Electronic Page Turner

ECE 445 Presentation

Team 7

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Problem

- Reading and multitasking can be difficult
  - Cooking using a cookbook
  - Playing an instrument

Problems of Existing Solutions

- Limited pages
  - Only turns 10 pages in one direction
- Extensive setup
  - Must attach individual pages to the device
- Expensive
  - Can exceed over $500

High Level Requirements

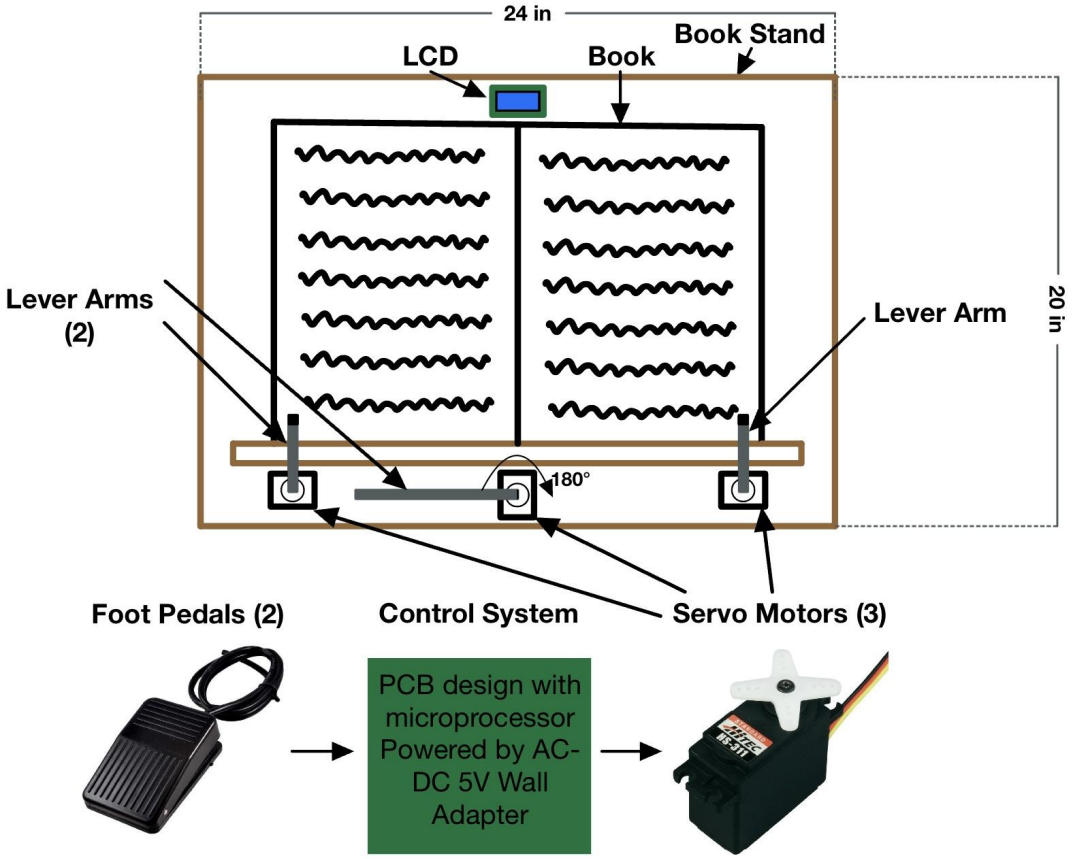
- The device must be able to turn one page within 5 seconds ± 2 seconds. This motion should be repeatable for turning a page backward.

- The device must be able to turn at least ten consecutive pages, with 95% ± 5% accuracy, and take at most 1 minute ± 10 seconds when the foot pedal is pressed consecutively.

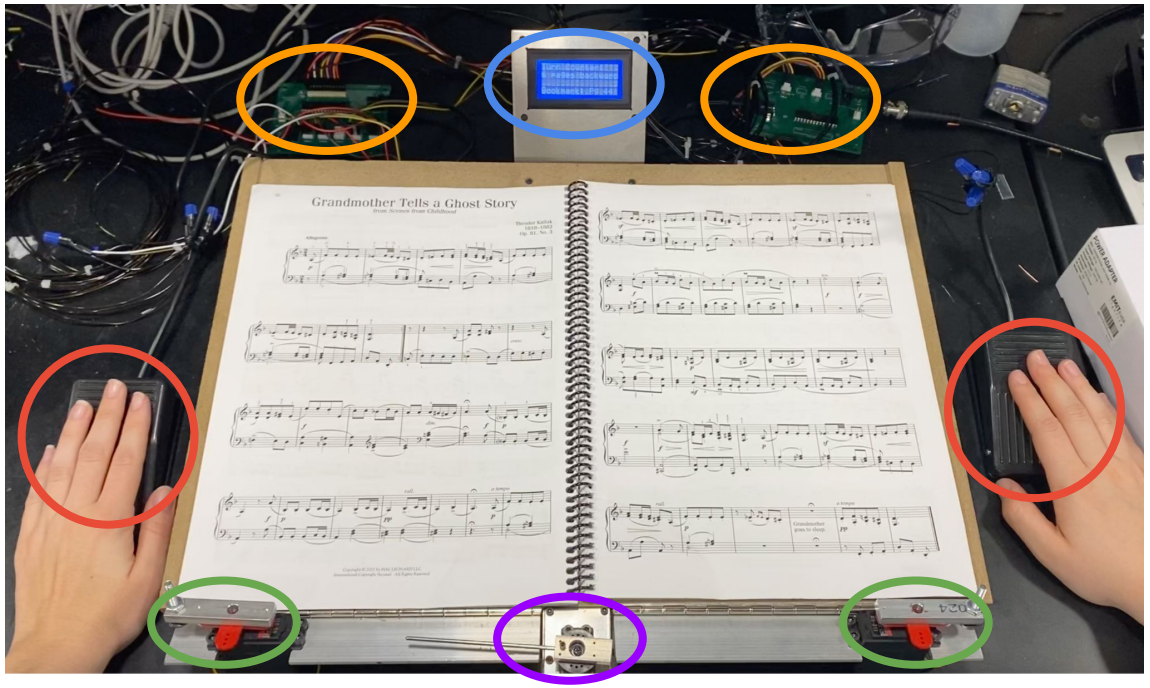
- The device must be able to store the total number of pages turned in a single sitting, with 95% ± 5% accuracy, and display this information to the reader.

Project Images

Design Sketch

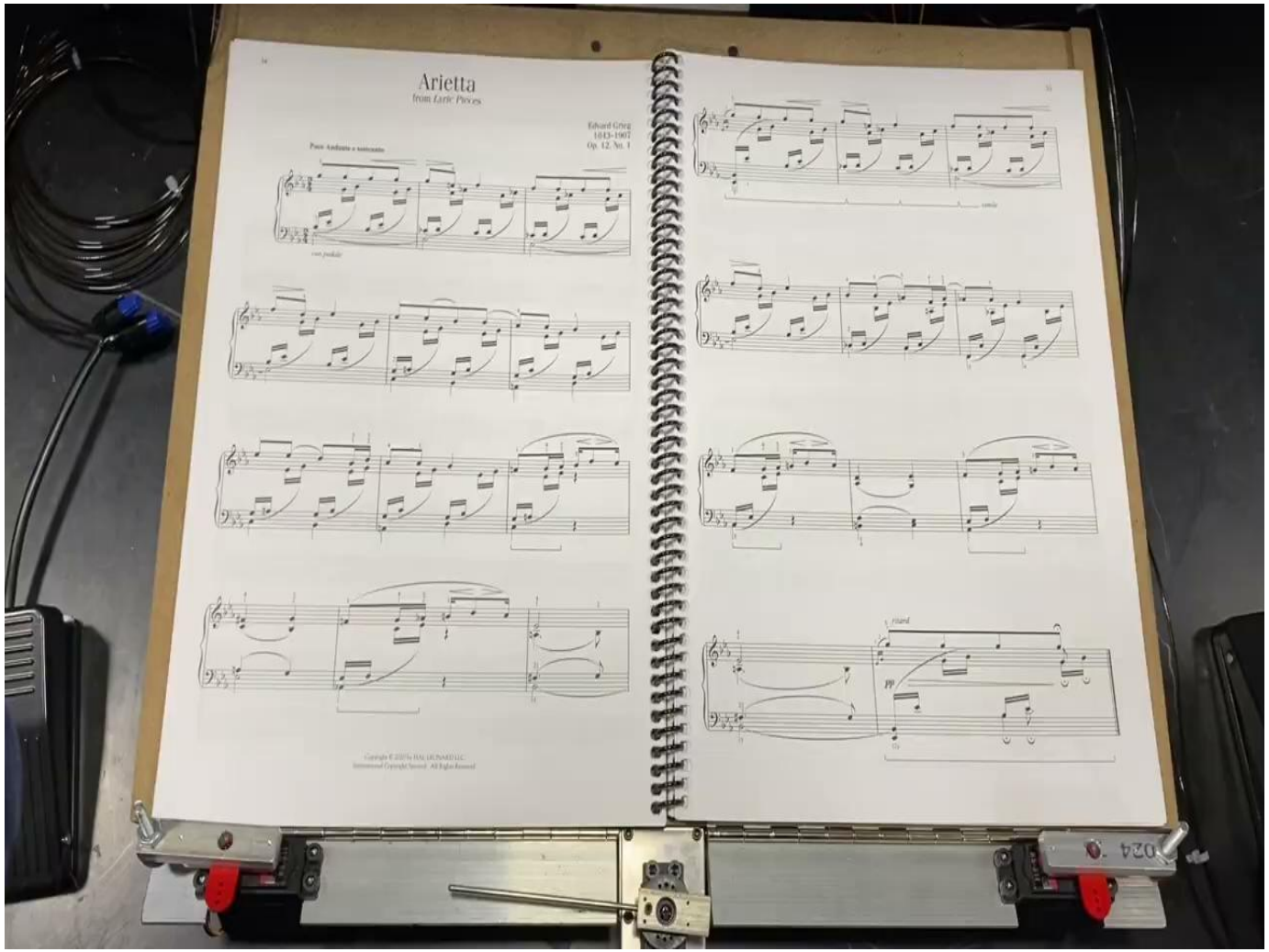


Physical Device



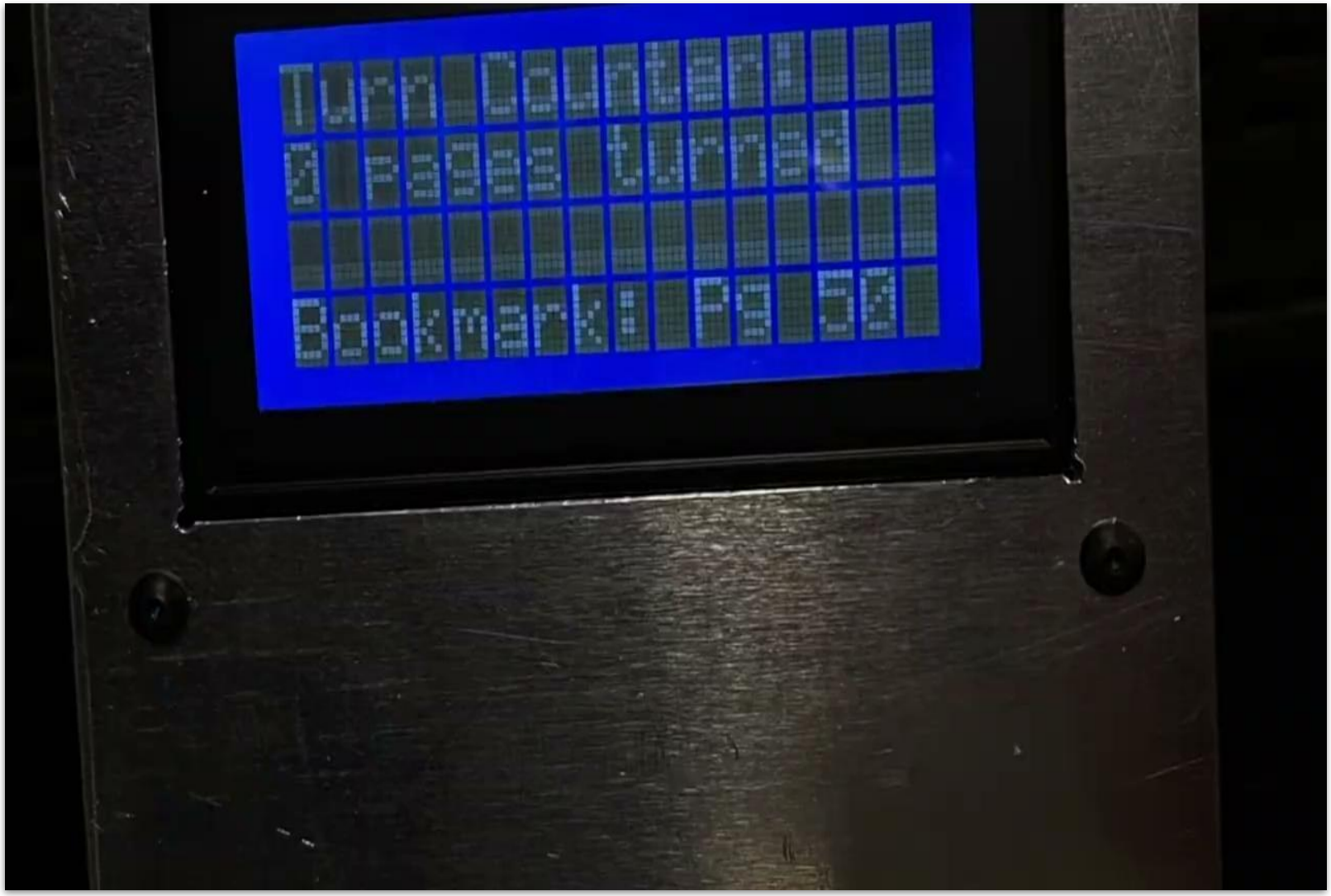
Foot Pedals | User Interface | PCB'S | Lifting Motors | Turning Motor

Functionality



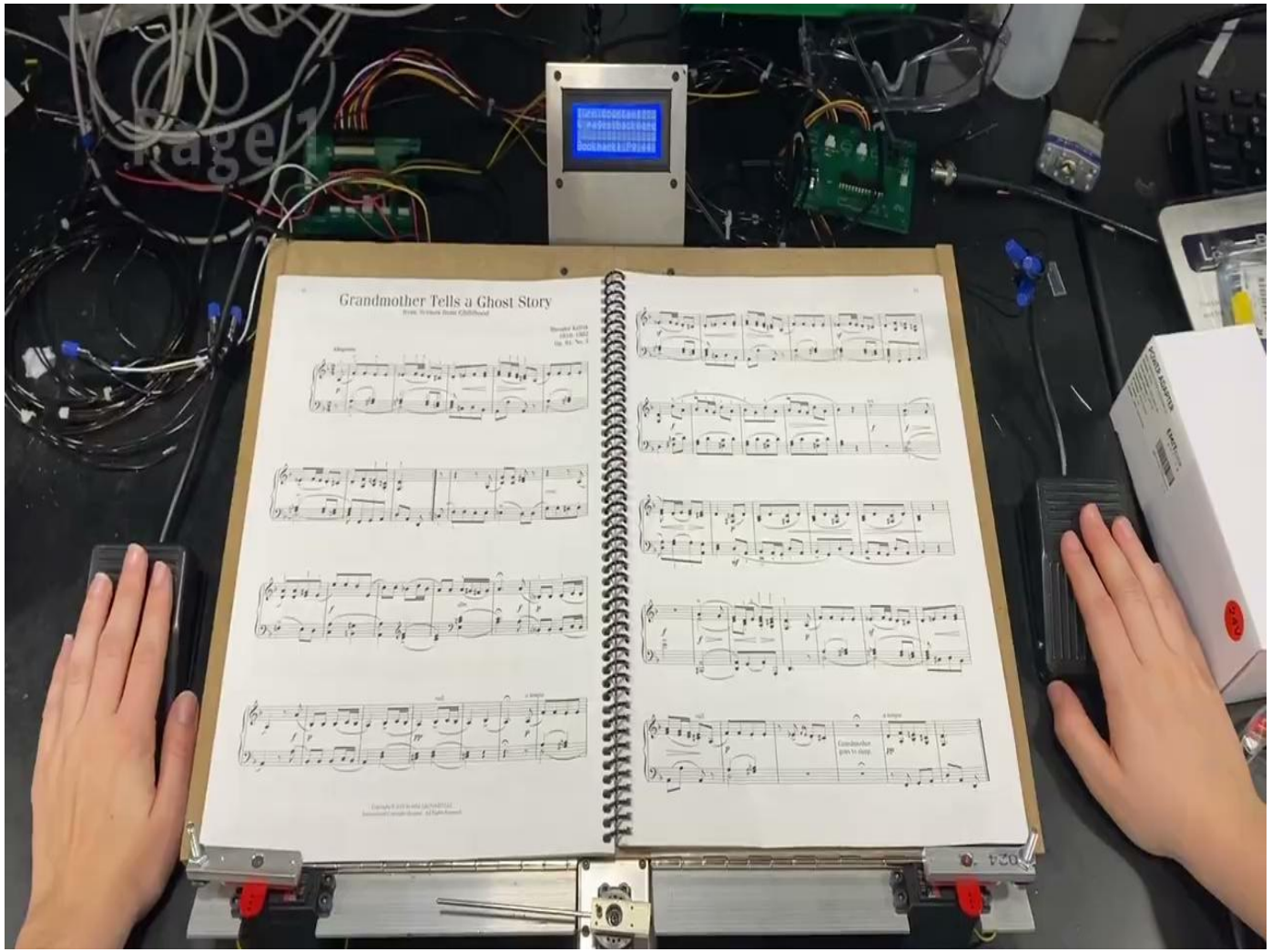
One Page Forward and One Page Backward

Functionality



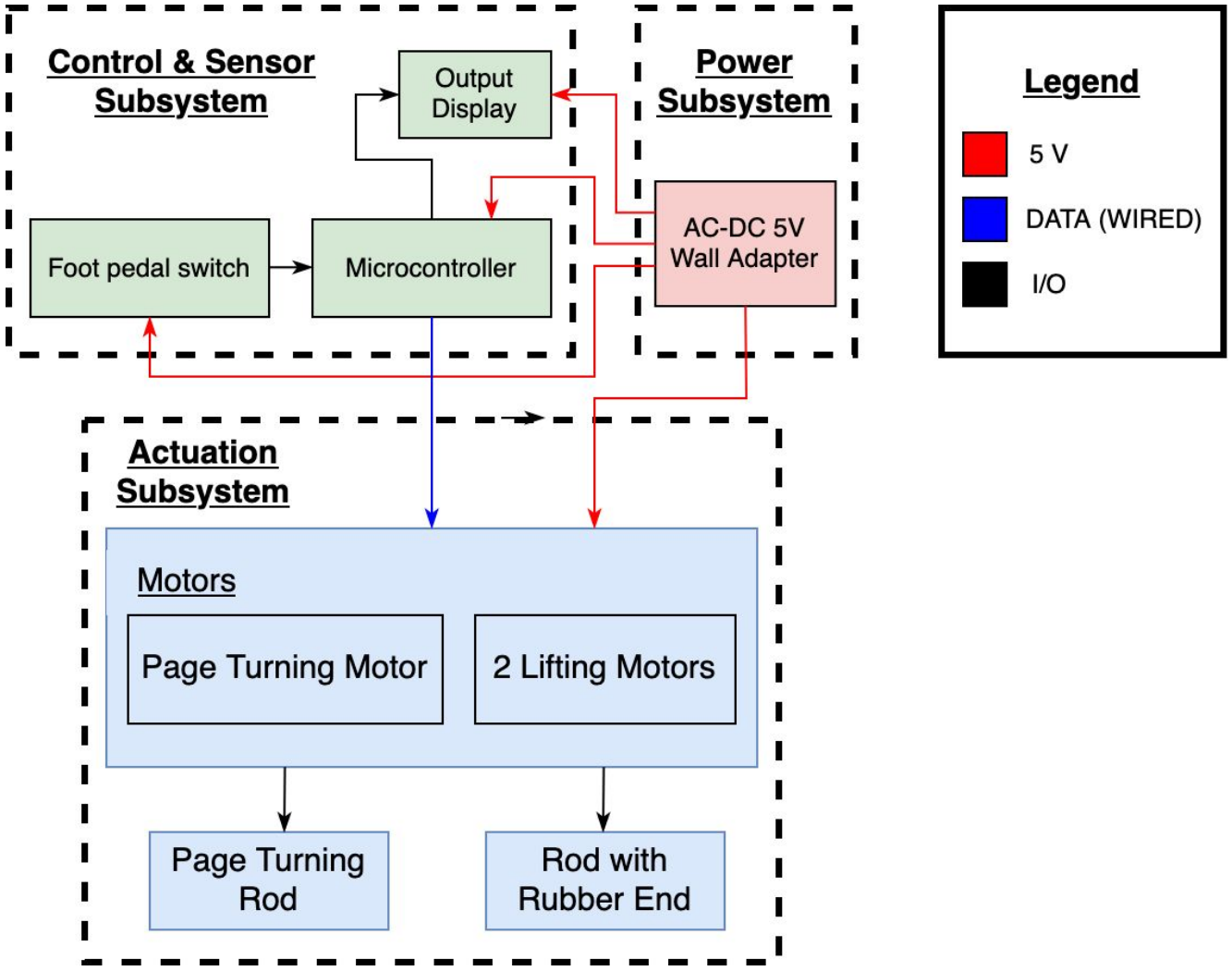
LCD Output

Short Demo Video



10 Consecutive Pages in 1 Minute

Block Diagram

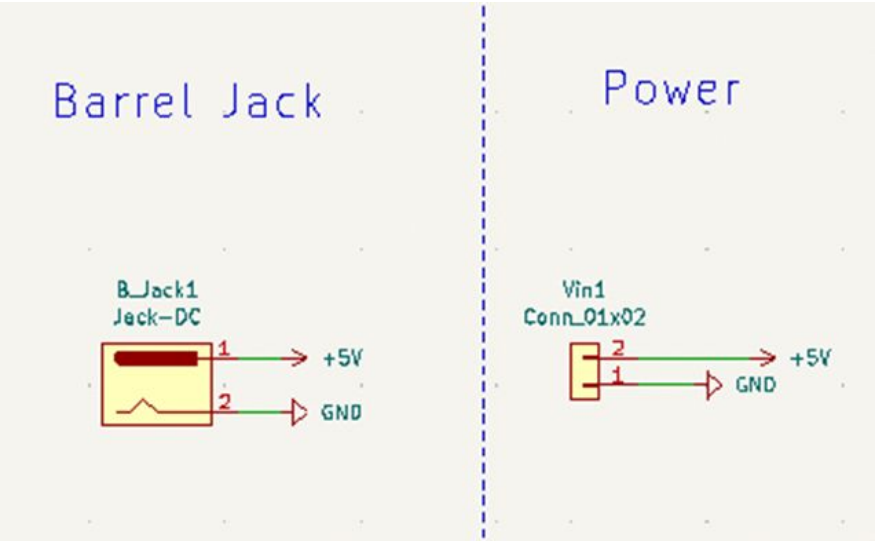


Three Subsystems: Power, Actuation, and Control & Sensors

Power Subsystem

Adia Radecka

Power Subsystem



Requirements	Verification
• Must have a 5V wall adapter that plugs into a wall outlet. • All components on the PCB must be supplied with 5 V ± 5%, when the device is idle and active.	• Use a multimeter to check that the wall adapter barrel jack is supplying 5V ± 5%. • Measure the voltage across each component using an oscilloscope. Repeat this process when a foot pedal is pressed.

5V AC-DC Wall Adapter

- Supplied 5V ± 5% DC to all components

Component	Mean Idle Voltage (V)	Mean Active Voltage (V)
Power Adapter	5.215	5.185
Left Motor	5.215	5.175
Center Motor	5.140	5.120
Right Motor	5.130	5.130
Microcontroller	5.200	5.150
Left Foot Pedal	5.200	5.170
Right Foot Pedal	5.145	5.135
Liquid Crystal Display (LCD)	5.200	5.140

Oscilloscope Testing Data

Challenges

Power Design Issues

9V Li-ion Batteries

- Batteries have internal resistance
- Active motors drain more current
- Causes the actual voltage supplied to drop

Buck Converter (DC-DC converter)

- Originally using a 12V wall adapter
  - Foot pedals needed 12V
  - Motors needed 6V
  - Microcontroller needed 3.3V

Solution

- 5V wall adapter and chose components that operate at 5V

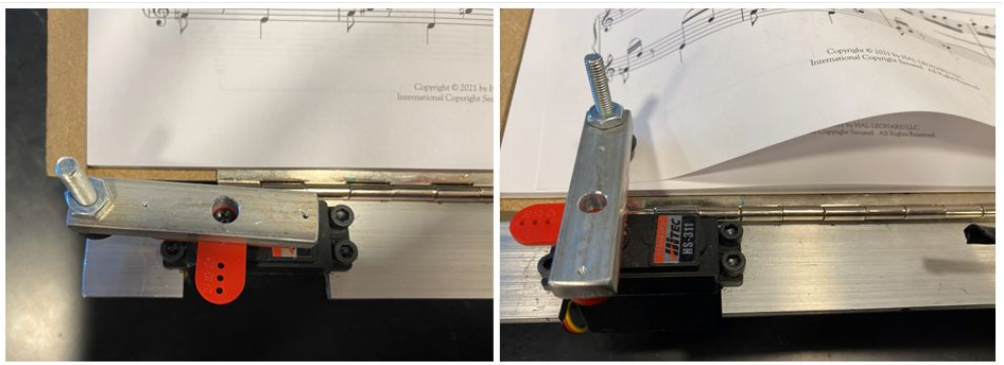
Actuation Subsystem

Alyssa Bradshaw

HiTEC HS-311 Servo Motors (3)

Operating Voltage Range	4.8 - 6.0 V
Range of Motion	0-180°

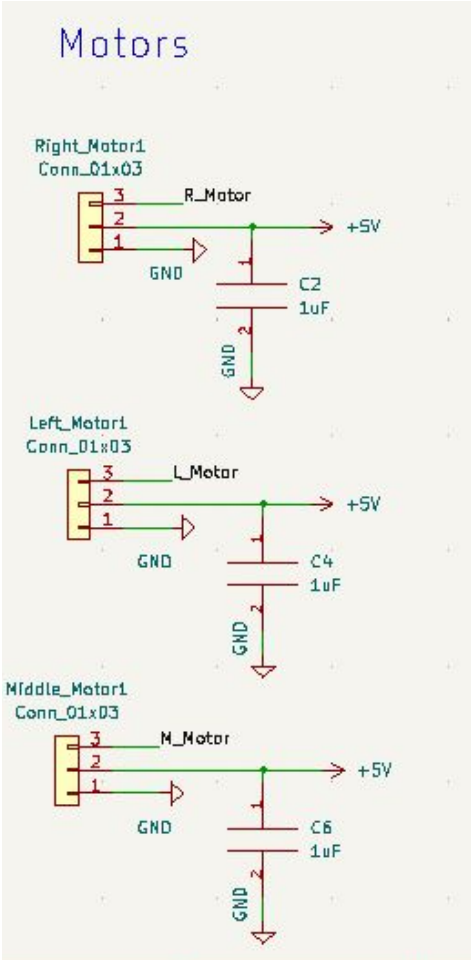
Lifting Motor(2)



Sweeping Motor

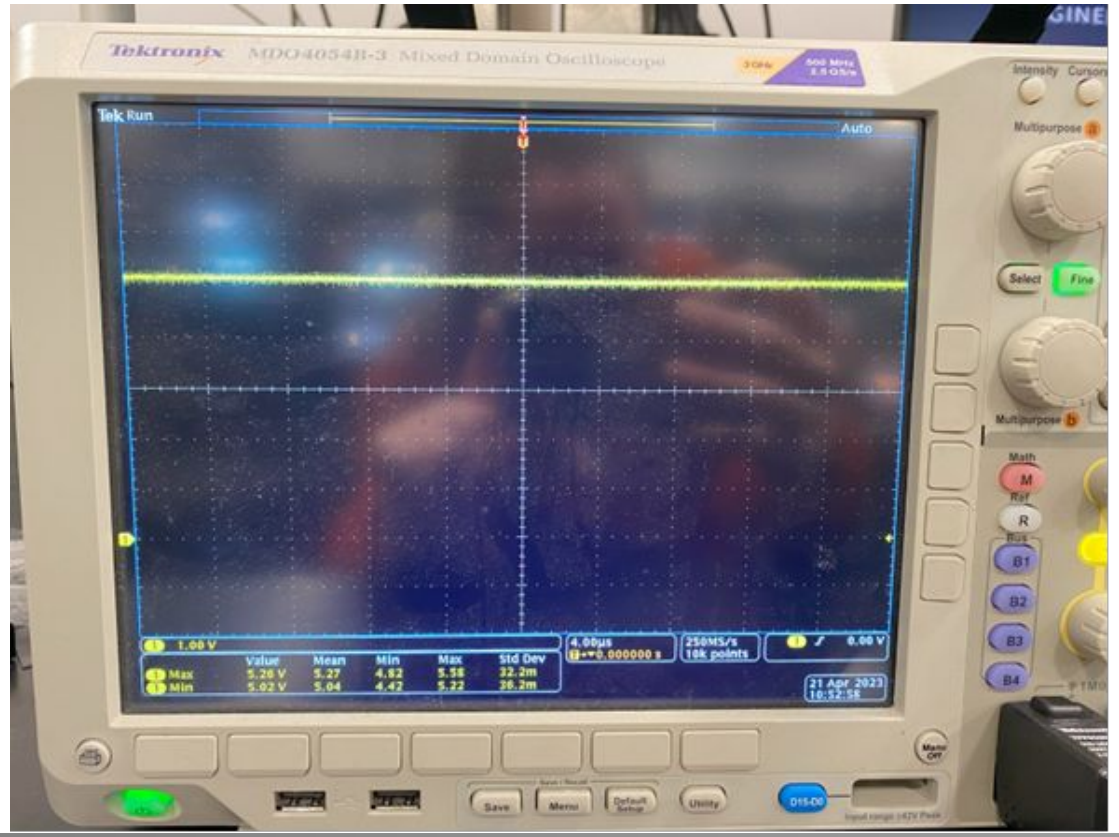
Actuation Subsystem

Requirement	Verification
• The servo motors must create negligible backwards EMF. • The motors should cause minimal to no damage or tearing to the pages in the book.	• Use an oscilloscope to plot the voltage of a motor when idle and when active. If the voltage spike is less than 1V ± 0.5V, we can consider the backwards EMF from the motor to be negligible. • Run 10 test trials to find the best angle and speed for each motor.

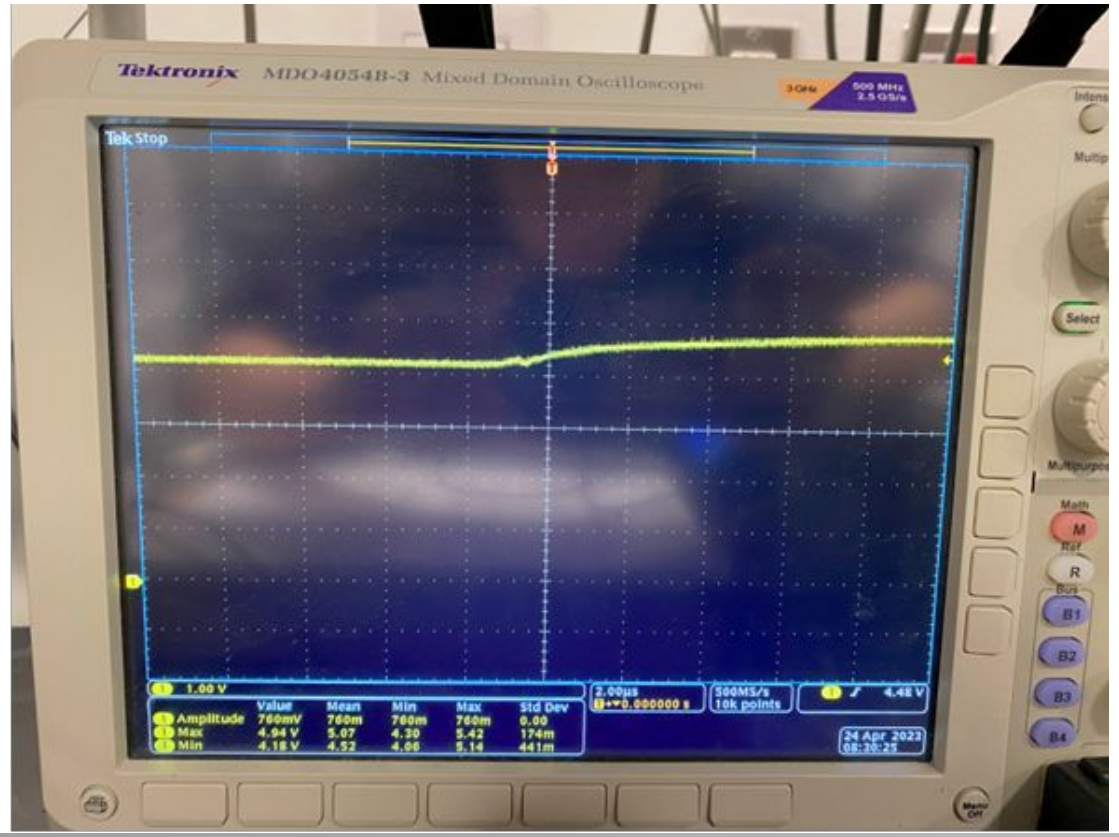


Oscilloscope Testing - Negligible Backwards EMF

Steady 5 Volts



Voltage Drop of 760 mV



Challenges

Original Design Issues

PCB Issue (1)

- Initially right motor would not work when connecting all components to one PCB

Solution

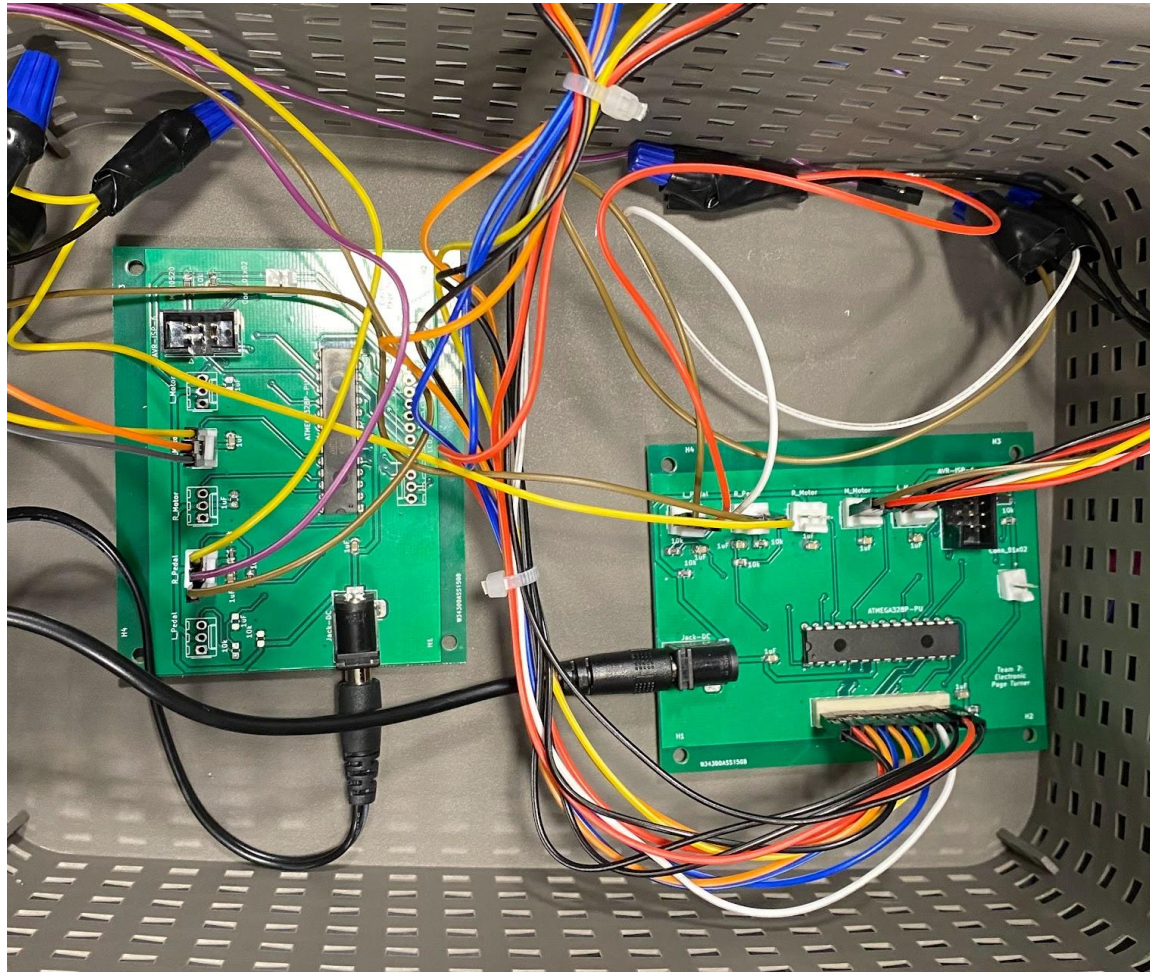
- Used a second PCB to control this motor
  - Two separate programs for each MCU
  - Center and right motor had to be in sync
- Better approach
  - 1 PCB with two Microcontrollers

PCB Issue (2)

- Right motor stopped working on 2nd PCB

Solution

- Rewired all connections
- Soldered a new 2nd PCB

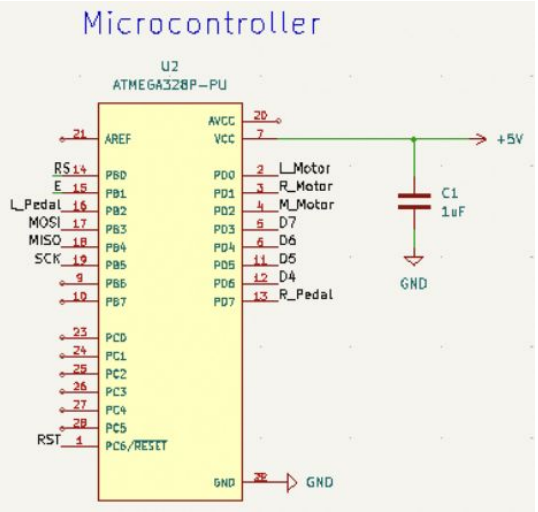


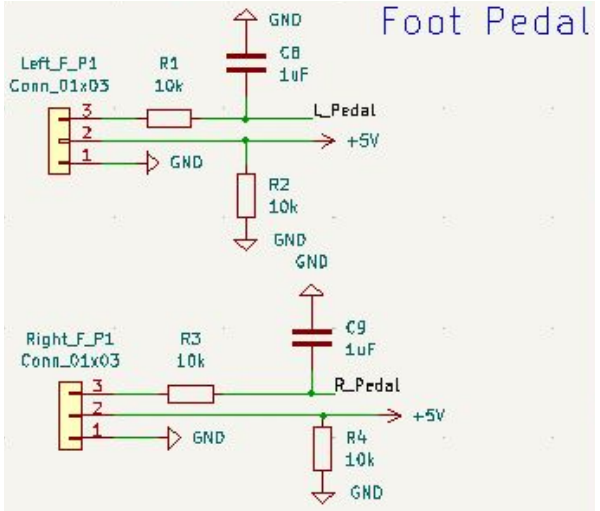
Control & Sensor Subsystem

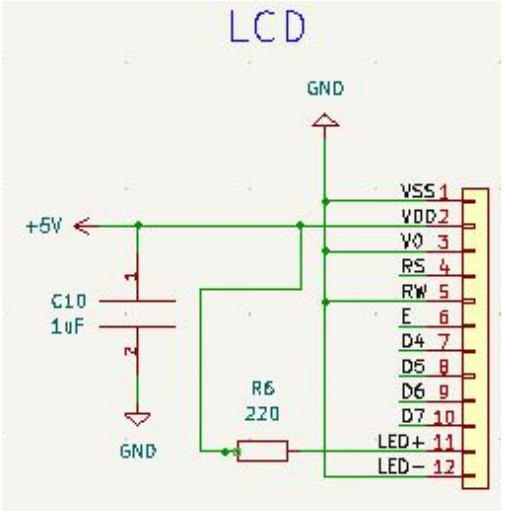
Javi Cardenas

R&V Table

Requirements	Verification
• When the left foot pedal is pressed, the motors should turn a page backward. When the right foot pedal is pressed, the motors should turn a page forward. • The LCD should track the number of pages turned forward.	• Ensure that the left motor rotates 45°-135°-45° and the center motor rotates 0°-90°-180° when the left pedal is pressed. Ensure that the right motor rotates 135°-45°-135° and the center motor rotates 180°-90°-0° when the right pedal is pressed. • When the right foot pedal is pressed, the count should increase by 1. If the left foot pedal is pressed, the count should decrease by 1.



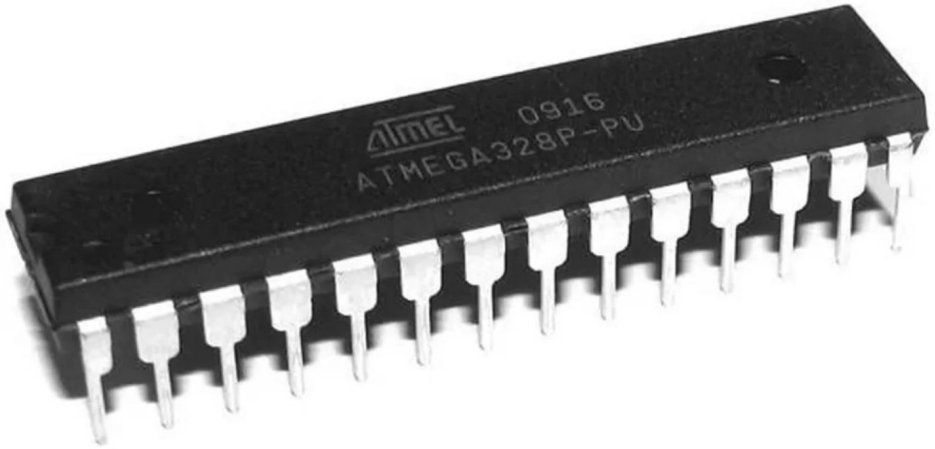




Control & Sensors

Twidec Foot Pedal Switches

ATMEGA328P Microcontroller



Focus 16x4 Liquid Crystal Display (LCD)

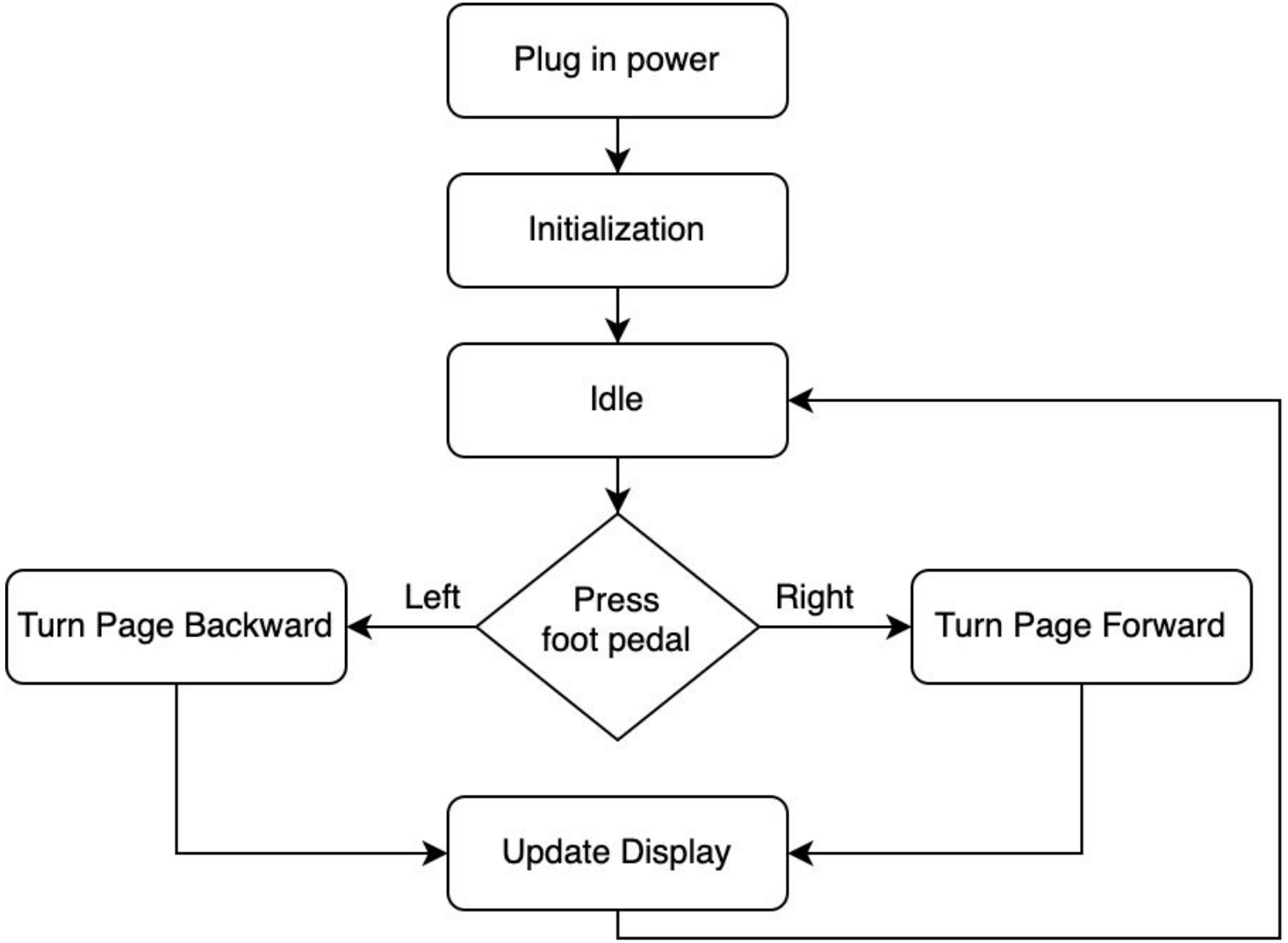
User Interface

Input

- Foot pedal switches

Output

- Motor actuation
- LCD



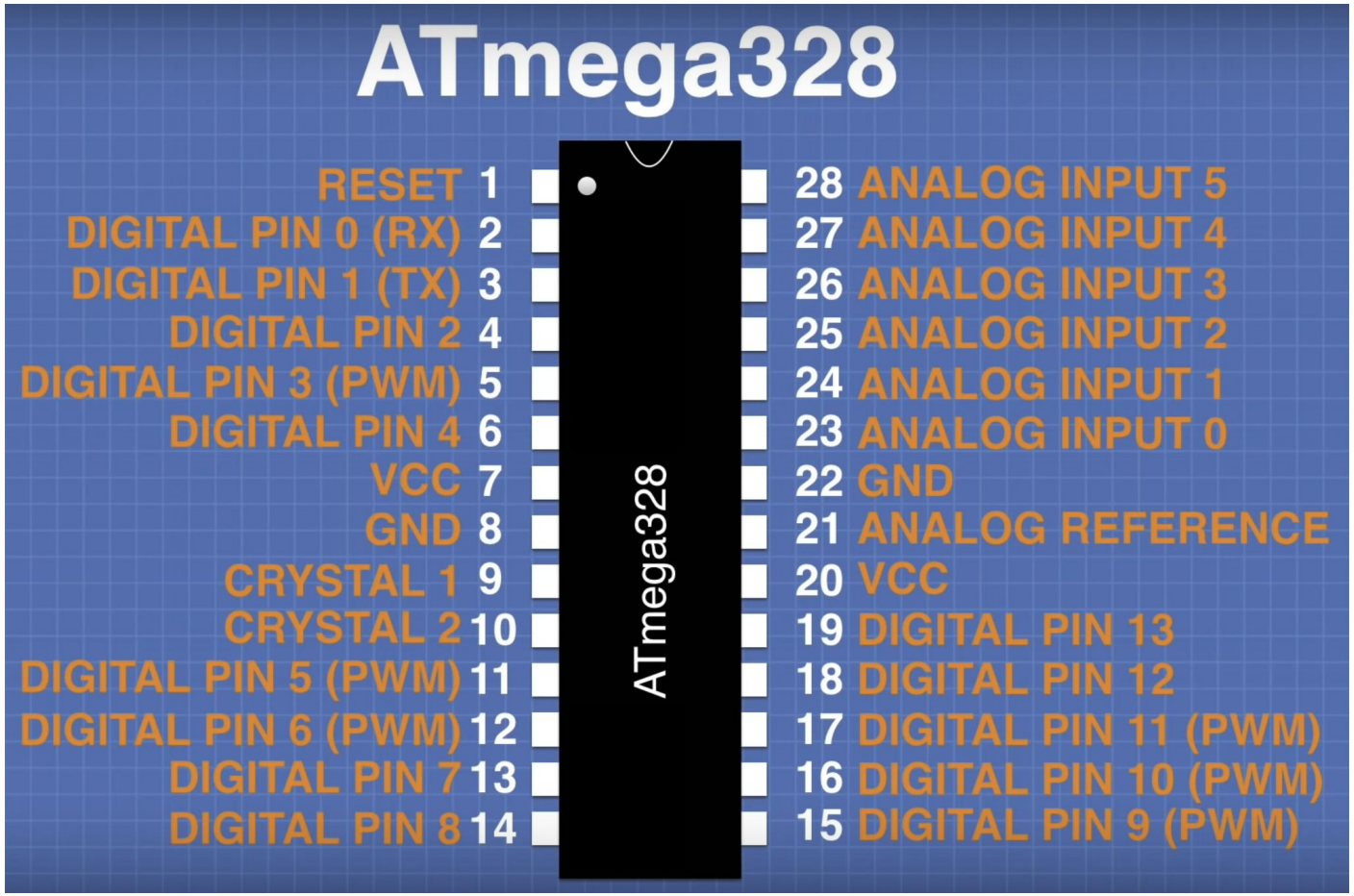
Challenges

Burning Bootloader

- Original MCU had issues

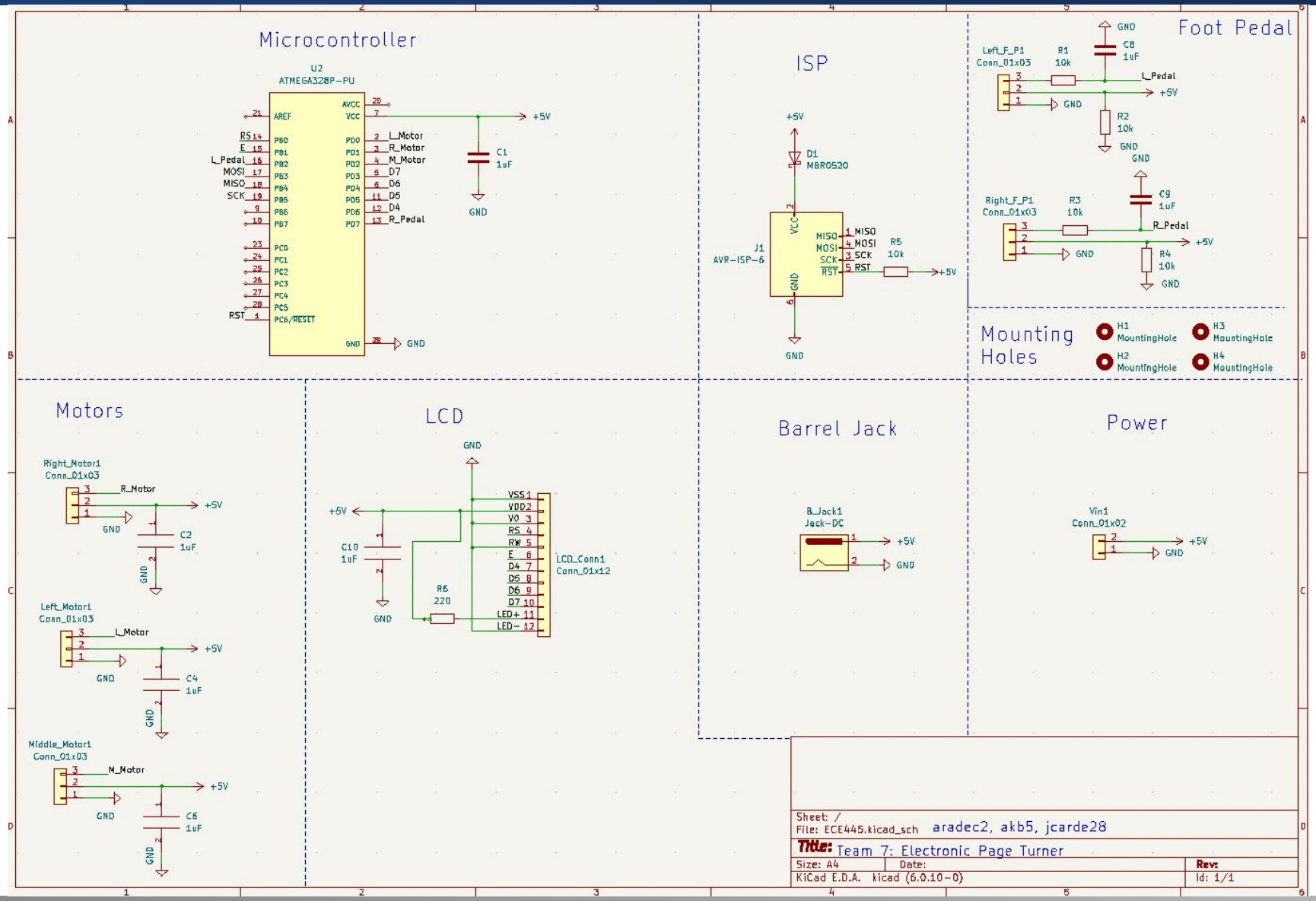
Hardware vs Software

- Arduino software uses digital pins
- Pin 2 maps to pin 0 in software



Physical Design

PCB Design


Microcontroller
U2
ATMEGA328P-PU
AREF
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
PC0
PC1
PC2
PC3
PC4
PC5
PC6/RESET
AVCC
VCC
GND
PD0
PD1
PD2
PD3
PD4
PD5
PD6
PD7
RS
E
L_Pedal
MOSI
MISO
SCK
RST
L_Motor
R_Motor
M_Motor
D7
D6
D5
D4
R_Pedal
+5V
C1
1uF
ISP
D1
MBR0520
J1
AVR-ISP-6
MISO
MOSI
SCK
RST
R5
10k
Foot Pedal
Left_F_P1
Conn_01x03
R1
10k
C8
1uF
R2
10k
Right_F_P1
Conn_01x03
R3
10k
C9
1uF
R4
10k
Mounting Holes
H1
MountingHole
H2
MountingHole
H3
MountingHole
H4
MountingHole
Motors
Right_Motor1
Conn_01x03
C2
1uF
Left_Motor1
Conn_01x03
C4
1uF
Middle_Motor1
Conn_01x03
C6
1uF
LCD
C10
1uF
R6
220
VSS
VDD
VO
RS
RW
E
D4
D5
D6
D7
LED+
LED-
LCD_Conn1
Conn_01x12
Barrel Jack
B_Jack1
Jack-DC
Power
Vin1
Conn_01x02
Sheet: /
File: ECE445.kicad_sch
aradec2, akb5, jcarde28
Title: Team 7: Electronic Page Turner
Size: A4
Date:
Rev:
KiCad E.D.A. kicad (6.0.10-0)
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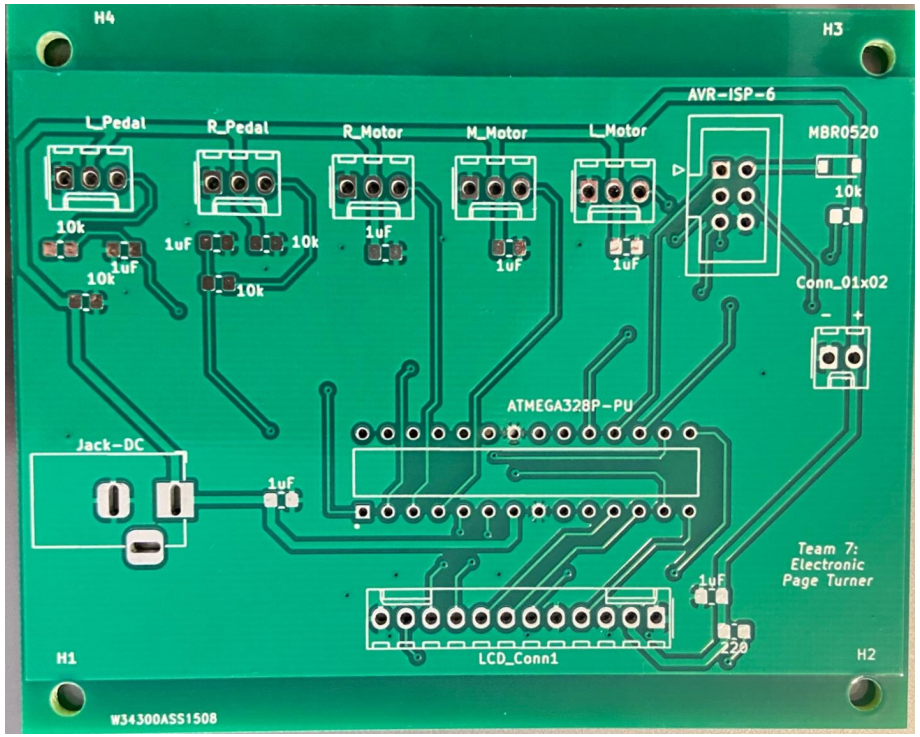
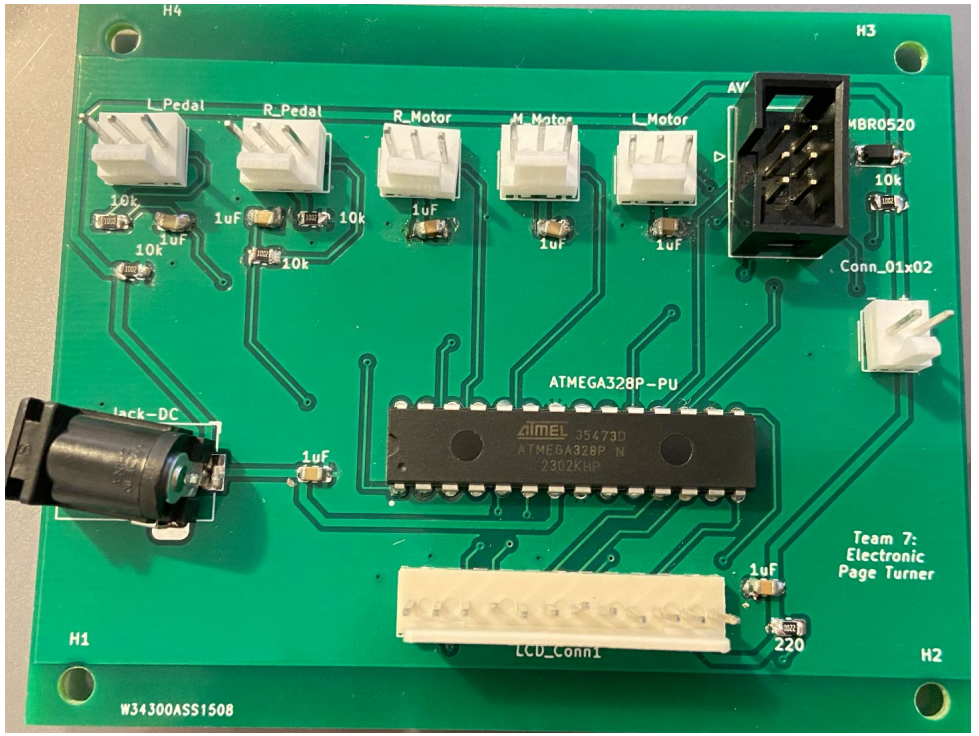
PCB Layout



Unsoldered PCB



Front Side of PCB

Challenges

PCB Design

Foot Pedal

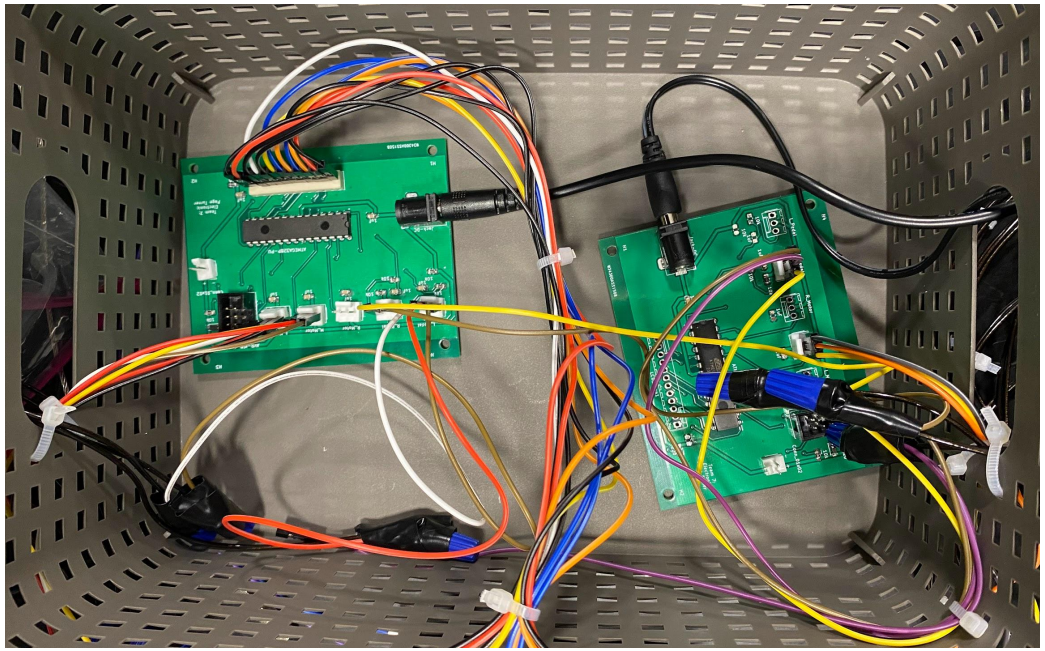
- Pull-Up resistor on voltage line
  - Originally on data line

Microcontroller

- Connect pin 3 to power
- Instead of a via, draw the ground wire on pin 7

Motors

- Add two capacitors for each motor
  - Helps with noise



Conclusion

What we learned and improvements to our device

Cost Analysis

Part	Part Number	Unit Price	Quantity	Total
Microcontroller	ATMEGA328P-PU	$7.21	2	$14.42
Foot Pedal	n/a	$10.43	2	$20.86
Servo Motor	HS-311	$14.76	3	$44.28
PCB Manufacture	n/a	$30.00	1	$30.00
Barrel Jack	PJ-102AH	$0.82	1	$0.82
5V Wall Adapter	1470-2771-ND	$6.50	1	$6.50
ISP Header	1597-114020164-ND	$2.80	2	$5.60
3 Pin Header	WM4201-ND	$0.27	7	$1.89
LCD Display	2632-C162A-BW-LW65-ND	$6.27	1	$6.27
10k Resistor	2197-294-10-RC-ND	$0.15	8	$1.20
1uF Capacitor	478-1836-ND	$0.82	9	$7.38
2 pin header	900-0022232021-ND	$0.15	2	$0.30
12 pin header	2057-LHA-12-TS-ND	$0.26	1	$0.26
Diode	1N4148W-13-F	$0.19	2	$0.38
Machine Shop Parts	n/a	$50.00	1	$50.00
			Total Cost	$190.16

Accomplishments

- Met all high-level requirements
- Affordable compared to existing devices
- Hands-Free

Recommendations for Further Work

- Reset Button or Feedback loop to deal with page jamming
- Force sensor to determine thickness of pages
- Use only one PCB

Questions?

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