<DEVICE NAME>
DESIGN RATIONALE

<PLACE LOGO HERE>

Completion Checklist (DELETE BEFORE POSTING)

- Update <MONTH> and <YEAR> in header
- Update V<X.Y.Z> in header
- Update <DEVICE NAME> in header
- Add logo to or remove the “Place Logo Here” textbox in header
- Update <YEAR> in footer
- Update <Author> in footer
- Update webpage link in footer
- Complete Overview page
- Complete Introduction
- Complete Requirements
    - List goals
    - List functional requirements
    - List non-functional requirements
    - List constraints
- Complete Research
    - Document commercially available options
    - Document DIY / maker friendly options
- Complete Ideation
    - Describe ideas created to meet the goals / requirements of the project
    - Include decisions about which ideas to continue with
- Complete Conceptual Designs
    - Describe the concepts created to meet the goal / requirements of the project
    - Include decisions about which concepts
- Complete Prototyping
    - Document prototypes developed
    - Include decisions on prototypes
- Complete Testing
    - Describe tests completed (or that would be good to complete)
    - Include results of tests
- Complete Detailed Design
    - Describe all aspects of the current version of the device to be released
- Complete Opportunities for Improvement (OFIs)
    - List OFIs for the device
- Check images have been inserted where required
    - Can search for <INSERT IMAGE OF DEVICE>
- Update Table of Contents
- Delete all help text

<PLACE LOGO HERE>

<DEVICE NAME>
DESIGN RATIONALE

- Delete Completion Checklist
- For detailed instructions on completing the Design Rationale, please see the OpenAT Documentation Guide

<PLACE LOGO HERE>

<DEVICE NAME>
DESIGN RATIONALE

Overview

The Design Rationale is intended to provide designers and maker information about the design process and design decisions behind the development of the <DEVICE NAME>, <INSERT ONE-LINE DESCRIPTION OF DEVICE>.

<INSERT IMAGE OF DEVICE>

<PLACE LOGO HERE>

<DEVICE NAME>
DESIGN RATIONALE

Contents

<PLACE LOGO HERE>

<DEVICE NAME>
DESIGN RATIONALE

Introduction

<DESCRIPTION OF WHERE IDEA FOR THE DEVICE ORIGINATED>

<Do NOT include identifying information on a specific end-user if they requested the device be designed (ex: name, age, gender, sex, location). >

<DESCRIPTION OF NEEDS BEING MET BY DEVICE>

<DESCRIPTION OF INTENDED END-USER. INCLUDE SPECIFIC NAMES OF CONDITIONS IF KNOWN.>

Requirements

The goals and requirements outlined here can be used to assess if a device would meet the needs of a user, and determine when a design is sufficient for release.

Goals

<GOALS ARE THE NEEDS THAT NEED TO BE MET BY THE DEVICE>

G01	Low force joystick
G02	Optimized for low volume builds
G03	Released as Open Source Hardware
G04	Compatibility with existing toppers
G05	Device should be ergonomic and not put strain on the user's wrist during use
G06	Device should have a physical range of motion comparable to LipSync or typical gaming thumbstick (e.g., ±10 mm)
G07	Minimize device envelope.

Functional Requirements

<FUNCTIONAL REQUIREMENTS ARE REQUIREMENTS RELATED TO HOW THE DEVICE WILL WORK TO MEET THE GOALS>

F01	With the default topper, the joystick must require 30 g or less of force to fully displace the joystick
F02	Linear range of the joystick must be between a minimum of ±5 mm and a maximum of ±20 mm.
F03	The device is operable in two operating modes: Joystick HID and Mouse HID.
F04	A secondary user must be able to switch between operating modes
F05	A Primary User should be able to switch between operating modes
F06	Device must give the user visual or auditory feedback on the current operating mode.
F07	A secondary user must be able to perform a neutral calibration of the joystick
F08	The primary user should be able to perform a neutral calibration of the joystick
F09	Device should have swappable toppers.
F10	Devices should have toppers that are swappable by a Secondary User.
F11	Device should utilize the Oak modular topper interface.

F12	Device must be mountable, either compatible with the OpenAT Joystick mounting adaptor or have a built in ¼”-20 UNC thread
F13	Device must output USB HID directly OR be compatible with an existing interface (e.g., LipSync Hub, Forest Hub)
F14	Design must be smooth with no sharp edges
F15	When passively resting on a desk or flat surface, the device must not slide when a horizontally applied force equal to the operating force is applied to the joystick.
F16	When passively resting on a flat surface, the device should not tip over when a horizontally applied force equal to the operating force is applied to the joystick in any direction.
F17	Device should function when mounted vertically or upside down
F18	Device produced a proportional output through the range of motion.
F19	Device should be able to withstand a drop of 3 feet onto a hard surface
F20	Device provides two axes of output.
F21	Device has an input deadzone.
F22	Device should have an input deadzone that is adjustable by a Secondary User.
F23	Device should have a sensitivity that is adjustable by a Secondary User.
F24	Device should have a way to invert the axes by a Secondary User.
F25	Device should be compatible with the XAC

Non-functional Requirement

<NON-FUNCTIONAL REQUIREMENTS DO NOT RELATE TO HOW THE DEVICE WORKS, BUT ARE RELATED TO THE GOALS OF THE PROJECT>

NF01	If device is bumped, it should not send an input to the connected device
NF04	Design must adhere to intuitive operations
NF05	Hysteresis (how well the device returns to center)

Constraints

<CONSTRAINTS ARE LIMITS ON THE DESIGN, SUCH AS COST, SIZE/WEIGHT, OR MATERIAL TYPES>

C01	Design must use off the shelf or 3D printed parts
C02	Design must use 3D printed plastic for gimbal and enclosure
C03	Device must not use batteries
C04	Commercial components should be available from multiple sources
C05	The parts should be sourced from as few suppliers as possible to lower shipping costs
C06	Parts must be available in low quantities
C07	Parts must not be region specific
C08	Device must be safe for the user and disclaim any potential hazards such as magnets
C09	Device should be assembled with commonly available tools
C10	Only use hardware found in the LipSync gimbal in the Willow gimbal
C11	The number of fastener types in the device should be minimized

C12	The Willow joystick must work on the same magnetic gimbal principal as the LipSync
C13	Assembly should not require high strength or torque
C14	Device should be shippable within a Canada Post flat rate shipping box.
C15	Device should cost less than the BoM cost for the LipSync 4

Research

<DESCRIBE HOW AND WHEN RESEARCH WAS CONDUCTED>

Commercially Available Options

Options that can be purchased but not made by a maker.

<COMMERCIALLY AVAILABLE DEVICE NAME>

<COPY AND PASTE THIS SECTION, AND COMPLETE IT FOR EACH COMMERCIALLY AVAILABLE DEVICE>

Title / Name of device	<TITLE / NAME OF DEVICE>
Link	<LINK TO WEBSITE, IF AVAILABLE>
Author	<DESIGNER / MANUFACTURER / DISTRIBUTOR>
License	<DISTRIBUTION LICENSE, IF APPLICABLE>
Cost	<COST (INCLUDE TYPE OF CURRENCY: CAD, USD< ETC.)>

<INSERT IMAGE OF DEVICE>

<SHORT DESCRIPTION OF THE DEVICE AND HOW IT WORKS>

Requirements Met	**Requirements Unmet**
<LIST REQUIREMENTS FROM PREVIOUS SECTION THIS DEVICE MEETS>	<LIST REQUIREMENTS FROM PREVIOUS SECTION THE DEVICE DOES NOT MEET>

Useful Design Features

<INCLUDE ANY DESIGN FEATURES OF THE DEVICE THAT COULD / SHOULD BE CONSIDERED IN THE DESIGN OF ANOTHER DEVICE>

DIY / Maker-Friendly Options

Options that can be made by a maker.

<DIY / MAKER-FRIENDLY DEVICE NAME>

<COPY AND PASTE THIS SECTION, AND COMPLETE IT FOR EACH COMMERCIALLY AVAILABLE DEVICE>

Title	<TITLE / NAME OF DEVICE>
Link	<LINK TO WEBSITE, IF AVAILABLE>
Author	<CREATOR OF THE DEVICE>
License	<DISTRIBUTION LICENSE, IF AVAILABLE>

Cost	<COST (INCLUDE TYPE OF CURRENCY: CAD, USD< ETC.)>
Test Build (Y/N)	<HAVE YOU BUILT THIS DEVICE?>
Add to Library (Y/N)	<SHOULD THIS DEVICE BE ADDED TO THE MMC LIBRARY?>

<INSERT IMAGE OF DEVICE>

<SHORT DESCRIPTION OF THE DEVICE AND HOW IT WORKS>

Requirements Met	**Requirements Unmet**
<LIST REQUIREMENTS FROM PREVIOUS SECTION THIS DEVICE MEETS>	<LIST REQUIREMENTS FROM PREVIOUS SECTION THE DEVICE DOES NOT MEET>

Useful Design Features

<INCLUDE ANY DESIGN FEATURES OF THE DEVICE THAT COULD / SHOULD BE CONSIDERED IN THE DESIGN OF ANOTHER DEVICE>

Joystick Force and Range of Motion Comparison

Joystick	**Operational Force**	**Range of Motion**	
Celtic Magic Feather	5, 10, 15, 20 g	Up to +/- 6 Degrees	
Celtic Magic J1, J2, J3	60 or 20 g	Unknown	
Celtic Magic Dangle Joystick	10 g	+/-35 degrees	
Mo-Vis Micro Joystick	8 or 5 g	3 mm movement	
LINX 400 Compact Remote	81 g	Unknown	
ASL Micro Extremity Control	18 g	Unknown	
LipSync	50 g	+/-10 degrees	10 mm
Oak Joystick	525 g	+/- 25 degrees	
Spruce Joystick	75 g	+/-30 degrees	
Birch Joystick	115 g	+/- 2mm	+/- 2 mm
Xbox One controller	57-86 g	+/- 23 degrees	

Research Summary

<Summary of findings; potentially viable solutions; any gaps in existing options>

Existing low force joysticks are in the 20g or less range, with a wide range of angles. Most of the extreme low force joysticks are in the ~+/-6 degrees range, while the rest of the joysticks do not go past +/-35 degrees.

<PLACE LOGO HERE>

<DEVICE NAME>
DESIGN RATIONALE

Ideation

<DESCRIBE THE INITIAL IDEAS GENERATED TO MEET THE GOALS OF THE PROJECT. THESE ARE BROAD CONCEPTS, NOT SPECIFIC IDEAS FOR PROTOTYPES, SPECIFIC COMPONENTS BEING USED, OR EXACT SOLUTIONS>

<INCLUDE SKETCHES, DESCRIPTION OF DESIRED FUCTION, AND HOW IT WOULD WORK>

<GIVE IDEAS NAMES / NUMBERS TO REFERENCE LATER>

Key Features

Output Architecture: Microcontroller vs Hub

Microcontroller Options

Criteria for microcontrollers:

Requirements

- Connect to the magnetic sensor via Stemma cable

Bonuses

- Minimize cost
- Minimize footprint
- Bluetooth
- Analog output for TRRS

Microcontroller	Cost	Footprint (mmxmm)	Stemma	Bluetooth	Analog Out	Other	Link
SAMD21 QT PY	$7.50 USD	22x18	Yes	No	Yes		Link
RP2040 QT PY	$9.95 USD	22x18	Yes	No	Yes	Dual core microcontroller	Link
CH552 QT PY	$4.95 USD	22x18	Yes	No	Yes	Almost no Arduino support, compiles in C not C++ so most libraries don't work	Link
Seeed XIAO nrf52	$9.90 USD	22x18	No	Yes	Yes		Link
CH32V203 QT PY	$4.95 USD	22x18	Yes	No	Unknown	Almost no Arduino support	Link

nRF52840 ItsyBitsy	$19.95 USD	36x18mm	No	Yes	Yes		Link
nRF52840 glasses driver	$24.95 USD	58x19	Yes	Yes	No	Has lots of unneeded sensors	Link
Metro Mini 328 V2	$14.95 USD	44x18	Yes	No	Yes		Link
ESP32 Pico QT Py	$14.95 USD	22x18	Yes	Yes	Yes	Also has Wi-Fi	Link

Microcontroller recommendation

If Bluetooth is not a requirement, the SAMD21 QT PY is the best choice for its low cost, small footprint, stemma and analog capabilities while not having any unneeded features such as extra sensors.

If Bluetooth is a requirement, the ESP32 Pico QT PY is the best choice for its small footprint, Bluetooth capabilities, analog output, stemma port while minimizing unnecessary features.

Microcontroller Pros

- Able to function as a standalone device
- Low cost

Microcontroller Cons

- To add capabilities beyond what is included with the microcontroller (More sensors or button inputs) either a stemma module or a protoboard and wires are required.
- Limited feedback abilities

Hub Options

Hub	Price	Inputs	Feedback	Adjustability	Output Modes
LipSync Hub	$107.48	• 3x 3.5mm switch Jacks • RJ11 i2c connector • 2x onboard push buttons	• Audio buzzer • 3x LEDs • Text display	• Neutral reset • Extent calibration • Cursor speed adjustment	• HID Gamepad • HID Mouse • Bluetooth • USB
Forest Hub	$78.54	• 5x 3.5mm switch Jacks • RJ11 i2c connector	• Audio buzzer • 5x LEDs	• Neutral reset • Cursor speed adjustment	• HID Gamepad • HID Mouse • USB

		• 2x onboard push buttons • 3.5mm TRRS jack			

To make the willow joystick work with the hubs, the hubs themselves would need a firmware update. The hubs would need the basic programming added to allow them to translate the readings from the magnetic sensor into the HID output. They would also need to have an addition that allows them to recognize when a willow joystick is connected. The forest hub would just need to check if the magnetic sensor is attached, but the LipSync hub would need to be able to tell the difference between a willow joystick and a LipSync joystick. The LipSync hub already has the firmware required to convert magnetic sensor readings into HID, although if the order of magnet and sensor is reversed a slightly different version would have to be used for the Willow.

Hub Pros

- Increased user feedback
- Integrated switch inputs
- Integrated neutral or extent calibration
- Integrated cursor speed adjustment

Hub Cons

- Increased cost
- Joystick cannot be used as a standalone
- Chosen hub will need a software update to include the software needed for the Willow
- No possibility of TRRS output

Neutral Calibration Options

- Microcontroller reboot/calibration on startup
- Externally triggered calibration

The two primary methods of neutral calibration are performing a calibration on microcontroller startup, and calibrating while the microcontroller is already powered on.

Calibration of the joystick during operation can be done by rebooting the microcontroller and taking advantage of the startup calibration. Most microcontrollers include a reboot button on the board itself, and the enclosure can be designed to allow a primary or secondary user to press the button to reboot the microcontroller and calibrate the neutral position. However, this would cause the loss of any data, such as cursor speed that was set since the last reboot.

Triggering the neutral calibration without rebooting the joystick would require an input to the microcontroller such as a button or switch jack. If the microcontroller does not have an onboard button that is not connected to the reset pin, then an external button or jack would be needed to allow the

user to trigger the reset. This button can either be directly wired to the microcontroller pins, or it can be connected a stemma button breakout board. This requires more parts, but works with accessible switches and preserves information between calibrations.

Extent Calibration Options

When performing an extent calibration on the LipSync, the user follows the directions on the screen, holding the mouthpiece in the four corners until the LipSync beeps.

To perform this type of extent calibration, the LipSync needs an input to initiate the calibration, and feedback to inform the user when to move to each corner. The text display also allows the instructions to be displayed to the user in real time, instead of having to refer to a user guide. This is not necessary for an extents calibration, but it does greatly simplify the process.

If using a hub, the extent calibration requirements are largely already met. The hubs have enough inputs that the user can use one to initiate an extents calibration, and both hubs have user feedback to time the different steps of the process. The LipSync Hub also has the text based display to show the steps in real time

When using a microcontroller, the user feedback and input need to be provided. The options for providing input are the same as the options for a non reboot neutral calibration. If the microcontroller does not have an onboard input button, and external button or switch jack would be required. These can either be soldered directly to the microcontroller pads or connected via the stemma port. To provide user feedback, most microcontrollers from Adafruit have an LED, and some come with a NeoPixel LED that can be used to give feedback in any colour. Additional audio or visual feedback can be added by wiring to the microcontroller pins or added via stemma port.

Centering Strength Adjustment

There are two general methods available to change the centering force of the Willow gimbal

- Change the distance between the gimbal and sled magnet
- Change the strength of the sled magnet

For the sake of keeping the strength adjustment user friendly, making changes to the magnet in the gimbal itself will be disregarded, focusing on making changes to the magnet in the sled which is more accessible to the user.

Changing the distance between the sled and gimbal allows for the strength to be changed without changing the magnet used. This can be done by using a screw to advance or retract the magnet, as well as having a variety of locations in the sled that the magnet can be mounted in. Mounting the magnet in different locations in the sled would require the sled to be opened and the magnet moved. Changing the position of the magnet using a screw allows for a secondary user to change the strength without opening the enclosure while allowing the strength to be adjusted anywhere between the two extremes.

Changing the strength of the sled magnet can be done in two ways. The first way that it can be done is changing the magnet used in the sled for a different magnet with a stronger field. The second method is to add more magnets. This does have diminishing returns as the number of magnets increases. The following is an excerpt from the LipSync Design rationale when exploring this option for the LipSync Gimbal

"When stacking magnets, the magnetic force increases until the thickness of the stack reaches the diameter of the magnets [first4magnets.com]. Since the magnets used in the LipSync are 2.5mm x 8mm, 3 to 4 can be stacked before reaching diminishing returns. This is demonstrated in a graph showing the force vs thickness of the magnet. Note the X axis does not increase linearly. [totalelement.com]

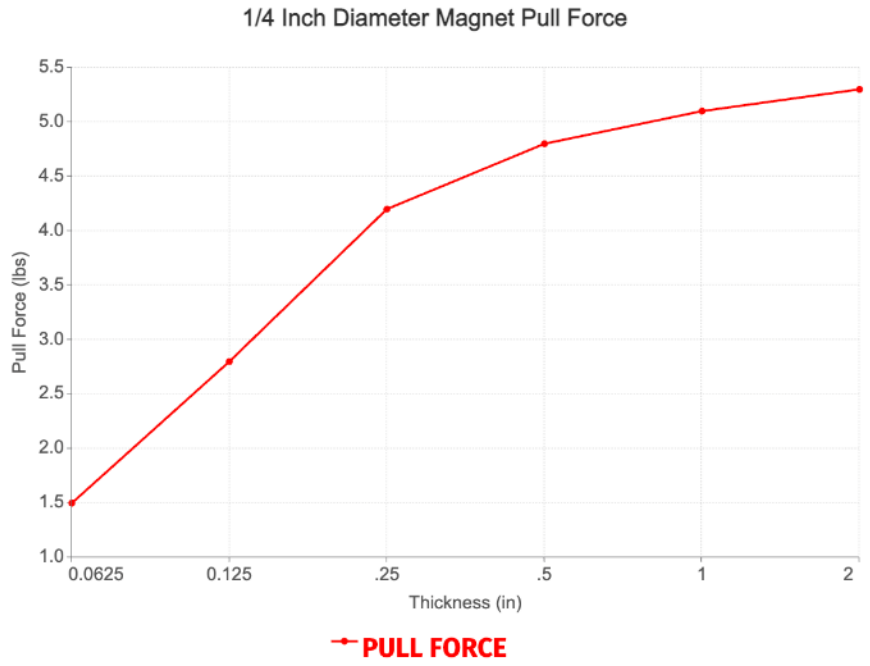


Figure 1. Magnetic Force with Greater Thickness.

"

Pros and Cons of Different Mounting Methods

Method	Pros	Cons
Different mounting locations	• Only uses one magnet	• Requires disassembling and reassembling the sled • The need to support the magnet makes the number of possible places very small

Variable mounting location (screw)	• Adjustable over the entire range with no defined stops • Only requires one magnet	• The rotation of the screw changes the location of the magnet slightly, requiring a recalibration
Stronger magnet	• Only uses one magnet	• Requires all the magnets of different strengths have the same dimensions • Need to take apart the sled to change magnets
Using more magnets	• If the first magnet is secured, more can be stacked in behind it from the exterior of the enclosure to change strength without opening the enclosure	• Different steps of strength with no in-between • Diminishing returns with more magnets, up to 3 or 4

Features of the LipSync Gimbal

The following is a list of all components of the LipSync gimbal, and a judgement of if they are required in the Willow joystick

Sled

- Centering magnet
  - Needed
- Sensing magnet
  - Needed, but could be moved to the gimbal
- Bearing seats
  - Needed
- Cable management
  - Needed
- Angle hard stops
  - Needed
- Sliding rails
  - Needed
- Arm tabs
  - Needed

Outer Gimbal

- Angle hard stops
  - Needed
- Cable management

  - Needed if the sensor stays on inner gimbal
- Part identifiers
  - Needed
- Bearing seats
  - Needed
- Bearing posts
  - Needed

Inner Gimbal

- Shield
  - Needed
- Luer adaptor
  - Unneeded
- Air path
  - Unneeded
- Pressure sensor
  - Unneeded
- Magnetic sensor
  - Needed, but could be moved to sled
- Centering magnet
  - Needed
- Angle hard stops
  - Needed
- Part identifiers
  - Needed
- Bolt holes
  - Needed, but only if magnetic sensor stays on inner gimbal
- Cable management
  - Needed, but only if magnetic sensor stays on inner gimbal
- Bearing posts
  - Needed

Bare Minimum Changes

- Remove pressure sensor, air tube, and Luer lock
- Design topper base that fits in Luer compartment

Maximum Changes

- Move magnetic sensor to the sled
- Remove pressure sensor, air tube and Luer Lock
- Move sensor magnet to inner gimbal
- Shrink the gimbal to remove the space
- Redesign Luer lock compartment to allow swappable toppers

Topper Compatibilities

Oak

The Oak toppers all come in small, medium and large, and connect to the oak joystick via a collet system that clamps onto the stick of the oak joystick module. The toppers then screw onto the collet. The oak comes with 5 styles of topper.

- Ball
- Concave
- Convex
- Goalpost
- Stick

Birch

The Birch toppers connect to the joystick by a friction press fit on the joystick module. They are designed for the sliding motion of the Birch joystick, and not the rotating motion of a traditional joystick. The birch comes with 5 different styles of topper.

- Concave
- Large Dome
- Medium Dome
- Ring
- Small Dome

Evaluation Criteria

The primary criteria that toppers will be evaluated on are attachment and weight. Attachment is a measure of how well the topper attaches to the joystick stick. Weight is a measure of how much each topper weighs.

Ideation Decisions

<DESCRIBE AND JUSTIFY WHY DIFFERENT IDEAS WERE ABANDONDED, MODIFIED, OR CHOSEN TO PROCEED>

Idea	Decision (Abandon, Modify, Proceed)	Justification
<IDEA 1>	<DECISION>	<JUSTIFICATION>
<IDEA 2>	<DECISION>	<JUSTIFICATION>

Conceptual Designs

<DESCRIBE DIFFERENT DESIGNS BEING WORKED ON. SHOULD INCLUDE DESIGNING PARTS, SELECTING COMPONENTS, AND OUTLINING CODE (IF APPLICABLE)>

<GIVE CONCEPTS UNIQUE NAMES / NUMBERS TO REFERENCE LATER>

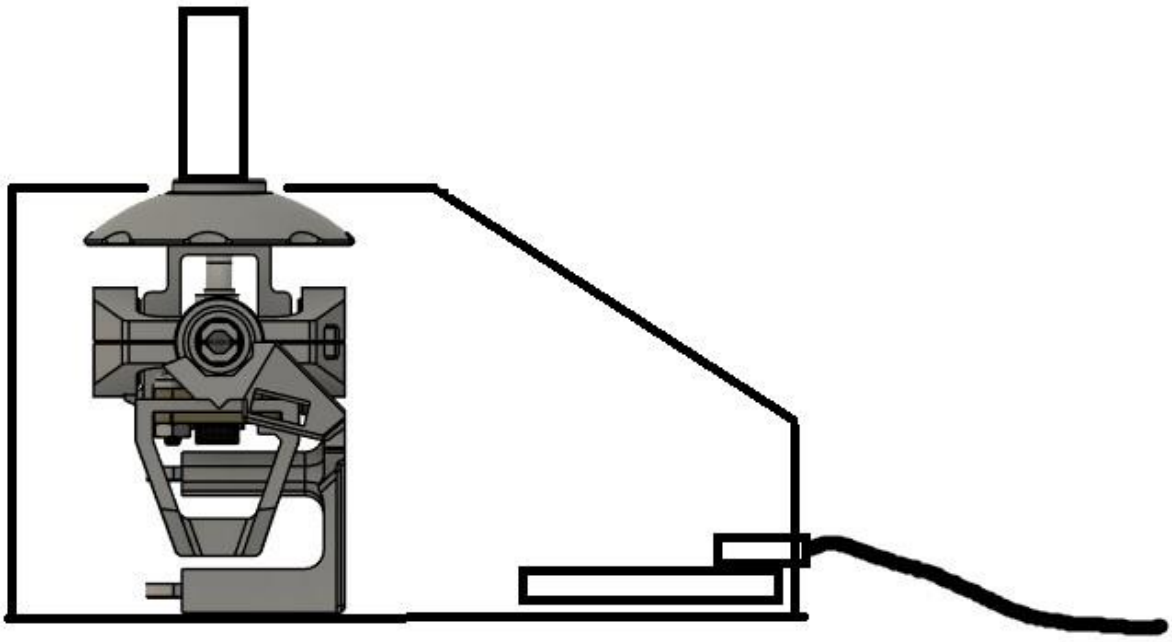
<COPY THE BELOW SECTION FOR EACH CONCEPT CREATED>

<IF PARTS ARE SHARED BETWEEN CONCEPTS (EX: THE CODE FUNCTION / STRUCTURE), ONLY DESCRIBE IT ONCE AND REFER TO IT IN OTHER CONCEPT SECTIONS>

<REMOVE IRRELEVANT SECTIONS IF NOT USED IN THE DESIGN>

<CONCEPT 1>

<INSERT ONE-LINE DESCRIPTION OF THE CONCEPT>



Physical Component / Enclosure

<INSERT DESCRIPTION OF THE PHYSICAL COMPONENTS / ELECTRICAL ENCLOSURE. INCLUDE IMAGES, LINKS TO PARTS, ETC.>

Electrical Components

<INSERT DESCRIPTION OF THE ELECTRICAL COMPONENTS. INCLUDE IMAGES, LINKS TO PARTS, ETC.>

Code Structure / Function

<INSERT DESCRIPTION OF THE CODE STRUCTURE / FUNCTION. LINK TO EXTERNAL LIBRARIES (IF USED)>

Concept Decisions

<DESCRIBE AND JUSTIFY WHY DIFFERENT CONCEPTS WERE ABANDONDED, MODIFIED, OR CHOSEN TO PROCEED>

Concept	Decision (Abandon, Modify, Proceed)	Justification
<CONCEPT 1>	<DECISION>	<JUSTIFICATION>
<CONCEPT 2>	<DECISION>	<JUSTIFICATION>

Prototyping

<DESCRIBE DIFFERENT PROTOTYPES BEING WORKED ON. SHOULD INCLUDE DESIGNING PARTS, SELECTING COMPONENTS, AND OUTLINING CODE (IF APPLICABLE)>

<GIVE PROTOTYPES UNIQUE NAMES / NUMBERS TO REFERENCE LATER>

<COPY THE BELOW SECTION FOR EACH PROTOTYPE CREATED>

<IF PARTS ARE SHARED BETWEEN PROTOTYPES (EX: THE CODE FUNCTION / STRUCTURE), ONLY DESCRIBE IT ONCE AND REFER TO IT IN OTHER CONCEPT SECTIONS>

<REMOVE IRRELEVANT SECTIONS IF NOT USED IN THE DESIGN>

<PROTOTYPE 1>

<INSERT ONE-LINE DESCRIPTION OF THE PROTOTYPE>

Physical Component / Enclosure

<INSERT DESCRIPTION OF THE PHYSICAL COMPONENTS / ELECTRICAL ENCLOSURE. INCLUDE IMAGES, LINKS TO PARTS, ETC.>

Electrical Components

<INSERT DESCRIPTION OF THE ELECTRICAL COMPONENTS. INCLUDE IMAGES, LINKS TO PARTS, ETC.>

Code Structure / Function

<INSERT DESCRIPTION OF THE CODE STRUCTURE / FUNCTION. LINK TO EXTERNAL LIBRARIES (IF USED)>

Prototype Decisions

<DESCRIBE AND JUSTIFY WHY DIFFERENT PROTOTYPES WERE ABANDONDED, MODIFIED, OR CHOSEN TO PROCEED>

Prototype	Decision (Abandon, Modify, Proceed)	Justification
<PROTOTYPE 1>	<DECISION>	<JUSTIFICATION>
<PROTOTYPE 2>	<DECISION>	<JUSTIFICATION>

Testing

<DESCRIBE THE TESTING COMPLETED, OR THAT SHOULD BE COMPLETED ON THE DEVICE>

<DESCRIBE THE GOAL OF EACH TEST COMPLETED>

<INCLUDE LINKS TO TEST CODE, IF APPLICABLE>

<INCLUDE IMAGES, IF APPLICABLE>

Test Methods

<DESCRIBE HOW THE TESTS WERE COMPLETED, WITH ENOUGH DETAIL FOR SOMEONE ELSE TO REPEAT THE TEST>

<GIVE TESTS DESCRIPTIVE NAMES / NUMBERS TO REFER TO LATER>

<TEST 1>

<DESCRIBE THE FIRST TEST, AS EXPLAINED ABOVE>

Test Results

<DESCRIBE THE RESULTS OF EACH TEST. INCLUDE RELEVANT IMAGES, DATA, AND FIGURES.>

Detailed Design

<DESCRIBE THE CURRENT VERSION OF THE DEVICE TO BE PUBLISHED>

<INSERT IMAGE OF DEVICE>

<INCLUDE GOALS AND REQUIREMENTS THAT WERE MET AND NOT MET>

Physical Component / Enclosure

<INSERT DESCRIPTION OF THE PHYSICAL COMPONENTS / ELECTRICAL ENCLOSURE. INCLUDE IMAGES, LINKS TO PARTS, ETC.>

Electrical Components

<INSERT DESCRIPTION OF THE ELECTRICAL COMPONENTS. INCLUDE IMAGES, LINKS TO PARTS, ETC.>

Code Structure / Function

<INSERT DESCRIPTION OF THE CODE STRUCTURE / FUNCTION. LINK TO EXTERNAL LIBRARIES (IF USED)>

<PLACE LOGO HERE>

Opportunities for Improvement

<DESCRIBE HOW THE DEVICE COULD BE IMPROVED IN FUTURE VERSIONS>

Physical Component / Enclosure

<INSERT DESCRIPTION OF IMPROVEMENTS TO THE PHYSICAL COMPONENTS / ELECTRICAL ENCLOSURE. INCLUDE IMAGES, LINKS TO PARTS, ETC.>

Electrical Components

<INSERT DESCRIPTION OF IMPROVEMENTS TO THE ELECTRICAL COMPONENTS. INCLUDE IMAGES, LINKS TO PARTS, ETC.>

Code Structure / Function

<INSERT DESCRIPTION OF IMPROVEMENTS TO THE CODE STRUCTURE / FUNCTION. LINK TO EXTERNAL LIBRARIES (IF USED)>