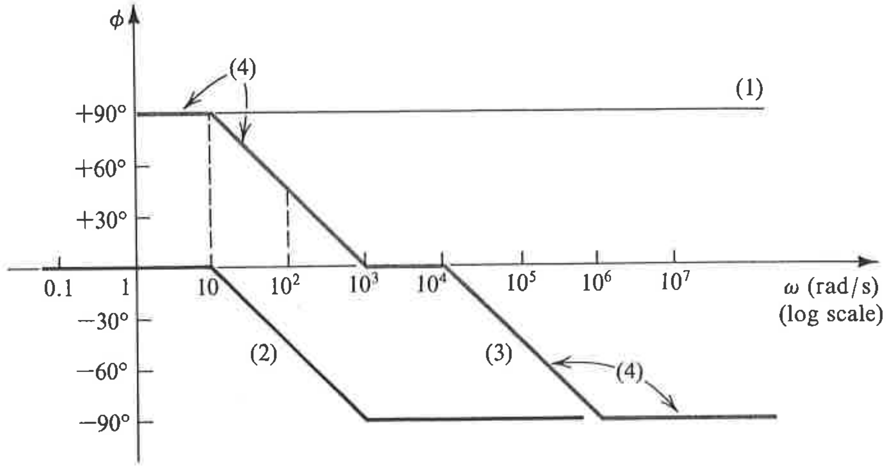

FIGURE E.4 Phase plots for Example E.2.

(the leading minus sign is due to the fact that this singularity is a pole). The asymptotic plot for this function is given by curve 2 in Fig. E.4. Similarly, the pole at $s = -10^5$ gives rise to the phase function

$$\phi_2 = -\tan^{-1}\frac{\omega}{10^5}$$

whose asymptotic plot is given by curve 3. The overall phase response (curve 4) is obtained by direct summation of the three plots. We see that at 100 rad/s, the amplifier phase leads by 45° and at 10^5 rad/s the phase lags by 45°.

E.4 AN IMPORTANT REMARK

For constructing Bode plots, it is most convenient to express the transfer-function factors in the form $(1 + s/a)$. The material of Figs. E.1 and E.2 and of the preceding two examples is then directly applicable.

PROBLEMS

E.1 Find the transfer function $T(s) = V_o(s)/V_i(s)$ of the circuit in Fig. PE.1. Is this an STC network? If so, of what type? For $C_1 = C_2 = 0.5\ \mu$F and $R = 100$ kΩ, find the location of the pole(s) and zero(s), and sketch Bode plots for the magnitude response and the phase response.

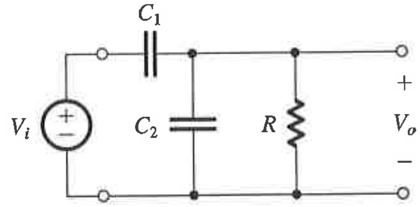

FIGURE PE.1

D*E.2 (a) Find the voltage transfer function $T(s) = V_o(s)/V_i(s)$, for the STC network shown in Fig. PE.2.

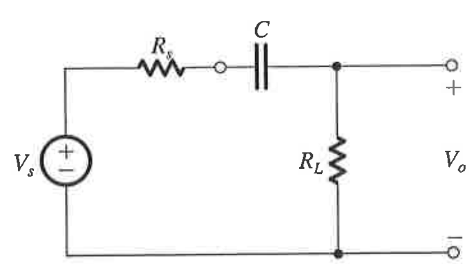

FIGURE PE.2

(b) In this circuit, capacitor C is used to couple the signal source V_s having a resistance R_s to a load R_L. For $R_s = 10\ \text{k}\Omega$, design the circuit, specifying the values of R_L and C to only one significant digit to meet the following requirements:

(i) The load resistance should be as small as possible.
(ii) The output signal should be at least 70% of the input at high frequencies.
(iii) The output should be at least 10% of the input at 10 Hz.

E.3 Two STC RC circuits, each with a pole at 100 rad/s and a maximum gain of unity, are connected in cascade with an intervening unity-gain buffer that ensures that they function separately. Characterize the possible combinations (of low-pass and high-pass circuits) by providing (i) the relevant transfer functions, (ii) the voltage gain at 10 rad/s, (iii) the voltage gain at 100 rad/s, and (iv) the voltage gain at 1000 rad/s.

E.4 Design the transfer function in Eq. (E.5) by specifying a_1 and ω_0 so that the gain is 10 V/V at high frequencies and 1 V/V at 10 Hz.

E.5 An amplifier has a low-pass STC frequency response. The magnitude of the gain is 20 dB at dc and 0 dB at 100 kHz. What is the corner frequency? At what frequency is the gain 19 dB? At what frequency is the phase −6°?

E.6 A transfer function has poles at (−5), (−7 + j10), and (−20), and a zero at (−1 − j20). Since this function represents an actual physical circuit, where must other poles and zeros be found?

E.7 An amplifier has a voltage transfer function $T(s) = 10^6 s/(s+10)(s+10^3)$. Convert this to the form convenient for constructing Bode plots [that is, place the denominator factors in the form $(1 + s/a)$]. Provide a Bode plot for the magnitude response, and use it to find approximate values for the amplifier gain at 1, 10, 10^2, 10^3, 10^4, and 10^5 rad/s. What would the actual gain be at 10 rad/s? At 10^3 rad/s?

E.8 Find the Bode phase plot of the transfer function of the amplifier considered in Problem E.7. Estimate the phase angle at 1, 10, 10^2, 10^3, 10^4, and 10^5 rad/s. For comparison, calculate the actual phase at 1, 10, and 100 rad/s.

E.9 A transfer function has the following zeros and poles: one zero at $s = 0$ and one zero at $s = \infty$; one pole at $s = -100$ and one pole at $s = -10^6$. The magnitude of the transfer function at $\omega = 10^4$ rad/s is 100. Find the transfer function $T(s)$ and sketch a Bode plot for its magnitude.

E.10 Sketch Bode plots for the magnitude and phase of the transfer function

$$T(s) = \frac{10^4(1 + s/10^5)}{(1 + s/10^3)(1 + s/10^4)}$$

From your sketches, determine approximate values for the magnitude and phase at $\omega = 10^6$ rad/s. What are the exact values determined from the transfer function?

E.11 A particular amplifier has a voltage transfer function $T(s) = 10s^2/(1 + s/10)(1 + s/100)(1 + s/10^6)$. Find the poles and zeros. Sketch the magnitude of the gain in dB versus frequency on a logarithmic scale. Estimate the gain at 10^0, 10^3, 10^5, and 10^7 rad/s.

E.12 A direct-coupled differential amplifier has a differential gain of 100 V/V with poles at 10^6 and 10^8 rad/s, and a common-mode gain of 10^{-3} V/V with a zero at 10^4 rad/s and a pole at 10^8 rad/s. Sketch the Bode magnitude plots for the differential gain, the common-mode gain, and the CMRR. What is the CMRR at 10^7 rad/s? (*Hint:* Division of magnitudes corresponds to subtraction of logarithms.)