Heart & Breath Sound Amplifier

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Problem Statement

- Increase stethoscope functionality three fold
  - Convert sound waves to filterable, amplifiable signal
  - Increase stethoscope reach so client can adjust medication and monitor heart beat
  - Allow dual listening capabilities: headphones and speaker
    - Used in both surgical and educational settings

Design Constraints

- Use existing stethoscope design but add electronic functionality
- Preserve diagnostic information
- Transportable to multiple operating rooms
- Cannot create electrical interference
- Budget \$100 to \$300

Background: Stethoscope

- Most common basic medical diagnostic tool
- Operates acoustically
  - Heart beat, fluid flow cause diaphragm to vibrate
  - Diaphragm vibrates in bell causing acoustic noise to pass up tubing
  - Tube acts a low pass filter
  - Sound passes through earpieces to listener
- [1]

Figure 1: Stethoscope Head [2]

Background: Competition

MSRP$496.00

- 3M Littman 3200 Electronic Stethoscope
  - *Very* expensive
  - Doesn’t increase stethoscope length
  - Not compatible with other heads (stethoscope, esophageal tube)
  - No external speaker

[3]

Figure 2: Littman Stethoscope [3]

Design Matrix: Microphone Type

Microphone Type				
Factors	**Weight**	**Rating (1-10)**		
		Condenser Mic	**Dynamic Mic**	**Piezo Mic**
Cost	0.10	4	5	2
Sensitivity/Fidelity	0.40	9	4	3
Size	0.25	7	6	4
Simplicity/Circuit Requirements	0.25	4	8	8
TOTAL	1.00	6.75	5.60	4.40

Figure 3: Microphone Matrix

Design Matrix: Power Source

Power Source			
Factors	**Weight**	**Rating (1-10)**	
		Batteries	**External Power**
Life	0.30	2	9
Life-Cycle Cost	0.15	3	4
Portability	0.35	9	2
Client Preference	0.20	7	5
TOTAL	1.00	5.60	5.00

Figure 4: Power Matrix

Design Matrix: Microphone Location

Microphone Location			
Factors	**Weight**	**Rating (1-10)**	
		Inside Tubing	**Inside Diaphragm**
Fidelity	0.35	7	4
Stability/Portability	0.10	4	7
Aesthetics	0.05	5	8
Multifunctionality	0.10	8	2
Safety	0.40	8	2
TOTAL	1.00	7.10	3.50

Figure 5: Location Matrix

Microphone Tube Coupling

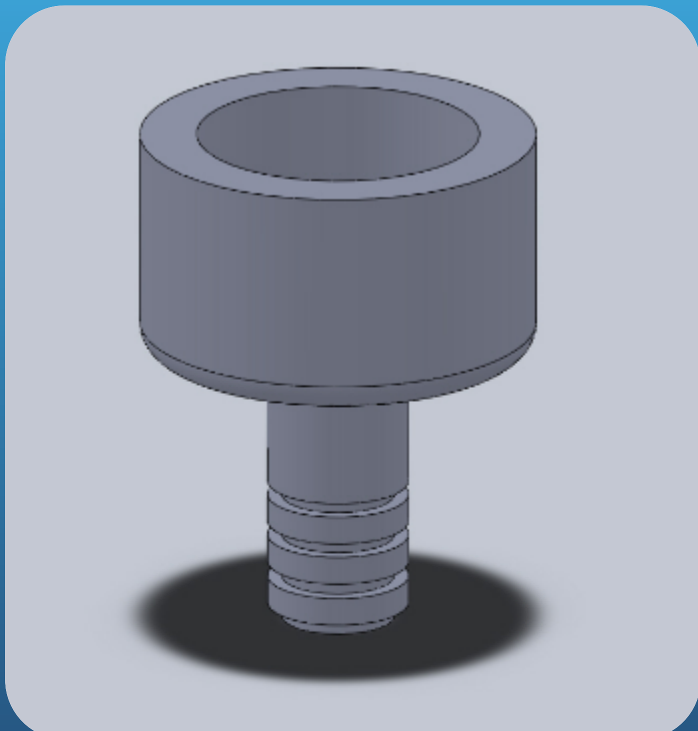


Figure 6: Coupling Model

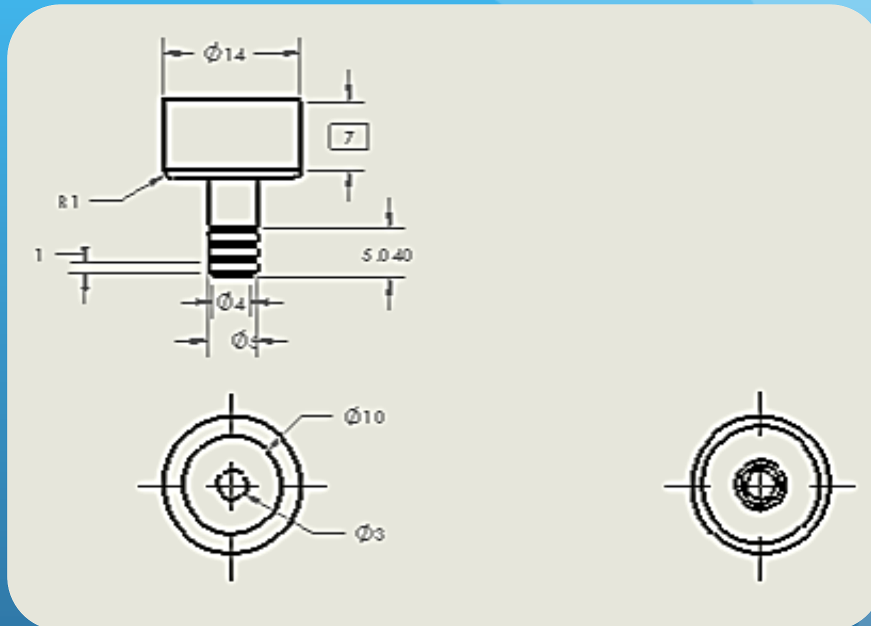


Figure 7: Coupling Schematic

General Setup: Block Diagram

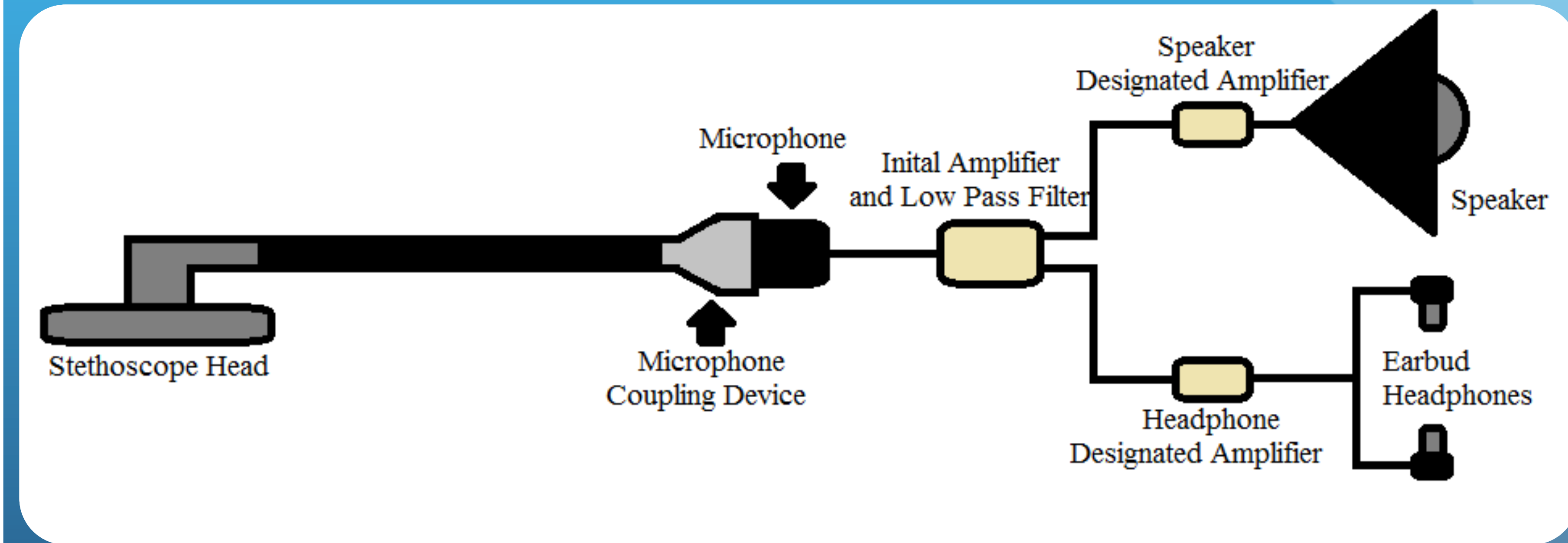


Figure 8: Operational Block Diagram

Sample Recording/Signal Processing

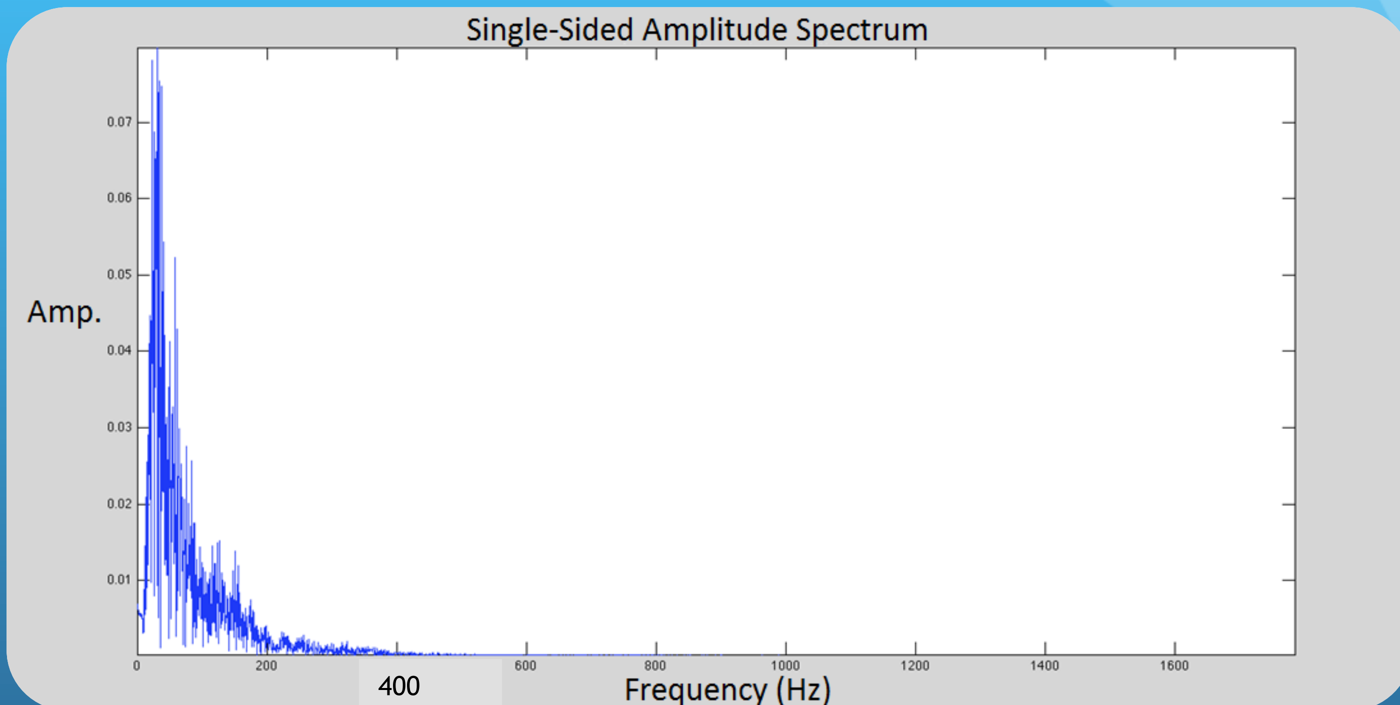
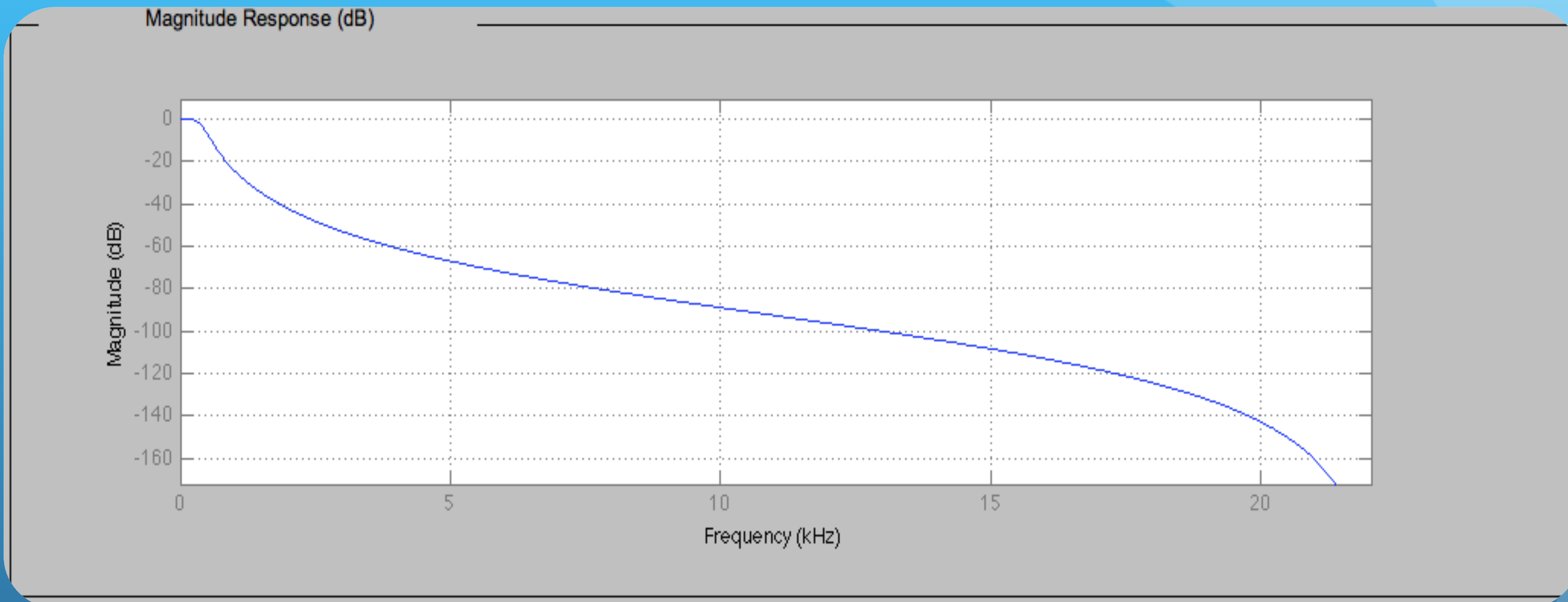


Figure 9: FFT Plot

- FFT Plot
  - Locate and identify frequencies of interest (approximately 0-400 Hz)
  - Heart Sounds: <300Hz [4]

Filtering

Figure 10: Low-pass Filter



- After picked up by microphone, signal passes through active low-pass Butterworth filter
- Third-order filter [5]
  - Better isolation of pass band
  - less excess noise

Heartbeat Recordings

Unfiltered Heartbeat

Filtered Heartbeat

Filter Circuit

$$Av = 1 + \frac{R_2}{R_1}$$

$$f_C = \frac{1}{2\pi\sqrt{R_3 R_4 C_1 C_2}}$$

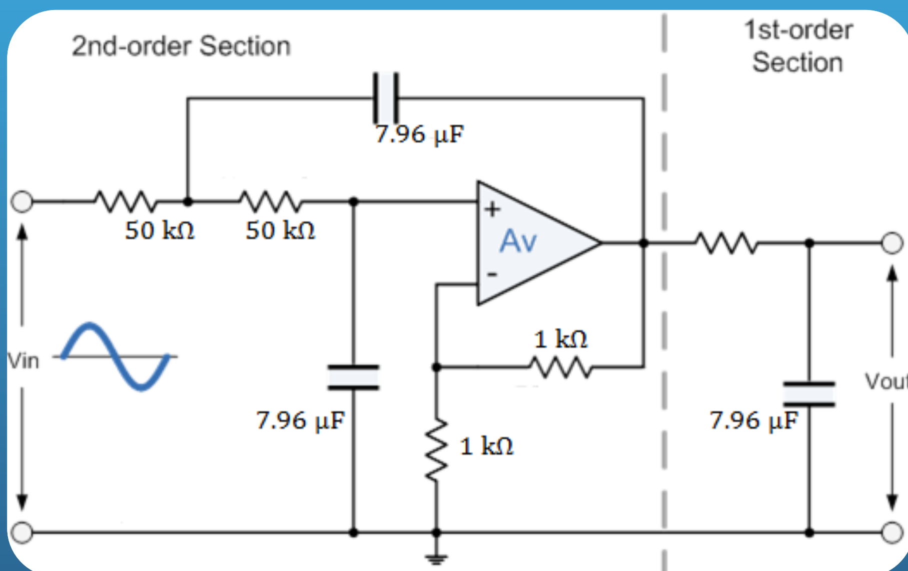


Figure 11: Analog filter circuit [5]

Gain (A): TBD

Corner Frequency: 400Hz

Design Specifications

- Amplify heart to minimum of 60 dB
- Circuitry housing no larger than 15cm x 15cm x 15 cm cube
- Weight under 3kg
- Device reach at least 3 meters
- Maintain Frequencies of 300Hz and lower

Future Work

- Determine desired gain factor for circuit
- Select Op Amp, Resistors, and Capacitors accordingly
- Select low-profile speaker for application
- Test apparatus on patient with irregularity of heart function (i.e. murmur, stuck valve, etc.)
- Determine if apparatus preserves diagnostic information
- Rework filter accordingly

Acknowledgements

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References

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