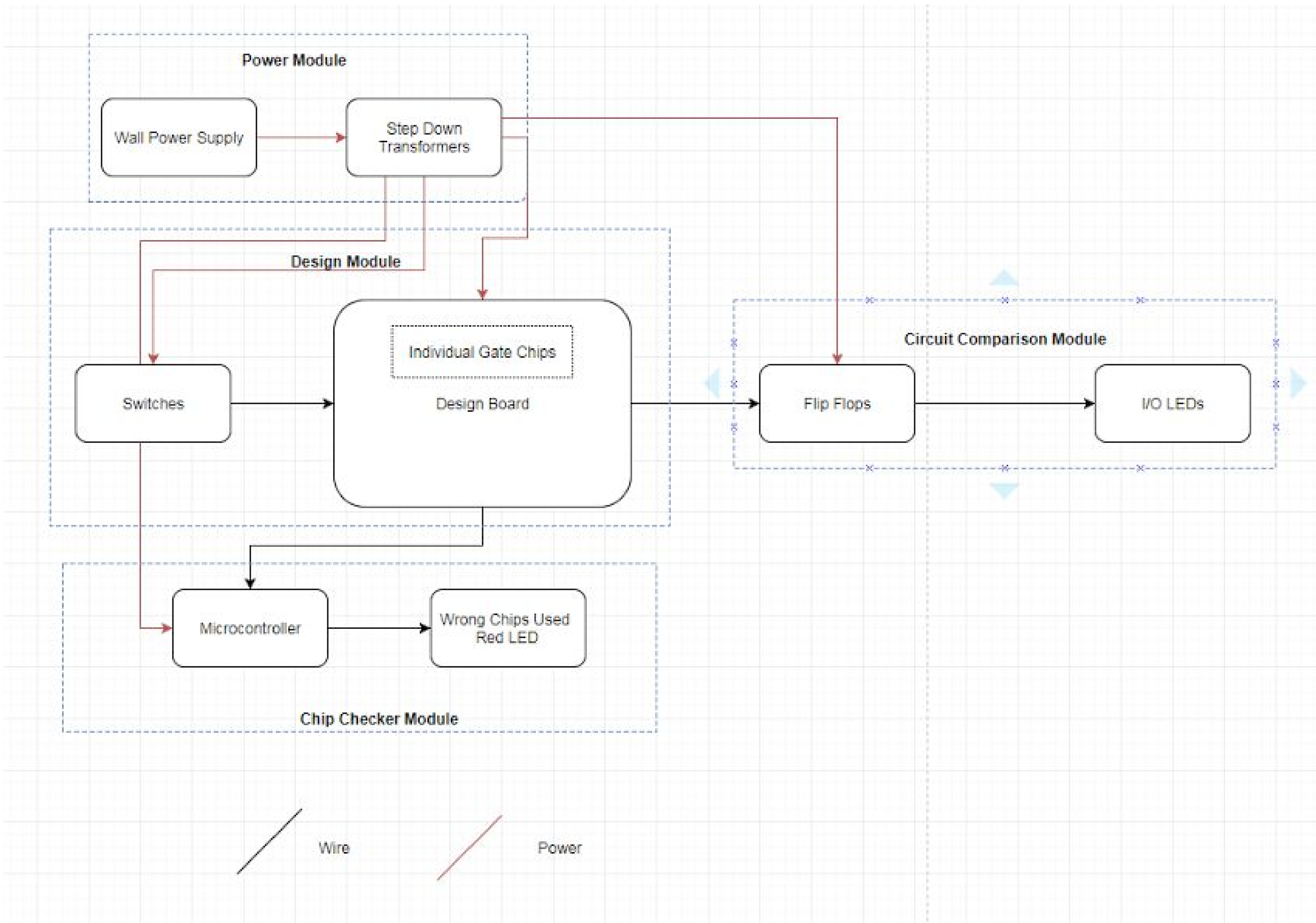
1.3 High-level Requirements List:

- One half of the board must only allow pieces representing either AND, OR, and NOT gates, the other half must only allow pieces representing NAND or NOR gates.
- The training board must have comparator logic abstracted away to compare the two halves to make sure that the two circuits designed are logically equivalent.
- The NAND/NOR half of the board must determine if the correct number of logic gates are being used for the most simplified version.

2.0 Design

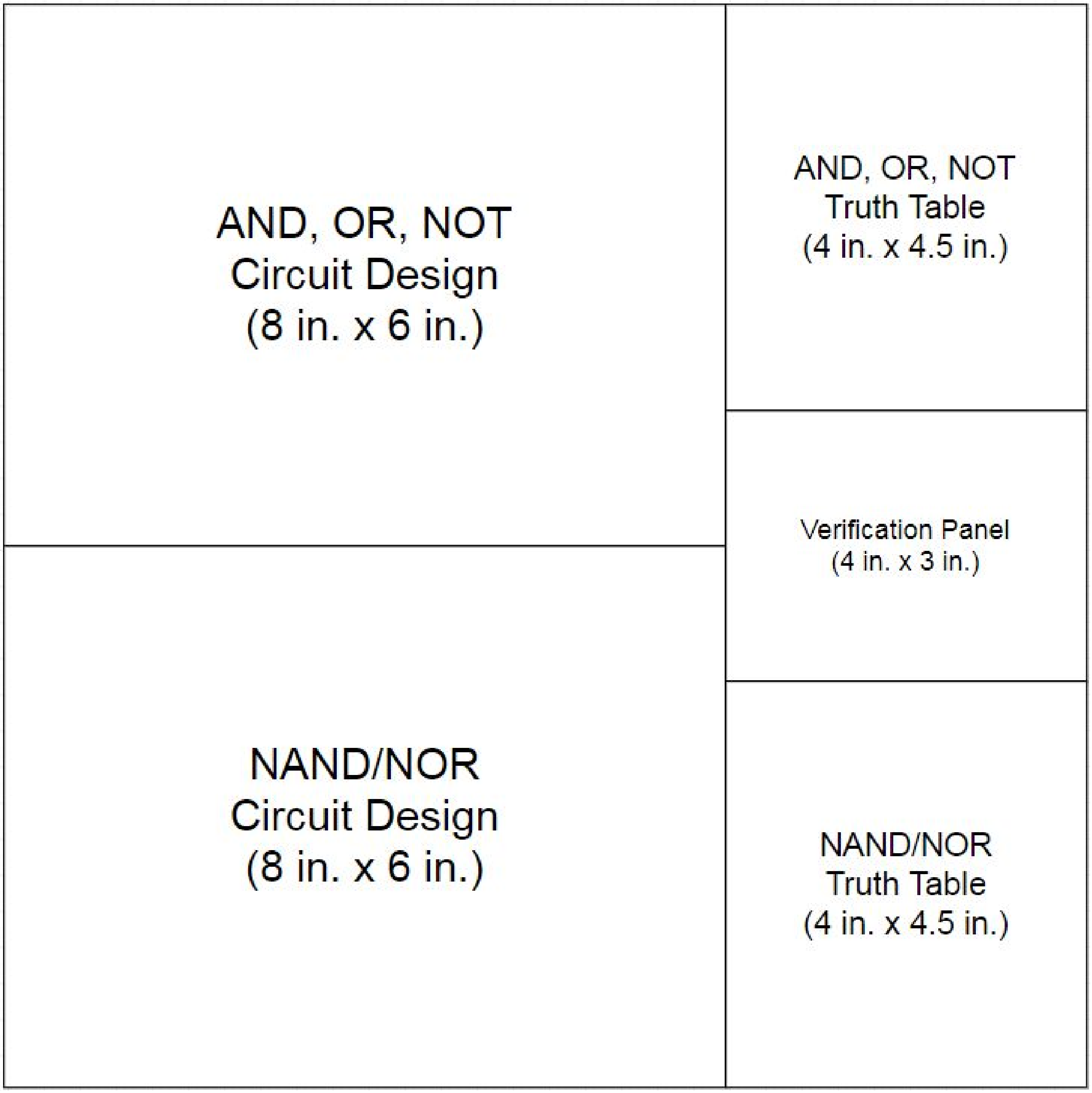
2.1 Block Diagram:

In order for the NAND/NOR Logic Gate Equivalent Training Tool to function properly it needs to be powered, have some way of checking to see if the correct type of TTL gate is used on each side of the board, a way to compare the logic outputs of the two circuits, and needs a way to figure out how to determine the simplest implementation of NAND/NOR equivalent possible. The Power Module's job is to take care of the power needs of every other module. The Design Module will output both the type of chips used on each side of the board, and how many of each chip is used to the Chip Checker Module where it will calculate if the board is being used properly and if the design being implemented by the user for the NAND/NOR equivalent is as simple as can be. Using the data from Chip Checker Module, an LED will go off if the wrong chips are used. And lastly, the Circuit Comparison Module compares the two circuits implemented and lets the user know if they are equivalent via LEDs.



Power Module
Wall Power Supply
Step Down Transformers
Design Module
Individual Gate Chips
Design Board
Switches
Circuit Comparison Module
Flip Flops
I/O LEDs
Microcontroller
Wrong Chips Used Red LED
Chip Checker Module
Wire
Power

2.2 Physical Design:



Our training board is to be a total of 12 inches wide by 12 inches long with a thickness of no more than 1.5 inches. The board is composed of 5 main sections: two to build the original and equivalent circuits, two to display the truth tables for the circuits built, and one verification panel which will display if the two circuits are equivalent and if the NAND/NOR is in its most simple form. The correctness of the equivalent circuit will be shown by a GREEN light, with an incorrect circuit displaying a ORANGE light. Each circuit design section of the board will have 8 spots for gate pieces to be placed. The truth tables will be that for a three-input, one-output circuit and the correct rows will light up dependent on the number of inputs. Our verification panel will consist of a orange LED, a green LED, a hexadecimal display (for minimum number of NAND/NOR gates required), and a button to activate the microcontroller for verification of the equivalent circuit.

2.3 Functional Overview:

2.3.1 Power Module

a.) Wall Power Supply - An outlet will supply the power to our board through some type of AC power cable.

b.) Step Down Transformers - Power from the wall is a 120V three-phase AC voltage, while the power necessary for the components of our board is a 5V DC voltage. This module will step-down the input voltage to allow for a basic AC-DC conversion to our desired value.

> *Requirements:* DC voltage of 6V with +/- 1% ripple at output of AC-DC converter

2.3.2 Design Module

a.) Switches - The number of switches activated on the AND, OR, NOT side of the board will tell both truth tables the number of values that should be populated.

> *Requirements:* With 2 switches active, 4 rows should be populated, and with 3 switches active, all 8 rows should be populated

b.) Design Boards

i.) AND/OR/NOT Side - This side of the board will hold the AND, OR, or NOT logic pieces only. It will contain 8 spots for the pieces to be placed into. Based on the pieces placed, it will populate the correct values into the AND, OR, NOT truth table.

ii.) NAND/NOR Side - This side of the board will hold either NAND logic pieces or NOR logic pieces. It will contain 8 spots for the pieces to be placed into. Based on the pieces placed, it will populate the correct values into the NAND/NOR truth table. There will also be a switch here that tells the NAND/NOR truth table whether it is reading a NAND only or NOR only circuit.

Requirements:

1. Each side of the board only accepts the pieces intended for that side, i.e. NAND/NOR side of the board will not accept any AND, OR, or NOT piece.

2. Truth table populated with correct values based on logic pieces present.

2.3.3 Circuit Comparison Module

a.) Flip Flops - These will hold the correct values for up to the 8 different spots in each truth table. A logic circuit will determine the values that should be stored in the flip flops based on the circuit design. In total for the two sides of the board, there will be 16 total flip-flops.

Requirements: When probed for a circuit that outputs a logical 1 for every input, the output of every flip-flop should also be 1.

b.) I/O LEDs - These will let the user know what the truth table is for each circuit designed by taking the logic highs and lows stored in the flip flops to toggle the LEDs appropriately. Blue means logical 1, orange means logical 0.

Requirements: The blue LEDs must light up whenever the corresponding flip-flop outputs a logic 1. Similarly, whenever the blue LEDs is off, which means the corresponding flip-flop is outputting a logic 0, the orange LED must turn on.

2.3.4 Chip Checker Module

a.) Microcontroller - This will decipher the signals coming from the Design Board and will output the correct message to be displayed on the Wrong Chips Used Red LED. It will also display how many chips are needed in the NAND/NOR equivalent.

Requirements: The microcontoller must be able to perform calculations necessary to tell if the correct chips are being used on the correct side of the Design Board, and output the decision appropriately so that the Wrong Chips Used Red LED can light up appropriately. It must also have a 7 segment display so as to be able to display the number of chips needed to complete the NAND/NOR equivalent.

b.) Wrong Chips Used Red LED - These will let the user know whether or not they are using the correct chips on the correct side of the board.

Requirements: The LED must light up so as to denote when the user has misplaced a chip, and this driving logic signal will come from the Microcontroller.

2.5 Risk Analysis: The interface that poses the greatest risk to successful completion of the project is the Microcontroller. We are both Electrical Engineers with an emphasis on Power electronics and thus have minimal Computer Engineering backgrounds, especially in the area of microcontrollers. Being able to use the microcontroller effectively to accomplish our goals will be a struggle, but that just comes with the territory of being an engineer; sometimes you just have to learn as you go in order to complete your day to day tasks.

3.0 Ethics and Safety

This project is designed to be used by introductory ECE students, whether that be at the university level or by PLTW students in high school. Our design must be one that is functional and safe to use for all students. Safe use of the board requires that all electrical components be contained within the board casing, within the board all electrical components are safely away from each other to avoid a short, board pieces are well built, and a fuse protects the power supply. Our main ethical concern is to maintain the originality of our project. We have based our project on one from a previous semester, thus we want ours to be uniquely different and not a replication of their project with minor variations