13.10 For the Wien-bridge oscillator of Fig. 13.4, let the closed-loop amplifier (formed by the op amp and the resistors R_1 and R_2) exhibit a phase shift of -0.1 rad in the neighborhood of $\omega = 1/CR$. Find the frequency at which oscillations can occur in this case, in terms of CR. (*Hint:* Use Eq. 13.11.)

13.11 For the Wien-bridge oscillator of Fig. 13.4, use the expression for loop gain in Eq. (13.10) to find the poles of the closed-loop system. Give the expression for the pole Q, and use it to show that to locate the poles in the right half of the s plane, R_2/R_1 must be selected to be greater than 2.

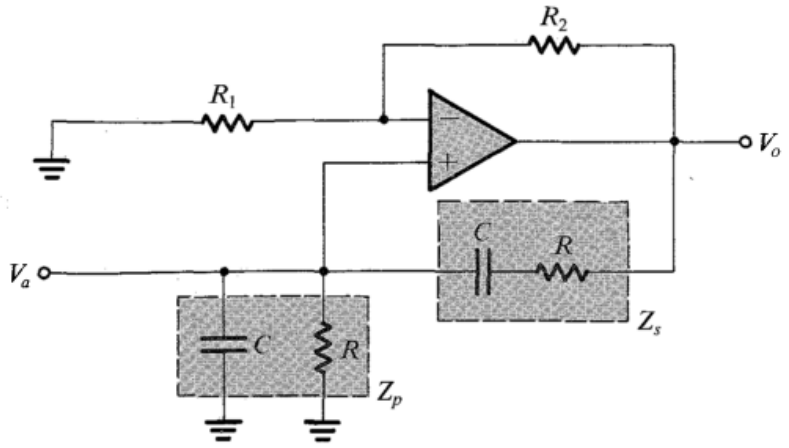
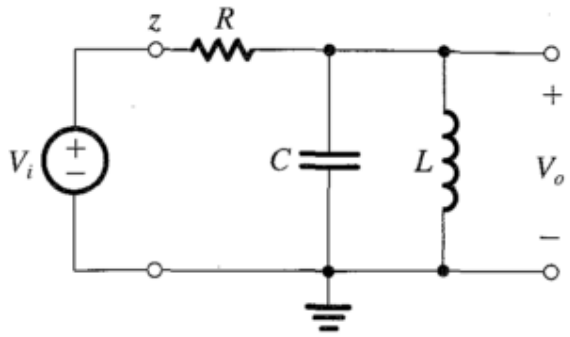


FIGURE 13.4 A Wien-bridge oscillator without amplitude stabilization.

D13.3 Sketch a circuit for a sinusoidal oscillator formed by an op amp connected in the noninverting configuration and a bandpass filter implemented by an RLC resonator (such as that in Fig. 12.18d). What should the amplifier gain be to obtain sustained oscillation? What is the frequency of oscillation? Find the percentage change in ω_0, resulting from a change of +1% in the value of (a) L, (b) C, and (c) R.



(d) BP

13.13 For the circuit in Fig. P13.13 find $L(s)$, $L(j\omega)$, the frequency for zero loop phase, and R_2/R_1 for oscillation.

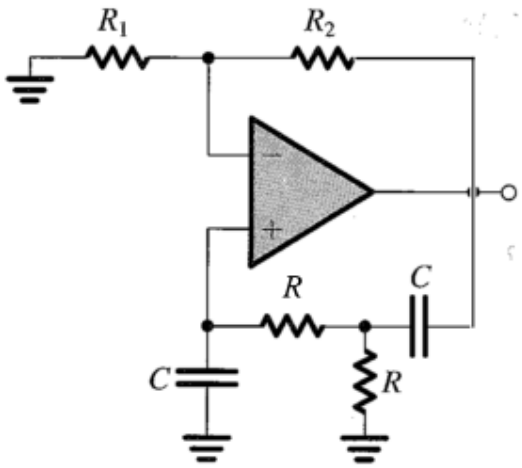


FIGURE P13.13