Efficient Card Shuffler with Cut Card Insert

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1. Introduction

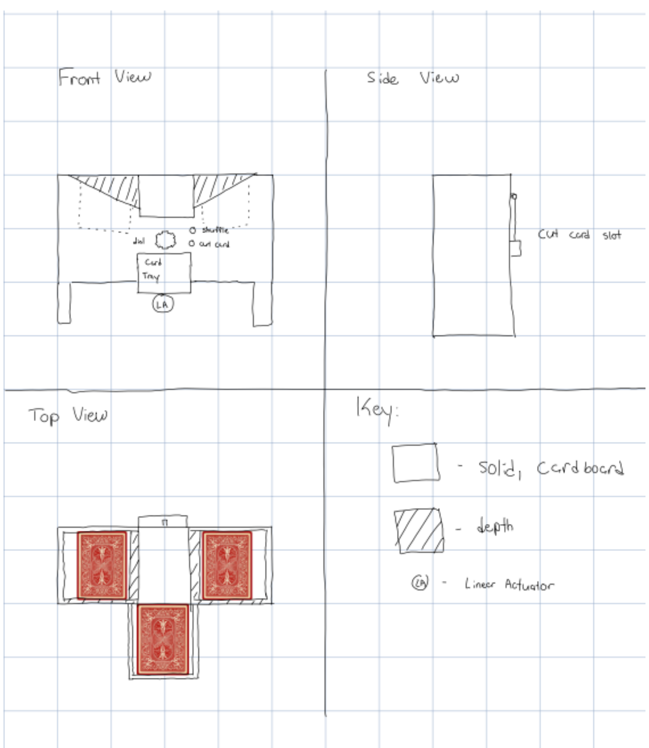
1.1 Problem

Across the country, people play card games whether it is in casinos, on the job site, or in the leisure of their own home. Many of these card games require the need to continuously shuffle between rounds of play. This process is extremely tedious for both the person dealing the cards and the players, as it cuts down on playing time and adds a lot of extra work. Automatic card shufflers have existed for a while, but a lot of them have very noticeable limitations, like a small deck capacity, limited features, or a tendency to be error prone. In addition to this, these machines tend to be relatively difficult to operate. Games like blackjack require multiple decks and frequent shuffling, depending on how many people are playing and how many decks you are using. Blackjack also requires the insertion of a cut card before play can begin. This cut card ensures randomness in the shuffle and fairness to the players in the game. There currently are not many automatic card shufflers on the market with an increased deck capacity, and there are none with a cut card insert feature. This results in having to put your deck through a shuffler multiple times in pieces and then manually insert the cut card outside of the shuffler, adding a lot of time to the shuffling process. A lot of shufflers also require constant pressing of the shuffle button, causing the overuse of motors as well as wasted energy. Many card shufflers available on the market require manual removal of the card tray from the bottom of the machine, which is often quite cumbersome and adds a good deal of time to the process of shuffling. Especially if you need to shuffle more decks than the capacity of the shuffler or add things like a cut card after the process of shuffling. These are all fundamental problems that we plan to address in our project.

1.2 Solution

Our solution is to build a card shuffler that comes equipped with the ability to tackle the issues all at once at the push of a couple of buttons. We will be increasing the deck capacity to six total decks, up from the typical two. In addition, we will be implementing a system that allows you to set the exact level of penetration in a deck shuffle to insert your cut card using a dial, this ensures even playing conditions for the player and fairness to the dealer. It would also have a one-time press button that shuffles the deck, taking away the need to push the button down the whole time adding extra strain to both the button itself and the motors it is turning on. These features all together lead to a total of six subsystems, namely card detection, deck shuffling mechanism, cut card insertion, card tray extension, power supply, and the control module. There will only be two button inputs available to the user, as mentioned previously, being the shuffle button and the extend/retract card tray button. There will also be a dial input with a gauge to represent the depth of the deck at which the cut card will be inserted. The order of operation for the machine will be to load the cards into the card inserts on top of the machine, press the button to shuffle all the cards together and the tray will extend automatically once the shuffling is concluded. If you wanted to put the cut card into the deck and play you would press the cut card delay button, which would delay the machine, set the cut card depth and after a short delay will automatically extend the tray with the cut card inserted ready to play.

1.3 Visual Aid



Physical Build

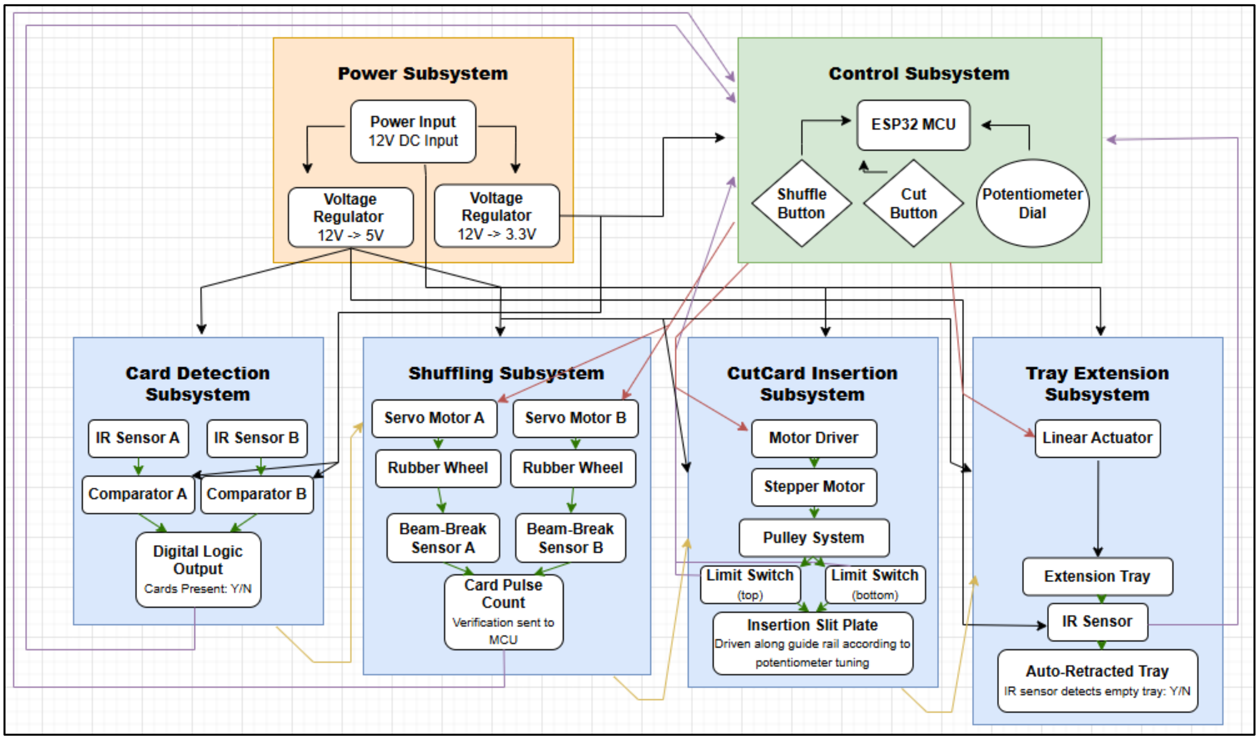
The card shuffler will be constructed out of primarily cardboard with several components being 3D printed. We plan to print the collection tray, cut card insertion slot, and various sections of the build as needed. As illustrated above, the top of the machine has two pre-shuffle trays that will hold the cards before they are shuffled. The collection tray is positioned at the bottom and collects the shuffle cards. This tray is positioned slightly off the ground to allow room for the linear actuator which drives the extension function of the collection tray. The dimension of the build is going to be roughly 8-10 inches wide and tall, and about 6 inches in depth. Most of the parts will be connected by hot glue and tape as needed.

1.4 High – level requirements list

- With the press of the start button, the device successfully shuffles 6 standard sized decks without manual intervention. Shuffling motors halt motion once all cards have been shuffled. Optical sensors accurately detect if cards are present.
- The shuffled product is extended out in the product tray after shuffle and/or cut card insertion completion. Once the cards are received from the collection tray, the tray will retract automatically. Optical sensors accurately detect if cards have been retrieved.
- Cut card insertion slot moves in accordance with the dial. The dial is measured as a percentage of deck penetration ranging from 10-90%, allowing for desired insertion at any reasonable level of deck penetration.

2. Design

Block Diagram

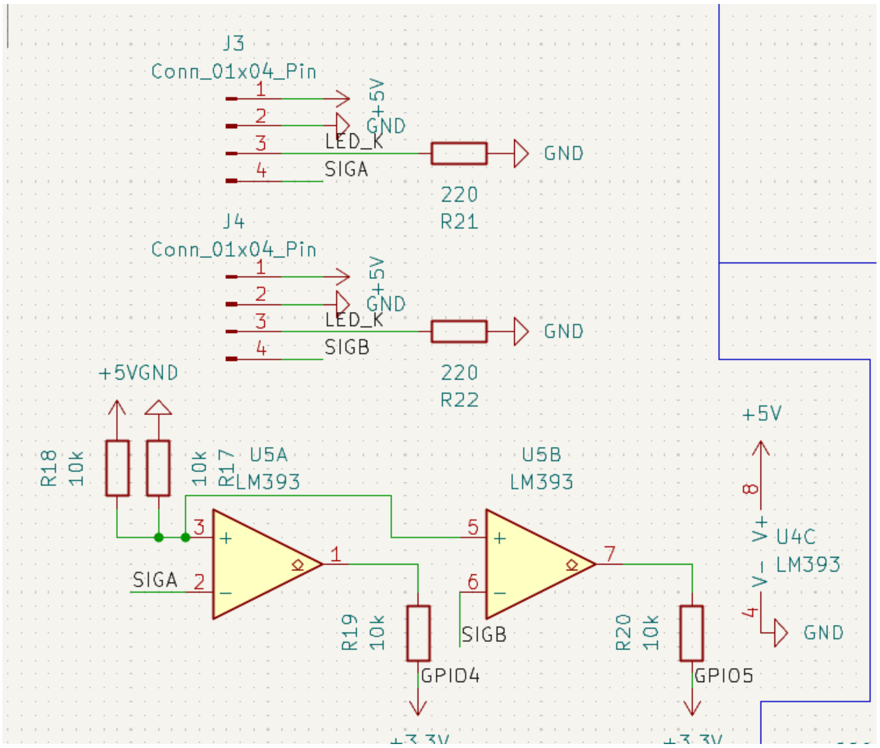


- Black lines denote paths for power distribution to the various subsystems.
- Red lines dictate digital signals from the MCU (control system) to various subsystems to trigger action items
- Purple lines feed data from subsystems to the MCU
- Yellow lines follow physical card progression from subsystem 1 – 4

The Power unit supplies all the power to the entire unit, and is responsible for providing specific voltage levels to the various components that are limited by voltage presence. This is critical for ensuring that there are no overexposures and that all electronic components of our project are safely handled and operated. Thus, it is routed to every other subcomponent. The control system, headed by the ESP32 MCU provides the instructiosn to the various operational systems on when to activate certain motors based on data inputs that are fed from the other subcomponents. The 4 components drawn out in blue are the electromechanical parts of our project that include sensors, motors, and other mechanical aspects that allow our project to perform the mechanical duties that are expected of it and feed the cards sequentially.

2.1 - Subsystem 1 – Card Deck(s) Detection

The purpose of this subsystem is to detect whether cards are present in the input trays for the shuffler. Detection will be determined by using reflective optical sensors and is critical for the prevention of overdriving motors, preserving battery life, and ensuring shuffling continues until completion. The reflective sensors on each tray will measure the light reflected off the bottom card of the stack to determine if the tray is empty or still full. The IR sensors will be flushed to the bottom of the tray's surface, and their outputs will be fed to a comparator to differentiate between the signals for when no cards are present and for when there are cards present. The IR sensor module is built in with the comparator. The digital signal output by the module is read by the MCU through GPIO inputs. When the sensors report that no cards are present, the MCU concludes that the shuffling process is complete. Following the completion of the shuffle process, subsystem 2 will be notified to halt motor motion and begin the next steps of operation.



The IR sensors will be interfaced with the board using connectors and we will include external LM393 comparators (in the case that the built-in comparator in the IR module does not operate functionally) and the comparator will be fed the inputs of the sensors (SIGA, SIGB) and send the determined output signal back to the MCU to conclude that the shuffling process is complete.

Subsystem Components

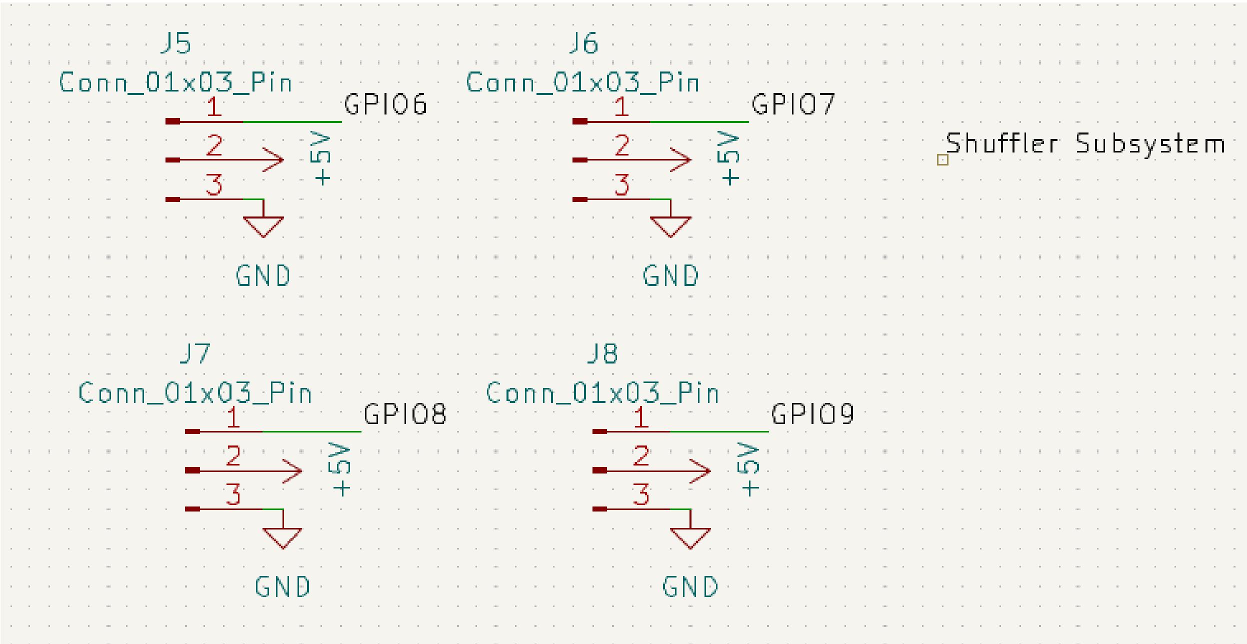
- Reflective infrared optical sensor module (TCRT5000) (2x)
- LM393 Comparator

Requirements	Verification
• The subsystem must have a latency of less than 200ms to ensure the MCU can halt the motors immediately upon the last card being drawn	• 1. Connect Oscilloscope to the sensor's Data out pin • Set the oscilloscope to 'Normal' trigger mode on a falling edge • Rapidly remove a card from the sensor's field of view • Measure time form physical removal to signal spike

• Sensors should be able to identify card presence accurately. Comparator outputs a “high” level when cards are present and “low” level when cards are not present.	• Place cards in pre-shuffle trays and verify the comparator analog output is greater than 2 volts. Remove cards from pre-shuffle trays and verify the comparator output is less than 0.8 volts. • This can be measured with multimeter from the data output pin of comparator
• Comparator must produce output signals within an interpretable and safe range to the ESP 32	• Using multimeter, ensure that the comparator low value outputs are within 0 < value < 0.8 volts and that the high values are 2 volts < value < 3.3 volts.
• The comparator threshold must be adjustable to account for different card back colors (red / blue)	• Place a dark-colored card in the tray and measure output voltage. • Place a light-colored card in the tray and measure output voltage. • Verify that a stable Logic HIGH is maintained for both colors.

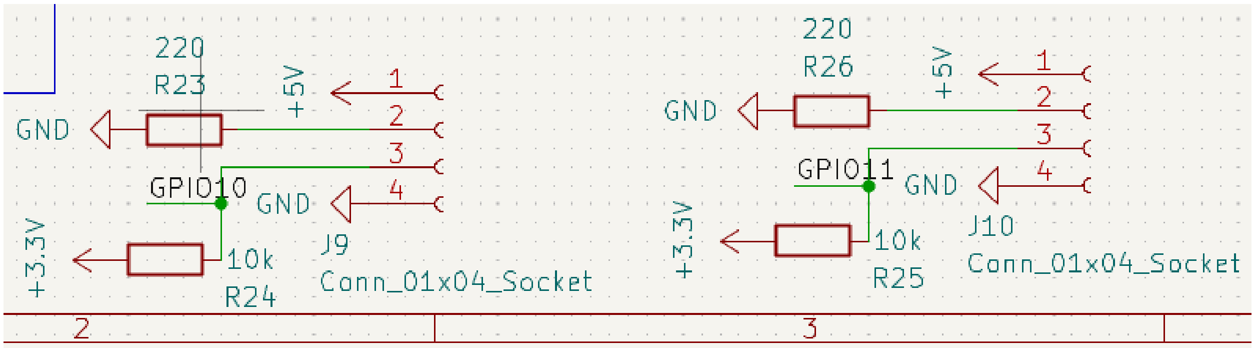
2.2 - Subsystem 2 – Deck Shuffling Mechanism

This subsystem is responsible for the physical shuffling of the cards from the pre-shuffle deck trays. It will involve four motors, which are grouped in pairs. Each pair is positioned at the bottom of the pre-shuffle deck trays. The motor pairs will slide one card at a time from their respective card stack inwards into a common pile forming a shuffled card pile. The motors will be in contact with the cards by a wheel with a rubber edge. When the shuffle button is pressed, the MCU will verify that the collection tray is fully retracted (from the previous operation), and that the optical sensors are detecting cards present in the pre-shuffle trays. The optical sensor signal will be received from subsystem 1 and the collection tray signal will be from subsystem 4. Once these two conditions are satisfied, the motors will begin shuffling. To ensure that the cards are being shuffled reliably, a beam-break sensor will be positioned below the motor wheels, and as each card passes through the slot, the sensor will generate a pulse that is read by the MCU to confirm that no jam has occurred (or if there is no pulse, that there has been a jam, and to reset the cards) and to keep count of the cards that have been passed through. Shuffling will continue until a signal is received by subsystem 1 that there are no more cards remaining to be shuffled.



Connectors to be interfaced with the servo motors (2 on each side) and connected to the MCU IO pins to communicate when to actuate the motors.

The beam-break sensors will be driven with the appropriate power regulations on the 3.3V line and connected back to the MCU for the pulse reading



Subsystem Components

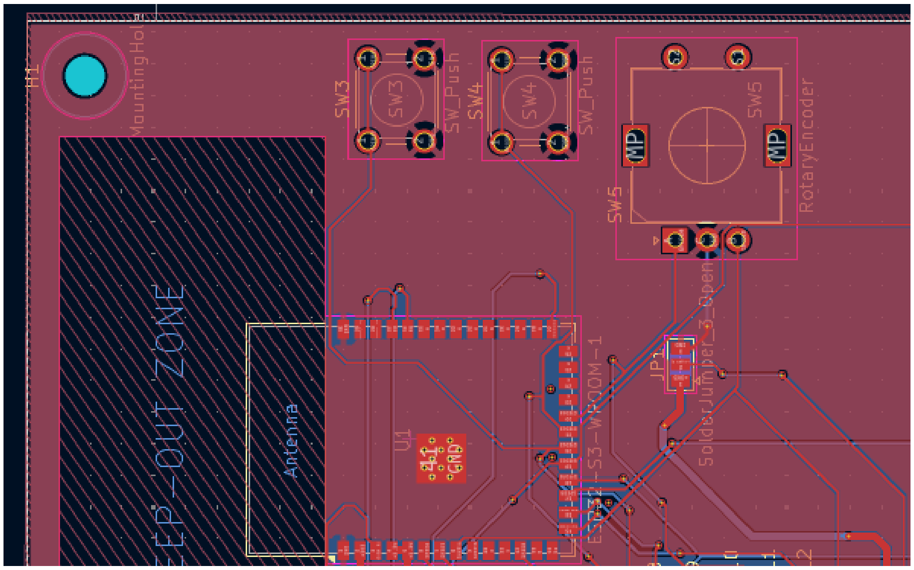
- Continuous motion servo motor - 4pck (Feetech)
- IR Beam Break Sensor - 4pck (MELIFE)

Requirements	**Verification**
• Motor wheel must advance one card per motor actuation under nominal conditions to ensure acceptable shuffling (success rate > 90%)	• Place a deck of red colored cards in one pre-shuffle tray and a deck of blue colored cards in the other pre-shuffle tray. After shuffling operation, examine how well the cards are mixed • Repeat operation several times to ensure consistency
• Shuffle operation will not begin until collection tray is fully retracted.	• Visually verify that the collection tray is fully retracted before the cards begin shuffling.
• Beam-break sensors must generate a pulse for at least 1ms duration so that it can be detected by MCU. Shuffling should pause in event of a jam.	• Connect oscilloscope to beam-break signal output pin • Slide card manually through dispensing slot at anticipated motor speed • Capture pulse width on oscilloscope and verify if pulse > 1 ms
• Servo motor torque must be able to overcome card friction without deteriorating cards	• Examine quality of the cards every 2 shuffle operations to ensure no damage is being done. • Confirm no anomalies and repeat procedure several times

2.3 - Subsystem 3 - Cut Card Insertion

This subsystem manages the insertion of the cut card into the shuffled deck of cards. The inputs to this subsystem are a user-controlled dial and a cut card shuffle button. The overall process is the following. When the user is ready to cut the card deck, they will set the dial to a desired deck penetration (10% - 90%) and press the cut card shuffle button (both the dial and the cut card shuffle button are components of the control module subsystem). The shuffler will shuffle the cards normally but instead of automatically extending the card tray, there will be a delay built in since the cut card button was pressed. This delay will allow time for an electronically coordinated slitted plate to move along the back of the shuffled card decks guided by vertical rails. Once the slitted plate is vertically aligned, the user will manually insert the cut card into the deck through the slitted plate. The movement along the vertical axis will be driven by a pulley and a stepper motor. The motion will begin with a lowering of the slitted plate until a limit switch detects the plate has been fully lowered. Once the plate is in the fully lowered position, the stepper motor will raise the plate with a pulley in accordance with the setting from the dial. The dial itself is a rotary encoder. This rotary encoder sends pulses ranging from 1-24 pulses depending on the rotation of the shaft. Each 15 degrees of rotation corresponds to 1 pulse. This means the accuracy of the encoder is within 100/24 = 4.16% of the actual encoder rotation (This degree of error will be further elaborated in the Tolerance Analysis). The pulses read from the encoder will be fed into an ADC on the MCU (ESP32 comes with an ADC). The output of the ADC will be scaled to a corresponding linear displacement for the slitted plate and will correspond to an amount of rotation for the stepper motor in the pulley system. Since we are using a pulley system, each rotation will correspond to a different amount of distance the slitted plate is being raised (pulley wheel fills up with rope). Due to this, the difference between each encoder pulse count will not be a linear relationship, and the MCU will rely on preset values from us determined through testing. To interface with the stepper motor, we will be utilizing a motor driver. This is because the current requirements of the stepper motor are not compatible with the ESP32.

Our design for our PCB features the buttons and rotary encoder on the edge of the board in order to support easy access for the user to interact with the buttons/encoder.



Subsystem Components

- Rotary Encoder 24PPR (Part No. 377) (physical button will be interfaced with control subsystem)
- Mini Momentary Pushbutton (physical button will be interfaced with control subsystem)
- Micro Limit Switch KW12-3 AC 250V 5A SPDT – Part No. 3-01-1546
- 12V Stepper Motor SMALL bipolar – Part No. 10551
- Motor driver TMC2208
- MGN7 150mm Linear guide rail – 2pcs

Requirements	**Verification**
• Rotary Encoder input must be able to map deck depth from 10 – 90% at increments of 4% to ensure user input is properly mapped	• Rotate encoder by set detents • Measure the height of the shuffled decks with a ruler, multiply this measurement by 0.1. Ensure that the cut card slot is above this measurement + bottom of deck and below the top of decks – measurement
• Limit switches must trigger within reasonable time when contact is made from lowering of the pulley system (3.3V to 0V within 1mm of physical contact)	• Use multimeter to monitor signal pin of limit switch • Lower the plate until the limit switch clicks • Verify that there is a voltage drop

	• Measure gap between plate and ground base to confirm tolerable distance
• Slot travel along the vertical axis must remain free from jams and the insertion window should remain relatively flat	• Command plate to move to highest position • Use ruler to measure height from bottom on left and right sides • One side of the slot should not be more than 0.5cm higher than the other. Any impediment to movement along the vertical axis should be considered a jam.

2.4 - Subsystem 4 - Completed Deck Tray Extension

This subsystem will be responsible for extending the completed shuffled deck at the end of the shuffle operation. This will require the use of a linear actuator, guide rails, and one optical sensor. Once subsystem 2 verifies that the shuffle operation is complete, the linear actuator will extend out the collection tray which will contain the shuffled cards. The collection tray will be guided by rails on its left and right side. On the floor of the collection tray, an optical sensor will detect when the shuffled deck has been retrieved. Once the deck has been retrieved, the linear actuator will retract, and the collection tray will move back to its start position. We plan to add a delay after the deck removal to ensure now there is no premature action from the actuator.

Subsystem Components

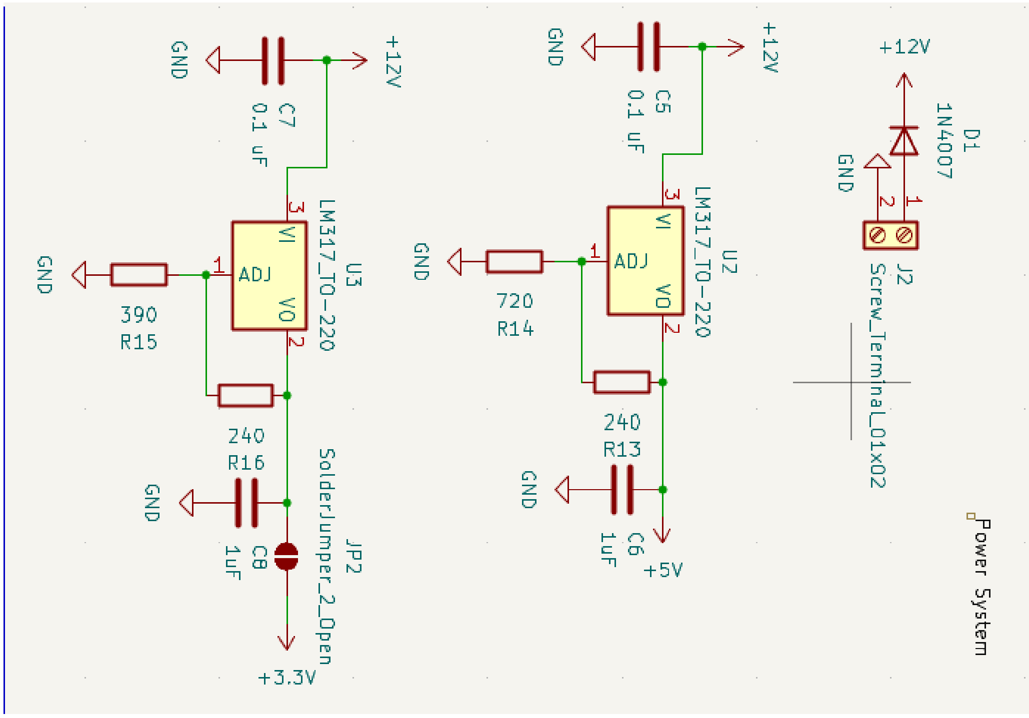
- Reflective infrared optical sensor (Vishay TCRT5000)
- Mini Linear Actuator 12V 4 Inch (SZAWINLI)
- Reflective infrared optical sensor module (TCRT5000)
- MGN7 150mm Linear guide rail – 2pcs

Requirements	Verification
• Optical sensor must detect deck removal	• Use multimeter to measure sensor output

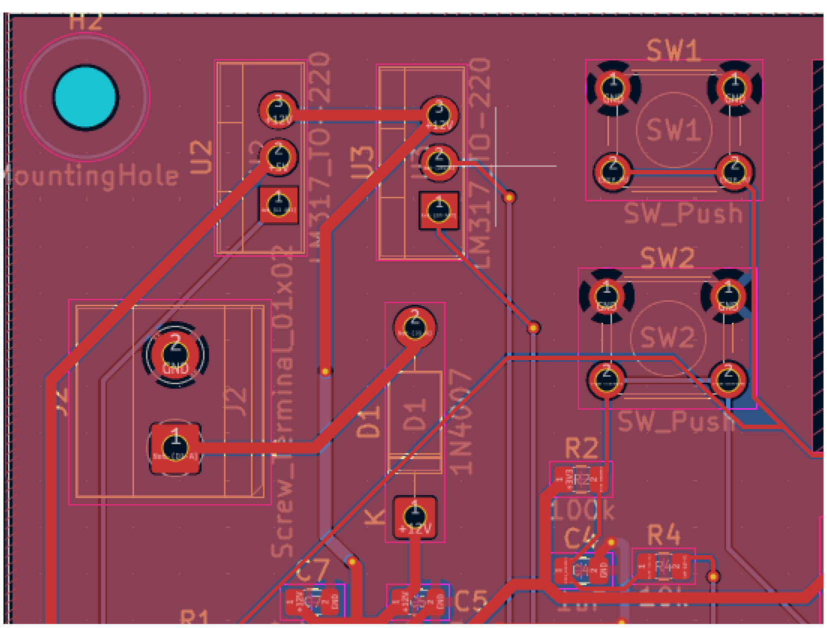
to allow for repeated shuffling processes (maintain logic HIGH vs logic LOW signals at appropriate settings)	voltage when cards are present (should read > 2.4V • Use multimeter to measure sensor output when cards are removed (should read < 0.8V) • Ensure timing difference between removal and voltage drop is below 100ms
• Tray needs to extend once shuffling operation is concluded.	• Visually ensure that the cards have cleared the feed trays before the bottom tray extends with the collected deck. • Time the gap between the cards clearing the feed trays and the collection tray extending to find out if there is the proper amount of delay. • Confirm time taken is not tedious
• Tray needs to fully extend out of the body to allow for removal of the cards. (to full extent of linear actuator)	• Measure the extension of the tray with a ruler and verify that it is extended out far enough for easy removal of the shuffled deck. • This will be done visually and through use of human interaction

2.5 – Subsystem 5 - Power Supply

The power supply subsystem is responsible for supplying power to the device and its various components. There are three different voltage levels required by the device. The stepper motor and motor driver require 12 volts, the servo motors require 4.8 – 6volts, and the ESP 32 along with the sensors and switches will all run on 3.3 volts. To achieve these various voltage levels, we will be using a 12-volt power supply and several voltage regulator modules. These regulators will constitute the power subsystem and will require traces routed from this subsystem to the rest of the other subsystems.



Our power subsystem includes the screw terminal for our 12V battery, as well as the voltage regulators that can be seen in the kicad schematic. We will have appropriate regulators to limit 12V down to 5V, 3.3V. These are located in a centralized location in the corner of our PCB design. This also features a diode to prevent reverse current flow and a subsequent voltage spike.



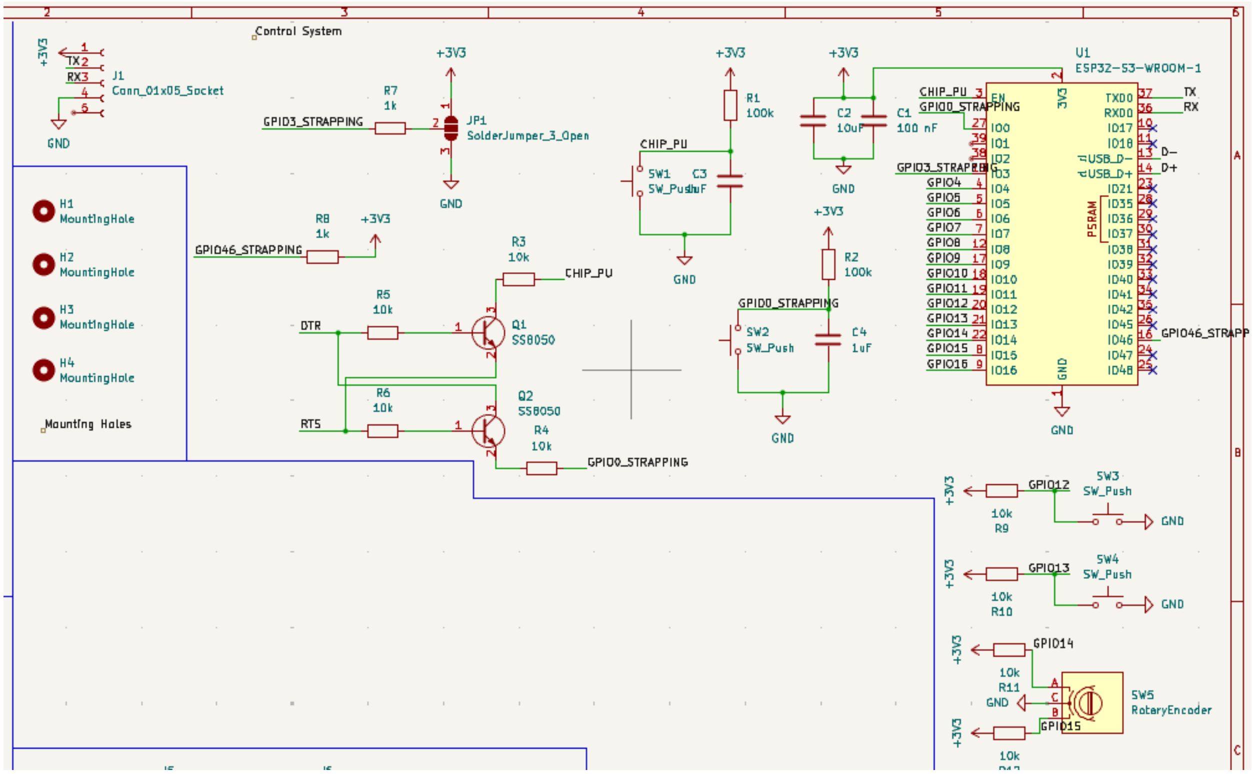
Subsystem Components

- 12v Power Supply ECE Supply Center 620130252
- LM317 Adj Voltage Regulator Module – 3pcs

Requirements	Verification
• Voltage outputs are of correct magnitude and within a reasonable level of tolerance o Ex. 3.3V rail must maintain voltage of within 5% of 3.3V under a max load of 500 mA to power the ESP32 and other sensor lines	• Use multimeter to measure output voltage at various points along the line • Ensure readings are within tolerance threshold
• The 5V rails for the servo motors must maintain proper powr distribution when all 4 motors are in rotation	• Connect oscilloscope to 5V power line • Activate all 4 servos simultaneously (shuffling cycle) • Monitor voltage to see if there is no voltage dip • Ensures that power dist. Is able to deliver at peak distribution for motors
• Traces routed from this subsystem are required to adhere to the correct minimum thickness to allow for proper power distribution	• Examine PCB design to ensure traces are of correct thickness. Measure voltage inputs at sensors and components to ensure they have met requirement.

2.6 – Subsystem 6 - Control Module

The purpose of this subsystem is to serve as the brain of the card shuffler. It receives power from subsystem 5, data, and various inputs from several other subsystems to control the devices' motors and the timing of operation. The inputs to this subsystem are the shuffle command, cut card insertion, and cut card penetration level. The first two inputs mentioned will be administered using pushbuttons, the cut card penetration level will be set by a dial. This dial will be on a scale from 0-100%.



This current schematic ensures proper execution of the ESP32 MCU. This includes strapping pins, reset buttons, and includes a connector for UART-to-USB programming of the MCU which will be critical in directing the operation of this project. Further connections to GPIO's will be added for subsystems 3 & 4, with the connections to subsystems 1, 2, & 5 present in the above schematic. For breadboard demo and initial prototyping, we will be utilizing an ESP32-devkit for slot connections with the breadboard and easier programming utilities.

Subsystem Components

- ESP32 MCU
- Pushbuttons ECE Supply Center - MPB-43 (2x)
- Rotary Encoder ECE Supply Center – part 377

Requirements	Verification
• Commands from input buttons and dials are correctly received and able to communicate across all subsystems	• Using a multimeter, measure the output of the buttons when they are pressed and not pressed and ensure reading is corresponds to action
• Must be able to continuously operate throughout multiple shuffling cycles to ensure proper operation (State Lockout)	• When shuffle cycle is in operation, pressing the buttons should have no impact on the machine • Ensure that no behavior is changed when a current cycle is in mode
• Read and store pulses from rotary encoder accurately	• Open digital monitor and test rotary encoder movements • Measure degree of turn and confirm it aligns with pulses

Tolerance Analysis

One aspect that poses a risk to our success is the accuracy of the card cut insertion feature. We expect there to be some degree of error between what the dial percentage is set to and the actual penetration of the cut card. Let's say we are shuffling 4 standard size decks. There are 4*52 = 208 total cards to be shuffled and cut. Our dial is on a scale from 0% to 100% deck level penetration. For simplicity, we'll say each percentage point is equivalent to roughly 2 cards (208/100 = 2.08). We would like our actual penetration level to be within +/- 5% of our desired dial setting. This means we will be within roughly 20 cards of our desired cut. Anything outside of this range will not reflect the desired setting by the user and should be considered a malfunction of the cut card insertion feature. Since our rotary encoder will take measurements in increments of 4%, we feel that a 5% margin is very appropriate.

Converting the percentage from the dial to a physical vertical height is dependent on the pulley diameter (D) and stepper angle (θ). It can be defined as:

$$H_{slot} = \text{Steps} \times \text{Distance Per Step}$$

$$H_{slot} = \left(\frac{P}{100} \times \text{Total Steps}\right) \times \left(\frac{\pi D}{S}\right)$$

where S number of steps per revolution of the motor.

Sources of error that may arise from this may be the stepper's resolution, which has an error of approximately 5% for a single step. However, due to each step being so small in relation to human movement of the dial, we feel this error is negligible. Additionally, the mechanical slipping of the pulley rope is another source of potential error, which is to be determined when we fabricate it to see just how significant this error will be.

Operating from the worst-case perspective, we can assume that for a standard deck height of 6 decks would be ~9.4 cm. The total expected error from the mechanical slippage can be estimated to be about 1.5mm due to the fact that we have limit switches that will be used to "reset" the slit plate back to a home starting position before each run which should ensure no mechanical jam or uneven starting position at the beginning of the program. Additionally, using linear guide rails should cause a 'stitching' effect which will momentarily cause one side to pause while the other side continues, and we estimate this to account for about 1-1.5mm of error. And this in conjunction with our 4% encoder error from earlier (4% * 9.4cm = 3.76 mm) accounts to about 5.25mm of linear error. 5.25mm is ~5.5% of 9.4 so there would be approximately a 5.5% margin of error in our linear distance for the cut-card insertion plate which we felt like was reasonable and lies near our 5% error margin. Thus we feel that this is a realistic and reasonable design for the success of this project.

3. Cost Analysis and Schedule

Cost Analysis

The total raw cost for parts is $180.66 which is also shown in the table below. We estimate 5% shipping costs and 10% sales tax on all parts that aren't supplied through the ECE supply shop, which brings our total part cost to $202.76. We estimate a salary of about $35 per hour and about 40 hours of work per person to build the machine. Our labor costs amount to $35/hr x 2.5 x 40 hrs x 3 team members = $10,500. This in addition to our total part cost brings the project total cost to $10,500 + $197.24 = $10,702.76. As mentioned, the breakdown of parts and cost per unit can be seen in the table below.

Description	Manufacturer	Part Number	Qty	Costper
10pcs TCRT5000 IR Sensor Module	HiLetgo	TCRT5000	1	8.79
Continuous motion servo motor (4pck)	Feetech	FS90R	1	26.99
IR Beam Break Sensor - 4pcs	MELIFE	B0G1SBQB9F	1	6.99
MGN7 150mm Linear guide rail – 2pcs	Uxcell	MGN7	2	18.69
Rotary Encoder 24PPR	Adafruit Industries	377	1	6.91
Micro Limit Switch KW12-3 AC 250V 5A SPDT - 10pcs	HiLetgo	3-01-1546	1	5.99
12V Stepper Motor SMALL bipolar	Sparkfun Electronics	10551	1	15.27
TMC2208 V1.2 Stepper Motor Driver – 2pcs	ALLGIFT	B0CQ2172D7	1	10.49
Mini Linear Actuator 12V 4 Inch	SZAWINLI	B0DCJRZY9Q	1	32.99
2V 2400mAh AA NI-MH Battery Pack	CBB	620130252	1	0.17
LM317 Adj Voltage Regulator Module – 3pcs	GODIYMODULES	B0F2YB668F	1	5.99
Mini Momentary Pushbutton - 10pcs	Gebildet	B0CJHXJWN3	1	6.99
ESP-WROOM-32 ESP32 Dev Board	HiLetgo	11181103	1	15.71

Schedule

Week	Task	Person
February 22nd – March 1st	Order parts from TA for subsystems 1&2	Everyone
	Work on PCB design and order by Thur	Steve
	Finish Design Document	Alex & Matt
March 1st – March 8th	Begin building subsystems 1&2	Everyone
	All ECE supply shop parts ordered by 3/3	Everyone

	All Amazon parts ordered by end of week	Alex
March 8th – March 15th	All parts ordered by 3/10 - final	Everyone
	Begin physical PCB wiring and interfacing with motors	Everyone
	Refine PCB design as needed	Steve
March 15th – March 22nd	Spring break	N/A
March 22nd – March 29th	Begin construction of remaining subsystems	Alex & Matt
	Finalize PCB design and reorder if needed	Steve
	Print any preliminary 3D parts	Everyone
March 29th – April 5th	Finalize construction of subsystem 3 and begin testing sensors	Alex & Steve
	Work on Assembly of Pulley system	Matt
April 5th – April 12th	Assemble all physical subsystems	Everyone
	Complete testing of sensor inputs and motor outputs	Everyone
April 12th – April 19th	Test machine and address inefficiencies	Everyone
	Reprint or replace any parts with 3D parts as needed	Alex
April 19th – April 26th	Mock demo	Everyone
April 26th – May 3rd	**Final Demo**	Everyone

4. Ethics and Safety

Our project aims to enhance public welfare by making the somewhat frustrating task of shuffling cards while playing poker somewhat easier. While the automatic shuffler already exists, our project intends to improve that design by making it more convenient for the dealer and the players. We will achieve this by having the card tray extend outward for easy removal with the push of a button, as well as a dial that allows the player to set a level of penetration to insert a cut card, ensuring fair play for everyone involved. These features, though, do add some safety risks that apply to the IECC code, one which says "to hold paramount to the safety, health, and welfare of the public" [1]. One of the safety risks that we will be adding is the addition of pinch points in the card tray that extends and retracts. If someone were to leave their fingers too long in the tray after pressing the button to retract, it could pinch their fingers in the closing gap as the linear actuator retracts. We will meet the IECC standards, however, by making the button used to retract the tray back into the body of the machine to have a short delay on it to ensure that all appendages get clear of the tray retracting. Our other safety concern that we run into is improper ventilation of the battery that we are using, which has a NIMH composition. While these types of batteries are pretty safe, they do run the risk of extreme temperatures that can cause an internal circuit, "this produces heat thus makes the cell to be unsafe" [2]. Our risk factor mitigation for this will be to add a heat sink to the area around the board, allowing the heat to be drawn out of the battery, which is a ton of current from using a lot of motors at once, it being drawn causing it to heat up.

One of the unique ethical concerns that applies to our project involves IECC code 1.5, specifically the part stating "uphold the highest standards of integrity." [1] This applies to our project, especially since this will be used in games where people could possibly be gambling on a small scale or playing games that are presumed to have a non-biased shuffling process. We can reduce this by taking a large sample of shuffles to run through the machine to ensure the randomness of the shuffle. We will also provide that data to prove that it is indeed random and cannot be easily influenced by the deal or the player. The cut card insert also adds a large degree of randomness, allowing the game to be fairer across the board.

Overall, we feel that our project will be a big help to people who like to play card games such as blackjack in an environment that is not controlled like a casino. Our procedures to mitigate both ethical and safety risks, we feel, will go a long way to making our product both safe and impartial to the play of the game.

References

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