Modular Cup Pong Scoring Device

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1 Introduction

1.1 Objective

Many college students enjoy a good game of cup pong. However, access to a regulation table is difficult and cumbersome. Generally, students make their own, which is large and almost impossible to bring to other places. It is also hard to keep track of score so an accurate method is needed. Our solution plans to solve both of these issues with a portable product that can be brought to wherever the party goes.

We plan on creating 2 waterproof, triangular pads that can be placed on top of any table, underneath the cups. A display will be connected to each triangle module. There will be load cells in the cups' positions to register when a cup has been taken away. This will subtract a point (starting from 10) from the respective team. Whenever a cup is registered as taken away, a ring of lights will help represent this by turning from green to red.

1.2 Background

Cup Pong is a popular college game which involves 10 cups arranged in a triangle on either side of a table. Players take turns attempting to throw a ping pong ball into the cups opposite of them. If a ball lands inside a cup, the cup is removed. The first team to get rid of all 10 cups wins. The game can be played on almost any table, however, a properly sized table is usually desired. The regulation sizes for a table are 8' x 2' [1], which is very difficult to bring anywhere. There is one solution that we have found, which consists of a table that can be taken apart [2]. The "RaveTable" costs $1,995.00 at the base customization. Our device plans to be more affordable and even more portable, as it will only be two 15" equilateral triangles with some extra UI modules, such as the score display.

1.3 Physical Design

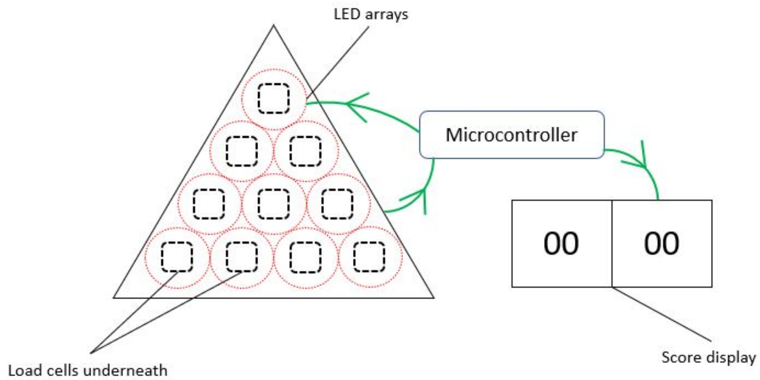

Fig. 1 Single Module Design

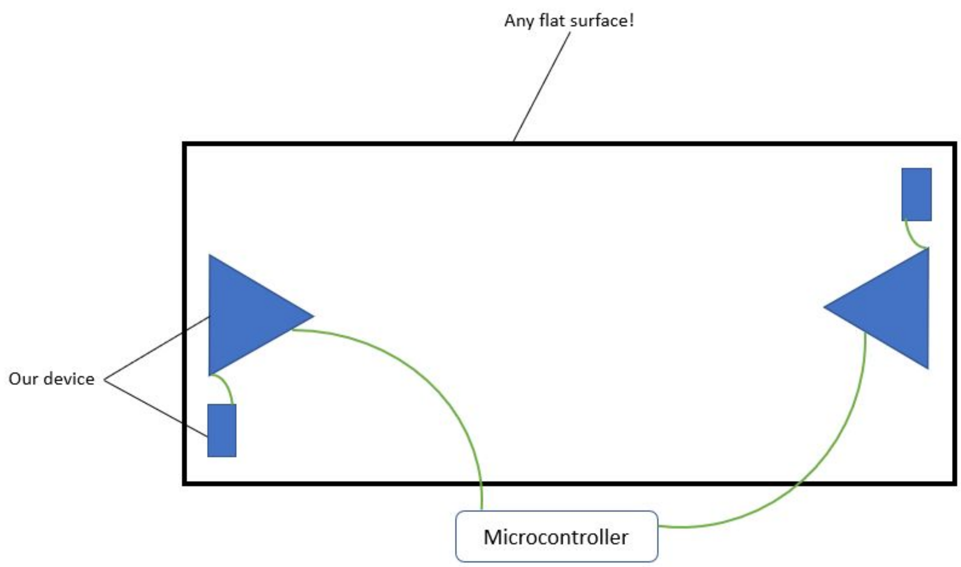

Fig. 2 Normal use case

Fig. 1 shows our design for a single module. Both modules will be connected to the same microcontroller to sync the data outputted from the two devices.

Fig. 2 shows how a user will utilize our product. Whether you want to put it on a table or even play sitting down on the ground, as long as the surface is flat, it can be placed anywhere. The distance between the front two cups should be 65" apart to be within the regulation size [1].

1.4 High-level Requirements

- The load cells underneath each cup will detect whether a point has been scored with 95% accuracy.
- The score display will update to match the corresponding game within 1 second of a cup's removal from the pad.
- Portability is a key component to the product – each module will be less than 20 pounds and 2 feet in either direction.

2 Design

2.1 Block Diagram

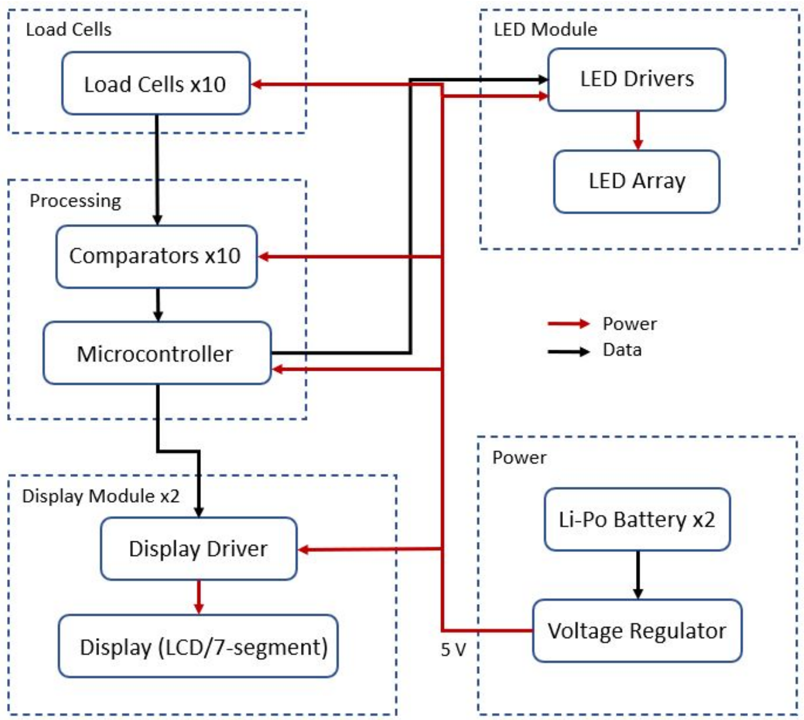

Fig 3. Block Diagram

Everything in the block diagram will interface with the microcontroller (ATmega328P). The MCU has a speed of 20 MIPS which will be fast enough to relay all the data needed almost instantly. The load cells act as variable resistors with a 2% uncertainty that will change with the force applied. By comparing the voltage change with a reference voltage in the comparators, the microcontroller decides whether a cup is present. This flag that the microcontroller makes is sent to both the display and the LEDs. The LEDs will change between red (no cup) and green (cup is present) while the display module will decrease the score as needed. The Li-Po batteries chosen for this project are thin enough to keep the entire device thin and light..

2.2 Functional Overview

2.2.1 Load Cells

In each triangle pad, there will be 10 load cells that will change resistance based on the force detected. By inputting a voltage into a resistor circuit, the output voltage can then be sent to be processed. These are the main data inputs into the processing module.

2.2.2 Processing

This is where all the data will be outputted by the MCU. The processing module will send data to the display module and the LED module. Based on the input from the load cells, the MCU will determine whether a cup has been removed from the game. Because of the amount of inputs and outputs needed to be processed, the controller will need to be fast enough to update the display and the LEDs in real time. This module will be the bridge between the two different triangle pads.

2.2.3 Display Module

There will be a display for each side of the table. It will show each team's score updated in real time. Starting from 10, the score is decreased by one when the processing module sends data that a cup is removed. First team that hits every cup will win the game and the display will go back to 10.

2.2.4 LED Module

The LED Module is mostly for aesthetic purposes, but also visibility. When every cup is present, the LEDs will shine green. As each cup is removed from play, the LEDs will turn red. This action should be as instant as possible to prevent confusion. The speed will be determined by the microcontroller.

2.2.5 Power

Each device in our design can take in a range of voltage. 5 V is within the operating range for every device which is why we will only use a single power rail. 5 V will also be enough to power red and green LEDs which have a typical voltage of 2.4 V and 3.8 V respectively.

2.3 Block Requirements

2.3.1 Load Cells

As mentioned above, the load cells will be used as resistors in a resistor bridge circuit. **Fig. 4** shows a recommended circuit to measure an output voltage. The load cells claim to have an uncertainty of 2%. This uncertainty cannot be too high as the voltage needs to change enough to produce different outputs when compared to the reference voltage.

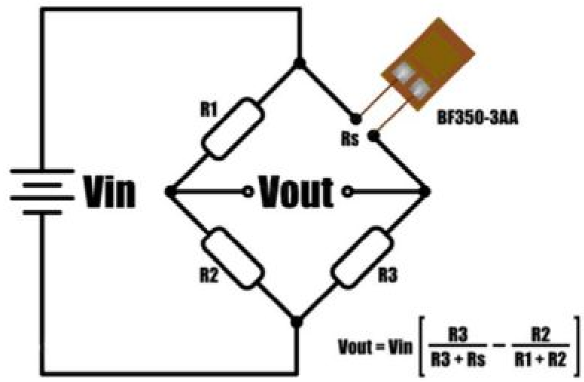

Fig. 4 Use Case for Load Cell [3]

2.3.2 Comparators

We have chosen the LM339 for the comparators. These are IC chips with 4 comparators which saves space on the PCB as we need 20 comparators in total. The needed reference voltage cannot be determined yet as we have to figure out the no load resistance of the load cells and the resistance with a load. The chosen reference voltage of the comparator has to be in the middle of the range of no load voltage and load voltage of the load cells.

2.3.3 Microcontroller

We have chosen the ATmega328P for a lower power consumption compared to the regular ATmega328. We are not sure if processing speed will be an issue, but the MCU will need to perform many instructions to have a flawless user experience.

2.3.4 Display Driver/Display

We have decided on using an LCD display for each pad due to less power consumption compared to an LED 7-segment display. An LCD display also allows more flexibility than a 7-segment display, as we can differentiate between both teams' scores on the display. The driver will allow the microcontroller to communicate with the actual display. The display will have to be waterproof as it will be used around liquids. If any liquid gets inside the display, it may destroy the functionality.

2.3.5 LED Drivers/LED Array

We will be using an array of alternating red and green LEDs. When the flag from the microcontroller shows that there is a cup present, the green LEDs will turn on. When there is not a cup, the red LEDs will turn on. The base color should be red as the load cells will not be detecting any force. The LED drivers will just consist of resistors in series with the LEDs. The resistors have to be sized for the correct voltage drop to power the LEDs. The resistors will also prevent voltage fluctuations created from the heat produced by the LEDs. Diodes in general are fragile devices and any current/voltage fluctuations can damage them. The LEDs will have to change correctly or it will be confusing to the users if the colors are not consistent.

2.3.6 Batteries

We decided on two 3.7 V lithium polymer batteries. While one 3.7 V battery is enough for most of the devices, the turn on voltage for green LEDs is a little bit higher at 3.8 V. The IC chips we have chosen all have an operating voltage range that includes 5 V. The batteries will need to produce more than 5 V continuously to the regulator. Due to being a device near liquids, the battery needs to be well protected. Any liquid that gets near the batteries can short the batteries and destroy every component in our design.

2.3.7 Voltage Regulator

A voltage regulator needs more voltage than what it is regulating to. This is why we are using two 3.7 V batteries to connect to the regulator. The regulator will keep the output power rail at 5 V and account for fluctuations automatically. If the regulator fails, it may also destroy the components of other modules. Because we have 7.4 V going into the regulator, devices with an operating voltage range smaller than 7.4 V will most likely become damaged.

2.4 Risk Analysis

The portion that poses the greatest risk to successful completion of the project will be the ability to communicate between the microcontroller and the comparators. We will need to be able to assign a voltage to the relative weight of the cup with liquid in it. Once the cup has been removed, the voltage needs to subsequently change significantly. After this, the microcontroller should detect this change and send data to update the score board. In addition, the LEDs underneath the cup that was removed should change color.

Doing all of these desired actions should be doable from a sequential approach. An issue that may arise, however, is completing all of this within a small period of time. We will most likely have to work around these synchronization issues to properly give the user a seamless experience with our product.

3 Ethics and Safety

Our project relates to a popular college drinking game. User safety is always the top priority. We will in no way encourage underage drinking or over-drinking in accordance with federal law and IEEE Code of Ethics, we "hold paramount the safety, health, and welfare of the public" [4].

Use of LEDs creates the risk of triggering seizures in those with photosensitive epilepsy. Flashing lights and patterns are particularly high risk. Flashes between 5-30Hz in particular are particularly dangerous [5]. To prevent seizures and keep users aware we will include an epilepsy warning stick on our device.

Liquids near batteries also pose a hazard. We plan on encasing the device in a sheet of acrylic. The power module will be covered on all sides with the acrylic. If we need to, we can coat the battery shell with an extra layer of waterproofing. We will also add additional precautions to ensure that cell voltages stay within safe limits ($3 V < x < 4.2 V$) [6].

References

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