P20068: Robotic Drum Assist
Phase 4: Detailed Design
Design Review Pre-Read

Review Date/Time: 4/23/20 (Thursday) at 2:00pm via Zoom video conference

This document contains reference materials available to interested parties and attendees of the Detailed Design review for P20068: Robotic Drum Assist. The review presentation gives an overview of progress made during the Detailed Design phase and the project in general, as it caps the portion of the project covered by MSD I. Important engineering analysis and design work completed during this phase will be shown, with all subsystems quantified and elaborated on with drawings, diagrams, schematics, and flowcharts. Findings from limited prototyping and testing will also be discussed. More complete references will be available in and from this document.

Review Agenda:

- MSD I Summary
- Problem Statement & Deliverables
- Customer and Engineering Requirements
- Design Summary
    - User Interface
    - Beat Programming
    - Motors
    - Power
    - Software
- Risk Management
- Test Plans
- MSD II Plans

Project Background and Scope:

Music is an important part of students' educational paths, and varying ability levels means that some students cannot independently participate in musical activities. The Robotic Drum Assist aims to allow these students to participate in music classes independently, using a variety of accessible interfaces to control a robotic drum set. These interfaces may include a real-time control system, where a user's actions correspond to each individual drum beat, or a pre-set beat pattern, where students can control the active instruments and the instructor has control over the pattern and tempo.

Detailed Design Overview:

In this phase, the team worked to expand on concepts and design flowcharts created during the System-Level Design phase and expanded on in the Preliminary Detailed Design phase. Limited prototyping was accomplished, and the Bill of Material was updated with additional components after an initial purchasing order went through. The work in this phase is intended to provide a strong foundation for beginning MSD II, where we will begin with rapid prototyping, testing, and the initial build stage. A plan for how the team will handle the start of MSD II, both for in person activities and a contingency plan for additional remote work, was established.

Other Resources:

The project wiki contains the most complete information for the project, and will be continually updated as progress is made and more specifics of the project are defined. The pages most relevant to this review are listed below.

Project Overview

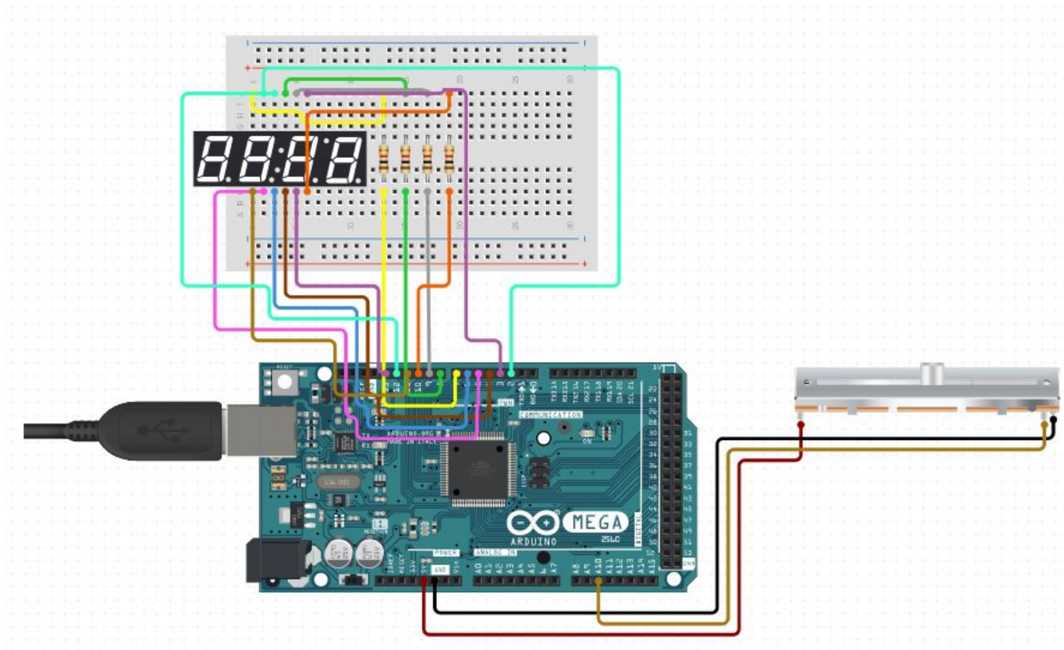
Detailed Design - The main page for the Detailed Design phase

P20068 Photos and Videos - Page containing links to demonstrations of remote prototyping and testing activities

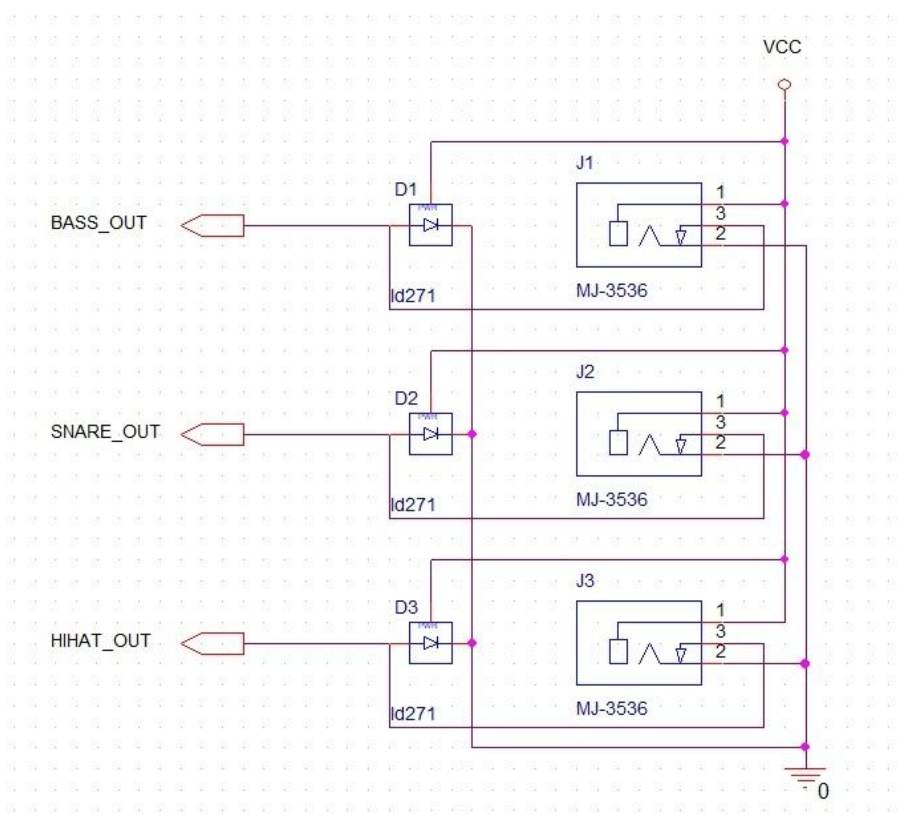
The wiki also holds various working documents that are updated as relevant progress is made. Links to these documents are available in the aforementioned wiki pages, or in the associated Documents page for that phase.

The following pages contain copies of the various engineering analysis documents produced during this phase as a quick reference for during/after the review.

Slider and Seven Segment Display Wiring Diagram
The wiring diagram for the slider and seven segment display with an Arduino Mega 2560

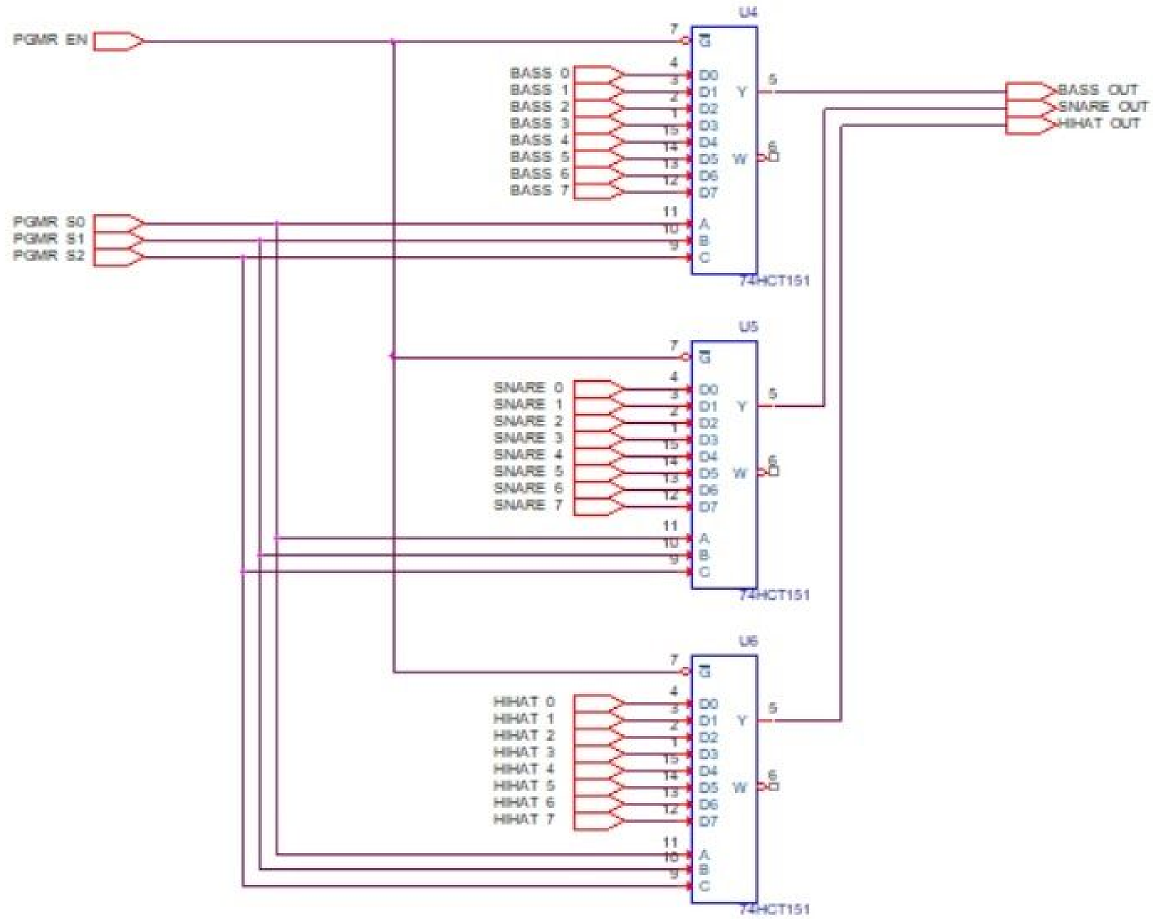


Button Interface Schematic
The wiring diagram for the 3.5mm jacks that the adaptive buttons will plug into.



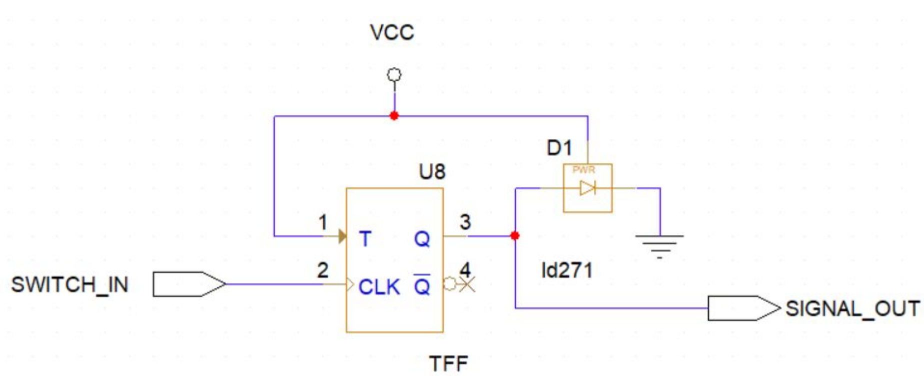
Beat Programming I/O Reduction Schematic

A hardware implementation for reducing the number of I/O pins needed for the microcontroller to read the beat programming inputs.



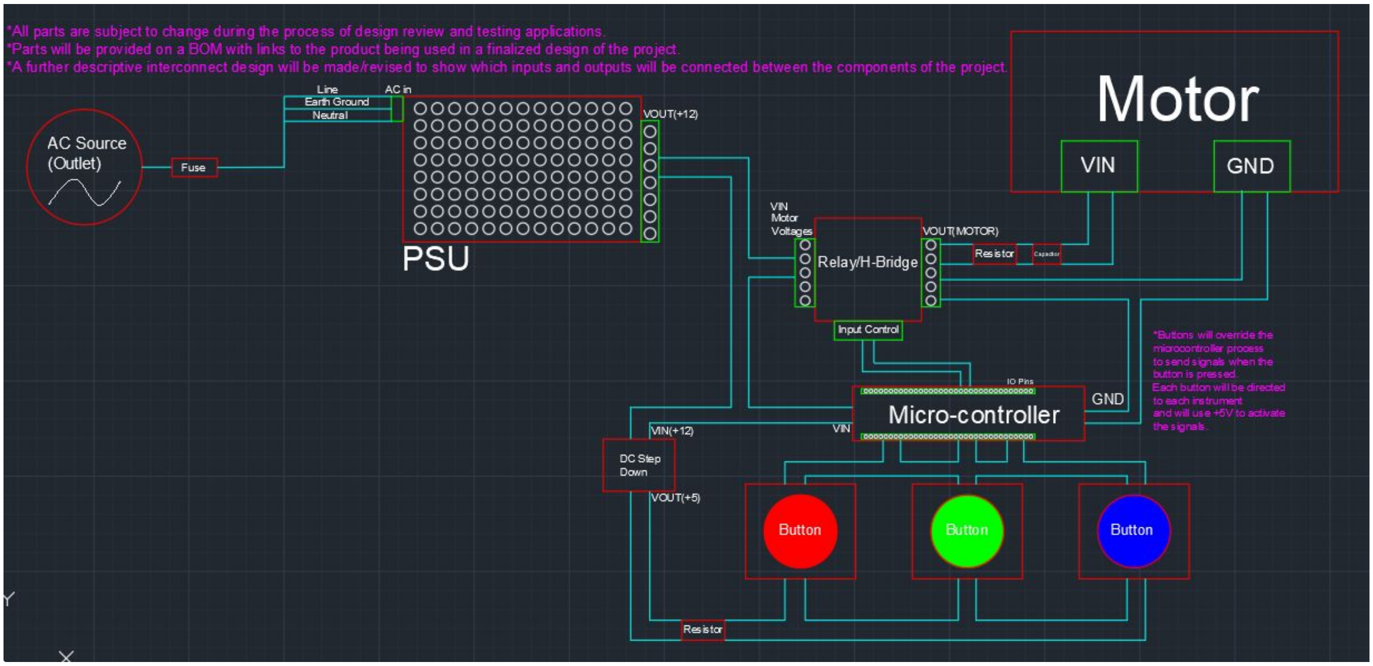
Toggle Switch Schematic

This schematic shows how the beat programming switches will be processed as toggle switches. There will be one of these circuits for every switch on the beat programming board.

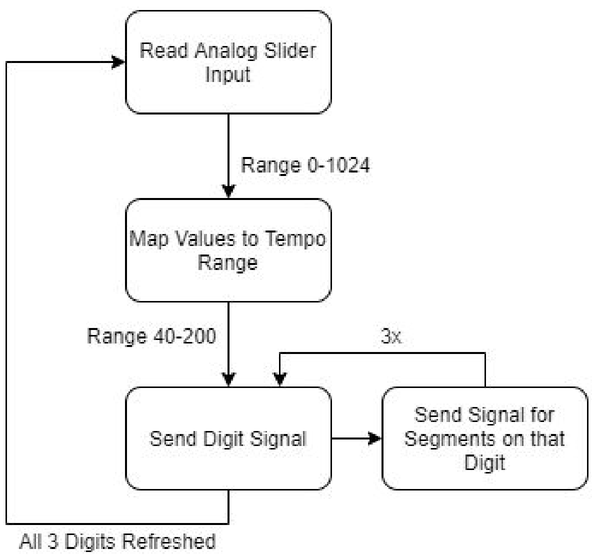


Power Distribution Interconnect Schematic

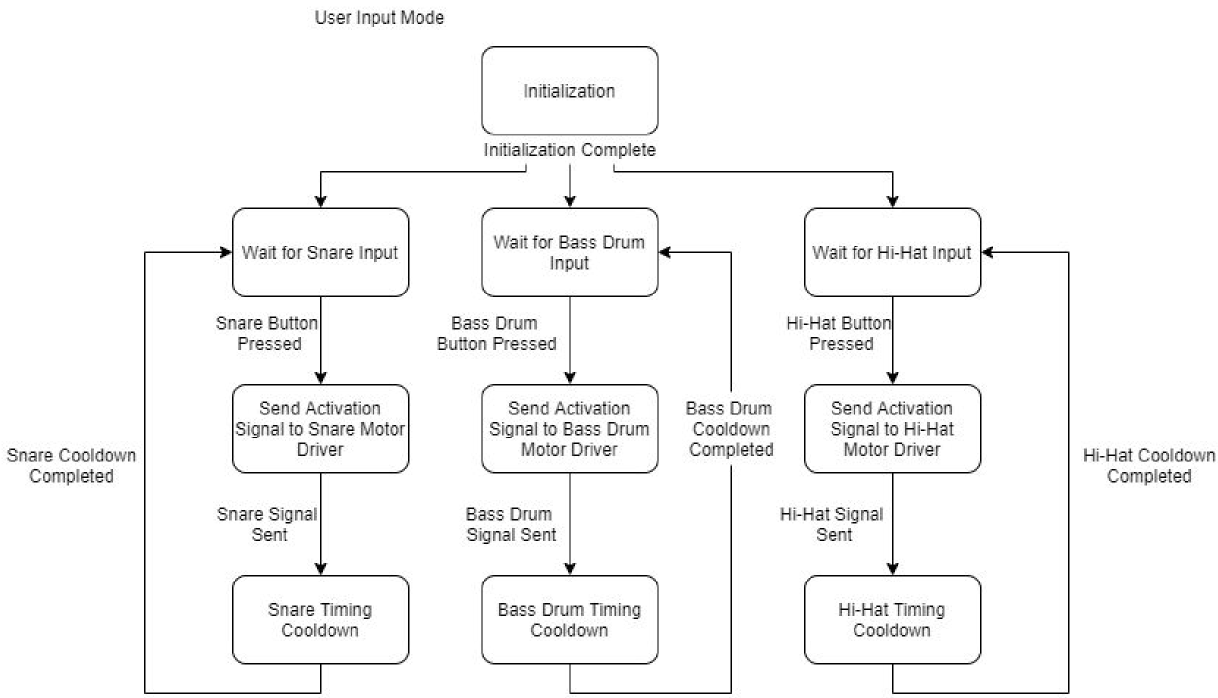
The distribution of power from the power supply to the microcontroller and drum motors.



Tempo Display Software State Diagram:

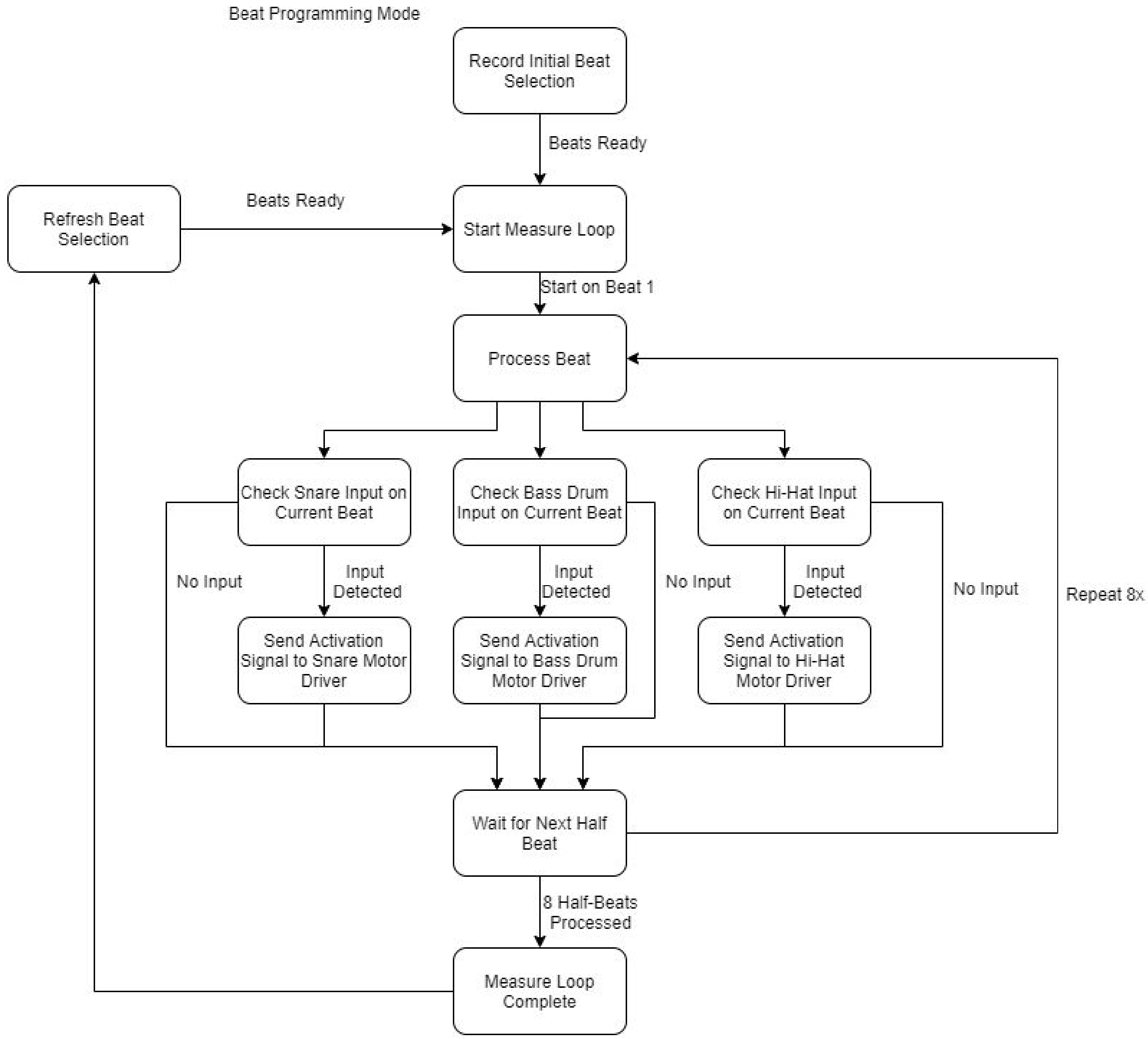


User Input Software State Diagram:
A description of how the software will operate in User Input mode.

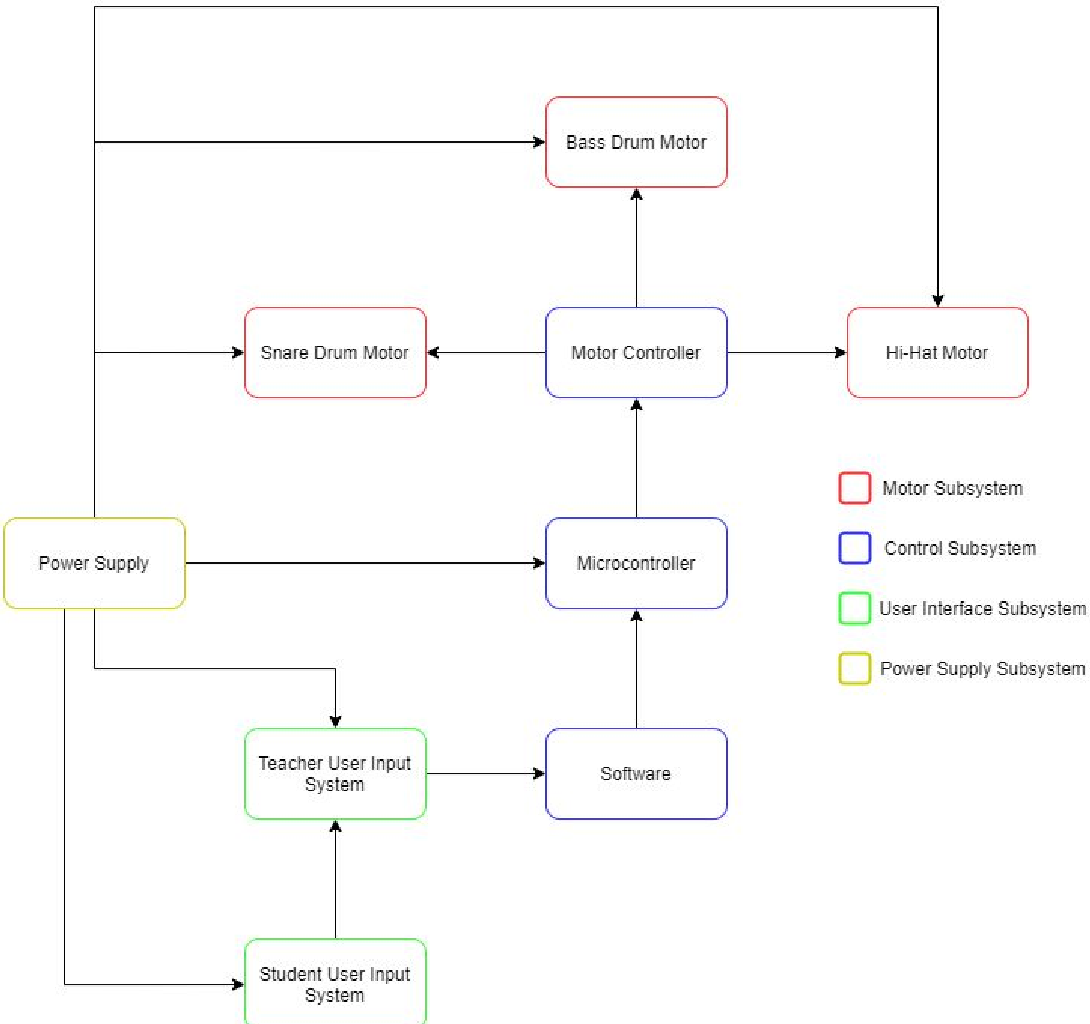


Beat Programming Mode Software State Diagram:

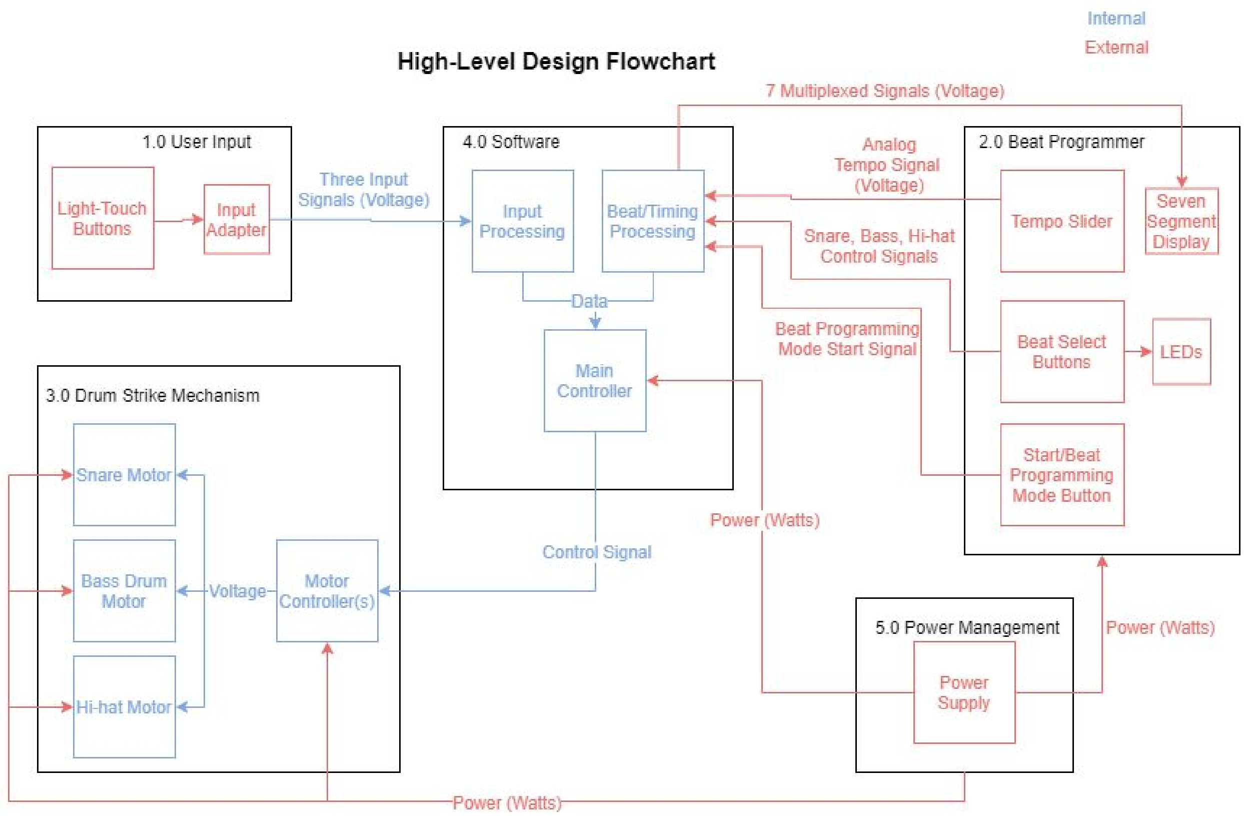
A description of how the software will operate in beat programming mode.



Systems Architecture:
A high-level block diagram depicting the flow of information and energy throughout the system.



Design Flowchart:
Another depiction of the overall design flow, breaking functions and components into separate modules. The connections between these modules are shown, with current thoughts regarding what form of data/energy will be passed between them.



Current Bill of Material:

A current view of the Bill of Material developed during this phase. The Bill of Material compiles expected expenses and desired parts. Highlighted entries indicate components that have already been purchased

Item Number	Quantity	Item	Description	Cost per pack	Cost for all	Shipping
1	1	Arduino Mega 2560	Microcontroller	$40.30	$40.30	$9.53
2	1	Door Lock Actuator	Built in motor for moving drumsticks (pack of four)	$13.99	$13.99	Free
3	1	AC to DC Converter	Converts AC from outlet into DC for components	$30.51	$30.51	
4	3	Relay/H-Bridge	Will drive the motors for linear action	$7.61	$22.83	
5	3	Cherry MX Switch	Speed Silver (pack of 10)	$11.51	$34.53	
6	10	Diffused Blue LED	Blue LED for Switches (10)	$0.52	$5.20	
7	10	Diffused Red LED	Red LED for Switches (10)	$0.56	$5.60	
8	10	Diffused Green LED	Green LED for Switches (10)	$0.36	$3.60	
9	2	DC-DC Step Down Converter	Step down converter from 12V to 9V/ 12V to 1.2V	$7.61	$15.22	
10	3	AbleNet Jelly Bean Twist Buttons	Adaptive Buttons, 2.5" diameter	$65.00	$195.00	
11	1	Percussion Claw	Mount for snare drum	$39.00	$39.00	
12	1	Slide Potentiometer	Slider for tempo adjustment	$5.90	$5.90	$4.99
13	1	Seven Segment Display (Green)	7SD for tempo slider	$3.95	$3.95	
14	1	Switch for AC Power	A switch when plugging into AC	$19.83	$19.83	
15	1	AC Cord	Cord for AC Power Switch	$5.36	$5.36	
16	3	MJ-3536 Mono 3.5mm Adapter	Adapter for adaptive button inputs	$1.24	$3.72	
				Subtotals:	$444.54	$14.52
				Total:	$459.06	

Risk Management:
An analysis of potential risks associated with the project, and some actions for mitigating risks. Some columns were omitted (Risk ID and Owner) so that the image could appear large enough in this document. The full Risk Management document can be seen on the project wiki.

Category	Risk Item	Effect	Cause	Likelihood	Severity	Importance	Action to Minimize Risk
What type of risk is this?	*Describe the risk briefly*	*What is the effect on any or all of the project deliverables if the cause actually happens?*	*What are the possible cause(s) of this risk?*	*L*	*S*	*L*S*	*What action(s) will you take (and by when) to prevent, reduce the impact of, and/or transfer the risk of this occurring?*
Technical/Safety	Motor Fails	Drum can't be hit as desired	Too much power, overuse	3	6	18	Research the expected lifetime and optimal operating conditions for each possible option
Resource	Team runs out of money	Cannot acquire new components	Too-expensive components, poor management of finances	3	9	27	Keep finances logged, budget ahead of time
Safety	Strikes with too much force	Device becomes unsafe to operators and drums	Failed motor, poor force constraints	3	9	27	Test strike force
Technical	Responsiveness is too slow	Device becomes frustrating to use	Poor program/circuitry optimization	6	6	36	Look at datasheets for circuitry used to figure out time delays; Continue testing software with motor before, during, and after build
Technical	Interface is not accessible	End-user can't sufficiently operate the device	Poor user testing, bad understanding of requirements, flawed interface concept	3	9	27	Test interface with students when possible
Technical	Device takes too long to assemble and use	Device becomes frustrating to use, detracts from classroom activities	Poor user testing, bad understanding of requirements, flawed physical concepts	6	6	36	Ensure part connections are not too complicated, conduct assembly trials
Technical	Device components wear out quickly	Device becomes unreliable, requires frequent maintenance and replacement, detracts from classroom activities	Bad component choices, inadequate longevity and stress testing	3	6	18	Review parts before ordering to ensure quality products.
Safety	System overheats	Components become unusable, system fails	Poor cooling of device, electrical components got too hot	3	6	18	Thermal analysis
Social	Inconsiderate Communication	Harm relationship between team and customer/users	Using improper terminology toward end user	3	3	9	Prepare for communication, review communication guidelines
Technical	Bad Documentation	Customers can't understand documentation, team can't follow documentation	Poor documentation standards	3	6	18	Make everything extremely detailed; Step-by-step troubleshooting
Safety/Resource/Technical	Insufficient Prototyping	Prototyping can't be completed, quality of final implementation is diminished	COVID-19 Restrictions	6	6	36	Prototype on smaller scales, run simulations, prepare design well so prototyping can begin as soon as we have better campus access
Resource	Components Unavailable or Unreasonably Delayed	Quality of material diminished, design setback, prototyping difficulty	COVID-19 Restrictions and Rations	6	9	54	Source good items with a history of being in stock, don't wait too long to buy, focus on parts with alternatives

Customer Requirements:

Customer Rqmt. #	Importance	Description	Comments/Status
CR1	9	Compatible with standard snare drum, bass drum, and hi-hat cymbal	Allows for use with current equipment in school
CR2	6	Needs to power all components reliably	Needs to be reliable
CR3	3	One drum interface with ability to have interchangable controls	For use by students with different ability levels
CR4	6	Durable and user-replaceable construction	Needs to be durable
CR5	9	User-replaceable drumsticks	Different needs for different instruments
CR6	6	Plays 4/4 metre beats	Must play fast enough and in time with a certain rate of play
CR7	3	Able to choose between different beats	Students can choose between preset beats
CR8	6	Able to have teacher change the tempo	Gives teacher more control over device
CR9	9	Portable	Needs to travel on teacher's cart
CR10	9	Compatible with pedal and drumstick actuation	Needs to work on 3 types of drums
CR11	9	Safe for student use	No sharp pieces, limited strike power
CR12	9	Safe for teacher/caregiver setup	No sharp pieces
CR13	6	Compatible with standard wheelchairs	Different students have different set-ups
CR14	3	Quick Set-up and Take-down	Interchanging interface shouldn't be a challenge
CR15	6	Capability to add personal beats	Students customizing their own pre-made track

Engineering Requirements:

	Importance	Source	Function	Engr. Requirement	Unit of Measure	Marginal Value	Ideal Value
ER1	9	CR1, CR13	Compatibility	Standard shape/size	in		
ER2	6	CR2	Power	Plug-in power supply	Voltage	12V	12V
ER3	6	CR3	Portability	Simple designs without too many components	boolean	TRUE	TRUE
ER4	6	CR4	Life of product	Metal/Wood structure to endure heavy swings	lbf		
ER5	9	CR5	Customizable	Requires an adjustable grip for different size ranged of drum sticks	boolean	TRUE	TRUE
ER6	6	CR6	Back-end programming	Programmable beats	boolean	TRUE	TRUE
ER7	6	CR7	Back-end programming/Interface	Pre-set beats	boolean	TRUE	TRUE
ER8	3	CR8	Settings for music preferences	Program settings for the teacher to change only on her behalf	boolean	TRUE	TRUE
ER9	9	CR9	Portable	Limited number of subsystems	number	8	5
ER10	9	CR10	Mechanical	Electric motors for actuation	boolean		
ER11	9	CR11	Safety	No sharp pieces or too small parts accessible	boolean	TRUE	TRUE
ER12	9	CR12	Safety	No sharp pieces	boolean	TRUE	TRUE
ER13	3	CR14	Portability	Parts fit together easily and are not overly complex	minutes	4	1
ER14	3	CR14	Portability	Lightweight design	lb		
ER15	6	CR15	Customizable/Interface	Self programmable beats	boolean	TRUE	TRUE
ER16	9	CR3	Performance	Interface is responsive	ms	100	25
ER17	9	CR10	Mechanical	Motors can actuate correctly at max tempo	ms	300	150