BottleRevive

ME 102B Final Project
Allan Ulloa, Yohana Samayoa, Cezar Carvajal

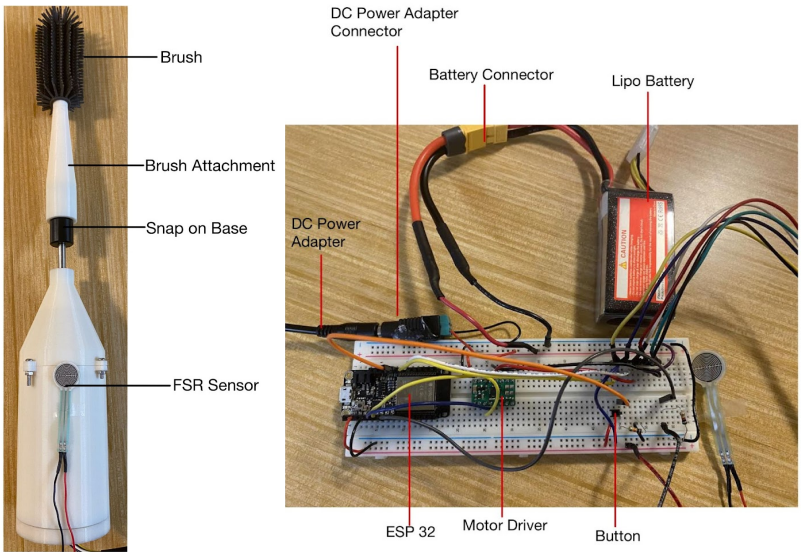
Project Opportunity

In envisioning our final project for BottleRevive, we aimed to create a water bottle cleaner that offers a more efficient way for people to clean their reusable water bottles. The envisioned product is designed to be a practical addition to kitchen appliances, providing a convenient and readily accessible solution for maintaining the hygiene of water bottles.

High-Level Strategy

The BottleRevive cleaner revolutionizes water bottle hygiene with its seamless operation and adaptable design. Users can effortlessly initiate the cleaning process by turning on the device and pressing the spinning button, which dynamically activates the brush at various pre-determined speeds, based on applied pressure. This innovative feature allows individuals to customize cleaning intensity according to their needs. BottleRevive's adaptability extends to unconventional bottle shapes, such as HydroFlasks and Stanley Bottles, overcoming the limitations of typical brushes. The user-friendly interface, featuring an easy-to-hold design and interchangeable brushes, ensures a tailored cleaning experience. Originally considering a linear actuator to ensure universal applications, the decision to interchangeable brushes reflects a commitment to user convenience.

Integrated Design



Functional Critical Decisions and Calculations

Motor: We wanted to choose a motor with medium power so we could achieve a high stall torque while being conservative money-wise. The high stall torque requirement we set for our prototype was a proactive measure as we intended to have interchangeable brushes which would vary in mass. After looking at similar products on the market, we decided to have our high speed be in the 50-60 rpm range so we needed a motor whose no-load speed was greater than our chosen range. After looking at common water bottles, we wanted our prototype to reach at least 10 $inches$ into the bottle. In terms of mass, we wanted to keep BottleRevive light so it would be easy to hold. For each of the interchangeable brushes,

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we chose a maximum of 250 $grams$. Maximum torque would be at the tip of the brush as the equation for torque is$\tau = Force * Distance$

Calculating Torque:

Conversion:$250\ g = 0.25kg$

$10\ inches = 25.4\ cm$

Torque = $25.4kg * 0.25\ cm = 6.35\ kg * cm$

The rule of thumb is to only use 60% of stall torque so:

$Stall\ Torque * 0.6 = 6.35\ kg/cm \rightarrow Stall\ Torque = 10.58\ kg * cm$

We needed a motor with a higher stall torque than $10.58\ kg * cm$.

These restrictions led us to choose a motor with the following specifications: Medium Power, 79 rpm no-load speed, 11 kg*cm stall torque, with an encoder.

Bearings: Initially, we didn't include bearings in our project and this resulted in a lot of friction between the stainless steel shaft and the ABS plastic nosecone.

$Coefficienrt\ of\ Friction\ (Stainless\ Steel\ on\ ABS\ Plastic) = 0.4$

We wanted to reduce this as much as possible using bearings which also allowed us to contrain the shaft in the vertical direction.

Choosing bearing material:

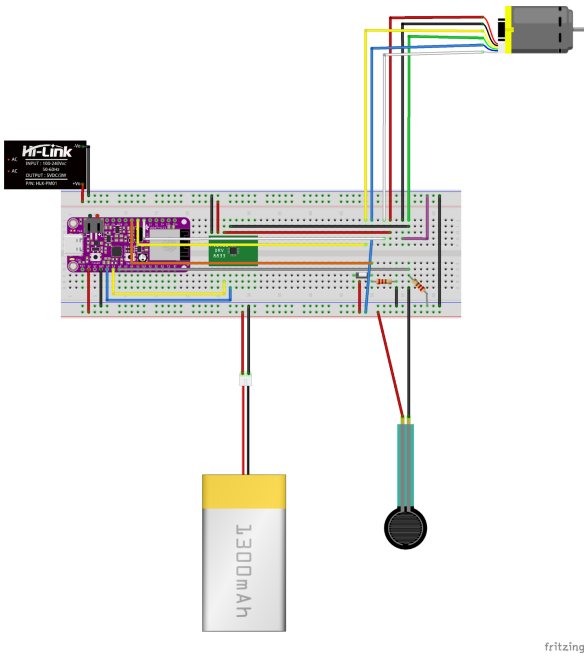
$Coefficienrt\ of\ Friction\ (Stainless\ Steel\ on\ Bronze)$: 0.16

$Coefficienrt\ of\ Friction\ (Stainless\ Steel\ on\ Copper)$: 0.18

$Coefficienrt\ of\ Friction\ (Stainless\ Steel\ on\ Nylon)$: 0.40

To allow for the smoothest rotation, we chose bronze which had the lowest coefficient of friction against stainless steel.

Updated Circuit Diagram



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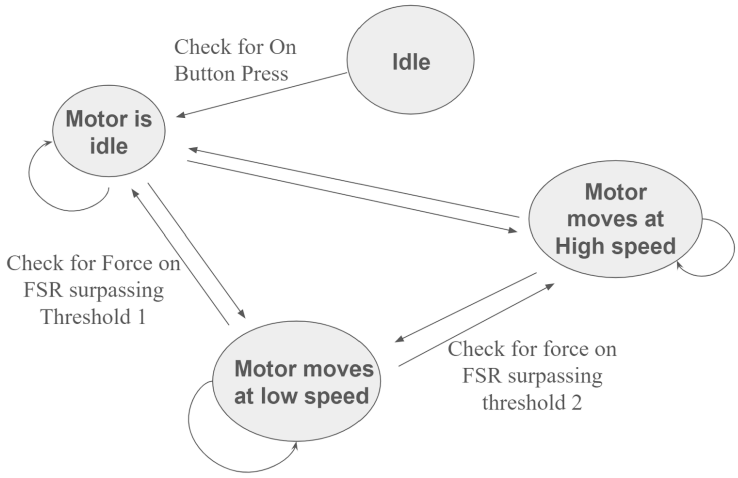
Updated State Transition Diagram



Reflection

For future students in the class, we found that paying meticulous attention to tolerances significantly reduced costs by minimizing the need for multiple prints. Being firm on our product's objectives and embracing simplicity were successful strategies, ensuring our project's success. It's crucial to focus on what is known and asked, avoiding unnecessary complications. Additionally, actively seeking clarification during office hours and utilizing available resources proved instrumental in understanding project requirements. On the flip side, our journey with BottleRevive highlighted the inevitability of setbacks, turning them into valuable learning opportunities. While setbacks are part of the process, we advise future students to balance innovation with adherence to project specifications, ensuring a practical approach to project development.

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Appendices

Appendix A: Bill of Materials

Link to Full BOM

Item	Individual Price	Quantity	Total Price	Vendor
Force Sensing Resistor	$14.32	1	$14.32	Amazon
Doseno Reusable Water Bottle	$7.99	2	$15.98	Amazon
Thin Film Pressure Sensor	$13.67	1	$13.67	Amazon
99:1 Metal Gearmotor 25Dx69L mm MP 12V with 48 CPR Encoder	$45.95	1	$45.95	Polulu
Pololu 12V Step-Up/Step-Down Voltage Regulator S18V20F12	$25.95	1	$25.95	Polulu
Zeee 11.1V 120C 1500mAh 3S RC Lipo Battery Graphene Battery with XT60 Plug for FPV Racing Drone Quadcopter Helicopter Airplane RC Boat RC Car RC Models(2 Pack)	$38.99	1	$38.99	Amazon
Ball Bearing, Sealed, Trade Number R4-2Rs, For 1/4" Shaft Diameter	$7.72	4	$30.88	McMaster Carr
Rotary Shaft, 303 Stainless Steel, 1/4" Diameter, 4" Long	$6.65	1	$6.65	McMaster Carr
Clamping Precision Flexible Shaft Coupling, Spiral, 7075 Aluminum, For 4mm x 1/4" Shaft Diameter, 28mm Long	$61.67	1	$61.67	McMaster Carr
Lipo Charger	$39.99	1	$39.99	Amazon
OPBYWE 12V 5A 60W Power Supply Adapter	$16.99	1	$16.99	Amazon
Press Fit Drill Bushing	$14.44	1	$14.44	McMaster Carr
Grease Seal	$5.85	1	$5.85	McMaster Carr
Square Profile O Rings	$12.75	1	$12.75	McMaster Carr
Press Fit Drill Bushing	$14.44	1	$14.44	McMaster Carr
Grease Seal	$5.85	2	$11.70	McMaster Carr

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Bronze Bearing	$0.89	4	$3.56	McMaster Carr
HELIFOUNER 540 Pieces	$9.99	1	$9.99	Amazon
5Pairs XT60H	$13.99	1	$13.99	Amazon
uxcell M3 x 6mm 304 Stainless Steel Cross Head Phillips Pan Head Screws	$5.99	1	$5.99	Amazon
Silicone Bottle Cleaning Brush	$9.99	1	$9.99	Amazon
ABS Print 1	$23.88	1	$23.88	UCB Machine Shop
ABS Print 2	$61.62	1	$61.62	UCB Machine Shop
ABS Print 3	$41.37	1	$41.37	UCB Machine Shop
ABS Print 4	$17.59	1	$17.59	UCB Machine Shop
Adafruit HUZZAH32 – ESP32 Feather Board	$0.00	1	$0.00	ME102B Kit
Motor Drive	$0.00	1	$0.00	ME102B Kit
USB Cable	$0.00	1	$0.00	ME102B Kit
DC Power Connector	$0.00	1	$0.00	ME102B Kit

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Appendix B: CAD

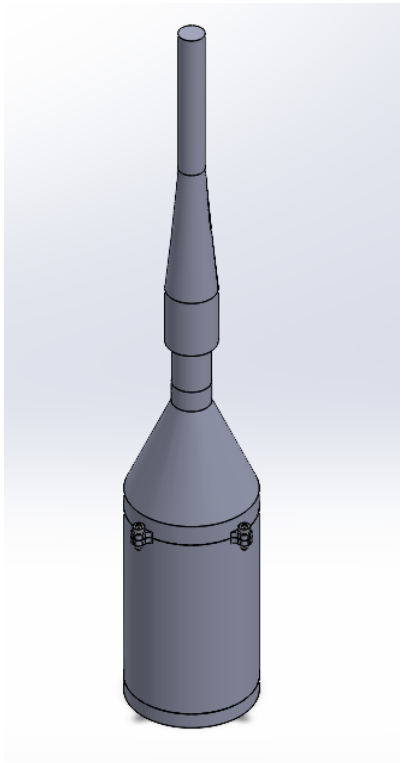


Figure 1:Isometric VIew

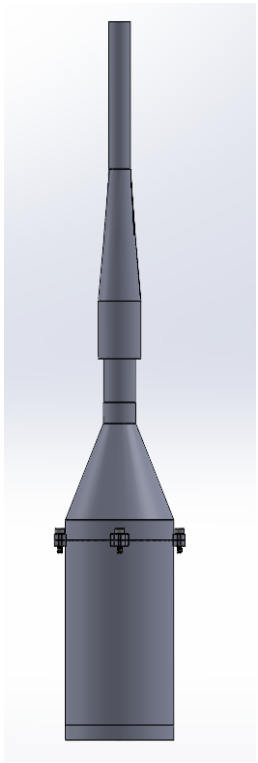
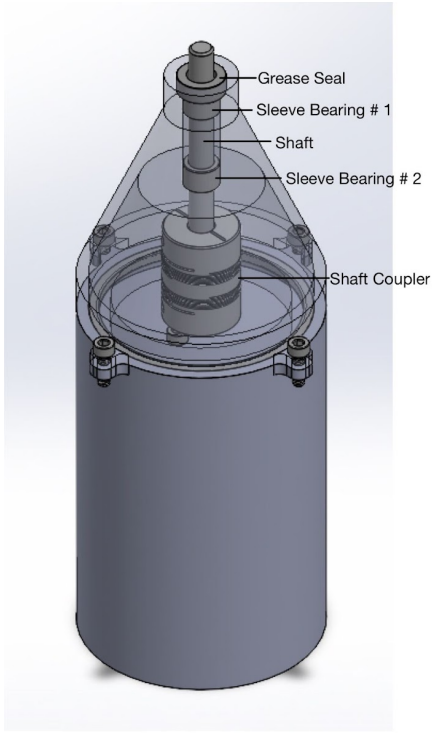


Figure 2:Front View



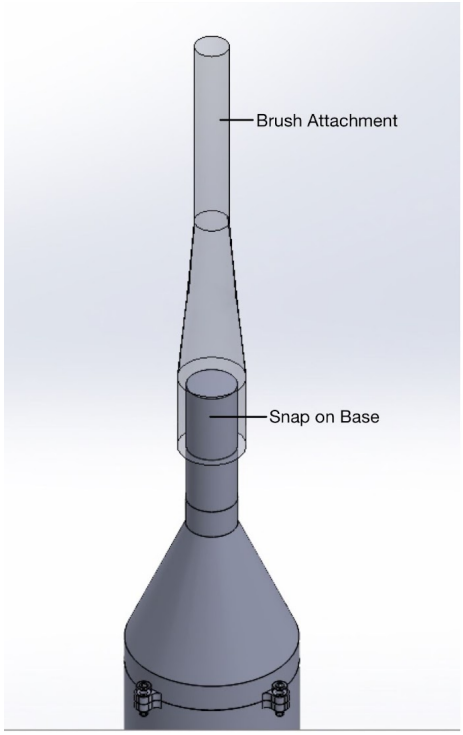


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Figure 3:Shaft Transmission

Figure 4:Brush Attachment

Appendix C: Full Code

final_code_102b.ino

```
#include <Arduino.h>
#include <ESP32Encoder.h>
ESP32Encoder encoder;
#define BIN_1 26
#define BIN_2 25
#define BTN 12
#define LED_PIN 13
#define FSR 34

const int freq = 5000;
const int pwmChannel = 0;
const int resolution = 8;
const int ledChannel_1 = 1;
const int ledChannel_2 = 2;
const int MAX_PWM_VOLTAGE = 255;
const int NOM_PWM_VOLTAGE = 220;

int threshHold1 = 500; // speed 1
int threshHold2 = 1500; // speed 2
int threshHold3 = 3000; // speed 3

volatile bool buttonIsPressed = false;
unsigned long startTime = 0;

int state = 1;
int D = 0;


//Setup interrupt variables ------------------------------
volatile int count = 0; // encoder count
volatile bool interruptCounter = false;    // check timer interrupt 1
volatile bool deltaT = false;     // check timer interrupt 2
int totalInterrupts = 0;   // counts the number of triggering of the alarm
hw_timer_t * timer1 = NULL;
portMUX_TYPE timerMux0 = portMUX_INITIALIZER_UNLOCKED;
```

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```
hw_timer_t * timer1 = NULL;
portMUX_TYPE timerMux0 = portMUX_INITIALIZER_UNLOCKED;
portMUX_TYPE timerMux1 = portMUX_INITIALIZER_UNLOCKED;

void IRAM_ATTR onTime1() {
  portENTER_CRITICAL_ISR(&timerMux1);
  count = encoder.getCount( );
  encoder.clearCount ( );
  deltaT = true; // the function to be called when timer interrupt is triggered
  portEXIT_CRITICAL_ISR(&timerMux1);
}


void IRAM_ATTR isr() {
  buttonIsPressed = true;
}

void setup() {
  pinMode(BTN, INPUT);
  pinMode(LED_PIN, OUTPUT);
  pinMode(POT, INPUT);

  attachInterrupt(BTN, isr, RISING);

  ledcSetup(pwmChannel, freq, resolution);

  ESP32Encoder::useInternalWeakPullResistors = UP; // Enable the weak pull up resistors
  encoder.attachHalfQuad(33, 27); // Attache pins for use as encoder pins
  encoder.setCount(0);  // set starting count value after attaching

  // configure LED PWM functionalitites
  ledcSetup(ledChannel_1, freq, resolution);
  ledcSetup(ledChannel_2, freq, resolution);
```

final_code_102b.ino

```
  // configure LED PWM functionalitites
  ledcSetup(ledChannel_1, freq, resolution);
  ledcSetup(ledChannel_2, freq, resolution);

  // attach the channel to the GPIO to be controlled
  ledcAttachPin(BIN_1, ledChannel_1);
  ledcAttachPin(BIN_2, ledChannel_2);

  timer1 = timerBegin(1, 80, true);  // timer 1, MWDT clock period = 12.5 ns * TIMGn_Tx_WDT_CLK_PRESCALE -> 12.5 ns * 80 -> 1000 ns = 1 us, countUp
  timerAttachInterrupt(timer1, &onTime1, true); // edge (not level) triggered

  // CHANGE TIMER DURATION HERE IF NEEDED (second input in timerAlarmWrite in microseconds)
  timerAlarmWrite(timer1, 10000, true); // 10000 * 1 us = 10 ms, autoreload true

  // at least enable the timer alarms
  timerAlarmEnable(timer1); // enable

  Serial.begin(9600);

  // Other setup code
}

void loop() {

  switch (state) {
    case 1:
      if (CheckForButtonPress()) {
        led_on();
        state = 2;
      }
      Serial.println("state 1");
      break;

    case 2:
```

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```
        Serial.println("state 1");
        break;

      case 2:

        if (CheckForThreshHold1()) {
          D=0;
          ledcWrite(ledChannel_1, LOW);
          ledcWrite(ledChannel_2, D);
        }

        if (CheckForThreshHold2()) {
          D=150;
          ledcWrite(ledChannel_1, LOW);
          ledcWrite(ledChannel_2, D);
        }

        if (CheckForThreshHold3()) {
          D=220;
          ledcWrite(ledChannel_1, LOW);
          ledcWrite(ledChannel_2, D);
        }

        if (CheckForButtonPress()) {
          led_off();
          D=0;
          ledcWrite(ledChannel_1, LOW);
          ledcWrite(ledChannel_2, D);
          state = 1;
        }
        Serial.println("state 2");
        break;
    }
  }
```

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final_code_102b.ino

```
bool CheckForButtonPress() {
  if (buttonIsPressed) {
    buttonIsPressed = false;
    return true;
  } else {
    return false;
  }
}

void led_on() {
  digitalWrite(LED_PIN, HIGH);
}

void led_off() {
  digitalWrite(LED_PIN, LOW);
}

bool CheckForThreshHold1() {
  int fsrReading = analogRead(FSR);
  if ( fsrReading < threshHold1){
    return true;
  }
  else {
    return false;
  }
}

bool CheckForThreshHold2() {
  int fsrReading = analogRead(FSR);
  if ( fsrReading > threshHold1 && fsrReading < threshHold2){
    return true;
  }
  else {
    return false;
  }
}

bool CheckForThreshHold3() {
  int fsrReading = analogRead(FSR);
  if ( fsrReading > threshHold2 && fsrReading< threshHold3){
    return true;
  }
  else {
    return false;
  }
}
```