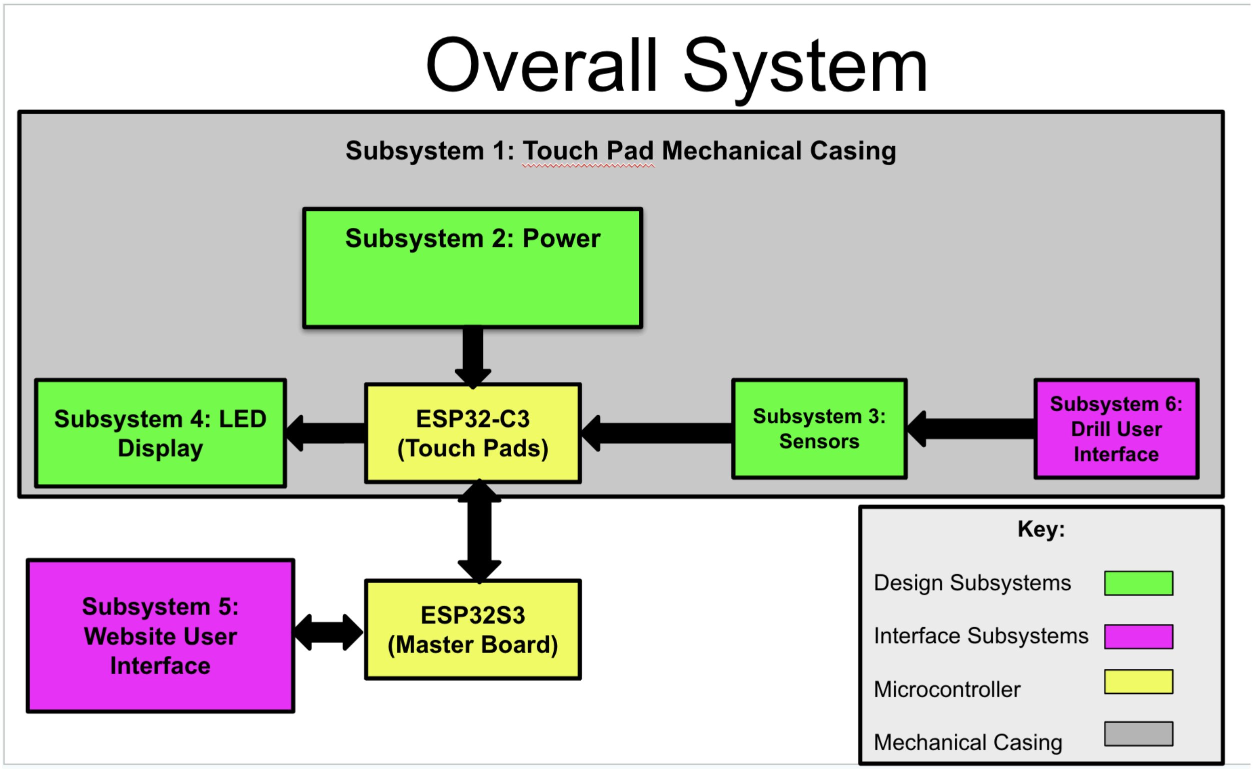
Design Review 1:

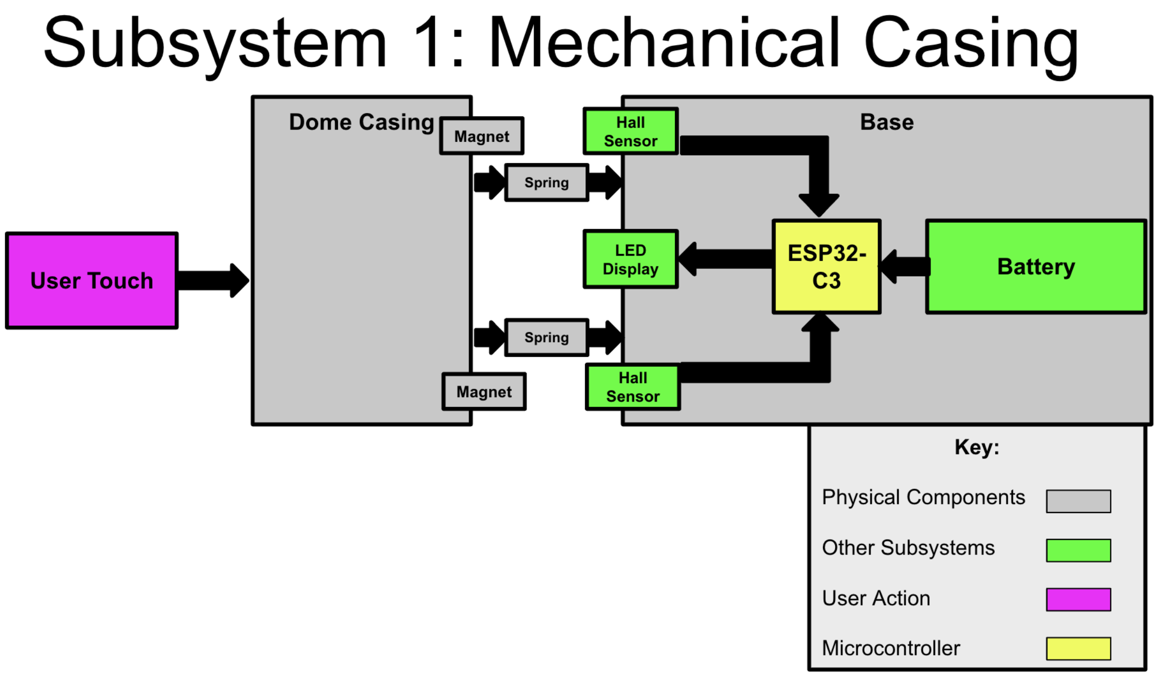
- Provide a detailed design of each major subsystem that includes all major components.

Overall System:



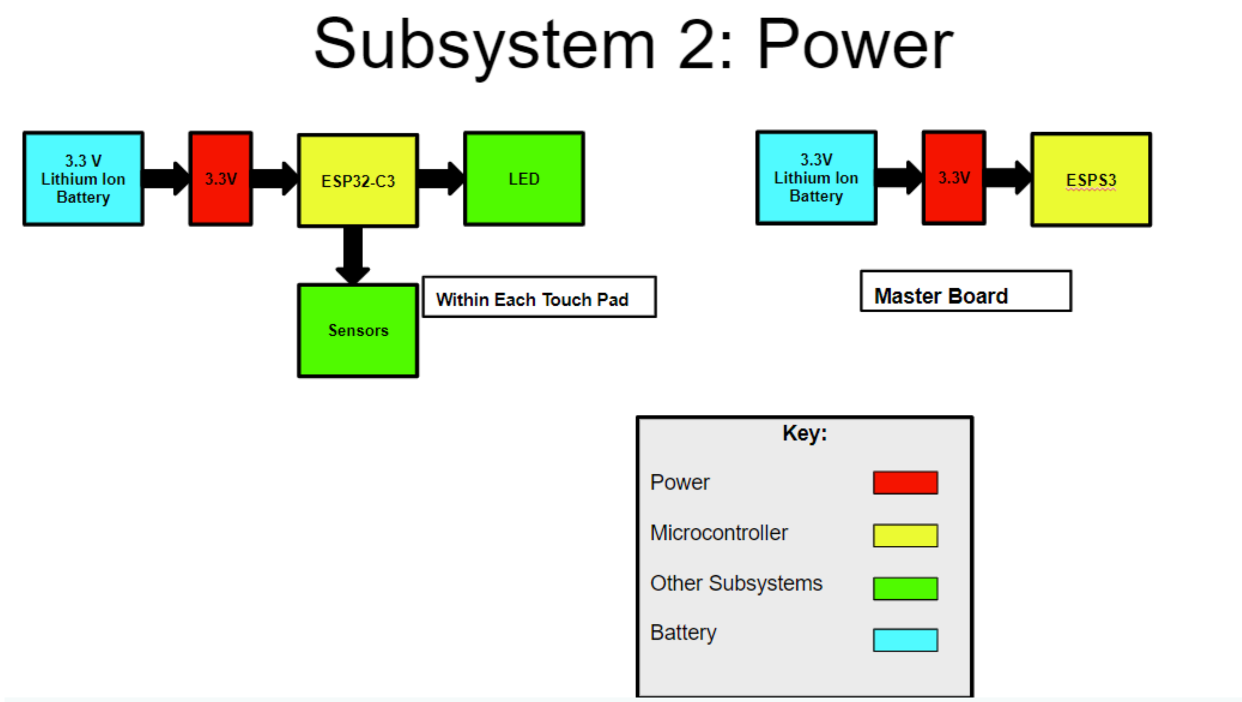
The overall system contains six subsystems. Subsystem 1 consists of the overall mechanical casing of the striking system. Subsystem 2 focuses on powering the striking system which relates to its internal system of powering the overall system. Subsystem 3 is the sensing mechanism within the striking system. Subsystem 4 consists of the LED lighting mechanism within each striking system. Subsystem 5 involves the software element to the user interface with the website that involves the collection, analysis, and displaying of data throughout workouts. Subsystem 6 focuses on the hardware side of this user interface as each drill is started. 3.3V directly powers the ESP32-Wroom; this 3.3V also powers Subsystem 2, which contains both types of push buttons. The push buttons of Subsystem 2 will be enclosed in a striking system involving a durable protective outer casing that the user will strike. Subsystem 2 also directly connects to the ESP32-Wroom; this ESP32 connects to both Subsystem 3 and Subsystem 4. The ESP32 connects to the user interface of Subsystems 5 and 6 via WiFi.

Subsystem 1:



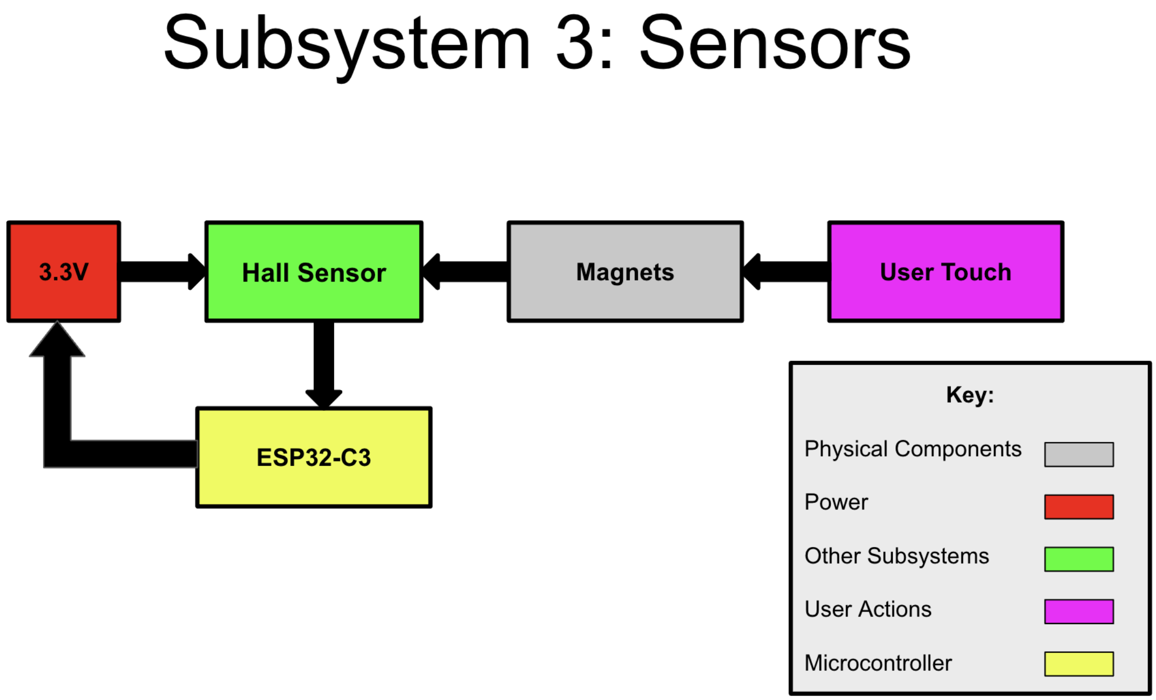
Subsystem 1, while being the most simple functionally, is arguably the most vital as it serves to protect the electronic hardware and provide a mechanical means of registering a response through user touch. The mechanical casing will be modeled in SOLIDWORKS and will consist of a dome that makes up the top of the button that is spring loaded to the base. The mechanical casing will need to be large enough to fit hardware including the hall sensors/magnets, LED, power system, and ESP32, but not too large that it poses a risk of being tripped over or unmountable to a wall. It will also need to be durable enough that it can last under heavy use and in different weather conditions.

Subsystem 2:



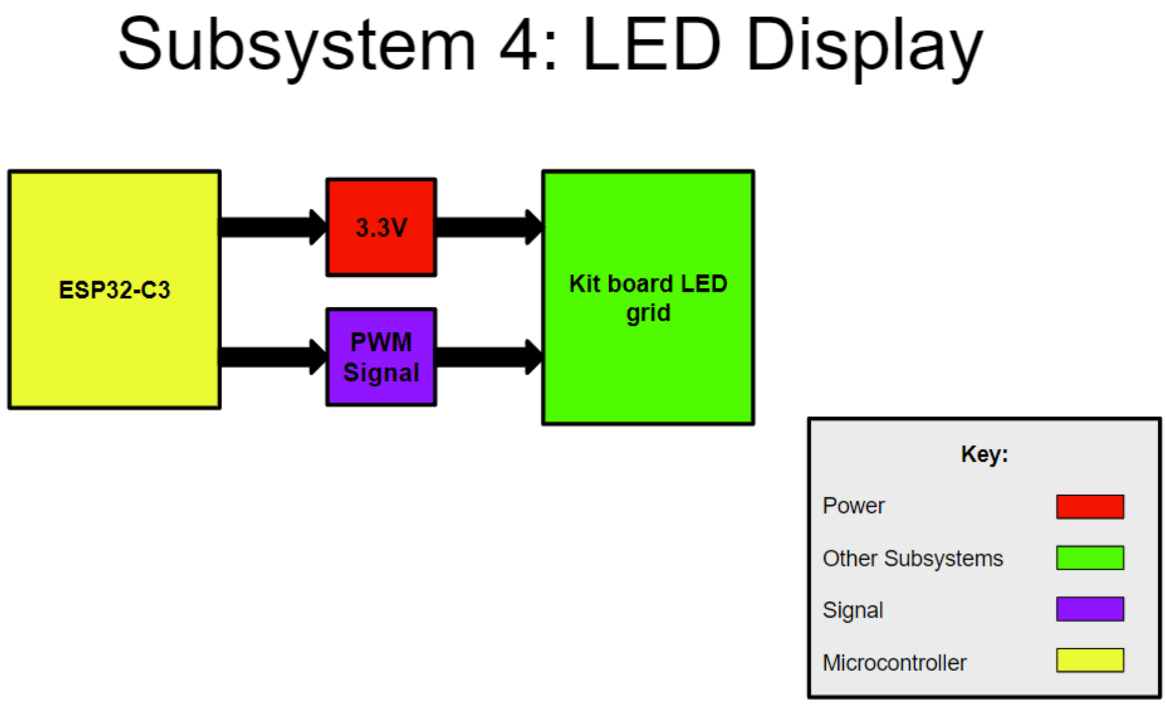
Subsystem 2 represents the power requirements necessary. The major components of the individual striking systems only require ~3.3 V; a 3.3V lithium ion externally rechargeable battery pack will power those individual pads, and will be integrated into the base structure of the design. The master board ESP32-S3-WROOM-1 has dual core 32-bit LX7 microprocessor, which operates with 2.4 GHz of Wifi; this allows for Wifi communication between master board and website. This series also operates with ESPNow, so individual boards can communicate with the master. This series is also powered with 3-3.6V, so the same rechargeable battery pack can be used.

Subsystem 3:



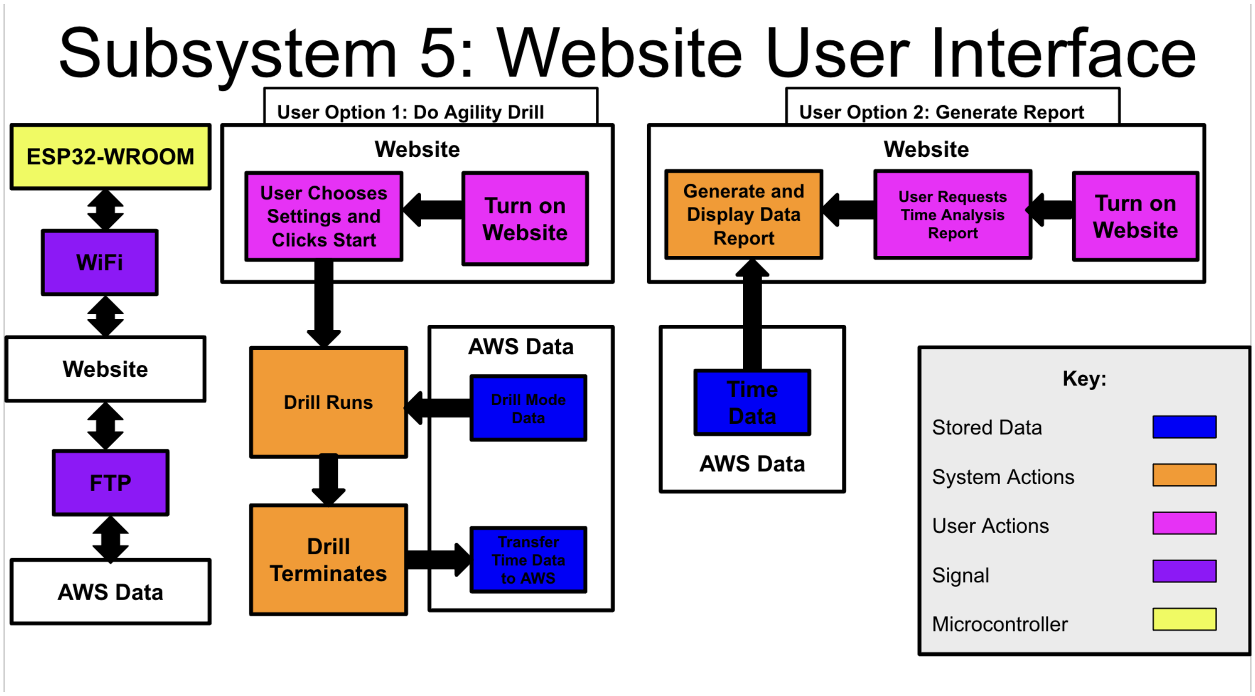
Subsystem 3 consists of the sensing system within the striking system. The system must be able to register user touch and communicate the touch with the ESP32 board. The system is powered using the 3.3 V lithium ion battery. The user touch is registered using a hall sensor. The hall sensor is the DRV5057Z2 linear hall effect sensor with PWM output. This operates within the 3-3.6V range. Two small, flat, circular magnets will be connected to the side of the mechanical casing and when the user strikes the casing, the magnets will move down. The hall sensor will register the change in magnetic field due to the magnet's movement. The hall sensor will be connected to the ESP32 board in the middle of the casing and when a change in magnetic field is detected, the hall sensor will send a signal to the ESP32 board, which will interface with the other subsystems.

Subsystem 4:



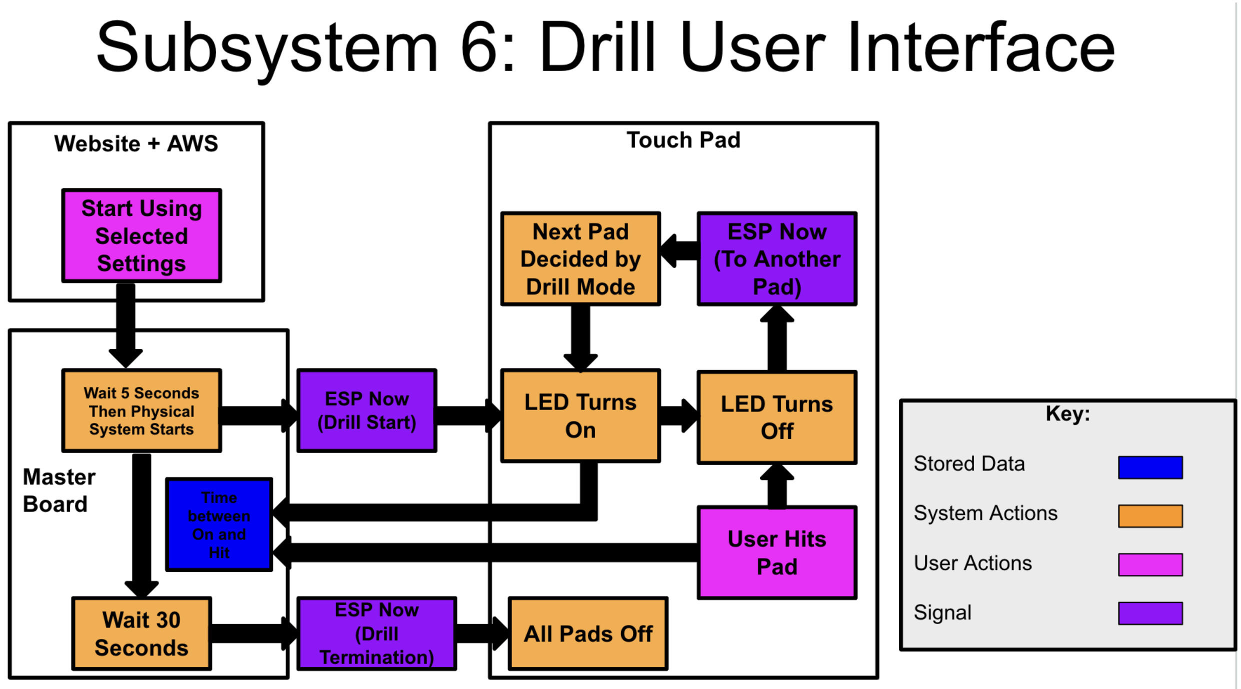
The ESP32-Wroom interfaces with a grid of individual LEDs that are integrated into the circuitry. The LEDs will be placed in the center of the structure to ensure the user sees it. The LED display will light up in response to the processor and must stay on until the pad is pushed. The LED will display different colors based on the program the user selects. Once the user pushes the pad, the LED must turn off and the LED on the next pad must turn on. Depending on the program, the LED may also turn off after a certain amount of time, even if the user does not touch it.

Subsystem 5:



The created website will interface with the ESP32-WROOM microcontroller via WiFi, and will use File Transfer Protocol in order to receive and store data in a bucket in AWS. When the user pulls up the website via their chosen device in order to run a drill, data will be transferred to the master board and then to the rest of the buttons. Once the user chooses their preferred settings the physical session will initiate. LEDs will turn on, and as the user hits the button, those LEDs will turn off. The time between the LED turning on and the user hitting it will be measured and stored. When the drill terminates, time data stored by the buttons will then be sent back to the master and into AWS where it will later be used to generate a data report for the user to see upon request.

Subsystem 6:



Subsystem 6 describes how the user interacts with the device once a drill is chosen. Once a workout is chosen on the website, the website sends the selected settings to the master board as well as the sequence/order that the buttons will light up. The master board then communicates with the other boards via ESPNow to execute the workout. Based on the workout chosen, a signal is sent from the master board to one of the other boards to turn its LED on. Once the button is pushed, the LED is turned off and a new signal is sent to the next ESP32 board via ESPNow. Each board records how much time it takes for the user to strike the button and stores this information to be sent to the master board and upon drill termination, to AWS. Completion of the drill initiates the data transfer back to AWS and the switch back to each button's initial state.

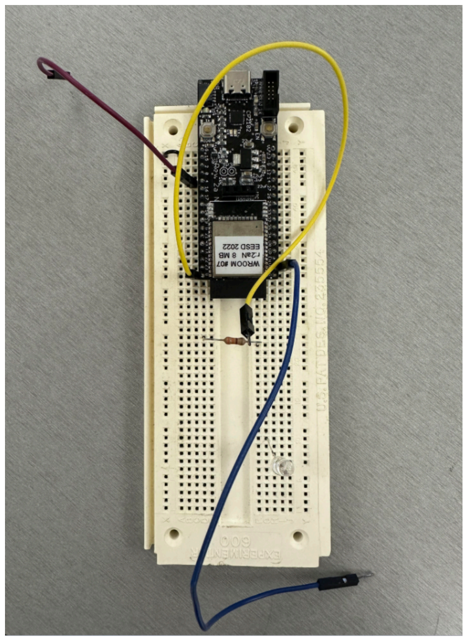
- Provide a brief explanation of why these major components were selected, including why you chose the ESP32 version you are using.
  - ESP32-C3-WROOM-02-H4
    - This version is good for complex applications, particularly involving smart home applications such as light control. It provides a wireless connectivity solution for Internet of Things (IoT) involving relevant applications. The ESP32-C series is supported by ESPNOW and specifically designed to work with it. This version contains RISC V 32-bit processors that are designed to consume less power; therefore, it requires only 3-3.6V of power, which aligns with our choice of power source. It also has hardware compatibility supporting long range applications, which gives the user

some leeway in picking the distances between the pads. It contains a dual-core 32-bit LX7 microprocessor which allows for high processing power.

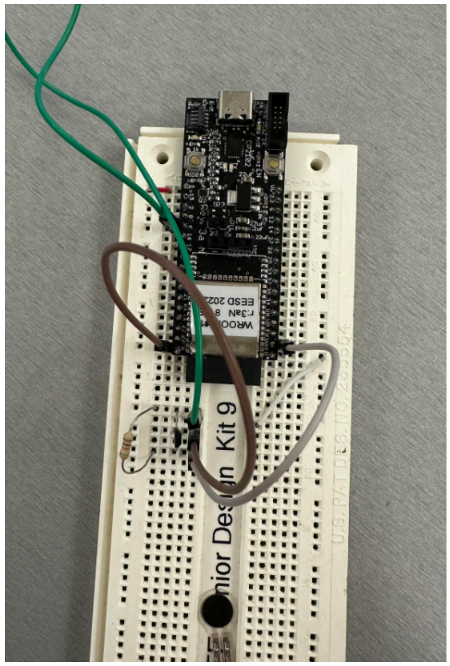
- ESP32-S3-WROOM-1
    - This will act as our master board. This was chosen because of its dual-core processor system that allows it to communicate via wifi, which is how the board and website will interact. This series is also compatible with ESPNow protocol, so individual boards can communicate with it. It also only requires 3-3.6V of power, so the same rechargeable battery can be used to power it.
    - https://www.espressif.com/sites/default/files/documentation/esp32-s3-wroom-1_wroom-1u_datasheet_en.pdf
- Circuitry
    - Hall Sensor DRV5057Z2 - This operates within the 3-3.6V range. It produces digital 0s or 1s depending on the presence of a magnetic pole. Proximity to one pole will switch the sensor ON, proximity to the other pole will switch the sensor OFF, and the absence of a pole will leave the sensor in its present state. This sensor was chosen because the magnet does not need to directly touch the sensor; only close proximity is required. The system will be configured to get a small magnet close enough to the sensor. Magnet was chosen because of its small-enough size to be integrated into the mechanical system, and is required for a hall effect sensor to operate.
        - https://www.ti.com/lit/ds/symlink/drv5057.pdf?HQS=dis-dk-null-digikeymode-dsf-pf-null-wwe&ts=1708883866051&ref_url=https%253A%252F%252Fwww.ti.com%252Fgeneral%252Fdocs%252Fsuppproductinfo.tsp%253FdistId%253D10%2526gotoUrl%253Dhttps%253A%252F%252Fwww.ti.com%252Flit%252Fgpn%252Fdrv5057
        -
    - Kitboard LEDs - The kid board LEDs will be oriented in a grid system in the circuit within the casing at the center of the pad. These will produce RGB colors depending on the sequence the user chooses. These also only require 3.3V to operate.

- Give a detailed description of your powering scheme. If you are using rechargeable batteries, the details of that should be included.
    - We decided to use a rechargeable lithium ion battery because of its thin, light shape, long life-span, and appropriate nominal and cutoff voltages. The Polymer Li-ion Rechargeable battery from SparkFun Electronics is a light-weight option in terms of lithium ion batteries due to its polymer casing.

- All electrical devices operate in the 3-3.7 V range, therefore the battery chooses has a nominal voltage of 3.7 V.
- The battery will be secured to the bottom of the mechanical casing and will have a charging mechanism on the side, allowing the battery to be plugged into an outlet or computer USB.

- Specify essential connections on all major components.
    - Wiring the board
        - LED circuit
            - 

            - This circuit includes an LED and a resistor
        - Hall sensor circuit

        - 

            - General schematic for a hall sensor based on data sheets. Resistor values will be updated based on new parts picked. The circuit contains the hall effect sensor connected to a resistor, Vdd, ground, and pin 4.
    - Boards wirelessly connected
        - The ESP32-C3 boards contained in each striking system will wirelessly connect to a main control box containing its own ESP32-S3 board. The boards will wirelessly connect and communicate with this board via ESPNOW.
    - Website to board
        - The ESP32-S3 board contained in the main control box will wirelessly connect to a website built using AWS via WiFi. The ESP3-S3 board will receive instructions via computer programs stored in S3 buckets of AWS. These computer programs will determine the workout deployed by the touchpads and, consequently, the sequence the LEDs would light up. The ESP32-C3 boards located in each striking system will communicate data to the ESP3-S3 via ESPNow which will then send the data to the website. The website will analyze and display the data received.
- Power requirements.
    - ESP32-C3-WROOM-02-H4 requires 3-3.6 V of power
    - ESP32-S3-WROOM-1 requires 3-3.6V of power
    - Kid board LEDs require 3.3V
    - DRV5057 Hall effect sensor operates between 3-3.6V of power.
- The nature of the interfaces (SPI, I2C, analog, etc.) between subsystems.

    - ESPNOW will be used to interface between each ESP32-C3 board located in the striking systems to the ESP32-S3 board located in the control box. ESPNOW is a wireless communication protocol designed to send and receive data between ESP32 boards programmed with Arduino IDE. ESPNOW enables multiple devices to communicate with each other. Each ESP32-C3 board in the striking systems will interface directly with the ESP32-S3 master board located in the control box. We will use two-way communication with ESPNOW with a single master ESP32-S3 sending and receiving data from multiple ESP32-C3 slaves. The control box will interface with the user interface via WiFi to send and receive data.
- Specify any unusual requirements, such as board layout recommendations from the manufacturer.
    - No expected unusual requirements or board layout recommendations.
- Briefly describe how you are going to demonstrate working subsystems for Design Review 2.
    - Subsystem 1: Mechanical Casing
        - We will demonstrate this subsystem by putting an esp32 in a 3-D printed casing, pressing the button, and ensuring that the springs oscillate back to "rest" and that the electrical components are not damaged. We will also ensure that the casing is strong enough to withstand a full hit and is satisfying for the user to press.
    - Subsystem 2: Powering Method
        - We will demonstrate this by connecting the battery pack to the other subsystems, demonstrating that the method sufficiently powers all subsystems. We'll confirm that the recharge is successful.
    - Subsystem 3: Sensor
        - We will connect the Hall Sensor and accompanying circuit to a kit board and measure its response to a magnet moving into its presence. The ESP32 will return either "magnet detected" (button has been pushed) or "magnet undetected" (button has not been pushed).
    - Subsystem 4: LED Display
        - We will connect the LED and accompanying circuit to a kit board and turn it on and off and change colors in a specific pattern. The pattern will be dictated by a "workout" code that is uploaded to the ESP32 prior to testing.
    - Subsystem 5: Website User Interface
        - We will demonstrate this by simulating a workout drill being performed from start to finish several times. A chosen participant will access the website created via a device, adjust settings as necessary, and will complete the drill in its entirety. We will ensure the interface functions as

expected, the settings are adjusted as the participant selected, and the data report that is generated is accurate and displayed properly.

- Subsystem 6: Drill User Interface
    - We will demonstrate this in a similar manner by performing a drill from start to finish several times. We will ensure the drill adjusts to changes in settings by varying them several times and that the LEDs on the striking system turn on and off as expected. We will ensure times recorded are accurate and data is transferred back to AWS correctly.