Prework Questions for KI2

In KI 2, we analyze the audio backend system of a generic smart phone. The system level diagram of the backend system is shown in Fig. 1. The circuit level schematic of the system is shown in Fig. 2. Construct this audio backend system in Cadence. Set the bias voltage to $v_b=0.65$ V. In place of the speaker use a resistive load of $R_L=100$ Ω.
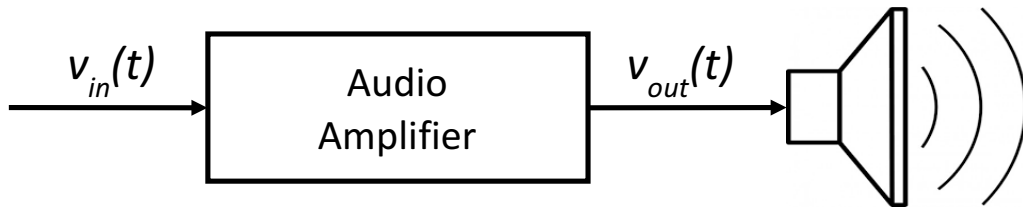

Fig. 1. System level diagram of the audio backend of a generic smart phone
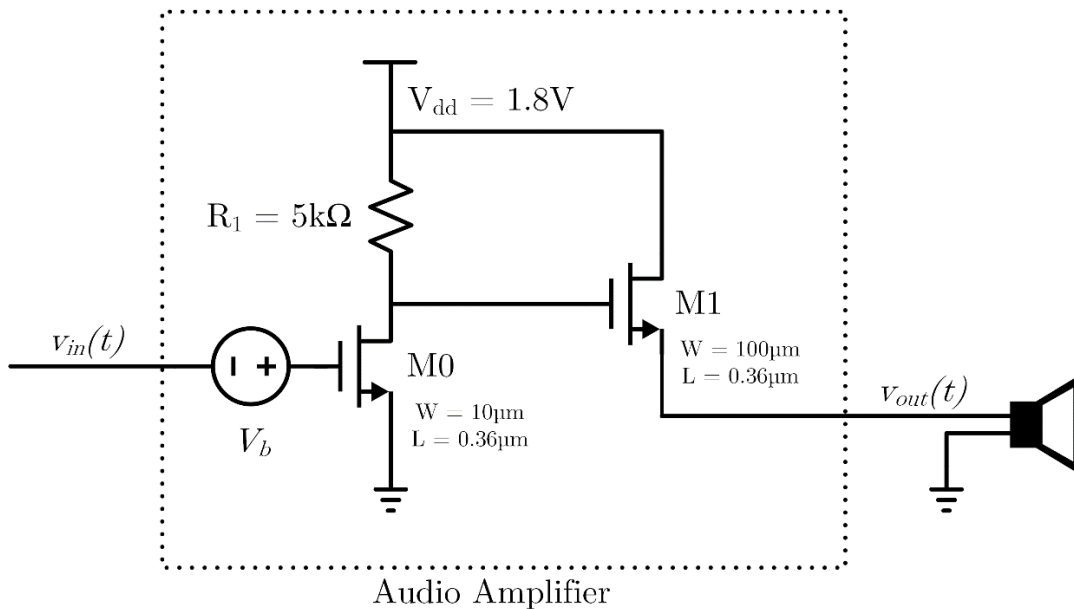

Fig. 2. Circuit level schematic

1. Assume that the audio amplifier is a linear-time invariant system. What is the output $v_{out}(t)$ of the audio amplifier in response to the input signal $v_{in}(t)=Acos(w_0t)$? Write your answer in terms of the magnitude $|H(jw)|$ and the phase $\angle H(jw)$ of the frequency response $H(jw)$ of the audio amplifier.

2. Consider the periodic square wave signal shown in Fig. 3, where $w_0=2\pi f_0$, $f_0=50$ KHz, and $A_1=10$ mV, as the input signal $v_{in}(t)$.
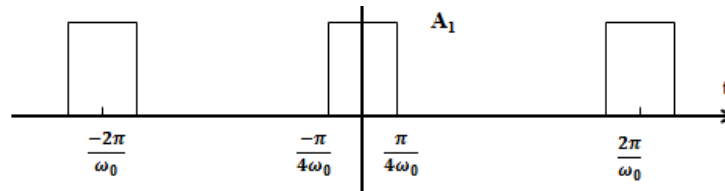

Fig. 3. Periodic square wave

Assume that the audio amplifier system has a frequency response of the form

$$H(jw) = \frac{\alpha}{1 + \beta\, jw}$$

with $\alpha > 0$ and $\beta > 0$

Write an expression for the output signal $v_{out}(t)$ in terms of the Fourier series coefficients a_k of $v_{in}(t)$ (for all k) and the frequency response $H(jw)$.

3. Focus on the speaker in the amplifier-speaker circuit shown in Fig. 1. Explain, in detail, how the speaker works, i.e., how it generates sound from the electric signal it receives. Sketch a figure showing the construction with all the essential parts of a speaker. Identify a magnetic circuit within the speaker and explain the purpose of this circuit. What kind of relationship exists between the sound intensity and different parameters of the magnetic circuit, such as the number of wire turns, the dimensions of the circuit, the type of magnetic material for the core (e.g., a neodymium magnet vs. a ceramic magnet, etc.), the magnetization curve of the core, and so on. Observe the hysteresis loops shown in Figure 5.23 in the Electromagnetics textbook. Which of the two materials should be used for making the coils ("magnetic winding") and the permanent magnet, respectively, in the speaker? Justify your answer. What would happen if we swap the materials?