SUKHMEET SINGH HORA

7884859

LAB1 LOGBOOK – ECE3760

References Used:

https://en.wikipedia.org/wiki/Curling#:~:text=Points%20are%20scored%20at%20the,than%20the%20opponent's%20closest%20stone.

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MSC
https://universityofmanitoba.desire2learn.com/d2l/le/content/505516/viewContent/3335632/View

LAB3 documentation
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ESP NOW https://randomnerdtutorials.com/esp-now-esp32-arduino-ide/

ESP NOW https://randomnerdtutorials.com/esp-now-two-way-communication-esp32/

20th January 2023

Curling: Curling is a sport in which players slide stones on a sheet of ice toward a target area which is segmented into four concentric circles. It is related to bowls, boules, and shuffleboard. Two teams, each with four players, take turns sliding heavy, polished granite stones, also called rocks, across the ice curling sheet toward the house, a circular target marked on the ice. Each team has eight stones, with each player throwing two. The purpose is to accumulate the highest score for a game; points are scored for the stones resting closest to the centre of the house at the conclusion of each end, which is completed when both teams have thrown all their stones once. A game usually consists of eight or ten ends. The player can induce a curved path, described as curl, by causing the stone to slowly rotate as it slides. The path of the rock may be further influenced by two sweepers with brooms or brushes, who accompany it as it slides down the sheet and sweep the ice in front of the stone. "Sweeping a rock" decreases the friction, which makes the stone travel a straighter path (with less curl) and a longer distance. A great deal of strategy and teamwork go into choosing the ideal path and placement of a stone for each situation, and the skills of the curlers determine the degree to which the stone will achieve the desired result.

Understanding how the curling equipments work and the dimensions of the rock and broom.


How does curling work? Video

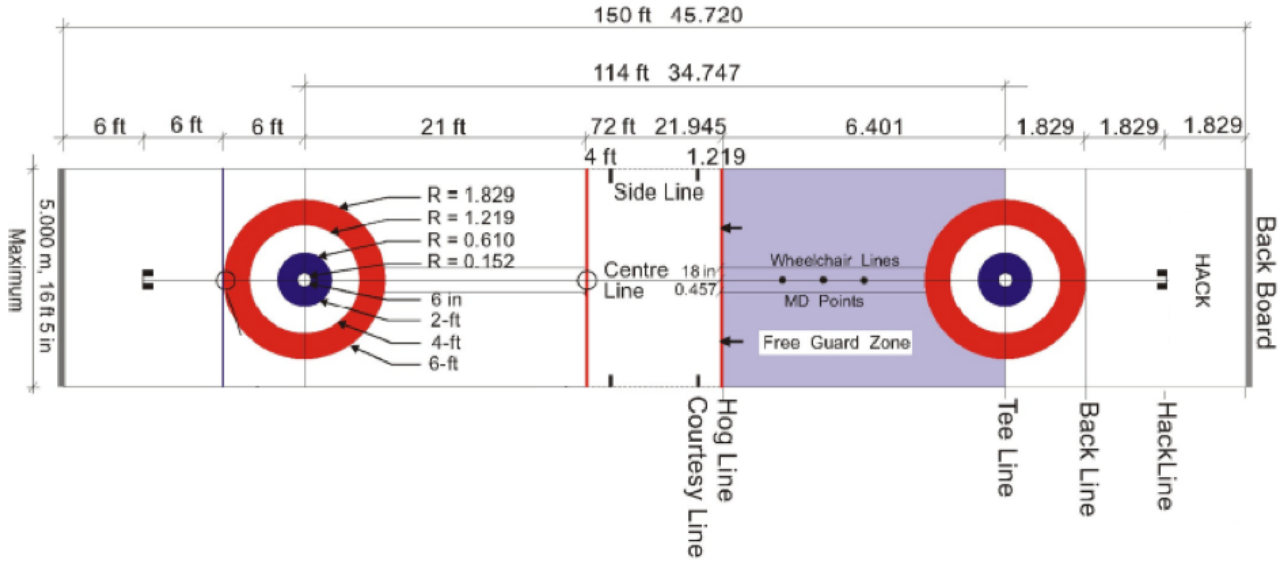
A 2minute curling game – to understand rules and the gameplay.

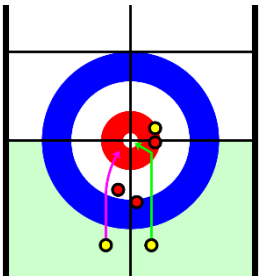
Learning about Sweeping.

UNDERTANDING THE DIMENSIONS OF THE ROCK AND BROOM AND ITS FUNCTIONS

- The dimensions of a curling rock, also known as a stone, are regulated by the World Curling Federation (WCF) and are as follows:
- The diameter of the stone must be between 36.6 and 38.1 centimeters (14.4 and 15 inches)
- The height of the stone must be between 11.2 and 11.5 centimeters (4.4 and 4.5 inches)
- The weight of the stone must be between 19.96 and 20.72 kilograms (44 and 46 pounds)
- The maximum circumference of the stone's running surface must be between 110.5 and 111.5 centimeters (43.5 and 44 inches)
- The maximum circumference of the stone's handle must be between 30.5 and 31.5 centimeters (12 and 12.4 inches)

Brush head should be between 8-14 inches in width and made of horsehair or synthetic materials. The handle should be at least 44 inches long and made of wood or composite materials. Broom is used in the game to sweep the ice to reduce the friction to make the rock curl in right the direction and move towards the house target with high or good sped and move straighter. The broom in held in position with one had in the top half and other in the bottom half as in the figure.

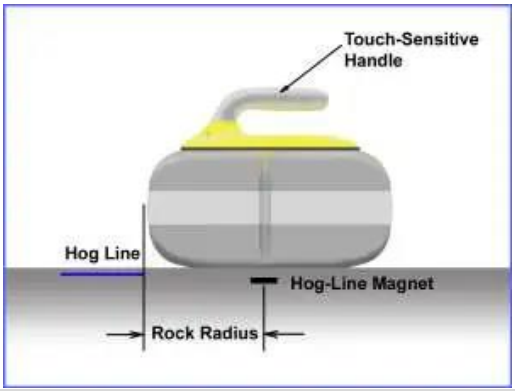


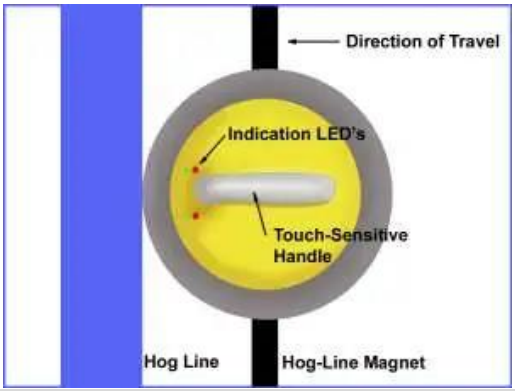


The next step was to understand the scoring rule basically the house (target dimensions) and the hog line violation rule and the electronic system to detect the system, also understanding the physical environment. The target area is called the house and the center is called tee; the team aim to sweep/slide rocks as close to the center of the target.

Hog Line violation occurs when rock thrower fails to release the stone before the stone crosses the hog line. In that case, the stone id removed from the play.

Eye on the Hog is a system that provides impartial hog-line judging for the sport of curling. It uses innovative technology to detect a magnetic strip frozen into the ice at the hog line and a bare hand touching the handle. Circuitry in the handle turns on green lights after a valid release or flashes red lights if a violation has occurred. The system is activated when the rock is tilted for cleaning. Circuitry turns off when not in use to extend the battery life to over 150 games. Operation of the touch sensor is confirmed by green lights that flash when the handle is not touched. Lights are off during delivery to prevent distraction.





Sukhmeet

Role of skipper:

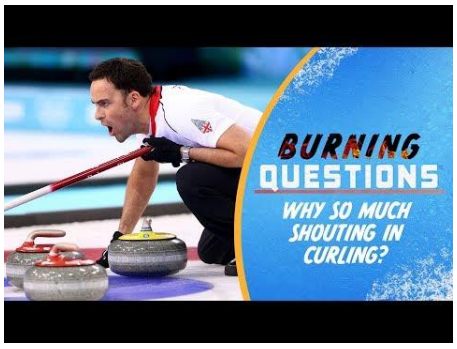
- Strategy
- Short and making calling instructions and informing the sweepers where to curl and tell the position skip wants the rock.
- Score keeping
- Team management

TEAM MEETING 01:

- Got to know each other as a team and discussed the strengths and weaknesses of each other.
- After discussing each others schedule, fixed a time for our weekly meetings.
- Discussed the project problem statement and made a to do list which included brainstorming ideas, thinking of constraints or challenges for the project and empathize deaf curlers situation.

PROBLEM STATEMENT:

To design a technology solution to help deaf curlers, specially to overcome the challenge of sweepers on ice not being able to hear the skip yelling sweeping instructions.



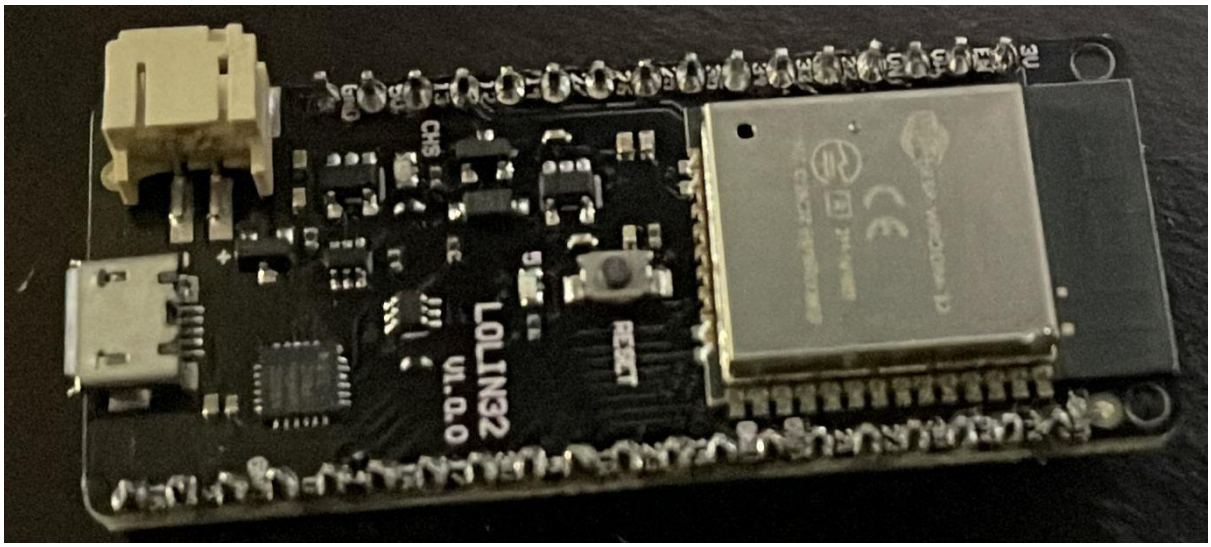
Understanding sweeping instructions.

Understanding the challenge and how overcome by professional deaf curler interview.

23rd January 2023

Lab Day: Soldering board ESP32

- Soldered the board and tried to activate the Bluetooth and test the board and installed the drivers for Bluetooth.
- Temperature : 360 degrees Celsius and used chisel tip.



<u>Emphatic Design Perspective</u>:

Deaf curlers face several unique challenges when it comes to participating in the sport of curling. Some of the main issues that deaf curlers face include:

- Communication: Curling relies heavily on verbal cues and instructions, making it difficult for deaf curlers to communicate effectively with their teammates on the ice. This can lead to confusion and mistakes during games and can make it more difficult for deaf curlers to compete at the same level as their hearing counterparts.
- Safety: Curling is a fast-paced sport that can be dangerous if proper safety precautions are not taken. Deaf curlers may have difficulty hearing warnings or emergency announcements, which can increase their risk of injury.
- Accessibility: Many curling clubs and facilities may not have the necessary equipment or accommodations to make the sport accessible to deaf curlers. For example, not having visual signaling systems or captioning during announcements can make it difficult for deaf curlers to fully participate in the sport.
- Socialization: Curling is a social sport and many curling club have a strong social aspect to it, participating in the sport can be an important way for people to connect with others and form friendships. For deaf curlers, the lack of verbal communication can make it more difficult to socialize with other curlers and form connections with teammates.

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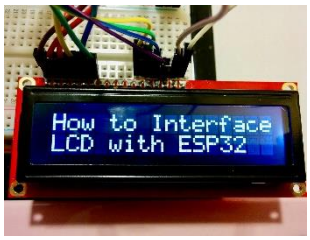
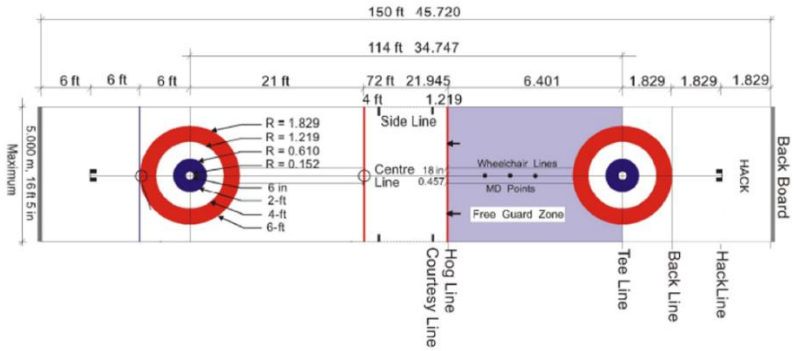
Understanding hand signal currently skip use which create a lot of distraction and disrupt the game.

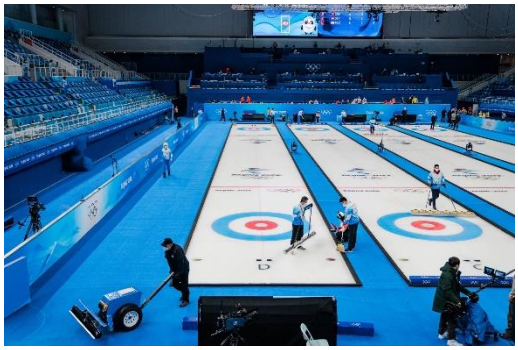


Instead, a visual LED display screen should be used to display the message given by the skip easily within the range of visual and easily be able to focus on the rock and the ice ahead.

Physical Environment: is a rectangular sheet of ice (curling ring) with a circular target called house and a hog line with stones and brooms for each team player.



Digital Environment: include scoreboards, shot tracking (track the speed of stone), video relay, communication device (to communicate remotely) and now assistive technology too (for wheelchair and deaf curlers).



o Scoreboards: Electronic or manual scoreboards that display the score of the game in real-time.

o Shot tracking: Systems that track the path and speed of the stones as they travel down the ice. This information can be used for analysis and training purposes.

o Video replay: Systems that allow players and coaches to review video footage of shots to analyze technique and strategy.

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o Communication devices: Systems that allow players and coaches to communicate remotely, such as walkie-talkies or headsets.

o Assistive technology: Systems that can help deaf curlers to communicate with their teammates and participate in the sport more fully.

Overall, the physical and digital environment around curling game can play an important role in enhancing the game experience for players and spectators. The physical environment provides a safe and comfortable place to play the game, while digital tools and systems can be used to enhance the game experience and improve performance.

26th January 2023

Constraints/Challenges

- Does not impede the ability to play the game (i.e., get in the way of the broom, etc.)
- Should be portable (not too heavy or intrusive)
- Two types of devices: one for skip (Transmit) and one for the sweepers (Receive)
- The devices should remain connected across the full range of the ice (156ft. or more).
- Communication with the sweepers should be through visual cues.
- Signals should be within the field of view of the sweeper so they can focus on sweeping.
- The sweeper must keep looking on the stone and the ice ahead.

BRAINSTORMING IDEAS AND TEAM MEETING 03 (DISCUSSION):

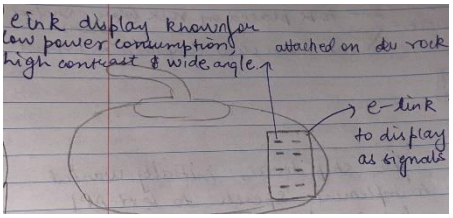
Ideas for sweepers' device:

1. Broom mounted visual signal display.
   a. LEDs: cheaper
   b. LCD display: more descriptive signals, more versatile/customizable
   Pros: in field of vision
   Cons: might interfere with holding/operating the broom, hard to read signals due to movement

2. Vibrating body mounted device.
   a. Hand/arm
   b. headset
   Cons: hard to feel the vibration while movements and sweeping actions

3. AR glasses to display visual cues:
   Pro: Easy to see
   Con: can come in the middle of vision, difficult to see surrounding and interfere with the game.

4. Visual signal display on the curling rock/ rock handle: 6 LEDs in total on the rock (LCD Display can also be used to replace the LEDs):



   Pro: more surface ae on the rock, normally rock moves really slow with less spin and sweepers have sign on the rock only to observe the curl and speed, so each to read the instructions displayed on the LED screen.

Ideas for Skips' device:

1. Handheld remote
   Pro: single handle which can be portable and modular, easy to use joysticks and buttons

2. Computer vision recognize the skips hand signals.
   Pro: like how the game is played
   Cons: The skip may also be deaf

3. Speech to text API (Application Programming Interface) connected to skips microphone.
   Pros: like how the game is played
   Cons: The skip may also be deaf , time limited to implement, and resource limited.

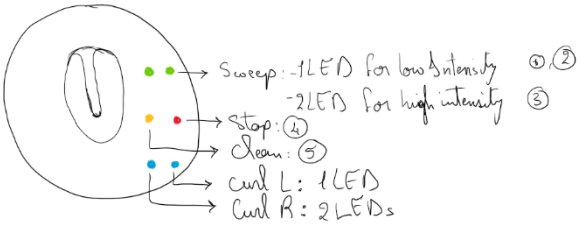
Design notes taken:

- Can't put it on the sides because the rocks hit each other.
- E-ink display for low power consumption.
- Modular/ portable design for convenience.
- Speech-to-text application (limited in time and resources, functional prototype)

Initial Design Idea decided in meeting:

Skippers Device: Handheld remote with buttons and joystick that is used to transmit instructions to the deaf curlers/sweepers, each button send signals with pre-programmed command/text messages to display on screen and light up the screen.

Sweepers Device: e link visual display attached on the rock to display text message and light up the screen with different colours corresponding to different buttons pressed.



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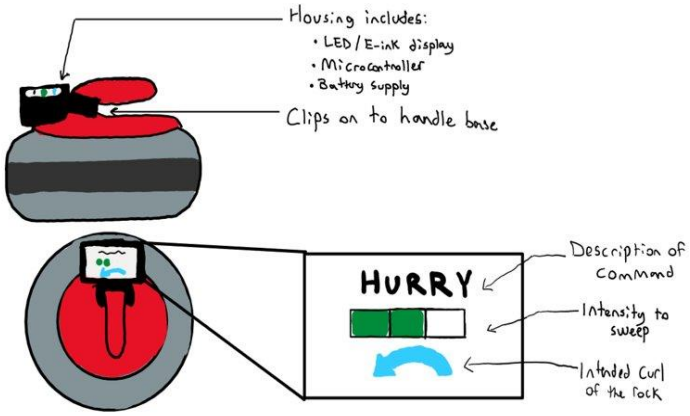
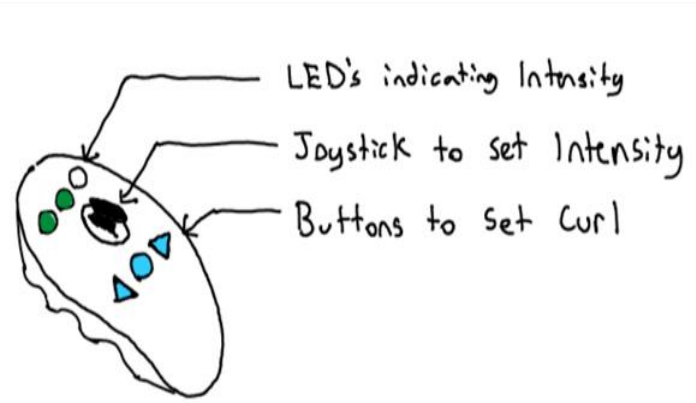
29th January 2023
INITIAL DESIGN ANALYSIS AND PITCH IDEA:

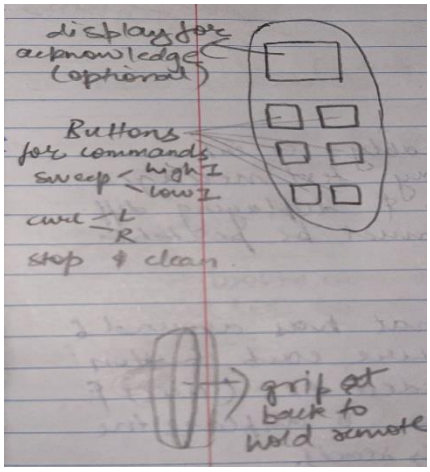
- Sweepers Device: Visual signal display on the curling rock/ rock handle for the sweeper's device which is a receiver for all the instructions given by the skip.
    - Portable so that it can be easily carried and comes in handy with the kit, also does not hinder the game play of either the sweepers or the curlers.
    - LCD Display like e-ink that can display colors and text would likely be a type of electronic paper display (EPD). E-ink technology is known for its low power consumption, high contrast and wide viewing angles, making it a suitable choice for applications where the display needs to be readable in different lighting conditions.
    - The design is such that the LCD will display the text messages in different color ways to indicate the instructions given by the skipper, the design will be more suitable for players to use in practise as it will easier for them to read the instructions and get to know exactly what the skipper has yelled.
    - shows the text or color that corresponds to the button pressed. This would allow the deaf curler to easily see and understand the communication from their skip. The device could also be programmed with different languages or signs to accommodate different deaf curlers.
    - Also, it will be more suitable to have this to have on the rock as the broom is moved rigorously, also the surface of rock is larger, and all the players will easily be able to see the instruction by bright color, bigger text, and high contrast display.
    - The size should be large enough (like 6 inches) to be easily read from a distance but small enough to be ported comfortably, have a high contrast between the display and text color, different color for different buttons and the text should be in readable form, The display can have a backlight to make it easy to detect in low light conditions.



    - The design must prioritize visibility, easy to handle and not disturb the game play.

- Skip Device: Handheld remote device with buttons that transmit instructions to the deaf curlers and the sweepers which instructions depending on the sweeping pressure, curling direction and need to clean.
    - each can send signals with preprogrammed text and light up the LCD display with different colors depending on different instructions or signals that could help deaf curlers to easily get instructions from the skip.
    - “Hurry” - sweep quickly.
    - “Hurry hard,” “hard” - sweep with a lot of downward pressure
    - “No,” “Off,” “Up” - stop sweeping.
    - “Clean” - sweep with minimal pressure to clear snow/debris from the surface
    - Curl left.
    - Curl right
    - The buttons should be arranged in a logical way with buttons mostly used closer and nonslip surface to ensure tight hold grip, on/off switch to turn on/off the device and have a rechargeable battery with long lasting life.
    - The device should also have a hand back to hold it around the hand so that it is securely attached to the skip.
    - This will be easy for the skipper to just press a button which can programmed as per need for the instruction’s words, pressing respective button will send programed text and light up the visual display.
    - An additional feature can be added to give skip feedback that the button was pressed successfully and acknowledge the message sent to display on LCD display.



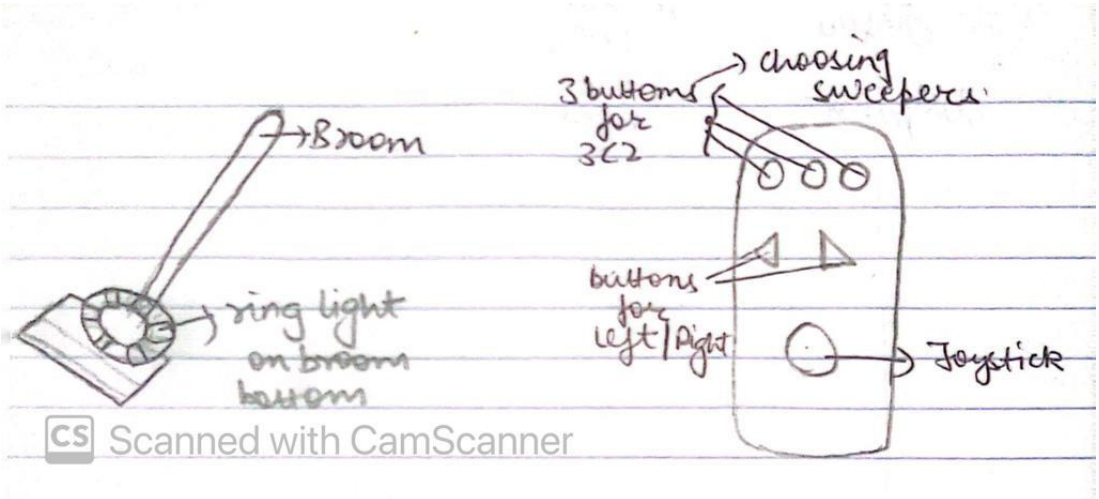


7th February 2023:

After the curling lab, me and my team decides on re-evaluating our design. After the presentation and reviews from the class, had already started to reconsider the idea of having LCD display on the curling stone. After curling the major limitation was looking on the stone while sweeping, the only place clearly visible while sweeping was the ahead and sometime the broom. Asking the sweepers and other professionals, the suggestion came to use vibration motor but still had some drawbacks. Another requirement or consideration was to have the skip device be able to choose 2 sweepers out of the three(3C2) for the initial though was to include 3 buttons (in sequence of Lead, Second, Third(Vice Skip)) to decide the sweepers.
The team had started to brainstorm ideas to be able to have OLED display or LEDs on the broom and change skip device to incorporate ways to choose 3C2, choose left or right sweeper/direction and have directional sweeping methods along with a way to set intensities: Stop, Clean, Sweep and Sweep Hard!

My Brainstormed Idea:

- Use the Digi Bob Ring lamplight to at the broom and only LEDs to change colours to indicate direction and shaped/fullness to show intensity.
- And for the skips device use joystick for intensity, have 3 buttons to choose sweepers (3C2 combination is needed).



10th February 2023

Then I tried to enable Bluetooth on Esp32 completely using platform IO in visual code and tested it using Putty Serial Line with my port number (COM#).It did this to just get started and try using Wi-Fi on my device.

Code for my later reference:

Sukhmeet

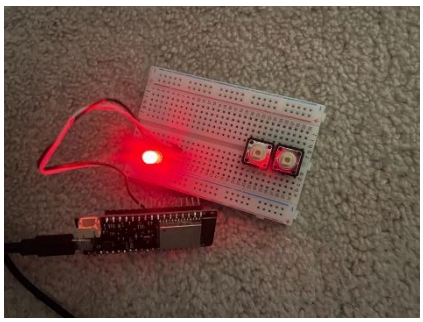
```
#include <Arduino.h>
#include "BluetoothSerial.h"

#if !defined(CONFIG_BT_ENABLED) || !defined(CONFIG_BLUEDROID_ENABLED)
#error Bluetooth is not enabled! Please run `make menuconfig` to and enable it
#endif

BluetoothSerial SerialBT;

void setup() {
  Serial.begin(115200);
  SerialBT.begin("ESP32test"); //Bluetooth device name
  Serial.println("The device started, now you can pair it with bluetooth!");
}

void loop() {
  if (Serial.available()) {
    SerialBT.write(Serial.read());
  }
  if (SerialBT.available()) {
    Serial.write(SerialBT.read());
  }
  delay(20);
}
```

11th February 2023

Tried to enable Wi-Fi communication on my board and then use a server with requests like clickable links (buttons) which can be used to turn on and off specific Led, found sample of code to turn on and off LEDS, also samples codes to enable Wi-Fi communication. I combined them and changed the pin configuration and made it work , link click on one button to turn on LED and click another button to turn off.
Then I thought of a way to communicate between 2 controllers.
The initial idea I found to implement the connection between two controllers is to use as a function that sends a GET request to the server and retrieve the state of the button of the other controller using HTTP client libraries if the response is 1 ,the LED is turned on other the LED is turned off if the response is 1 and use Digital Write to control the state of the LEDs. The other controller must also be configured to give the state of the button.

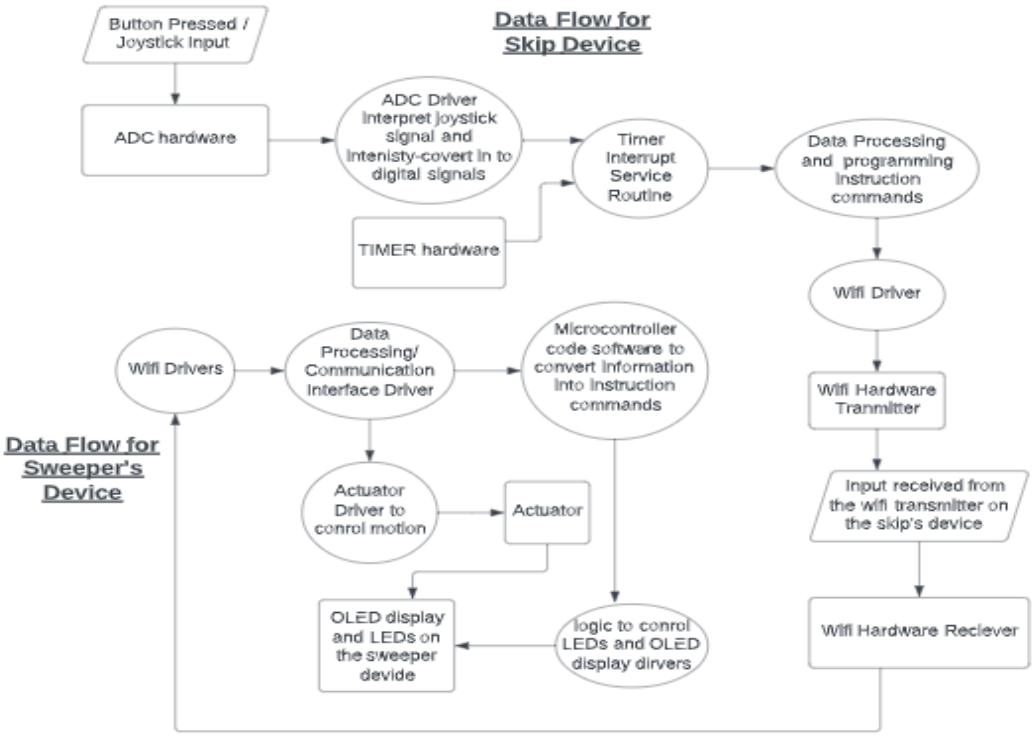
I combined some codes I found online changed the server ids, pin configuration and tried to implement but could not make it work so thought to implement a more simpler but will get back to make work later and work on communication between microcontroller later with one of my team members to have button on one and led display another.

I suspected to have some issues with the codes, possibility with the port number and could not make it work so then I decided to just try to turn on led using built in libraries in Arduino. I set up Adafruit ,VSM connected the board to the LED using the pin number 26, set up digital feed then the setup code was to set pin, start serial connection, wait for serial monitor and connect to io.adafruit.com wait for connection, there was also a message handler which is called when digital feed message is received , which checks the data pin level and then set the LED to on if high and off if low using digitalWrite.



12th February 2023:

Decide to research a bit about data flow for both the skip and sweepers device. For the skipper's device – thought of the need of having ADC in the skip to be able to convert or any other protocol to convert the input into programming instruction ad commands and then pass then to other controller using Wi-fi, for the sweeper's device – Wi-fi receive will get the commands -convert the code into instruction that can be used a logic to control LEDs and display text commands on the Oled display , thought there will need for actuator to control the motion. All these are subject to change depending on team discussion and further research.

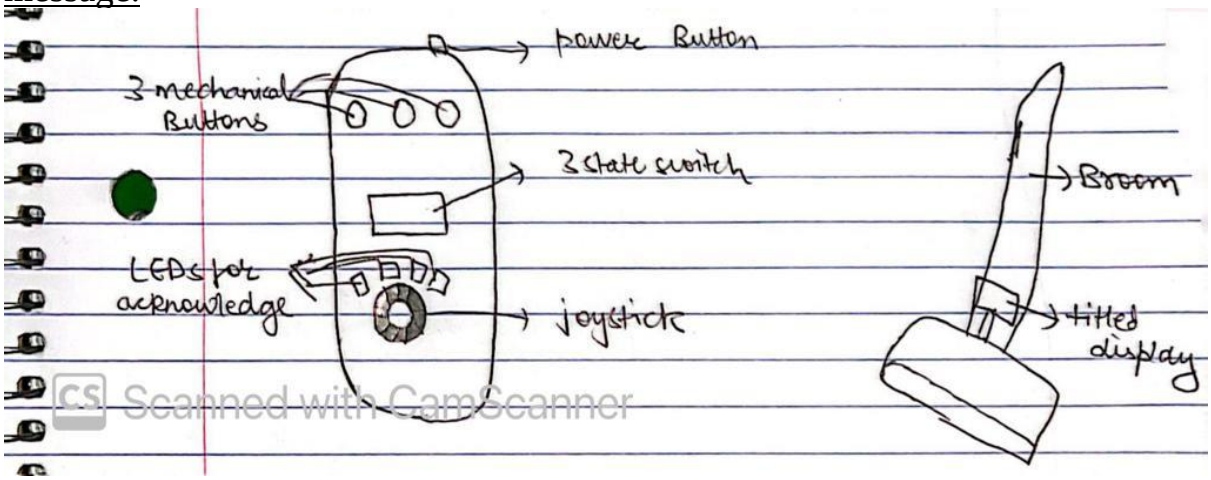


13th February 2023:

Had a meeting with the team to decide the final design after the changes from the last presentation and to decide the parts and equipment required to order.

The final decided after considering things like the skip's button should not be complex (with too many button), should be single finger control and short enough to easily handle and use efficiently during game. Had many decision between using slider (linear potentiometer or joystick for intensity), decided to have a joystick as it will easy to use, have three mechanical buttons to decide 3C2 i.e choose 2 sweepers and hen a 3state switch to decide the direction. With a power switch on the top.

The design for sweepers device was divided to switch to the broom with Oled display attached at the bottom with a tilt towards a sweepers side keeping in mind to have a short and strong mount between broom and display, which will display text, which is instruction commands given by skip, also change the background to different colours to make it easy for sweepers to notice the message.



The parts decided to have from the shop, order or get from Digi Bob are:

- 2x LOLIN dev boards (Digi Bob)
- 1x OLED Display (Digi Bob)
- 1x Joystick (Digi Bob)
- 3x mechanical buttons (order online)
- 1x 3-state switch (Digi Bob)
- 2x Power switches (Digi Bob)
- Leds and others from shop

Must still decide the exact the component and place orders both from online and Digi Bob by Thursday

Sukhmeet

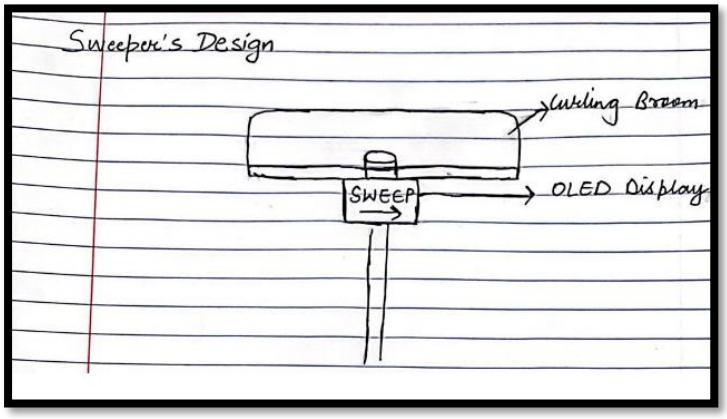
19th February 2023

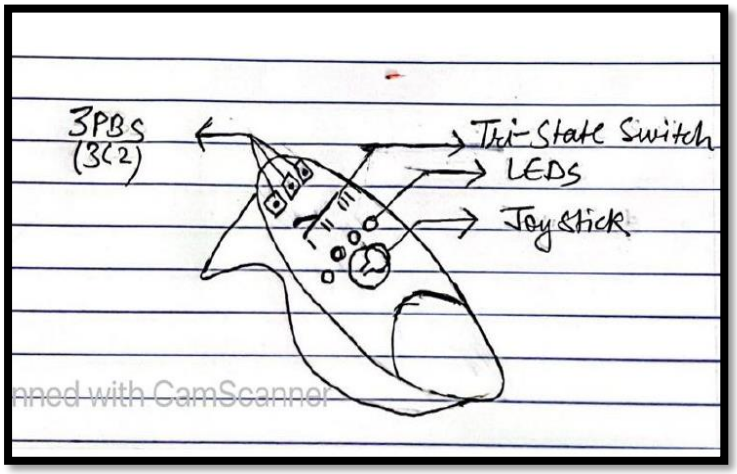
State charts are typically made up of states, transitions, events, and actions. A state represents a condition or mode that a system can be in, while a transition represents a change from one state to another in response to an event or condition. Events are external inputs that trigger transitions, while actions are the activities or behaviours that occur when a transition is made. Together, these elements allow designers to model the behaviour of a system and identify potential problems or areas for improvement.

Things and States to consider:

- Power Saving Mode State
- Idle State
- Connecting State
- Reading input from the skip , converting into analog signals and send to the sweeper device after establish a secure connecting with sweeper.
- On the sweeper side, interpret the signal received and convert into preprogramed commands and then display on OLED display.

Design solution at this point:





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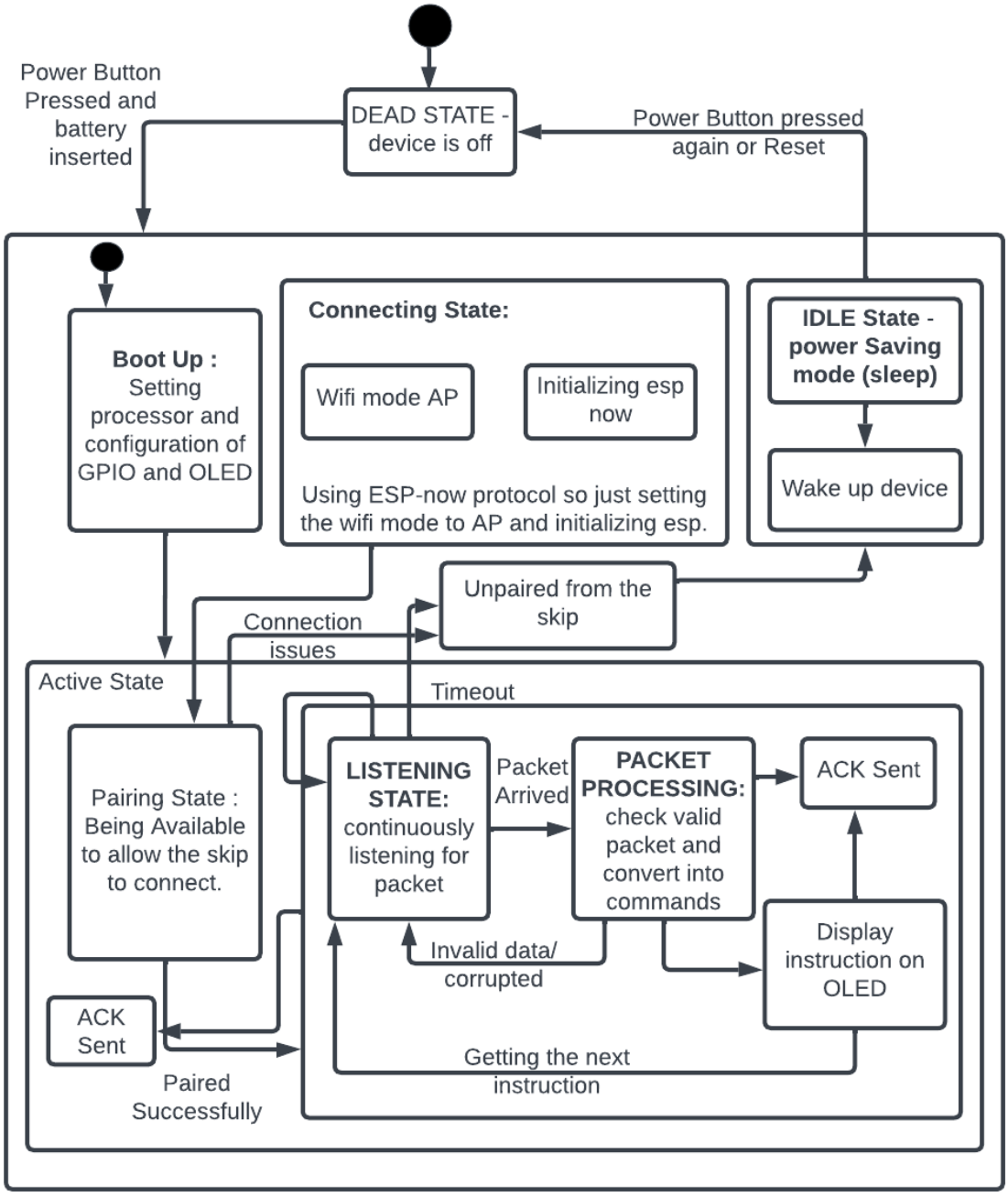
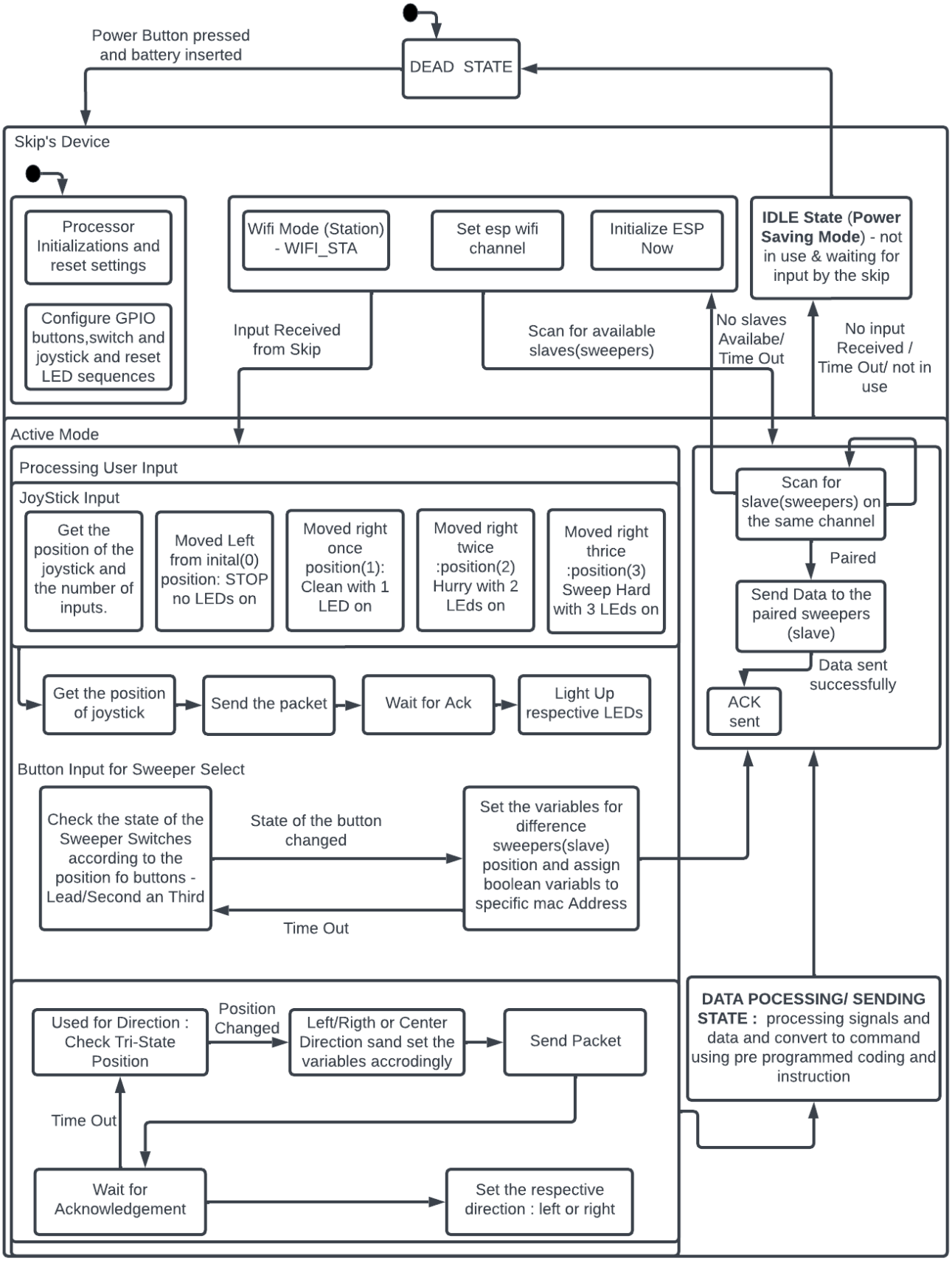
State Charts:




Power Button pressed and battery inserted
DEAD STATE
Skip's Device
Processor Initializations and reset settings
Configure GPIO buttons,switch and joystick and reset LED sequences
Wifi Mode (Station) - WIFI_STA
Set esp wifi channel
Initialize ESP Now
IDLE State (Power Saving Mode) - not in use & waiting for input by the skip
Input Received from Skip
Scan for available slaves(sweepers)
No slaves Availabe/ Time Out
No input Received / Time Out/ not in use
Active Mode
Processing User Input
JoyStick Input
Get the position of the joystick and the number of inputs.
Moved Left from inital(0) position: STOP no LEDs on
Moved right once position(1): Clean with 1 LED on
Moved right twice :position(2) Hurry with 2 LEds on
Moved right thrice :position(3) Sweep Hard with 3 LEds on
Get the position of joystick
Send the packet
Wait for Ack
Light Up respective LEDs
Scan for slave(sweepers) on the same channel
Paired
Send Data to the paired sweepers (slave)
Data sent successfully
ACK sent
Button Input for Sweeper Select
Check the state of the Sweeper Switches according to the position fo buttons - Lead/Second an Third
State of the button changed
Set the variables for difference sweepers(slave) position and assign boolean variabls to specific mac Address
Time Out
Used for Direction : Check Tri-State Position
Position Changed
Left/Rigth or Center Direction sand set the variables accrodingly
Send Packet
Time Out
Wait for Acknowledgement
Set the respective direction : left or right
DATA POCESSING/ SENDING STATE : processing signals and data and convert to command using pre programmed coding and instruction

21st February 2023

A lot of things to consider and rethink the design solution after feedback from state chart assignment.

- Design solution could be considerably reduced in complexity.
- Make the connection connectionless like use something Udp, ESP Now
- The skip's UX is redundant: reads the inputs at least three times like joystick, buttons and three state switches read the same inputs and is used in a wrong way like sending both direction and sweeper select, joystick.
- Some requirements:
    - Left and right, sweep hard or stop.
    - Left sweep hard or stop.
    - Right sweep hard or stop.
    - Clean or slow sweep
- Joystick that is capable of encoding direction was used for intensity.
- The meaning of the arrows may cause confusion, especially since individual sweepers receive separate commands.
- Additionally, displaying more metrics takes up space on the screen and will be harder to read given the broom movement.
- When throwing the rock, the broom is held upside down meaning the display cannot protrude from the base of the broom.
- Skip's Device must be reduced to a single finger control.

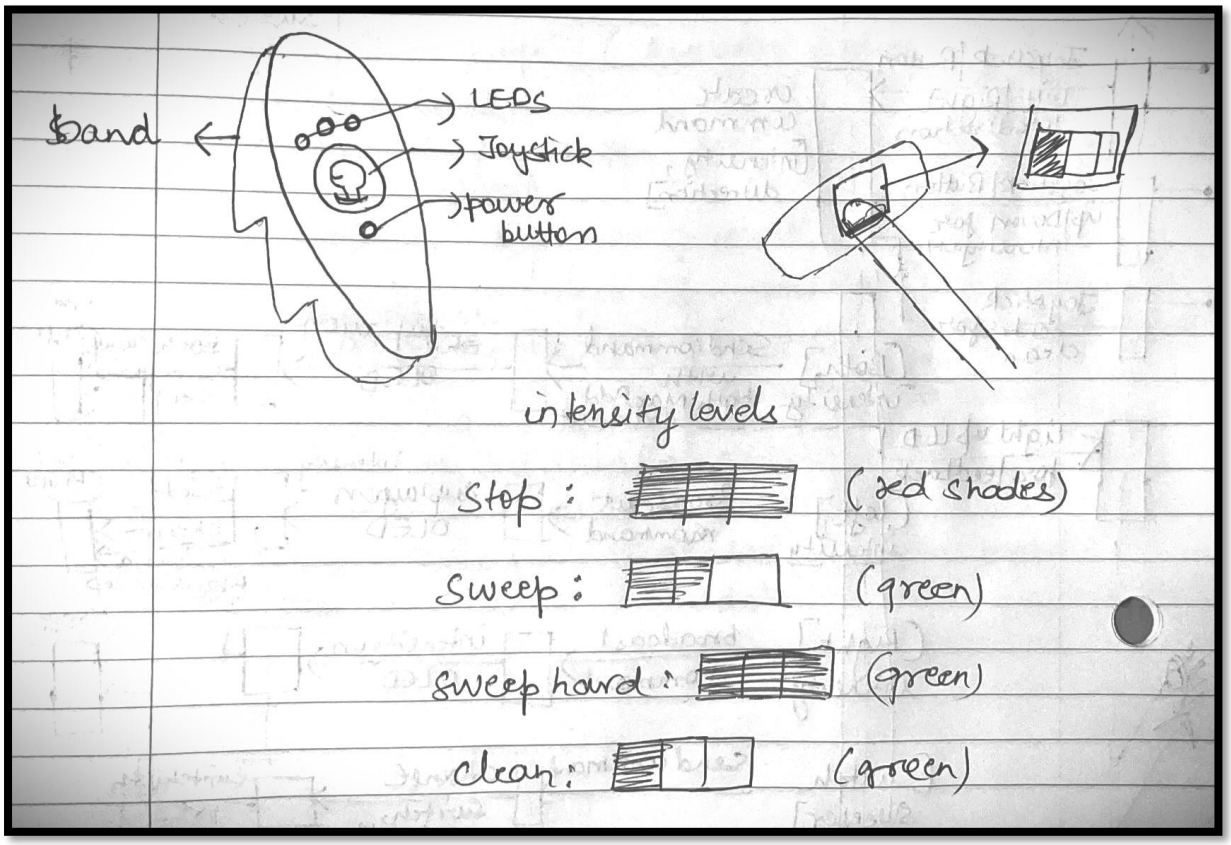
Brainstormed ideas:

Skip's Device-

- Use Dual-axis Analog Joystick only on the skip with two options
    - Map the quadrant to 9 different commands with Left, Right and Both on x Axis and Stop, Sweep and Sweep Hard on y axis with a centre press/push joystick for clean.
    - Use the joystick as buttons, joystick pressing up increases intensity and pressing down decreases intensity, joystick left and right to set direction and centre press for clean.
- Have Leds for feedback.
- A power button below the joystick which will do the initial start, boot and configure the system.

Sweeper's Device:

- Just have OLED display ST7735 that displays intensity level.



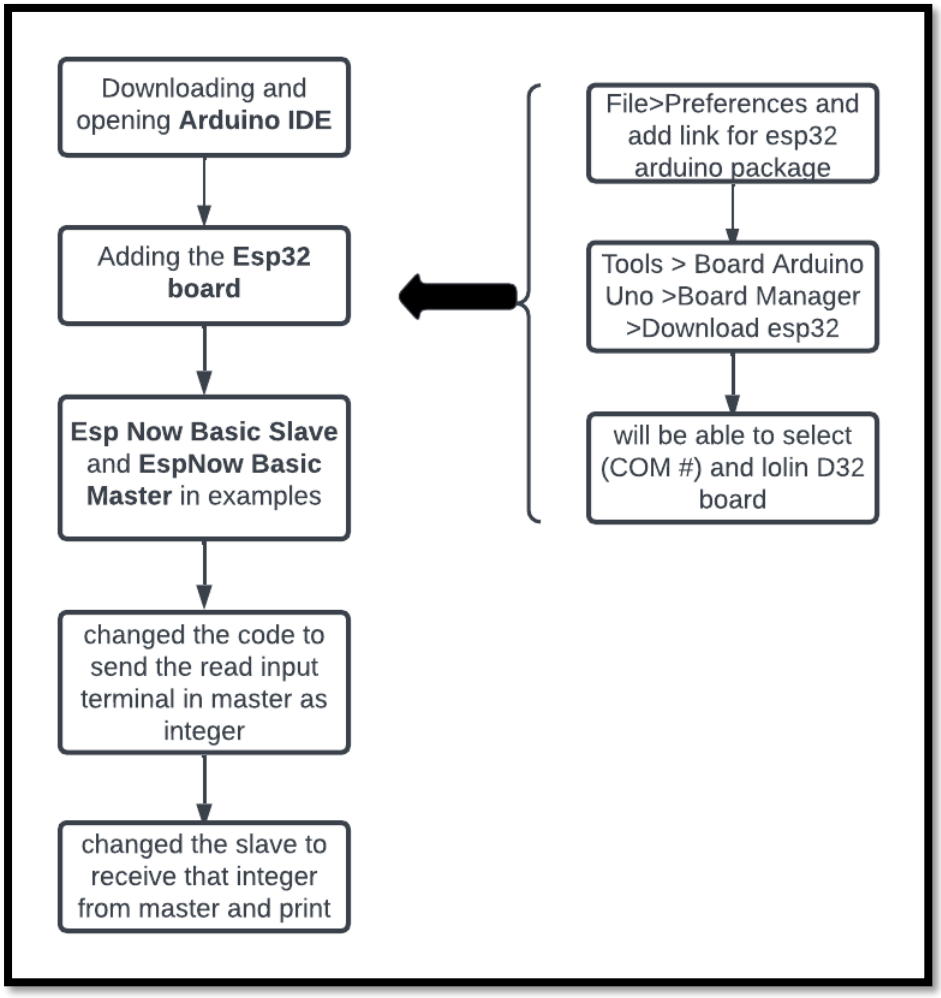
23rd February 2023

ESP Now Protocol using Arduino:

- ESP-NOW is a low-power, low-latency protocol designed for communication between ESP32 or ESP8266 microcontrollers over Wi-Fi.
- ESP-NOW allows for direct point-to-point communication between two devices, without the need for a Wi-Fi router or other intermediary device. It uses a simple packet-based protocol with a 128-bit encryption key for secure communication. The protocol is designed to be very lightweight, with a small code and memory footprint, making it ideal for low-power IoT devices.
- ESP-NOW supports both unicast and broadcast communication which can be useful for applications where multiple devices need to receive the same information simultaneously.

Sukhmeet

Setting up ESP32 board on Arduino and using ESP Now protocol:



- Collaborated with Antony to test the connection between 2 boards and were able to successfully send data from master to slave and print.

Checked the mac Address of the board:

- The example slave code printed the mac Address of the board using:
  - For Master: Wifi.macAddress()
  - For Slave in AP mode: WiFi.softAPmacAddress()

Communication Protocol decided:

- Send positions (1-8) from the master to the slave and then map each position with commands.
- Send the command to the slave as a struct that contains both intensity and direction.
  - For direction left, right or both.
  - For intensity: sweep, sweep hard or stop and a clean command.

Sukhmeet

27th February 2023

LAB3:

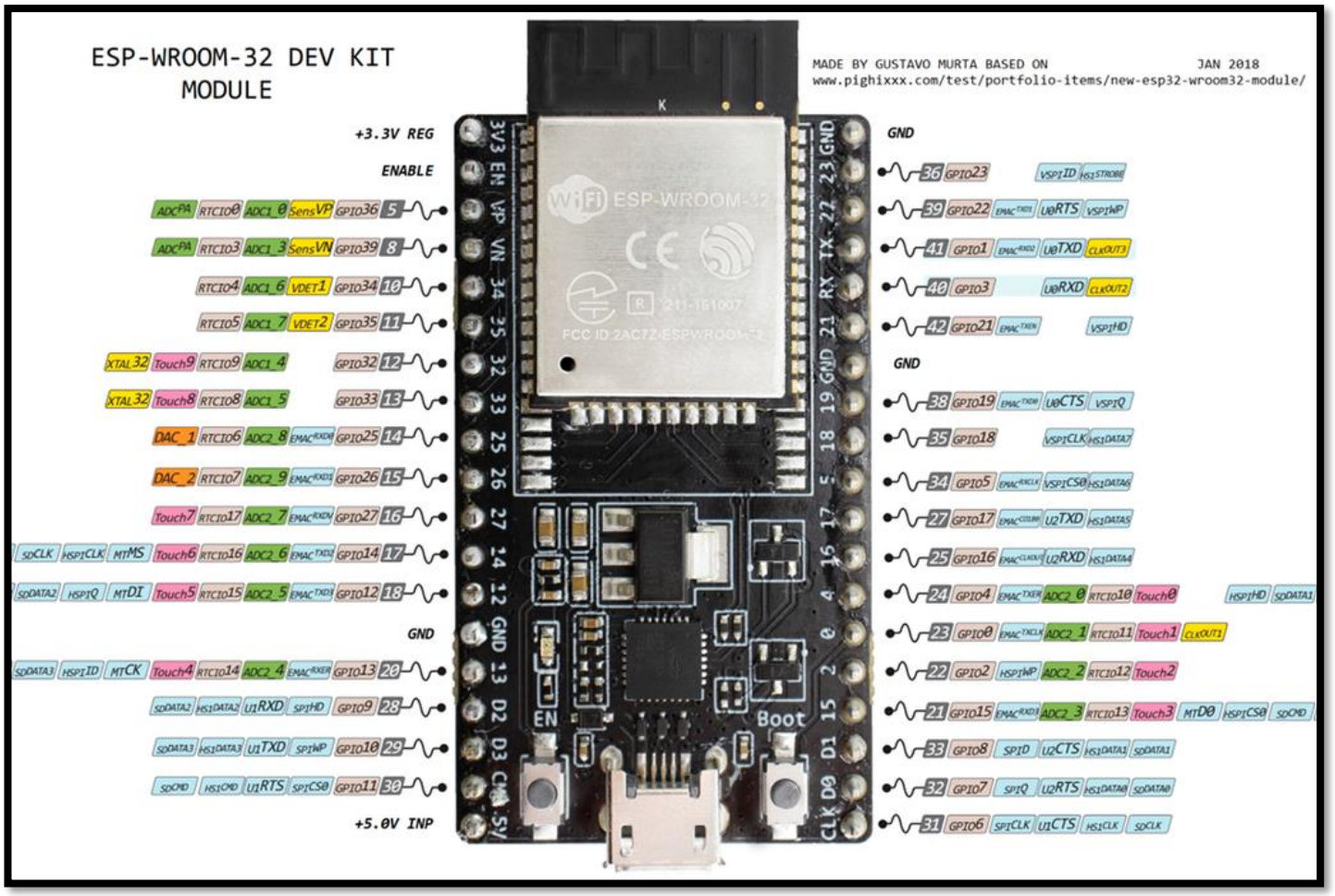


Fig: taken from the internet will be used to read pin and see the pin to use for ADC and LED.

1. **Reading Analog inputs & Moving Average Filters**
    a. Wire the outputs of the joystick to ADC inputs.
        i. Analog input pin for position X: 36
        ii. Analog input pin for position Y: 39
    b. Wire the joystick to 3v3 and GND to form a resistive voltage divider for X & Y axis.
    c. Used analogRead () to read voltage value from an analog input pin and then used the map function to convert the input value to a range from 0 to 3 using

Sukhmeet

x_pos = map(x, 0, ADC_Resolution, 0, dimension_Division);
y_pos = (dimension_Division-1) - map (y, 0, ADC_Resolution, 0, dimension_Division);

pos = x_pos + (dimension_Division * y_pos); // to convert the position (x,y) into a integer position according to quadrant shown below.

6	7	8
8	4	5
0	1	2

2. **Acting on Analog Data Inputs Neopixel LED ring**
    a. LED pin used is 19 and number of leds is 12 (0-11).
    b. Used the header file FastLed.
    c. Depending on the position received, ring up the led, an example of one of the cases is given below.

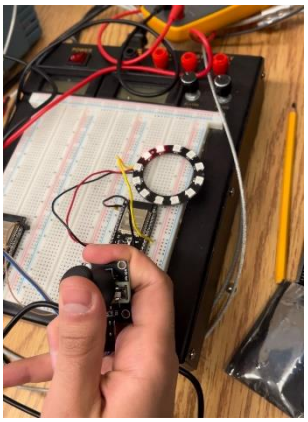
```
void lightRing(int region){

  switch (region){
    case 0:
      leds[0]= CRGB(0, 0,0);
      leds[1]= CRGB(0, 0,0);
      leds[2]= CRGB(0, 0,0);
      leds[3]= CRGB(0, 0,0);
      leds[4]= CRGB(0, 0,0);
      leds[5]= CRGB(0, 0,0);
      leds[6]= CRGB(0, 0,0);
      leds[7] = CRGB(50, 0,0);
      leds[8] = CRGB(50, 0,0);
      leds[9] = CRGB(0, 0,0);
      leds[10]= CRGB(0, 0,0);
      leds[11]= CRGB(0, 0,0);
      FastLED.show();
      break;
```

3. **ESP-Now TX & RX**
    a. uint8_t broadcastAddress [] = {0x40, 0x22, 0xD8, 0xEB, 0x0B, 0x65}; const uint8_t *peer_addr; esp_now_peer_info_t peerInfo; to

send the data directly to the slave device using its mac Address. And adding it as a peer memcpy(peerInfo.peer_addr, broadcastAddress, 6); peer_addr = peerInfo.peer_addr;

b. the master is STA mode.
c. **sending a single integer** using esp_err_t result = **esp_now_send** (peer_addr, &position, sizeof(position));
d. slave in **AP** mode and receiving data from master using void **OnDataRecv**(const uint8_t * mac, const uint8_t *data, int len) { position = *data; }.

SETUP:



I. Connecting the joystick to the master board, **pin 36 for x position and pin 39 for y position**.
II. Connecting the **LED Ring** to the slave board with mac Address is **40:22: D8:EB:0B:64 at the pin number 19.**
III. Read the ADC inputs from the joystick, converting that into position using the map and conversion mentioned above, then **send that position to the slave** and using the position received light up the LED Ring.

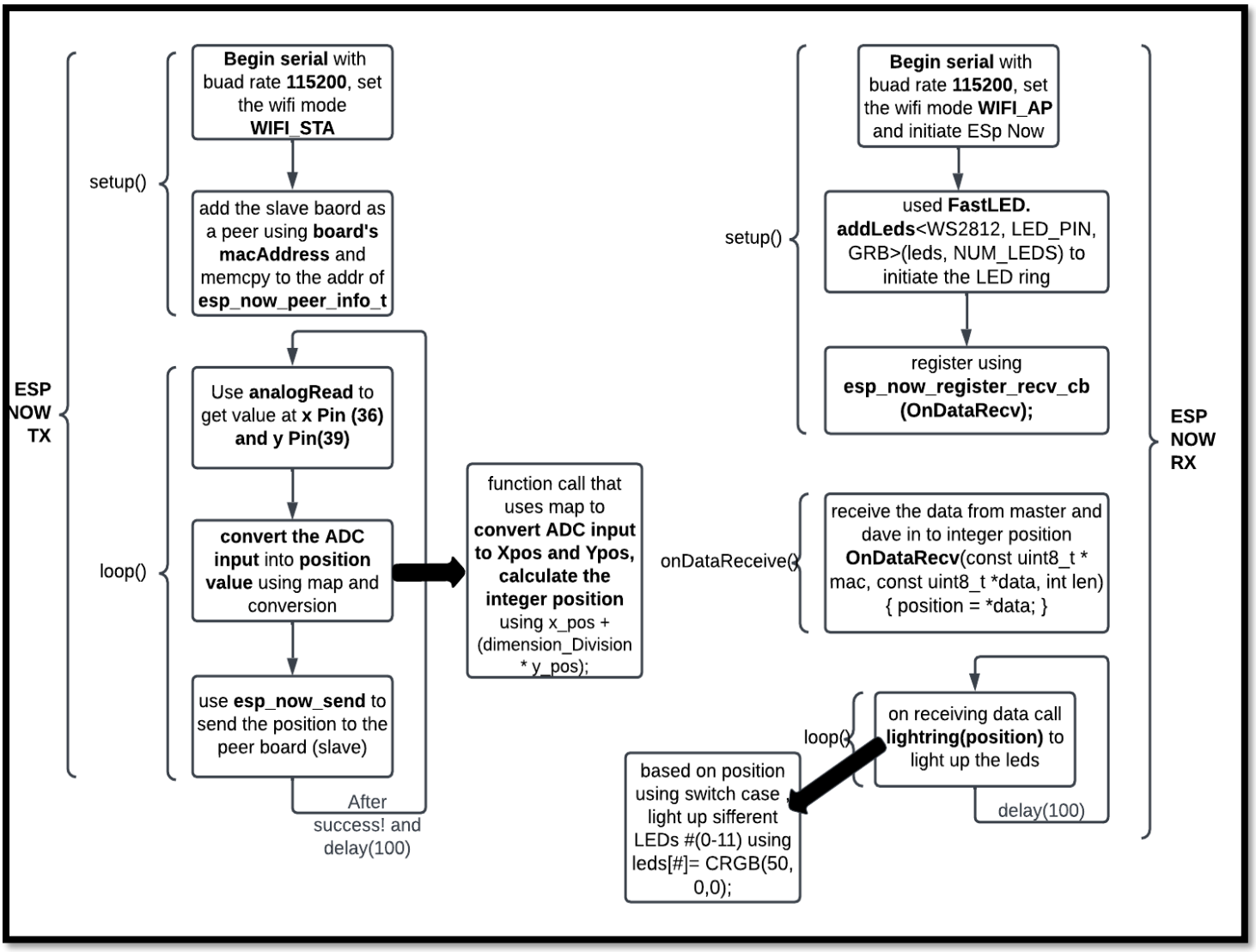
Q. ways to improve your device's usability? (Will implement in the next week)

- Use the button in the middle joystick position to toggle something like a base-level illumination of all LEDs on the ring.
- overlay the position of the receiver's joystick using colour mixing.
- For a message indicating the rest position, display the last non-resting position for about 500mSec, or have it fade out gradually.
- Add some feedback option and confirm correct data is transferred.

Q. Performance issues:

- Slower response time and a bit of lag while changing joystick positions.
- Can be fixed or improved by optimizing code, using interrupt and increasing processing power.

The final CodeFlow:



Below is the demonstration video of the implementation!

Demonstration Video

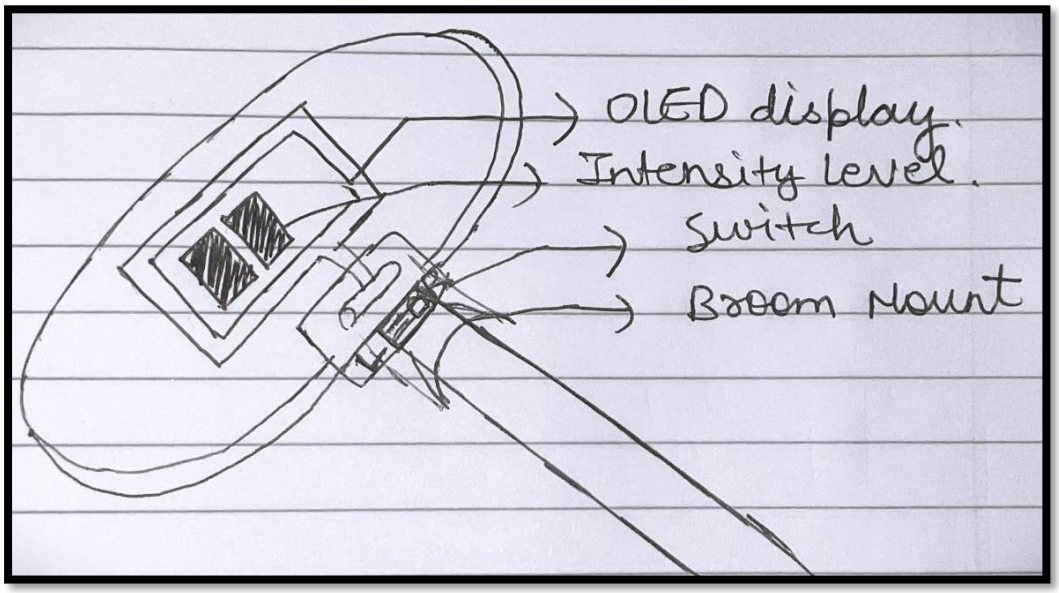
Demonstration Video_Lab3.mp4

Sukhmeet

1st March 2023

Updated Design Solution after team meeting:

- **Sweepers' Device**
  - Broom Mountable
  - Collapsible design to accommodate throwing the rock.
  - Simpler visuals to compensate for faster broom movement.
  - Switch determines whether left or right instructions are executed allowing the skip to send selective commands.
  - We reduced our UI to the minimum required signals (Occam's razor), but this has not been finalized. Depending on testing and time we may add indications for carve/straight or different text (if it is shown it can be interpreted correctly).
  - One advantage of the OLED display is that these decisions do not alter the physical design or communication and can be decided later.

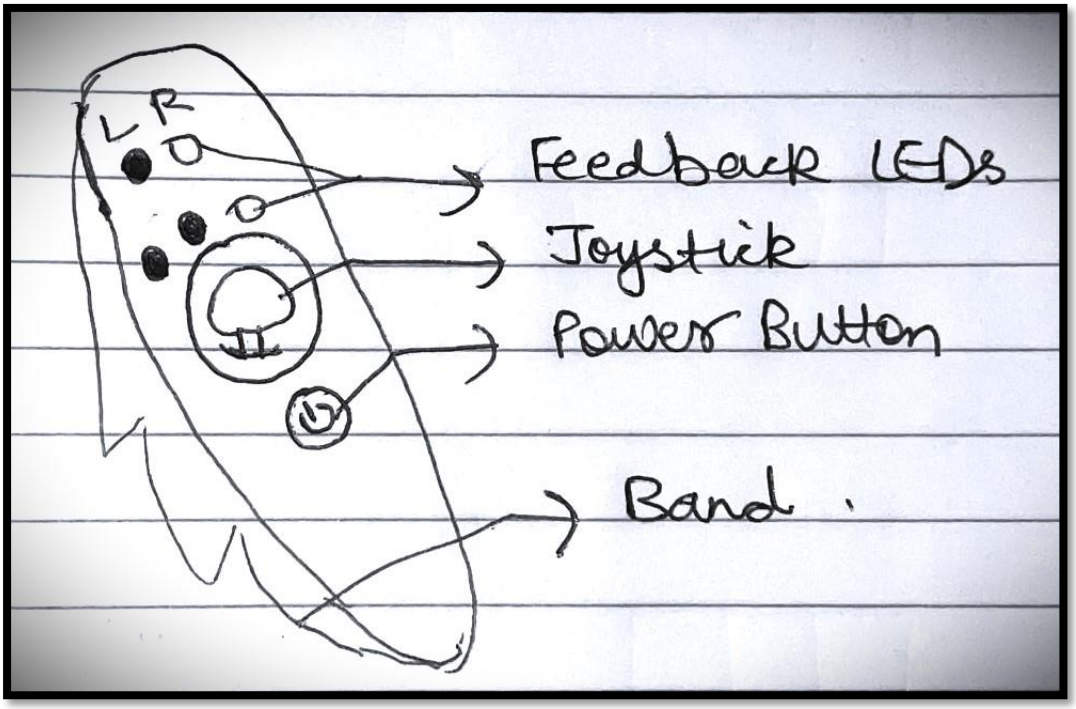


Design Sketch for sweeper's device

- **Skip's Device**
  - A joystick is now used for both intensity and sweeper selection (got ideas after implementing lab3 and using my previous idea)
  - Single input reduces time to make changes for the skip.
  - Click down to update a mode based on x position, intensity is incremented or decreased with the y position.
  - We wanted to eliminate the need to continuously hold the joystick in a position, and ambiguity in boundaries if we tried implementing a grid like mapping (like lab 3)

Sukhmeet

- LEDs will reflect the current settings if on an individual sweeper or more recent if both (in case skip forgets).
- Still considering a button layout due to increased speed and reduced ambiguity but this is at the expense of complexity.
- User Friendly
- Less buttons
- LED Acknowledgments
- In Band Transmission

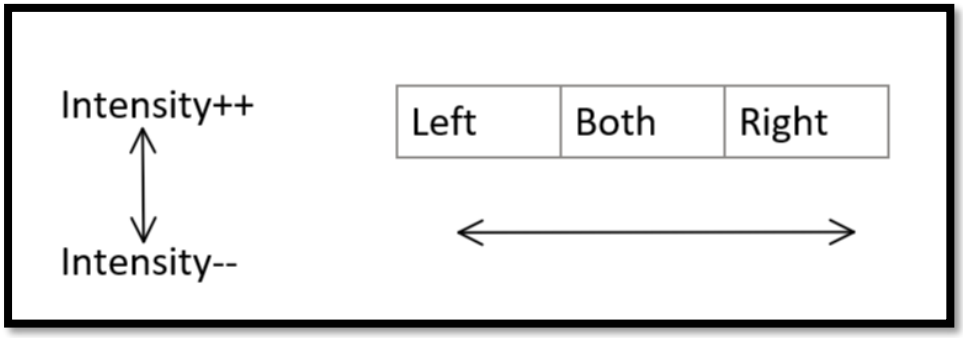


Design Sketch for skip's device

4th March 2023

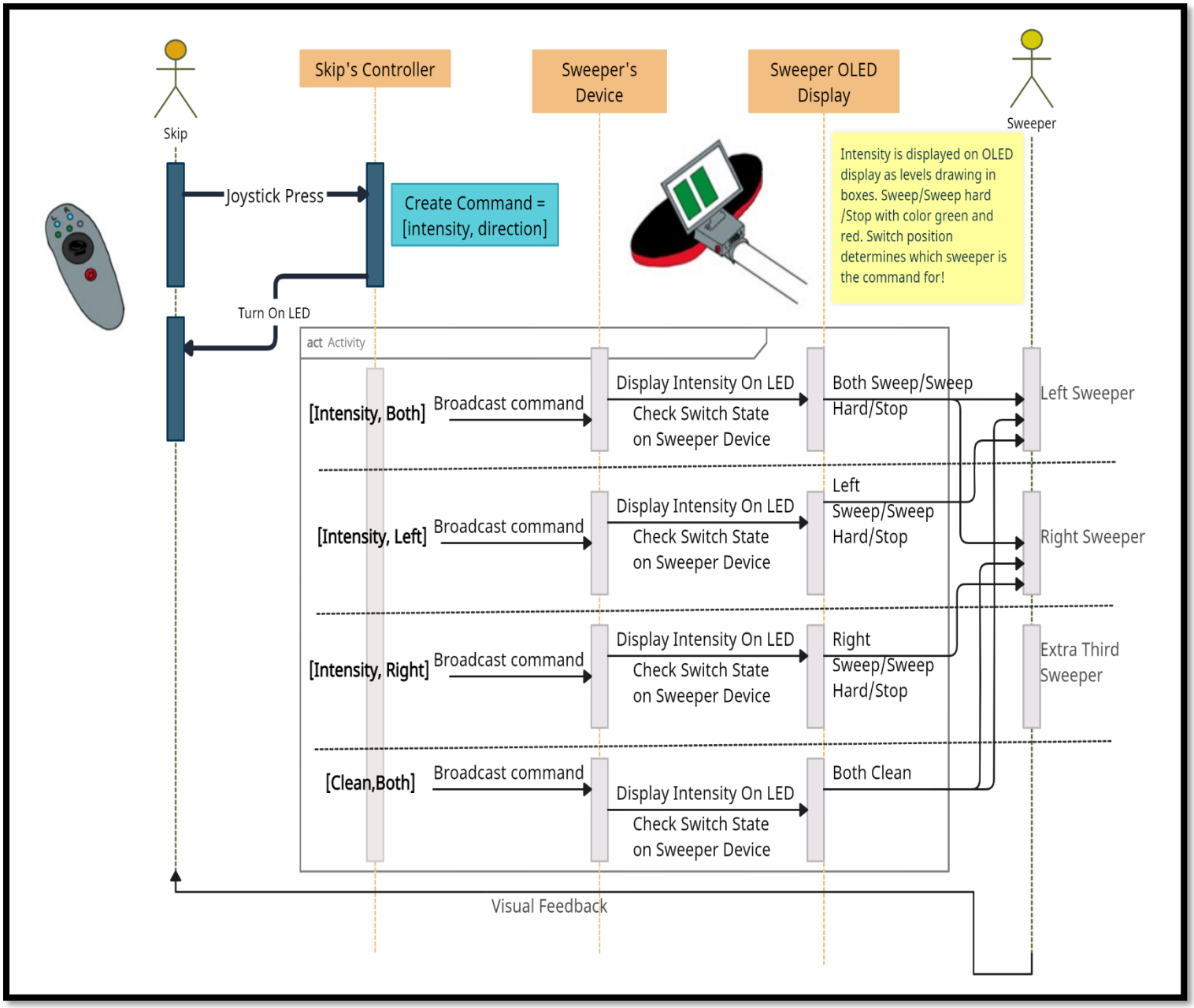
Message Sequence Chart:

Joystick used for the skip input in the following way.



Things considered:

- Send Intensity and direction – mainly broadcast it and turn on LED for feedback.
- On the sweeper side, using the state of switch it is decided which sweeper the message is for left, right or both and the point of view is taken from the skip side.



Sukhmeet

7th March 2023:

After the design review 2 feedback , decided to change the sweepers device ro replace the LCD display and make the skips device more user friendly/ easy to operate and switch between commands.

Feedback and solutions thought :

- LCD may not be the most robust choice of sweeper UI/UX : this can be solved by replacing the LCD with LED Ring(we have used in labs, was also one of my initial ideas)

- The folding sweeper display likely a reliability concern. (Wires through hinge) Addressed by moving display up the shaft to avoid touching ice when the person is throwing : The broom will go through the LED Ring and that will be mounted to the middle of the broom making it easy for the sweepers to see the command and avoids touching ice.

- For the skip UX : decided to map the joystick positions to the skip commands and added a gear to improve accuracy and precision.

- **Power Management** : Researched about a few techniques to implement power saving modes.
    - Event driven Transmission : Introduce interrupts at the pi so that message is only sent when input from the skip is given
    - Radio TX Power Reduction
    - CPU Clock Rate Reduction
    - Light/Deep Sleep modes.

- **In band control** : In-band control is a characteristic of network protocols with which data control is regulated. In-band control passes control data on the same connection as main data. Protocols that use in-band control include HTTP and SMTP. In ESP-NOW, application data is encapsulated in a vendor-specific action frame and then transmitted from one Wi-Fi device to another without connection. CTR with CBC-MAC Protocol(CCMP) is used to protect the action frame for security. ESP-NOW is widely used in smart light, remote controlling, sensor, etc.
- ESP-NOW uses in-band control to transmit data and control information over the same connection. The protocol is designed to operate without the need for Wi-Fi connection, making it a suitable option for low-power, high-speed communication between ESP32 and ESP8266-based devices.

- ESP-NOW encapsulates application data in a vendor-specific action frame that includes a header with control information. This control information includes the source and destination MAC addresses, the length of the data payload, and a sequence number to ensure that the frames are delivered in order.
- The vendor-specific action frame is then transmitted over the same Wi-Fi channel as the main data, using in-band control. This approach allows ESP-NOW to use the same connection for both data and control information, without the need for a separate control channel.
- ESP-NOW uses the CTR with CBC-MAC Protocol (CCMP) to protect the action frame for security. CCMP provides encryption, authentication, and integrity protection for the action frame, ensuring that the data is not compromised during transmission.
- Overall, ESP-NOW's use of in-band control allows for efficient and low-power communication between ESP32 and ESP8266-based devices. The encapsulation of data and control information in a vendor-specific action frame, along with the use of CCMP for security, ensures that the communication is reliable and secure.

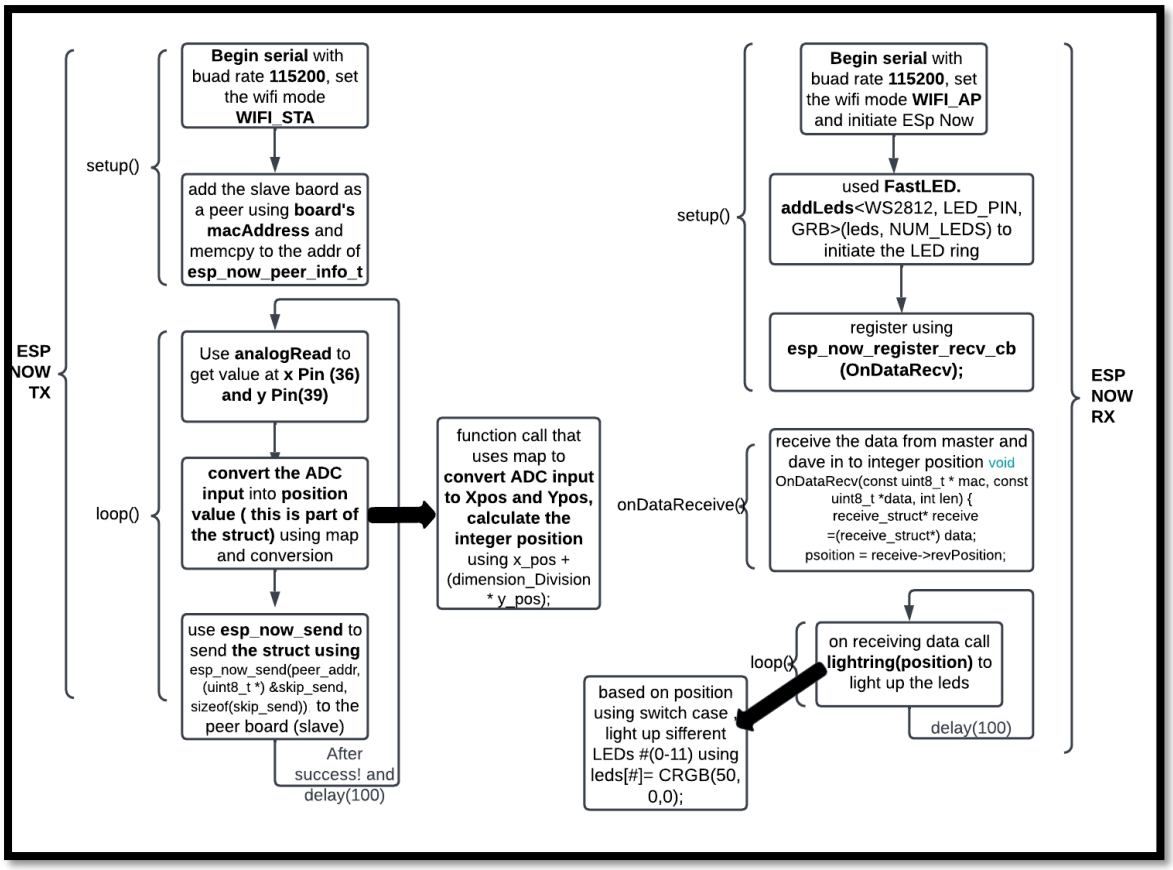
13th March 2023

Lab 4 day!

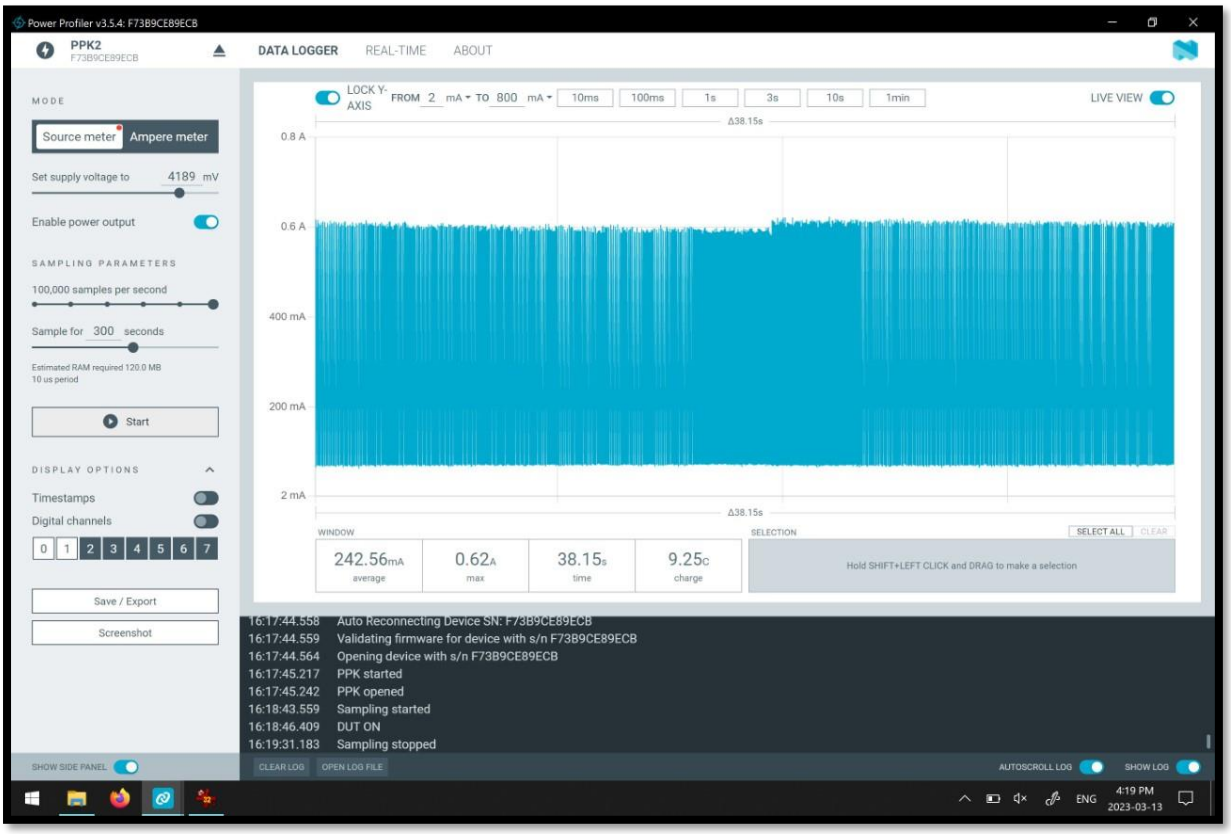
- Modified the code for the TX (and RX) units to use exactly the following struct:

```
typedef struct{
    int coordinate; //The location of your joystick (0 through 8)
}esp_message;
```

  - ❖ Changes made with the code :
    - Update the position variable of the struct while reading the ADC inputs (after mapping into a grid location)
    - Send the struct to slave using esp_now_send(peer_addr, (uint8_t *) &skip_send, sizeof(skip_send));
    - receive_struct* receive =(receive_struct*) data; position = receive->revPosition;



Asked the TA to do a baseline power consumption.



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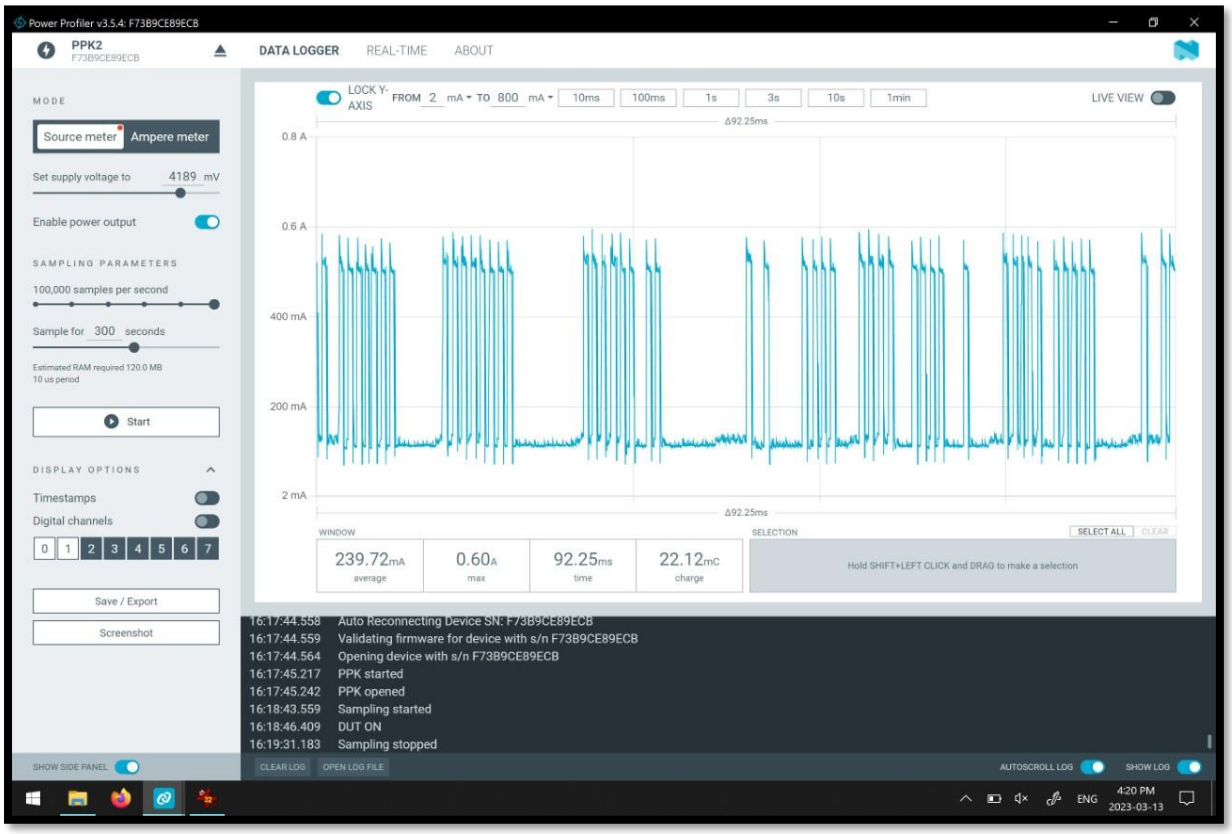
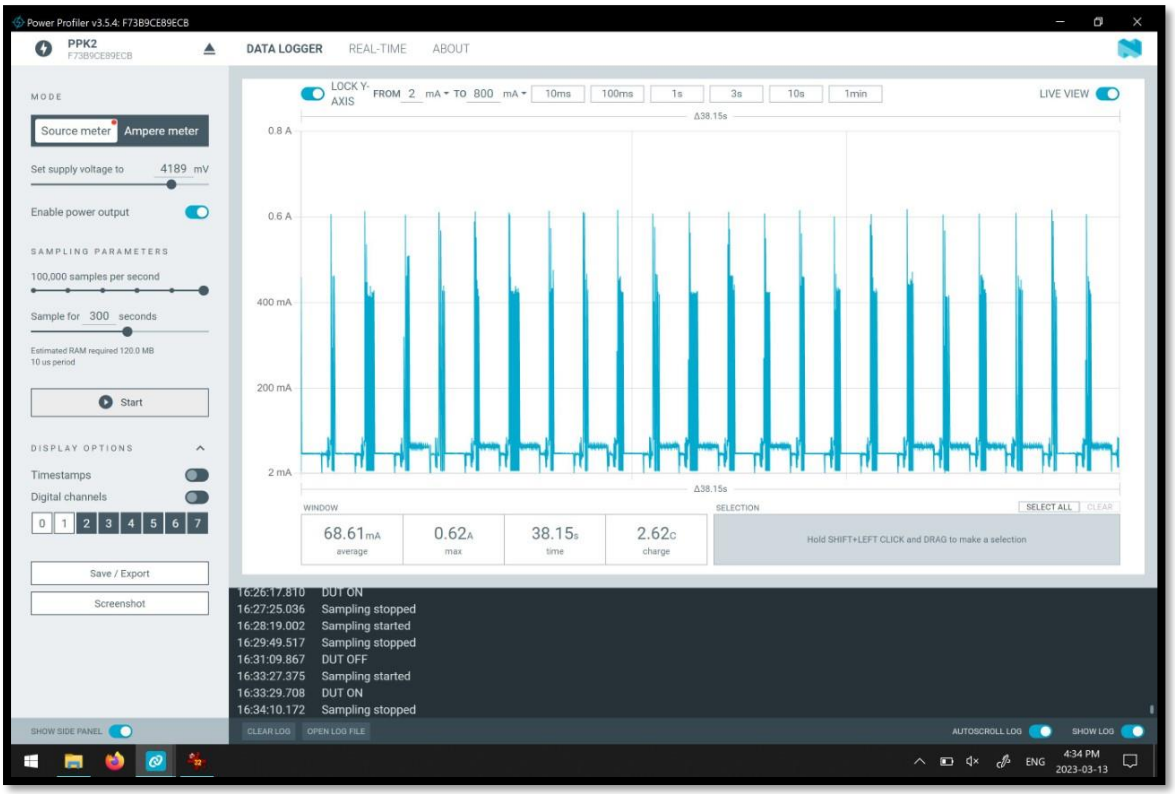


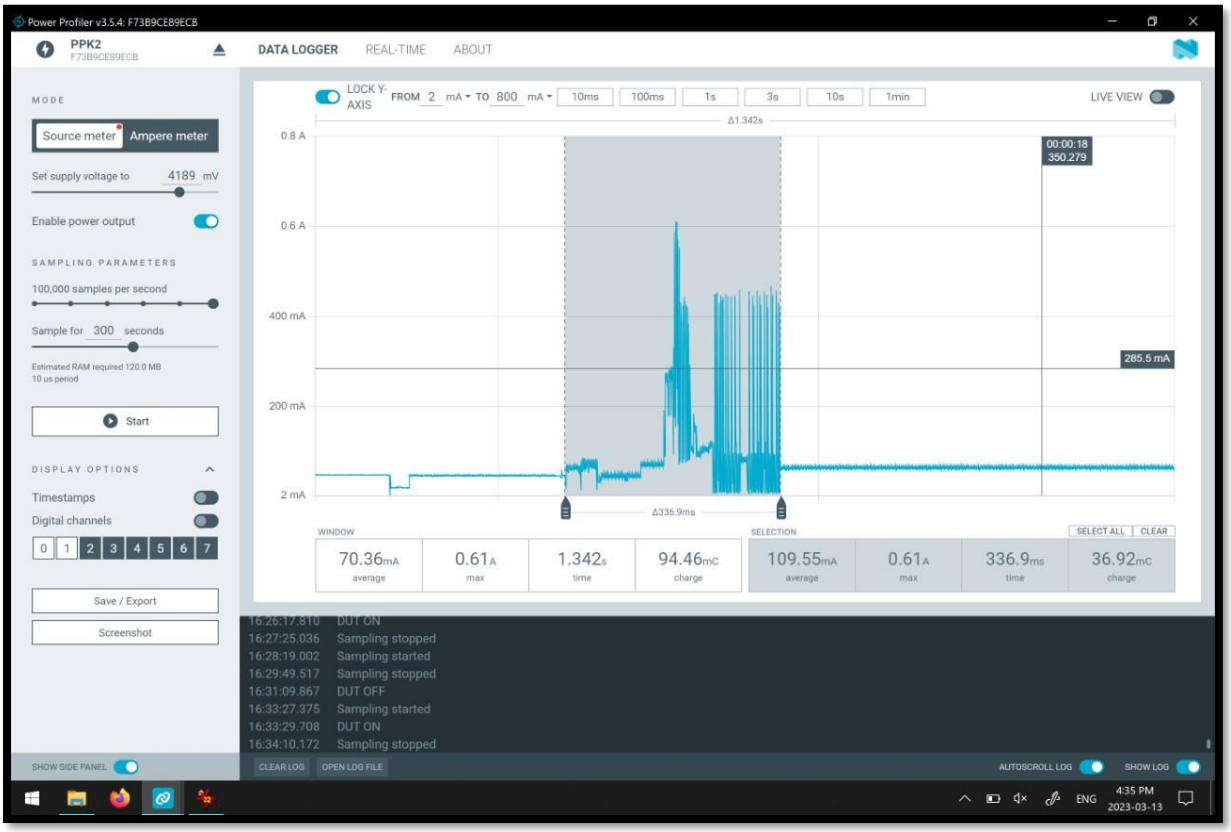
According to the initial baseline, we had a high-power consumption which was because at that time the clock frequency was set at 160 , also we were continuously sending the struct to the sweeper and the device was working all the time.

I. Decided to implement :
   a. Set the clock frequency to 80MHz using!
      i. #define CPU_Frequency_MHz 80
         setCpuFrequencyMhz(CPU_Frequency_MHz);
   b. Set the Tx Power using.
      i. WiFi.mode(WIFI_STA);
         WiFi.setTxPower(WIFI_POWER_7dBm);
   c. Implement the light sweep mode.
      i. esp_light_sleep_start
      ii. esp_sleep_enable_timer_wakeup() wakes up the device after a certain amount of time has elapsed.

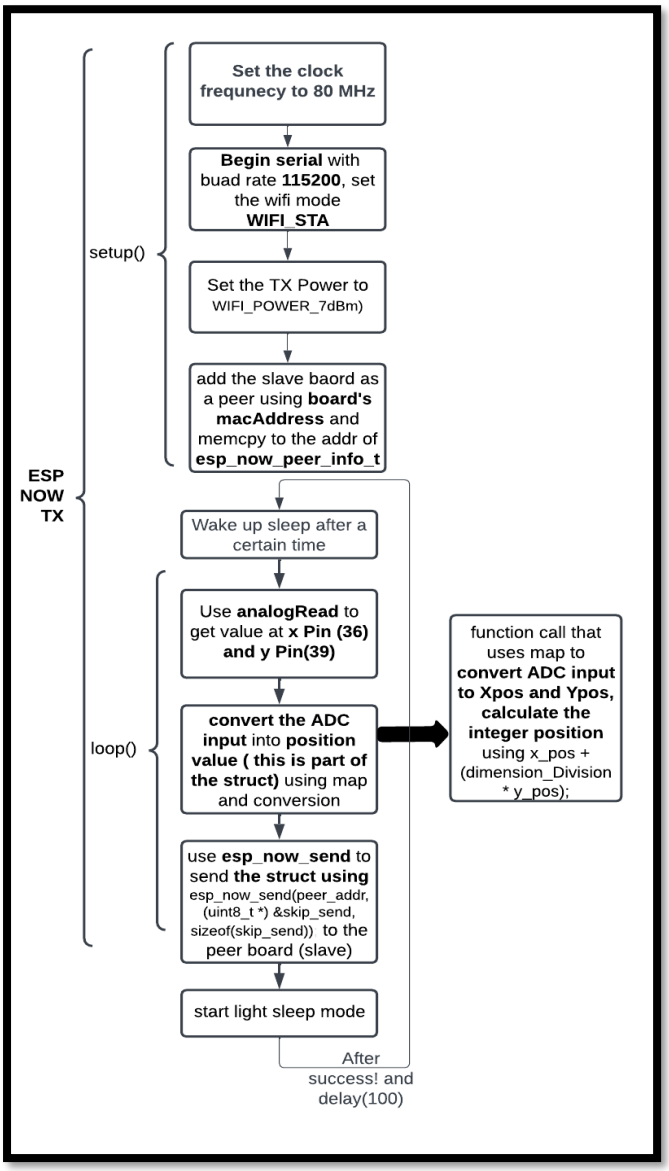
❖ Advantages of these implementations:
   - Reduced the power consumption.
   - Improves efficiency.
   - The device goes into sleep mode and is not actively running.

Second Baseline Consumption :





- From the result above it is clear that
    - consuming charge at a high rate, the battery will be depleted more quickly, reducing the overall battery life.
    - When a device consumes power, the battery delivers electrical energy to the load, and the rate at which the energy is being consumed determines how quickly the battery will be depleted.
    - The power consumption has been reduced considerably which also reduces the battery consumed.
    - This also increased the efficiency.
    - **<u>Reducing the power consumption even more will decrease the energy consumption and will increase the battery life.</u>**
    - **<u>Charge consumed at lower rate will extend battery life as battery can no longer power the device is charge is depleted.</u>**



Key differences between light sleep and deep sleep :

- The main difference between light sleep and deep sleep mode is the level of power consumption and the amount of time it takes to wake up the device.
    - In light sleep mode, the device reduces its power consumption by lowering the clock frequency and turning off certain peripherals, while keeping the processor running. This allows the device to quickly wake up and respond to external events or interrupts. Light sleep mode typically consumes more power than deep sleep mode but is faster to wake up.
    - In contrast, in deep sleep mode, the device shuts down the processor and all peripherals except for a timer, RTC (real-time clock), and some low-power RAM. This drastically reduces the power consumption, allowing the device to remain in a low-power state for an extended period. However, since the processor is not running, the device cannot respond to external events or interrupts until it wakes up from deep sleep mode, which typically takes longer than waking up from light sleep mode.

To summarize:

Light sleep mode: Reduces power consumption by lowering the clock frequency and turning off some peripherals but keeps the processor running to quickly respond to external events. Consumes more power than deep sleep mode but wakes up faster.

Deep sleep mode: Shuts down the processor and most peripherals except for a timer, RTC, and some low-power RAM, reducing power consumption to an extremely low level. Cannot respond to external events until it wakes up from deep sleep mode, which takes longer than waking up from light sleep mode.

TECHNIQUES SHOULD HAVE IMPLEMENTED to reduce power consumption more :

- The effect of any power savings techniques you may apply to your receiver devices is limited to about 30mA. (Why is this? Assuming you can't change the hardware, what are some ways around this?
    a. **The power savings will be limited to about 30mA because the**
        i. **Receiver is only working when it is receiving data so only way to reduce power on the consumer side is reduce the size of the data packets, using component**

like led ring instead of LCD display which consumes less power, low transmission rate during the protocol and receiver is not sending any packet back to the sender.

ii. **Implement duty cycling : Duty cycling involves turning the receiver device on for a short period to receive data, then turning it off for a longer period to conserve power**.

- 500mAh LiPo battery, it is reasonable to de-rate this by 20 to 30% to account for aging!
    a. **This means that instead of assuming the full capacity of the battery, the system should plan for a lower capacity, typically 20-30% lower, to ensure that the battery can still provide enough power as it ages.**
- A WS2812b LED needs 30mA max RGB, w/ a linear reduction per channel from 0 – 255
    a. **The led has a reduction rate : setting that to around 128 will draw half of the current (15mA) and can reduce the value further to reduce the current.**

I. Implement both deep sleep and light sleep modes at the same time to achieve even more power savings , this can be achieved when the device spends most of the time most of its time in deep sleep mode, consuming minimal power, and only wake up briefly to respond to external events in light sleep mode.

a. Steps to implement :
    i. Set up the sleep mode settings by selecting both light sleep and deep sleep , configuring the times
    ii. Initialize the interrupts and timers.
    iii. Implement the deep sleep mode:
        1. esp_sleep_enable_timer_wakeup(sleep_time_us); esp_deep_sleep_start();
    iv. implement the light sleep mode:
        1. esp_sleep_enable_timer_wakeup(light_sleep_time_us) ; esp_light_sleep_start();
    v. Call the esp_light_sleep_start() function to enter light sleep mode while the device is in deep sleep mode. The device will wake up from light sleep mode when the timer or external interrupt is triggered, and then immediately go back to deep sleep mode.
    vi. Wake up from the sleep resume execution from the point where it went to sleep using esp_sleep_get_wakeup_cause().

The device will spend most of its time in deep sleep mode, consuming minimal power, and only wake up briefly to respond to external events in light sleep mode.

- Enable interrupt on the pins to enable the light sleep mode when the interrupt is triggered.
    a. **Just want to send the message when there is change in the input command and reduce the power consumption.**
    b. **Set up the event handler loop , register the even handler and send data on event trigger.**

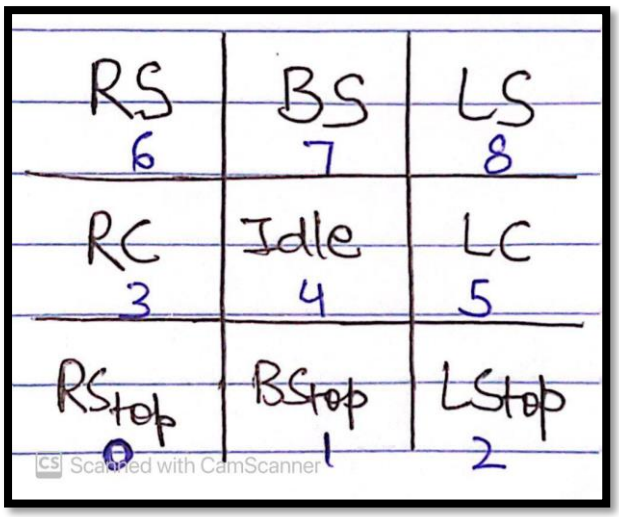
HAVENT STILL IMPLEMENTED ALL OF THIS , PROBABLY WILL BY NEXT WEEK- NEED TO FINALIZE THE WORKING FINAL PROTOTYPE, BATTERY MANAGEMENT SYSTEM AND POWER BUTTON TO IMPLEMENT SLEEP MODES AND EVENT HANDLER. THE CODE SUBMITTED TO UMLEARN STILL NEEDS TO HAVE IMPLEMENTED THE SLEEP MODES AND EVENT DRIVEN TRANSMISSION.THE CODE WAS WROTTEN IN LAB4 ACCORDING TO LAB4 REQUIREMENTS BUT UPDATED AND OVER WROTE IT WITH NEW CODE AND THE UPDATED COMMUNICATION PROTOCOL.

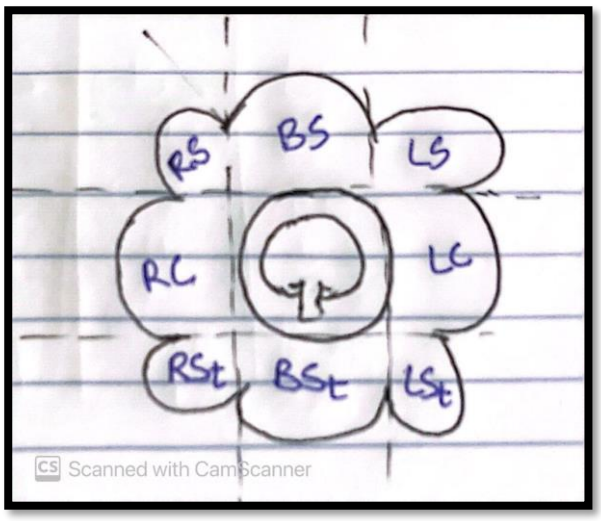
16TH MARCH 2023

Team meeting , considerations and discussing the final prototype.

Skip's Design

- Use a joystick and map the joystick positions to number positions just like lab3.
- Use a gear to control the position of the joystick for each specific position.

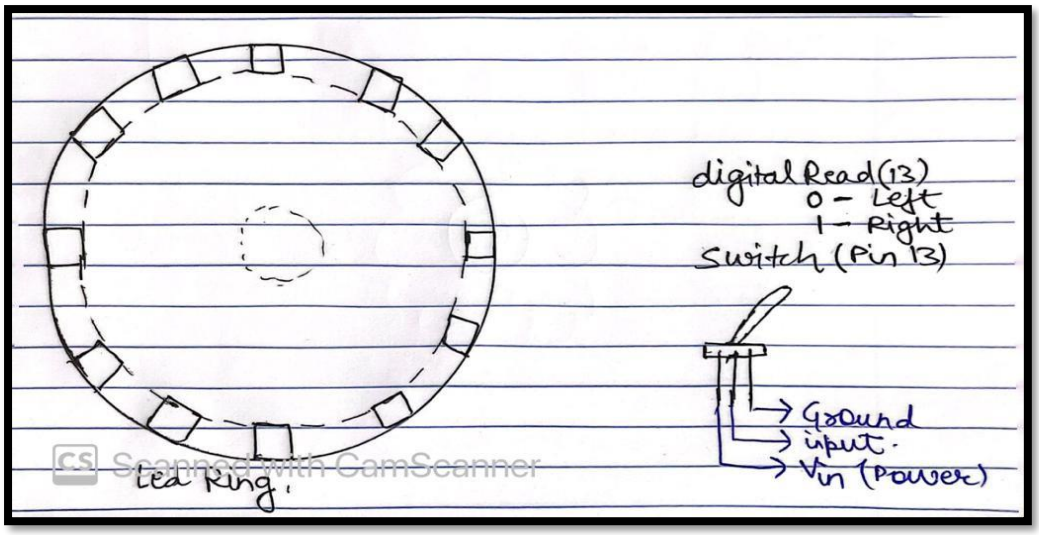




Sweeper's Design

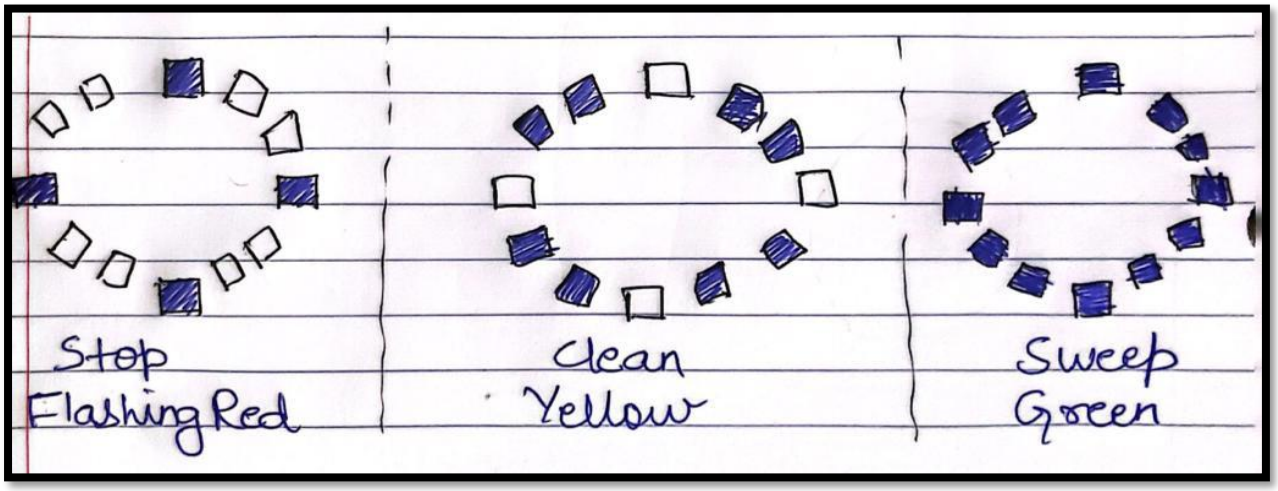
- Use the LED Ring through the broom and be mounted in the middle.
- Use a switch (Left/Right) that is used to match and see for which the command has been sent by the skip.

Sukhmeet

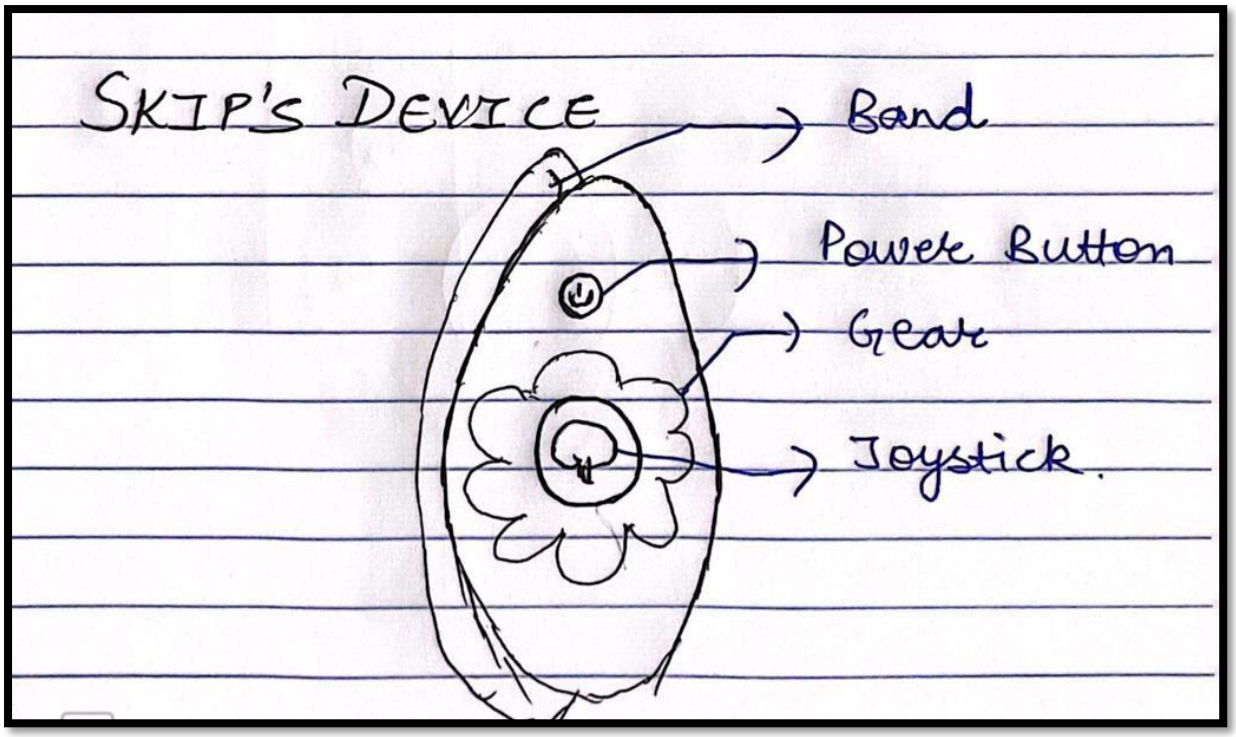


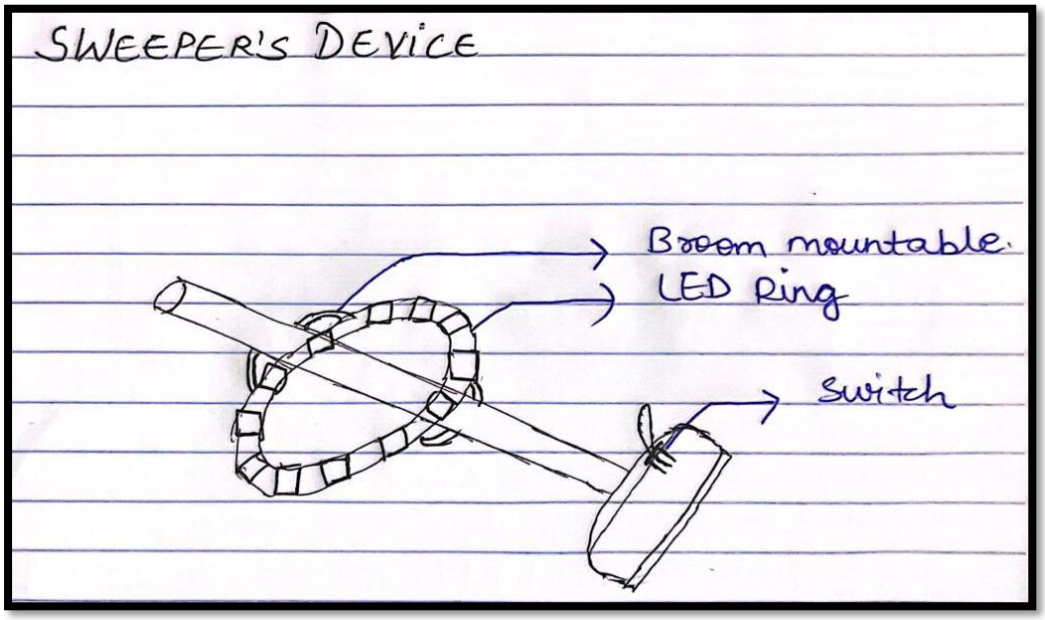
Patterns for different intensities on the LED ring :

- Different colours.
- Different patterns for colour blind people.



FINAL DESIGN SOLUTIONS SKETECH:





18th March 2023

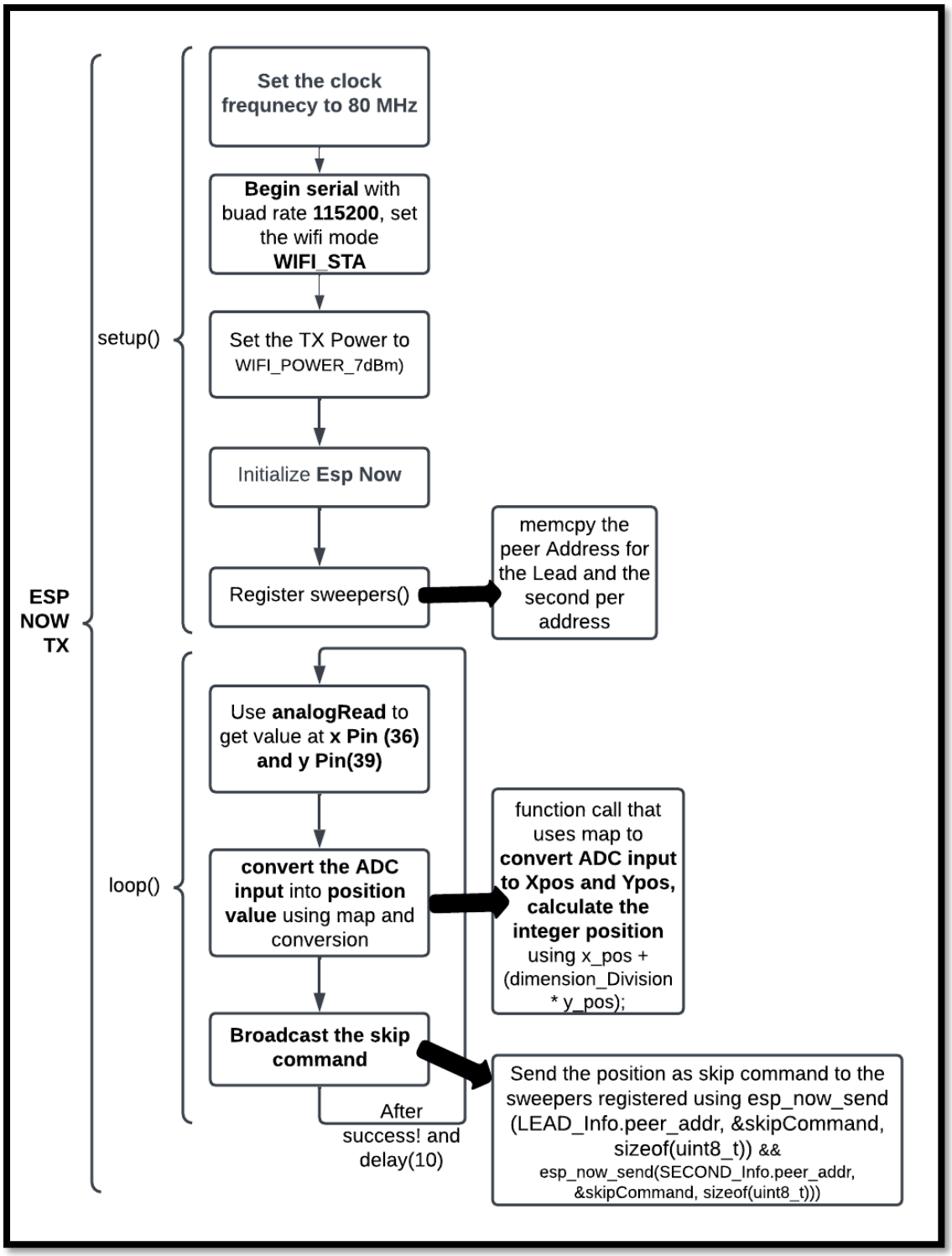
Has a work session with team to finalize the communication protocol and finalize the code for the transmit and receive code.

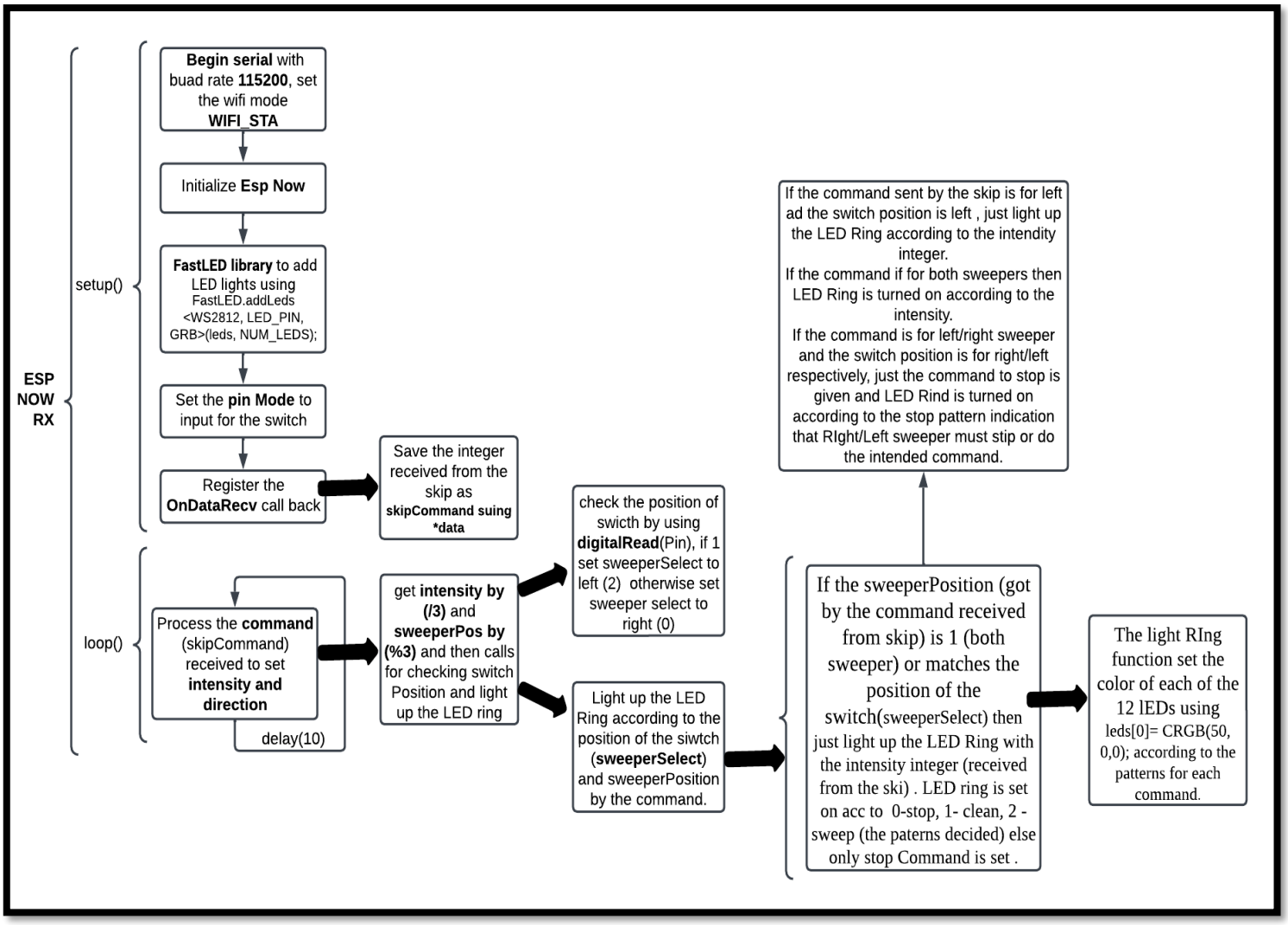
The Communication Protocol :

- The skip will read the ADC inputs from the joystick inputs, convert the ADC input into a position by mapping the values and then send the single int position to the sweeper.
- The sweeper will interface the packet(the single int position received)
    - Convert it into intensity value by intensity = position/3;
        - 0 for stop.
        - 1 for clean.
        - 2 for sweep.
    - Convert into sweeperPosition by position % 3;
        - 0 for right.
        - 1 for both.
        - 2 for left.
    - Then read the state of the switch y using digitalRead(Pin)
        - 1 – left sweeper
        - 0 – right sweeper
    - Light up the Led Ring according to the patterns and different colours
        - Flashing Red – stop
        - Yellow – Clean
        - Green – Sweep

The team divided work for Tx (by Antony), Rx by me (sukhmeet),LED ring(by Mohammad),switch(me and Mohammad),Joystick(Corben and Antony) and battery management (by Corben (In Progress)).Overall, everyone verified each other's combines and combine by fixing issues.

Flowchart for the skip's device :


ESP NOW TX
setup()
Set the clock frequnecy to 80 MHz
Begin serial with buad rate 115200, set the wifi mode WIFI_STA
Set the TX Power to WIFI_POWER_7dBm)
Initialize Esp Now
Register sweepers()
memcpy the peer Address for the Lead and the second per address
loop()
Use analogRead to get value at x Pin (36) and y Pin(39)
convert the ADC input into position value using map and conversion
function call that uses map to convert ADC input to Xpos and Ypos, calculate the integer position using x_pos + (dimension_Division * y_pos);
Broadcast the skip command
Send the position as skip command to the sweepers registered using esp_now_send (LEAD_Info.peer_addr, &skipCommand, sizeof(uint8_t)) && esp_now_send(SECOND_Info.peer_addr, &skipCommand, sizeof(uint8_t)))
After success! and delay(10)

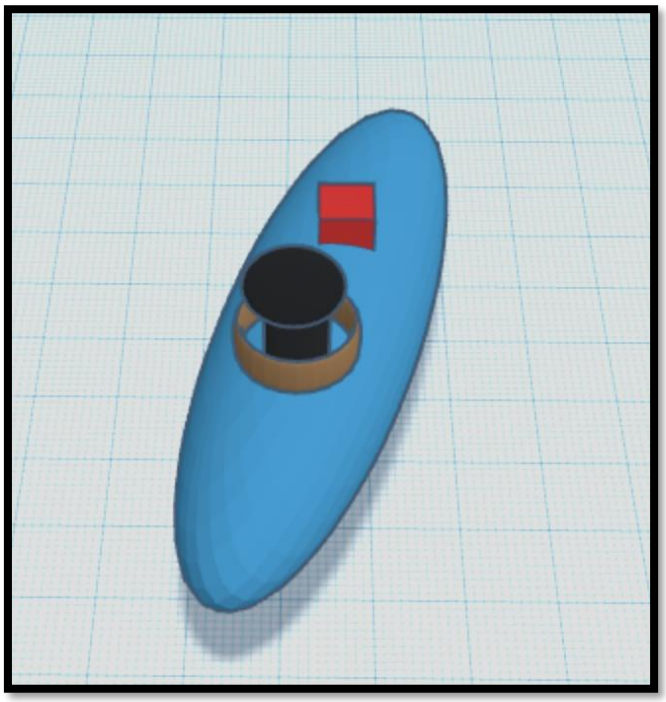


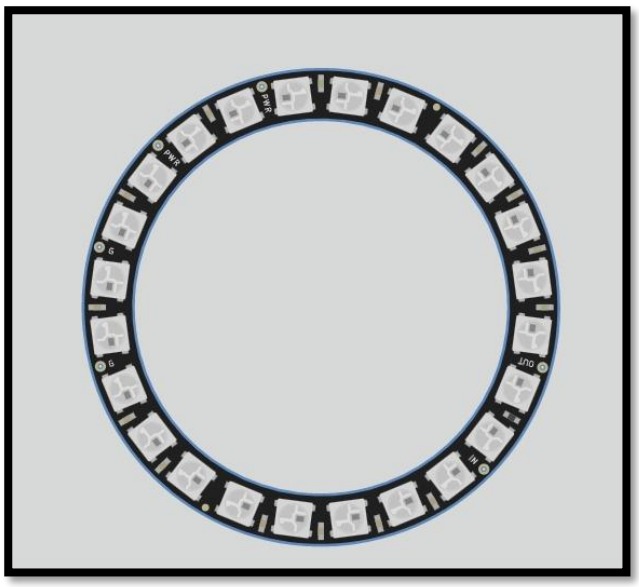
Still need to implement some power saving modes in this Tx side like Event Driven and Sleep Modes like described above.

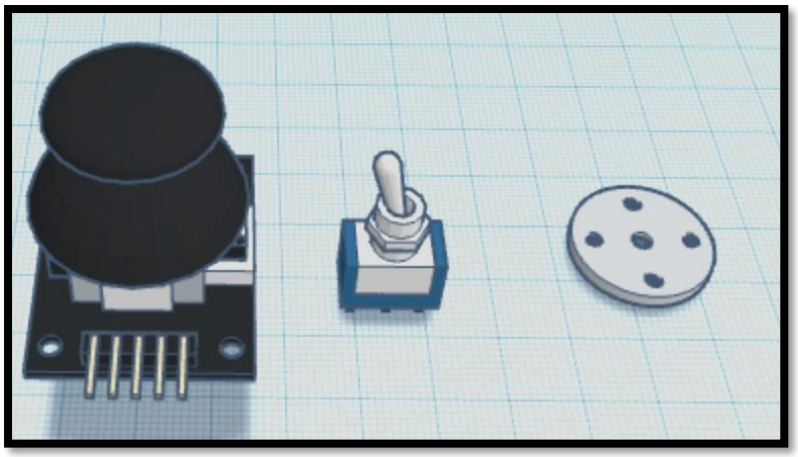
19th March 2023 :

Started to work on 3D model and deciding a Business/marketing Plan.

The images below are just some starting prototype images that I made to try out using tinker Card , will need a lot of work for some finishing and finalizing the prototype. Will get the prototype completed by the end of the week.







March 24th, 2023

Worked on the Physical prototype:

Some considerations for skip's device:

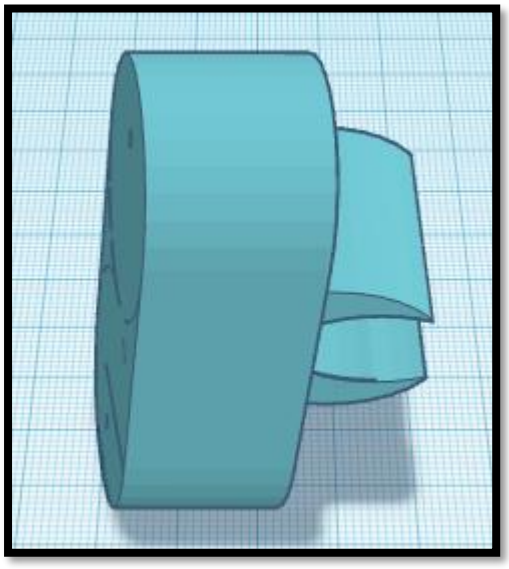
- A Wii shaped controller
- Joystick will be sticked in a round gear.
- Power button

Some considerations for skip's device:

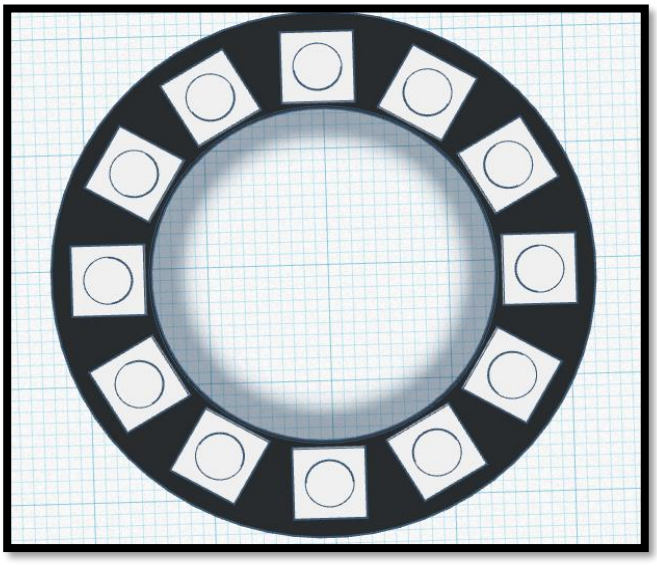
- The Led Ring goes through the broom.
- Dimensions of the broom: 1inch in diameter
- Dimension of Ring:
    - Inside Diameter: 36mm
    - Outer Diameter: 50mm
- Need a broom Mountable.
- Switch at the bottom of the broom

Tinker Card shapes/images to be used:

Broom Mountable

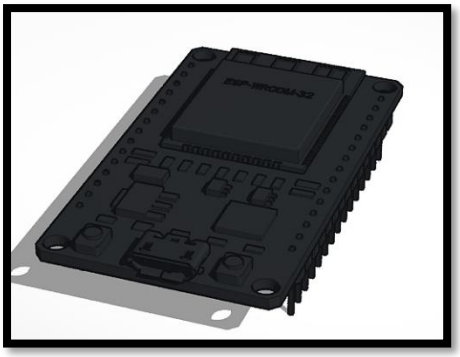


LED Ring

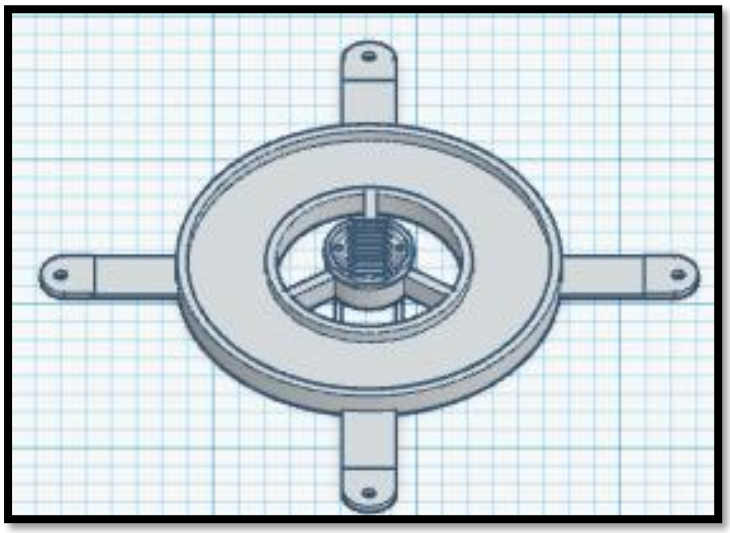


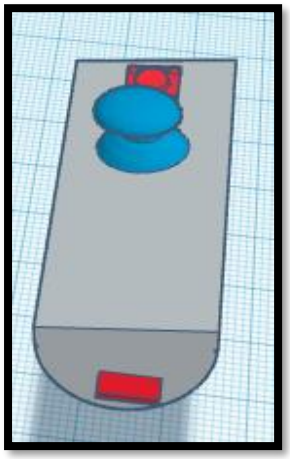
Sukhmeet

ESP-32



LED Ring Case- initially though to have 2 bands to wrap around the broom.





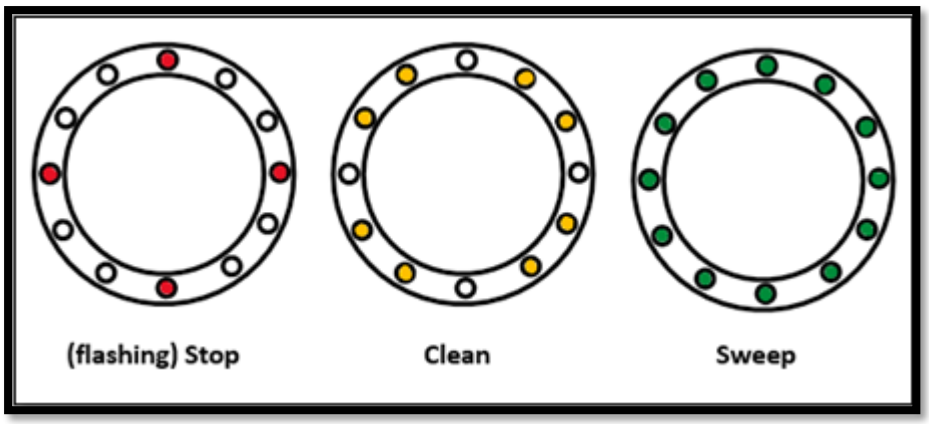
Skip's Controller with a shape of TV remote . with joystick mounted in and power button on the top.

25th March 2023

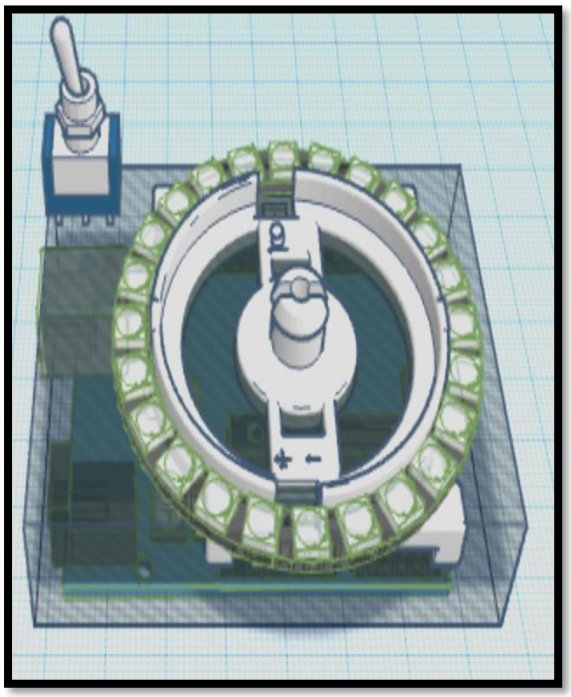
Worked on the **Business/Marketing Plan**

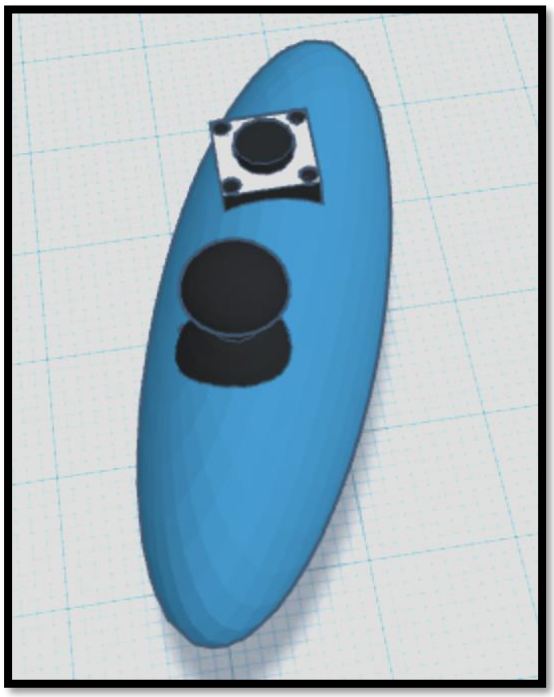
Decided on a template to follow :

- Introduction : The buddy to your broom – introducing the broom busy(skip and sweepers device), accessibility evolution in curling, marketing plan introduction and goal of the device
- Presentation – Aesthetics of the design to be user friendly and easy to use without affecting game play.



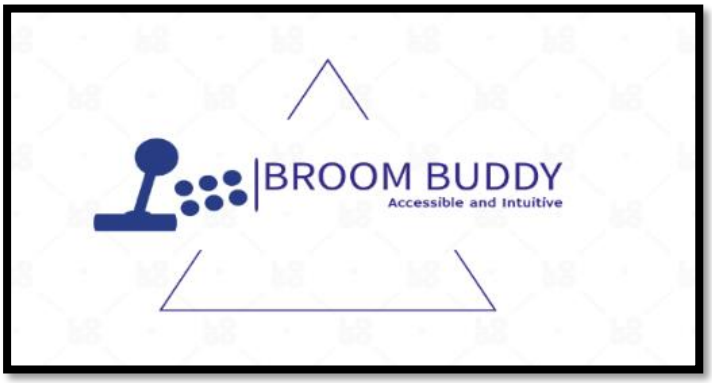
  - Product Design – Aesthetics, Features of the devices
  - Packaging – , Packaging, and accessibility features





Sukhmeet

- Brand - Identity , Logo , Colour scheme
    - Logo with tagline: Accessible and Intuitive". Identity practical, innovative, and accessible design of our product, demonstrating inclusivity and intuitive features, Appealing colour scheme



- Market Demographics
    - Curling popularity
    - Canadian Curling Stats
    - Hard of Hearing Stats
    - Market Size Estimate

Curling Popularity in Canada

Curling Frequency per Season	Number of Curlers
Light (1-2 times)	1,109,000
Medium (3-9 times)	324,000
Heavy (10+ times)	553,000
Competitive	15,000
Total	**1,986,000**

- Place
    - Virtual - Broom Buddy website
    - Physical - goods stores, pro shops at curling rinks, and other retailers
    - Selected Market - Canadian Market
- Price - considering components costs fort both devices, manufacturing, marketing and distribution cost , bundles for discounts
    - we estimate the **cost to be $55.57**. This cost includes the costs of materials, manufacturing, marketing, and distribution. If we Sell our product at a price of **$69.99, we can achieve a profit margin of around 25.9% on each bundle**.
    - Offering services like warranty, customer support, and a return policy

- Promotion – partner with brands, influencers, organizations, curling teams, customer incentives, partnerships with CDSA and WCF
- Measurement – measuring success.
- Conclusion

After an initial discussion , divided stuff among team and completed the plan.

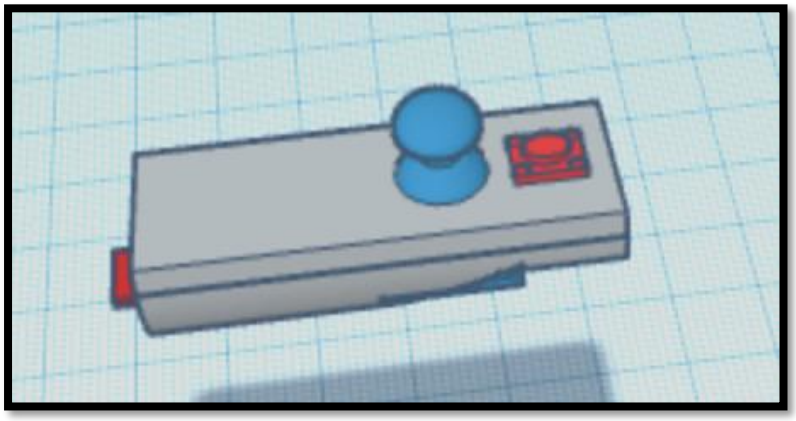
March 28th, 2023

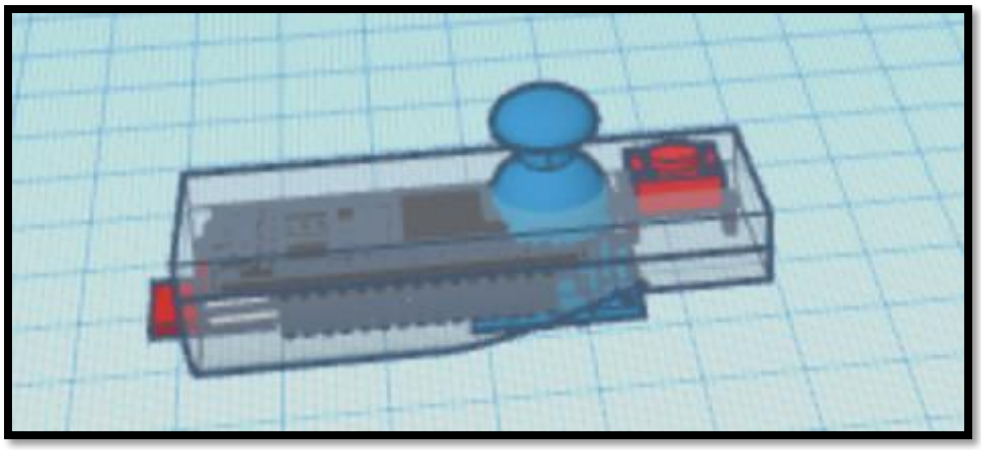
Some considerations for skip's device:

- A Wii (not a pill shaped) shaped controller.
- Joystick will be sticked in a round gear.
- Power button

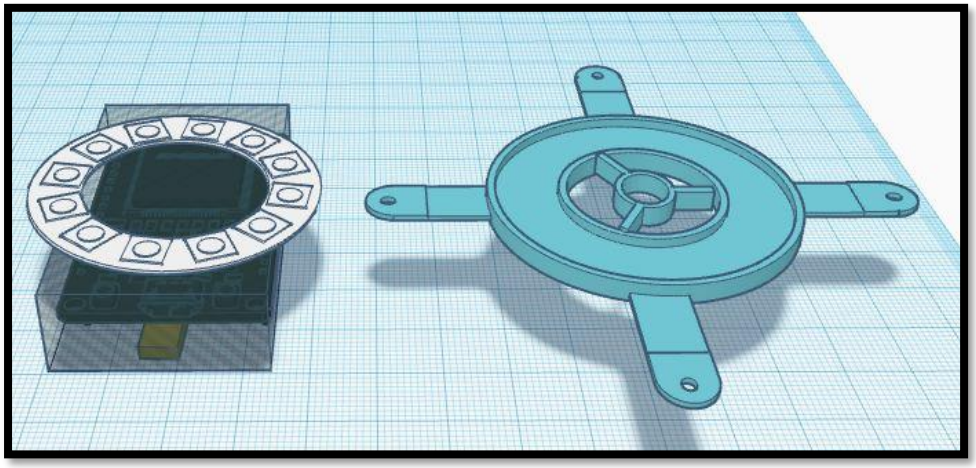
Some considerations for skip's device:

- The Led Ring goes through the broom.
- Dimensions of the broom: 1inch in diameter
- Dimension of Ring:
    - Inside Diameter: 36mm
    - Outer Diameter: 50mm
- Need a broom Mountable or a band to wrap around.
- Switch at the bottom of the broom

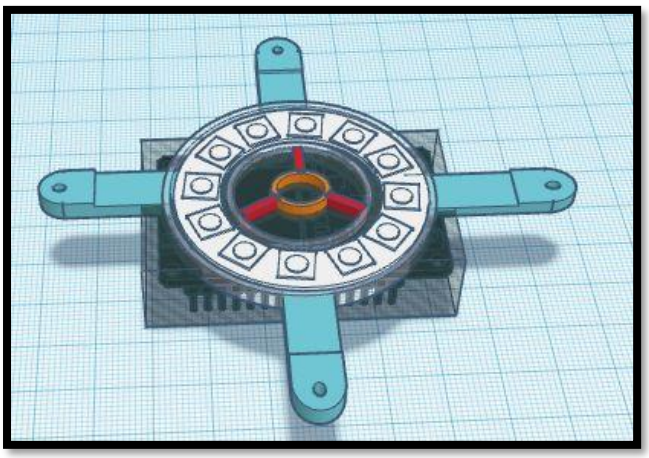


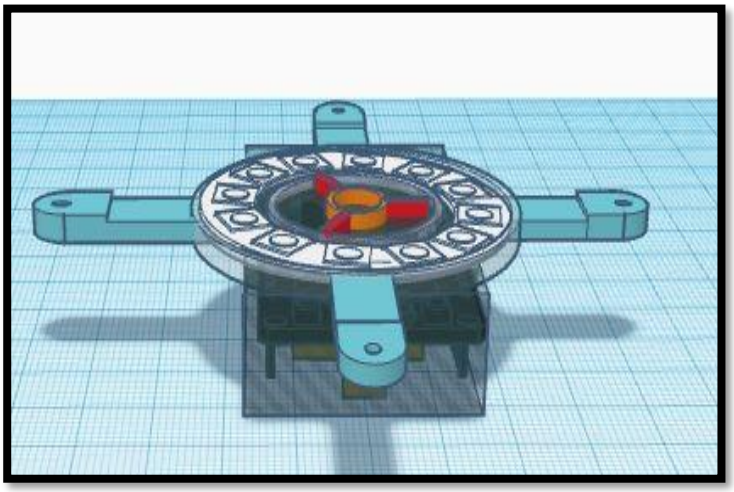


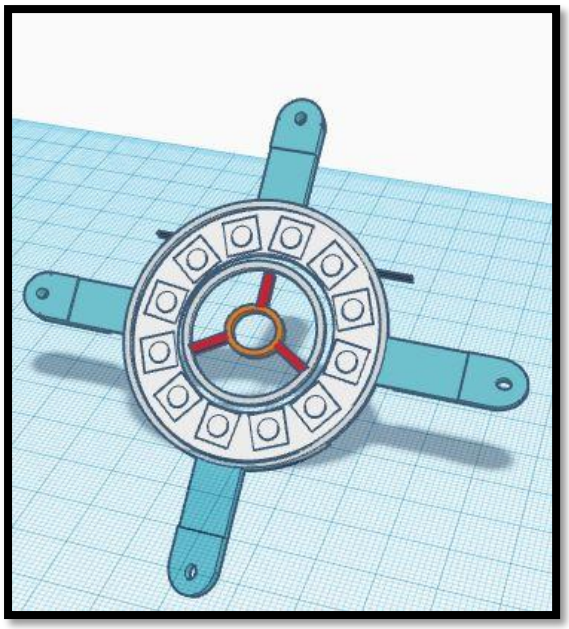
The Skip's Design is made as TV Remote shaped with joystick and power button, the esp32 board, battery, usb port will be fitted compacted into the controller shaped remote.



The LED Ring Case with bands and battery box shaped with board and battery mounted such that, LED Ring will be placed on the case and will wrap around the broom and LED Ring will go through it.







April 3rd, 2023

Finalized our code and tested the working of the codes both skip and sweeper.

Started to try to implement duty cycling (Suggested by David afterlab4)- looking into possible solutions , deep with light sleep modes.

Researched on all three topics and will start implement after last day of classes till the presentation day.

Implement Duty Cycling

- Duty cycling refers to a technique where a device is turned on and off periodically to conserve power. This technique is commonly used in battery-powered devices to extend their battery life.
- Duty cycling is a technique that can be used to conserve power in battery-powered devices. When combined with ESP-NOW, it can enable efficient and reliable communication between two or more ESP boards. Here are the implementation steps and advantages of implementing duty cycling with ESP-NOW:

Implementation Steps:

- Define the duty cycle time, which is the total time for which the device is turned on and off.
- Define the on time and off time, which are the periods during which the device is turned on and off, respectively.
- Initialize ESP-NOW in the setup() function.

- Register the receiver's MAC address using esp_now_add_peer() function.
- In the loop() function, turn on the device, wait for the on time, turn off the device, and wait for the off time. During the on time, send a message to the receiver using esp_now_send() function.
- In the receiver code, add a callback function to handle incoming messages using esp_now_register_recv_cb() function.

Advantages:

- Power efficiency: Duty cycling helps to conserve power by turning off the device during the off time, which reduces the overall power consumption.
- Reliable communication: By using ESP-NOW, communication between two or more ESP boards can be established without the need for a Wi-Fi network or a router. This ensures reliable communication even in areas where Wi-Fi signals may be weak or unavailable.
- Power saving: By turning off the radio during the off time, you can save power and extend the battery life of your ESP board.
- Fast communication: ESP-NOW provides fast communication between ESP boards without the need for a Wi-Fi network or a router. This can be especially useful in applications where real-time data transmission is important.
- Low latency: ESP-NOW has low latency, which means that data can be transmitted quickly and without delay.

Deep sleep mode with light mode in Esp-Now

entering deep sleep mode and turning off the radio for the sleep time, you can save power and extend the battery life of your ESP board. By entering light sleep mode for the light sleep time, you can still maintain some functionality while using very little power.

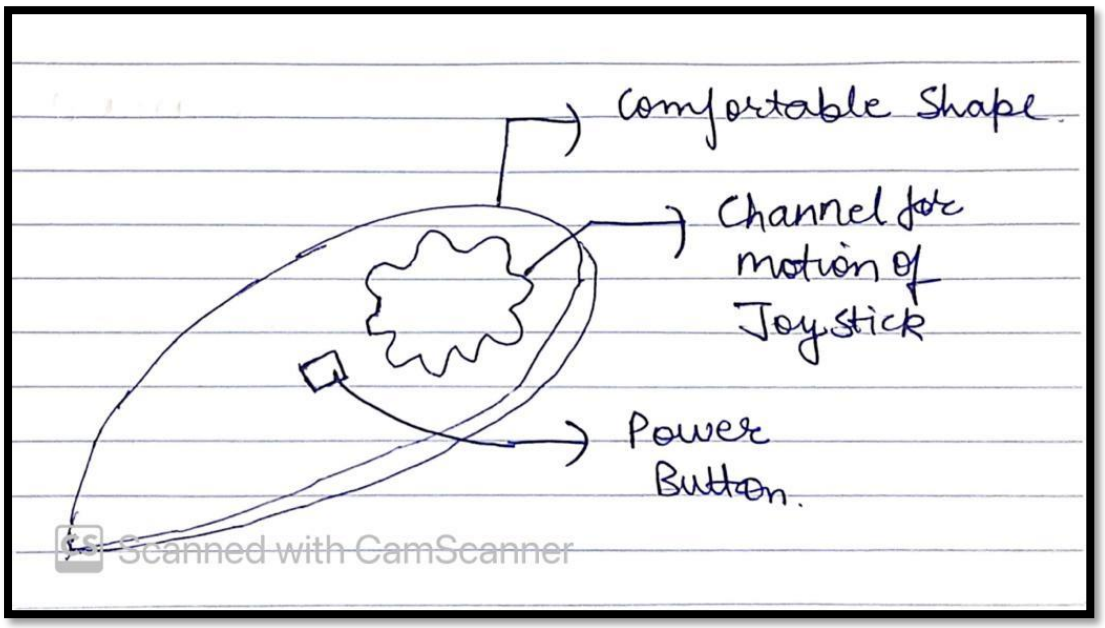
putting the board into deep sleep mode for a period, you can save power and extend the battery life of your ESP board. Light sleep mode can also be used to reduce power consumption while still maintaining communication capabilities.

April 9th, 2023

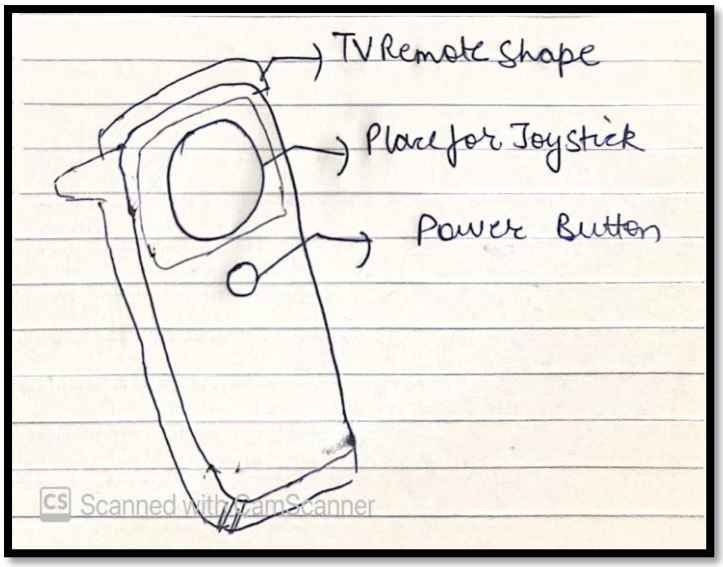
Had a team meeting to discuss the best of the team prototype and decide on the prototype to be printed.

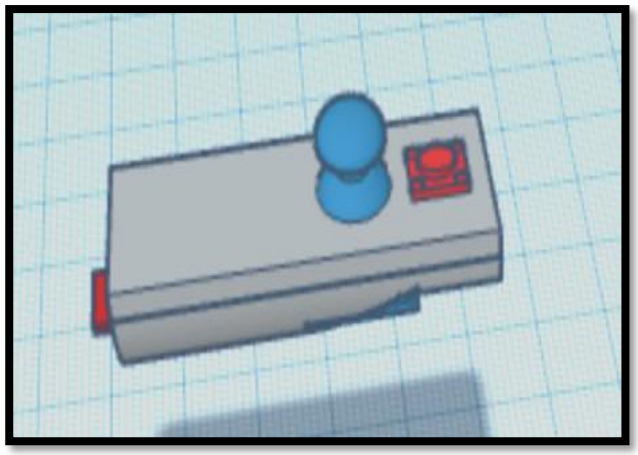
For the skip device:

- Mould made by **Antony** was the best option. – Included a sketch, not the 3D model as it was made by Antony.
    - Had a comfortable and easy to handle shape.
    - Seemed more ergonomic.
    - Had channels for the range of motion of the joystick.
- Back-Up Option for the skip's Device: Made by **Corben, like one I prototyped. Have included a sketch below and my 3D mode,** not mould as It was drawn by Corben.
- For the sweeper's Design: **Made by Corben**. Included a sketch below not 3D model as it was drawn by Corben. Considered as the best solution , had two places to mount to the broom to have a tight grip to the broom and will be rigid even with vigorous movement, a perfect case for the LED Ring to be placed with USB ports for the battery and the LED.
- **Got them printed.**



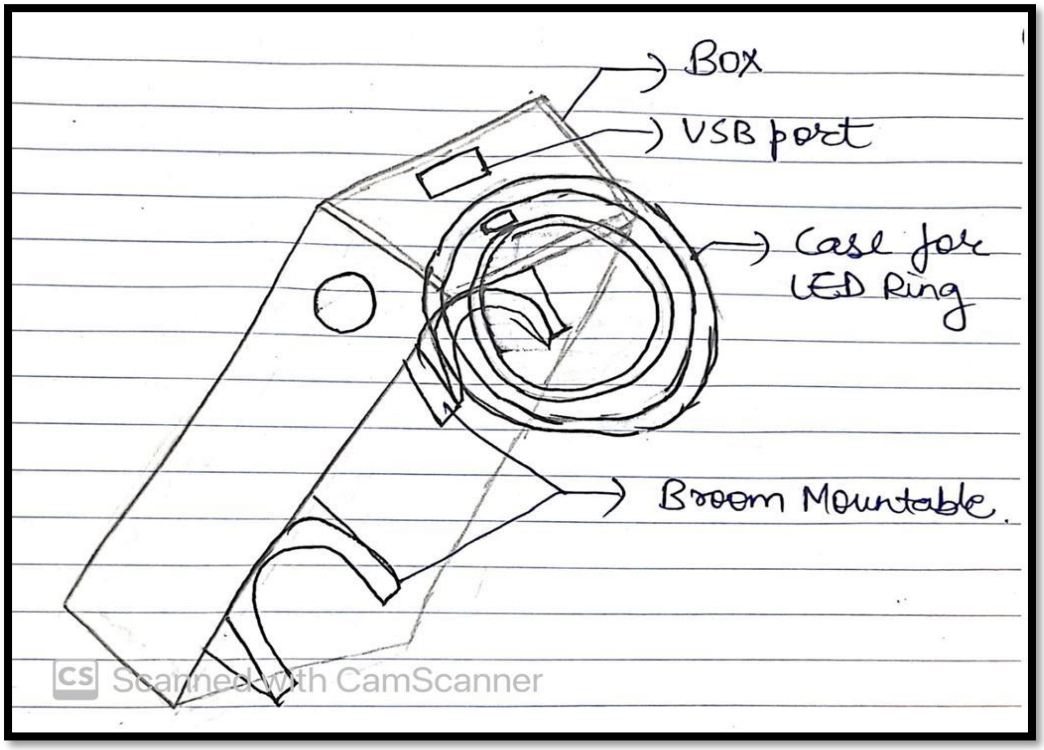
Sukhmeet





BACKUP FOR SKIP

SWEEPER:



Sukhmeet