

EE4445 Quiz 2

March 7, 2008

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Instructions. *Print* your name in the spaces above and at the top of all other pages in your quiz. Draw a box around answers. Express all answers as a decimal number. Draw a horizontal line between problems.

- 1 of 3. (a) What is meant by the proximity effect in microphones? Name one type of microphone which has the proximity effect. Ans: a low-frequency boost that becomes larger as one gets closer to the microphone. Ribbon and cardioid (combination) microphones.
(b) What type of microphone must be designed so that its fundamental resonance frequency is at the upper end of the audio spectrum? Condenser microphone.
(c) What type of transducer does the dynamic microphone have? Moving-coil.

2 of 3. An 8-inch loudspeaker driver is to be designed for use in an infinite baffle. The piston radius is specified to be $a = 8$ cm. The total quality factor is specified to be $Q_{TS} = 1.2$.

- (a) If the mechanical quality factor is estimated to be $Q_{MS} = 4$, what is the required electrical quality factor Q_{ES} ?

$$Q_{ES} = \frac{Q_{MS}Q_{TS}}{Q_{MS} - Q_{TS}} = 1.714$$

- (b) If the lower cutoff frequency is specified to be $f_\ell = 30$ Hz, calculate the required resonance frequency f_S .

$$x = \left[\left(\frac{1}{2Q_{TS}^2} - 1 \right) + \sqrt{\left(\frac{1}{2Q_{TS}^2} - 1 \right)^2 + 1} \right]^{1/2} = 0.736$$

$$f_S = \frac{f_\ell}{x} = 40.8 \text{ Hz}$$

- (c) The mechanical mass of the diaphragm plus air load is specified to be $M_{MS} = 25$ g. Calculate the required mechanical compliance C_{MS} of the suspension.

$$C_{MS} = \frac{1}{M_{MS} (2\pi f_S)^2} = 6.10 \times 10^{-4}$$

- (d) What is the reference efficiency η_0 of the driver?

$$\eta_0 = \frac{4\pi^2 f_S^2 V_{AS}}{c^3 Q_{ES}} = 0.132\%$$

- (e) The voice-coil resistance is specified to be $R_E = 8 \Omega$. Use the values of R_E , Q_{ES} , C_{MS} , and M_{MS} to solve for the required value of the $B\ell$ product.

$$B\ell = \left(\frac{R_E}{Q_{ES}} \sqrt{\frac{M_{MS}}{C_{MS}}} \right)^{1/2} = 5.47$$

- (f) Sketch the straight-line and the smooth curve **low-frequency** Bode magnitude plots for the normalized on-axis pressure response. Label the straight-line slopes in decades per decade and the break frequency in hertz. Clearly show how the normalized response at the resonance frequency is determined. Slope of +2 dec/dec for $f < f_S$ and 0 dec/dec for $f > f_S$. Peaks up to a relative value of 1.2 (1.584 dB) at $f = f_S$.

3 of 3. A closed-box loudspeaker system is to be designed for a B2 alignment with $Q_{TC} = 1/\sqrt{2}$ and an internal volume of $V_{AB} = 1.5 \text{ ft}^3 = 4.25 \times 10^{-2} \text{ m}^3$. It can be assumed that the total acoustic mass of the diaphragm is the same for the driver in an infinite baffle as it is for the driver in the closed box, i.e. $M_{AC} = M_{AS}$.

- (a) The lower -3 dB cutoff frequency is specified to be $f_\ell = 40 \text{ Hz}$. Calculate the required value of the closed-box resonance frequency f_C . For the B2, $f_C = f_\ell = 30 \text{ Hz}$.
- (b) The compliance ratio is specified to be $\alpha = 8$. Use the values of α and f_C to calculate the required value of the driver resonance frequency f_S . Ans:

$$f_S = \frac{f_C}{\sqrt{1 + \alpha}} = 13.33 \text{ Hz}$$

- (c) The box is filled and the closed-box mechanical quality factor is estimated to be $Q_{MC} = 3.5$. Use the values of Q_{TC} and Q_{MC} to calculate the required value of the closed-box electrical quality factor Q_{EC} .

$$Q_{EC} = \frac{Q_{MC}Q_{TC}}{Q_{MC} - Q_{TC}} = 0.886$$

- (d) Use the values of α and Q_{EC} to calculate the driver electrical quality factor Q_{ES} .

$$Q_{ES} = \frac{Q_{EC}}{1 + \alpha} = 0.886$$

- (e) Use the values of α and V_{AB} to calculate the driver volume compliance V_{AS} .

$$V_{AS} = \alpha V_{AB} = 0.34 \text{ m}^3$$

- (f) Use the values of f_S , V_{AS} , and Q_{ES} to calculate the driver reference efficiency η_0 .

$$\eta_0 = \frac{4\pi^2 f_S^2 V_{AS}}{c^3 Q_{ES}} = 0.262\%$$

4 of 4. The figure shows the impedance analogous circuit for a mechanical system. Draw the mobility analogous circuit. Label the circuit, including the velocities u_1 through u_4 .

