Augmented Beer Pong Mat

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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 its lack of progress has not reflected the spirit of innovation seen in today's technology.

The goal of our product is to improve the game of beer pong. We will realize this goal by incorporating modern technology into the game to enhance functionality and entertainment. We hope to complete this objective by making our product portable, accurate, and long-lasting. Our product will consist of two mats, one per each team's cups, connected to a central logic hub. We will have dynamic lighting embedded in the mats and speakers in the central hub to add to the excitement. Additionally, our product will keep track of score, player shot streaks, and a champion's run counter.

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 of them include Dartmouth fraternities in the late 50's, early 60's, as well as Delta Upsilon at Bucknell 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 few products currently on the market which are bulky, expensive, and unresponsive to sensory input; all-in-all these products flicker LEDs at a preset rate, or continuously turn LEDs on for a glow effect [2] [3]. Our product will offer the ability to adapt to any table or surface, respond to game-play, and emit sound and visuals based on the state of the game.

1.3 High-Level Requirements

- Length of play: the system must be able to run for five to six hours of gameplay.
- Portability: the two mats and central hub combined must weigh less than seven pounds for mobility.
- Sensor Accuracy: the gameplay must not be significantly altered by sensors misreading input. 90% accuracy for cup removal, 75% for hit detection.

2 Design

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 LED visuals based on gameplay.

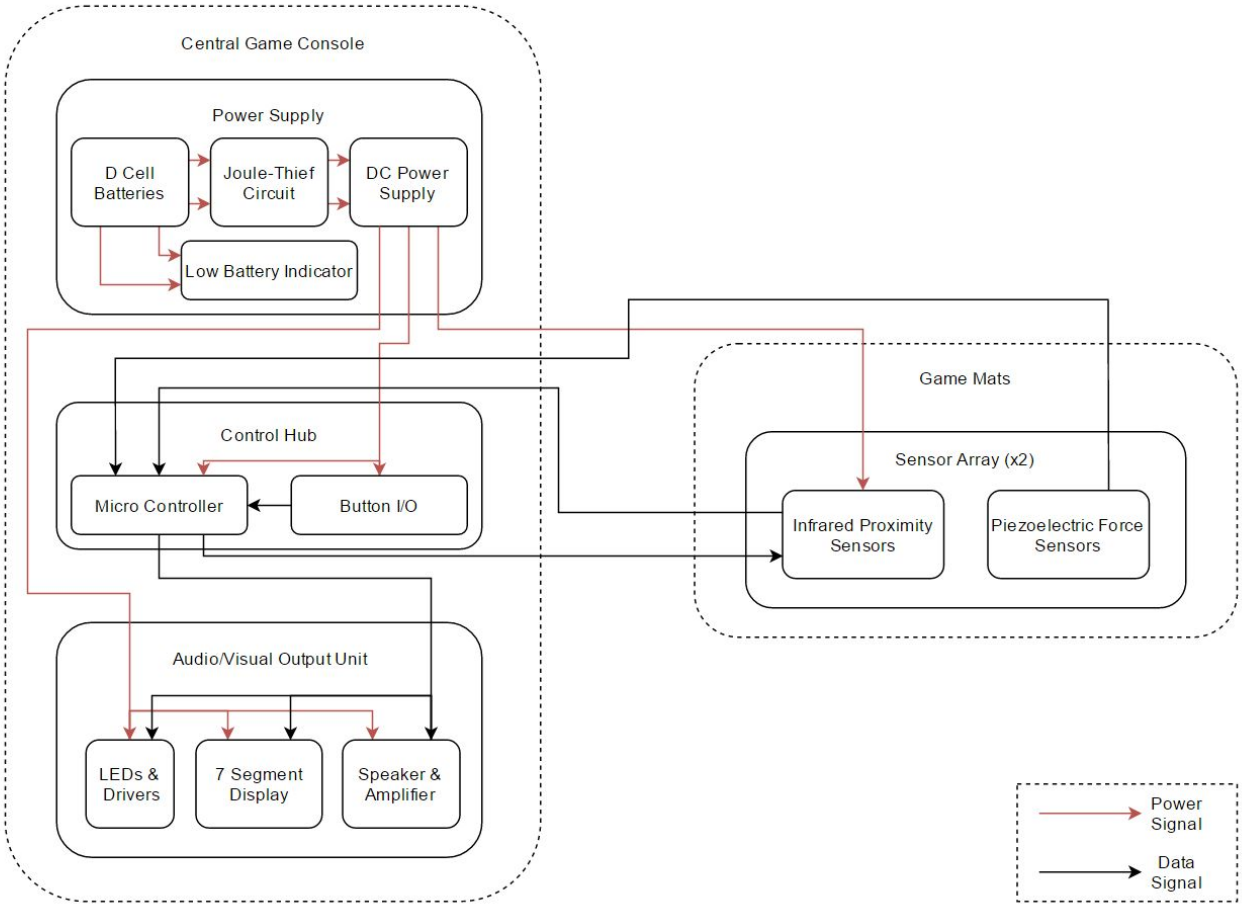

Figure 1 - Block Diagram

2.2 Physical Design, Functional Overview, Block Requirements

Power Supply

- **D Cell Batteries: (**with BH141 battery holder from ECE shop.) We have two tactics to decide between when powering our product. The first is the obvious and is all components being simultaneously powered on. The second is scanning through each individual LED and scanning through each individual IR ROSs/piezo disks at a fast enough rate to emit bright enough light and accurately poll for objects/vibrations respectively. The scanning method will dramatically reduce our power consumption, but will possibly hinder our sensor accuracy. We will need to do testing on each of these methods.
  Constant: We estimate that each battery needs to supply 1.11 Watts with a capacity of about 6000 mWh. With four batteries, we have an estimated 24 Wh and need a constant 4.44 Watts leaving us with a battery life of around 5.4 hours.

Scanning: Constant: We estimate that each battery needs to supply 0.222 Watts typically and a max of 0.444 Watts with a capacity of about 18000 mWh. With four batteries, we have an estimated 72 Wh and need a constant 0.222 Watts leaving us with a battery life of around 324.32 hours.

- **Joule-Thief Circuit:** This circuit is a small oscillating circuit centered around a properly wound inductor and an NPN bipolar junction transistor. This circuit will create a pseudo-sinusoidal output which will be input to the DC power supply described below. The purpose of this circuit is to drain more energy from the disposable batteries and therefore increase the playable time of our product.
  Requirements: Must take a nominal 1.5V input and output the current necessary to power the DC power supply.

- **DC Power Supply:** This module will take an alternating-current (AC) input and output a steady voltage for a wide range of load currents. The circuit will consist of a rectifying section (likely a full-wave rectifier), a smoothing section (a resistor and capacitor), and an output section (a reverse-biased Zener diode). These three sections combine to rectify, smooth, and set the output voltage of the DC power supply, while careful calculations will ensure the output voltage remains stable during changes in load current.
  Requirements: Must output a steady voltage (3.3V or 5V depending upon the choice of MCU) for the range of currents dictated by our design choices mentioned above.

- **Low Battery Indicator:** This circuit will provide a notification to the users of the product to change the batteries when their remaining charge is no longer sufficient to power the game system. This circuit will likely consist of a comparator whose inputs are connected to the positive battery terminal, and a reference voltage. As the voltage drops, the comparator output will be raised to a logic high level, and will turn on the gate of an NMOS device. The NMOS gate voltage is therefore raised above the threshold of the device and will provide drain current to an LED which will notify the game's users of the low battery voltage.
  Requirements: Must properly turn on at low battery voltage to notify the user when there is approximately 1 hour of play time left, and this module must not add significantly to the overall power consumption.

Control Hub

- **Micro Controller:** This module will comprise the brains of the project. Using C code, we will program the MCU to track relevant aspects of the game from scores, player shot streaks, and a champions win streak. Additionally, this module will send control signals to power the LEDs, output audio to an amplifier and speaker, and receive input from buttons on the main hub to control the flow of the game.
  Requirements:
  Constant Power: At least 32 analog I/O pins will be needed to output LED controls, input sensor data, and to output audio. The MCU may operate at a lower frequency in this case since I/O is performed in parallel.
  Scanning Power: LED outputs will greatly decrease in this case since a decoder can be used to select and power the appropriate LED. Analog multiplexers may also be used to select the incoming data signal as well. As such, it appears at most 10 I/O pins will suffice for this design, but a higher clock frequency may be necessary to ensure smooth gameplay.

- **Button I/O:** Two buttons, one on each mat. Something similar to COM-00097 ROHS. Used for manually overriding the game in case someone misses the table completely, or in the case of a sensor misread. Tells the game logic to go to the next player.
  Requirements: the button does not need to be flashy, we can use any cheap, durable button.

Sensor Array

- **Piezoelectric Force Sensors:** 8 Piezoelectric Disks (or Force Sensitive resistors which need more testing for decision). Piezoelectric disks (piezo's) 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 piezo's vibrate, the internal structure of the crystals create a large voltage differential that can be measured and converted to a digital representation of a "hit". We will use this vibration-voltage data to determine if the player hit a cup and if the product should play a noise.

Requirements: Large enough to cover the playing area with a small number of disks. I.e. around an inch and a half and 4 disks. Also, thin enough to detect a small amount of vibrations with high voltage differential.

- **Infrared Proximity Sensors**: 20 Infrared (IR) Reflective Object Sensor (ROS): At most, only 10 sensors will be powered at any given time. These IR ROS's both emit and receive infrared radiation If one of these IR ROSs is in close proximity to an object, the object will reflect the emitted infrared signal back to the receiver, signalling the presence of an object. We will use this signal to turn on lights if a cup is present as well as keeping score when the cup is not present. This requires power from the power supply as well as a data signal to the microcontroller. The IR ROSs we want to use are JAMESCO's OPB606A with 20mA and 1.5V.
  Requirements: Low current (~20mA) and low voltage (<3.3V) with adequate accuracy reading to about a centimeter away.

Audio/Visual Output Unit

- **LEDs & Drivers:** 32 LEDs will be installed. At most, only 20 LEDs will be powered at any given time. The LEDs will be placed under or around the cup locations. Only the LEDs with its respective cup present will be lit. We will also have 3 LEDs for each player to keep track of the "shot streak". These will require a powered connection to the Power Supply. The LEDs we want to use are Epistar 5050-PW6000 with 3x20mA and 3.2V.
  Requirements: Bright enough to light up a red solo cup (>500 mcd estimate) with minimal power

- **Speaker & Amplifier:** Made up of 2 speakers. These will not typically consume power and instead are only on for short bursts when a cup is hit, miss button pressed. We are looking to use GF0401M-ND speakers from DigiKey at 100mW. These speakers are low profile and have a wide range of frequencies that they can emit which is perfect for our product.
  Requirements: Low profile and loud drawing minimal current. Ideally, less than 500mW.

- **Seven-Segment Display:** One display showing the streak of the current champions. Achieved by checking the data from the IR sensors. Something similar to a COM-08546 ROHS.

2.3 Risk Analysis

The sensor array unit is the largest risk to completing our project in its entirety. First, we will need to choose a type of vibration or force sensor which is sensitive enough to indicate a hit has occurred. We will also need to choose an infrared reflective object sensor which is sensitive enough to indicate if a cup has been removed even when the cups are not quite placed correctly.

Next we will need to choose a physical arrangement of sensors which fits our needs by outputting the most useful data. There are many ways to arrange the sensors within the mat, so experimenting with these patterns will require extensive testing to find an optimal solution for the sensor placement.

Finally, we will need to test how quickly data must be retrieved from the sensor. Additionally, if polling these sensors intermittently causes us to miss relevant data points, we will need to consider an alternative which allows us to capture important events during the course of a game.

If any of these factors cause significant problems for us, then the sensor array will be inaccurate and our high-level requirement of sensor accuracy will not be met. This would cause a significant blow to our project's entertainment value and turn the game into a static light-up table.

3 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" [4]. We will need to obey an IP54 rating which consists of resistant against splashing of water.

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" [4]. 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” [4]. 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.

References

[1] "The World Series of Beer Pong." *BPONG*. N.p., n.d. Web. 08 Feb. 2017. https://www.bpong.com/wsobp/

[2] "Glowing Americana Beer Pong Table - 8 Ft - Spencer's." *Starter*. N.p., n.d. Web. 08 Feb. 2017. http://www.spencersonline.com/product/129192.uts#.WJpMnqC1BfE

[3] Rich. R, Floor Manager of the Rock Bar Las Vegas, Julie P., Steve D., Jessie V., and Brandon D. "Infinity Glow L.E.D Beer Pong Table." *Infinity Beer Pong*. N.p., n.d. Web. 08 Feb. 2017. http://www.infinitybeerpong.com/products/customized-infinity-glow-led-beer-pong-table

[4] "IEEE IEEE Code of Ethics." *IEEE - IEEE Code of Ethics*. N.p., n.d. Web. 08 Feb. 2017. http://www.ieee.org/about/corporate/governance/p7-8.html