Automated Vinyl Record Flipper Design Document

Riyaan Jain (riyaanj2)
Mohammed Alkawai (alkawai2)
Alfredo Velasquez (av28)

Final Report for ECE 445, Senior Design Project, Spring 2025

University of Illinois Urbana-Champaign

TA: Chi Zhang

Team 20

Abstract

This project presents an automatic vinyl record flipper designed to enhance the usability of traditional turntables by eliminating the need for manual record flipping. The system uses an ESP32 microcontroller to coordinate three servo motors and a hall effect sensor, enabling the detection of playback completion and precise mechanical flipping of a 7-inch vinyl record. The prototype integrates with the Crosley Cruiser Premier but is designed with future compatibility in mind for record players with automated tonearms to provide a fully automated record listening experience. Testing confirmed reliable tonearm detection, consistent flipping mechanics, and precise reseating of the record onto the 45 RPM adapter, supported by a custom tapered adapter to improve alignment. The system successfully preserves the analog charm of vinyl playback while introducing modern convenience.

Table of Contents

1. Introduction

Vinyl records have experienced a resurgence in popularity due to their warm analog sound and tactile listening experience. However, a key limitation remains: modern record players typically require manual flipping of the record once one side finishes playing, interrupting continuous playback. While earlier automated flipping systems existed—such as those found in vintage jukeboxes—they were bulky, mechanically complex, and are no longer manufactured. Our project addresses this functional gap by developing an automatic vinyl record flipper that preserves the analog charm of vinyl while introducing modern automation for improved user convenience.

Our system is built around an ESP32 microcontroller that coordinates three servo motors to physically lift, rotate, and reseat a 7-inch vinyl record. A Hall effect sensor, paired with a magnet mounted on the tonearm, detects when the tonearm returns to its resting position, signaling the end of a record side and initiating the flipping sequence. The system is currently integrated with a Crosley Cruiser Premier turntable, which requires manual tonearm placement, but it has been designed with future adaptability in mind for mid-range players like the Audio-Technica LP60x, which feature automatic tonearm return functionality.

The system is divided into four major subsystems: the power system, which supplies regulated 5V and 3.3V DC voltages; the sensor system, which detects tonearm position; the microcontroller system, which handles all control logic; and the record flipper mechanism, which performs the flipping operation. A block diagram illustrating the system structure is shown in Figure 1.

Key performance requirements from the final proposal include: a flipping time under 25 seconds to minimize playback interruption; flipping accuracy of at least 99.9993%, or 100%, to meet reliability benchmarks inspired by vintage jukebox MTBF values; and precise tonearm detection to prevent mistimed flipping. Over the course of the semester, no major structural changes were made to the block diagram, but adjustments were made to the clamping mechanism, adapter design, and circuit components to improve alignment and prevent vinyl damage. Additionally, a hall effect sensor was used instead of an ultrasonic sensor due to its simplicity. These changes, along with careful sequencing of motor operations to reduce power draw, were critical to achieving smooth and consistent system performance.

1.1 Block Diagram

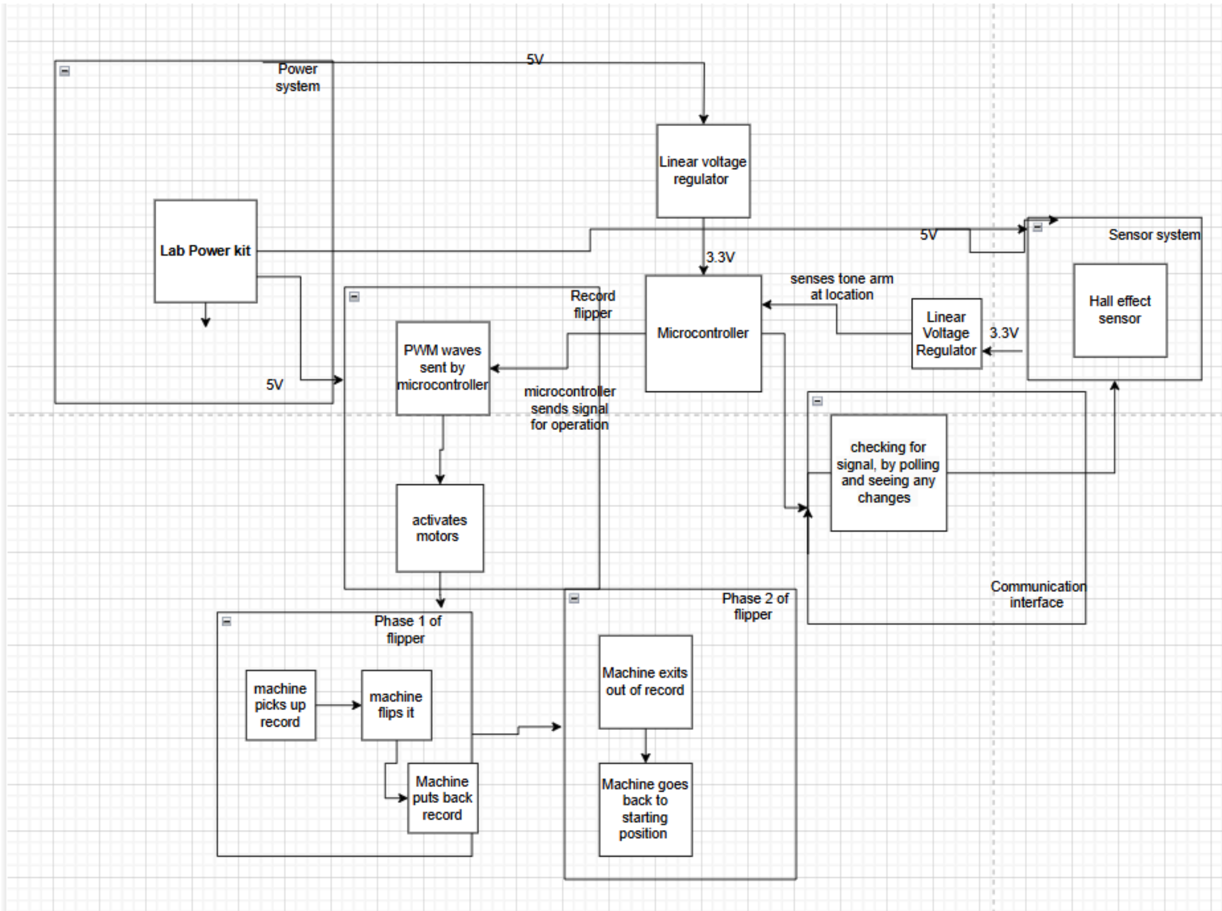

Figure 1: Block diagram overviewing the subsystems of our project and their communication between each other

1.2 Project Visual Aid

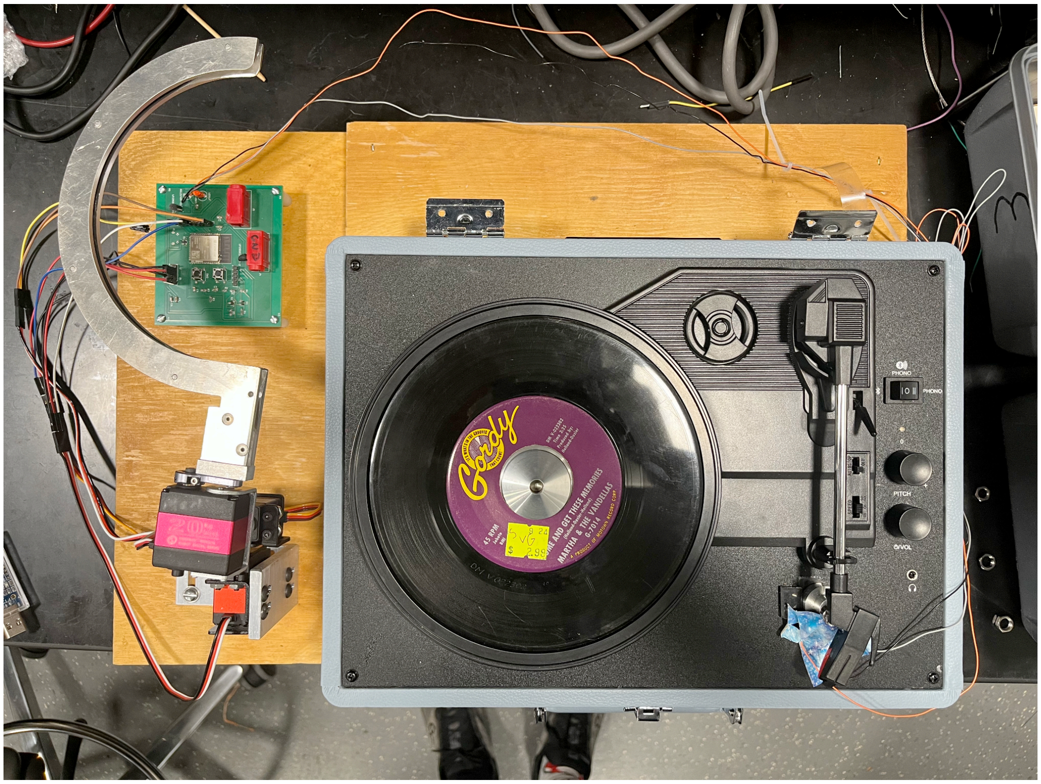

Figure 2: Overhead view of the completed system. Shown here is the Crosley Cruiser Premier record player integrated with the custom PCB, Hall effect sensor mounted near the tonearm, and the three-servo flipping mechanism with clamp assembly.

2. Design

2.1 System Overview

The system is composed of four primary subsystems working in coordination to enable automated vinyl record flipping. The power system provides a regulated 5V DC supply to all components, including the ESP32 microcontroller, servo motors, and the Hall effect sensor, ensuring safe and stable operation. The record flipper subsystem handles the physical flipping process in three stages: gripping the record, lifting and rotating it, and finally reseating it onto the turntable. This process is triggered by the microcontroller once it receives input from the sensor system. The sensor subsystem uses a Hall effect sensor positioned near the tonearm's resting location, detecting when playback has finished via a magnet attached to the tonearm. Upon detection, the sensor sends a signal to the microcontroller, which serves as the central controller for the entire system, managing communication between subsystems and coordinating their operation in a smooth and sequential manner.

2.2 Power Subsystem

The power system is designed to deliver a stable DC voltage of 5V with a variance of ±0.1V to all components of the circuit. This 5V supply is the primary driver of the entire system, powering both the ESP32 microcontroller and the servo motors. While the ESP32 draws relatively low current, each motor can demand a stall current of over 2.1A under load. To ensure stable operation under peak demand, we designed the system to supply up to 2.5A. The lab kit power supply used during testing met these requirements, providing a regulated 5V at 2.5A. To meet the ESP32's operating requirement of 3.3V, we used an LP2950-CZ1 voltage regulator module to step down the 5V rail. In addition, two decoupling capacitors were placed between the power and ground lines—one at the regulator input and one at the output—to suppress voltage ripple and prevent unpredictable behavior from transients or noise.

We verified voltage and current stability through multiple tests. Voltage was sampled every second over a 20-second period using a multimeter connected to the breadboard's power rails. The observed fluctuation remained within ±0.05V, well within the acceptable ±0.1V tolerance. To test thermal stability and sustained load capacity, we operated the DS3235 35kg servo under maximum load conditions for 10 minutes by applying added mechanical resistance. No thermal shutdowns or instability were observed.

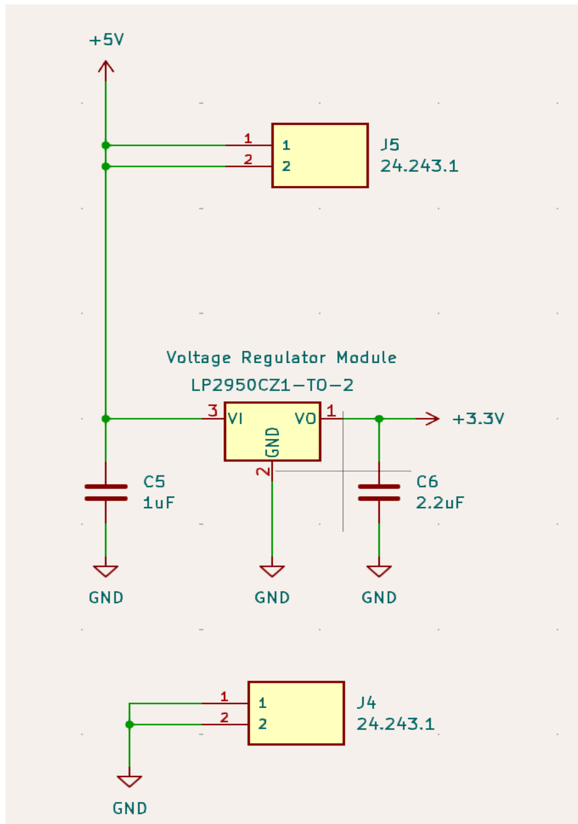

Figure 3: KiCad schematic diagram of power supply

Based on the LP2950-CZ1 datasheet, we selected 1 µF ceramic capacitors on both the input and output to ensure regulator stability and minimize voltage ripple. For additional noise immunity and improved transient response under switching loads from the ESP32, we opted for 10 µF polarized capacitors, which are well within the recommended range. The required minimum output capacitance was confirmed using

$$C = I \cdot \frac{dt}{dV} \quad , \tag{1}$$

yielding approximately 1 µF for a transient current of 100 mA and allowable ripple of 100 mV over 1 µs.

Requirements	Verification
Provide adequate voltage to all components of the circuit.	Multimeter confirmed 5V to motors and 3.3V to ESP32
Supply adequate current (≥ 2.1A)	Lab power supply confirmed to send 5V, 2.5A
Avoid thermal shutdown or instability	10-minute stress test at full load
Maintain voltage stability	Sampled voltage every second for 20 seconds

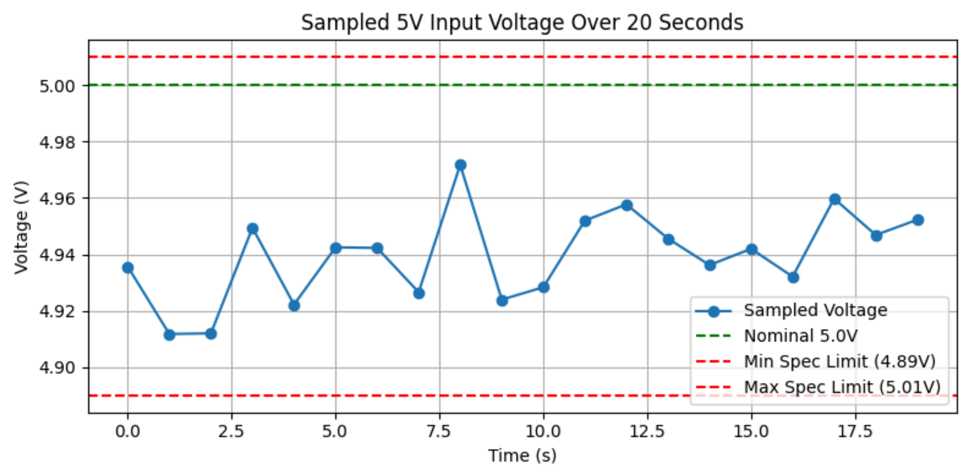

Figure 4: Measuring 5V power rail voltage on breadboard using multimeter

2.3 Record Flipper Subsystem

The record flipper subsystem ensures precise vinyl handling through coordinated servo control and mechanical optimization. Three servos, two Miuzei 20kg and one DSServo 35kg-operate sequentially via ESP32-generated PWM signals (4.8 – 6V range), minimizing peak current draw while executing lifts, rotations, and reseating. The DSServo's 9.4 kg-cm torque reliably drives the record-clamping mechanism, exceeding operational demands. Mechanical challenges in centering records on the turntable were resolved with a custom 45 RPM adapter featuring a steep conical taper, fabricated in collaboration with the mechanical shop. This design passively corrects positional errors during reseating, enhancing repeatability despite servo backlash or minor misalignments. The system balances electrical safety, torque redundancy, and self-aligning geometry for consistent performance.

Requirements	**Verification**
Servo motors must rotate 0° to 180°	PWM signals tested from ESP32 using power supply
Smooth and controlled transitions	Observed gradual motion during PWM modulation
Motors must support the record's weight	Servo lifted and held record repeatedly without slipping
Motors must operate reliably	Flipping process run 50 consecutive times, and multiple testing runs spaced across multiple days
Base must remain stable under load	System held position without shifting or tipping

This subsystem proved to be mechanically reliable and robust under repeated use, meeting all functional and safety requirements necessary for consistent, damage-free record flipping. The full flipping sequence was completed in approximately 17 seconds, well below our 25-second threshold for an uninterrupted user experience. However, during testing, we observed that the bare metal clamp occasionally caused minor surface scratches on the vinyl. While these did not affect playback, such imperfections are undesirable for vinyl enthusiasts. To address this, future iterations of the clamp will incorporate a wider insert and add a rubber lining to provide a softer, more protective grip on the record surface.

2.4 Sensor Subsystem

This subsystem will consist of a sensor that will be located right above the tone arm and will be able to detect when the tone arm is at its rest position to signal the flipper to begin operation. From the data sheet, it is apparent that the sensor **HAL-214** contains three pins, one for V_{DD} (supply voltage), one for the GND (ground), and lastly, one for the V_{OUT} (which is for the output voltage). The sensor system will be powered by the power system, receiving the nominal voltage of 5V which will be attached to the V_{DD} pin of the sensor. Once the sensor has received a strong enough magnetic signal (around 150 Gauss), the output voltage (V_{OUT}) will match that of the input voltage (V_{DD}). We plan on attaching a disc shaped $\frac{3}{8}$ $inch$ diameter, $\frac{1}{4}inch$ thick grade N52 magnet to the tone arm, which will act as the signal emitter for the Hall effect sensor to know when the tone arm is at its resting position. The magnet will emit a magnetic field of 151 Gauss when it is within $\sim\ 0.62\ inches$ from the sensor by using the calculator[6], and anything below that distance will result in a higher magnetic field, meaning that the sensor will be activated. We do not have to worry about any higher magnetic field, as the sensor does not have a maximum operating limit of magnetic field per the datasheet. For the magnet, we propose to use the PO - P1315208 Bob Wallace, 3/8 x 1/4 Neodymium Magnet (available in the ECEB workshop store) which should have a weight of approximately 0.01 lbs, light enough to be attached to the tone arm without hindering its performance. In the end, we hope to have the Hall effect sensor receive a signal from the tone arm's magnet which will then send a signal to the microcontroller by first converting the 5V output into 3.3V using a linear voltage regulator, telling it that the tone arm is at its resting position and to begin the operation for the record flipper.

There should not be any interference from the electronic components of the vinyl record player flipper to the sensor, thus the sensor will not accidentally trigger. This is because the sensor needs a minimum 50 Gauss magnetic field to activate at room temperature and since every component we are using for the project uses low current (at most 2.5A for the motors), the magnetic field produced by the electronic components will be much less than the minimum field required by the sensor to activate. Accounting for the distance between the electronic components and the sensor, which will be about a dozen inches or even more, we know that the great distance weakens the magnetic field signal output from the electronic components, thus we can safely assume that the distance will negate any magnetic field from the electronic components to the sensor. There are also no other magnets found within the vinyl player that can give off a strong enough signal to falsely trigger the sensor, so we can be sure there will be no accidental triggering.

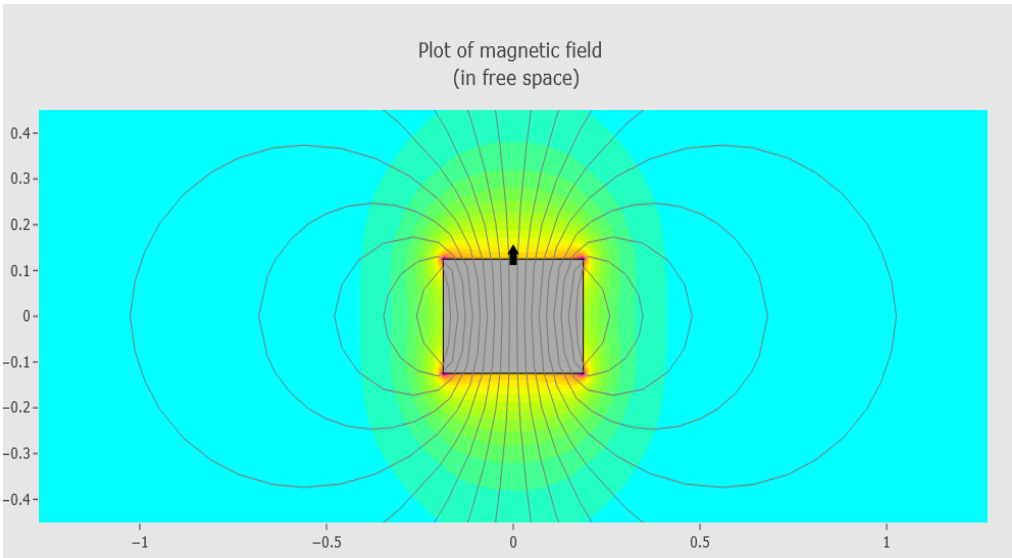

Figure 5: Showing the magnetic field of our magnet with varying distances (in inches)

Requirements	**Verification**
The sensor is able to detect when the tone-arm’s magnet is within a reasonable distance (< one inch) to detect the record has finished playing.	The record finished playing and the tone-arm is in its resting position when the signal to begin operation begins.
Ensure the sensor does not send a signal to begin operation when the tone-arm is not in its resting position.	The sensor does not have any false triggering from any unwanted magnetic fields imposed on it other than the magnet attached to the tone-arm which determines the tone-arm is in its resting position.

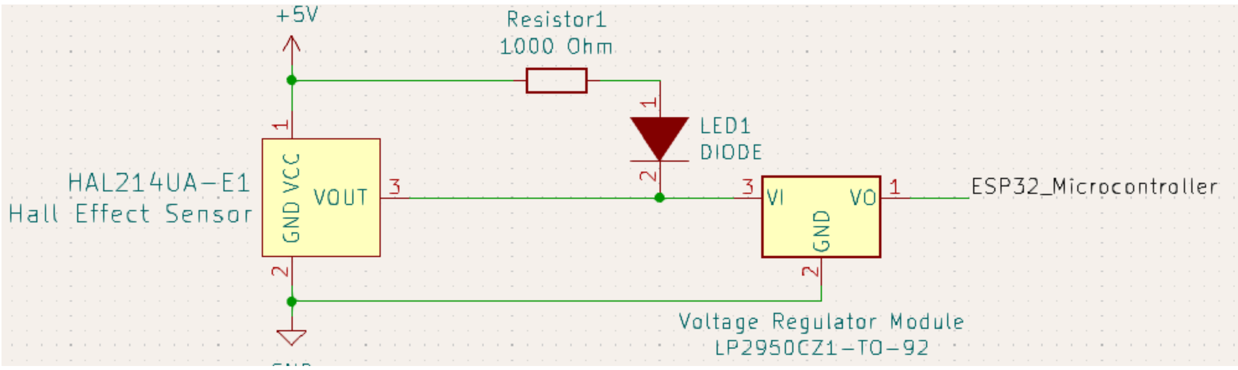

Figure 6: Hall-Effect sensor circuit

2.5 Microcontroller system

The ESP32-S3-WROOM-1 microcontroller, operating on the system's regulated 3.3V supply, serves as the central controller for the record flipper. It generates PWM signals through GPIO pins 15, 16, and 18 to drive three servo motors, utilizing the ESP32Servo library within the Arduino IDE environment. GPIO5 is designated for input from the Hall effect sensor, which detects when the tonearm reaches its resting position. Upon detection, the microcontroller initiates a pre-programmed flipping sequence by issuing PWM signals to the servos. Each servo is initialized from a calibrated "home" position to ensure consistent mechanical alignment during each cycle. This configuration enables rapid response times of less than two seconds between sensor activation and servo movement, supporting both precise timing and reliable actuation. The system is fully compatible with the voltage and control requirements of the Miuzei 20 kg and DSServo 35 kg motors, ensuring robust operation across all components.

Requirements	**Verification**
Generate correct PWM signals to control servos	Connect the microcontroller to the powered system and observe PWM output on GPIO pins using an oscilloscope. Confirm adjustable pulse widths corresponding to

	expected servo angles.
Receive input signal to trigger flipping sequence	Apply a test signal to the Hall effect sensor input (GPIO5) and verify that the microcontroller registers the input and initiates the servo control sequence.
Ensure consistent and repeatable servo movement	Program the flipping sequence and run it repeatedly. Confirm that the servos follow the expected motion path—grabbing, lifting, flipping, and reseating the record—without deviation across multiple trials.
Return to accurate starting (home) position after each cycle	Test the microcontroller's ability to return each servo to its pre-defined home position at the end of each cycle. Repeat multiple runs to ensure consistent alignment for reliable operation in consecutive flips.

3. Cost Analysis

3.1.1 Individual Components

Walmart:

Component (quantity)	Manufacturer	Cost ($)	Link
Vinyl record player (1)	Crosley	$35	Link

Record Swap:

Component (quantity)	Manufacturer	Cost ($)	Link
7-inch vinyl record (2)	Scepter Records	$2.5 ea. (total $5)	N/A

ECEB Workshop:

Component (quantity)	Manufacturer	Cost ($)	Link
Miuzei 20KG Servo Motor High Torque RC Servo motors (1)	Miuzei	Workshop lent	Link
DSservo DS3235 35KG (2)	Stemedu	Workshop lent	Link

ECEB Self-Service Shop:

Component (quantity)	Manufacturer	Cost ($)	Link

Digikey:

Component (quantity)	Manufacturer	Cost ($)	Link
ESP-32-WROOM1-N16R8(6)	Atmel	SMD Request	SMD Request
BES-100	Omron Electronics	$0.57	Link
M20-9990546	Harwin Inc	$0.20	Link
M20-9990945	Harwin Inc	$0.41	Link
SP0503BAHTG	Littlefuse.Inc	$0.63	Link
10118194-0001LF	Amphenol ICC (FCI)	$0.41	Link
SS8050-G	Comchip Technology	$0.24	Link

ECE Supply Center Shop:

Component (quantity)	Manufacturer	Cost	Link
PO - P1315208 Bob Wallace ⅜ x ¼ Neodymium magnet (1)	Bob Wallace	$2.99	Link

Amazon:

Component (quantity)	Manufacturer	Cost	Link
24.243.1 PCB, SOCKET, 4MM,RED	Multicomp	$4.72	Link

3.1.2 Labor Cost

The average salary of an Electrical or Computer Engineering bachelor's degree graduate of University of Illinois at Urbana-Champaign is about $98,473 (average salary between electrical engineering and computer engineering majors per the 2021-2022 academic year).

The project length starting from the fourth week of the semester (when the team contract was finalized) is until the final demonstrations is about two months and a week length, for the sake of simplicity, we will round the work length to two months as the team will not work on some days due to examinations and/or religious observances. Considering the salary of a UIUC ECE graduate is $98,473 yearly, which translates to about $8,206 monthly, the labor cost of employing three UIUC ECE graduates to work on this project for two months would equate to:

$8,206 (monthly salary) * 3 (three employees) * 2 (two months labor time) = $49,236

The combined cost of the entire project with the projected student labor cost and component cost comes to about $$50.17 for the individual purchased components and $49,236 for anticipated labor costs which totals to $49,286.17

4. Ethics and Safety

4.1 Safety

Our project design incorporates a linear DC voltage regulator, and due to the presence of risks associated with overheating and potential fires due to said regulator, we've decided to adopt a set standard of safety when handling the power subsystem component of the overall design. For our project, we will be implementing the 1100 IEEE Emerald Book standard for handling the powering and ground electronic equipment, which should provide adequate guidelines for a safe and robust power system, reducing downtime, failures and electrical hazards which may be present in the project.

Throughout the creation, testing, and finalization of the project, we will be adhering to the University of Illinois' laboratory safety guidelines which prioritize proper handling of electronic components and safe usage of said material. As part of Illinois' safety guidelines, we will be conducting all laboratory work with the proper personal protective equipment (PPE) and ensure proper storage of all project components in the storage area allocated for the team for this semester.

4.2 Ethics

We assert that this team will maintain intellectual and ethical honesty in our endeavors. In accordance with IEEE code (IEEE), section 1, parts 1-6, we will not by any means cut any corners and we will use the most accurate data we note down. If any behaviors happen that would benefit the individual, team, or project but also hinder the progress of society, they will be discarded in favor of honest work towards the betterment of society. Specifically noting down, we will "seek, accept, and offer honest criticism of technical work, [acknowledge] and correct errors, [be] honest and realistic in stating claims or estimates based on available data, and [credit] properly the contributions of others", to quote the IEEE code of ethics.

5. Conclusion

The Automatic Vinyl Record Flipper successfully addresses a key limitation of vinyl record players by automating the record-flipping process, enabling seamless transitions between sides without interrupting the listening experience. The system integrates four subsystems—power, record flipping, sensor, and microcontroller—all working together to perform accurate and synchronized flipping. The final prototype demonstrated consistent, reliable performance, completing a full flip in just 17 seconds, well below the 25-second threshold established through user testing, and achieving 100% operational accuracy during repeated trials. While the system met all core functional requirements, minor design issues such as superficial scratching of records were noted due to the bare metal clamp. Future improvements include adding a rubber lining and increasing the clamp's contact area to better protect the vinyl. Overall, this project delivers a cost-effective, modular solution that enhances the traditional vinyl listening experience with modern automation, offering a compelling intersection between analog audio and digital convenience.

6. References

1. IEEE. "IEEE - IEEE Code of Ethics." www.ieee.org, https://www.ieee.org/about/corporate/governance/p7-8.html. Accessed 12 February, 2025.

2. Statista. (n.d.). LP sales in the United States. Statista. Retrieved February 12, 2025, from https://www.statista.com/chart/7699/lp-sales-in-the-united-states/

3. GlobeNewswire. (2024, August 8). Vinyl records business report 2023-2030: Market to grow by $900 million; Growth of collectible and limited edition vinyl releases spurs dynamics. GlobeNewswire. Retrieved February 12, 2025, from https://www.globenewswire.com/news-release/2024/08/08/2927039/0/en/Vinyl-Records-Business-Report-2023-2030-Market-to-Grow-by-900-Million-Growth-of-Collectible-and-Limited-Edition-Vinyl-Releases-Spurs-Dynamics.html

4. Quora. (n.d.). *Did people who bought vinyl singles get sick of having to stand in front of the record player and flip each record over after the song was done to hear the B-side and then have to change the record to hear the next?* Quora. Retrieved February 12, 2025, from https://www.quora.com/Did-people-who-bought-vinyl-singles-get-sick-of-having-to-stand-in-front-of-the-record-player-and-flip-each-record-over-after-the-song-was-done-to-hear-the-B-side-and-then-have-to-change-the-record-to-hear-the-next

5. Honeywell. (2015, October). Low Gauss, Bipolar Digital Hall-effect Sensor ICs: SS41 (PK 87881) Datasheet. Honeywell. Retrieved February 12, 2025, from https://prod-edam.honeywell.com/content/dam/honeywell-edam/sps/siot/en-us/products/sensors/magnetic-sensors/bipolar-position-sensor-ics/common/documents/sps-siot-bipolar-digital-hall-effect-sensor-ic-installation-instructions-ss41-pk87881-6-en-ciid-50342.pdf?download=false

6. K&J Magnetics, Inc. (n.d). Magnetic Strength Calculator. K&J Magnetics, Inc. Retrieved February 12, 2025, from https://www.kjmagnetics.com/magnet-strength-calculator.asp

7. Applied Magnets Superstore, (n.d) N52 Neodymium Magnets 3/8 in x 1/4 in Rare Earth Disc. Applied Magnets Superstore. Retrieved February 12, 2025, from https://appliedmagnets.com/n52-neodymium-magnets-3-8-in-x-1-4-in-rare-earth-disc/

8. Audio Karma, (n.d) Turntable centre spindle size/thickness? Audio Karma. Retrieved February 13, 2025, from https://audiokarma.org/forums/index.php?threads/turntable-centre-spindle-size-thickness.515619/

9. RECORD INDUSTRY ASSOCIATION OF AMERICA, INC. (October 16, 1963) STANDARDS FOR STEREOPHONIC DISC RECORDS. Retrieved February 13, 2025, from http://www.aardvarkmastering.com/riaa.htm

10. Interalloy Australia. (n.d) Tolerance Tables. Retrieved February 13, 2025, from http://www.interlloy.com.au/wp-content/uploads/2015/04/Tolerances2015.pdf

11. Physics department, University of Connecticut. (n.d) Critical Bandwidths and Just-Noticeable Differences. Retrieved February 13, 2025, from https://www.phys.uconn.edu/~gibson/Notes/Section7_2/Sec7_2.htm#:~:text=Between%20these%20two%20mechanisms%2C%20the,is%20about%200.5%25%20or%200.005

12. Wikipedia. (n.d) Phonograph record. Retrieved February 13, 2025, from https://en.wikipedia.org/wiki/Phonograph_record

13. ServoDatabase. (September 16, 2025) TowerPro MG996R Servo Specifications. Retrieved February 13, 2025, from

https://servodatabase.com/servo/towerpro/mg996r

14. IEEE Xplore. (May 24, 2006). 1100-2005 - IEEE Recommended Practice for Powering and Grounding Electronic Equipment. Retrieved February 13, 2025, from https://ieeexplore.ieee.org/document/1638205

15. Ali Express. (n.d) XL4016 data sheet. Retrieved March 7, 2025, from https://ja.aliexpress.com/item/1005007519923629.html?channel=twinner

16. BMI Gaming, (n.d.). Discontinued Jukebox Machines. BMI Gaming. Retrieved March 6, 2025, from https://www.bmigaming.com/Discontinued/discontinued-jukebox-machines.htm

17. Tinuiti, (n.d.). Spotify Ads: Everything You Need to Know. Tinuiti. Retrieved March 6, 2025, from https://tinuiti.com/blog/tv-audio/spotify-ads/

18. Peak Vinyl, (n.d.). Record Playtimes. Peak Vinyl. Retrieved March 6, 2025, from https://peakvinyl.com/record-playtimes/

19. RC Art CB, (n.d.). Miuzei 20kg Servo Motor - High Torque Digital Servo, Waterproof. RC Art CB. Retrieved March 6, 2025, from https://rcart-cb.com/products/miuzei-20kg-servo-motor-high-torque-digital-servo-metal-waterproof-1-10-scale-servo-for-r-c-car-robot-ds3218-control-angle-270

20. Amazon, (n.d.). Waterproof Coreless DSSERVO Stainless Climbing Servo. Amazon. Retrieved March 6, 2025, from https://www.amazon.com/Waterproof-Coreless-DSSERVO-Stainless-Climbing/dp/B0D4YKK4YQ#productDetails

21. Amazon, (n.d). Dell DA130PE1-00 Power Adapter JU012-PA-4E. Amazon. Retrieved March 7, 2025, from https://www.amazon.com/da130pe1-00-power-adapter-supply-charger/dp/B00C2BYGWI

7. Appendix A

Requirements	**Verification**	**Result**
Provide adequate voltage to all components of the circuit.	Multimeter confirmed 5V to motors and 3.3V to ESP32	Pass – stable voltage observed
Supply adequate current (≥ 2.1A)	Lab power supply confirmed to send 5V, 2.5A	Pass – no current limitation or shutdown
Avoid thermal shutdown or instability	10-minute stress test at full load	Pass – no overheating or power failure
Maintain voltage stability	Sampled voltage every second for 20 seconds	Pass – fluctuation within ±0.05V
Servo motors must rotate 0° to 180°	PWM signals tested from ESP32 using power supply	Pass – full rotation range achieved
Smooth and controlled transitions	Observed gradual motion during PWM modulation	Pass – no jitter or erratic motion
Motors must support the record's weight	Servo lifted and held record repeatedly without slipping	Pass – no slippage or strain observed
Motors must operate reliably	Flipping process run 50 consecutive times, and multiple testing runs spaced across multiple days	Pass – consistent operation without failure
Base must remain stable under load	System held position without shifting or tipping	Pass – no shifting or instability

The sensor is able to detect when the tone-arm's magnet is within a reasonable distance (< one inch) to detect the record has finished playing.	The record finished playing and the tone-arm is in its resting position when the signal to begin operation begins.	Pass – triggers reliably at expected proximity
Ensure the sensor does not send a signal to begin operation when the tone-arm is not in its resting position.	The sensor does not have any false triggering from any unwanted magnetic fields imposed on it other than the magnet attached to the tone-arm which determines the tone-arm is in its resting position.	Pass – no false positives recorded
Generate correct PWM signals to control servos	Connect the microcontroller to the powered system and observe PWM output on GPIO pins using an oscilloscope. Confirm adjustable pulse widths corresponding to expected servo angles.	Pass – duty cycles aligned with servo positions
Receive input signal to trigger flipping sequence	Apply a test signal to the Hall effect sensor input (GPIO5) and verify that the microcontroller registers the input and initiates the servo control sequence.	Pass – trigger consistently initiates flip

Ensure consistent and repeatable servo movement	Program the flipping sequence and run it repeatedly. Confirm that the servos follow the expected motion path—grabbing, lifting, flipping, and reseating the record—without deviation across multiple trials.	Pass – accurate and repeatable motion
Return to accurate starting (home) position after each cycle	Test the microcontroller's ability to return each servo to its pre-defined home position at the end of each cycle. Repeat multiple runs to ensure consistent alignment for reliable operation in consecutive flips.	Pass – alignment maintained between cycles