SASTA OLIPHANT SCIENCE AWARDS

SOUTH AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Prize Winner

Programming, Apps & Robotics

Year 5 - 6

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SOUTH AUSTRALIA Government of South Australia Department for Education

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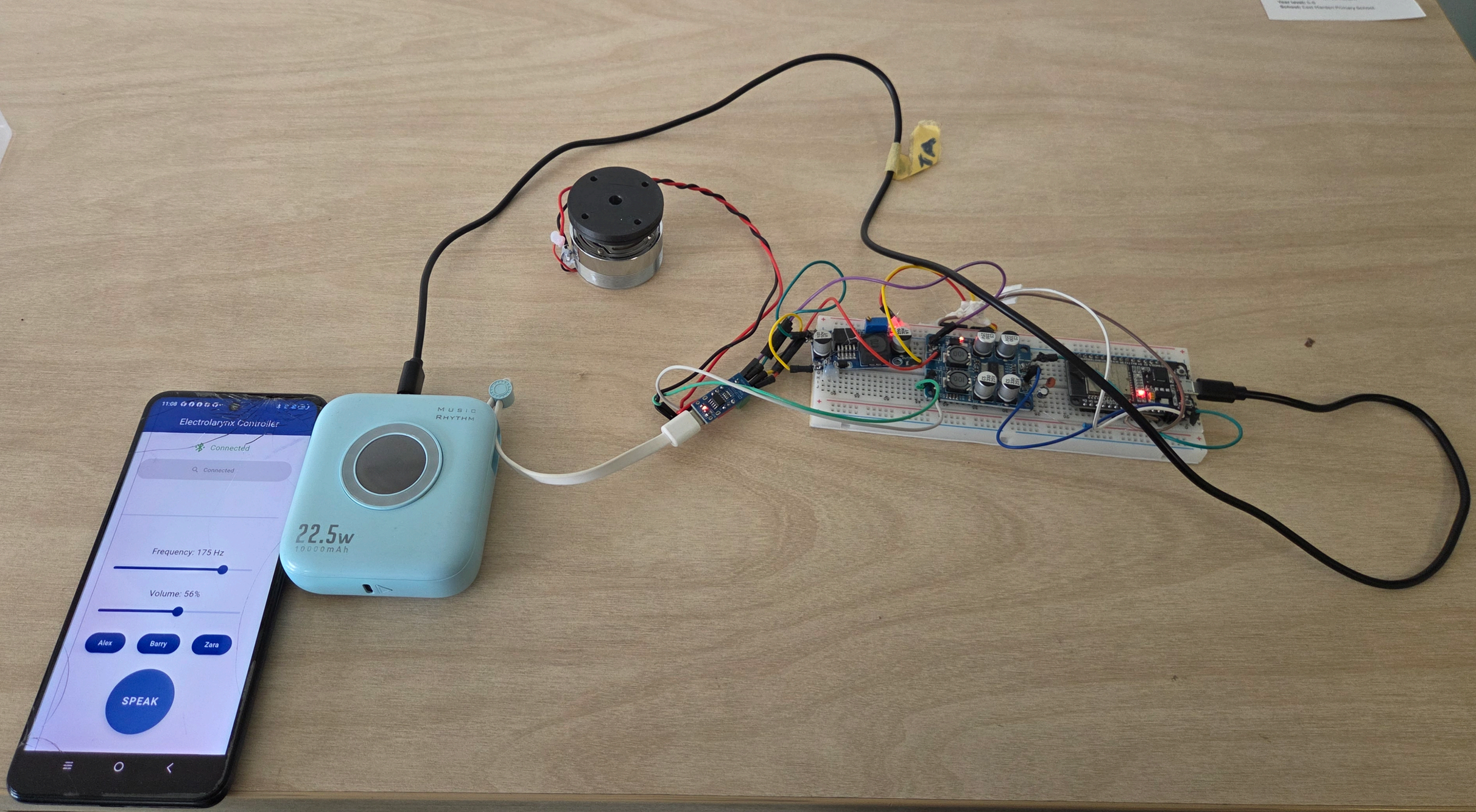
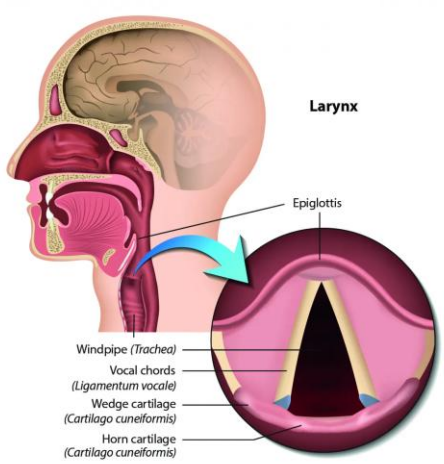

ID: 0136-030
11:08
Electrolarynx Controller
Connected
Connected
Frequency: 175 Hz
Volume: 56%
Alex
Barry
Zara
SPEAK
MUSIC
RHYTHM
22.5w
10000mAh

Project : A Prototype Electronarynx for Oliphant Science

By Azan



What is an electrolarynx?

An electrolarynx is a medical grade device used to help people talk again after having their larynx removed for reasons like cancer or neck injury etc.

What transpired me to do this?

One day one of my dad’s friend’s brother came to our house for a visit. They were having a chat. All of a sudden I heard a robotic voice.I was curious and went up to them and had a look and noticed that my dad’s friends' brother was holding a torch like a heavy thing holding on to his neck and moving his mouth just like talking, so i asked ”what is that?” Then my dad replied it is a device used for speaking when the voice box is removed, I asked why then his brother replied saying due to cancer his voice box had to be removed. I was so sad to hear and thought about why he should speak in a robotic voice and not in his own voice or a human-like voice and why the device is heavy and needs to be held whenever he wants to talk. I thought I would do something to make it easier. He replied” this that i’m holding is called an electrolarynx.”So i was curious why the electrolarynx he was holding in his hand responded to a robotic sound? So then that’s when I got the idea of making an electrolarynx!

Research

I did some research on how’s and why’s for this project, below I have elaborated them.

How is sound generated?

Sound is produced when an object vibrates—moving back and forth rapidly—which creates pressure waves (sound waves) in a medium like air, water, or solids.

How can we make sound?

We can make sound by vibrating something.

How do humans make sound?

Humans make sound by vibrating the vocal folds.

Why when you remove the larynx humans can't make sound?

because the vocal cord is part of the larynx

How does a normal person's voice is generated?

The voice generation process begins at the lungs which blows out air through the vocal cord which vibrates the air then goes to the larynx which generates the raw sound, the articulators shape out the raw sound turning it into speaking words.

What are articulators?

Articulators are solid objects that shape the raw sound into speaking words.

Examples of Articulators

- Tongue
- Teeth
- Tongue palette
- Lips

What happens if you don't have a larynx?

You can't generate raw sounds so then you can't talk.

What do I do to fix this?

The only part that is removed is the vibrating part, the rest of them remains such as the lungs and the articulators.

I only need to replace the vibrating parts with an artificial one.

What's my replacement?

A vibrating part, that is a transducer controlled by a software.

Parts of the electrolarynx

My electrolarynx contains following 3 major parts

Software

The Mobile App is the software part of the project which helps control the frequency and the volume. Which helps by connecting wirelessly using bluetooth. Frequency helps by changing the voice to a Female and a male throughout the app. Lower the frequency Male, higher the frequency female.

Hardware

Power bank- to power the circuit

Pdc004- to increase the voltage(5—12v) because to

Tpa3118-

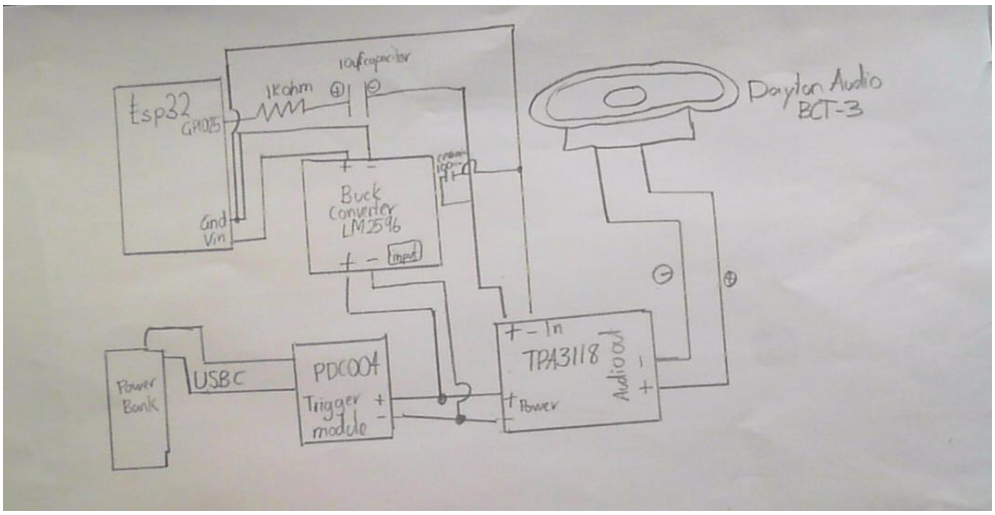
Lm2596- to reduce the voltage(12–5v) for the esp32, otherwise the esp33 will burn

Dayton audio bct-3-to generate the vibration

Esp32- to generate h pulse frequency nd sound

Capacitor– to smoothen the digital pulse to analog form so that the robotic voice is closer to the human voice.

Circuit diagram



Firmware

The code written inside the esp32 vroom module to:

generate the frequency pulses

Change the frequency from 150hz–280hz

Change the volume

To connect mobile app device to control the hardware through the BLUTOOTH

What did I try as vibrating components?

8 Ohm speaker

Dayton Audio DAEX-13-4SM

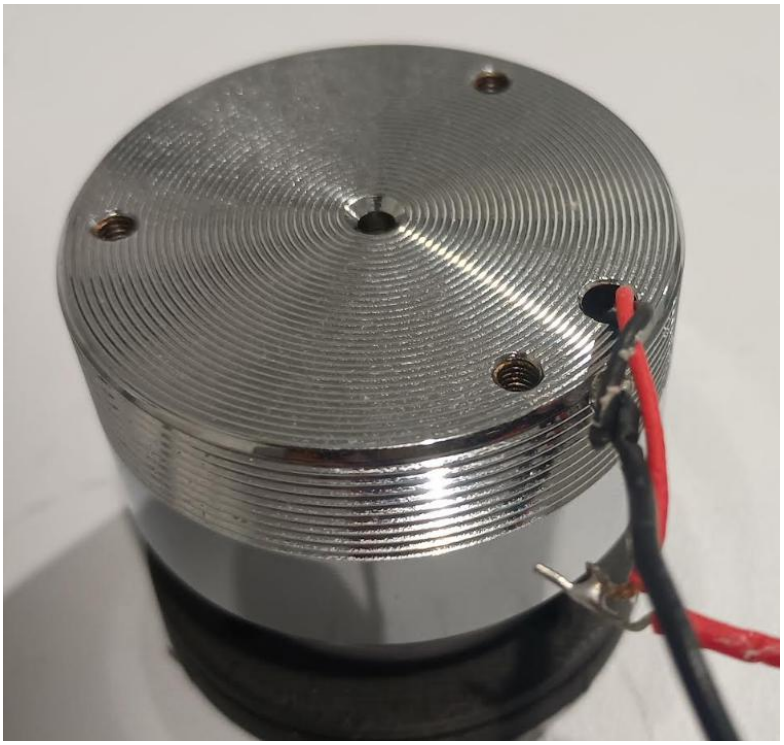
Dayton Audio BCT-3

Why did I use each?

I thought the 8 ohm speaker would have enough vibration to vibrate the tissue and the larynx, but after researching I found out it vibrates the air which in turn is not enough to vibrate the tissue and to vibrate the air in the pharynx to generate the raw sound.

Then, I used the Dayton Audio DAEX-13-4SM because I thought it would vibrate enough to vibrate the skin, tissue,and pharynx and air in the pharynx, but it could not generate enough vibration power to vibrate the air in the pharynx.

Ultimately, I did research using Claude AI to understand how it works. It pointed me to transducers which vibrate the surfaces that it has contact with instead of the air.After further research on how electrolarynx work, the best one to use was identified as the DAYTON AUDIO BCT-3. So, I used the Dayton Audio BCT-3 which had enough vibration power to generate enough raw sound.

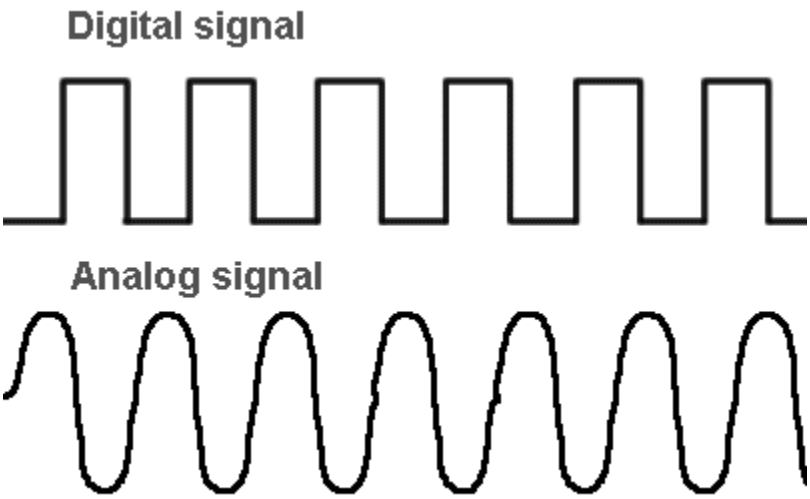


What is the difference between a normal speaker and transducer?

A speaker vibrates the air and a transducer vibrates an object.

Why is the electrolarynx sound robotic?

Because it uses digital signals instead of smooth, clean analog sine waves.



How do we reduce the robotic effect?

Make the signal smoother like an Analog wave.

What is the human normal speaking voice frequency range?

males are 85–180 Hz and females are 165–255 Hz

How did I make the frequency range of the device closer to the human frequency range?

Because I made the signal an Analog sine wave.

How can it help the world?

It can help the world by helping the people who don't have a larynx

How is it going to be different in what's in the market?

making it compact less costly,affordable

What more do I need to do?

I need to do a lot of research to make it harmless to humans

I need to do more testing

Hardware tools / components

- Computer
- Power Bank
- Buck converter (LM2596)
- Trigger module (PDC004)
- TPA3118
- Esp32
- 1K om resistor
- 10 microfarad capacitor
- Ceramic Capacitor 100 ohms
- Dayton Audio

- Jumper wires

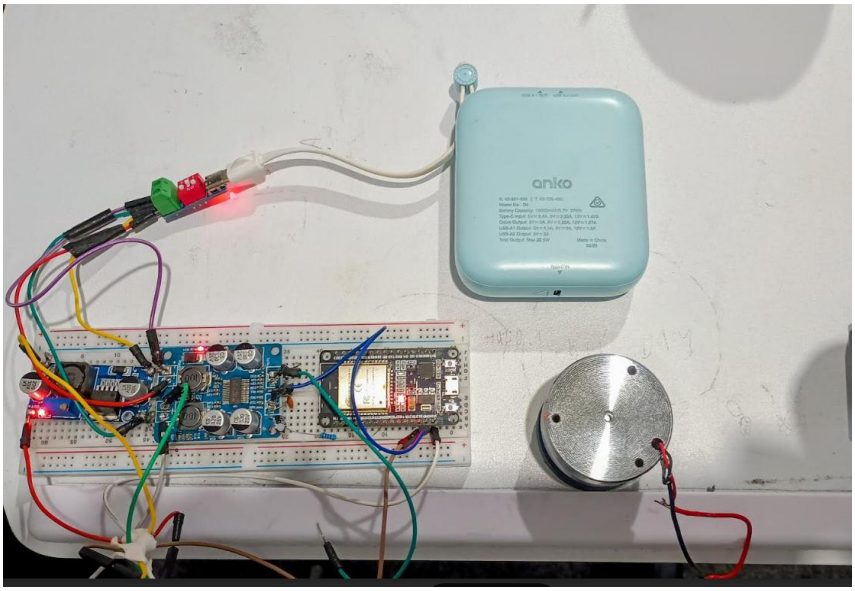
What is the price of an electrolarynx in the market?

about $1200

What's my objective for this project?

My objective is to create an affordable online controlled electrolarynx.

Photo of the device



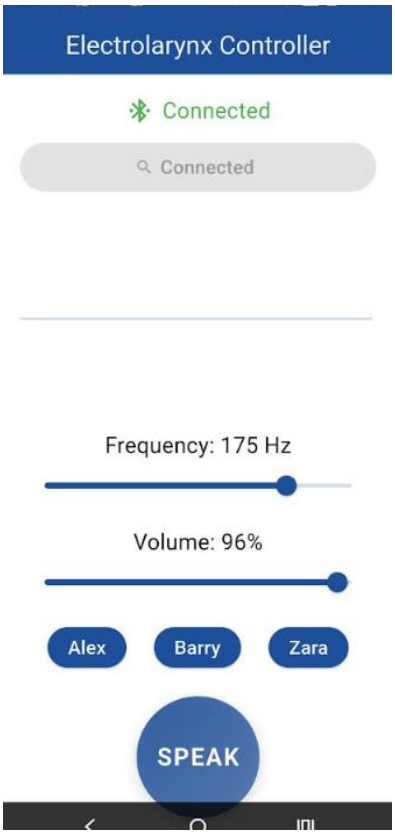
Video Demo of how my prototype electrolarynx works?

https://www.youtube.com/watch?v=P1zqowgXGjc

Electrolarynx Mobile App Code

https://drive.google.com/file/d/17EzJ3YjzQQsCTOvlwEGbS82kf1YAG79Z/view?usp=gmail

Mobile App Screenshots



Firmware code

```
#include <Arduino.h>
#include <BLEDevice.h>
#include <BLEServer.h>
#include <BLEUtils.h>
#include <BLE2902.h>

//Code Version 4.0
// UUIDs for the Flutter app
static const char* SERVICE_UUID    = "12345678-1234-5678-1234-
56789abcdef0";
static const char* FREQ_CHAR_UUID  = "12345678-1234-5678-1234-
56789abcdef1";
static const char* POWER_CHAR_UUID = "12345678-1234-5678-1234-
56789abcdef2";
static const char* AMP_CHAR_UUID   = "12345678-1234-5678-1234-
56789abcdef3";

// Hardware Configuration
const int OUTPUT_PIN = 25;   // To Resistor/Capacitor filter
const int MUTE_PIN   = 27;   // Optional: To TPA3118 MUTE/SD pin

// State Variables
volatile uint8_t amplitudeRaw = 100; // 0-100
volatile bool powerOn = false;

float currentFreq = 120;
float targetFreq = 120;

// Preset Frequencies (Hz)
const uint32_t FREQ_ALEX  = 105;
const uint32_t FREQ_BARRY = 135;
const uint32_t FREQ_ZARA  = 175;

// BLE Objects
BLEServer* pServer = nullptr;
bool deviceConnected = false;
```

```
// Frequency Mapper (Targeting BCT-3 Resonance)
uint32_t mapFreq(uint8_t raw) {
  if (raw < 1) raw = 1;
  // Map 0-255 slider to 80Hz - 300Hz for best vibration
  return map(raw, 0, 255, 80, 300);
}

// ---- BLE Callbacks ----
class MyServerCallbacks : public BLEServerCallbacks {
  void onConnect(BLEServer* pServer) override {
    deviceConnected = true;
    Serial.println("Connected");
  }
  void onDisconnect(BLEServer* pServer) override {
    deviceConnected = false;
    BLEDevice::startAdvertising();
    Serial.println("Disconnected - Advertising...");
  }
};

class FreqCallbacks : public BLECharacteristicCallbacks {
  void onWrite(BLECharacteristic* characteristic) override {
    String value = characteristic->getValue(); // Arduino String for Core
3.x
    if (value.length() == 0) return;
    uint8_t raw = (uint8_t)value[0];

    if (raw == 201) targetFreq = FREQ_ALEX;
    else if (raw == 202) targetFreq = FREQ_BARRY;
    else if (raw == 203) targetFreq = FREQ_ZARA;
    else targetFreq = mapFreq(raw);
  }
};

class PowerCallbacks : public BLECharacteristicCallbacks {
  void onWrite(BLECharacteristic* characteristic) override {
    String value = characteristic->getValue();
    if (value.length() == 0) return;
    powerOn = (value[0] == 1);
  }
```

```
};

class AmpCallbacks : public BLECharacteristicCallbacks {
  void onWrite(BLECharacteristic* characteristic) override {
    String value = characteristic->getValue();
    if (value.length() == 0) return;
    amplitudeRaw = value[0] > 100 ? 100 : value[0];
  }
};

// ---- Core Logic Functions ----

void setupOutputPWM() {
  pinMode(OUTPUT_PIN, OUTPUT);
  digitalWrite(OUTPUT_PIN, LOW); // Prevent idle buzzing

  pinMode(MUTE_PIN, OUTPUT);
  digitalWrite(MUTE_PIN, HIGH); // Start Muted (Assuming High = Mute)

  // Core 3.x Syntax: Attach pin, frequency, resolution (13-bit = 0-8191)
  ledcAttach(OUTPUT_PIN, 100, 13);
}

void updateOutput() {
  // Smooth frequency transitions
  currentFreq += (targetFreq - currentFreq) * 0.45f;  //15//25

  if (powerOn) {
    digitalWrite(MUTE_PIN, LOW); // Unmute Amp

    // Set tone
    ledcWriteTone(OUTPUT_PIN, (uint32_t)currentFreq);

    // 2048 is ~25% duty cycle at 13-bit.
    // Higher than this risks melting the BCT-3 in an enclosure.
    uint32_t targetDuty = (2048 * amplitudeRaw) / 100;
    ledcWrite(OUTPUT_PIN, targetDuty);
  } else {
    // Stop all vibration immediately
    ledcWrite(OUTPUT_PIN, 0);
```

```
    digitalWrite(OUTPUT_PIN, LOW);
    digitalWrite(MUTE_PIN, HIGH); // Mute Amp
  }
}

void setup() {
  Serial.begin(115200);

  setupOutputPWM();
  BLEDevice::init("Electrolarynx-V4");
  pServer = BLEDevice::createServer();
  pServer->setCallbacks(new MyServerCallbacks());

  BLEService* pService = pServer->createService(SERVICE_UUID);

  auto createChar = [&](const char* uuid, BLECharacteristicCallbacks* cb)
{
    BLECharacteristic* pChar = pService->createCharacteristic(
      uuid, BLECharacteristic::PROPERTY_WRITE |
BLECharacteristic::PROPERTY_READ);
    pChar->setCallbacks(cb);
    pChar->addDescriptor(new BLE2902());
  };

  createChar(FREQ_CHAR_UUID, new FreqCallbacks());
  createChar(POWER_CHAR_UUID, new PowerCallbacks());
  createChar(AMP_CHAR_UUID, new AmpCallbacks());

  pService->start();
  BLEAdvertising* adv = BLEDevice::getAdvertising();
  adv->addServiceUUID(SERVICE_UUID);
  adv->start();

  Serial.println("Electrolarynx Ready.");
}

void loop() {
  updateOutput();
  delay(10); // Stability delay
}
```

Software and Hardware tools to build this

- Mobile Phone
- Computer
- Flutter - To Develop the Mobile App
- VS Code - To Develop the Mobile App
- Arduino IDE - To Develop the Firmware code
- Data USB Cable - To upload the firmware code to the ESP Wroom

Risks

- This has not been medically tested.
- EXCESSIVE USE MAY CAUSE NECK INJURY

References

- **How do I make my first Flutter app**
- **How to speak with an electrolarynx**
- **https://www.facebook.com/therealpars/videos/what-is-a-transducera-transducer-provides-an-output-quantity-having-a-specified-/1261628907762287/**
- Claude AI to ask questions on how things work, how to code for Mobile App, how electrolarynx work
- **Android Studio - https://www.youtube.com/watch?v=saKrGCWlJDs**
- Explanations on how voice works by Dr. Shamila Farzan
- Google - To research how human voice is generated, what is laryngectomy

- My dad's help on debugging the code as well as helping me with soldering and buying me the required items, And also reviewing the documentation.
- East Marden Primary School Science Teachers for reviewing the report