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EE3110 Electronic Circuits

Oscillator

Name: _____ Student Number: _____ Date: _____

- Figure 1 is a phase-shift oscillator using 3 op-amp, A_1 , A_2 , A_3 . Determine the oscillator frequency and required amplifier gain if $R = 1k$ and $C = 0.1\mu F$. Hence, calculate the required value of R_2 .

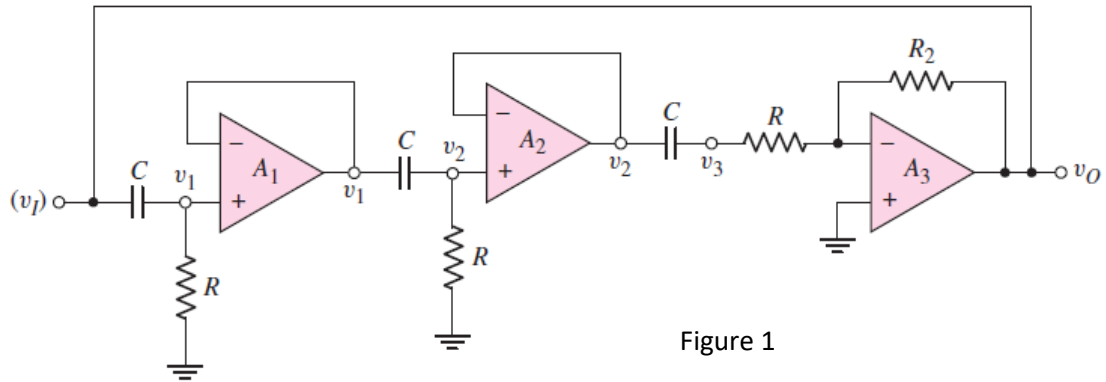


Figure 1

Hint: the criterion for the above circuit to oscillator is $A(j\omega)\beta(j\omega) = 1$, where $A(j\omega)\beta(j\omega)$ for the circuit is for the above circuit is

$$A(j\omega)\beta(j\omega) = -A_3 \times \frac{(j\omega RC)(\omega RC)^2}{(1 - 3\omega^2 R^2 C^2) + j\omega RC(3 - \omega^2 R^2 C^2)}$$

where A_3 is the gain between v_O/v_3 .

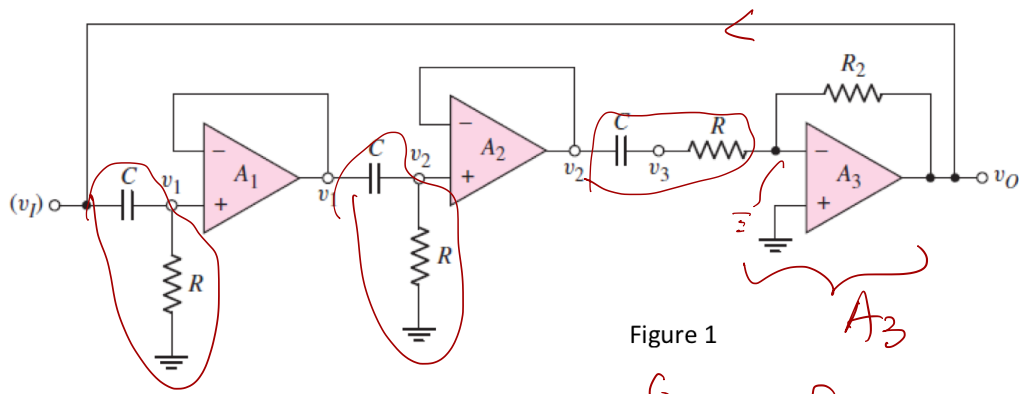
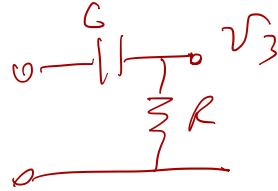


Figure 1



$$A(s) \beta(s) = A_3 \left(\frac{R}{R + \frac{1}{sC}} \right)^3 = A_3 \left(\frac{sCR}{1 + sCR} \right)^3$$

$$A(s) \beta(s) = A_3 \left[\frac{s^3 C^3 R^3}{(1 + 2sCR + s^2 C^2 R^2)(1 + sCR)} \right]$$

$$= \frac{A_3 s^3 C^3 R^3}{1 + 3sCR + 3s^2 C^2 R^2 + s^3 C^3 R^3}$$

$$A(s) \beta(s) = \frac{A_3 s^3 C^3 R^3}{(1 + 3s^2 C^2 R^2) + sCR(3 + s^2 C^2 R^2)}$$

$$A(s)\beta(s) = \frac{A_3 s^3 c^2 R^3}{(1 + 3s^2 c^2 R^2) + s c R (3 + s^2 c^2 R^2) - A_3 (\hat{\gamma} \omega c R) (c^2 R^2 \omega^2)}$$

$$s = j\omega \quad A(j\omega)\beta(j\omega) = \frac{-A_3 (\hat{\gamma} \omega c R) (c^2 R^2 \omega^2)}{(1 - 3\omega^2 c^2 R^2) + \hat{\gamma} \omega c R (3 - \omega^2 c^2 R^2)} \quad (*)$$

$$\text{at } \omega = \omega_0 \quad \text{s.t. } \text{Im}\{A(j\omega_0)\beta(j\omega_0)\} = 0 \quad - (a)$$

$$\text{Re}\{A(j\omega_0)\beta(j\omega_0)\} = 1 \quad - (b)$$

Apply condn 'a' to equation (*)

$$1 - 3\omega_0^2 c^2 R^2 = 0 \Rightarrow \omega_0 = \frac{1}{\sqrt{3} c R}$$

Apply condn 'b' to equation (*) $\Rightarrow \omega_0 c R = \frac{2}{\sqrt{3}}$

$$\frac{-A_3 (\hat{\gamma} \omega_0 c R) (c^2 R^2 \omega_0^2)}{\hat{\gamma} \omega_0 c R (3 - \omega_0^2 c^2 R^2)} = 1$$

apply cond 1 'b' to (A)

$$\frac{-A_3 (\cancel{j\omega_0 R}) (C^2 R^2 \omega_0^2)}{\cancel{j\omega_0 R} (3 - \omega_0^2 C^2 R^2)} = 1$$

$$-A_3 \underbrace{C^2 R^2 \omega_0^2}_{\frac{1}{3}} = \underbrace{3 - \omega_0^2 C^2 R^2}_{\frac{1}{3}}$$

$$\therefore \omega_0 = \frac{1}{\sqrt{3} CR}$$

$$\Rightarrow -\frac{A_3}{8} = 3 - \frac{1}{3} = \frac{8}{3}$$

$$\Rightarrow A_3 = -8 = -\frac{R_2}{R}$$

if $R_2 = 8R$ for a given R

2. Figure 2 is a Wien-bridge oscillator using an op-amp. Assume $R=R_1 = 10k$. Determine C and R_2 to oscillator an 800Hz frequency.

Hint: the criterion for the circuit to oscillator is $A(j\omega)\beta(j\omega) = 1$, where $A(j\omega)\beta(j\omega)$ for the circuit is

$$A(j\omega)\beta(j\omega) = \frac{A}{3 + j\omega RC + (1/j\omega RC)}$$

where A is the gain between v_o/v_y .

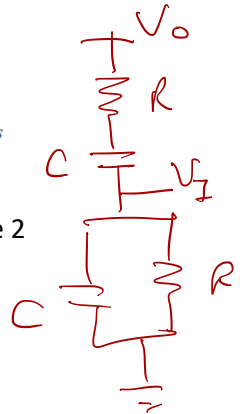
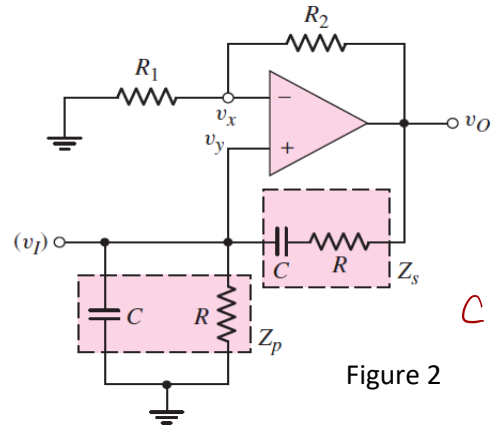


Figure 2

$$\beta(s) = \frac{v_I}{v_o} = \frac{v_y}{v_o}$$

$$\beta(s) = \frac{v_I}{v_o} = \frac{(R \parallel \frac{1}{sC})}{(R + \frac{1}{sC}) + (R \parallel \frac{1}{sC})}$$

$$\omega_o = ??$$

800Hz C, R_2