EE4445 Quiz 3

November 24, 2008

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Instructions: Place a box around numerical answers. Express numerical answers as a decimal number, i.e. do not give an answer that involves fractions, square roots, or symbols such as π. **Honor Code Statement:** *I have neither given nor received help on this quiz.* Initials __________

1. *For credit on this problem, you must draw the phasor diagrams and clearly label each phasor.* A 3rd-order high-pass filter crossover network is used on a midrange in a 3-way loudspeaker system. The crossover frequency between the woofer and the midrange is to be at the frequency for which the phase lead of the midrange transfer function is $45\,^\circ$ and the phase of the woofer transfer function is $0\,^\circ$. Determine the lowest order low-pass filter crossover network for the woofer that will prevent phase cancellation between the midrange and the woofer at the crossover frequency. Specify the electrical phase of the midrange connection to the crossover network.

2. *For full credit on this problem, draw the pertinent horizontal and/or vertical lines on the design chart and circle the pertinent points.* A driver with an advertised diameter of 12 in ($a = 12\,\text{cm}$) is to be designed for the fundamental resonance frequency $f_S = 25\,\text{Hz}$. It is to be used in a vented-box enclosure with a lower $-3\,\text{dB}$ cutoff frequency $f_\ell = 40\,\text{Hz}$. The $Q_L = 7$ design chart is to be used for the system design.

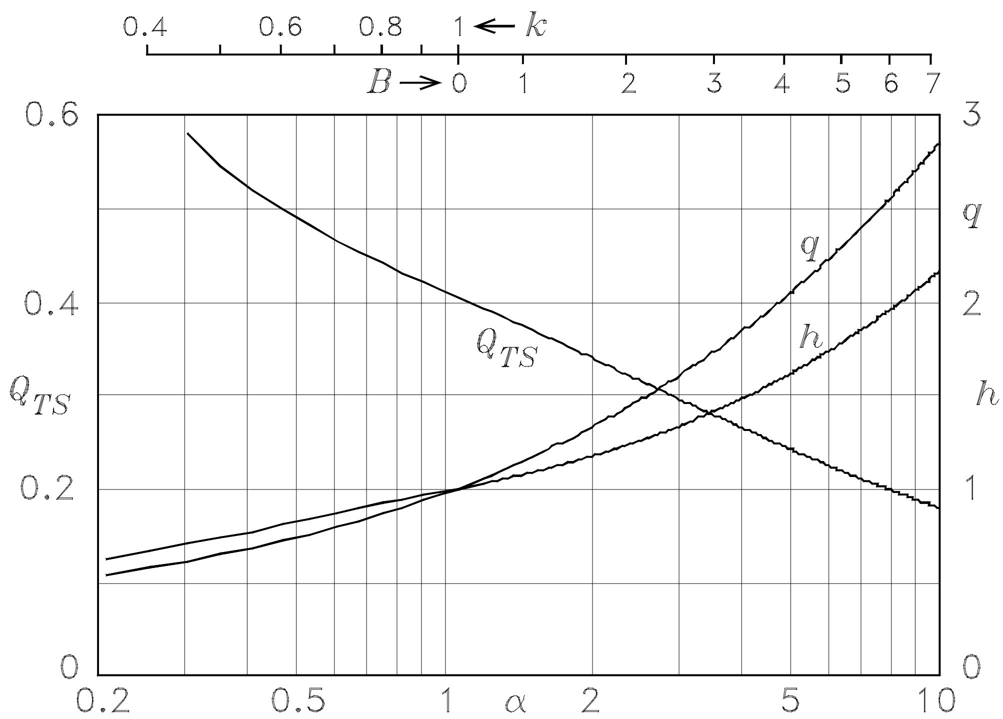
   (a) If the internal volume of the enclosure is to be $V_{AB} = 2.2\,\text{ft}^3 = 0.0623\,\text{m}^3$, what is the required volume compliance V_{AS} of the driver?

   (b) What is the required Helmholtz resonance frequency f_B of the system?

   (c) What is the vented-box "alignment" of the system?

   (d) If the mechanical quality factor is estimated to be $Q_{MS} = 3.5$, what is the required electrical quality factor Q_{ES}?

   (e) If the driver is to have a voice-coil resistance $R_E = 7\,\Omega$, what must be the $B\ell$ product of the driver?



$Q_L = 7$ design chart.

3. An audio power amplifier is rated at 150 W average power with an 8 Ω load. Before feedback, the amplifier has an open-loop gain of 4000, a first pole in its open-loop transfer function at 10 kHz, and an open-loop output resistance of 5 Ω. Feedback is to be added to reduce the gain of the amplifier to 15 (23.5 dB).

   (a) What is the damping factor before and after feedback is added?

   (b) If the amplifier has a second pole in its open-loop transfer function, what is its lowest frequency if the phase margin is to be 45° or greater?

   (c) If two of the amplifiers are connected in a strapped or bridged configuration. What would be the maximum output power into an 8 Ω load?

4. An audio power amplifier has an open-loop gain of 2500 and a full-power distortion of 3%. Feedback is added to reduce the gain to 20.

   (a) If the amplifier is rated at 80 W average power into 8 Ω, what rms input voltage is required for full output power before and after the feedback is added?

   (b) What is the amount of feedback in dB?

   (c) What is the closed-loop percent distortion at full power?

Problem 1

First order out of phase, second order in or out of phase.

Problem 2

$a := 0.12$ $f_S := 25$ $f_L := 40$ $q := \frac{f_L}{f_S}$ $q = 1.6$ $V_{ABft} := 2.2$ $V_{ABm} := 0.0623$

From the chart $h := 1.3$ $\alpha := 3$ $B := 2.6$ $Q_{TS} := 0.31$

$V_{ASft} := \alpha \cdot V_{ABft}$ $V_{ASft} = 6.6$ $V_{ASm} := \alpha \cdot V_{ABm}$ $V_{ASm} = 0.187$

QB3

$Q_{MS} := 3.5$ $Q_{ES} := \frac{Q_{MS} \cdot Q_{ES}}{Q_{MS} - Q_{ES}}$ $Q_{ES} = 0.875$

$S_D := \pi \cdot a^2$ $S_D = 0.045$ $C_{AS} := \frac{V_{ASm}}{\rho_0 \cdot c^2}$ $C_{AS} = 1.331 \cdot 10^{-6}$

$C_{MS} := \frac{C_{AS}}{S_D{}^2}$ $C_{MS} = 6.502 \cdot 10^{-4}$ $M_{MS} := \frac{1}{(2 \cdot \pi \cdot f_S)^2 \cdot C_{MS}}$ $M_{MS} = 0.062$

$BL := \sqrt{\frac{R_E}{Q_{ES}} \cdot \sqrt{\frac{M_{MS}}{C_{MS}}}}$ $BL = 6.691$

Problem 3

$P_{ave} := 150$ $R_L := 8$ $A := 4000$ $f_1 := 10000$ $R_o := 5$ $A_v := 15$

$AmtFB := \frac{A}{A_v}$ $AmtFB = 266.667$ $R_{out} := \frac{5}{AmtFB}$ $R_{out} = 0.019$

$DF_{before} := \frac{R_L}{R_o}$ $DF_{before} = 1.6$ $DF_{after} := \frac{R_L}{R_{out}}$ $DF_{after} = 426.667$

$bA := AmtFB - 1$ $bA = 265.667$ $f_2 := bA \cdot f_1$ $f_2 = 2.657 \cdot 10^6$

$P_{aveStrapped} := 4 \cdot P_{ave}$ $P_{aveStrapped} = 600$

Problem 4

$A := 2500$ $Dist := 0.03$ $A_v := 20$ $AmtFB := \frac{2500}{20}$ $AmtFB = 125$ $R_L := 8$

$P_{ave} := 80$ $V_{orms} := \sqrt{P_{ave} \cdot R_L}$ $V_{orms} = 25.298$ $V_{iBeforeFB} := \frac{V_{orms}}{2500}$

$V_{iBeforeFB} = 0.01$ $V_{iAfterFB} := \frac{V_{orms}}{A_v}$ $V_{iAfterFB} = 1.265$

$20 \cdot \log(AmtFB) = 41.938$ $Dist_{withFB} := \frac{Dist}{AmtFB}$ $Dist_{withFB} \cdot 100 = 0.024$ percent