

EE4445 Quiz 3
November 23, 2009

Professor Leach

Name _____

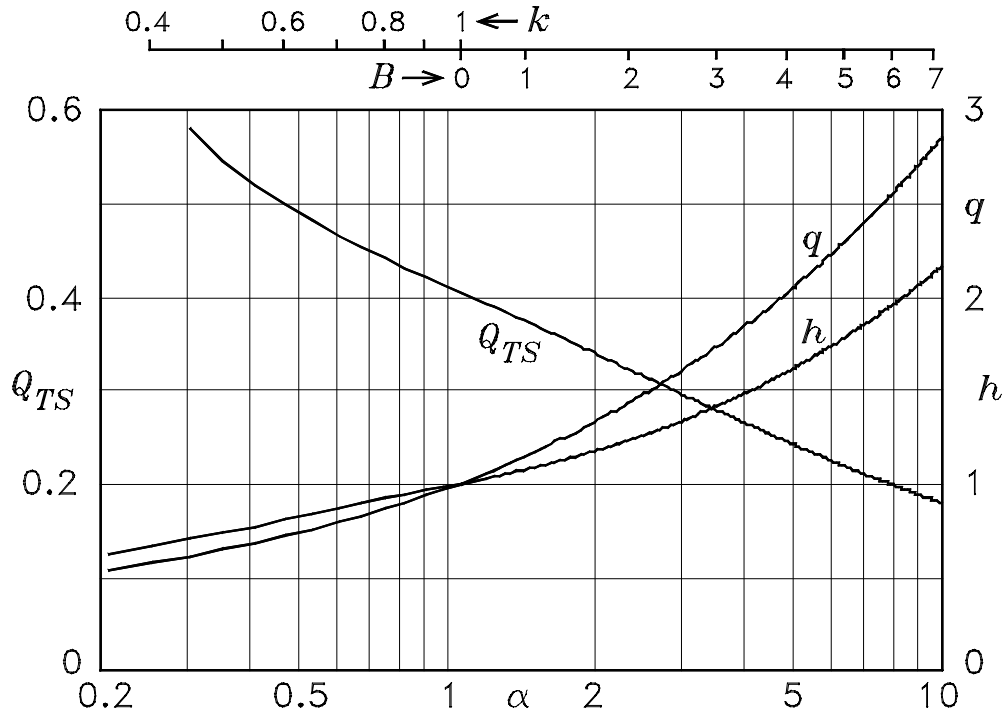
Instructions. Print your name in the space above and at the top of all other pages in your quiz. Express all numerical answers as a decimal number. When appropriate, draw a box around answers. Points may be deducted if your writing is not legible or too small to read. **Honor Code:** *I have neither given nor received help on this quiz.* Initials _____

1. A loudspeaker driver is to be designed to be used in a vented-box enclosure having an internal volume $V_{AB} = 1 \text{ ft}^3$ (28.3 liters) and a lower -3 dB cutoff frequency $f_\ell = 38 \text{ Hz}$. The particular suspension chosen for the driver has a spring constant that results in a volume compliance $V_{AS} = 4 \text{ ft}^3$ (113 liters). The resistance of the voice coil is $R_E = 6.5 \Omega$. (See the design chart below. Draw any vertical and/or horizontal lines on the chart and circle the pertinent points to show how you obtained your answers.)

$$\alpha = \frac{V_{AS}}{V_{AB}} = 3.99 \quad \text{From the chart: } Q_{TS} = 0.264 \quad h = 1.48 \quad q = 1.84$$

- (a) What is the driver resonance frequency f_S ? - $f_S = f_\ell/q = 20.7 \text{ Hz}$
 (b) What is the system Helmholtz frequency f_B ? - $f_B = hf_S = 30.6 \text{ Hz}$
 (c) What is the driver total quality factor Q_{TS} ? - $Q_{TS} = 0.264$
 (d) If the driver mechanical quality factor is estimated to be $Q_{MS} = 4$, what is the efficiency of the system?

$$Q_{ES} = \frac{Q_{MS}Q_{TS}}{Q_{MS} - Q_{TS}} = 0.283 \quad \eta_0 = \frac{4\pi^2 f_S^3 V_{AS}(\text{m}^3)}{c^3 Q_{ES}} \times 100\% = 0.339\%$$



2. A midrange in a closed-box baffle has the a voice-coil resistance $R_E = 7.5 \Omega$. It can be assumed that the crossover frequency is *equal to or greater than* the midrange resonance frequency f_C .
- (a) A second-order high-pass filter crossover network having a quality factor $Q_m = 0.5$ is to be designed for the midrange. The crossover frequency is to be 400 Hz. Draw the circuit diagram for the midrange network and calculate the element values.

$$C_{m1} = \frac{Q_m}{2\pi f_{co} R_E} = 26.5 \mu\text{F} \quad L_{m1} = \frac{R_E}{2\pi f_{co} Q_m} = 5.97 \text{ mH}$$

- (b) Draw the phasor diagram representing the midrange pressure output at the crossover frequency. Indicate the range of angles that the midrange phasor can lie in. The phasor for the midrange pressure is in the angular range:

$$90^\circ < \theta_m < 180^\circ$$

- (c) Consider the cases where the woofer crossover is a first-order network, a second-order network, and a third-order network. For proper phase addition, should the drivers be connected *in phase*, *out of phase*, or *either* to the crossover networks? You must draw a phasor diagram for each containing both the woofer and the midrange phasors. – Let θ_w be the angle of the woofer pressure phasor.

$$\text{First order:} \quad \theta_w = -45^\circ \quad \text{Reverse midrange phase.}$$

$$\text{Second order:} \quad \theta_w = -90^\circ \quad \text{Reverse midrange phase.}$$

$$\text{Third order :} \quad \theta_w = -135^\circ \quad \text{Reverse if} \quad 90^\circ < \theta_m < 135^\circ$$

$$\text{Third order :} \quad \theta_w = -135^\circ \quad \text{Do not reverse if} \quad 135^\circ < \theta_m < 180^\circ$$

3. (a) An audio amplifier has an output voltage $v_o = 20 \text{ V rms}$ with no load connected to the output. When a load $R_L = 8 \Omega$ is connected to the output, the voltage drops to $v_o = 19.4 \text{ V rms}$. What is the damping factor?

$$\text{Voltage Division } \frac{8}{R_{out} + 8} \times 20 = 19.4 \implies R_{out} = 0.247 \Omega$$

$$DF = \frac{8}{0.247} = 32.3$$

- (b) An amplifier is to be designed for an average output power of 200 W per channel into 8Ω with a sine wave signal. If the positive and negative power supply voltages must be larger than the peak output voltage at the clipping level, what is the minimum value of the power supply voltages?

$$P_{ave} = \frac{V_p^2}{2R_L} \implies V_p = \pm \sqrt{2R_L P_{ave}} = \pm 56.6 \text{ V}$$

- (c) An amplifier has a gain without feedback $A = 150$. Feedback is to be added to reduce the gain to 10. What is the required value of the feedback factor b ?

$$\frac{A}{1 + bA} = 10 \implies b = \frac{1}{10} - \frac{1}{A} = 0.093$$

(d) Draw the block diagram of an amplifier that has a gain without feedback A , a feedback ratio b , and an output resistance without feedback R_o . Use the diagram to solve for the output resistance R_{out} with feedback. – See text for diagram.

$$R_{out} = \frac{V_{o(oc)}}{I_{o(sc)}} = \frac{\frac{AV_i}{1+bA}}{\frac{AV_i}{R_o}} = \frac{R_o}{1+bA}$$