

Homework Assignment #5

Reading Assignment:

Read the following sections in Electric Circuits, 8th Edition by Nilsson:
 Chapter 14, Chapter 15 (Sect. 1-2), Appendix D (The Decibel), and Appendix E (Bode Diagrams)
 Section 14.9 in Linear Signals & Systems, 2nd Ed. by Lathi

Problem Assignment:

- 1) Work the following Ch. 14 problems: 3, 4(a-b only), 5, 10(a-b only), 19, 21, 23
 Work the following Ch. 15 problems: 2, 3, 20, 22
- 2) Plot the Bode LM plots for the transfer functions below with to the following specifications:
 - use 4 cycle semi-log graph paper (available from instructor's web page)
 - label all levels in dB and all slopes in dB/decade

$$G_1(s) = \frac{500(s + 200)}{(s + 4,000)}$$

$$G_2(s) = \frac{500,000}{(s + 200)(s + 1000)}$$

$$G_3(s) = \frac{50(s + 2,000)(s + 5,000)}{(s + 10,000)(s + 80,000)}$$

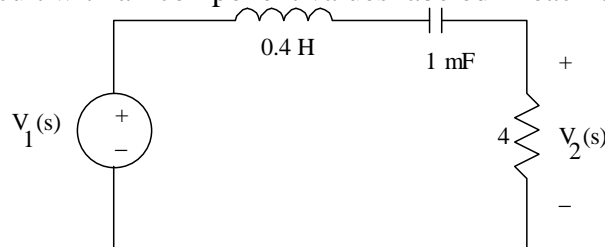
$$G_4(s) = \frac{5,000(s)(s + 800)}{(s + 200)(s + 4,000)}$$

$$G_5(s) = \frac{0.5(s + 20)^2(s + 500)}{s(s + 100)}$$

- 3) Plot the Bode phase plot for $G_1(s)$ and $G_2(s)$ above with the following specifications:
 - use 4 cycle semi-log graph paper
 - label all levels in degrees and all slopes in degrees/decade
- 4) Plot the **exact** LM and phase plots for $G_1(s)$ and $G_2(s)$ using MathCad, Excel, or some other graphing software. Include a printout of both the graph and the spreadsheet, equations, etc., used to produce the graph. Compare the graphs to the Bode plots generated for $G_1(s)$ and $G_2(s)$ in problems 3 and 4.
- 5) For the circuit shown below, $H(s) = V_2(s)/V_1(s)$ is the transfer function of a bandpass filter with a center frequency of $\omega_0 = 50$ rad/s. Use impedance and frequency scaling on the circuit such that $\omega_0 = 20,000$ rad/s if

a) $C = 1\mu\text{F}$ b) $L = 1$ mH c) $R = 1$ k Ω

Draw the scaled circuit with all component values labeled in each case.



Selected Answers:

14.3) a) $H(s) = \frac{\frac{R}{L}}{s + \frac{R + R_1}{L}}$ b) $|H(j\omega)|_{\max}$ occurs when $\omega = 0$

c) $|H(j\omega)|_{\max} = \frac{R}{R + R_1}$ d) $\omega_c = \frac{R + R_1}{L}$

e) $\omega_c = 6300 \text{ rad/s}$
 $H(j0) = 0.9524 / 0^\circ$
 $H(j\omega_c) = H(j6300) = 0.6734 / -45^\circ$
 $H(j0.3\omega_c) = H(j1890) = 0.9122 / -16.70^\circ$
 $H(j3\omega_c) = H(j18,900) = 0.3012 / -71.57^\circ$

14.4) a) $f_c = 1989.44 \text{ Hz}$

b) $H(j\omega) = \frac{12,500}{12,500 + j\omega}$

$H(j\omega_c) = H(j12,500) = 0.7071 / 45^\circ$
 $H(j0.2\omega_c) = H(j2500) = 0.9806 / -11.31^\circ$
 $H(j8\omega_c) = H(j100,000) = 0.1240 / -82.87^\circ$

14.5) a) $H(s) = \frac{\frac{1}{RC}}{s + \frac{R + R_L}{RR_L C}}$ b) $|H(j\omega)|_{\max}$ occurs when $\omega = 0$

c) $|H(j\omega)|_{\max} = \frac{R}{R + R_L}$ d) $\omega_c = \frac{1}{RC} \left(1 + \frac{R}{R_L} \right)$

e) $\omega_c = 13,333 \text{ rad/s}$
 $H(j0) = 0.9375 / 0^\circ$
 $H(j\omega_c) = H(j13,333) = 0.6629 / -45^\circ$
 $H(j0.2\omega_c) = H(j26667) = 0.9193 / -11.31^\circ$
 $H(j8\omega_c) = H(j106,667) = 0.1163 / -82.87^\circ$

14.10) a) $f_c = 1591.55 \text{ Hz}$

b) $H(j\omega) = \frac{j\omega}{10,000 + j\omega}$

$H(j\omega_c) = H(j10,000) = 0.7071 / 45^\circ$
 $H(j0.1\omega_c) = H(j1000) = 0.0995 / 84.29^\circ$
 $H(j10\omega_c) = H(j100,000) = 0.9950 / 5.71^\circ$

14.19) $B = 1.59 \text{ kHz}$, $f_{c1} = 11.96 \text{ kHz}$, $f_{c2} = 13.55 \text{ kHz}$

14.23) a) $f_o = 254.65 \text{ kHz}$

b) $Q = 8$

c) $f_{c1} = 239.23 \text{ kHz}$

d) $f_{c2} = 271.06 \text{ kHz}$

e) $B = 200 \text{ krad/s} = 31.83 \text{ kHz}$

15.2) a) $H(s) = \frac{-\left(\frac{C_1}{C_2}\right)\left(s + \frac{1}{R_1 C_1}\right)}{s + \frac{1}{R_2 C_2}}$ b) $H(j0) = \frac{-R_2}{R_1}$ c) $H(j\infty) = \frac{-C_1}{C_2}$

15.3) a)
$$H(s) = \frac{-\left(\frac{1}{R_1 C_2}\right)(s)}{\left(s + \frac{1}{R_1 C_1}\right)\left(s + \frac{1}{R_2 C_2}\right)}$$
 b) $H(j0) = 0$ c) $H(j\infty) = 0$

15.20) $R' = 477.46 \Omega$, $L' = 40.53 \mu\text{H}$, $\omega_{C1} = 1469.57 \text{ krad/s}$, $\omega_{C2} = 1679.01 \text{ krad/s}$,
 $B = 209.44 \text{ krad/s}$

15.22) $L' = 40 \text{ mH}$, $R' = 105 \text{ k}\Omega$, $i_o(t) = [15 + e^{-100,000t} - 16e^{-400,000t}]u(t) \text{ mA}$

- 5) a) $R = 10$, $L = 2.5 \text{ mH}$, $C = 1 \mu\text{F}$
 b) $R = 4$, $L = 2.5 \text{ mH}$, $C = 2.5 \mu\text{F}$
 c) $R = 1000$, $L = 250 \text{ mH}$, $C = 10 \text{ nF}$