EE324: Experiment 4

Noise Cancellation in headphones

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1 Introduction

- We had to design and implement an analog circuit for active noise cancellation in headphones.
- Active noise cancellation involves taking the surrounding noise as input via the microphone, and the compensator that we design cancels this noise by producing signals that cancel out the noise.

2 Aim of the experiment

- To achieve an attenuation of 20 dB, when a noise of 100 Hz frequency is applied.
- To design an analog compensator to stabilize the system, i.e. loop shaping of the loop transfer function

3 Experimental Setup

- To begin the experiment, we connected the headphone setup to both the function generator and the DSO (Digital Storage Oscilloscope). We provided a sinusoidal waveform as the input, varying the frequency from 100 Hz to 5000 Hz. Using the obtained data, we plotted the magnitude and phase response.

- Next, our task was to design an amplifier for the system that would ensure a 20 dB attenuation at 100 Hz for the closed-loop system. Additionally, we needed to design a compensator to stabilize the system without compromising the gain at 100 Hz.

- For the compensator design, we utilized Matlab to plot the Bode plot for the transfer function. We superimposed it with the system's original Bode plot to obtain the cascaded Bode plot. To ensure stability, we aimed for the cascaded plot to have a gain margin and phase margin of at least 5 dB and 30 degrees respectively.

- After designing the system and compensator, we closed the loop and introduced noise based on the closed-loop block diagram. We then measured the output-to-noise ratios at 100 Hz, 500 Hz, and 1000 Hz to evaluate the system's performance in dealing with noise.

- Overall, this experimental process involved connecting the equipment, plotting magnitude and phase responses, designing an amplifier and compensator, evaluating the stability of the cascaded system, and finally measuring the output-to-noise ratios at specific frequencies.

4 Design Algorithm

- For the stability of the system , we need positive phase and gain margins. The bode plots were obtained for the cascaded and the original non compensated system by using the inbuilt functions for plotting transfer function in Matlab

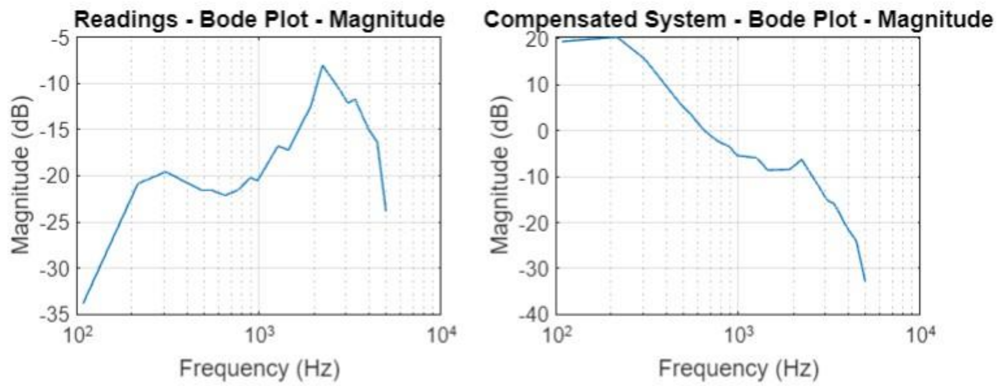

Figure 1: Magnitude Bode plots

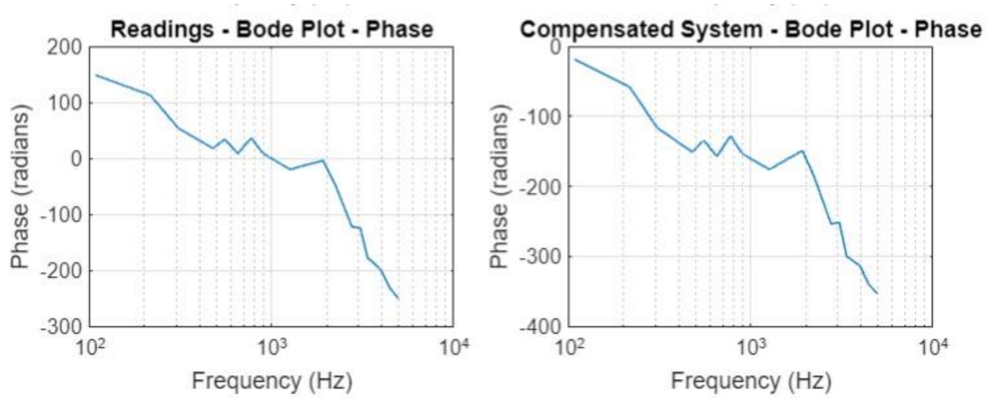

Figure 2: Phase Bode plots

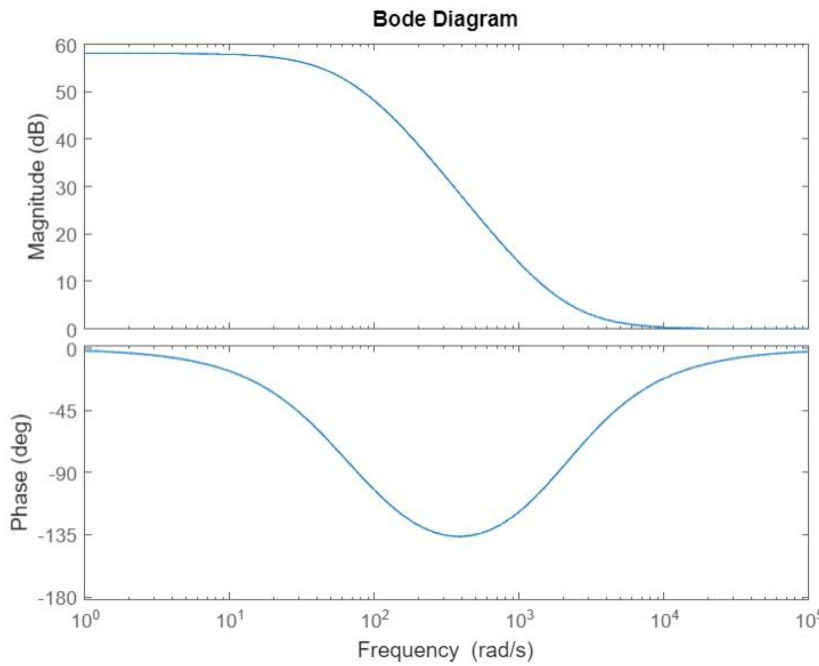

Figure 3: Transfer Function Plot

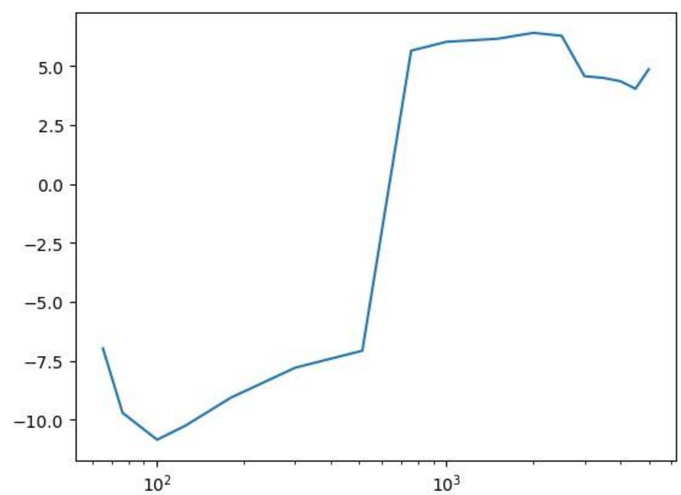

Figure 4: Closed Loop Bode plots

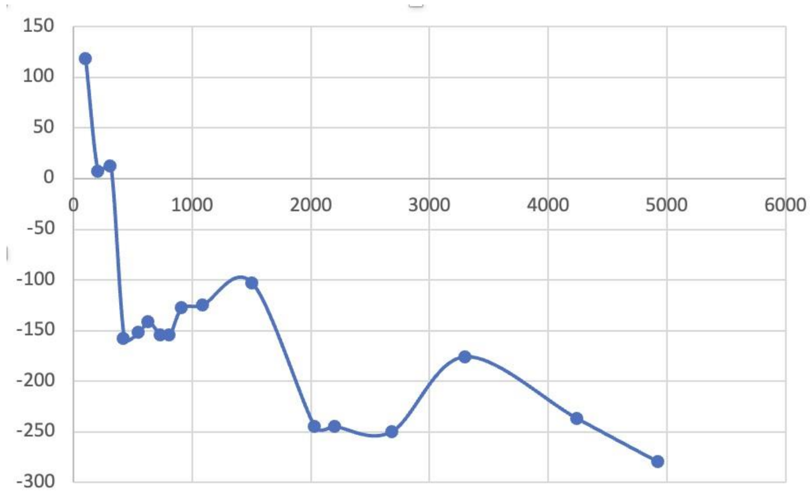

Figure 5: Experimental Phase Plot of the compensated System

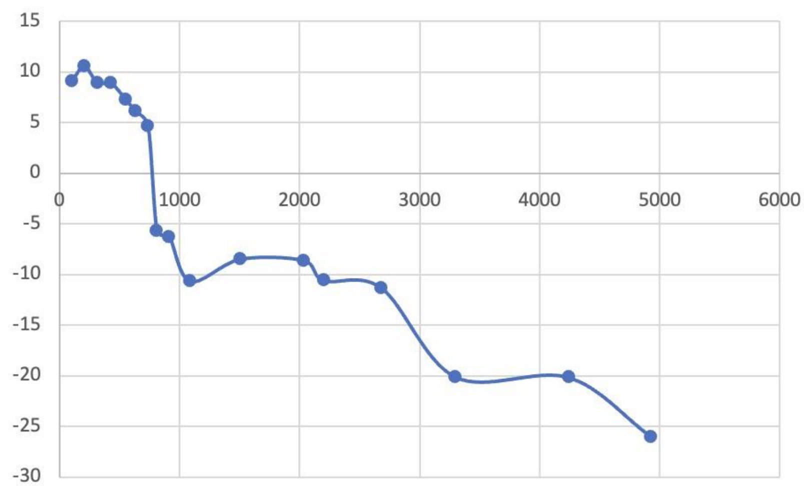

Figure 6: Experimental Gain Plot of the compensated System • For stability, we had to ensure that for the cascaded syatem, when the gain crosses 0dB, phase should be greater than -180 degrees (Phase margin = phase at 0dB - (-180)). When phase crosses -180 degrees, gain should be negative. Gain margin = 0dB - gain at -180 degrees

- We kept tuning the poles and zereos to attain our desired stable system.

5 Problems faced and their solutions

- The system had appropriately attained 20dB as expected, but when the gain margin was checked, it turned out to make the system unstable • We had to recalculate values of the resistors and capacitors of the compensator because the values we wanted weren't available or was too less. We solved it by tuning the poles and zereos and maintaining the positive gain margin.

- Minor circuit issues where the opamp was defective or where there was human error while making it

6 Results

- We got an attenuation of 11dB

- The closed loop came out to be around -10dB

- Transfer Function = $\frac{40(s+2000)(s+2000)}{(s+50)(s+100)}$

- Phase margin = 34 degrees

- Gain margin = 9dB