ELECTRONIC STETHOSCOPE

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PURPOSE AND PROBLEM

- The goal of this project was to create an electronic stethoscope capable of capturing bodily sounds (Heartbeat, abnormalities, etc.) and amplifying the resulting signals at the discretion of the user.
  - Both stereo audio as well as Bluetooth for wired/wireless transmission of signal

BACKGROUND INFORMATION

Stethoscope

An acoustic medical device used for listening to internal sounds of an animal or human. Equipped with a diaphragm(disk) and bell(cup), each side uses the vibration of the body to send acoustic pressure waves to the user. Sometimes criticized for low sound level

Bluetooth

Bluetooth is a standard wire-replacement communications protocol designed for low power consumption, with a short range based on low cost transceiver microchips in each device. Because a radio communications system is used, they do not have to be in a visual line of sight with each other, but a quasi optical wireless path must be viable

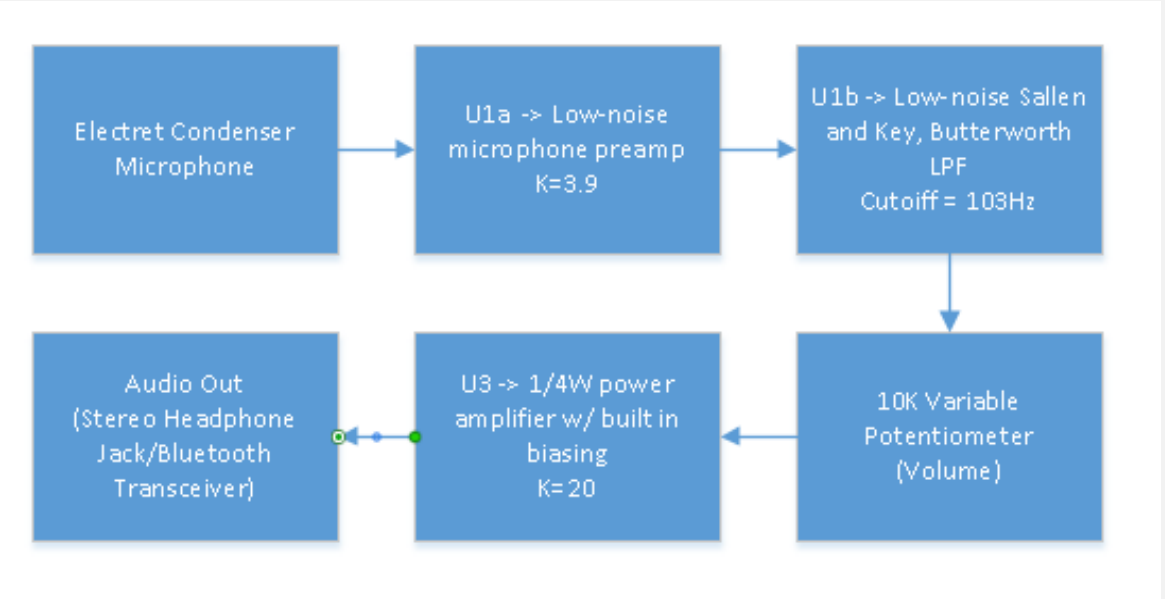
BASIC DESCRIPTION

- Acoustic stethoscope head and tubing
  - Head used to capture body vibrations and create pressure waves, LPF; tubing to shield the microphone wire and provide a seal from head to microphone
- Low-noise microphone preamp
- Low-noise Sallen and Key, Butterworth LPF
- Audio power amplifier
- Stereo audio headphone jack
  - JETech Tx/Rx Bluetooth modules
- Operates on 2 replaceable 9V batteries

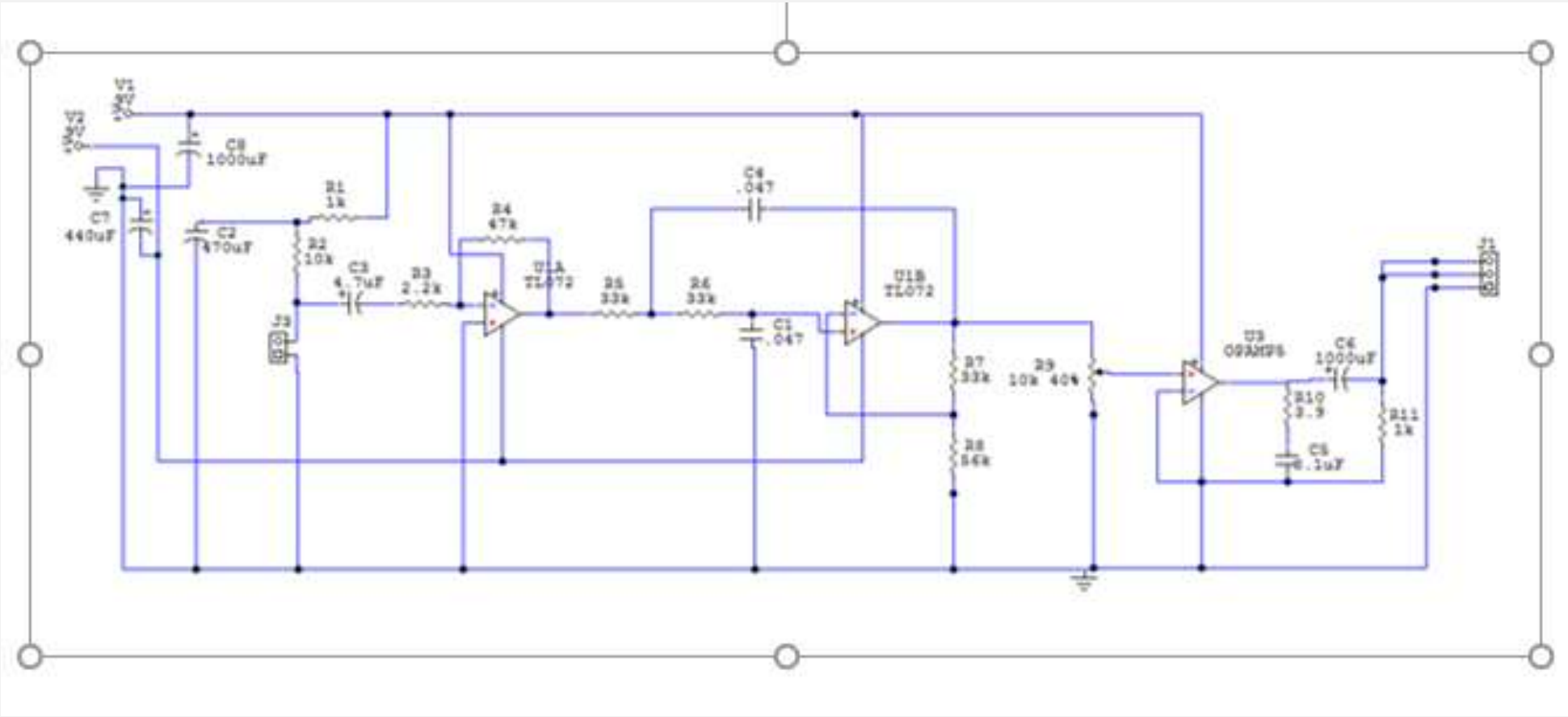
FUNCTIONAL DESCRIPTION

- Technical specifications
  - Electret condenser microphone
  - TL072 Low-noise deal operational amplifier
    - U1 – Low-noise preamplifier – gain = 3.9
    - U2 – Low-noise Butterworth LPF – cutoff = 103Hz
  - 1 to 10K variable resistance potentiometer
    - Used for gain control, volume of signal
  - LM386 Low-noise audio power amp
    - Audio amp w/ built in biasing – gain = 20
  - Stereo headphone jack/BT modules
    - Desired audio output

Functional Block Diagram



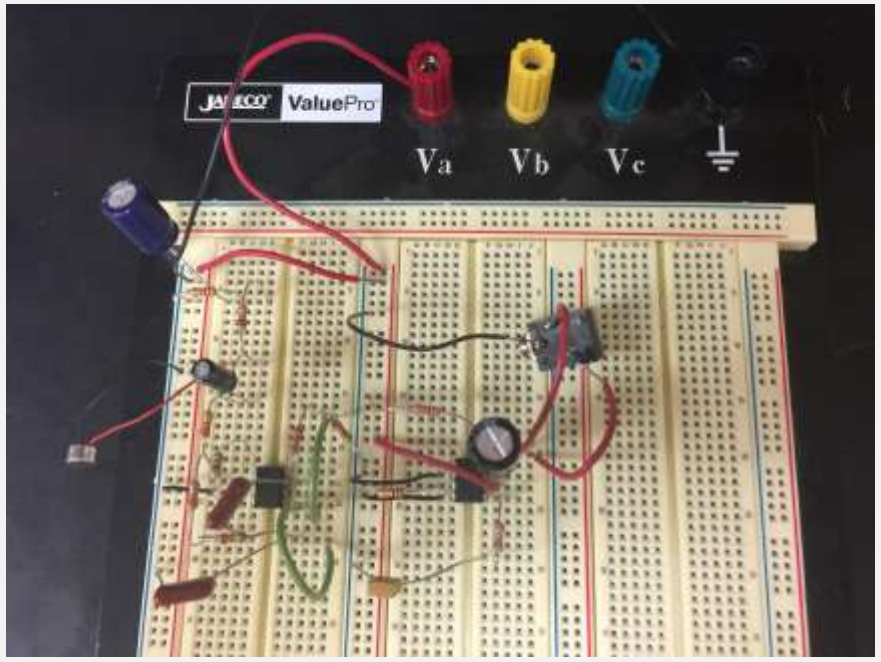
SCHEMATIC


V1
5V
V2
5V
C8
1000uF
C7
440uF
C2
470uF
R1
1k
R2
10k
C3
4.7uF
R3
2.2k
J3
R4
47k
U1A
TL072
R5
33k
R6
33k
C4
.047
C1
.047
U1B
TL072
R7
33k
R8
56k
R9
10k 40%
U3
C6
1000uF
R10
3.9
C5
.1uF
R11
1k
J1

PROTOTYPING AND TESTING

- Breadboarding Process
  - During breadboarding, problems arose in regards to sound quality and abundance of white noise
  - Found that certain connections were bad, which fixed noise but not quality
  - Microphone quality was bettered with addition of capacitor bank at power source
- PCB testing process
  - Initially, two tracks were assigned to wrong I/O on LM386
    - Changed, and circuit worked
  - Far reduced noise in PCB
    - More sporadic and unpredictable
  - Microphone quality & pickup lack luster

Breadboard Prototype



PACKAGING PROTOTYPING

- Packaging the prototype proved to be more difficult than originally expected
  - Looking to create a compact and lightweight solution that had aesthetic qualities
- Prototype "1" (Top)
  - Product of custom 3D box (left of picture) being printed in a dimension too small to mount PCB
  - Wires were crammed in to the box with little to no space
  - No aesthetic qualities
  - Lack of mounts for peripherals
  - Stethoscope head attached to microphone in unsecure fashion
- Final Prototype "2" (Bottom)
  - Second custom 3D box was printed with the correct dimensions, but was printed with a solid inside – no room for stuffing
  - Mounted inside of a 7"x3"x4" tin box
    - Larger than initially anticipated
  - Microphone attached to stethoscope head via tubing
    - Far better sensitivity and quality
  - Wires contained much better
  - Knob for easy access to volume control

RESULTS

- Successes
  - Model is capable of providing amplification of the acoustics of the inner body
  - Volume is tunable to the user's desire to better pick out desired sounds
  - Can reliably detect the heartbeat of patient under heart distress
    - Heavy Palpitations, increased HR from exercise
  - Capable of providing a wired/wireless audio link with flexibility for the user/patient's desires
- Failures
  - Unreliable at detecting resting/calm heartbeats
    - Can, but not always – product of quality of microphone, stethoscope head, and gain of circuit
    - Packaging is larger than what is generally convenient
      - still more convenient to use acoustic stethoscope if not sharing audio playback
    - Audio from Bluetooth devices has a small delay – real time audio signal is more desirable

CONSIDERATIONS

- Cost Analysis
  - 2x 9V Battery Holder: $6.00
  - 4x 9V battery: $6.00
  - Acoustic Stethoscope: $6.00
  - Custom 3D Print Enclosure/Box: $20.50
  - Stereo headphone Jack: $1.25
  - 2x Bluetooth Modules: $33
  - Electret Microphone: $1
  - Audio Potentiometer: $1.29
  - Miscellaneous: $10
  - Total: $84.04 ($77.54 w/o 3D costs)
- Ethical/Political Considerations
  - Bluetooth, in current form, is not secure (HIPAA)
  - On board chip w/ security protocol would meet standards
- Health and Safety
  - Device is usable to all; current levels are below dangerous levels (<100mA), no exposed wires
- Aesthetic
  - Current package is larger, and less appealing, than originally intended to be
- Manufacturability
  - Easy and Cheap to produce; can be resold at high profit margins
- Sustainability
  - Integration of rechargeable battery would reduce waste/cost to user
  - Plastic design initially

CONCLUSION

- Project was not as successful as I would have liked it to be
  - Modifications helped the product in the end, but it is not as reliable as needed for health standards
- Changes to consider in the future
  - Integration of BT Audio/Data chip – Increased security, higher sound quality, allow for integration of PCG data transfer
  - Work to reduce size of product as well as increase aesthetic value
  - Use of higher quality base materials (Microphone, Stethoscope) to increase quality of signal

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