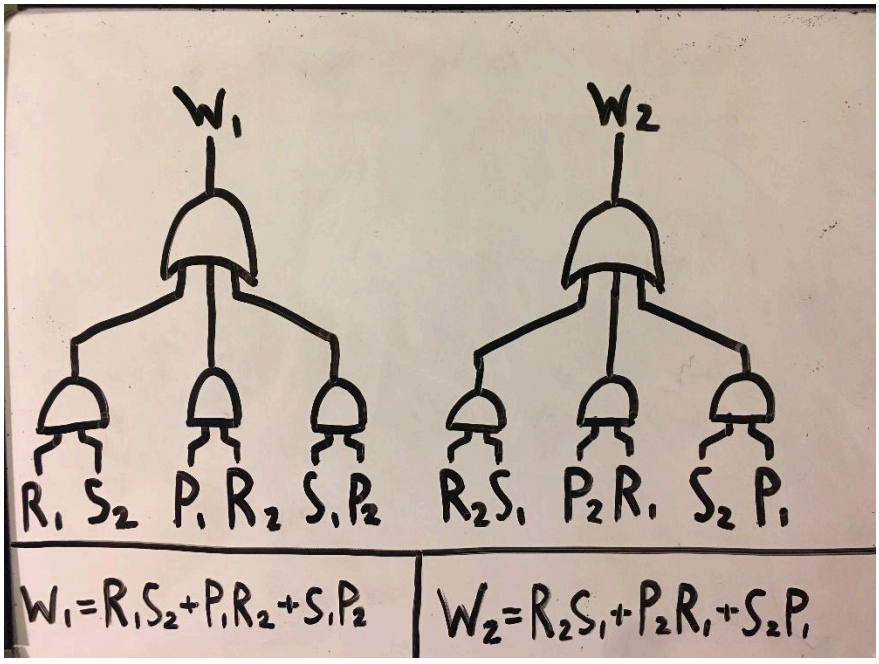
Class:	**EE320 Microelectronics II**	Semester:	**Fall 2021**

Points		Document author:	**Abraham Castañeda** **Edreese Basharyar**
		Author's email:	castaa7@unlv.nevada.edu basharya@unlv.nevada.edu
		Document topic:	**Final Project: Rock Paper Scissors (RPS) Implemented using Diode Logic**

Instructor's comments:

1. Introduction / Theory of Operation

The ability of diodes to only allow current to run in a single direction makes them great candidates for the implementation of logic-based circuits. The method of incorporating logic with diodes is aptly named diode-logic. For our project, we aimed to use diode logic to incorporate a game of Rock Paper Scissors with 6 AND gates and 2 OR gates. The circuit would have a total of 2 outputs and 6 inputs, each divided among both players (i.e. 3 inputs and 1 output per player). Below is a high-level simplification of the logic involved:



For reference, R = Rock, P = Paper, S = Scissors, and W = Win.
The Numbers 1 and 2 correspond to Player 1 and Player 2.

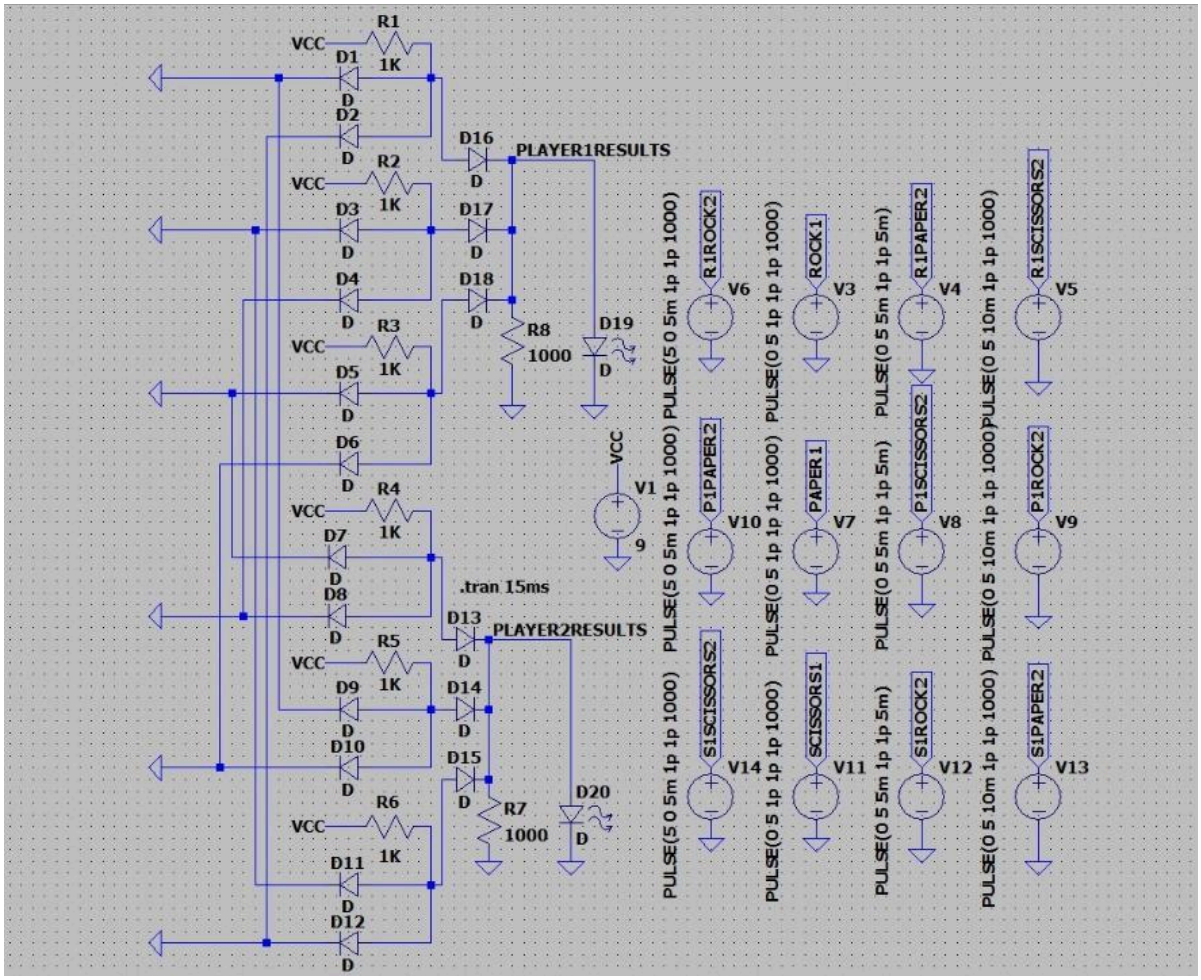
As one can see, we can use the Boolean expressions for the win conditions of both players to construct a circuit modeled after this high-level simplification. All that was needed was to replace the AND and OR gates with their diode equivalents and translate all of the connections to physical wiring through the use of a breadboard. We also chose to make it easier to detect which player won by connecting LEDs to the two outputs.

For our AND gates, we placed 2 diodes in the reverse direction going from the player inputs (which draw from input voltage Vin) to 1k resistors hooked up to the bias voltage Vcc. For our OR gates, we placed 3 diodes in the forward bias direction going from the 3 AND outputs to a 1k resistor and LED placed in parallel.

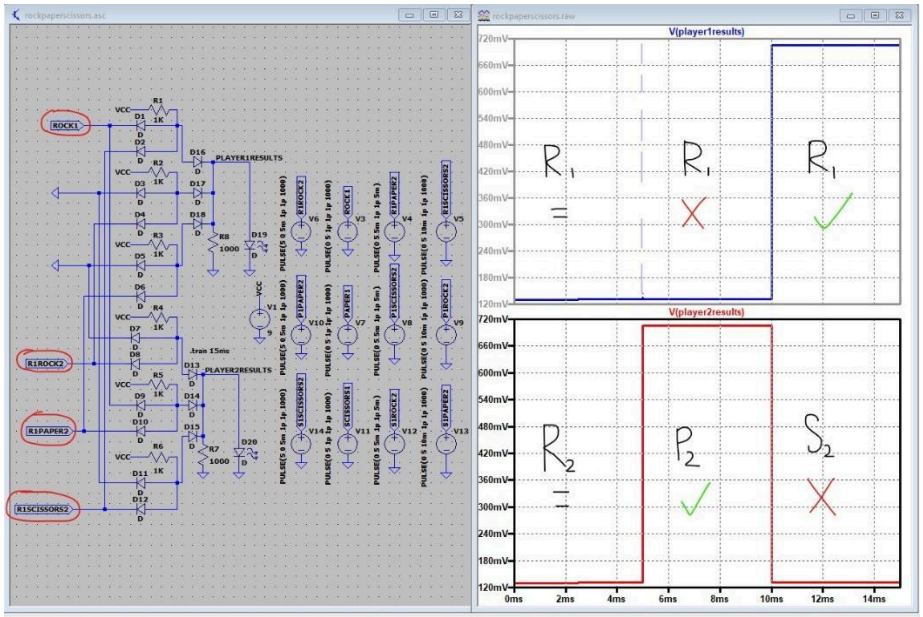
2. Description of Experiments

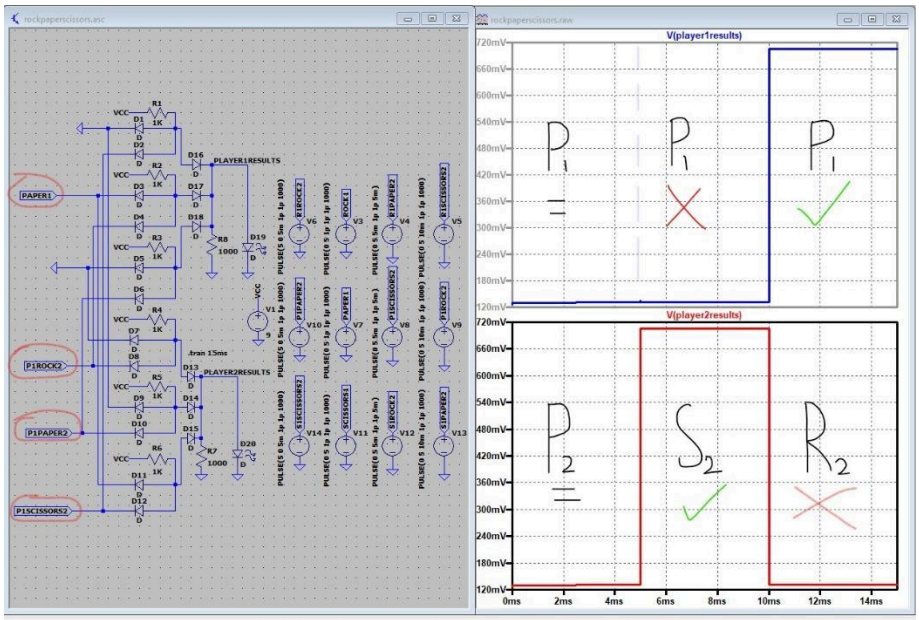
LTSPICE SIMULATIONS:

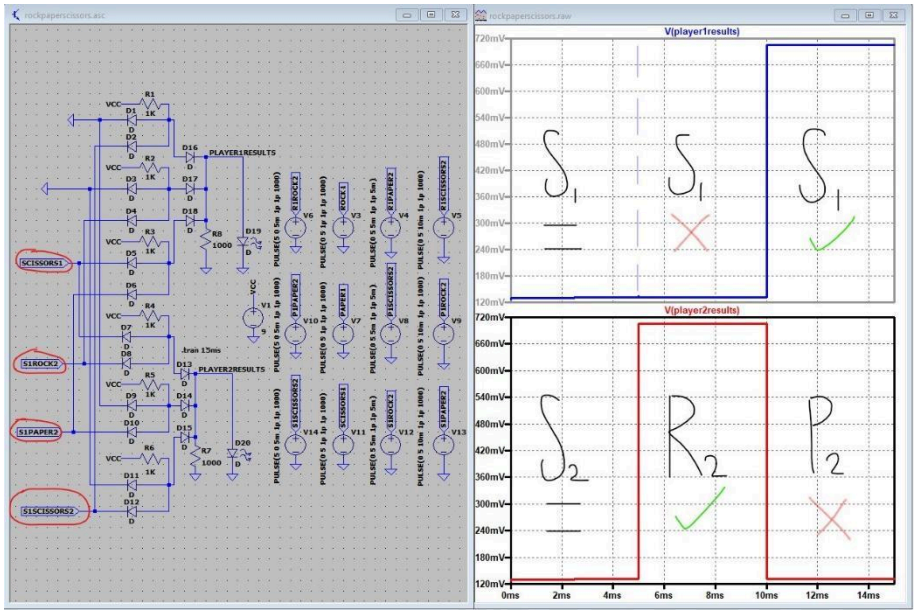
Circuit Schematic



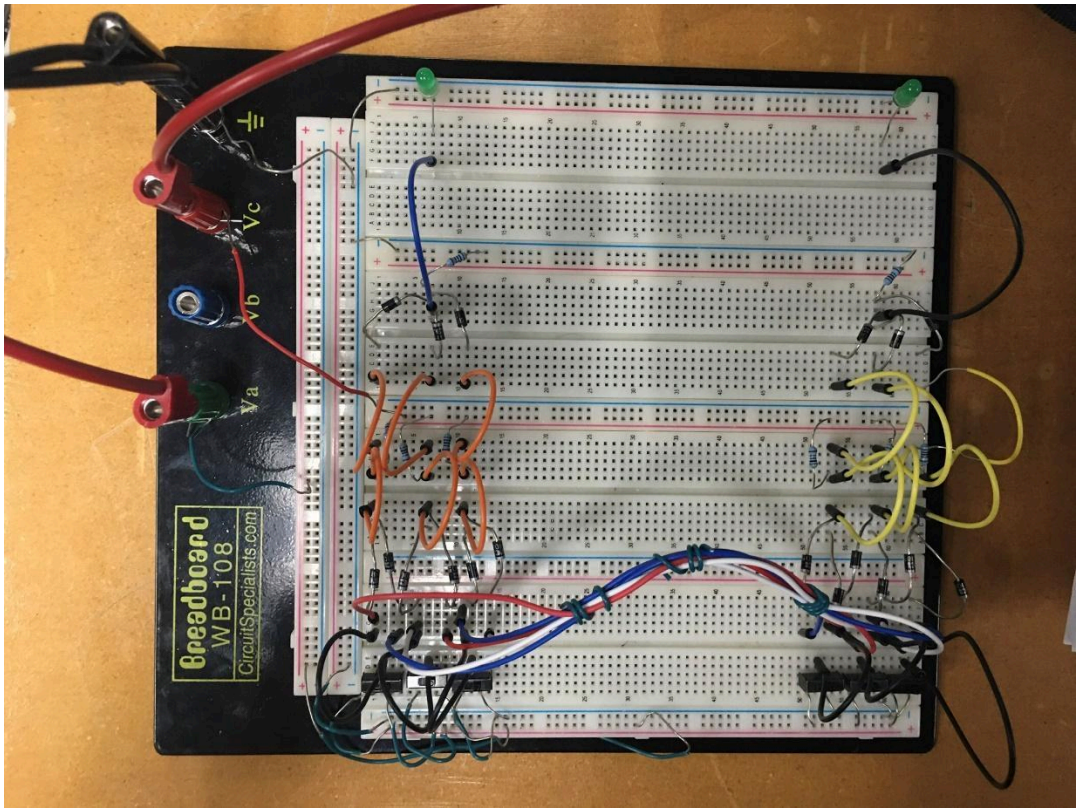
LTSPICE Simulations for Player results (all 9 combinations tested)







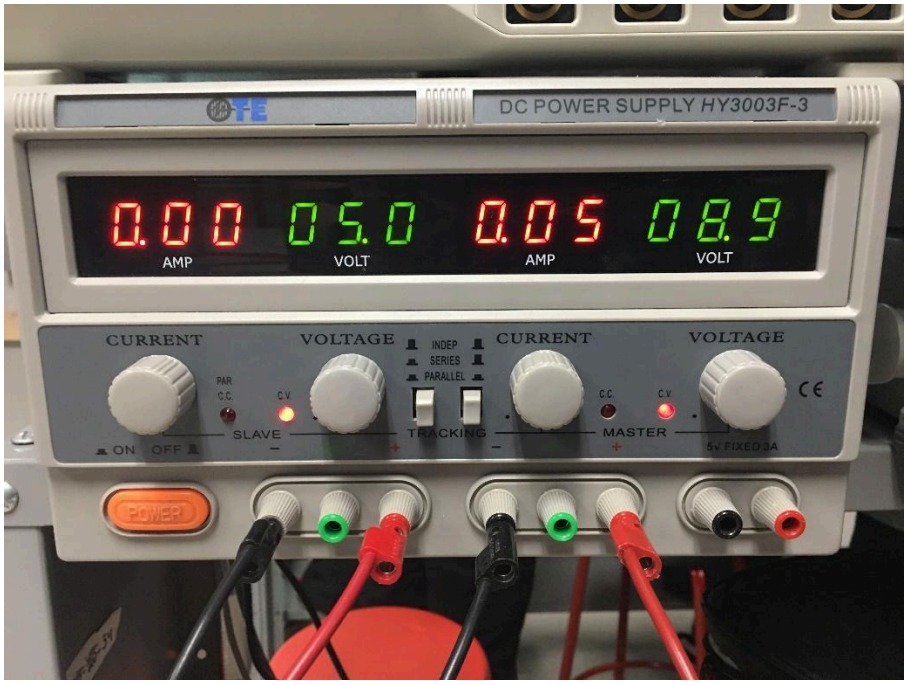
Bird's Eye View of RPS Breadboard Configuration (the Vc pictured below is Vcc from our schematic and the Va pictured below is our Vin for the player inputs)



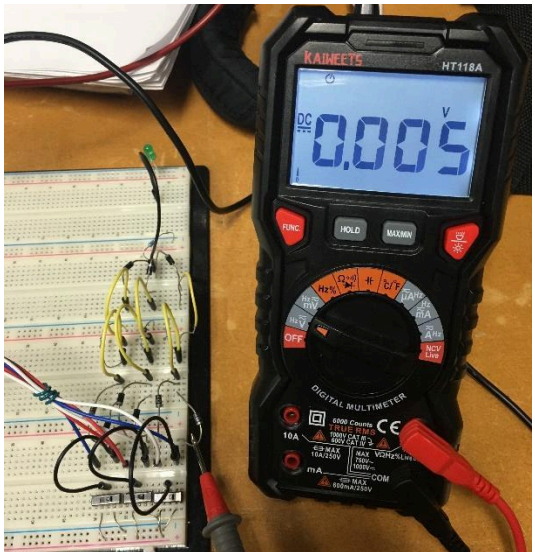
As we can see, each player is essentially working with the same circuit on either side. Ideally, there would be a barrier placed between the players to prevent them from seeing what choice the other player is about to make, but for all intents and purposes, the circuit allows both players to

operate independently of one another (while still implementing the required logic for their choice of Rock Paper or Scissor with respect to the other player).

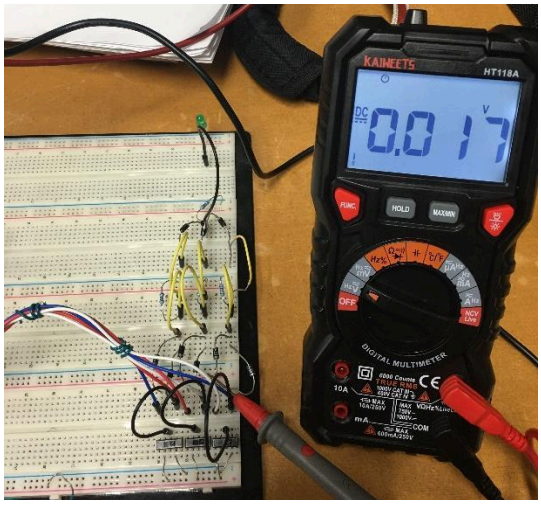
Power Supply Used □ Vin = 5V (Va in breadboard picture), Vcc = 8.9V (Vc in breadboard picture)



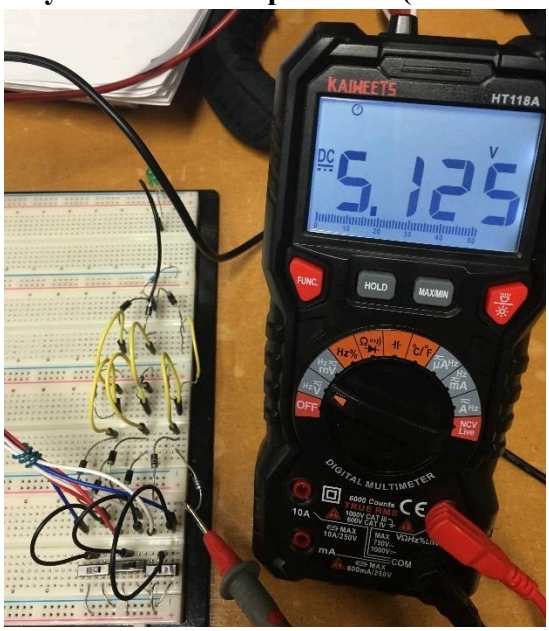
<u>MULTIMETER PROBING SAMPLE:</u>
<u>Scenario: Player 2 side with Player 2 choosing scissors and Player 1 choosing paper)</u>
Player 2 Scissors Input Node (SWITCH OFF)



Player 1 Paper Input Node on Player 2 Side (SWITCH OFF)

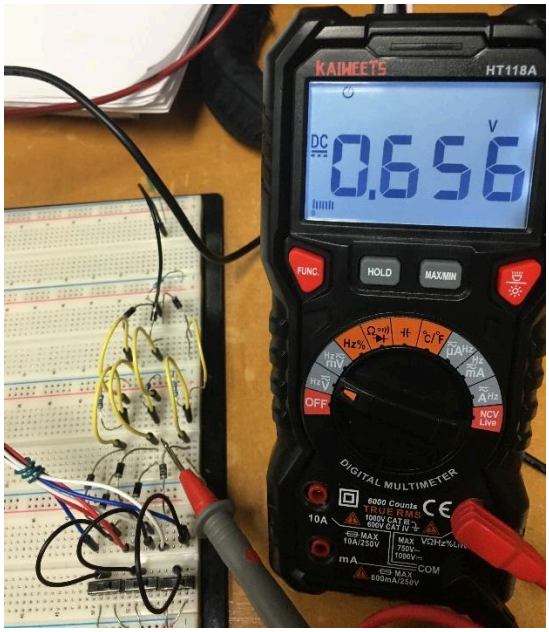


Player 2 Scissors Input Node (SWITCH ON)

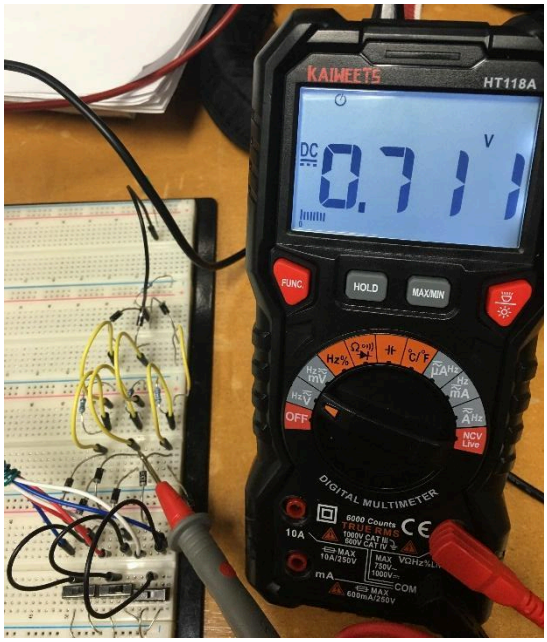


We can assume that the Player 1 Paper input node would be at this same voltage when switched ON

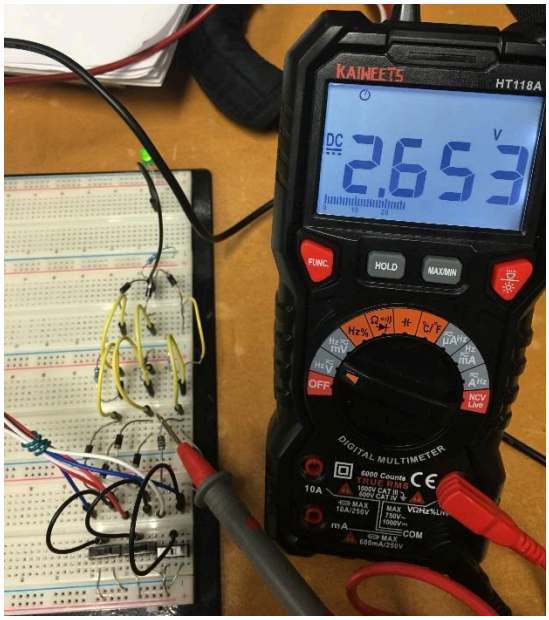
AND Gate Output (both Player's switches OFF)



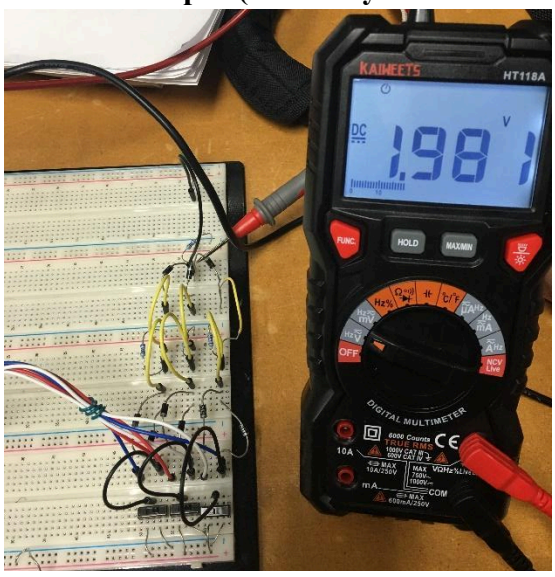
AND Gate Output (Player 1 Paper OFF and Player 2 Scissors ON)



AND Gate Output (both Player's switches ON)

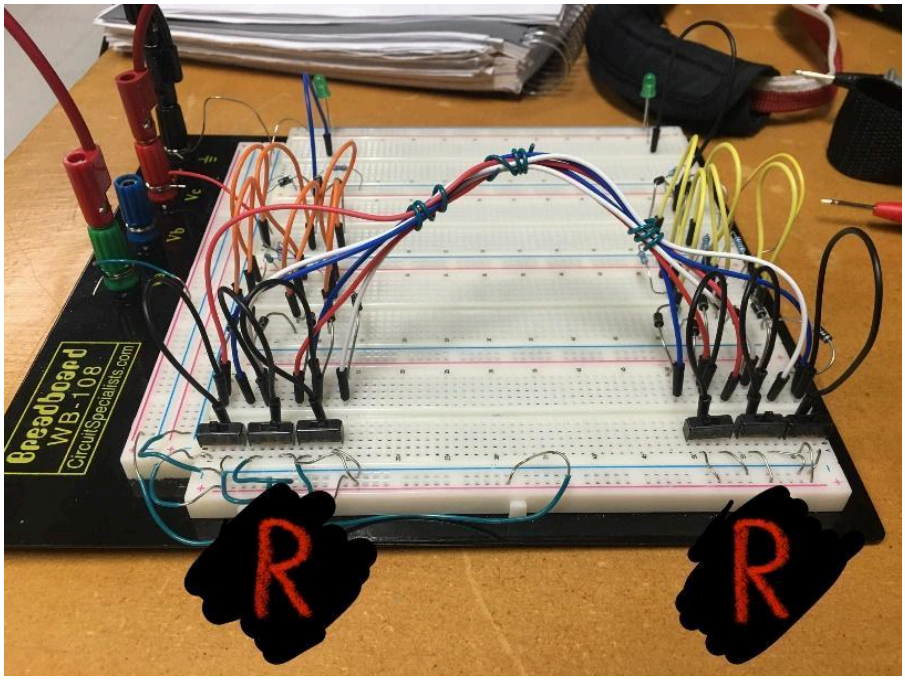


OR Gate Output (both Player's switches ON)

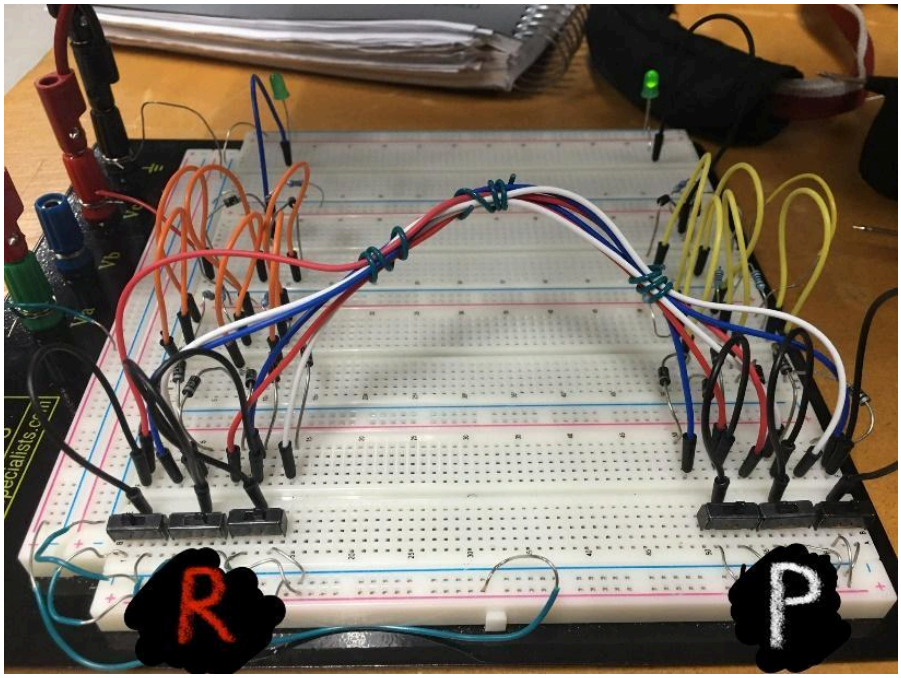


This resultant voltage after the OR gate is what lights up the LED at the end of the circuit, indicating that, in this case, Player 2 has won (since this LED is on the right side of the breadboard and thus Player 2's side).

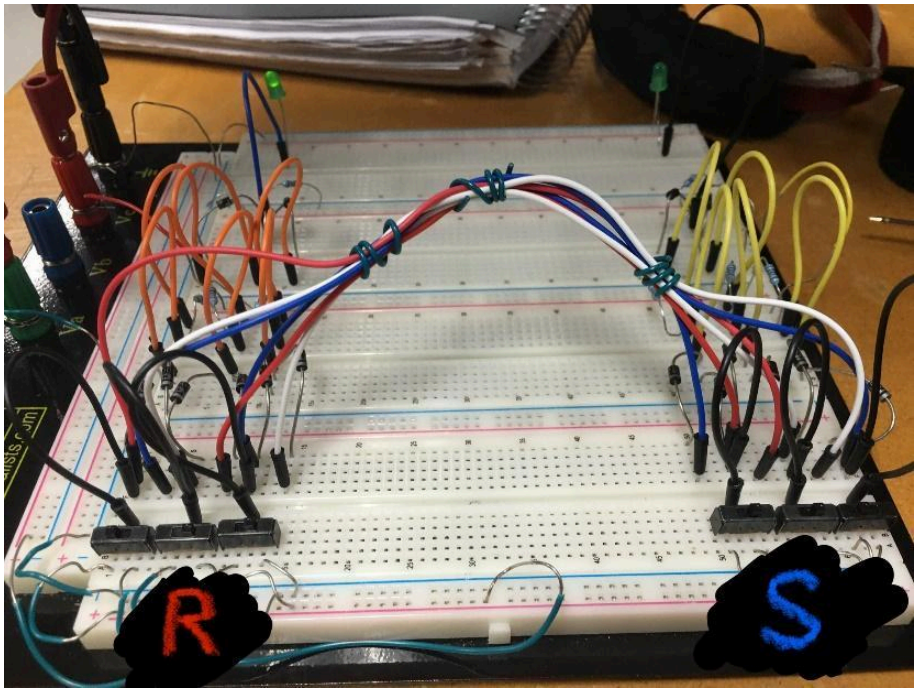
<u>ALL POSSIBLE PLAYS TESTED:</u>
Player 1: Rock
Player 2: Rock
Tie (Both lights off)



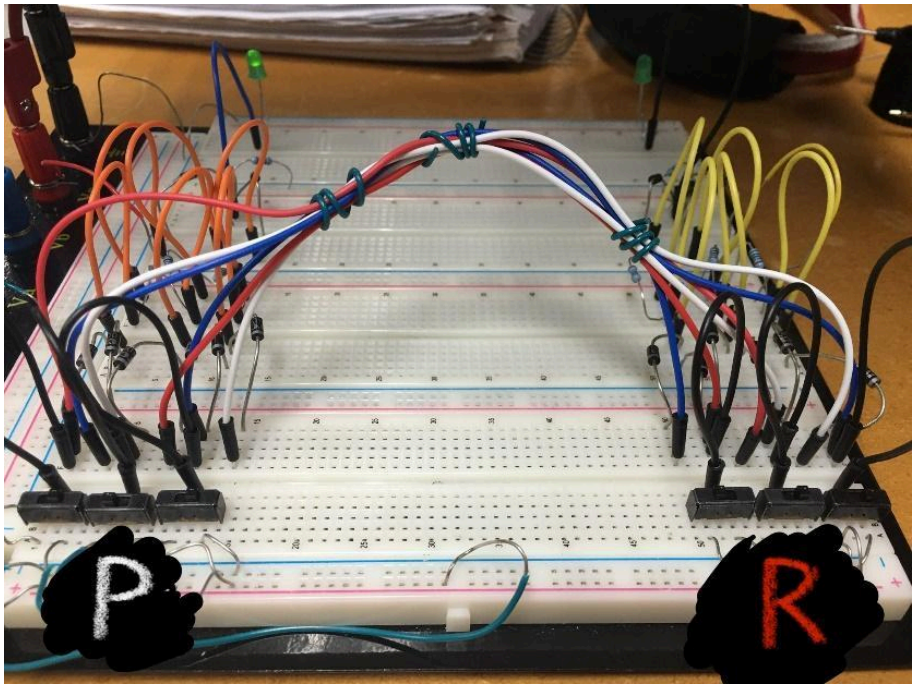
Player 1: Rock
Player 2: Paper
P2 win (Right light on)



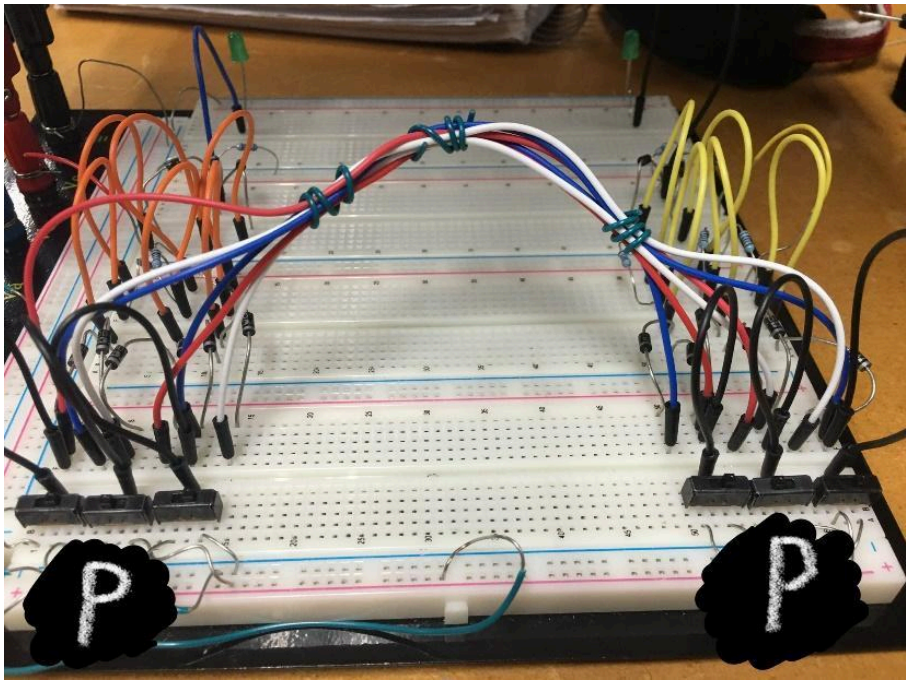
Player 1: Rock
Player 2: Scissors
P1 win (Left light on)



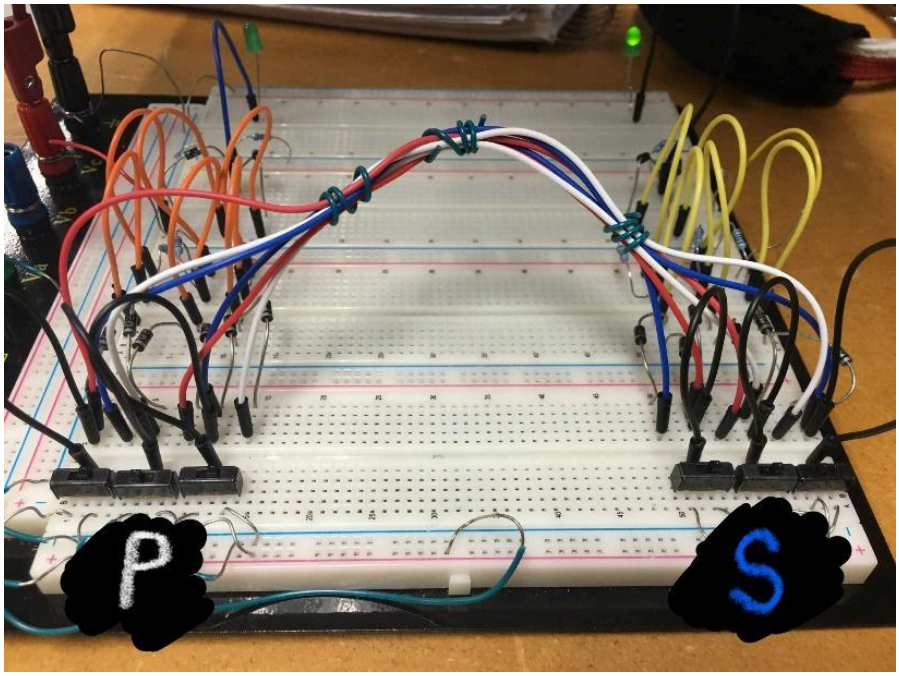
Player 1: Paper
Player 2: Rock
P1 win (Left light on)



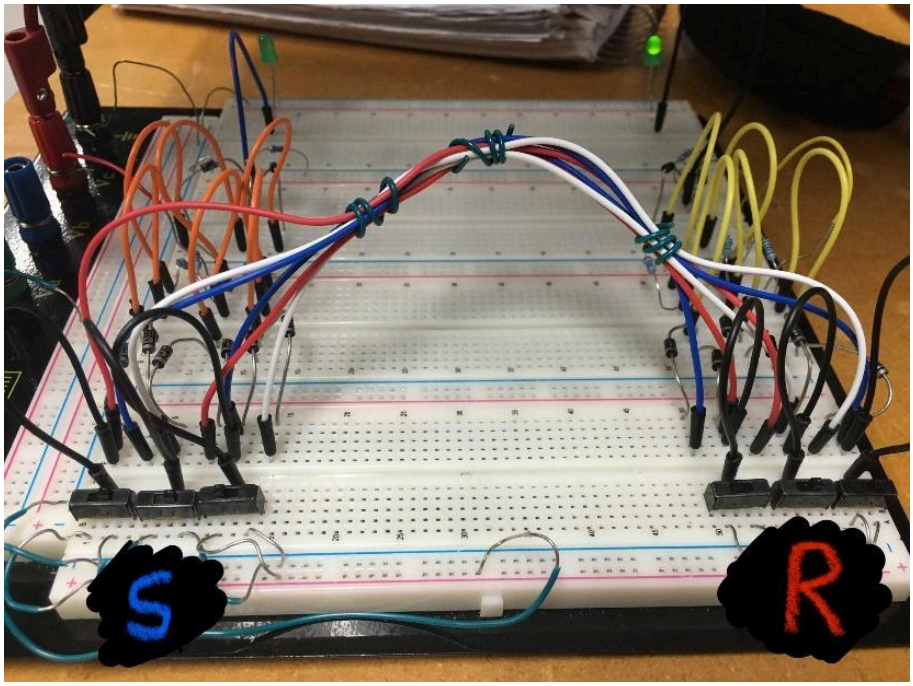
Player 1: Paper
Player 2: Paper
Tie (Both lights off)



Player 1: Paper
Player 2: Scissors
P2 win (Right light on)

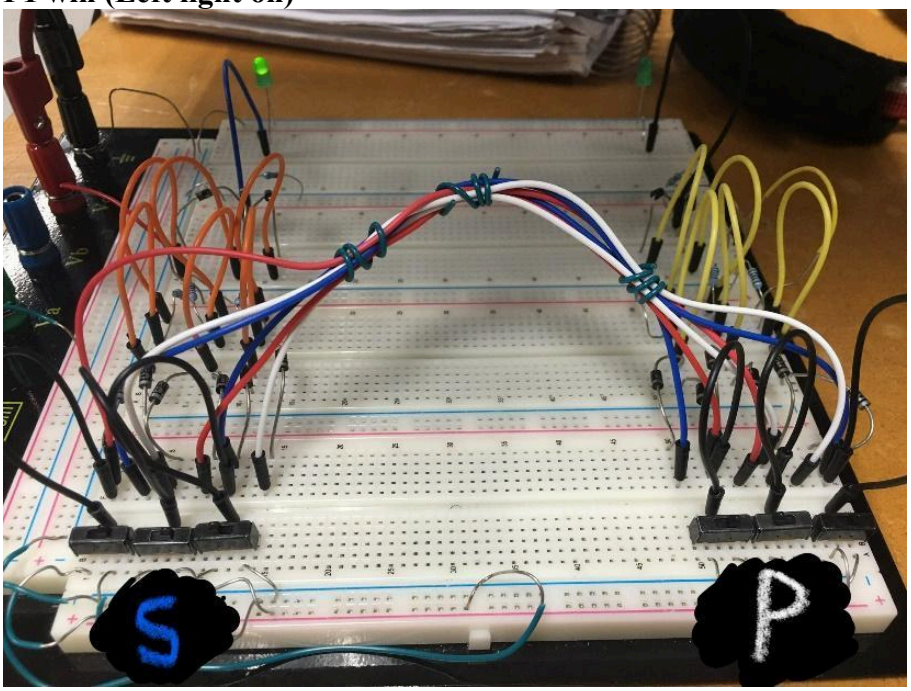


Player 1: Scissors
Player 2: Rock
P2 win (Right light on)

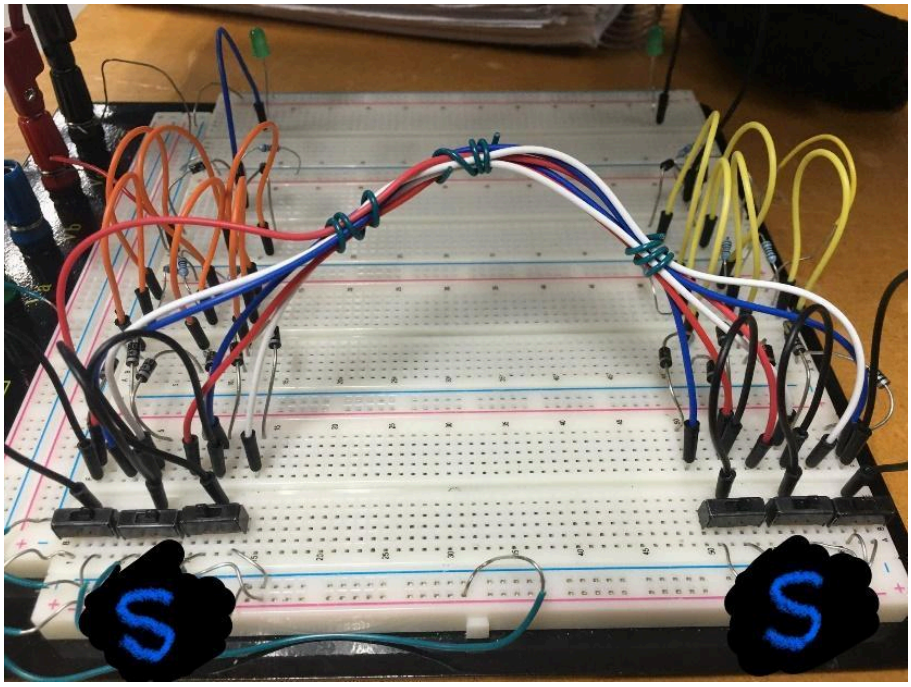


Player 1: Scissors
Player 2: Paper

P1 win (Left light on)



Player 1: Scissors
Player 2: Scissors
Tie (Both lights off)



3. Encountered Problems

The only problem we encountered in our design of this game was with regards to the method of managing the user inputs. When first implementing the game of breadboard, we only had push-buttons at our disposal, and planned to use them as the user's means of introducing the voltage Vin into the circuit (to turn the signal from 0V to 5V, or in terms of logic, from 0 to 1). However, we came across a problem once we wired up our AND gates. When the button for an option was not being pressed down (in other words, the player was not making a move), the voltage at the node for that option (scissors for example) was way higher than 0V. It was, in fact, very close to the value of the bias voltage Vcc, which was needed for the functioning of the diode AND gates. We quickly realized that the button being decompressed was creating an open where the Vcc voltage was piling up. In order to fix this, we decided to use SPDT switches instead of push-buttons so that the user can choose one of two options:

1) Flip the switch to the left, thus creating a path for the Vin voltage to enter the circuit
2) Flip the switch the right, which would ground the node to 0V (all of the options would be in this position by default at the start of each round)

4. Summary

To summarize this final project, we started brainstorming the idea of creating logic gates by implementing the diode logic that we have learned this semester. We continued this process by creating a schematic involving multiple AND and OR gates, in which we thought of making the classic game, "Rock, Paper, Scissors." We started creating calculations for the game by making boolean algebra truth tables in order to create two simple equations for the outputs of our circuit. The first equation defines the winning combinations needed for the first player to win, while the second equation defines the winning combinations needed for the second player to win. The purpose of making these equations is because they can be deconstructed into simple AND and OR gates. We learned how to create the logic gates by using diodes, and we eventually applied these gates based on the two equations we had made earlier. Each AND gate in this schematic consisted of two inputs, while each OR gate consisted of three inputs. In this schematic, we used 6 AND gates and 2 OR gates; since each input goes through a diode, there are a total of 18 diodes overall. In order for the player to choose between rock, paper, and scissors, we installed basic switches for both players. There are a total of six switches in the schematic, with three switches included for each player. For the output of the schematic, we used a light-emitting diode for each player. This particular diode makes it easy to tell when a certain player has won. For example, if Player 1 chooses rock and Player 2 chooses scissors, we will see that the LED only turns on for the first player. Now, all we needed to do was to debug our final version of the schematic. We played the game and tested out all of the combinations that were available, and the LED accurately matched what the intended outputs should have been. We also tested the voltages of each part of the circuit to make sure that there were no stochastic errors that could lead to future errors. However, there were no errors found in the final version of our schematic; therefore, the only other options were making the schematic look formal and making sure all of the inputs and outputs were placed in the correct locations.

5. Conclusions

In our experience with the final project, we think that this was a great culmination of using the concepts that we have learned throughout the semester and practically applying them with our own ideas. This project could not have been done without understanding the basic concepts of diodes, logic gates, and circuit theory. We learned that the ideas that are presented in class provide tons of potential to create something more advanced and complex in the engineering field. Although we may be learning the fundamental concepts of circuits and their components, they are also the most valuable information needed in order to apply these circuits in a practical sense. This project also provided a lot of hands-on experience and provided the creative freedom to create something that was originally just an idea in our heads. Therefore, we believe that creating this project was not only a great experience, but also a great foundation for how we can use the topics we learned for the real world.