Group 3
Mulugeta Damamo, @02577567
Lloyd Eley, @02496796
Cesar Gomes, @02515835

Hybrid Class
Dr. Charles Kim
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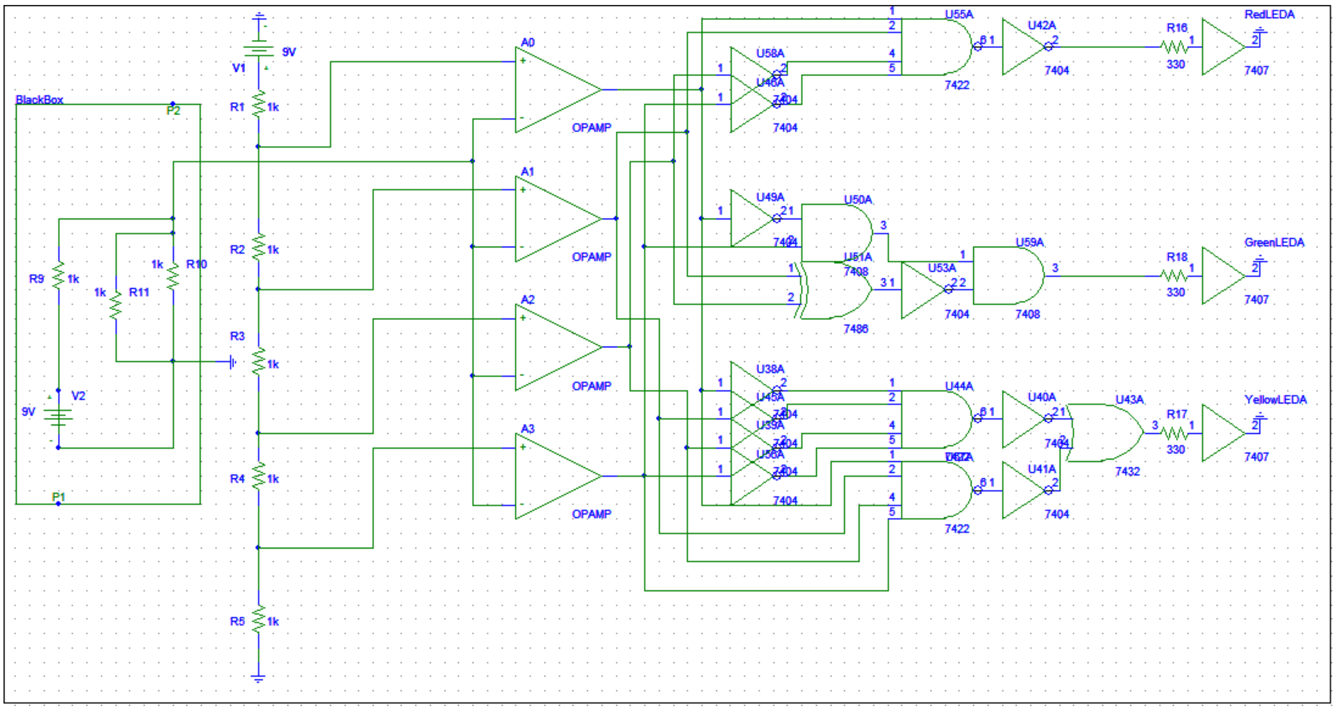
Group Project: Terminal Voltage Recognizer



Problem Statement:

The purpose of this project was to create combinational logic in order to determine the type of resistor configuration within a theoretical black box by illuminating one of three LEDs. The only knowledge we are provided is that the components of each configuration consists of three resistors of the same resistance and a 9[V] source, as well as 5 different configurations that break down as follows:

- RED: The configuration that should light the red LED is described as 1-1-1. This means that there is a resistor between each terminal.
- YELLOW: The configurations that should light the yellow LED are described as 2-0-1 and 1-0-2, which means in the first configuration, there are two resistors between the terminals A and B, none between B and C, and one resistor between C and A. For the second configuration, the there are two resistors between the terminals A and C, none between C and B, and one resistor between B and A.
- GREEN: The configurations that should light the green LED are described as 3-0-0 and 0-0-3. For the first configuration, there are three resistors between A and B, and none only the 9[V] source attached to C. In the second configuration, there are three resistors between A and C, and B being connected via the 9[V] source.

Underlying the main objective of this lab was the process of combining the different engineering tactics and skills learned within Digital Systems, as well as other engineering courses, with out circuit analysis methods to learn the collaboration of the two classes and skill sets.

Procedure:

The first step we took was to calculate the voltage at the two terminals that would be available from within the black box. After the calculations, and the revising of the configurations, we found that regardless of the setup, the terminal B would always tend equal 0. So the only thing to really concern ourselves with was the voltage at terminal A. Each configuration revealed a particular voltage output at their respective A terminals. For the RED configurations, the voltage at terminal A was 4.5[V], for GREEN the voltage was 3[V] for 2-0-1 and 6[V] for 1-0-2, and finally for YELLOW the voltage was 0[V] for 3-0-0 and 9[V] for 0-0-3. With this knowledge, along with testing and digital systems processes, we found that the circuit could be implemented as illustrated in Figure 1. As seen in the schematic, we have only the two outputs from within the black box. Since we need to have conditions in order for each LED to be illuminated, we came to the conclusion of using resistors and comparators to do the job. After our testing and PSPICE simulations, we found that our previous submission was incapable of performing the set task because of logic errors and the our incorrect usage of the resistors. So we made the following changes to come to the final design that is shown in Figure 1:

- comparators are problematic in that they do not always provide the proper output if the inputs are obscure;
- utilizing resistors as direct inputs to the comparator is an incorrect assumption in terms of voltage laws.

Therefore, instead of using a comparator, we opted for a LM324 operational amplifier (OPAMP), as well as changing the resistor setup to be in series from its own 9[V] source. The OPAMP functions very much like a comparator, however, when the positive input is even millivolts higher, the OPAMP asserts HI/1 as its value, and vice versa if the negative is higher. With these changes, we continued with normal methods. The initial value from terminal A is input into the negative input of each OPAMP. The second input of each OPAMP gets a value from the series of resistors. In this way, we can have varying sources of voltage across the series of resistors, then compare them with the value given from terminal A of the black box configuration. Since we calculated the values at terminal A within each possible configuration, we utilized these values to compare with the descending value of voltage across our series of resistors. With each configuration having its own unique voltage output, we found that we could create certain conditions to illuminate the proper LED. Below in Figure 2 is the truth tables used to come to the combinational logic in Figure 1.

A0	A1	A2	A3	R-G-Y
0	0	0	0	001
0	0	0	1	010
0	0	1	0	000
0	0	1	1	100
0	1	0	0	000
0	1	0	1	000
0	1	1	0	000

0	1	1	1	010
1	0	0	0	000
1	0	0	1	000
1	0	1	0	000
1	0	1	1	000
1	1	0	0	010
1	1	0	1	000
1	1	1	0	000
1	1	1	1	001

Figure 2.

Top Design:

In our honest opinion, we believe that our design is the best simply because it is all inclusive of every element of electrical and computer engineering. By this, it is meant that the inclusion of such engineering practices, as well as its straight-forward logic, makes our design ideal for teaching with. It can be implemented in parts, particularly the logic and the OPAMP-resistor setup, which in turn allows for easier testing, teaching interaction, and abstracted thinking. Thought we do not have the smallest, or most innovative, we have the most user/student friendly.

Conclusion:

This project truly tested our engineering prowess and analytical skill by throwing us into a situation that required more than what was within the boundaries of the course. It also showed us the value of teamwork. The recognizer proved troublesome in its access limitations. Still, by combining what we learned in earlier and adjacent courses, we were able to come to a firm solution. This project was very interesting and challenging.