Signal Generators and Waveform-Shaping Circuits

There are two different approaches for the generation of sinusoids:

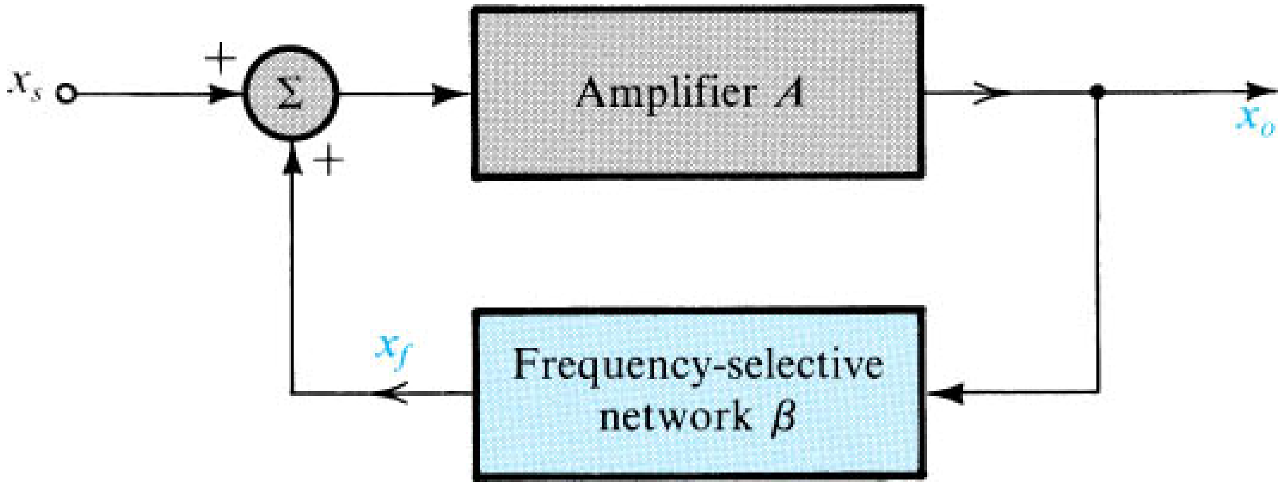
positive-feedback loop consisting of an amplifier and an RC or LC frequency-selective network.

A sine wave is obtained by shaping a triangular waveform.

Circuits that generate square, triangular, pulse, etc., are called oscillators or function generators, employ circuit building blocks known as multivibrators.

There are three types of multivubrators: bistable, astable, and monostable.

Sinusoidal Oscillators: Feedback Loop

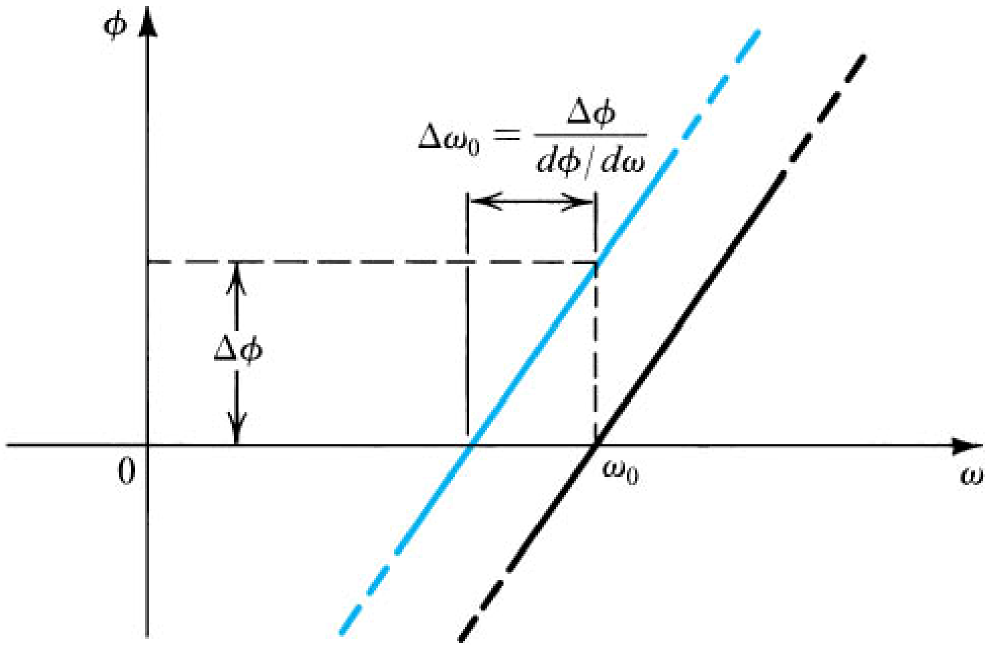


$$\text{Gain with Feedback}: A_f = \frac{A(s)}{1 - A(s)\beta(s)}$$

$$\text{Loop Gain}: L(s) = A(s)\beta(s)$$

$$\text{Characteristic Equation}: 1 - L(s) = 0$$

Dependence of the Oscillator Frequency Stability on the Slop of the Phase Response



$$L(j\omega_o) = A(j\omega_o)\beta(j\omega_o) = 1$$

$$x_f = \beta x_o; A x_f = x_o$$

$$A\beta = 1$$

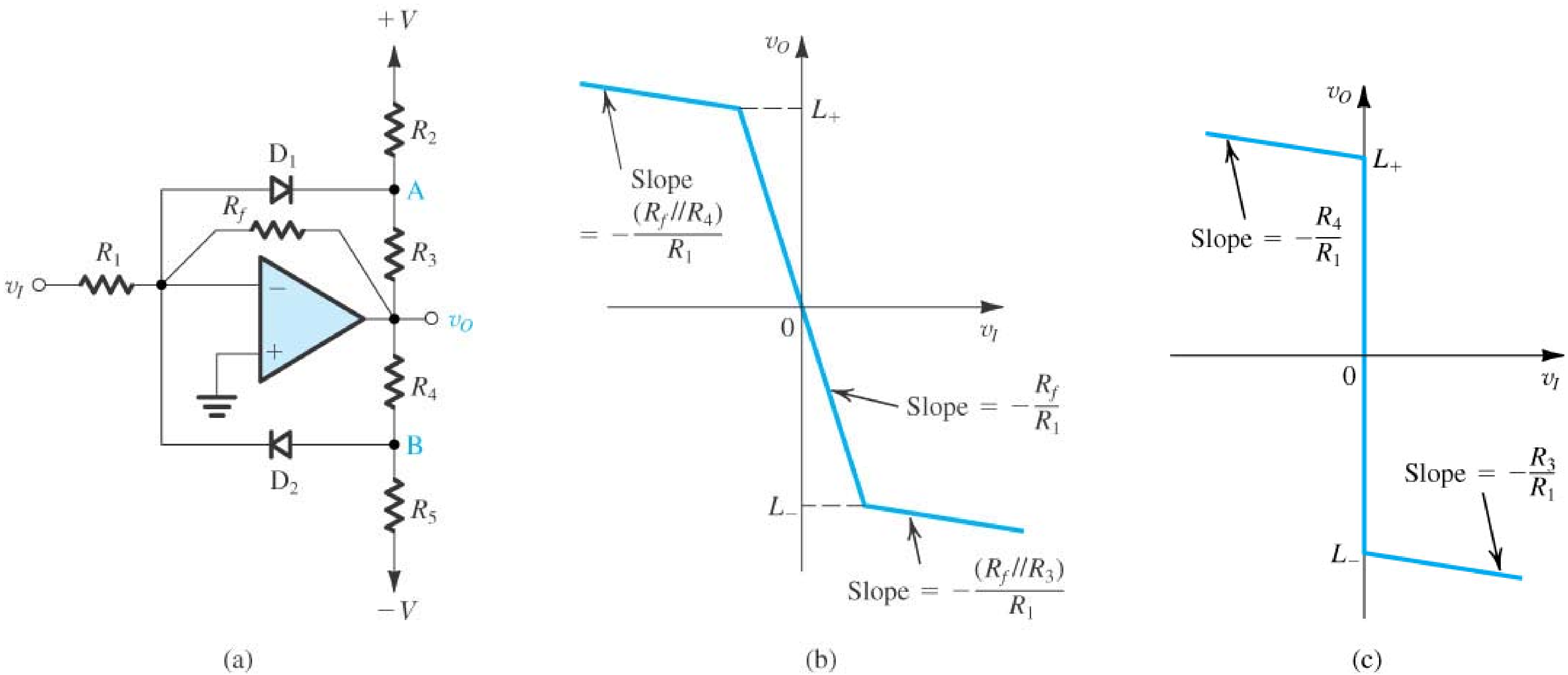
$$v_o = -(R_f / R_1)v_1$$

$$v_A = V\frac{R_3}{R_2 + R_3} + v_o\frac{R_2}{R_2 + R_3}$$

$$v_B = -V\frac{R_4}{R_4 + R_5} + v_o\frac{R_5}{R_4 + R_5}$$

$$L- = -V\frac{R_3}{R_2} - V_D\left(1 + \frac{R_3}{R_2}\right)$$

$$L+ = V\frac{R_4}{R_5} - V_D\left(1 + \frac{R_4}{R_5}\right)$$



$$v_O = -(R_f / R_1)v_1$$

$$v_A = V \frac{R_3}{R_2 + R_3} + v_O \frac{R_2}{R_2 + R_3}$$

$$v_B = -V \frac{R_4}{R_4 + R_5} + v_O \frac{R_5}{R_4 + R_5}$$

$$L- = \_V \frac{R_3}{R_2} - V_D\left(1 + \frac{R_3}{R_2}\right)$$

$$L+ = V \frac{R_4}{R5} - V_D\left(1 + \frac{R_4}{R5}\right)$$

The slope of the transfer characteristic in the positive limiting region is $-\left(R_f // R_4\right)/ R_1$

Exercise 13.2: Use a popular limiter circuit with V = 15 V, R_1 = 30 kΩ, R_f = 60 kΩ, $R_2 = R_5$ = 9 kΩ and $R_3 = R_4$ = 3 kΩ. Find the limiting levels and the value of v_I at which the limiting levels are reached. Also, determine the limiter gain and the slope of the transfer characteristic in the positive and negative limiting regions. Assume that V_D=0.7 V.

$$L+ = V\frac{R_4}{R_5} + V_D(1+\frac{R_4}{R_5}) = 15(\frac{3}{9}) + 0.7(1+\frac{3}{9}) = 5.93\text{ V}$$

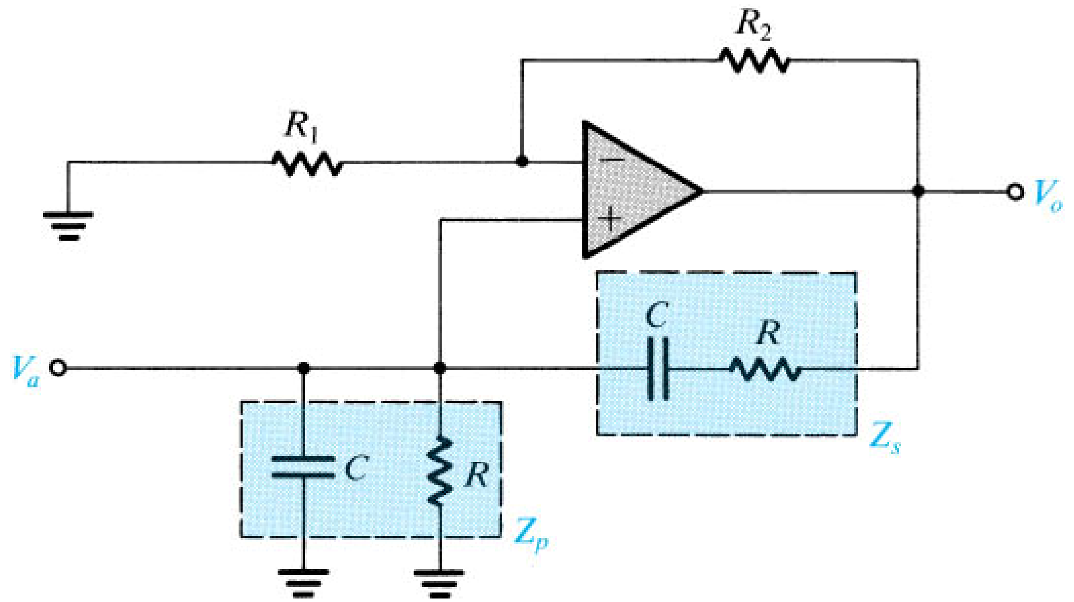
$$L- = -V\frac{R_3}{R2} - V_D(1+\frac{R_3}{R_2}) = -15(\frac{3}{9}) - 0.7(1+\frac{3}{9}) = -5.93$$

$$\text{Limiter gain} = \text{-}\frac{R_f}{R_1} = -\frac{60}{30} = -2\text{ V/V}$$

$$\text{Limiting occurs at} \pm\frac{5.93}{2} = \pm 2.97$$

$$\text{Slop in the limiting region} = -\frac{R_f \,//\, R_4}{R_1} = -.095\%\text{ V/V}$$

The Wien-Bridge Oscillator

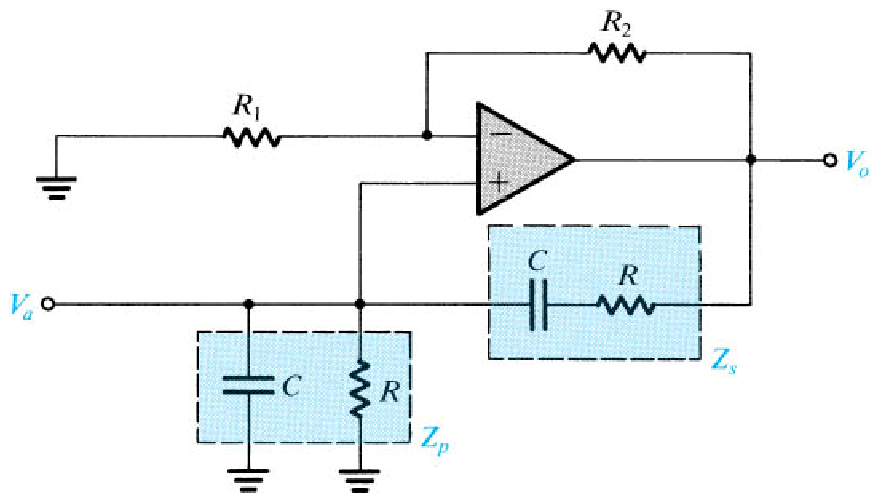


$$L(s) = \left[1 + \frac{R_2}{R_1}\right] \frac{Z_p}{Z_p + Z_s} = \frac{1 + R_2 / R_1}{3 + sCR + 1/sCR}$$

$$L(j\omega) = \frac{1 + R_2 / R_1}{3 + j(\omega CR - 1/\omega CR)}$$

$$\omega_o CR = \frac{1}{\omega_o CR}; \omega_o = \frac{1}{CR}; \frac{R_2}{R_1} = 2$$

Design a Wien-bridge circuit to oscillate at f_o = 20 kHz



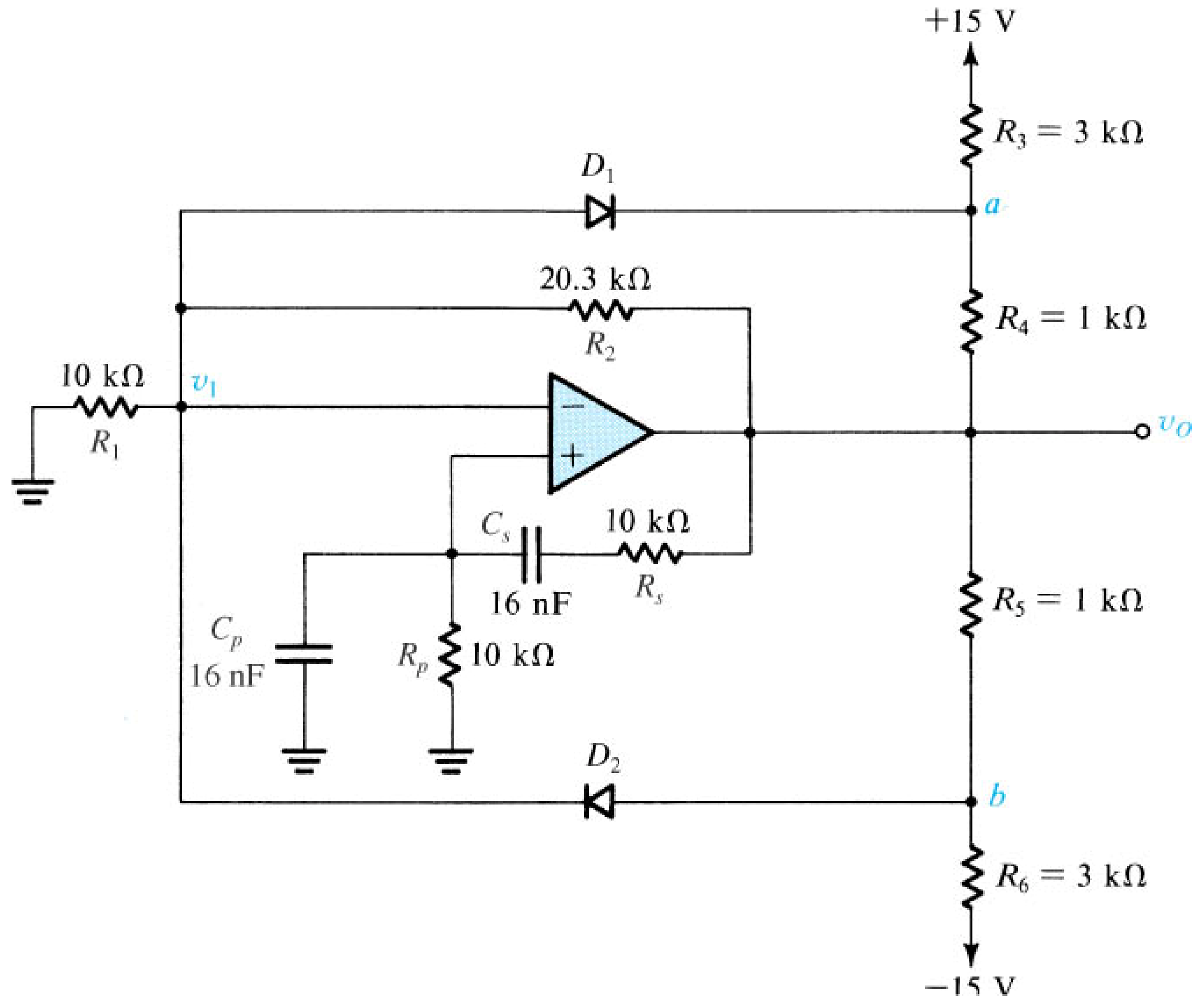
$$RC = \frac{1}{2\pi f_o} = \frac{1}{2\pi(20\times10^3)} = 7.96\times10^{-6}$$

$R = 10\,\Omega$ and $C = 796$ pF

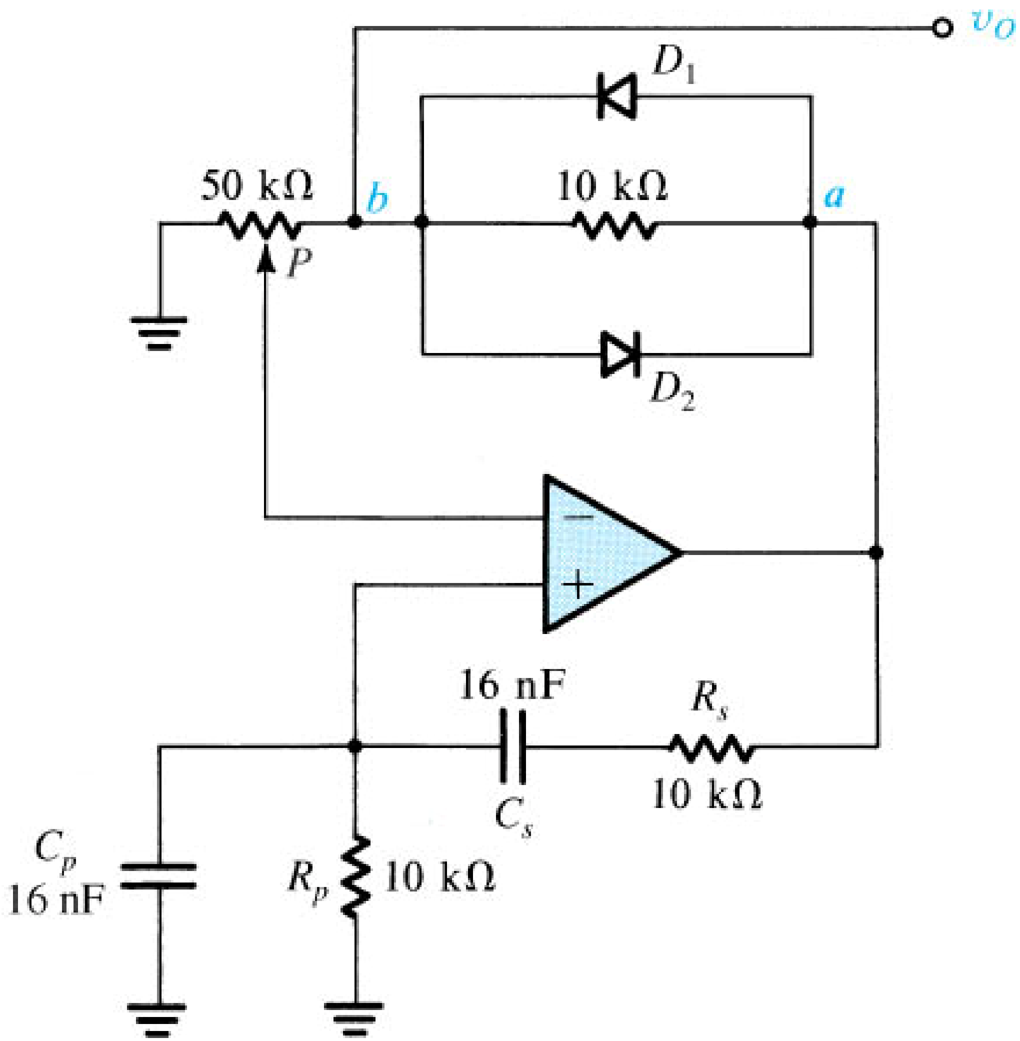
Since the amplifier resistor ratio must be $R_2 / R_1 = 2$

We may choose $R_2 = 20\,\text{k}\Omega$ and $R_1 = 10\,\text{k}\Omega$

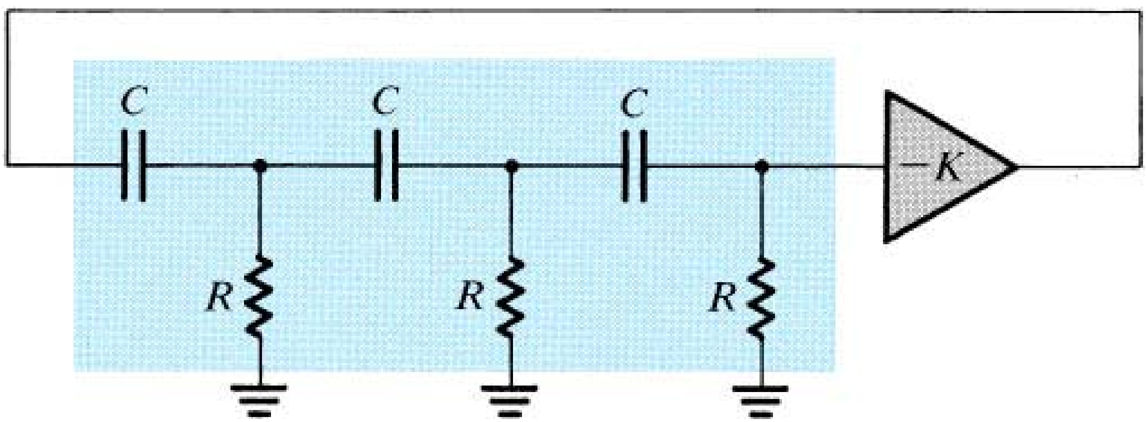
A Wien Bridge Oscillator with a Limiter for Amplitude Control



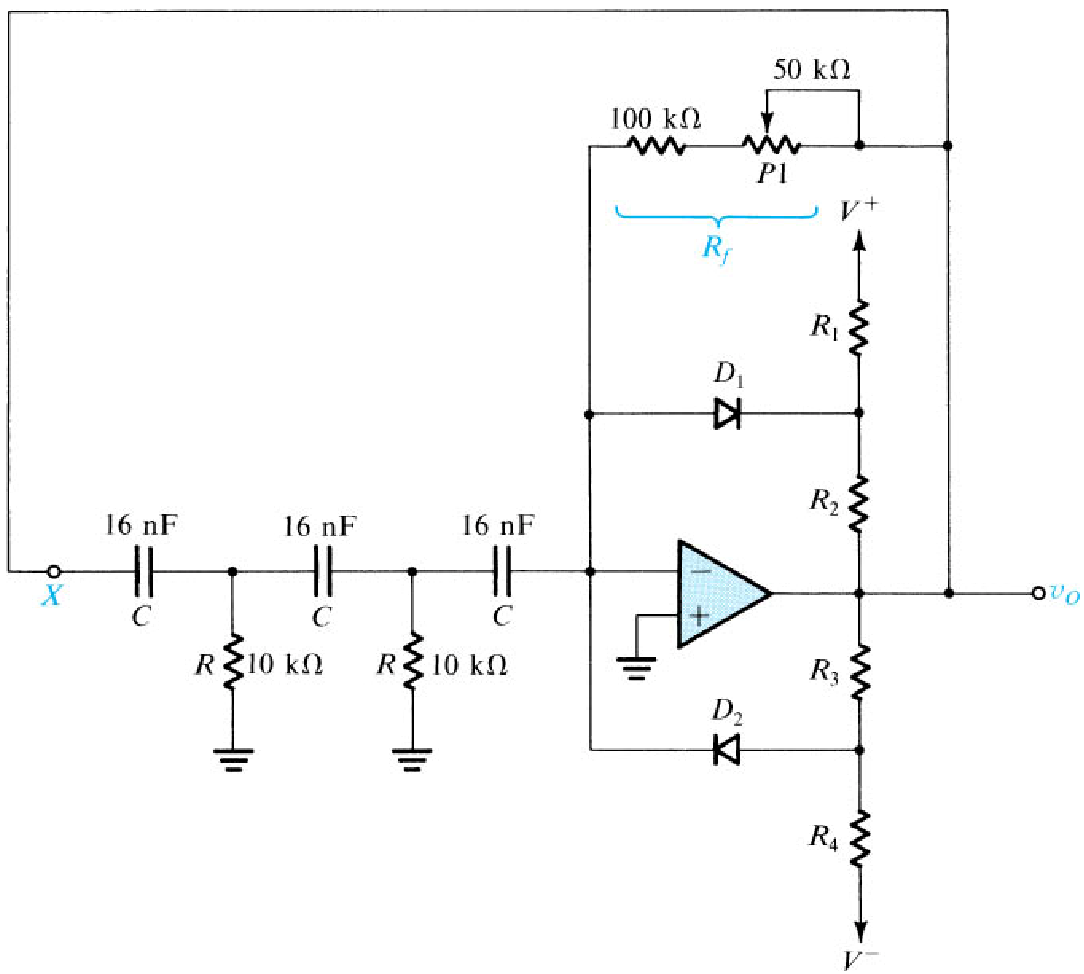
A Wien Bridge Oscillator with another Method for Amplitude Stabilization



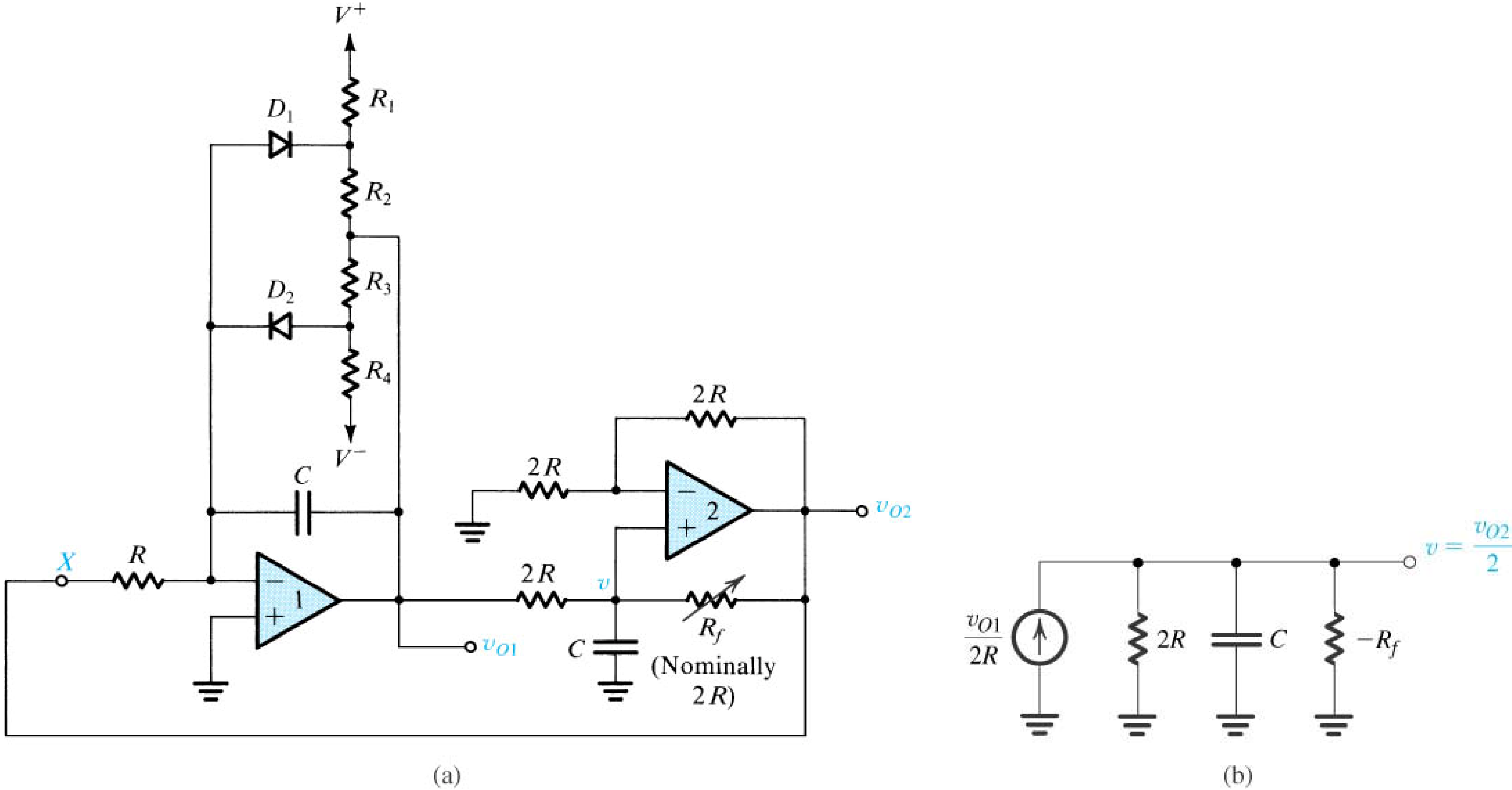
A Phase Shift Oscillator



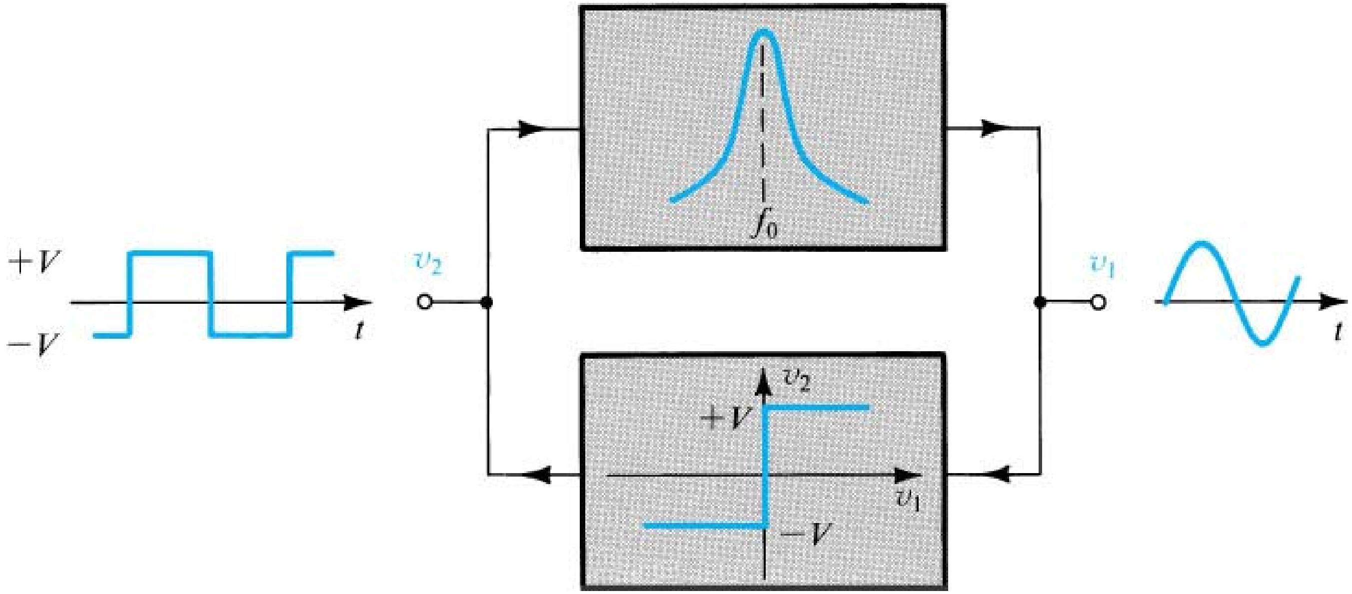
A Phase Shift Oscillator with a Limiter for Amplitude Stabilization



A Quadrature-Oscillator Circuit



Active Filter Tuned Oscillator



Active Filter Tuned Oscillator