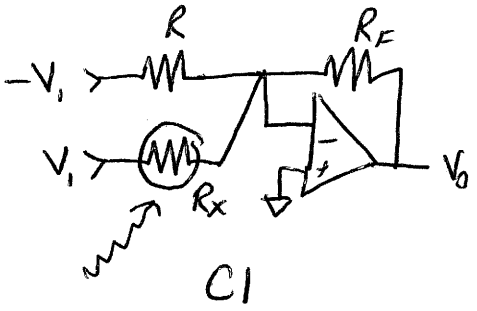
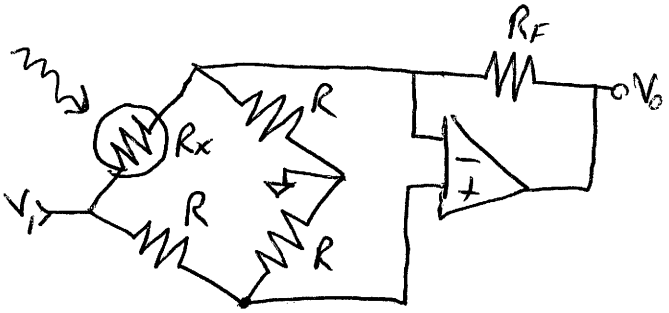
ENGR 210 Make-up Homework Spring '05

#1



C1



C2

$V_o = KV_1$

Darkness $R_x = 10k\Omega$
Sunlight $R_x = 2k\Omega$

a) What is K for C1 and C2

C1 KCL at − terminal

$$\frac{-V_1}{R} + \frac{V_1}{R_x} = \frac{-V_o}{R_F}$$

$$V_o = V_1\left(\frac{R_F}{R} - \frac{R_F}{R_x}\right)$$

$$\boxed{K = \frac{R_F}{R} - \frac{R_F}{R_x}}$$

C2 $V_+ = \frac{V_1 R}{R+R} = \frac{V_1}{2}$ Voltage Divider

KCL @ V_-

$$\frac{V_1 - V_1/2}{R_x} = \frac{V_1}{2R} + \frac{\frac{V_1}{2} - V_o}{R_F}$$

$$\boxed{K = \frac{1}{2}\left(1 + \frac{R_F}{R} - \frac{R_F}{R_x}\right)}$$

b) $V_1 = 15v$ R, R_F = ?
$V_o = -10$ sunlight
$V_o = +10$ darkness

① $10 = 15\left(\frac{R_F}{R} - \frac{R_F}{10k}\right)$

② $-10 = 15\left(\frac{R_F}{R} - \frac{R_F}{2k}\right)$

Subtract equations

$$\frac{20}{15} = -\frac{R_F}{10k} - \frac{R_F}{2k}$$

$$\boxed{R_F = \frac{10k}{3} = 3.3k\Omega} \Rightarrow \boxed{R = \frac{10k}{3} = 3.3k\Omega}$$

c) Repeat b for C2

$$-\frac{20}{15} = 1 + \frac{R_F}{R} - \frac{R_F}{2k}$$

$$\frac{20}{15} = 1 + \frac{R_F}{R} - \frac{R_F}{10k}$$

subtract equations

$$\frac{40}{15} = -\frac{R_F}{10k} + \frac{R_F}{2k}$$

$$\boxed{R_F = \frac{100k}{15} = 6.67k\Omega}$$

$$\boxed{R = 6.67k\Omega}$$

#1 d) C1 uses 2 fewer resistors compared to C2

Power is power through each resistor summed together (assuming opamp power is equal)

if $R_x = 2k$

$$P_{C1} = \frac{15^2}{3.3k} + \frac{15^2}{2k} + \frac{10^2}{3.3k} = 210mW$$

$$P_{C2} = \frac{(\frac{15}{2})^2}{2k} + \frac{(15/2)^2}{6.67k} + \frac{2\cdot(15/2)^2}{6.67k} + \frac{(\frac{15}{2} - -10)^2}{6.67k} = 99mW$$

Similar calculation when $R_x = 10k$

$P_{C1} = 121mW$

$P_{C2} = 32mW$

So, C2 uses less power but uses more components.

#2 $V_p = V_n \quad i_p = i_n = 0$

KCL @ (A)

$$\frac{5-3}{500} + \frac{V_{o2}-3}{3k} = \frac{3-1}{1k}$$

$$12 + V_{o2} - 3 = 6$$

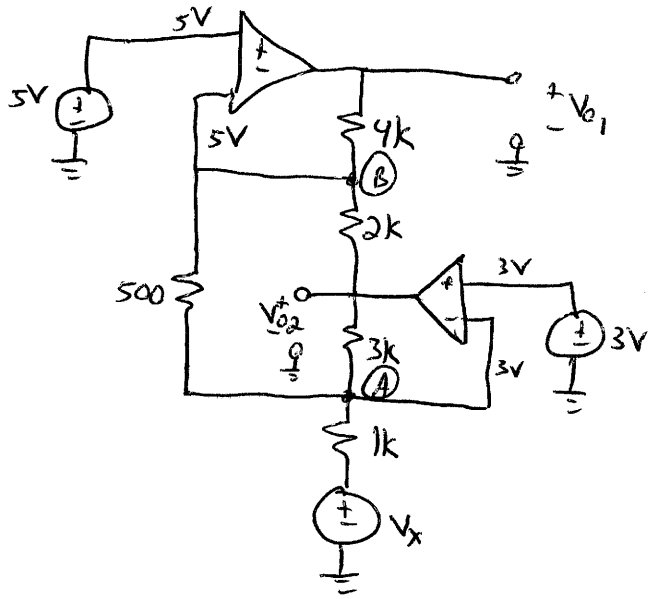
$V_{o2} = -3V$

KCL @ (B)

$$\frac{V_{o1}-5}{4k} = \frac{5--3}{2k} + \frac{5-3}{500}$$

$$V_{o1} - 5 = 16 + 16$$

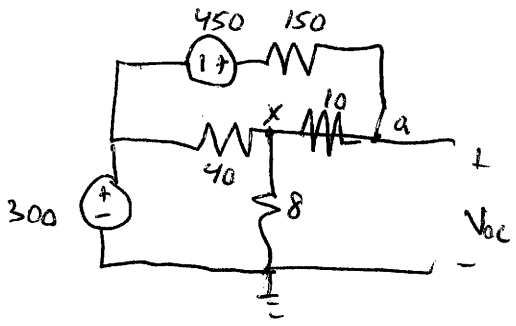
$V_{o1} = 37V$

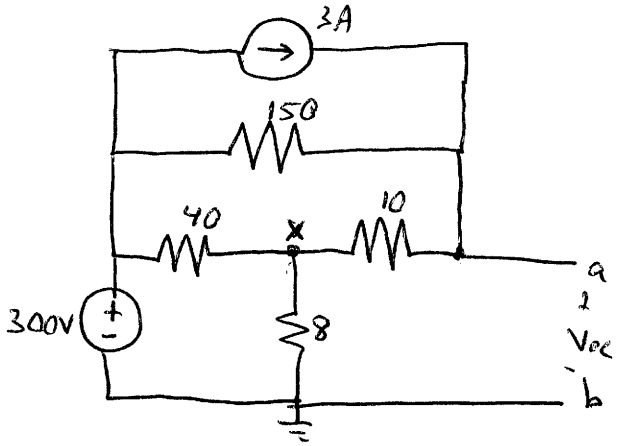


#3 Find V_{oc} and R_T

$V_{oc} = V_{ab} = V_a$

Source transformation on current source





KCL @ x

$$\frac{300 - V_x}{40} = \frac{V_x}{8} + \frac{V_x - V_a}{10}$$

KCL @ a

$$\frac{V_x - V_a}{10} + \frac{750 - V_a}{150} = 0$$

$$15V_x - 15V_A = -750 + V_a$$

$$V_x = \frac{-750 + 16V_A}{15}$$

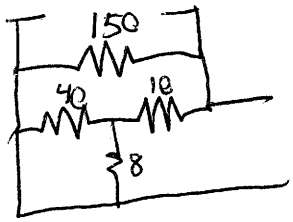
Plug into KCL @ x eqn.

$$\frac{300}{40} - \frac{(-750 + 16V_a)}{15(40)} = \frac{-750 + 16V_x}{15(8)} + \frac{-750 + 16V_a}{15(10)} - \frac{V_a}{10}$$

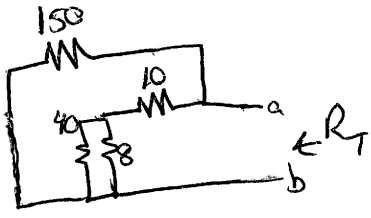
$$4500 + 750 - 16V_a = -3750 + 80V_a - 3000 + 64V_a - 60V_a$$

$$V_{oc} = V_a = 120V$$

Find R_{th}: Turn off all sources

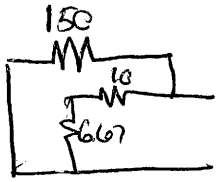


⇒



$$\frac{40(8)}{48} = 6.67$$

⇒

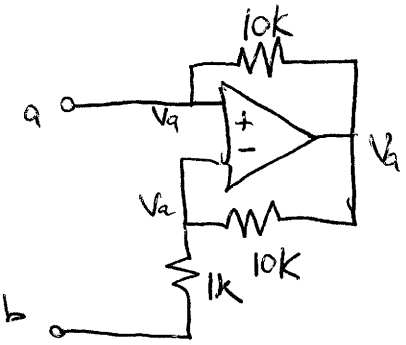


$$R_T = 50 \,//\, (10 + 6.67)$$

$$= \frac{50(16.67)}{66.67}$$

$$R_T = 15\ \Omega$$

#4 $V_a = V_p = V_n$



$\frac{V_p - V_o}{10K} = 0$ (Not current flows into opamp or through open ckt)

$V_p = V_o = V_n$ ← So no current through the other 10k

↳ No current through 1K by KCL @ V_n

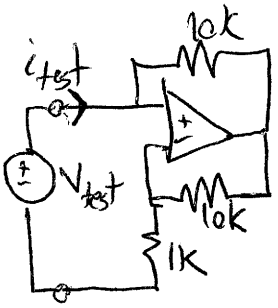
$V_b = V_a \Rightarrow \boxed{V_{oc} = 0V = V_T}$

To find R_T apply a "test" voltage source and determine test current.

Voltage Divider

$i_{test} = \frac{V_{test} - V_o}{10k}$ $\quad V_{test} = V_p = V_n = \frac{1k}{1k+10k} V_o$

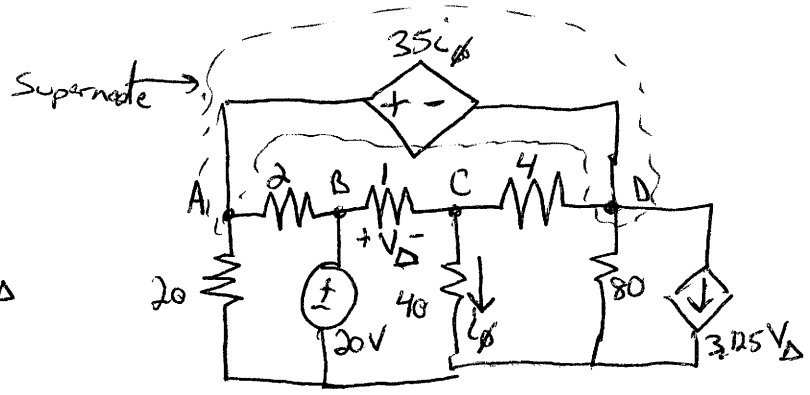
$V_o = \frac{11k}{1k} V_{test} = 11 V_{test}$



$i_{test} = \frac{V_{test} - 11V_{test}}{10k}$

$\frac{V_{test}}{i_{test}} = \boxed{R_T = \frac{10k}{-10} = -1k}$

#5 Node Voltage



KCL @ super node

$$\frac{0-V_A}{20} + \frac{V_B-V_A}{2} = \frac{V_D-V_C}{4} + \frac{V_D}{80} + 3.125V_\Delta$$

$$V_\Delta = V_B - V_C$$

$$-4V_A + 40V_B - 40V_A = 20V_D - 20V_C + V_D + 250V_B - 250V_C$$

$$-44V_A - 210V_B + 270V_C - 21V_D = 0 \quad \text{Equation 1}$$

KCL @ C

$$\frac{V_B-V_C}{1} = \frac{V_C}{40} + \frac{V_C-V_D}{4} \Rightarrow 40V_B - 51V_C + 10V_D = 0 \quad \text{Equation 2}$$

$$V_B = 20 \quad \text{Equation 3}$$

$$V_A = V_D + 35i_\phi \qquad i_\phi = \frac{V_C}{40}$$

$$40V_A - 35V_C - 40V_D = 0 \quad \text{Equation 4}$$

Put into calculator to solve.

$V_A = -20.25V$

$V_B = 20$

$V_C = 10$

$V_D = -29$

KCL @ B

$$\frac{V_A-V_B}{2} + \frac{V_C-V_B}{1} = i_{20V} = -30.125A$$

$$P = IV = (-30.125A)(20V)$$

$$\boxed{P = -602.5W}$$

↑ minus sign means the 20V source is delivering power.