<u>Cornhole/Bags Electronic Scoring System</u>

Design Review

Team #11

Travis DeMint and Kabir Singh

TA: Ryan May

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University of Illinois
Department of Electrical and Computer Engineering
ECE 445

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I. Introduction

Cornhole, or bags, was originally adopted from the Blackhawk Native American tribe who "filled pigs' bladders with dried beans and competitively tossed them for entertainment" [2]. They would throw these pigs' bladders at various objects and mentally remember which player was able to hit the furthest target [2]. As the game progressed into its current form, its primitive method of scoring did not change. We propose to update this traditional game into modern times by being able to electronically keep track of both teams' scores. The user will toss their respective teams' bag on the game board, depending on where it lands; the system will tabulate a correct score for each team. Three points will be awarded for each bag detected through the hole and one point will be awarded for each bag found on the game board surface. The score will be updated as each round is completed on a respective board. A number display will showcase each team's score.

Objectives

The main goal we are trying to address with the completion of this project is for two teams, consisting of two players each, to be able to successfully play the game of bags without having to keep their own scores. As a player from each team faces off, the game board will continuously check for a team's bag, either on the board (1 point) or through the hole (3 points). If it is able to detect one of these two cases the microcontroller will output the updated score for each team during the end of a round.

Benefits:

- Teams don't have to remember their scores from each round
- Aesthetically pleasing score display
- Compact design does not alter traditional rules of play
- Game board weight should not significantly change with added electronic components, allowing for ease of mobility between site to site

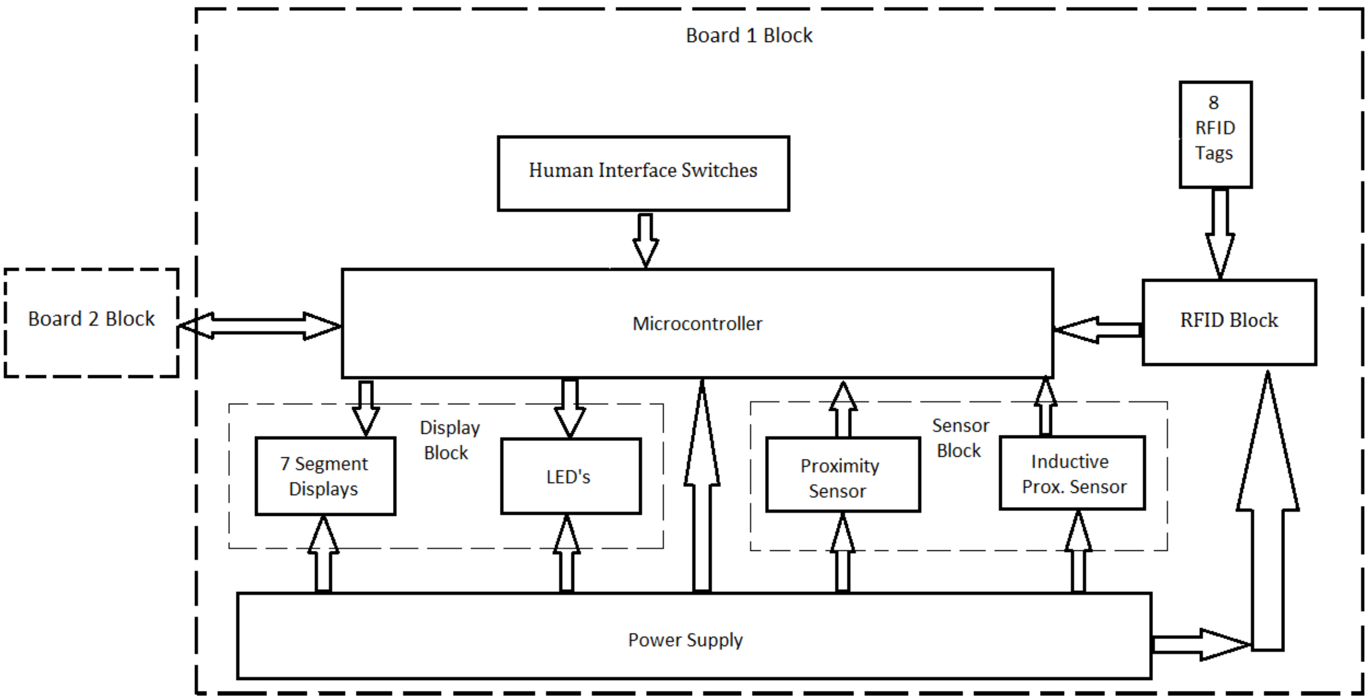
Features:

- Electronic scoring
- Capacitive Sensor to detect Team 1's bags through the center hole
- Inductive Sensor to detect Team 2's bags through the center hole
- LED's light up indicating bag going through center hole
- Scores update after each side has thrown their respective set of bags
- Communication between both boards to output correct score
- 4 distinct RFID Tags assigned to each team to differentiate when scoring
- Switch for users to store previous round score and start the next round

II. Design

Block Diagram

The design of this project includes two block diagrams that are duplicates of each other. Since the game consists of two playing boards, each board will have the same block diagram connected to the microcontroller of game board 1. This will allow the two boards to communicate with each other in order to calculate the correct total score before it is displayed.



Block Descriptions

RFID Tags - One of the eight RFID tags will be placed in each bag. This will give each bag a unique serial code that will be transmitted at 13.5 MHz to the antenna and RFID reader. The RFID tags are passive and will receive their power from the signal sent from the RFID reader through the 13.5 MHz antenna.

RFID Block – This block consists of a 13.56 MHz antenna connected to a RFID reader which deciphers each tags' serial number and relays this information to the microcontroller. Four distinct serial numbers will be associated with each team in order for the microcontroller to differentiate the point totals. The RFID block will be powered through the 12V power supply.

Microcontroller - The microcontroller we are choosing to use is the Arduino Mega 2560. This will receive input signals from the RFID reader, capacitive sensor, inductive sensor, and the human interface switches. It will then use these signals to compute the proper score at the end of a round. The completion of a round will allow a new user to trigger the human interface in order to start the next round. The microcontroller will then send signals to the 7 segment displays when the score is to be updated. This update will occur at the end of every round until completion of a game. The microcontroller will also light the LED's indicating a bag has been detected going through the center hole on the game board. The Arduino board will be powered through the main 12V power supply.

Human Interface Switches - The human interface switches are physical switches that the user will hit when they reach the end of a round or the end of the game. There will be two toggle switches, one to turn the game on or off and the other to put the board in game play or score mode. The game play mode is selected when the user begins a new round and remains in this position until all bags have been thrown. When the user finishes a round (all bags have been tossed), they will flip the toggle switch to the score mode in order for the microcontroller to calculate the current rounds' score and update the displays. A third push button will be placed on the board for the user to reset the scores to zeros when a new game is to be started.

7 Segment Displays - The 7 segment displays will receive the scoring signal from the microcontroller and will display the current scores for each team to view.

LED's - The LED's will receive a signal from the microcontroller when a bag passes through the center hole and triggers the proximity sensors. When they receive this signal they will light up signaling a 3 point shot.

Capacitive Sensor - The capacitive sensor will be placed inside the board to detect bags that went through the center hole for Team 1. This sensor will be strategically placed over a chute designed to catch all bags passing through the center hole. The strategic placement of the sensor is to compensate for its limited range of 25 mm. When it senses a make, it will send a signal to the microcontroller in order to update the score calculation and light up the LED's placed around the hole.

Inductive Sensor - The inductive proximity sensor will sense the metallic BB's placed in one team's set of bags. This sensor will be placed alongside the capacitive sensor over the chute to detect bags passing through the hole for Team 2. Again the strategic placement of this sensor over the chute is to compensate for its limited range of 15 mm. If a bag is detected a signal will be sent to the microcontroller to update the score and light up the LED's.

Power Supply- A 12 Volt battery power supply will provide the power for all elements in the block diagram. If the RFID block requires 24 Volts, two 12 Volt batteries will be used to power the RFID system.

Board 2 Block- The board 2 block is identical to the board 1 block in theory and is designated for the second game board. The two boards will be connected together using a wired connection from game board 2 directly to the Arduino microcontroller on game board 1. This connection will allow us to demonstrate the ability of our design to communicate between the two game boards to determine a correct score. Instead of using the same equipment twice we will simulate game play on board 2 using two toggle switches. Toggle switch 1 will simulate Team 1's score. Flipping up will simulate a three point shot and flipping down will simulate a one-point shot. Toggle switch 2 will simulate Team 2's score, following the same flipping pattern as switch 1 mentioned above. Once the total scores are calculated, the scores will be displayed on the 7 segment displays located on each board.

Schematics

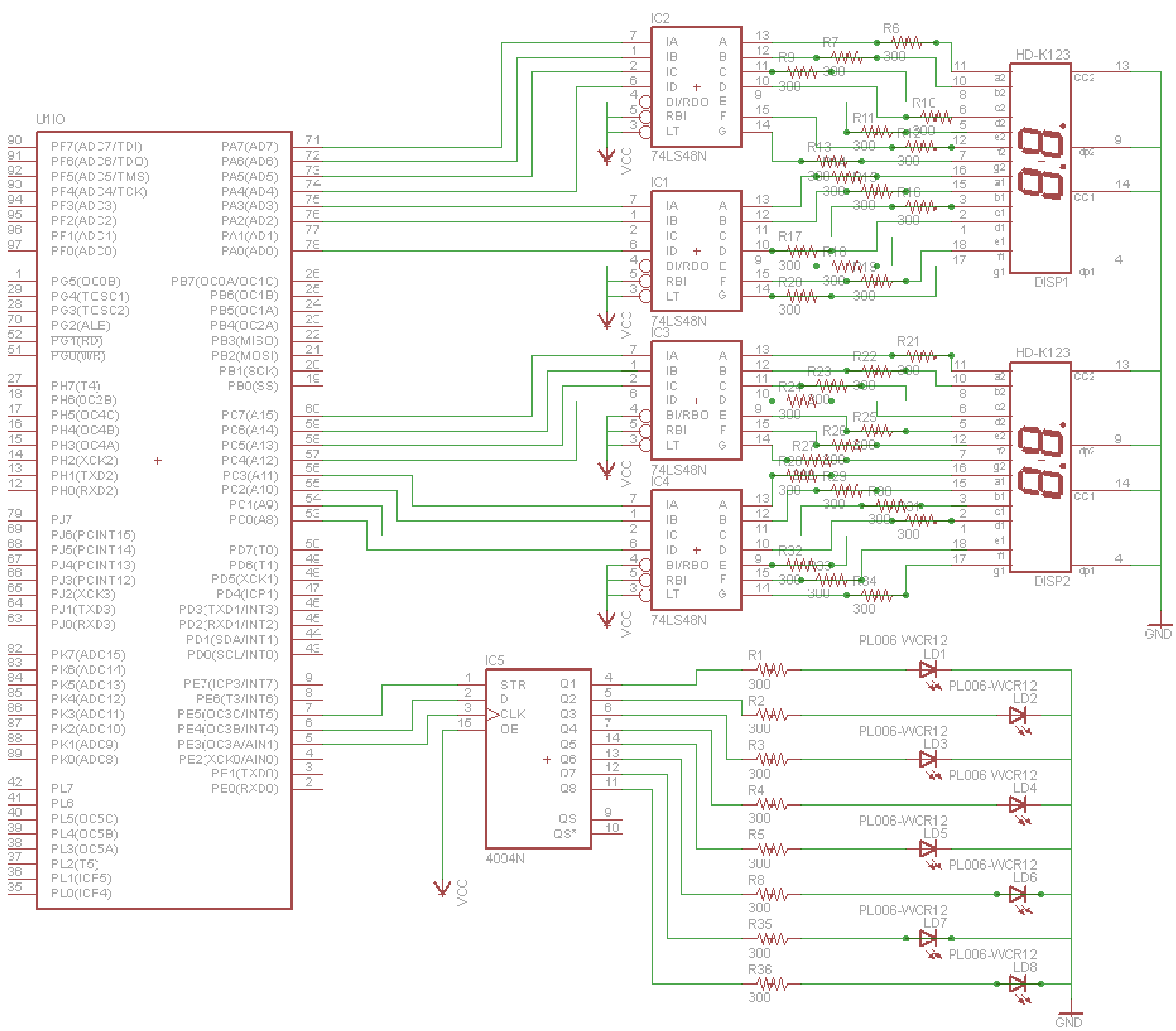


Figure 2. 7 Segment Display and LED lights schematic

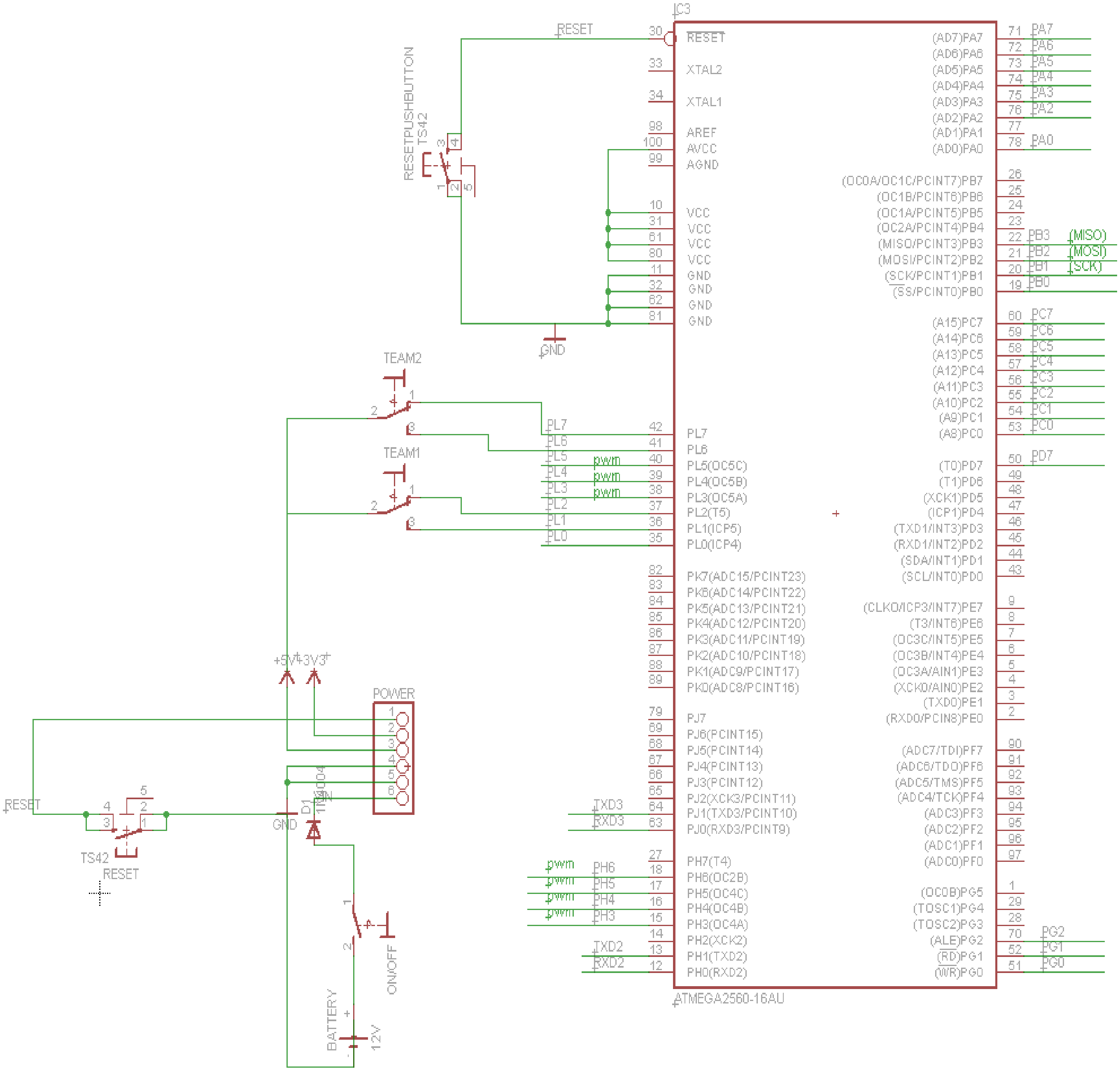


Figure 3. Human Interface and Power switches

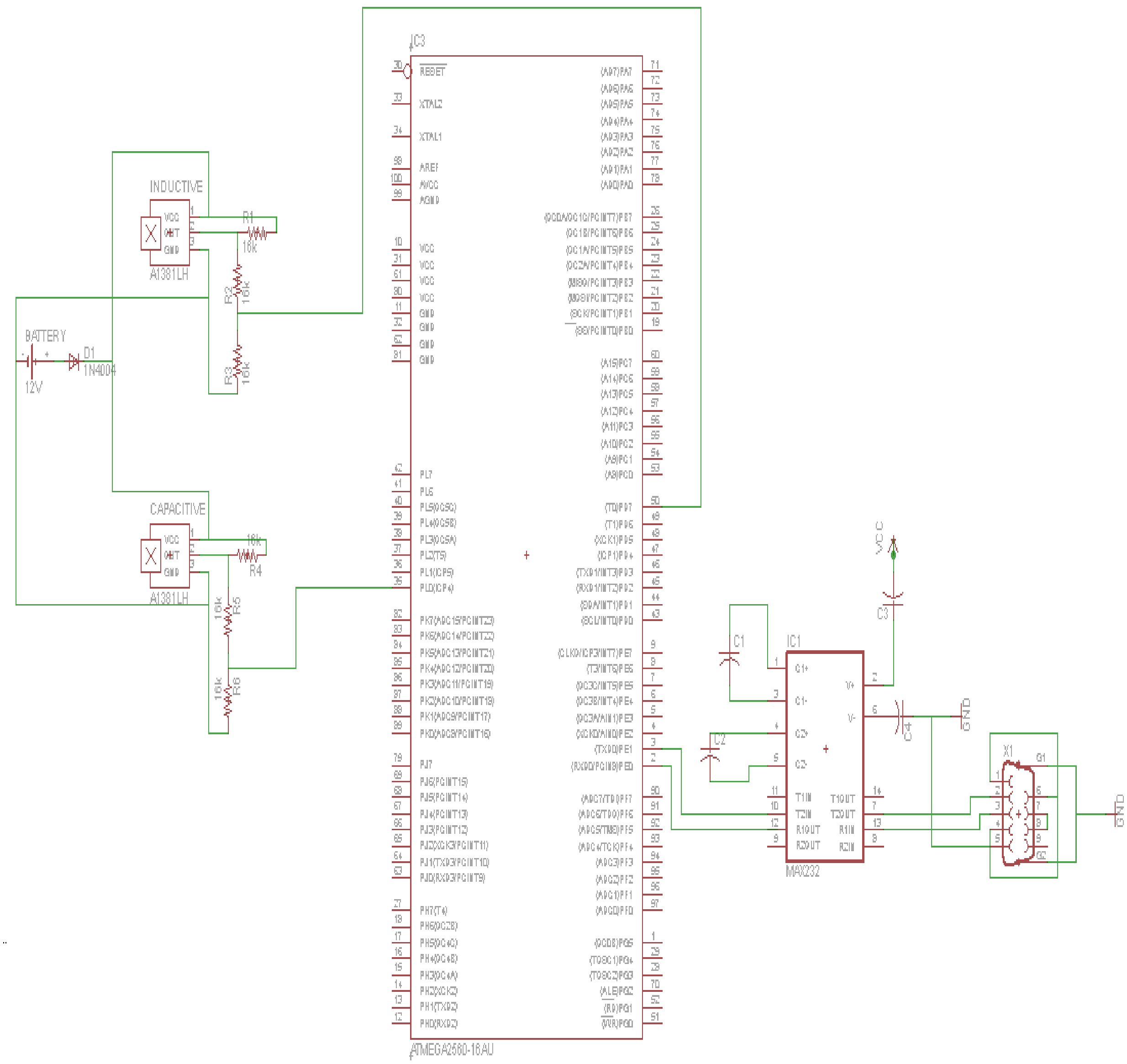
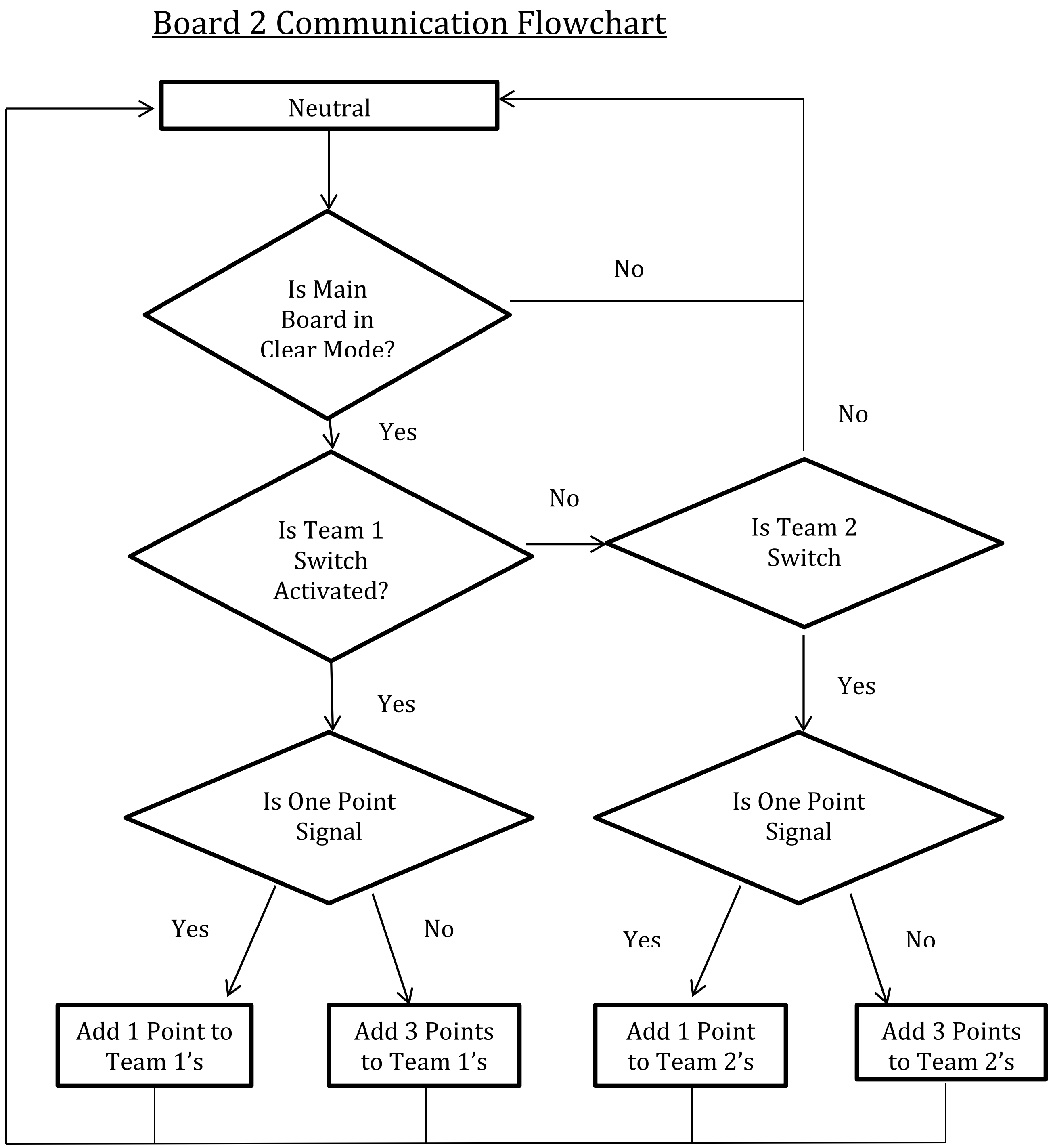


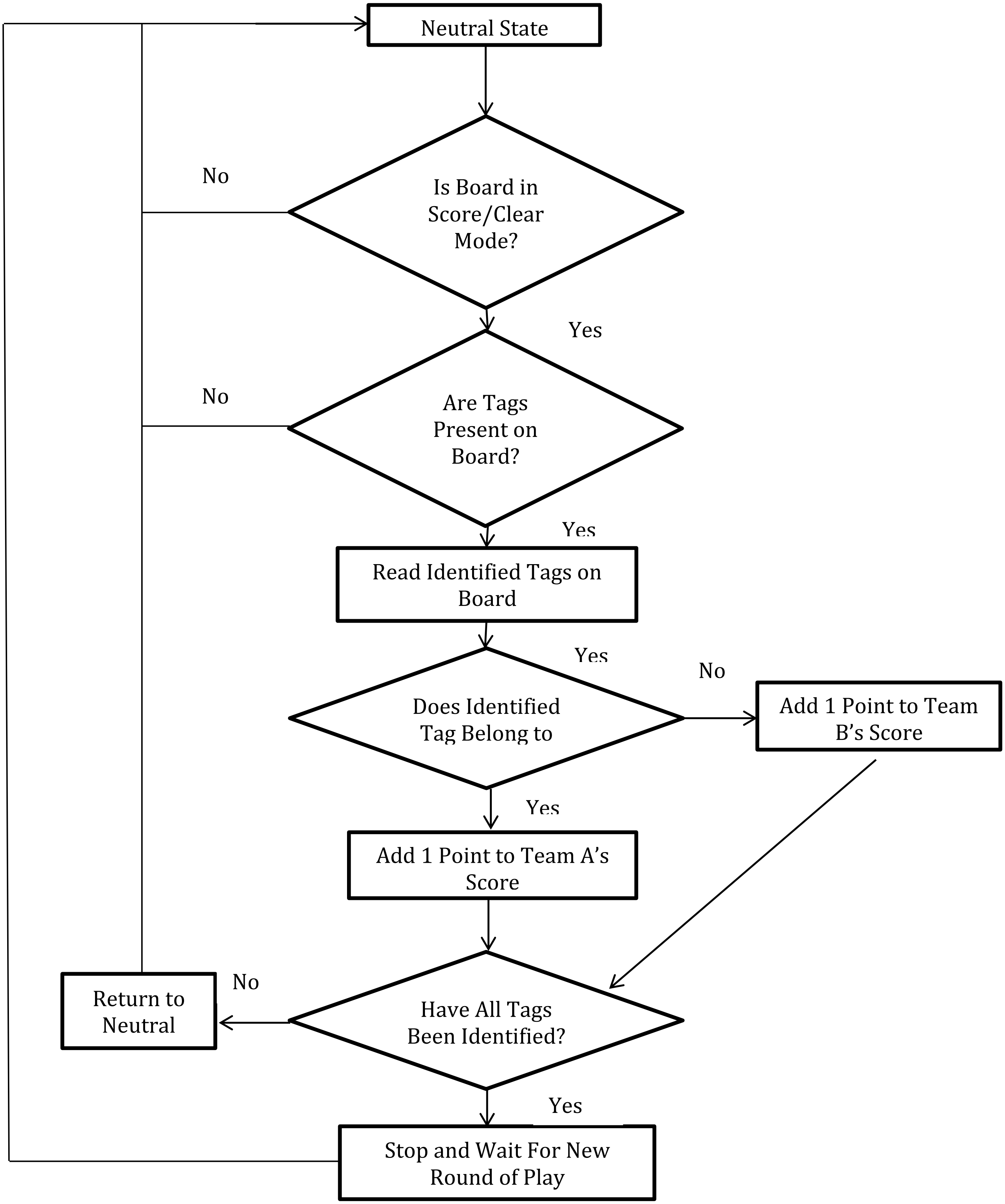
Figure 4. Capacitive, Inductive and RFID block schematic

Flow Charts

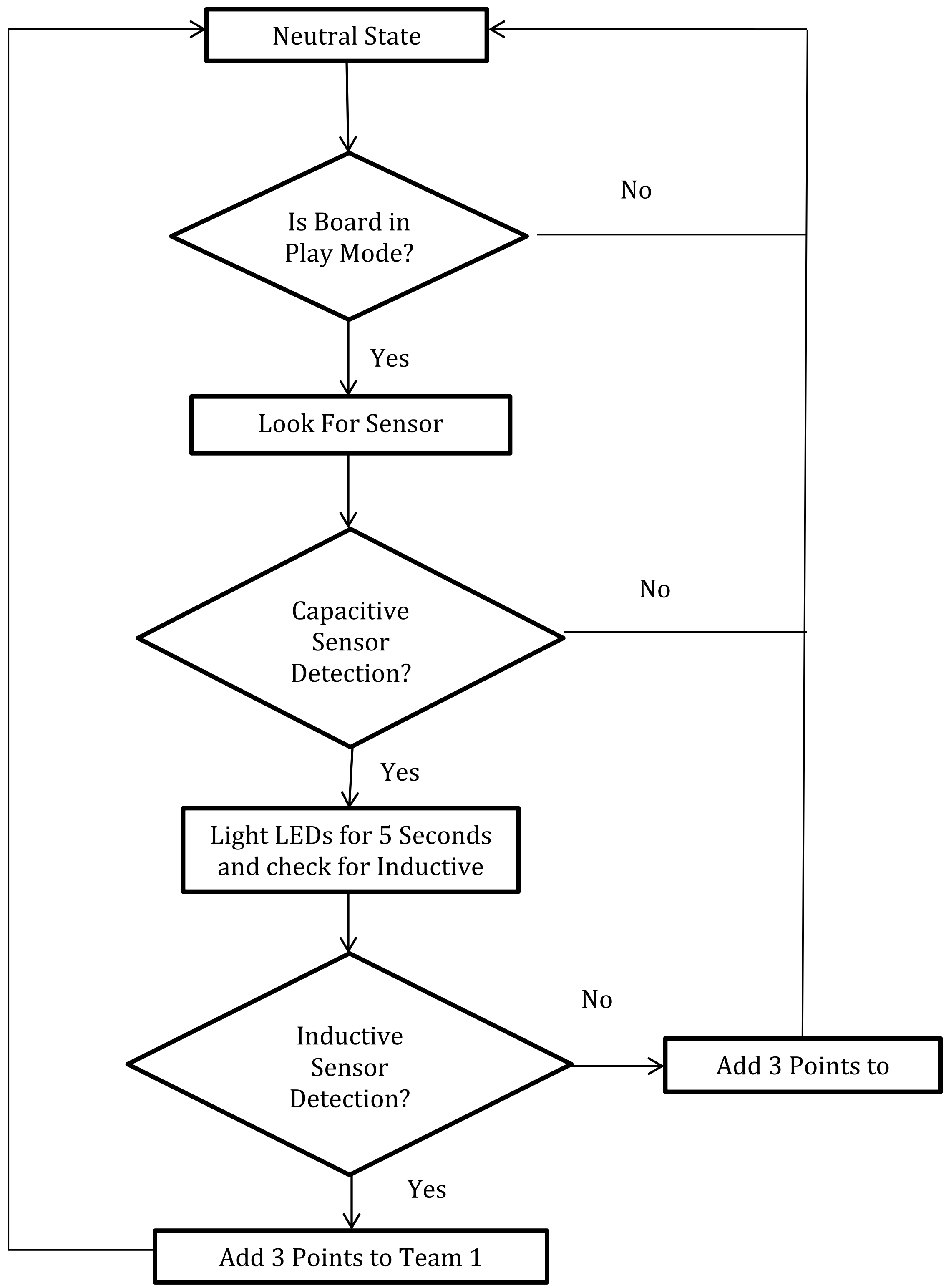


Board 2 Communication Flowchart
Neutral
Is Main Board in Clear Mode?
No
Yes
No
Is Team 1 Switch Activated?
No
Is Team 2 Switch
Yes
Yes
Is One Point Signal
Is One Point Signal
Yes
No
Yes
No
Add 1 Point to Team 1's
Add 3 Points to Team 1's
Add 1 Point to Team 2's
Add 3 Points to Team 2's

RFID Scoring System Flowchart



Sensor System Scoring Flowchart



Simulations

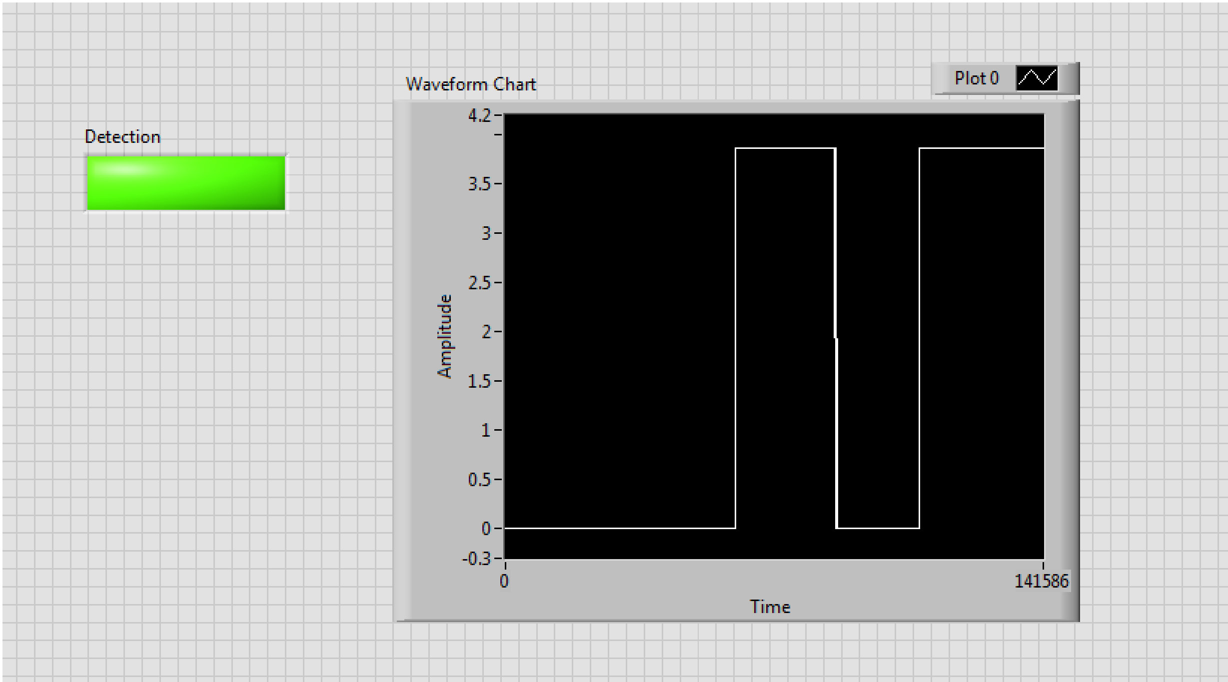


Figure 5. Capacitive and Inductive Sensor Detection LABVIEW

The simulation above was performed in LABVIEW to demonstrate the performance of both the inductive and capacitive sensors used in this design. When a capacitive sensor detects a bag filled with capacitive material it will output a HIGH signal approximately equivalent to 3.87 V. When an inductive sensor detects a bag filled with ferrous material it will output a HIGH signal approximately equivalent to 3.31 V. These signals will then be interpreted by the microcontroller to determine the correct score.

Calculations

This design relies heavily on digital inputs being fed into the Arduino microcontroller. Most of the required conversions are carried out by the Arduino board itself. After all the processing has taken place with the programmed microcontroller, it will attempt to display its results to the user. The first display will be the LED's display. In order to calculate the resistor values needed to run the LED's we used the following formula:

$$R = \frac{(V_s - V_f)}{I} = \frac{(5v - 2v)}{10mA} = 300\Omega$$

Here V_s is the input voltage and V_f is the voltage across the diode. The LED's we are using run at 10 mA. This resistor value can be shown in our schematics above.

The second display we have to output is the 7 segment display. The current needed to drive the display needs to be 10 mA with an input voltage of 5 volts and the voltage across the diode set to 2 volts. In order to find the resistance needed, we use the same equation as above, resulting in the same resistor values of 300Ω when connecting the 7 segment display to our design.

Our final calculation requires us to compute the output voltages corresponding to each sensor in order to determine it's on voltage. The following circuit was used to determine these values:

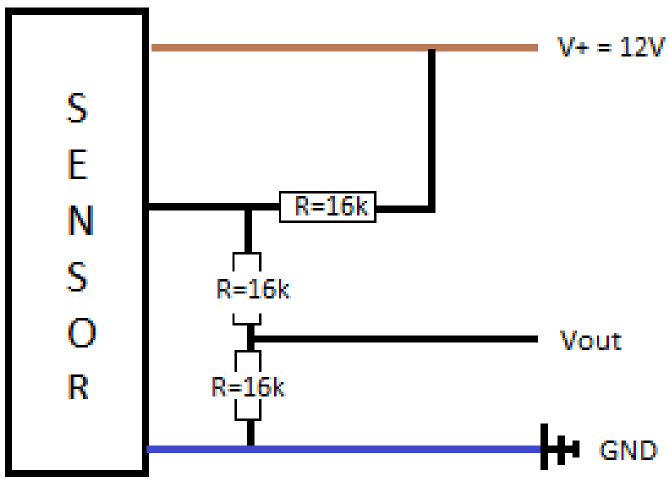


Figure 6. Capacitive and Inductive Sensor Circuit

From the circuit above we can see that the voltage supplied to the microcontroller after detection is found using the following formula:

$$V_{out} = V_{in} * \frac{R_3}{(R_1 + R_2 + R_3)} = 12v * \frac{16k\Omega}{(16k\Omega + 16k\Omega + 16k\Omega)} = 4v$$

The 4 volts is the HIGH signal the sensors output when detecting a bag either filled with capacitive material or ferrous material.

III. Requirements and Verification

Our electronically scored bags game will consist of the 10 modules as shown in our block diagram above. Each module will be an integral part of this system to correctly function. Acceptable results from module block will constitute in a working system.

At the top level the system must be able to detect all bags on the surface of the game board and all bags that passed through the center hole. Detection of bags on the surface of the game board will cause the RFID system to send each detected serial tag to the microcontroller to update the score. The sensors will detect bags going through the center hole. A HIGH voltage will be sent from the capacitive sensor to the microcontroller when it detects a bag for Team 1. A HIGH voltage will be sent from the inductive sensor to the microcontroller when it detects a bag for Team 2.

Requirement	Testing/Verification
1. RFID Tags each have a unique serial code.	1. Each of the eight RFID tags will be individually detected using the antenna and reader system to determine each tags unique serial code to distinguish Team 1 from Team 2.
2. The RFID system is able to pick up all tags located on surface of game board	2. The 13.56 MHz antenna is able detect up to 1.6 ft. from all sides of the antenna. The antenna has dimensions of 1.05 ft. by 1.10 ft. In order to detect the entire surface of game board the antenna needs to detect up to 1 ft. in all directions. Bags containing tags will be placed on the edges of game board to ensure proper detection and shielding.
3. The Microcontroller should be able to detect signal from various inputs to distinguish correct score for each team and output this score to the display. a. Capacitive sensor detection giving Team 1 three points. b. Inductive sensor detection giving Team 2 three points. c. RFID tag differentiation giving the correct team the extra point.	3. After having programmed the microcontroller to correctly output the score for each team, we will supply it with predetermined inputs to test that all cases correctly function to output a valid score. a. Providing a HIGH input to demonstrate a bag being detected by the capacitive senor causing microcontroller to increase Team 1's score by three points. b. Providing a HIGH input to demonstrate a bag being detected by the inductive senor causing microcontroller to increase Team 2's score by three points.

	c. Providing the microcontroller with several serial inputs representing unique tags to test whether program can distinguish between each team's tags and update the score accordingly.
4. The human interface switches correctly function to allow for smooth game play. a. Power on/off switch b. Game play/Score switch c. Reset button	4. Each of the switches will be individually tested to assure proper game function. a. Assuring 12 volts is supplied to game board when switch is flipped to on position and 0 volts supplied when switch is flipped to off position. b. Flipping switch to game play mode will supply LOW voltage to the microcontroller to update score for bags going through center hole but not for bags on the surface of the board. Flipping switch to score mode will supply HIGH voltage to allow for bags on the game board to be scored up and displayed in the output. c. Pushing reset button will supply HIGH voltage to reset entire game.
5. Each 7 segment display correctly outputs its respective teams score.	5. Predetermined inputs will be supplied to the microcontroller from both game boards to determine whether the 7 segment display output is correctly displaying the computed score for each team.
6. LED's light up when bag is detected through the center hole.	6. Predetermined inputs will be supplied to the microcontroller to determine whether the LED lights correctly function in our system

	to indicate a bag passing through the center hole on the game board.
7. The capacitive sensor is able to detect Team 1's bags through the center hole.	7. We will isolate the capacitive sensor form the rest of the system and place each one of Team 1's bags in front of the sensor within its given range (25mm) to determine if a HIGH output will be sent to the microcontroller. LABVIEW will be used to simulate this detection as shown in the simulation above.
8. The inductive sensor is able to detect Team 2's bags through the center hole.	8. We will isolate the inductive sensor form the rest of the system and place each one of Team 2's bags containing metal BB's in front of the sensor within its given range (15mm) to determine if a HIGH output will be sent to the microcontroller. LABVIEW will be used to simulate this detection.
9. A single 12-volt power supply battery will be used to power the entire system.	9. The battery will be individually tested with all components (sensors, reader and antenna, LED's and the 7-segment display). Individual tests will allow us to determine battery life for the entire game when the system is fully wired up.
10. Board 2 can effectively communicate with the microcontroller on board 1 to output correct score on display.	10. Switches will be flipped up/down to simulate point accumulation on board 2 for both teams. Switch 1 will be used to add points to team 1's score (up=3pts, down=1pt) and switch 2 will be used to add points to team 2's score using the same method as mentioned for switch 1. Accumulated points will be sent to the microcontroller on board 1 to be displayed on the 7 segment display. This test will show the ability to communicate between both boards.

Tolerance Analysis

One of the most important subsystems of this project is the RFID system. This system needs to be able to accurately distinguish between a bag that is on the board face and one that isn't. With the possibility of having up to eight bags on the board at once, this system must perform flawlessly under all conditions in order to calculate the correct score. There is no contingency in the RFID system. It must either detect or not detect a RFID tag on the game board. In order to isolate the system from its atmosphere and allow the antenna to only pick up valid bags on the game board, we propose to shield the board using aluminum foil. This shielding mechanism will consist of foil being placed around the outside edges of the board to protect form electromagnetic interference from the atmosphere. Foil will also be placed below the RFID antenna system to block tags from being scored after falling through the center hole of the game board. Shielding of the board is vital to the success of this project.

In order to test the tolerance of this system, bags will need to be tested in many different locations both on and off of the board. The antenna should be able to pick up bags located directly on the game board. It is the extreme cases around the perimeter of the game board that need to be thoroughly tested. Bags will be placed on both sides of the extreme condition. The first is a valid bag just within the perimeter of the board. The antenna needs to pick up this tag and allow the microcontroller to update one of the team's score by a point. The second extreme position will be placed just outside the perimeter of the game board to test whether the shielding mechanism used efficiently works for this system. If no tag is detected by the RFID system, we will have a correctly functioning RFID system.

IV. Cost and Schedule

Cost Analysis

LABOR COST	
Employee	**Cost**
Kabir Singh	(\$40/hr) x (2.5) x (180 hr) = \$18,000.00
Travis DeMint	(\$40/hr) x (2.5) x (180 hr) = \$18,000.00
TOTAL	**\$36,000.00**

PARTS					
Part	**Part Number**	**Manufacturer Name**	**Unit Price**	**Quantity**	**Total Price**
Cornhole/Bags Set		Original Tailgate Toss	$62	1	$62
ArduinoMircocontroller	Arduino Mega 2560	Arduino	$50	1	$50
RFID Tags		Printronix	$0.50	8	$1.20
RFID Reader	ISC.LR200-x	Digi-Key	$200	1	$200.00
Antenna	ISC.ANT 300/300-A	Digi-Key	$473.85	1	$473.85
LED's	HLM P3507	Avago Technologies	$0.15	10	$2
7-Segment Display	TDA 545	All Electronics Corp.	$0.92	2	$1.84
12 V Battery	SLA5-12	Rhino	$11.48	1	$11.48
Capacitive Sensor	E2K-X8MY2	Omron	$79	1	$79
Inductive Senosr	E2E-X7D1-N	Omron	$46	1	$46
Toggle Switch	683-0114	Allied	$1.06	1	$1.06
Push Button	30-1	Grayhill	$1.91	1	$1.91
Three Position Switch	MTS-541	All Electronics Corp.	$1.03	3	$3.09
300 Ohm Resistor	20J300E	Ohmite	$1.01	36	$36.36
16 kOhm Resistor	20J16K	Ohmite	$2.12	6	$12.72
9 Pin D-Subminature Plug	DS-9P	Pan Pacific	$0.50	1	$0.50
Zener Diode	1N4728A-TR	Motorola	$0.15	10	$1.50
Capacitor 6 uF	P5189-ND	Panasonic	$0.15	4	$0.60
RS232 Converter	MAX232	TI	$1.95	1	$1.95
BCD to 7 Segment Decoder	74LS48N	TI	$1.99	4	$7.96
Shift Register	4094N	TI	$1.95	1	$1.95
PCB			$15	1	$15
TOTAL				96	**$1,011.47**

Total Project Cost = $36,000 + $1,011.47 = $37,011.47

Schedule		
Week	**Task**	**Team Member**
6-Feb	Finish Proposal	DeMint
	Work on design review	Singh
2/13/2012	Complete schematics for design review	DeMint
	Complete design review	Singh
2/20/2012	Present design review	DeMint
	Design shielding mechanism for antenna to detect within vicinity of the game board	Singh
	Test sensors with various materials to decide which ones need to be put in the bags	DeMint
	Test RFID network and determine where tags need to be placed	Singh
2/27/2012	Learn how to program Arduino Board for RFID system	Singh
	Learn how to program Arduino Board for sensors	DeMint
3/5/2012	Work on Individual Progress Reports	DeMint
	Start programming microcontroller for RFID system	Singh
	Start programming microcontroller for sensor system	DeMint
3/12/2012	Complete Individual Progress Reports	DeMint
	Program microcontroller for LED lights	Singh
	Program microcontroller for 7-Segment Display	DeMint
3/26/2012	Design circuit layout for PCB	DeMint
	Get PCB fabricated	Singh
4/2/2012	Attach RFID system and shielding mechanism to game board	Singh
	Attach Sensor system to game board	DeMint
	Attach Microcontroller to game board with all parts programmed	Singh
	Attach power source	Singh

	Test the current design to check that major parts of the project are working	DeMint
4/9/2012	Attach LED lights to game board	Singh
	Attach 7-Segment Display to game board	DeMint
	Start Working on Final Presentation	DeMint
4/16/2012	Attach second board with each component to match the first board and connect this board to the single 7-Segment Display	DeMint
	Test all parts for correct functionality	Singh
	Finish Final Presentation	Singh
	Start Final Paper	DeMint
4/23/2012	Demo	Singh
	Presentation	DeMint
	Work on Final Paper	Singh
4/30/2012	Final Paper Due	Singh
	Checkout	DeMint

Ethical Considerations

With all engineering design projects, ethical issues must be taken into consideration. This particular project contains a few ethical considerations that must be addressed. Rule five of the IEEE Code of Ethics states “to improve the understanding of technology, its appropriate application, and potential consequences”. This guideline directly pertains to the RFID system used in the project and its associated radiation frequency. There are certain frequency allocations which are set aside for multiple applications. For this certain application, the RFID system will be operating at a HF (High Frequency) of 13.5 MHz. This particular frequency falls within the industrial, scientific and medical (ISM) radio band which is allocated internationally for the use of radio frequency energy for industrial, scientific and medical purposes. This frequency is the appropriate and ethical choice for the RFID system used in this project. Our choice of 13.5 MHz will prevent any interfere with important frequencies within the electromagnetic spectrum. Another important ethical consideration that needs to be addressed is rule three of the IEEE Code of Ethics. The code states “to be honest and realistic in stating claims or estimates based on available data”. For this project we will be testing multiple sensors and a RFID detection system. When stating nominal sensing ranges and limitations of our systems we will remain honest and report the correct values for the devices used. Also when recording our test results we will not exaggerate what we observe in the lab. If our systems do not perform as intended will make the appropriate accommodations within our project in order to complete a satisfactory end product. Finally, all references used in this project will be given the proper credit and will be acknowledged when it is the appropriate time to do so.

V. References

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