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| UMass-Lowell-logo.png (295×358) | **Course Project** | **Touch-Sensor Maze Game** | |
|  |  | |
| Yolmorakatpanhcharong Lim Lab Partner: N/A | | |
| Bench # 424-08 | | |
| EECE.3120 – Electronics II Section 802 | | |
| Date submitted: 04/24/2022 | | |
| Due date: 04/29/2022 | |  |

I. SUMMARY

This course project integrates a resistive touch sensor to make a maze game. The objective of this game is to drag a finger across the base of the maze following the path and successfully come out the other end without touching the walls of the maze. Touching the walls or any part of the maze will result in the red LED and the buzzer going off which means you have lost the game. To win the game, you must complete the maze without touching the maze’s walls or any part of the maze. The green LEDs indicates that you are not touching any part of the maze, having it always on means you are on the right track to winning the game.

II. EQUIPMENT

Table 1 shows the list of equipment used in this Course Project.

**Table 1. Equipment Used**

|  |  |  |
| --- | --- | --- |
| **Equipment Type** | **Details** | |
| Breadboard | *Make:* | R.S.R Board |
| *Model:* | *MB-104 WWK* |
| *Serial Number:* | N/A |
| DMM Bench-Top | *Make:* | Keithley – A Tektronix Company |
| *Model:* | 2110 5 ½ Digital Multimeter |
| *Serial Number:* | 8008078 |
| DMM Hand-Held | *Make:* | Tenma |
| *Model:* | 72-9385 |
| *Serial Number:* | H200299550 |
| Analog Discovery 2 | *Make:* | Digilent |
| *Model:* | Analog Discovery 2 |
| *Serial Number:* | SN:210321AD1587 |
| Bench Shoebox | *Make:* | UMASS Lowell |
| *Model:* | N/A |
| *Serial Number:* | N/A |
| Dual Power Supply (+12V and -12V) | *Make:* | Digilent |
| *Model:* | PowerBRICK 12V |
| *Serial Number:* | 410-293-A |
| Function Generator | *Make:* | Tektronix |
| *Model:* | AFG1022 Arbitrary Function Generator |
| *Serial Number:* | 1731189 |
| Oscilloscope Bench-Top | *Make:* | Tektronix |
| *Model:* | MDO3014 |
| *Serial Number:* | C044990 |
| DC Power Supply | *Make:* | Tektronix |
| *Model:* | 2231A-30-3 |
| *Serial Number:* | TBD |
| Resistor Decade Box | *Make:* | TBD |
| *Model:* | TBD |
| *Serial Number:* | TBD |

Table 2 list all the components used in this Course Project, showings its quantity and details.

**Table 2. Components Used**

|  |  |
| --- | --- |
| **Component Type** | **Details** |
| Operational Amplifier | LM741 (1) |
| Diode(s) | 1N3064 (2) |
| LED Diode | Red (3) |
| LED Diode | Green (3) |
| Transistor | 2N3904 (1) |
| Buzzer | HY-05 HYCOM (1) |
| Resistor | 5.6 MΩ (1) |
| Resistor | 1 kΩ (1) |

III. INTRODUCTION

This course project embodies a resistive touch sensor to make a simple maze game. The point of the game is to drag your finger across the base of the maze without touching the walls of the maze. Touching the wall of the maze will cause red LEDs to light up and sound a pop or beep from the buzzer meaning you lose the game. To win the game, one must drag their finger across the maze without touching the walls of the maze and reach the other end successfully. Putting the objective of the game simply, the green LEDs are your indication to a successful maze completion whereas red LEDs and a popping sound indicate that you have lost the game.

The resistive touch sensor for this game works by putting two resistors in series. The first resistor is a 5.6 MΩ which will reduce the high 5V input connected at the start of the series (only when the sensor is touched), the second smaller resistor 1 kΩ is connected to the maze game that is wrapped in aluminum foil. The node in which the two resistors are connected are connected at pin 2 of the op amp. To have the game function, the player will need to hold a ground cable wire at the metal, this acts as an Earth ground which completes the circuit of voltage input, two resistors in series, foil, resistor (you), and ground. Earth ground is needed to dissipate the current going through the circuit.

Some background information of the operation of the circuit:

When you do not touch the sensor, the BJT is in the cutoff region, so the LEDs are not connected to a ground channel. Since there is no ground connection, there is no current traveling through the LEDs, meaning that the LEDs are turned off.

VB < VC; VB < VE

When you do touch the sensor, the BJT is in the forward active region, so the LEDs are connected to ground. The current traveling from the collector to emitter is proportional to the current traveling into the base of the BJT. Since current is able to travel between the collector and emitter, there is a current flowing from the LED voltage supply, meaning that there is a sufficient voltage across the LEDs, allowing them to turn on.

VC > VB > VE

BJT:

When Collector > Base > Emitter = Forward Active Mode

When Collector & Emitter > Base = Cutoff

IV. CIRCUIT DESCRIPTION  
Note: Please refer to the APPENDIX for all photos of this Course Project report.

Graphical user interface, application

Description automatically generated

This circuit schematic incorporates 3 major components and other minor components to imitate a resistive touch sensor. The three major components are one LM741 Op Amp, one 2N3904 BJT, and two 1N3064 diodes. Other components include 6 LEDs: 3 Red LEDs and 3 Green LEDs, and a buzzer.

This op amp acts as a comparator, meaning the negative and positive terminal battle each other to be outputted at pin 6 of the op amp. In short, when the touch sensor is touched, the internal resistance from our body will cause a voltage drop in the circuit in which that voltage now is less than that of the voltage going through the positive terminal of the op amp. This will allow the op amp to output a positive voltage which will be supplied to the base of the BJT along with the 4V supply allowing proportionality of current from the collector to emitter in comparison to the base. Thus, when the sensor is not touched, negative voltage will be supplied into the op amp and power the green LEDs. All LEDs are connected in parallel to ensure that the same voltage goes through all of them.

The addition of the buzzer is simply an extra non-major component to allow the user of the game to hear when there is an error in the play. The buzzer will make a sound when the touch sensor is touched along with the red LEDs lighting up. The buzzer is also connected in parallel to the red LEDs to make sure that the same voltage goes through all 4 parallel components.

**Multisim Video Demonstration**

[](https://www.youtube.com/embed/XsxqVdqtX3A?feature=oembed)

V. MEASUREMENTS

**Output Voltage when touching the sensor**

Graphical user interface

Description automatically generated

**Green LED without touching sensor**

Graphical user interface

Description automatically generated with medium confidence

**Red LED without touching sensor**

Graphical user interface

Description automatically generated

**Red LED with touching sensor**

Graphical user interface

Description automatically generated

VI. DISCUSSION

When measuring the voltage of the green LEDs when the touch sensor is not being touched, we can see that a negative 3 volts is entering the green LEDs, thus lighting it up. This happens because the cathode of the 1N3064 is facing towards the incoming negative voltage which allows the voltage to pass through the diode instead of having the diode face the other way, causing an open circuit. This logic is also true for the green LEDs. The negative leg or cathode of the green LEDs are faced towards the incoming negative voltage so they can take in the voltage and light up.

As for the red LEDs, the anode of the 1N3064 is facing towards the incoming positive voltage and lets the voltage through and onto the base of the BJT. The red LEDs are also supplied by a 4V voltage supply at their anodes. As said in the introduction of this report, when you touch the sensor, the BJT is in the forward active region, so the LEDs are connected to ground. The current traveling from the collector to emitter is proportional to the current traveling into the base of the BJT. Since current is able to travel between the collector and emitter, there is a current flowing from the LED voltage supply, meaning that there is a sufficient voltage across the LEDs, allowing them to turn on.

After touching the sensor, there will be a voltage drop at the red LEDs, thus as we can see in the picture above, the measurement for that voltage drop happens to be 335.2 mV. This voltage drop can vary depending on the internal resistance of the LED diodes used in the physical construction of the circuit. As Multisim shows, when touching the sensor, the voltage dropped from 4 volts to 2.05 volts at the red LEDs.

VII. CONCLUSION

In this course project, the LM741 Operation Amplifier is used as a comparator to supply positive and negative voltage to the main circuit. The positive voltage will be supplied and used by the red LEDs and buzzer to light up and produce a sound. The op amp outputs positive voltage throughout the circuit because when touching the touch sensor with your finger, you’re introducing another resistive element, thus reducing the voltage (voltage drop). Also, because the op amp is a comparator, the now low voltage is compared with the 4V input in the positive terminal of the amplifier, taking the larger 4V and outputting that into the circuit. This works the same way as not touching the sensor, the negative 5V input will be outputted into the circuit. In summary, touching the sensor produces a positive voltage for the output which turns on the red LEDs and the buzzer while the green LEDs stay off. When not touching the sensor, there will be a negative output which keeps on the green LEDs on while the red LEDs and the buzzer stays off. Overall, the game works as intended with the main objective of the game being to traverse through the maze with a finger from one point of the maze to the other without physically touch to any walls or part of the maze.

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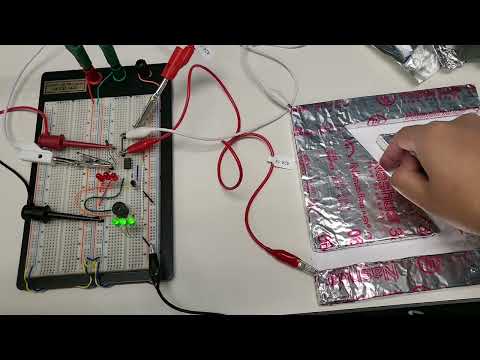
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APPENDIX

**Laboratory Videos**:

1. Course Project Video Demonstration
   1. <https://youtu.be/MYTWFYbDTUg>

[](https://www.youtube.com/embed/MYTWFYbDTUg?feature=oembed)

**Laboratory Pictures**:

1. Course Project Circuit

