BALL RETURN PUTTING MAT WITH SCOREKEEPER

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1 Introduction

1.1 Objective

Golf is a sport that requires a lot of time and practice in order to improve. However, it is a very weather dependent sport and many players are not able to practice during the winter months or during rainy days without spending a lot of money to go to indoor practice facilities or to purchase practice mats for their homes. There are some cheaper practice mats available, especially for putting, but they do not return the ball to the player or allow you to keep track of made putts.

Our goal is to build a low-cost putting mat that will allow players to practice indoors. This putting mat will include a mechanism that returns made putts to the user, allowing for more efficient practice time. It will also utilize a control circuit that will operate the return mechanism as well as keep count of all made putts by the user. This circuit will transmit a signal to a hex display via bluetooth every time a putt is made. This hex display will keep track of the number of putts made, as well as include a timer for competitive purposes.

1.2 Background

In sports, there are a lot of advancements being made with analytics and statistics to help players to track progress and continue to improve. Our device would allow a user to practice and track progress in the number of putts made over a given time span or to practice through competition. Our putting mat would allow users to do just that, as there is no putting mat available on the market that will track the number of putts made and return the ball to the user.

1.3 High Level Requirements

- The scoreboard will increment when a ball has entered the hole. It will keep score up to 99 made putts and can be reset to 0 when a pushbutton is pressed.
- The scoreboard will take an input from a pushbutton allowing the time to be set, up to 9 minutes. The timer will count down and keep an accurate time, within 5%, for each game.
- The return mechanism will hold the ball for no more than 10 seconds and be released and returned to the player.
- The infrared transmitter and receiver will output the speed of the ball to a laptop or computer that will record that data.

2 Design

Living in the midwest, it is hard to practice or compete in golf during the winter. One of the most important parts of a player's game is putting so the ability to practice indoors during the winter is important in improving one's game. On the market there are lots of indoor putting mats including some that will return the ball to you, however there isn't a mat that keeps score and allows to compete against a friend.

2.1 Block Diagram

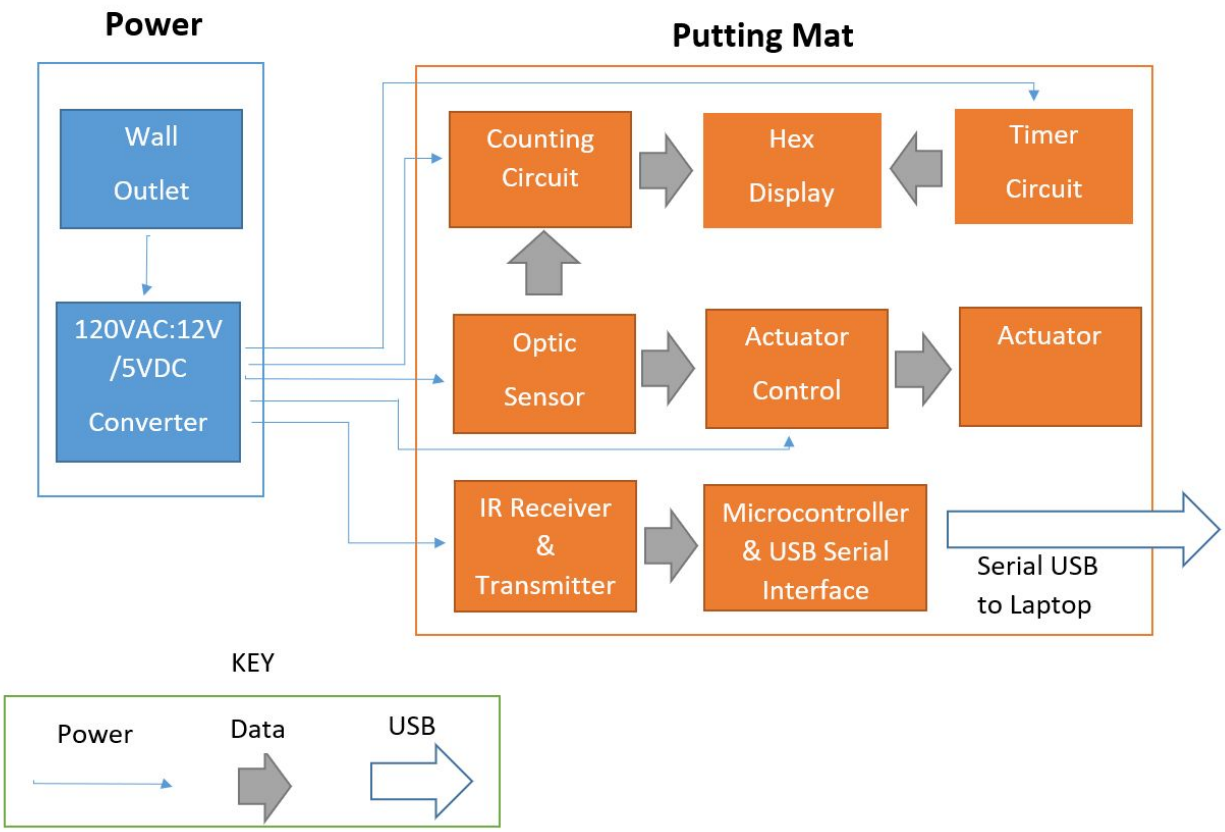

Figure 1: Block Diagram

2.2 Physical Design

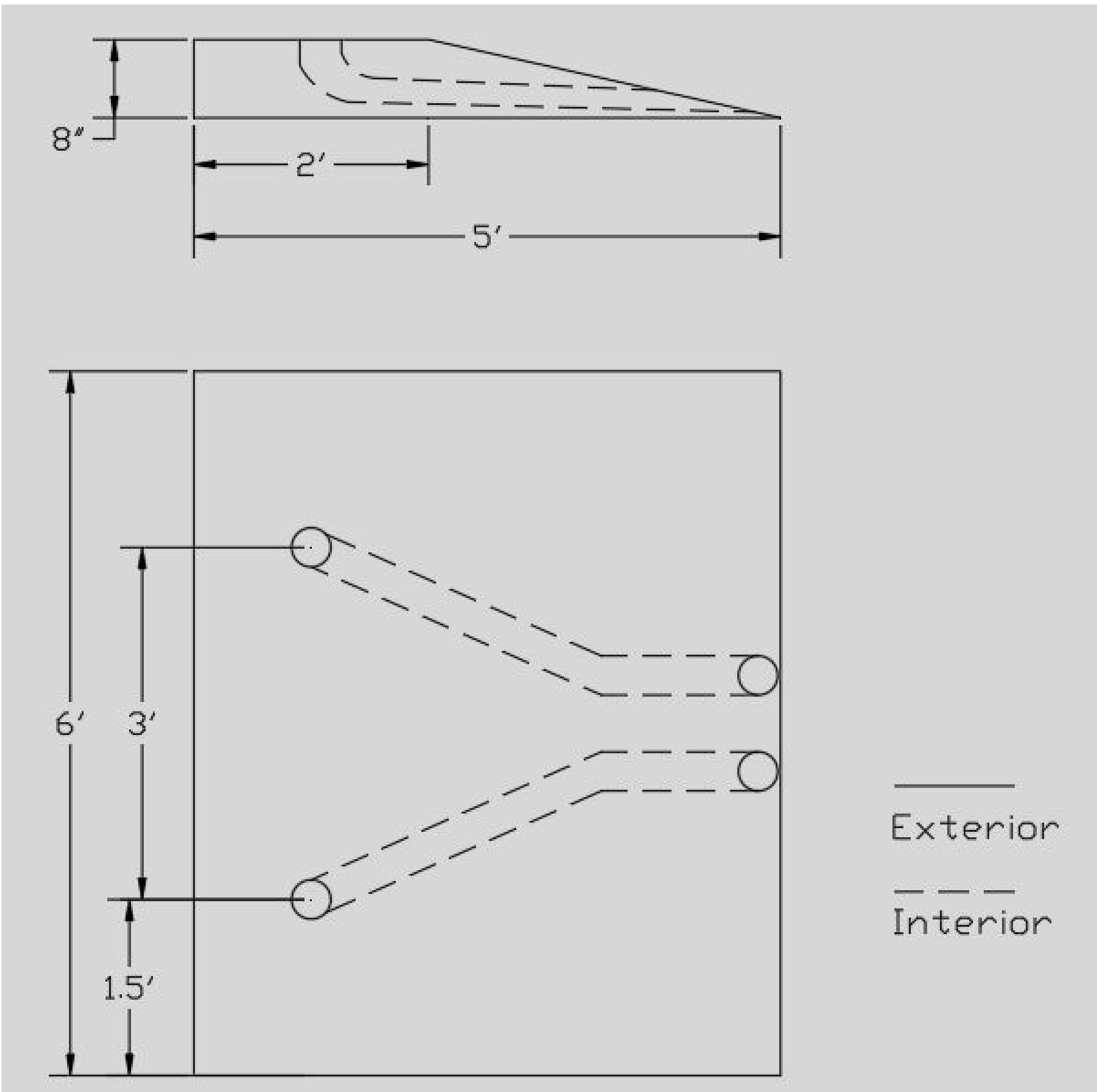

Figure 2: Physical Design Diagram

2.3.1 Power Supply

The Putting Mat will be powered by a wall plug and this will converted to 12VDC and voltage regulators will be used to get the correct voltage.

1 AC/DC Converter

The 120V AC will need to be converted to 12V DC and 5V DC to be used to power our counting circuit, microcontroller, actuator control circuit and actuator.

Requirement	Verification
1. A transformer and bridge circuit will be used to get an output of 12V DC ±3V. 2. Voltage regulator (MC78L12) will be used to output 5V DC ±5%. 3. Voltage regulator (LM78L05) will be used to output 12VDC ±5%.	1. To test the transformer and bridge converter, use an oscilloscope to measure the output waveform. 2. Use an oscilloscope to measure the output of the regulator. 3. Use an oscilloscope to measure the output of the regulator.

2.3.2 Putting Mat

We will use the space underneath the mat to house our circuitry that will allow a made to be counted and transmitted and then return the ball to the user.

1 Optic Sensor

This will sit inside the edge of the hole, when the ball is detected it will output a logical high that go to the solenoid control circuit and the counting circuit. We will use an infrared optical sensor.

Requirement	Verification
1. When there is no ball in the hole, the sensor output voltage is in a range of 0V to 0.5V. 2. When there is a ball in the hole, the sensor output is a voltage in	1. Place the sensor inside the hole and check the output voltage with multimeter. 2. With the sensor inside, place a ball in the hole and check the output

the range of 4V to 5.5V.	voltage of sensor using a multimeter. If the voltage is out of range, adjust the placement of the sensor.

2 Counting Circuit

Counter will be implemented on an ATmega328p microcontroller. One microcontroller per hole, this will increment a count each time the ball enters the respective hole. (3)

Requirement	Verification
1. Counting circuit will increment the current count by one each time the sensor produces a high output. 2. Counting circuit will have the ability to count within a range of 0-99. 3. Counting will circuit will halt counting when it receives the halt signal. 4. Count will reset to zero when reset signal is received.	1. Verify high output by connecting LED to sensor and seeing if it lights up. 2. Connect counter to 2 hex displays and check that it increments and resets at 99. 3. Send a halt input to the microcontroller and test that circuit will not increment when sensor is high. 4. Increment count to a number greater than zero and send a high reset signal to the processor, the count will reset to zero.

3 Actuator Control

This circuit will be design to have the solenoid extended to block the ball from initially returning. Once the sensor has seen the ball, it will cause the solenoid to retract and drop the ball allowing it to return. A fet (MTP3055EL) will bes used as a switch, when sensor is high, detecting ball, solenoid will power up.

Requirement	Verification
1. When sensor is high, 4-5.5V, the	1. Set gate side to 5V and measure

solenoid circuit will allow the current to pass through the actuator. When high the source and drain resistance need to be less than one ohm. 2. The actuator will be driven within 10 seconds of the ball entering the cup.	resistance across the drain and source of the fet. 2. Test the ball triggering the sensor and measure the time it takes for the ball to be dropped.

5 Actuator

The actuator will need to extend to cover the 4” hole to prevent the ball from passing. This will be powered on a 12V supply.

Requirement	Verification
1. When current is passed through the actuator, the actuator arm will draw back and allow the ball to pass.	1. Put 12V on the actuator with a pull down resistor, the actuator arm will draw back.

6 Timer Circuit

This circuit will count down from a time that is set by the user, the time can be set using a push button and another pushbutton to start the timer. A microcontroller will be used to set the initial time to four IC4026 ic’s that will be used to do the actual counting. This count will be displayed on a seperate hex display.

Requirement	Verification
1. Starting timer will increment by 1 minute when increment pushbutton is pressed. Max starting time will be 9 minutes. 2. Timer will count down time accurately, within ±5% 3. Circuit will output a halt signal when the timer is done counting.	1. Press pushbutton to test that time will increase by 1 minute on 7 segment displays. 2. Begin timer and track how long the timer takes compared to a digital timer. 3. When timer is complete, test that halt pin will output 5V signal.

7 Seven Segment Display

This will consist of seven hex displays and will require seven hex drivers. Four of these will be used to display the score of the users, two per user. The other three will be used to display the time of the counter.

Requirement	Verification
1. Circuit will receive an 8-bit string for each score, decoders will convert this string and display values on 7 segment displays. 2. Will receive a 12-bit string for the current time of the timer, which will be displayed to three 7-segment displays.	1. Hook decoders up to switches and test that the corresponding values are displayed. 2. Hook decoders up to switches and test that the corresponding values are displayed.

8 Infrared Transmitter and Receiver

An infrared transmitter (LTE-302) and receiver (LTR-301) will be mounted to view the ball as it rolls on the incline. These will measure the distance to the ball from the sensor. The receiver will detect the infrared light that is reflected from the ball. Based on the distance to the ball, the receiver will give a of range of outputs. (4)

Requirement	Verification
1. The receiver will detect the reflected light from a golf ball. 2. The receiver output voltage will change when the distance between the ball and receiver is changed.	1. Point emitter and receiver at a golf ball with the ball a 2-5 feet away. Use multimeter to verify the receiver is outputting a voltage greater than no ball in view. 2. Point emitter and receiver at a golf ball as it's rolled toward and away from the receiver. Use multimeter to check the voltage will change as distance is changed.

9 USB Serial Interface for Speed measurement

The output from the infrared receiver will be sent to an ATmega328p. The ATmega328p will collect the data from a series of measurements of the distance to the ball over time. It will then integrate this data to develop an average velocity during the detection period. The ATmega328p will be connected to USB serial chip (CP2102) that will allow the data to be collected on a laptop/computer.

Requirement	Verification
1. ATmega328 will receive the input from each IR receiver as an analog input and will collect data and produce an average velocity.	1. The microcontroller will output a string to the serial chip.
2. The USB serial chip will output the data of the speed in a compatible USB format for a laptop.	2. Connect a laptop to the serial chip and verify receiving the speed of the ball.

2.3.4 Supporting Documents

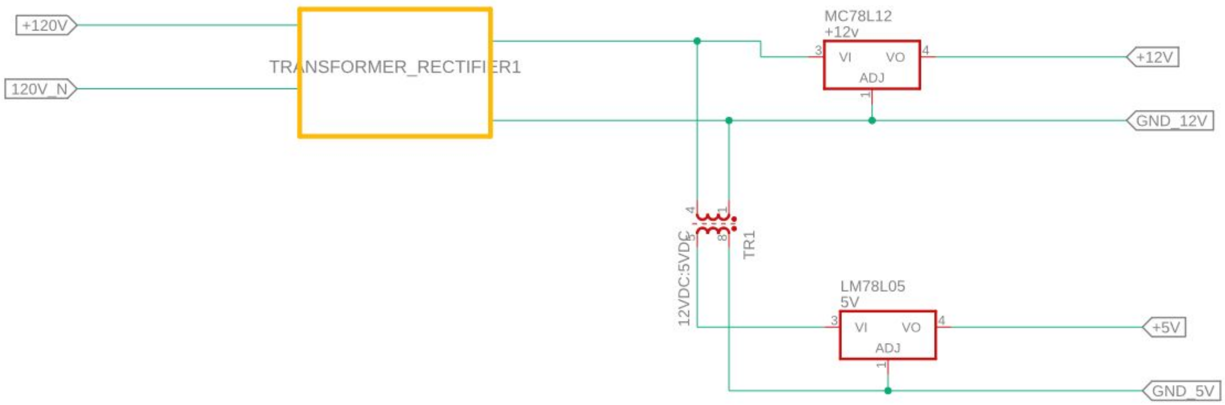

Figure 3: Power Circuit.

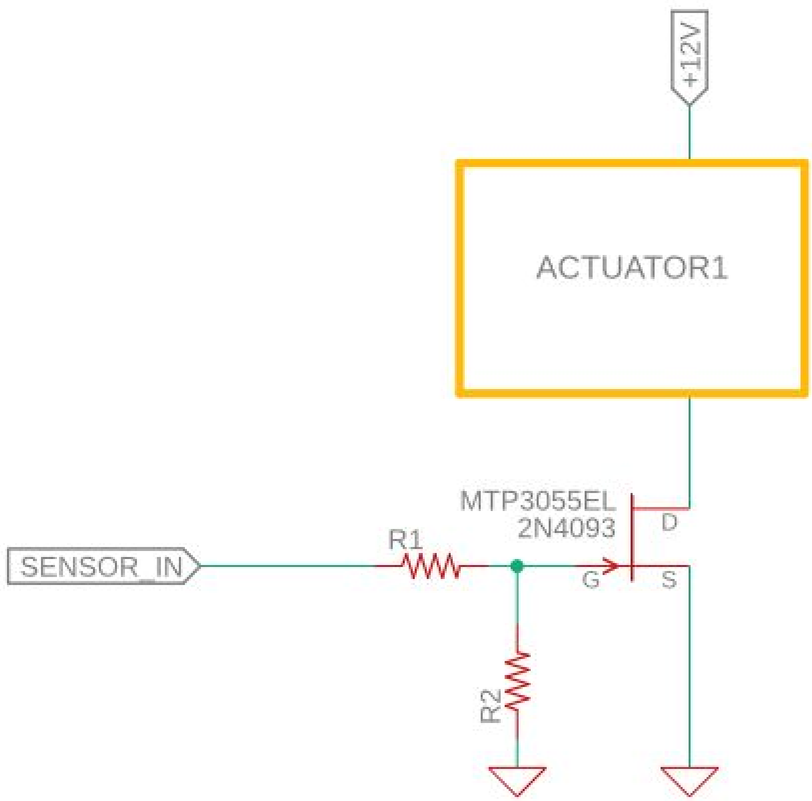

Figure 4: Actuator Circuit.

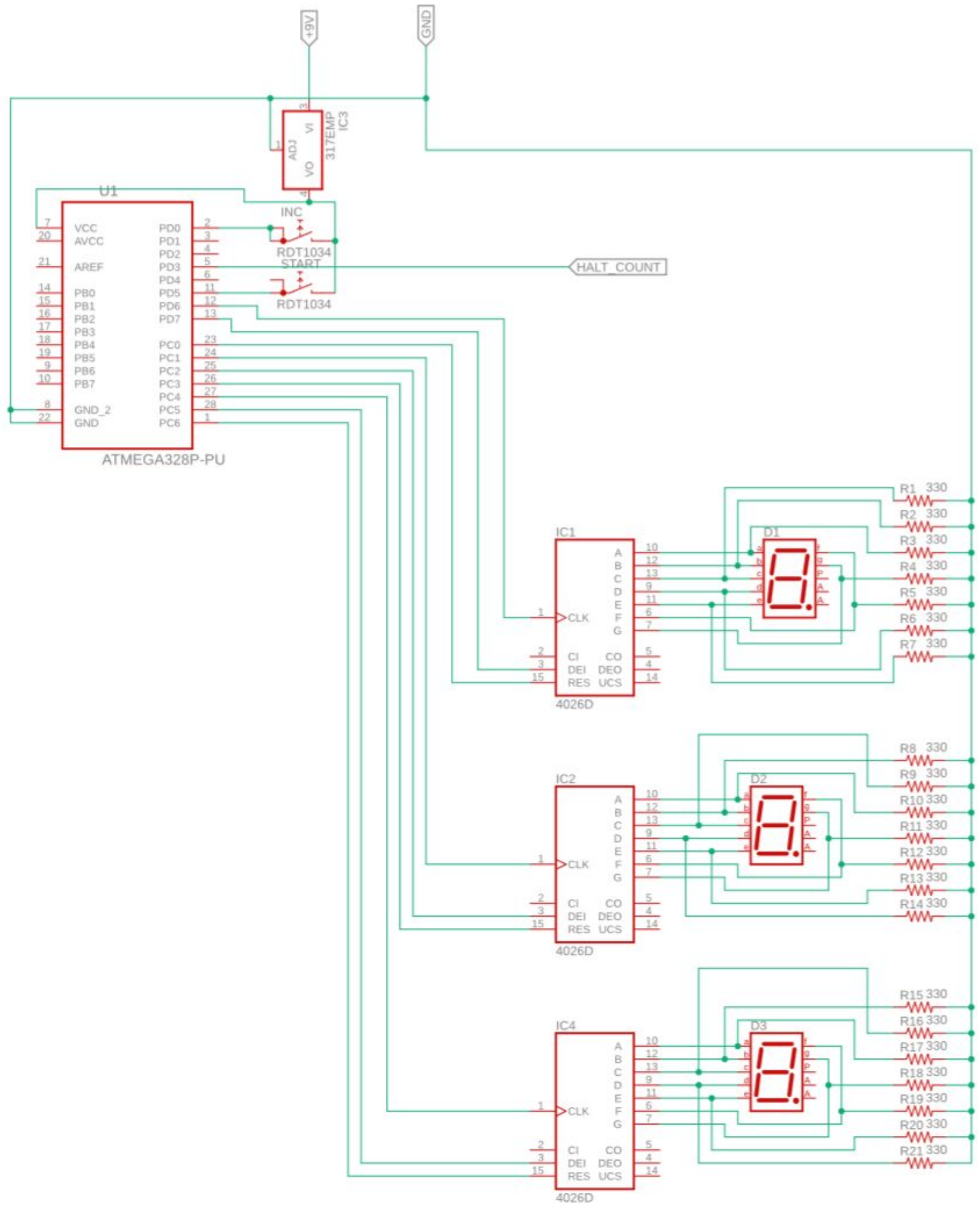

Figure 5: Timer circuit

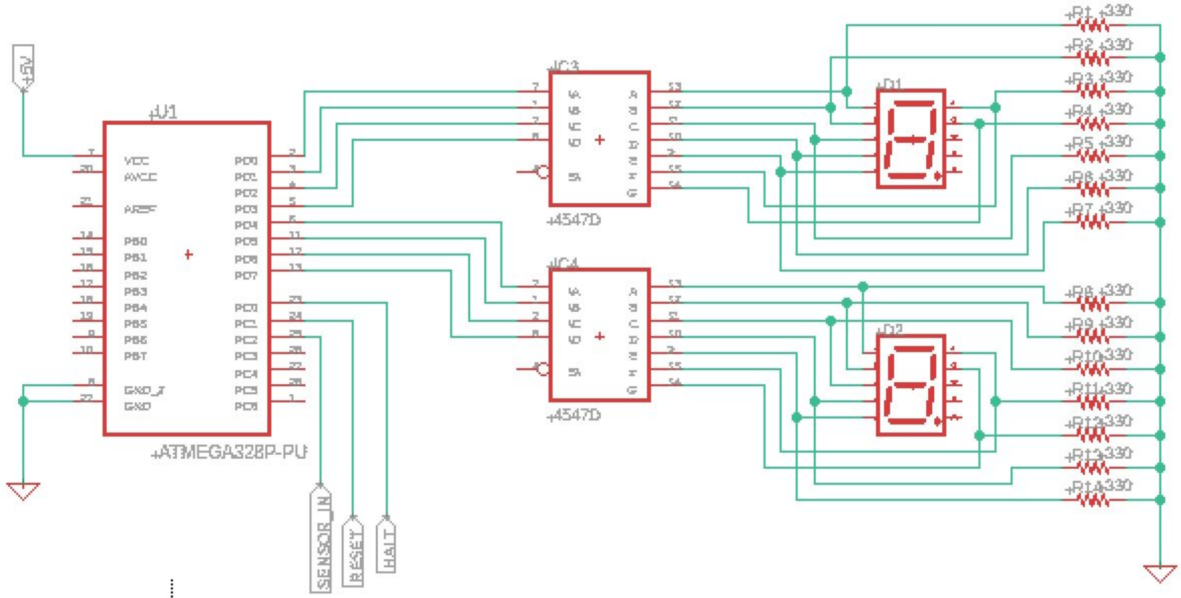

Figure 6: Counting Circuit, One for each hole

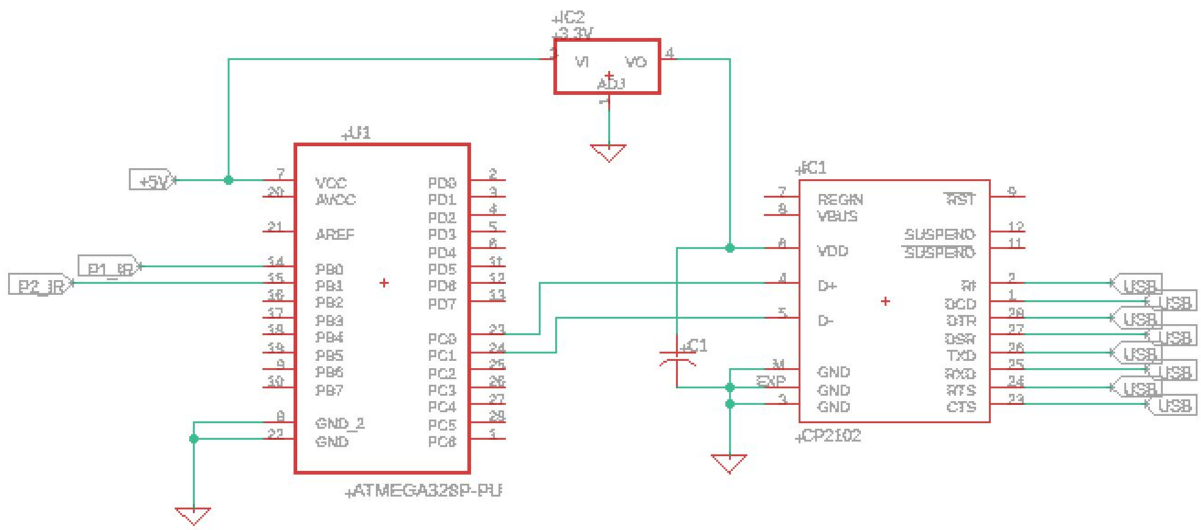

Figure 7: Microcontroller and USB Serial Interface

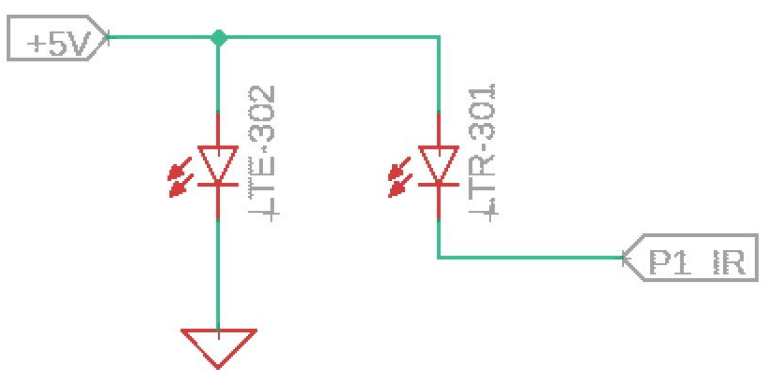

Figure 8: Infrared receiver and transmitter

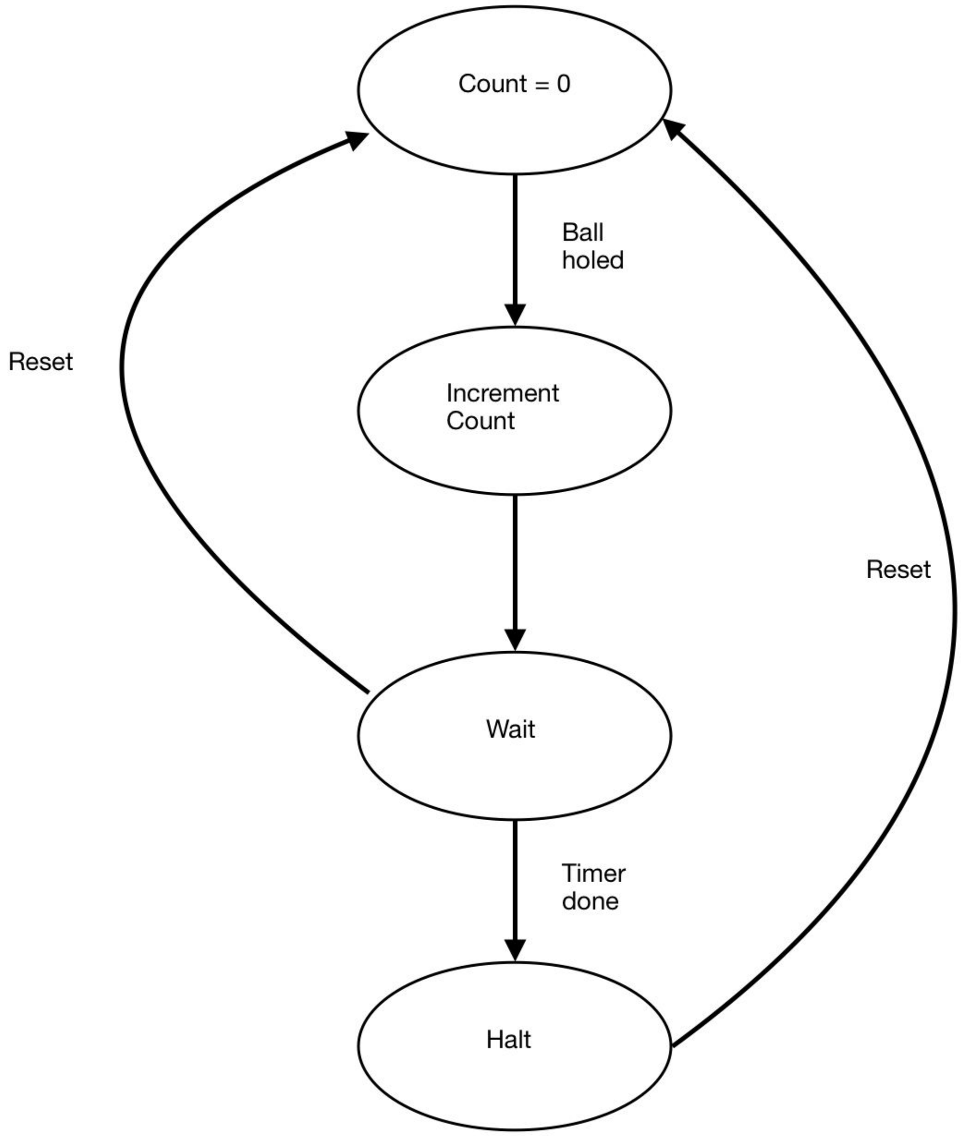

Figure 8: Counter State Diagram

2.4 Tolerance Analysis

We chose to do a tolerance analysis on the 5V Voltage regulator. This is one of the most important aspects of our design because it is used to power the microcontrollers and sensors that are implemented in the design. If the voltage regulator cannot deliver enough power, then none of the sensors or microcontrollers will function correctly.

First, we can use the datasheets of the various parts to determine their operating voltages. The Atmega328p microcontroller requires 2.7-5.5 V. The IRA-S210 optical sensor requires 4-5.5 V. The transmitter (LTE-302) and receiver (LTR-301) each require 0-5 V. From this we determine that each of these components need 4-5V from the regulator in order to function. From there we can find the tolerance:

$$\text{Tolerance} = \frac{5-4}{4.5} * 100\% = 22\%$$

Our system has a calculated tolerance of 4.5 ± 11%. From the voltage regulator data sheet, we find that the regulator has a tolerance of 5 ± 4%. Therefore the voltage regulator will not impact the functionality of our design.

3 Cost and Schedule

3.1 Cost Analysis

In order to determine our fixed labor costs, we assumed that we would be making the average EE salary found on the ECE website[1]. We also assumed that the average salary based worker works 40 hours a week for 50 weeks out of the year. We also figured we would be working for 16 weeks and around 10 hours a week. For the two of us this comes out to be:

$$\frac{\$71,000}{year} * \frac{1\ year}{50\ weeks} * \frac{1\ week}{40\ hours} * \frac{10\ hours}{week} * 16\text{ weeks} * 2 * 2.5 = \$28,400$$

We also have to factor in manufacturing costs from the machine shop. We were given a quote of $55/hr for labor. They predicted a total job time of 8 hours. This comes out to $440 in manufacturing costs.

Below is a list of the costs for the parts needed to build our design:

Item	Unit Price	Quantity	Total Price
Artificial surface	$2.59 / sqft	19	$49.21
10’ PVC	$18.29	1	$18.29
90 degree PVC	$8.99	2	$17.98
45 degree PVC	$8.30	2	$16.60
.5 x 4 x 8 Plywood	$15.95	2	$31.90

2 x 4, 8ft	$5.00	2	$10.00
ATmega328p	$1.22	5	$6.10
IRA-S210 Sensor	$3.12	1	$3.12
Actuator	$14.95	1	$14.95
PCB	$5.00	5	$25.00
7-segment Display	$.94	7	$6.58
Assorted resistors, capacitors, ICs, push buttons	$10.00	N/A	$10.00
DC-DC Converter (12V - 5V)	$7.00	1	$7.00
AC-DC Converter (120V - 12V, 5A max)	$24.95	1	$24.95
Total Sum:			**$241.68**

Our total manufacturing and labor costs come out to be $29,081.70. In the future, some of these costs could be lowered if there was ever a decision to mass produce.

3.2 Schedule

Week	Ben	Chris
2/18/19	Design document	Design document
2/25/19	Start programming microcontrollers	Start PCB design for counter circuit
3/4/19	Continue programming, start PCB design for timer circuit	Continue PCB design for counter, start PCB design for hex display circuit
3/11/19	Finish programming and timer PCB	Finish counter and hex PCB design
Spring Break	Progress assignment	Progress assignment

3/25/19	Connect microcontrollers to each circuit and begin testing data transmission	Start actuator and sensor design
4/1/19	Finish microcontroller connections	Finish actuator and sensor design
4/8/19	Begin connecting parts to exterior design	Begin connecting parts to exterior design
4/15/19	Finish exterior and begin testing	Finish exterior and begin testing
4/22/19	Prepare for presentation	Prepare for presentation
4/29/19	Final report	Final Report

4 Ethics and Safety

In accordance with the IEEE Code of Ethics, #1, we are responsible for making sure our project is safe for the public to use and that we disclose any potential factors that might endanger the public [2]. The main concern for safety in our project is the ball return mechanism. We do not want to design this in such a way that the user can be harmed by the ball while it is being returned. Our design addresses this concern by returning the ball under the putting surface and at a slow speed.

The main safety concern is our 120V AC/DC converter. At the moment, we are unsure how much power this will need to pull which means there could be dangers in overheating of parts in this converter. Heat syncs can be used as well as housing the converter outside of the mat. There is also a potential hazard in using this much voltage.

5 Citations

[1]E. I. T. S. Services, “Rankings and Statistics,” *Fields of Specialization :: ECE ILLINOIS*. [Online]. Available: https://ece.illinois.edu/about/rankings-and-statistics.asp. [Accessed: 22-Feb-2019].

[2] IEEE.org, "IEEE - IEEE Code of Ethics", 2019. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 7- Feb- 2019].

[3] Countdown Timer Circuit Diagram with 7 Segment Display. (2018, December 15). Retrieved from https://electronics-project-hub.com/countdown-timer-circuit-diagram-with-7-segment-display/

[4]Kosnkov. (n.d.). How to measure speed of a ball. Retrieved from https://electronics.stackexchange.com/questions/196761/how-to-measure-speed-of-a-ball