Augmented Beer Pong

ECE 445 Design Document

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1. Introduction

1.1. Objective

Beer pong is a popular drinking game played by all different types of people from all over the world. Beer pong has remained relatively unchanged since its conception in the mid-20th century. The game has become trite and has seen little to no upgrades even though today's technology continues to improve.

The goal of our product is to be able to keep track of score, player shot streaks, and a champion's run counter, while remaining portable, accurate and long lasting. Also, we will have dynamic lighting embedded in the mats as well as speakers in the central hub. We hope that by adding modern technology to the game of beer pong, players will see an increase in functionality and experience added entertainment. The physical product will consist of two mats, one for each team's cups, which are connected to a central logic hub. We hope to complete our goal by making our product offer the ability to adapt to any table or surface, respond to game-play, and emit audio and visual stimuli based on the state of the game.

1.2. Background

Beer pong has become the staple of any party scene. From parties at college campuses around the country to tailgating at major sporting events, beer pong has become a well-known catalyst for having a great time. In fact, the game has become so popular that each year, the World Series of Beer Pong is held with more than 1,000 contestants competing for a prize pool worth over $65,000 [1].

There is not a consensus as to where beer pong originated, however, the most notable include Dartmouth College's fraternities in the late 50's and early 60's, as well as the Delta Upsilon fraternity at Bucknell University in the 1970's. Although no one is sure who the real creator is, one thing is for sure, it has become one of the most recognizable drinking games of all time. The most common way to play is with 20 red solo cups, a table, and two ping pong balls. Sinking a ball into the opposing partners cups forces the opposition to remove that cup. The first team to sink all of their opposing team's cups wins the game.

There are a couple of products currently on the market, however, they are bulky, expensive, and do not include gameplay monitoring options such as cup and hit detection. The main purpose of these products is to flicker LEDs at a preset rate, or continuously turn LEDs on for a glow effect [2] [3].

1.3 High-Level Requirements

- The system must be able to, at a bare minimum, run for a 100 hours of play.
- The system must be portable. Meaning both mats and central hub should weigh less than a seven pounds (the size of a large laptop). Also the mats must be wide enough to fit 10 cups in a pyramid shape and no more than twenty-four inches wide. The opposite sides of mats should be no further than ninety-six inches apart [4].
- The system must reach a correct sensor accuracy threshold of 95% cup removal detection and 80% ball colliding with cup detection.

2. Design

2.1. Summary

The game will require multiple modules to meet the objectives: a power supply, control hub, two sensing arrays, and output audio/visual unit. The power supply draws current from disposable D-cell batteries, and boosts the voltage to usable levels for the other modules. The sensor array consists of IR sensors to detect cup removal and piezoelectric sensors to detect a hit. The control hub consists of a microcontroller to process sensor data and create output response. Lastly, the audio/visual unit will accept data from the microcontroller and output exciting noises and power LEDs based on gameplay.

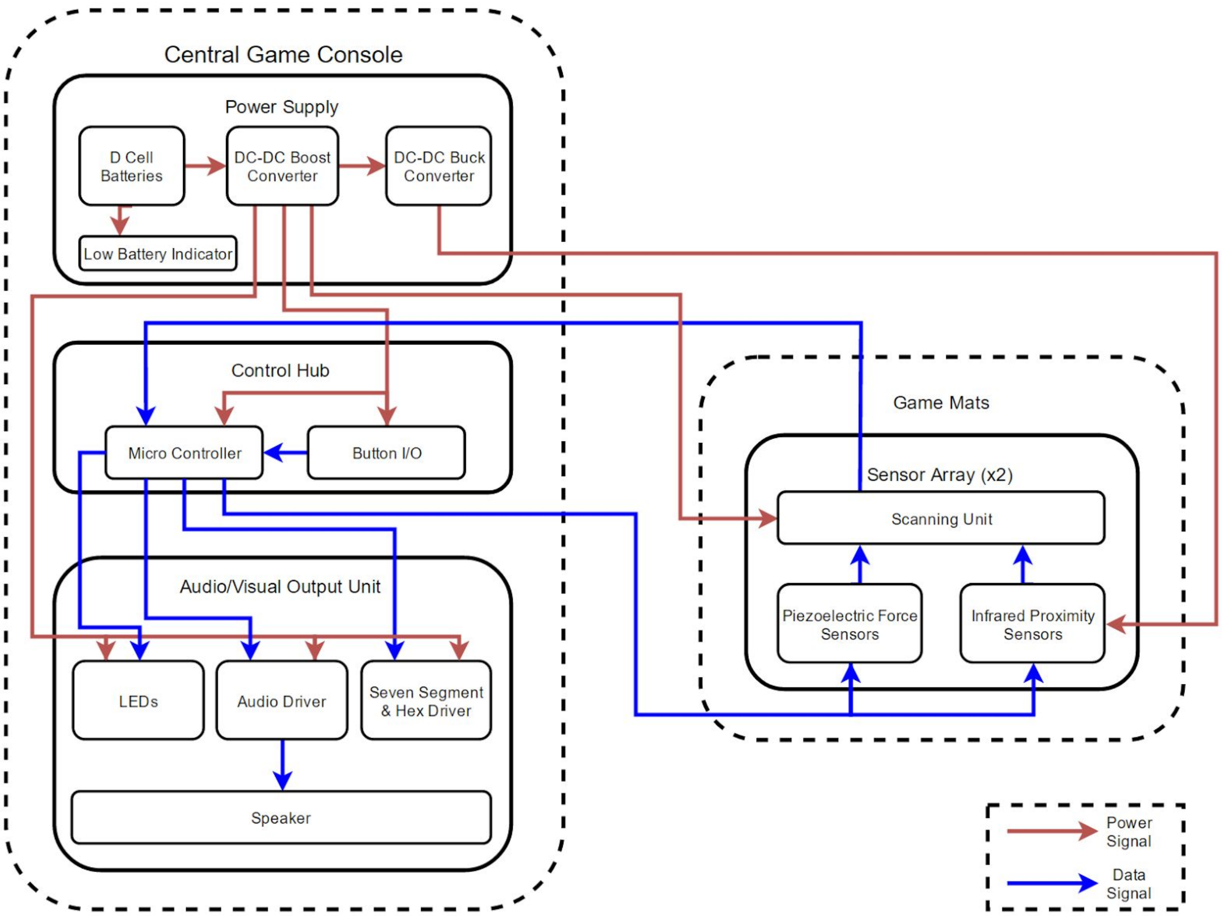

Figure 1 - System Block Diagram

2.2. Physical Design

Included below are drawings of the game mats upon which cups will be placed. Figure 2 shows the first drawing which describes the relative placement of the cups on the mat including dimensions of the mat as well. The second drawing is shown in Figure 3 and provides a profile view of the mat which shows the vertical thickness as well as the placement of the infrared sensors. Please note that the piezoelectric sensors and LED's will be placed under the center of each cup indent (spaced in order to fit near each other). They are under an opaque film and thus not visible in the physical design images.

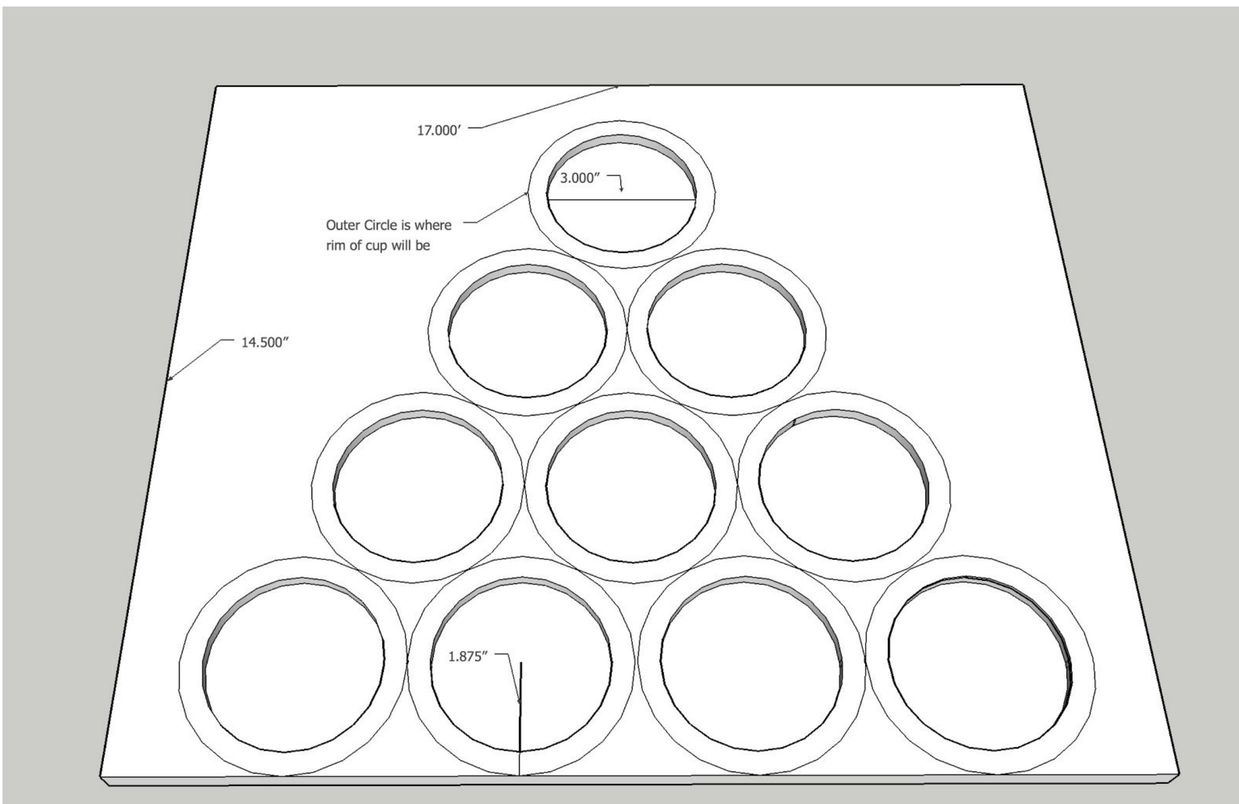

Figure 2 - Top Profile of Mat

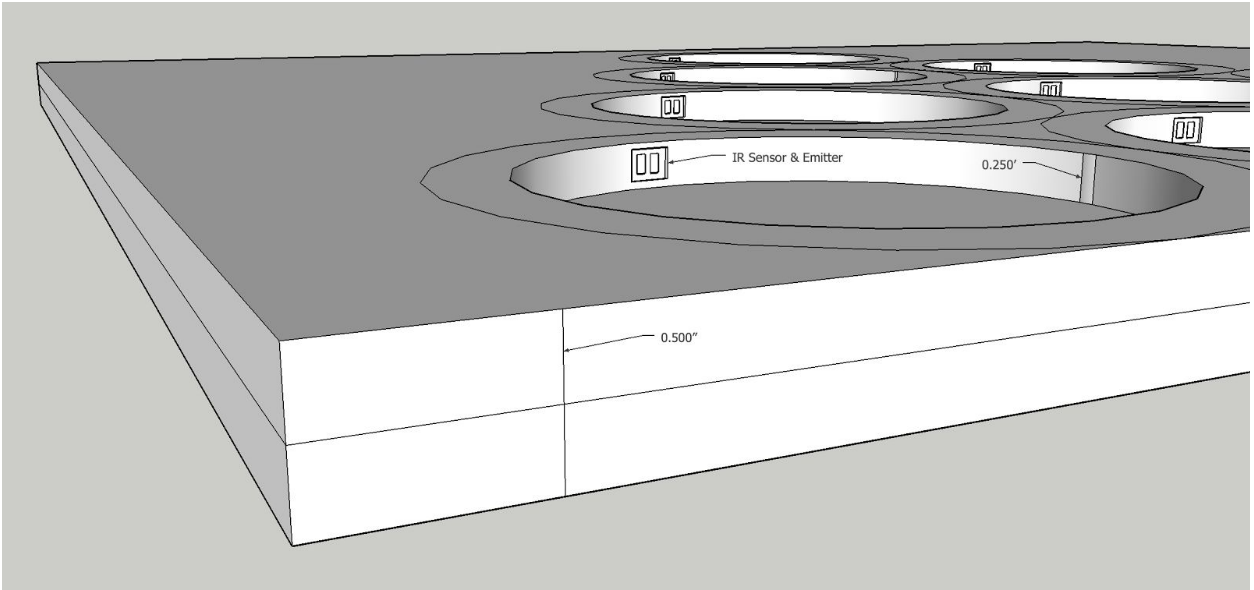

Figure 3 - Side Profile of Mat

2.3. Block Design

2.3.1. Power Supply

The power supply section of our block diagram is responsible for equipping each sub-module with the required power needs. We will fulfill these needs with 4 D-cell batteries in parallel running through a DC-DC boost converter to generate a 3.3V output. This output will power the microcontroller, LEDs, audio amplifier, while a DC-DC step down converter will turn the 3.3V output into the 1.7V output required to run the infrared sensors.

D-Cell Batteries (_/2 pts)

In order to dramatically reduce our power consumption, we have chosen to scan through our infrared sensors and LEDs instead of simultaneously checking all of the sensors. With a scanning approach, we limit not only the power drawn by the microcontroller, but also the power consumed by turning on the infrared sensors and LEDs. We will use four alkaline D-cell batteries. Each of these batteries will need to supply approximately 118 milliwatts during typical use and 186 milliwatts during peak power consumption (speakers playing). We expect to see a maximum of 72 watt-hours when combining four batteries rated at 18 watt-hours, but understand that these capacaties will derate based upon power consumption. The derating of these batteries is characterized by Energizer battery tests [5]. Further information regarding these calculations may be found in **Section 2.4**.

Requirement(s)	Verification(s)
1. Open circuit battery voltage of at least 1.5V nominally 2. Must supply 124 mA of current	1. Measure open circuit voltage with digital multimeter 2. Simulate maximum load while measuring output voltage ensuring it remains above 0.5V

DC-DC Boost Converter (_/3 pts)

In order to provide a 3.3V supply rail to our project, we will utilize a Linear Technologies DC-DC boost converter LTC3526L-2 which will regulate the varying battery voltage (due to a loss of charge as the batteries age).

Requirement(s)	Verification(s)
1. Accept input in the range of 0.5-2.5V while delivering a steady output of 3.3V 2. Deliver an output current of 125 mA	1. We will sweep through the input voltage between 0.5 and 2.5V at 0.1V intervals while measuring the output voltage of our 3.3V rail. 2. With maximum load circuit, measure the output current with a multimeter

DC-DC Step Down Converter (_/7 pts)

While most of our circuit operates at 3.3V, the infrared sensors operate at 1.7V instead. To accomplish the step down from our 3.3V supply rail to the 1.7V needed for proper IR sensor operation, we will be designing a buck converter utilizing an LM555 timer chip.

Requirement(s)	Verification(s)
1. Must accept input voltages between 3.1 and 3.3V 2. Must provide adjustable output around 1.73V (+/-0.2V). 3. Must provide at least 20mA of output current.	1. Apply voltages between 3.1 and 3.3V at the input of the device at 0.05V intervals. 2. This will be tested by choosing an 85Ω resistor for the output feedback and measured to confirm 1.7V operation. 3. This will be tested using a resistive load in the laboratory.

Low Battery Indicator (_/3 pts)

A low battery indicator will provide visual feedback to the end-user of our project as to the status of the currently installed batteries. Since our battery module will output a range of voltages between 0.5V and 1.5V (perhaps slightly higher with fresh batteries), we will treat this range as linear relative to the battery life of the project. As such, we can use a 0.85V threshold (corresponding to approximately 25% battery life remaining) at the battery output to determine when the low battery indicator should turn on. This will be accomplished using a comparator (comparing the battery voltage to a 0.75V reference) which will turn on an LED when this threshold is passed.

Requirement(s)	**Verification(s)**
1. Must turn on an LED when the battery voltage drops below 0.75V.	1. We will test this functionality by sweeping the input voltage of this module by 0.1V intervals from 0.9V to 0.8V and ensuring the output LED turns on at the proper voltage level.

2.3.2. Control Hub

Microcontroller (_/3 pts)

The microcontroller, PIC24FJ32GA002, is in charge of simultaneously scanning through and polling the piezoelectric and infrared sensors, scanning through LEDs, storing static memory, and processing and updating game states. Game states include player streaks, scoring, champions streaks, and current player's turn. This MCU will allow us to cycle through all sensors in order to detect their corresponding "events" described in detail in modules below.

Requirement(s)	**Verification(s)**
1. Must have at least 18 digital I/O pins 2. Power draw must be less than 50 mW	1. Verify through specifications sheet 2. Run at 16MHz and 3.3V while measuring current drawn

Button I/O (_/2 pts)

We will use two Omron Electronics SW400-ND switches for our game input. These buttons will signal to the microcontroller to start the game, switch to the next player; or end the current game when both buttons are pressed.

Requirement(s)	Verification(s)
1. Deliver a logic high when pressed 99% of the time	1. These switches will be tested on the bench before installation into the control hub to ensure proper functionality. We will also test these buttons by using the oscilloscope to analyze the voltage response when pressed

2.3.3. Audio/Visual Output Unit

LEDs (_/4pts)

We will be using Epistar's 5050 SMD LED. This LED is low power consuming and is rated at 19 lumens. They are also very low profile (under 1.6 mm height) and will fit under the cups in the mat without hindering the cups. There will be 32 LEDs installed, however, due to our microcontroller scanning across the LEDs, there will only be one powered at any given time. Each LED will be in series with an NMOS transistor which has its gate connected to one output of the decoder. When the decoder pulls the gate high, the current will flow from our supply rail through the LED and to ground giving off light.

Requirement(s)	Verification(s)
1. Output greater than 20 lumens (+/-2 lumens) at 60mA 2. Possess vertical dimension less than 0.4 inches when connected to remain below bottom mat surface.	1. Apply 60mA to the LED and measure the lumens with a light meter 2. Measure with a digital caliper

Seven-Segment Display (_/2 pts)

A Vishay TDSR1050 seven-segment display will provide feedback to the players of the current champions' streak. This seven segment display will be controlled by the microcontroller.

Requirement(s)	Verification(s)
1. Each segment outputs a value greater than 10 millicandelas (minimum expected output of display) at 20mA	1. Apply 20mA current to each segment and measure the candelas with a light sensor

Speaker (_/2 pts)

We plan to use DB Unlimited's SM300208-1 as our speaker. We chose this speaker primarily because it paired well with the audio driver that we chose to use. It has an 8 ohm nominal impedance and a maximum input power of 1 watt capable of reaching levels of 92 dB.

Requirement(s)	Verification(s)
1. Must output a sound greater than 75 dB (busy restaurant or social gathering level)	1. Play audio clip from our audio driver and record the dB of the speaker in a quiet environment with decibel meter

Audio Driver (_/4 pts)

We plan to use an ISD8120 as our audio driver. We chose this device primarily because it allows for easy audio recording and playback of pre-recorded audio with simple communication from the microcontroller. This device will allow our group to record our desired cup-collision noise before installation into the project. Once installed, playback will be initiated by pulling a level-sensitive input high for the desired playback time.

Requirement(s)	Verification(s)
1. Must record one 5 second clip while powered and store the recorded data in non-volatile memory. 2. Must be remotely controlled by a single level-sensitive pin.	1. A 5 second recording will be made with the device powered. After powering the device off, the device will be powered again and the recording will be played to ensure data retention. 2. After recording sound clip, the clip will be replayed by pulling a single enable high and verifying audio output.

2.3.4. Game Mats

Infrared Proximity Sensor (_/4 pts)

Using Optic Technology's OPB606A we will be able to detect the presence of a cup in its respective slot. The IR emitter and receiver needs to be able to detect a cup inside of the circular indent it is mounted against. Paired with a comparator, the microcontroller will receive a logical high if a cup is present. If a cup changes from present to removed, the sensor will communicate this to the microcontroller, which will in turn update the current game's state and score.

Requirement(s)	Verification(s)
1. Output a logical high when 0.25 inches from the side of a red Solo Cup 2. Output a logical low when there is no cup present in the indent	1. Measure V_{out} from sensor while the IR sensor a quarter of an inch away from the cup. (must be > 1.96V) 2. Measure V_{out} from sensor when the cup has been removed from the indent. (must be < 1.96V)

Piezoelectric Force Sensor (_/4 pts)

We are using Murata Electronic's 7BB-41-2L0 piezoelectric sensor to detect hits from the ball onto the cup. Piezoelectric disks (piezos) consume no power when detecting vibrations. Since they are passive, we will not need to have any connections to the Power Supply Module. Instead, we will only have data connections to the microcontroller. When the sensor is placed under the cup, vibrations across the sensor generate a voltage differential when the ball strikes the cup. After analyzing the test data graphed in Figure 5, we were able to set a benchmark of 1.96V that differentiated table bumps and cup hits with high accuracy. If a ball hits a cup, the sensor will communicate to the microcontroller to play a noise.

Requirement(s)	Verification(s)
1. Sensor must output voltages linearly proportional to the force of impact for use as an impact detector	1. Drop 2.7 gram ping pong ball at intervals of 5 centimeters and record voltage levels to determine force voltage relationship

Scanning Unit (_/10 pts)

To follow along with signal names, see Figure 4. To light LEDs on our game mat we are using two CD74HC15M96 4:16 Decoders to scan through each LED that needs to be on. These will be located one in each game mat. The addresses into the devices (LED_SCAN) will be generated by the MCU and only cycle through LEDs that should be on. The decoder will turn on a discrete PMOS transistor NX7002AKVL which will then sink current through the LED, turning it on.

The scanning of sensors, piezoelectric and infrared, will be done in a similar way. The MCU will cycle through 4-bit addresses constantly (INPUT_SCAN) as inputs to 16:1 analog multiplexers using part CD74HC4067. The four outputs from the multiplexers will be routed to our central game console for further selection. The MCU will also generate a signal to distinguish between the left and right side of the table (MCU_DIRECTION) and a signal to distinguish between IR and piezoelectric sensors (MCU_SENSOR). Finally, this output will pass through a comparator, LM393PE3. This comparator will determine for IR sensors if a cup has been removed, and will determine for piezoelectric sensors if a hit has been detected. This value will be passed to the MCU for further processing.

Requirement(s)	Verification(s)
1. Must be able to turn LEDs completely on or off 2. Must take multiple analog inputs and output a single digital output corresponding to the current address	1. We will enable and disable LEDs while measuring current through them to ensure they are turning on and off properly 2. We will cycle through addresses with different inputs on each pin to ensure A/D conversion

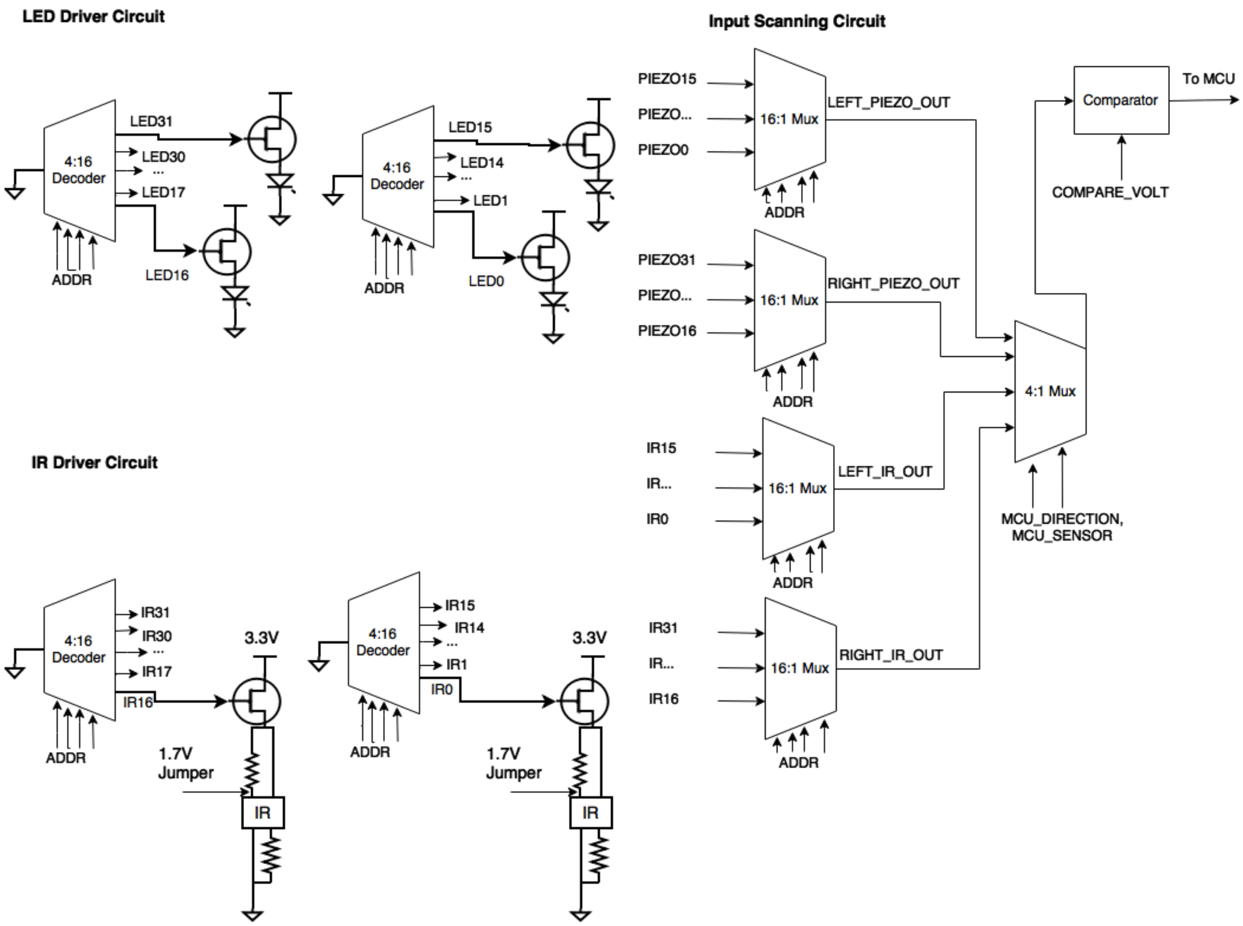

Figure 4 - Multiplexer and Decoder Design for Scanning

2.4. Calculations

2.4.1 Power Estimation and Battery Derating

Led power consumption = 3.2V * 60mA = 192mW (1)

IR sensor power consumption = 1.7V * 20mA = 34mW (2)

Microcontroller power consumption = 3.3V * 3.15mA = 10.4mW (3)

Audio driver power consumption = 3.3V * 41mA = 135mW (4)

Total system power consumption = $\sum_{1}^{n} P_i$ (5)

(where P_i are the individual power consumption values calculated above)

Thus we see that our system power consumption is $\sum_{1}^{4} P_i$ = 371.4mW (6)

(While audio is being played)

And our system power consumption is $\sum_{1}^{3} P_i$ = 236.4mW (7)

(While audio is not being played, which is the nominal case)

2.4.2 Sensor Polling Frequency

To accurately determine the frequency of the microcontroller our project would use, we first needed to set a high confidence, minimum scanning frequencies to pick up hits with the piezoelectric sensors. After testing multiple frequency ranges, we chose to use a 2.2 KHz piezoelectric disk. Using data compiled to create the graph in Figure 5, we were able to dial in on an adequate polling frequency that we would require from the microcontroller.

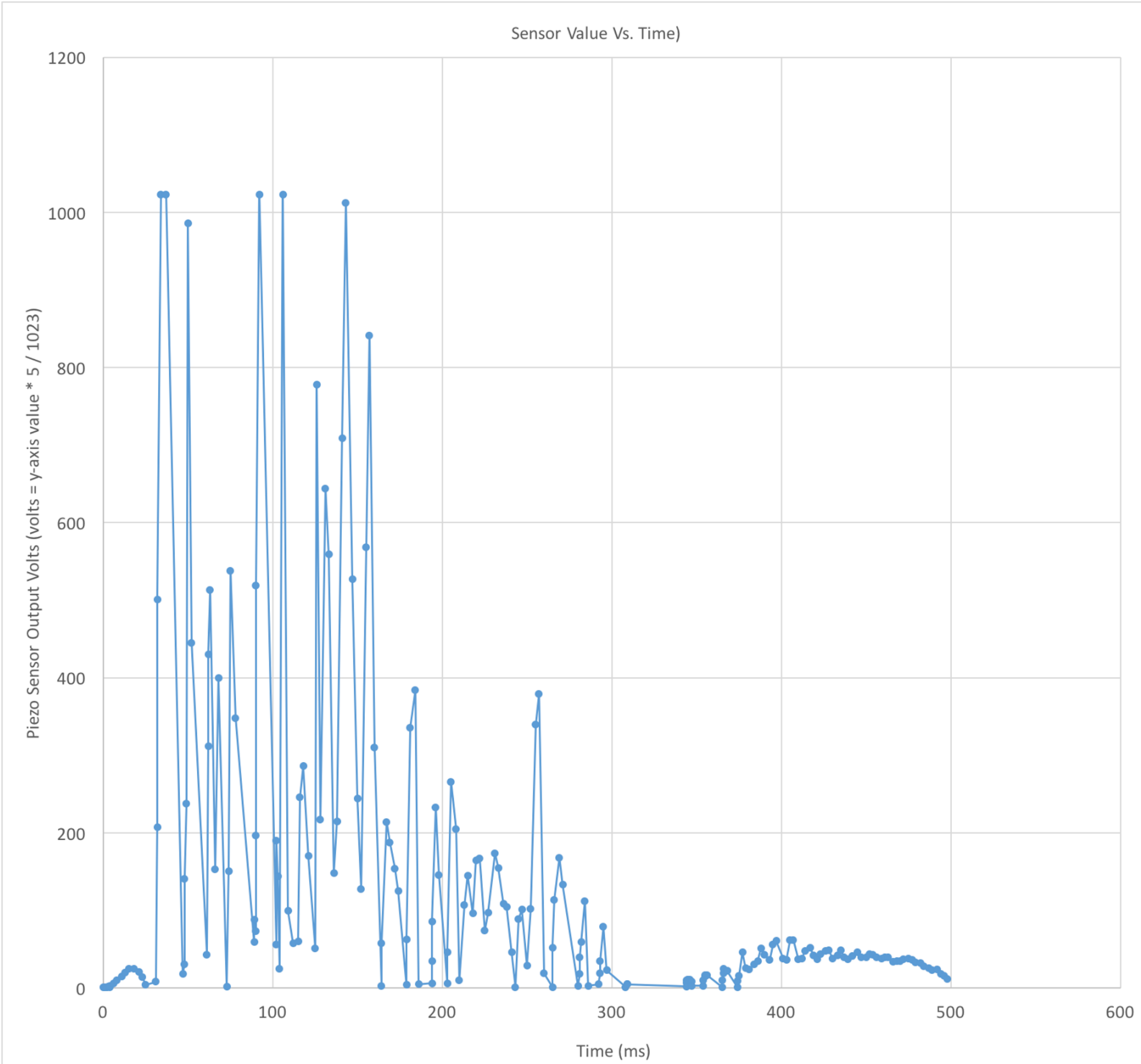

Figure 5 - Example Data Plot of 2 KHz Piezo Voltage Output

First we calculated the average time of impact above a threshold. This threshold is one we've chosen to be 1.96 volts. We chose this doing testing and comparing table bumps/impacts and cup impacts. At this threshold is where a solid table bump peaks and a solid cup impact fluctuates at a little over twice this threshold. With this in place, we were able to create Table 1 and Table 2.

Table 1 - Average Time of Impact Above Threshold of 1.96V

Trial 1	Trial 2	Trial 3	Average
128 milliseconds	135 milliseconds	85 milliseconds	116 milliseconds

Table 2 - Number of Hits/Polls Impact Above Threshold of 1.96V

Trial 1	Trial 2	Trial 3	Average
20 hits / 52 polls	17 hits / 54 polls	16 hits / 38 polls	18 hits / 48 polls

With this data we were able to find a frequency on which to poll the sensors with a high confidence of detecting cup hits.

$\frac{48\ polls}{.116\ sec.} = 413\ polls/second$ which we round up to $500\ polls/second$ for cleanliness (8)

We also decided that we will scan across 10 piezo sensors but poll at the same frequency per sensor. Thus, our final calculation for the frequency of sensor switches controlled by the microprocessor should be at a bare minimum:

$$500\ polls/second * 10\ sensors = 5000\ polls/second = 5KHz \quad (9)$$

Looking at today's microprocessor's specifications, we think this is very achievable and with scanning, we have greatly reduced our power consumption.

2.4.3 LTC3526L-2 Design-In [6]

The LTC3526L-2 is a DC-DC boost converter which we are using to step-up the voltage from the batteries (0.5V-1.5V) to a constant 3.3V. This can be accomplished by using equation 10. We plug in 3.3V to Vout to obtain a ratio between resistors R2 and R1. After finding the resistor ratio, the resistor values were chosen to be large so that the power consumption was low.

$$Vout = 3.3 = 1.195(1 + \frac{R2}{R1}) \quad (10)$$

An inductor is necessary for the switching functionality of the boost converter. The chip allows for greater output current, but with our application, we do not need this capability. We are choosing a value of 2.2uH which will supply plenty of output current without being overly bulky in a physical sense.

Next, we to reduce noise at the input due to voltage change in the batteries we add capacitor C1. It also helps prevent coupling and interference amongst other connections in our PCB.

We add capacitor C2 in order to improve the stability of the feedback system. We chose a capacitor slightly larger than the minimum in order to ensure the output reference tracking is as accurate as possible.

Lastly, we insert capacitor C3. The minimum value of the capacitor for the system to remain stable is 4.7uF. The larger this capacitor is, the lower the output voltage ripple is, so with some simulation a 200uF capacitor shows the ability to achieve under a $\pm 3\%$ voltage ripple at the output.

2.4.4 Buck Converter Design [9]

We are building a buck converter to achieve the stepped down voltage that the IR sensors require. First of all, to achieve the correct output voltage of 1.73 from the minimum input voltage one, we calculate the duty cycle, D:

$$D = V_{out}/V_{in} = 1.73/3.1 = 0.558 \quad (11)$$

Next, we settled on a frequency achieveable by our timer chip, Fsw:

$$F_{sw} = 600 \text{ kHz} \quad (12)$$

Finally, we select the maximum load current based on our earlier calculations, plus some breathing room. The max current at the load is chosen to be Iload = 180mA.

We are able to calculate the minimum capacitances and inductances used by C4 and L2.

$$I_{ripple} = 0.3 * 180mA = 60mA \quad (13)$$

$$L2 = (V_{in}-V_{out})*(D/F_{sw})/I_{ripple} \quad (14)$$

$$L2 = 22.3 \text{ uH minimum} \quad (15)$$

$$\text{deltaT} = D/F_{sw} = 930ns \quad (16)$$

$$\text{deltaV} = 50mV \quad (17)$$

$$C4 = I_{rip}*\text{deltaT}/(\text{deltaV}) \quad (18)$$

C4 = 1.12uF minimum (19)

2.5. Schematics

Shown below in Figure 6 is a schematic of the power system for our project. This schematic incorporates three modules described earlier in this document (D Cell batteries, DC-DC Boost converter, and DC-DC Buck converter). For more information concerning these individual modules, see their descriptions above in section 2.3.1.

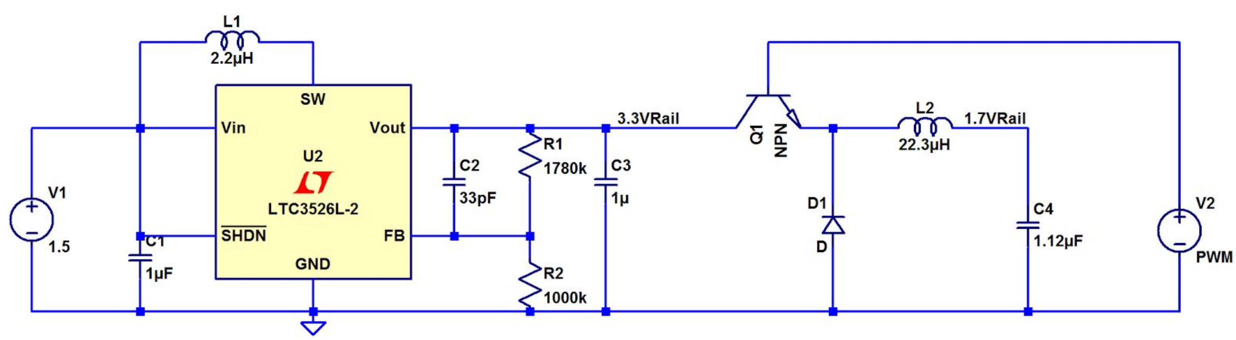

Figure 6 - Power System Schematic

Shown below in Figure 7 is a schematic of how we will use the microcontroller for our project. This module outputs five LED_SCAN pins, four INPUT_SCAN pins, MCU_DIRECTION, and MCU_SENSOR to the scanning unit. The module outputs one pin, AUDIO_EN to the audio driver. The microcontroller outputs four HEX_DRIVER pins to the hex driver. In terms of inputs, there are two BUTTON pins, from the button I/O module and one COMPARE_IN from the scanning unit.

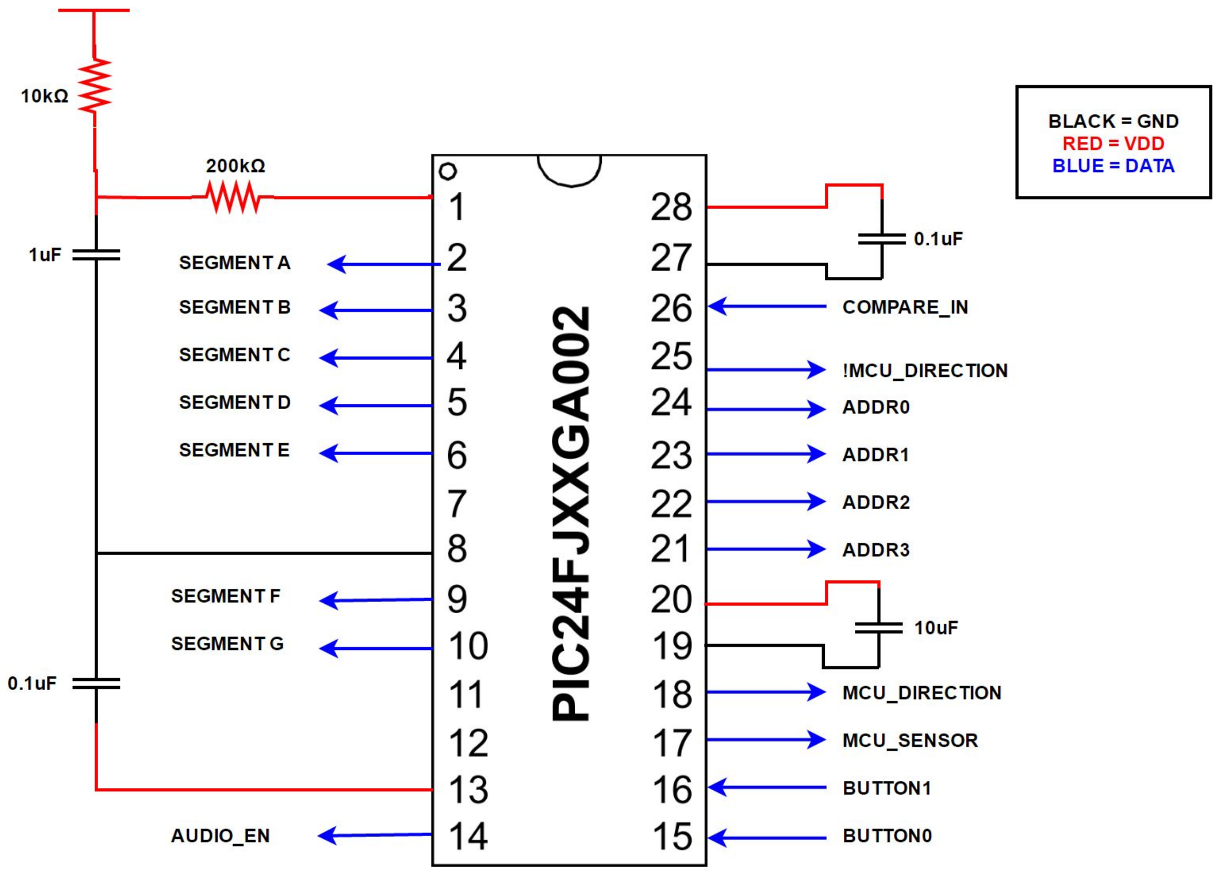

Figure 7 - Microcontroller Schematic

2.6. Software

The software for this project will consist of embedded C code on the microcontroller. There are main jobs for the software to accomplish which are tracking the game state (score, streaks, available cups, etc.), polling sensors and selecting LEDs to be powered correspond to the game state, and listening for user input. Below in Figure 8 is a flowchart outlining the software's functionality.

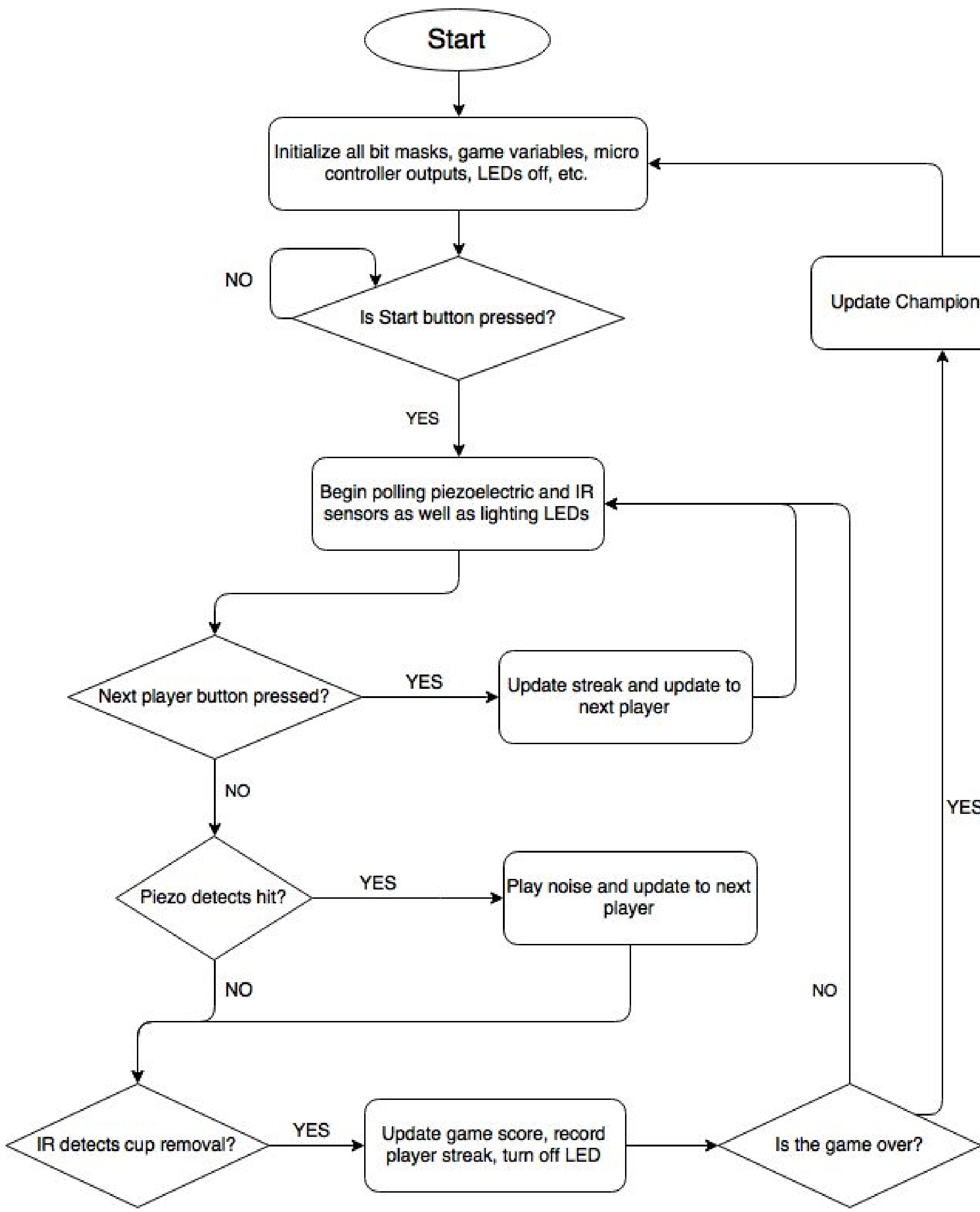

Figure 8 - Microcontroller Software Flow Chart

2.7. Tolerance Analysis

One of the most crucial aspects of our design is the power system. In particular, the boost converter connected to the batteries must be able to function properly even at low input voltages. Since our design will require a relatively constant input power (coming from the 3.3V rail), this challenge falls upon the boost converter.

The components within any circuit are highly susceptible to fluctuations in supply voltage. For example, digital logic circuits which provide rail-to-rail outputs rely on a steady supply voltage to ensure the proper operation of downstream circuits. In the case of our project, the microcontroller requires a stable supply voltage to power an internal core-voltage regulator which powers the CPU within the device. While this internal regulator can smooth most of the supply noise, it cannot cope with large swings. As such, our power supply required extensive testing under all input conditions to ensure the output was regulated with less than 3% ripple even under full load.

Seen below in Figure 9 is the *overloaded* functionality of our power supply with a 1.5V input. Resistive loads were used to load our power supply past the point of normal or even maximum current draw. This will be the nominal battery voltage and therefore describes the nominal response of our circuit to a very large load.

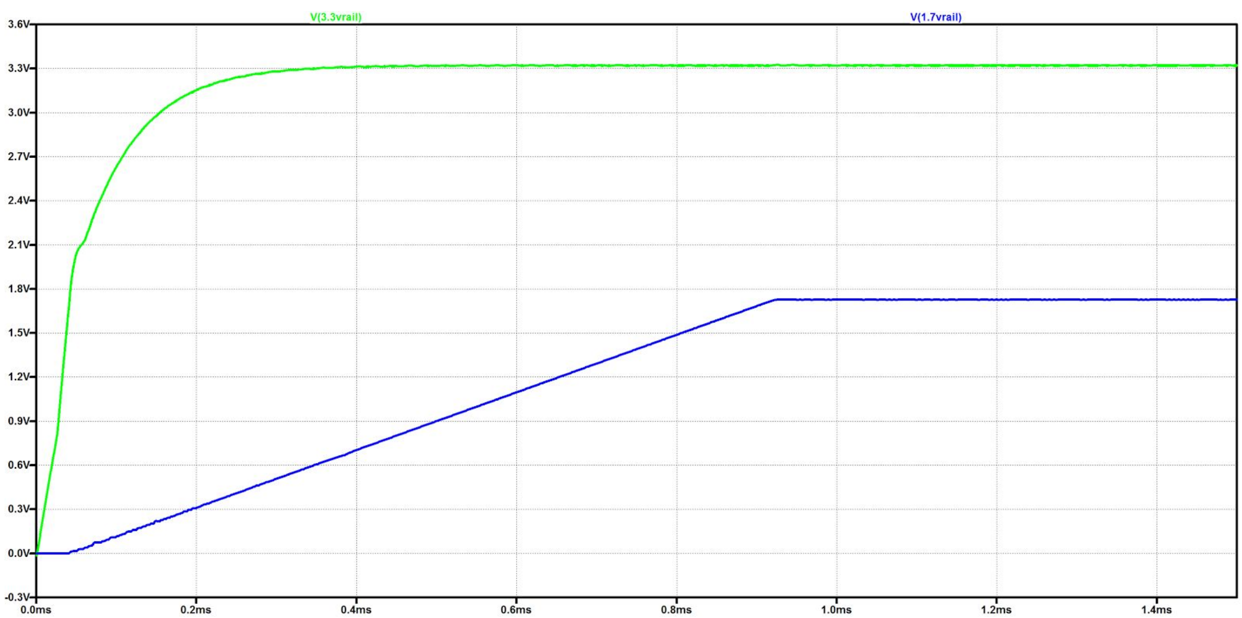

Figure 9 - 3.3V and 1.7V rail voltages during power-up with a 1.5V battery voltage

After testing the nominal case, we simulated our circuit’s response to a lowered input voltage. This case, shown in Figure 10, considers the worst possible scenario for our power supply. Not only is the load larger than the maximum load seen during operation, but the batteries would nearly be drained at an input voltage of 0.8V. Our power supply had a tougher time raising the output voltage in this case, but the output voltage remained within an acceptable range after reaching steady-state, and the ripple was well within our bounds for proper operation.

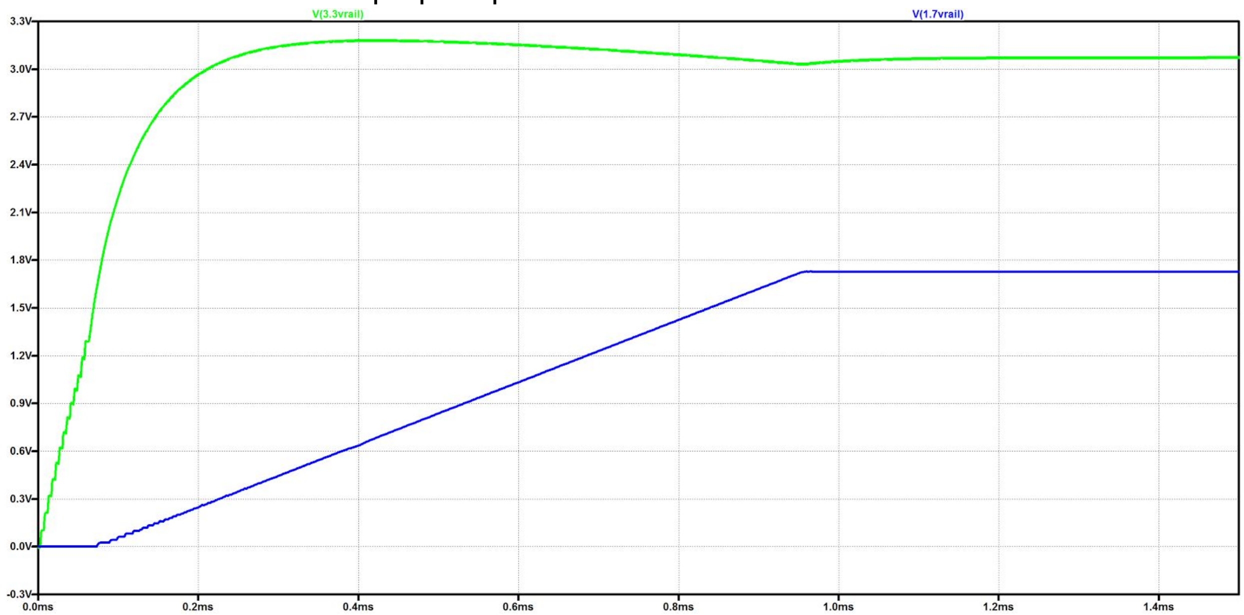

Figure 10 - 3.3V and 1.7V rail voltages during power-up with a 0.8V battery voltage

After completing this testing, we are now certain that our power supply circuitry will be able to cope with the varying loads and voltages experienced within our project's normal operation.

3. Costs & Schedule

3.1. Cost Analysis

Name	Part #	Qty	$/unit proto.	$/unit bulk	Cost proto.	Cost bulk
LED	5050 SMD LED	33	0.05	0.01	1.65	0.33
Discrete PMOS	NX7002AKVL	33	0.11	0.016	3.63	0.528
Battery Holder	SS20508-2FF	1	1.00	1.00	1.00	1.00
Speakers	SM300208-1	1	2.66	1.20	2.66	1.20
Audio Driver	ISD1820PY	1	1.00	1.00	1.00	1.00
Seven Segment	TDSR1050	1	1.78	0.61	1.78	0.61
Hex Driver	AS1108	1	4.42	1.92	4.42	1.92
IR Sensors	OPB606A	20	1.16	0.923	23.20	18.46
Piezoelectric Sensors	7BB-41-2L0	20	1.27	1.11	25.40	22.20
Comparator	LM393PE3	1	0.45	0.094	0.45	0.094
16:1 Analog Mux	CD74HC4067	4	0.82	0.297	3.28	1.188
4:1 Analog Mux	MAX4518EEE	1	2.31	1.90	2.31	1.90
4-16 Decoder	CD74HC15M96	2	0.63	0.23	1.26	0.46
Buttons	SW400-ND	2	0.35	0.172	0.70	0.344
Microcontroller	PIC24FJ32GA002	1	2.45	1.78	2.45	1.78
Boost Converter	LTC3526LBEDC-2	1	4.53	2.48	4.53	2.48
Buck Converter	Custom	1	3.35	1.69	3.35	1.69
Assorted Discrete Parts	Multiple	1	5.00	0.50	5.00	0.50
Total Parts Cost:					88.07	57.68

$$Labor\ Cost\ =\ 3\ people\ \times\ \frac{\$40}{1\ hour} \times \frac{10\ hours}{week} \times 16\ weeks\ \times 2.5\ =\ \$48,000$$

$$Total\ R\&D\ Cost\ =\ Total\ Parts\ Cost\ (Proto)\ +\ Labor\ Cost\ =\ \$48,088.07$$

3.2. Project Schedule

Week	Adam	Alex	Chance
2/27 - Design Review	Order Parts (pending Design Review)	Complete in-depth schematics (pending Design Review)	Begin PCB layouts (pending Design Review)
3/6	Research embedded programming	Researching game mat materials	Researching game hub construction
3/13	Begin writing program code.	Tying up loose ends before Spring Break	Complete first PCB revision and place board order
3/20 - Spring Break	Hopefully nothing - I don't see the point in lying on this schedule.	Hopefully nothing - I don't see the point in lying on this schedule.	Hopefully nothing - I don't see the point in lying on this schedule.
3/27	Continue embedded code and begin debugging	Begin construction of the game mat(s)	Complete final PCB revision and begin revision 1 assembly
4/3	Test embedded code on PCB revision 1	Test game mat responses	Begin final PCB assembly
4/10	Ready presentation material	Ready game mats for mock demo	Ready game hub for mock demo
4/17 - Mock Demo	Participate in mock demo & peer reviews	Participate in mock demo & peer reviews	Participate in mock demo & peer reviews
4/24 - Demonstration	Finalize presentation	Finalize game mats	Finalize game hub
5/1 - Final Paper	User testing of the finished device.	User testing of the finished device.	User testing of the finished device.

4. Ethics and Safety

As a device which will constantly be surrounded by water or beer-filled cups, we will adhere to water-resistivity to a certain degree to follow IEEE Code of Ethics, #9: “to avoid injuring others, their property, reputation, or employment by false or malicious action” [8]. We will need to obey an IP54 rating which consists of resistant against splashing of water.

Our plan for waterproofing the project includes spill and splash resistant game mats. The game mats are at the highest risk of exposure to conductive liquids. This poses not only an issue for the functionality of our project, but is also a major safety concern despite the relatively low voltages and currents present. As such, we will waterproof these game mats by using a two-layer design which sandwiches the exposed electrical components between an opaque plastic mat with pockets for the cups and a closed-cell neoprene material which will not only offer water resistance, but help to isolate the sensors from the vibrations induced in the table.

Due to the inherent risks of consuming alcohol we want to reduce play time per person as to spread out the consumption to be in accordance with IEEE Code of Ethics, #1: “To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment” [8]. One way we have found to accomplish this is by installing a streak counter on a seven segment display which would only count up to nine. If a team continuously wins over and over again, eventually their streak would come to an end and restart to zero.

Additionally, one IEEE code which may need to be violated to comply with public health and safety of underaged users would be IEEE Code of Ethics, #8: “to treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression” [8]. We will market this product only to those who are over the age of 21, in order to not glamorize drinking for those who are inexperienced and impressionable.

5. References

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