Noninvasive Photoglottography Device

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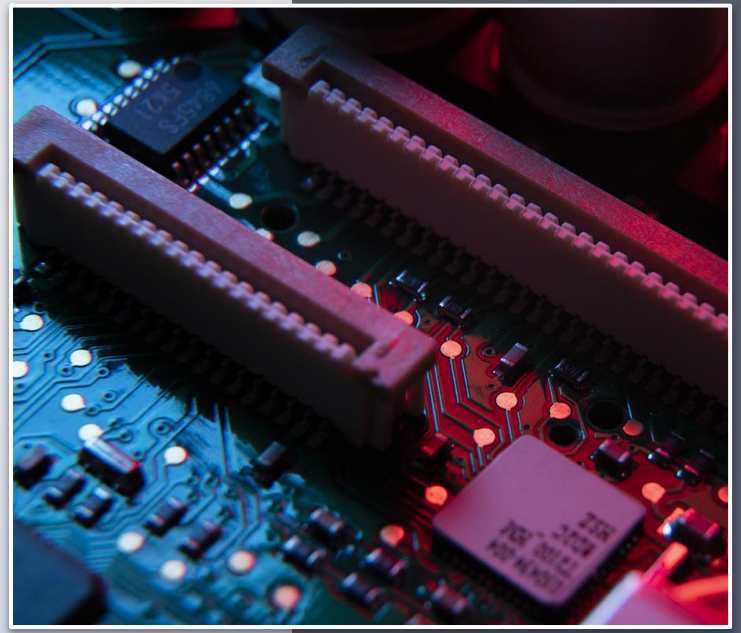

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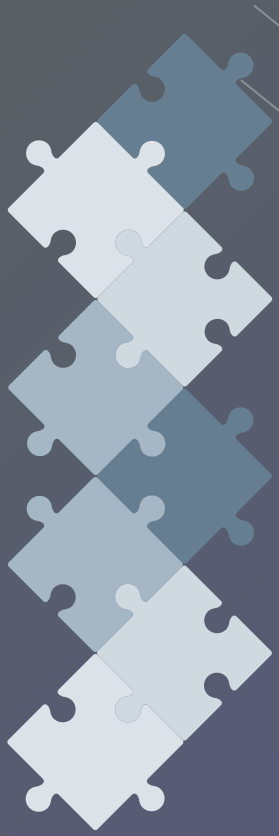
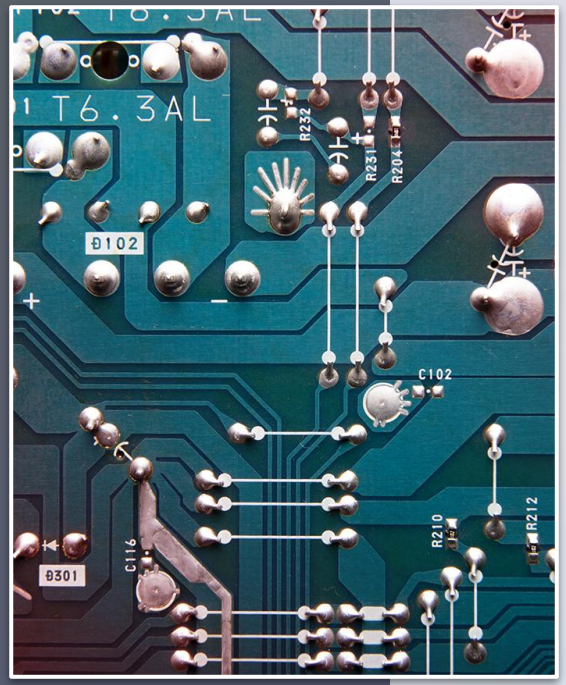


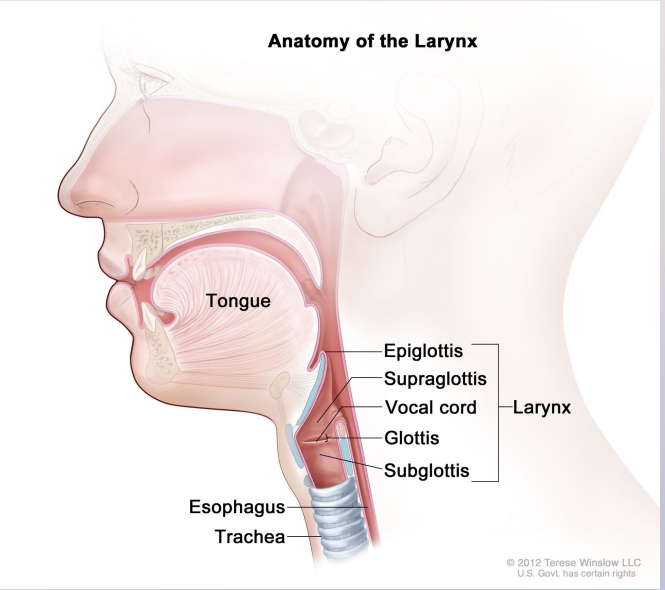


01

Background and Motivation

What is photoglottography?

- The glottis is the part of the larynx that contains the vocal folds; it is crucial in the production of sound
- Basic states of glottal passage: open, in vibration, narrowed, closed
- Photoglottography: light source placed above or below vocal folds; light sensor is placed on other side of the folds to convert light intensity to voltage

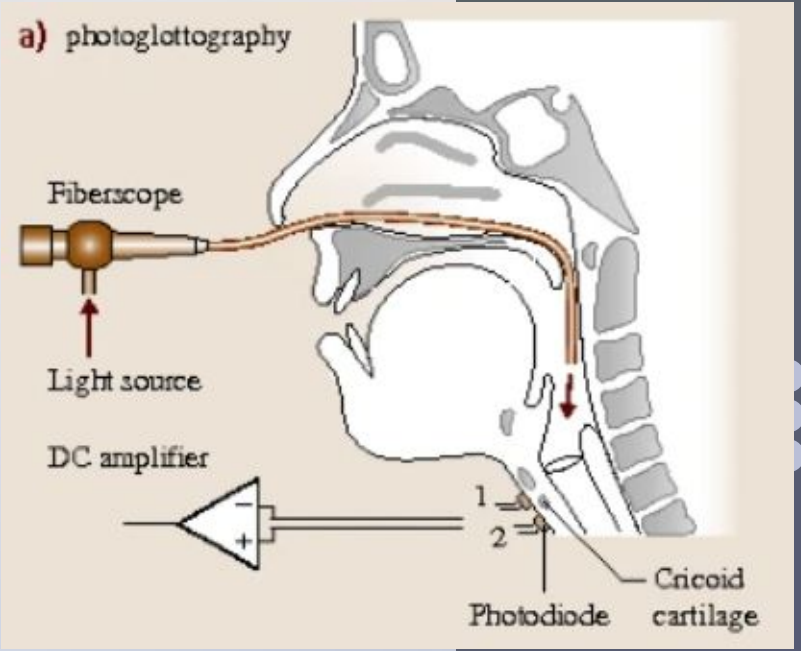


NCI Dictionary of Cancer terms. National Cancer Institute. (n.d.). https://www.cancer.gov/publications/dictionaries/cancer-terms/def/glottis

Photoglottography Methods

- Invasive photoglottography:
  - optical sensor is placed on the neck
  - flexible endoscope is used as a light source
- Problems:
  - operation of fiberscope must be done by a medical specialist
  - some glottis movement can be obstructed
  - method is invasive

- **Goal:** Design a *noninvasive* photoglottography device to measure the aperture of vocal cords



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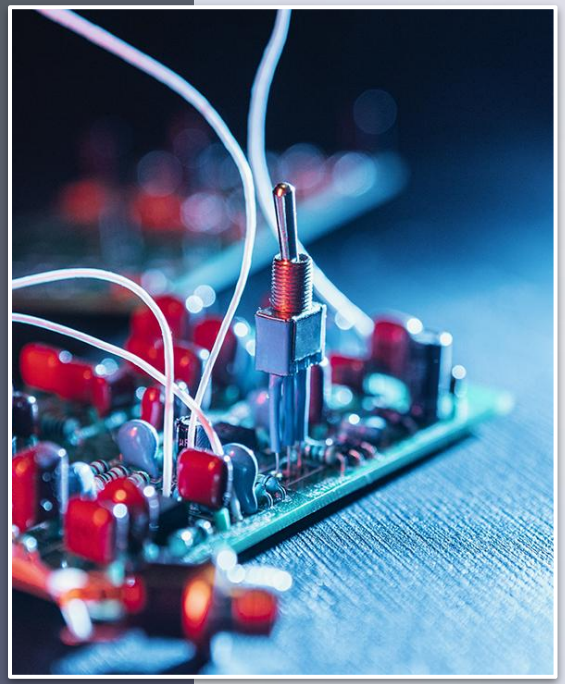

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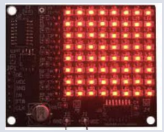
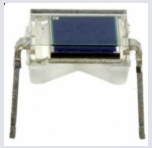
Bioinstrumentation Design

General Device Schematic



IR LED array

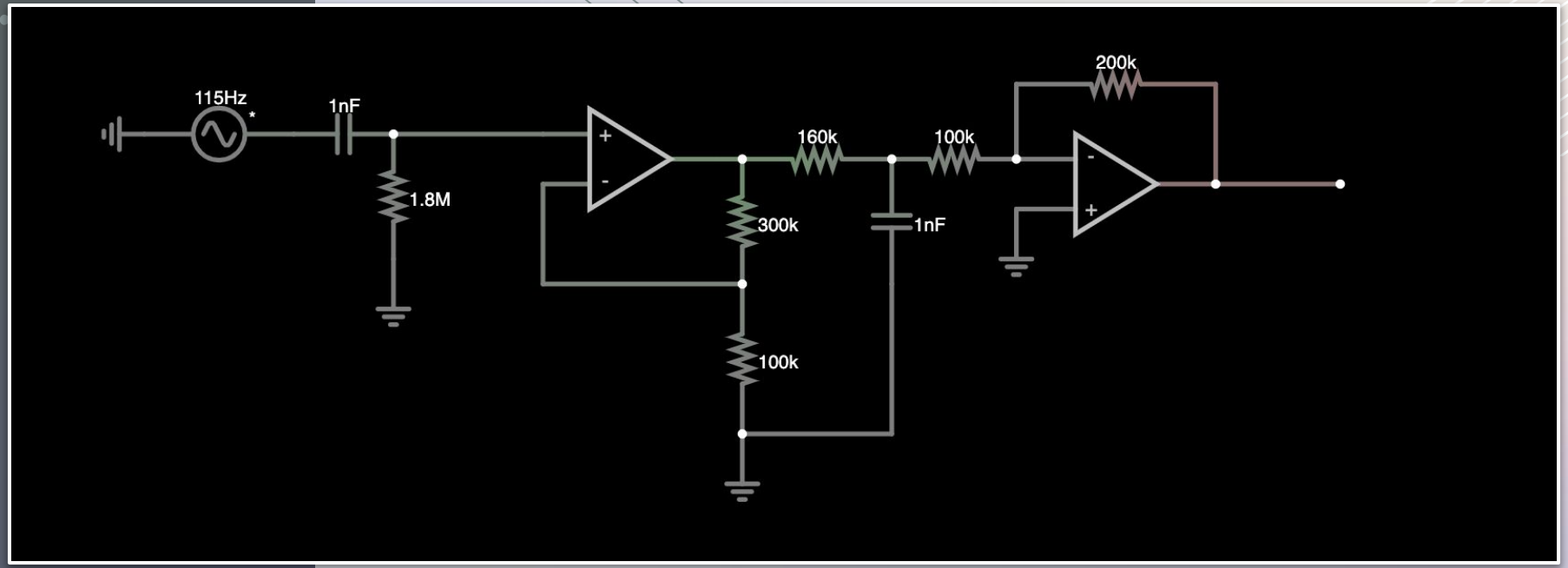
Vocal cords flanked by the IR sensor and IR LED array



IR sensor BPW34

Main circuitry to generate the signal

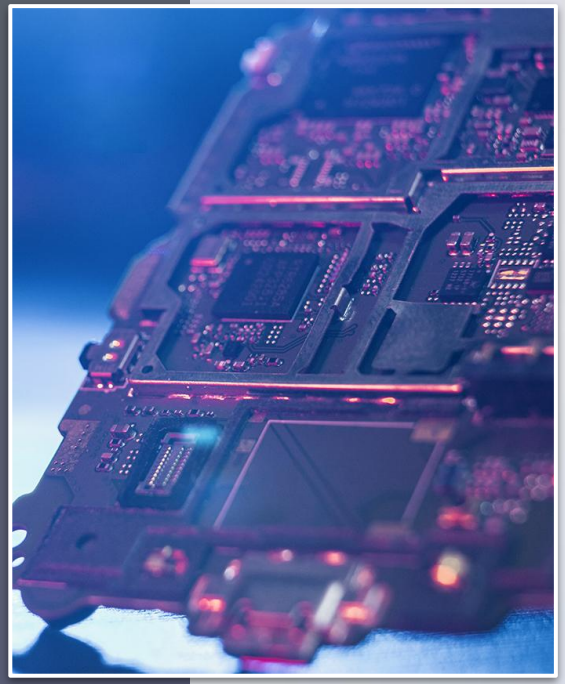
Signal analysis to deduce what is going on



Whole Circuit for a Sensor

Consists of a amplified sensor, a band pass filter and non-inverting amplifier

All op amps have a power supply of +3.3V and -3.3V



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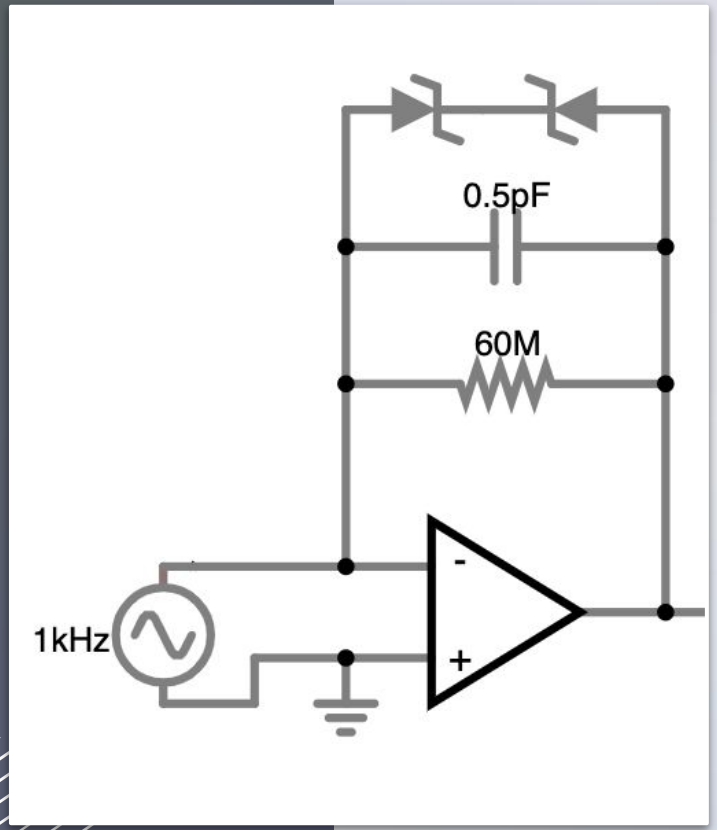
Design Analysis

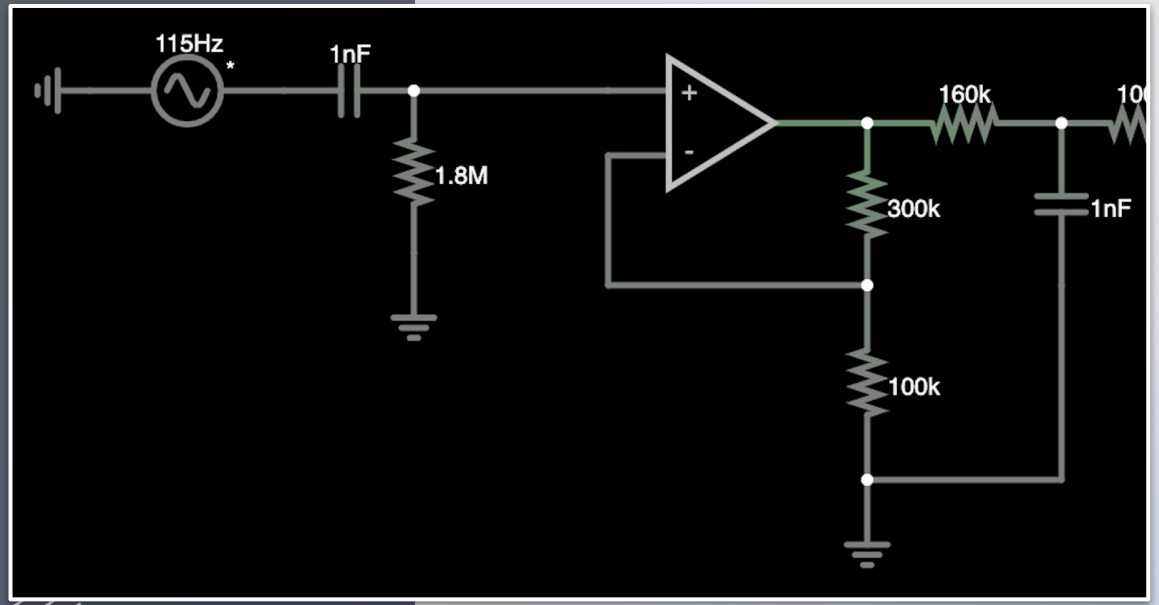
Sensor Amplifier



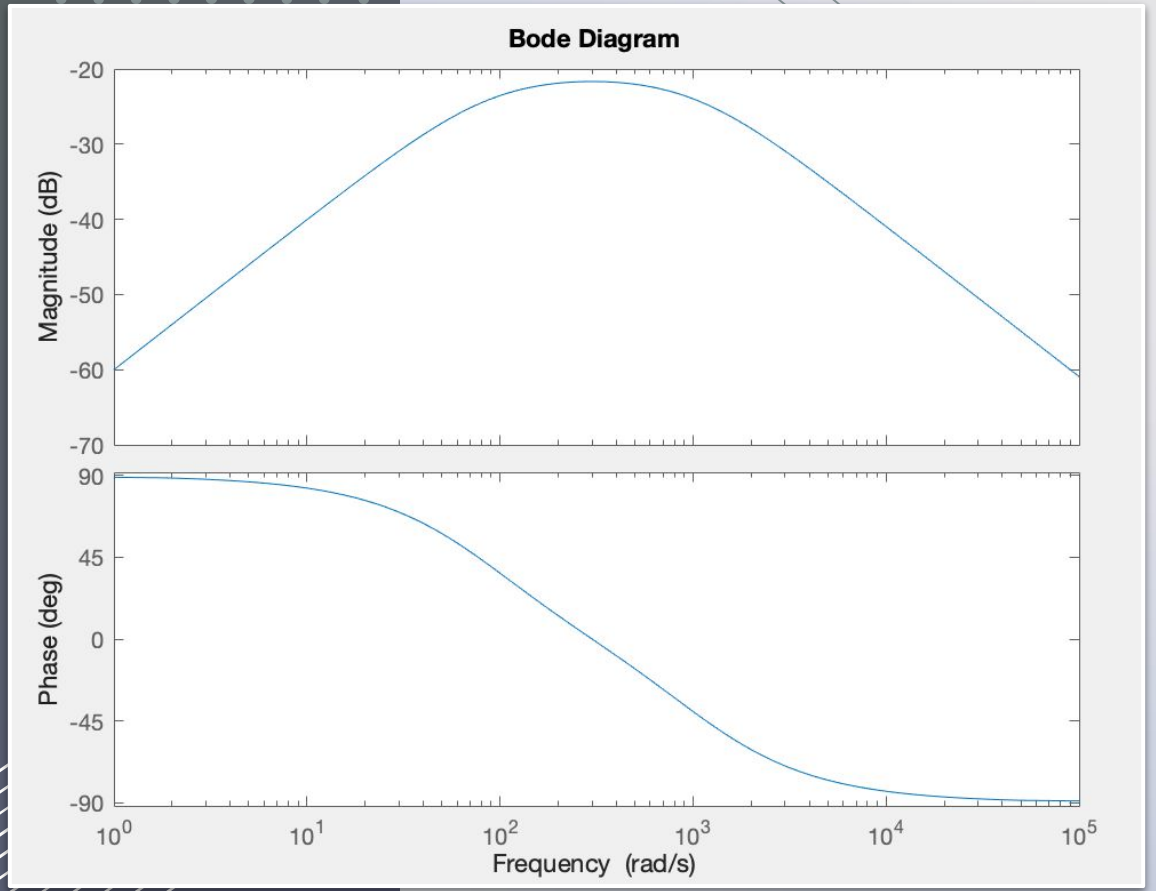
Voltage source represents the optic transducer (BPW 34)

- Op amp and resistor increase output voltage to about 0.42 volts
- Capacitor is in parallel to the resistor to reduce noise
- Zener diodes have a breakdown voltage of 2V, are present to prevent op amp saturation due to artifacts/uneven signals

Band Pass Filter
90 Hz – 1000 Hz



- First op amp circuit: high pass filter
  - Cutoff frequency of 90 Hz
- Second op amp circuit: low pass filter
  - Cut off frequency of 1000 Hz
- 90 Hz is the low end of the male vocal cord frequency range (also removes 60 cycle) and 1000 is the high end of the female vocal cord frequency range

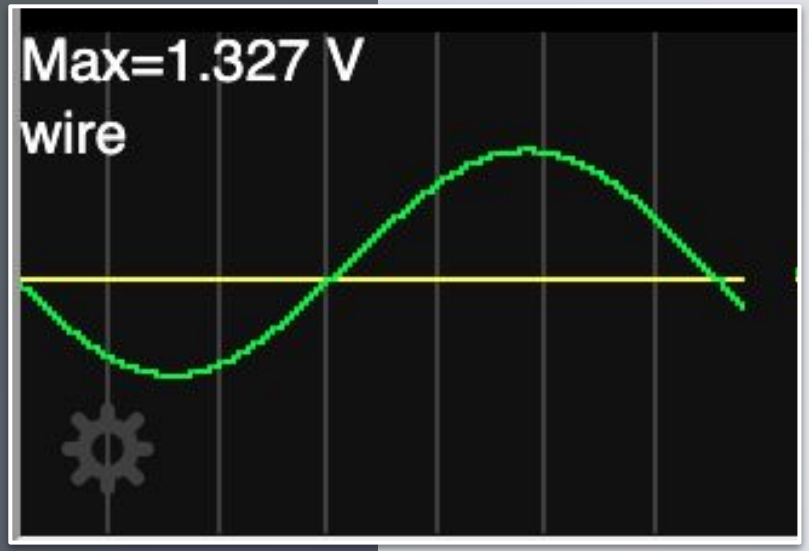


Bandwidth of Circuit

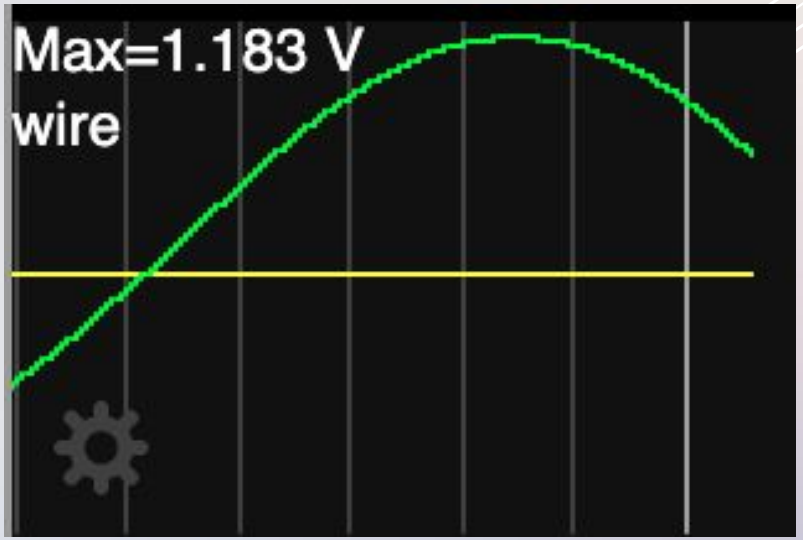
Bandpass filter attenuates incoming frequencies

Bandpass has a lower cutoff frequency of 90Hz and higher cutoff frequency of 1000Hz

Resonant frequency is 300 Hz

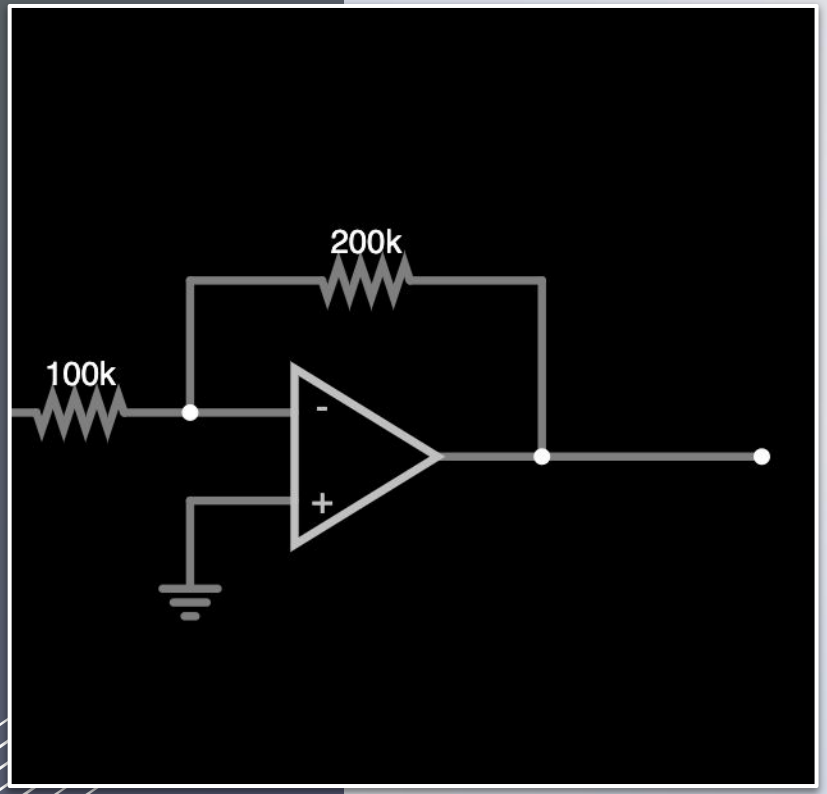


Max Output voltage at resonant frequency 300 Hz



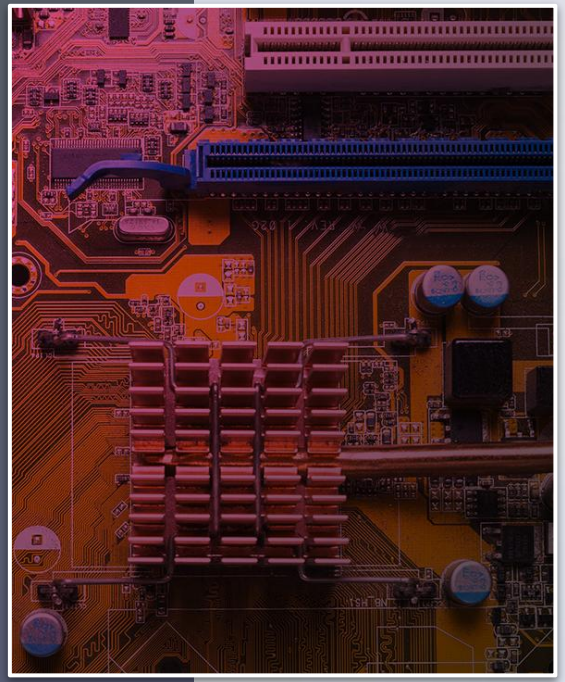
Max Output voltage at average speaking frequency of males and females ~ 160 Hz

Non-Inverting Amplifier



- Amplifies signal by 2 times original voltage, brings the signal range around +1.3V to -1.3V

- Open wire goes to computer/graphing program



04

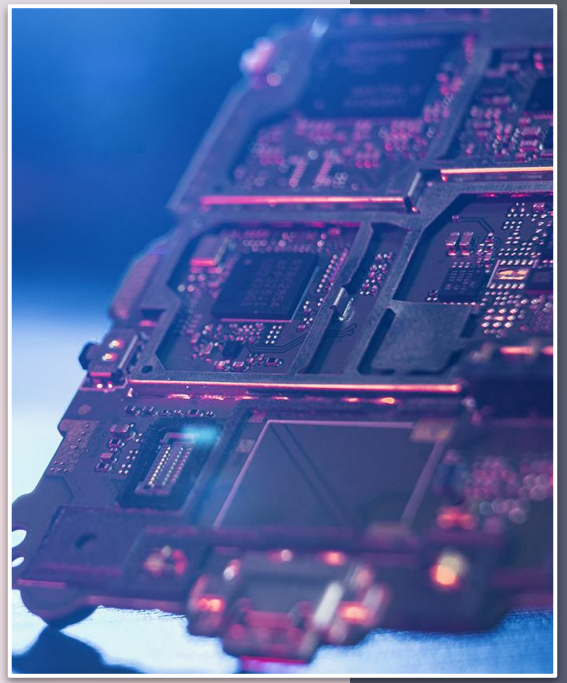
Conclusions

Design Improvements

In practical settings, the light variation is still extremely faint due to tracheal absorption and has trouble with even slight anatomical variations of the glottal position.

An additional light source or more sensitive sensor with a greater gain ratio may improve measurement accuracy.

Pairing the device with a microphone may further improve the pairing of sound to speech.



Design Applications

- Experimental phonetics
- Vocal assessment
- Phonatory effect of diseases
- Disorders of the larynx
- Wearable systems for monitoring speech

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