Nilsson & Riedel, Ch. 5
\# 8, 9, 23, 38, 41

Engineering II
Electrical Circuit Analysis
Assignment 4 Solutions

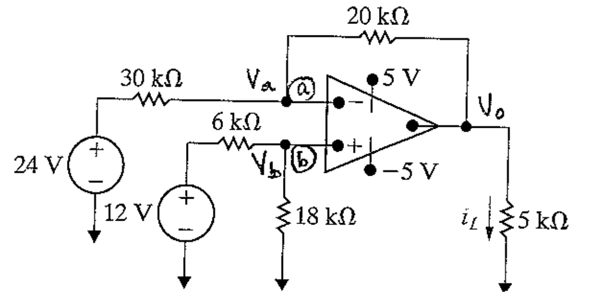
2005
LAM

(1. 5.8) Find i_L in μA. $V_b = V_a$

$$\sum_a i = 0 = \frac{24 - V_a}{30k} - \frac{V_a - V_o}{20k}$$

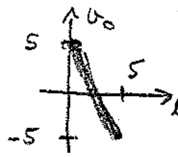
$$\sum_b i = 0 = \frac{12 - V_a}{6k} - \frac{V_a}{18k}$$

$\Rightarrow V_a = 9\text{ V};\ V_o = -1\text{V}$ so $\boxed{i_L = \frac{V_o}{5k} = -200\mu A}$



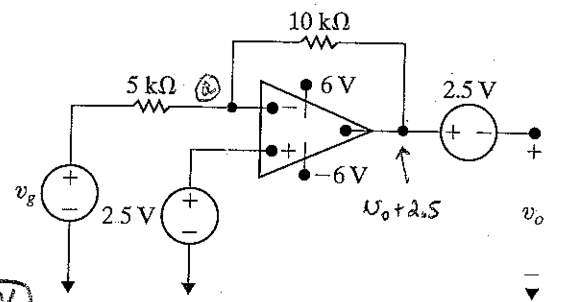
(2. 5.9) $-5 < v_o < 5$ for $0 < v_g < 5$ V. Note $V_a = 2.5$ V.

(a) Sketch



$$\sum_a i = 0 = \frac{v_g - 2.5}{5k} - \frac{2.5 - (v_o + 2.5)}{10k}$$

(b) Yes ✓



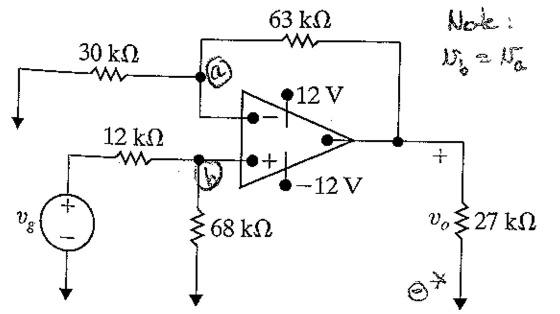
(3. 5.23) (a) For $v_g = 4$ V, find v_o. By V ÷, $v_b = v_a = \frac{68}{68+12} v_g$

$$\sum_a i = 0 = \frac{v_o - v_a}{63K} - \frac{v_a}{30K} = 0 \quad \Rightarrow v_a = .85 v_g;\ \boxed{v_o = 10.5\text{ V}}$$

(b) Find range of v_g for linear operation ($|v_o| < 12$ V)
Combining eqs. above, $\frac{v_o}{63k} - \left(\frac{1}{63k} + \frac{1}{30k}\right)\left(\frac{68}{80} v_g\right) = 0$
$\Rightarrow \boxed{|v_g| \leq 4.55\text{ V}}$ to keep $|v_o| \leq 12$ V

(c) For $v_g = 2$ V, & 63k → R, find R for saturation ($|v_o| = 12$V)
$\frac{\pm 12}{R} - \left(\frac{1}{R} + \frac{1}{30k}\right)\left(\frac{68}{80} \cdot 2\right) = 0$ Choose $v_o = 12$ V for $R > 0$.
$\Rightarrow \boxed{R = 182\,\Omega}$

Note: $v_b = v_a$



(4. 5.38) Find R for CMRR ≥ 1000. Using eqs. 5.29 & 5.30,

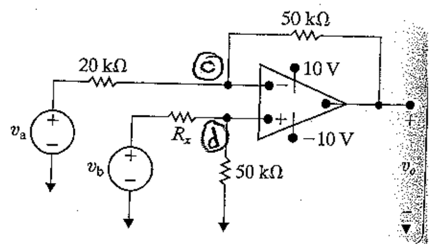
w/ $R_a = 20k\Omega$, $R_b = R_d = 50k\Omega$, $R_c = R_x$

$$A_{cm} = \frac{R_a R_d - R_b R_c}{R_a (R_c + R_d)}$$

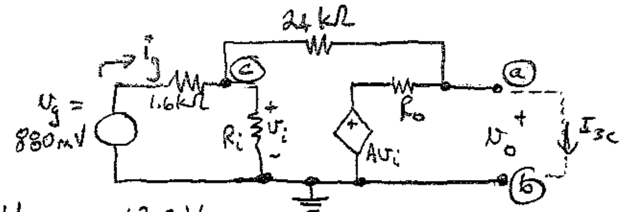
$$A_{dm} = \frac{R_d (R_a + R_b) + R_b (R_c + R_d)}{2R_a (R_c + R_d)}$$

$$\Rightarrow \frac{A_{dm}}{A_{cm}} = \frac{120 + R_x}{2(20 - R_x)} = \pm 1000$$

or $19.93\,k\Omega \leq R_x \leq 20.07\,k\Omega$



(5. 5.41) (a) Find Thevenin equiv. @ a, b for $v_s = 880$ mV, $R_i = 500k\Omega$, $R_o = 2k\Omega$, $A = 10^5$.

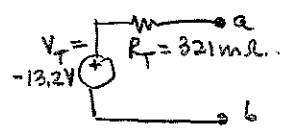


$V_T = V_{oc} = v_o$: $\sum_c i = 0 = \frac{.88 - v_i}{1.6k} - \frac{v_i}{R_i} - \frac{v_i - v_o}{24k}$

& $\sum_a i = 0 = \frac{v_i - v_o}{24k} - \frac{v_o - A v_i}{R_o}$; sub in $A, R_i, R_o \Rightarrow V_T = -13.2$ V

I_{sc} = current when a, b shorted. Now $\sum_c i = 0 = \frac{.88 - v_i}{1.6k} - \frac{v_i}{R_i} - \frac{v_i - \cancel{v_o}^{\,0}}{24k}$

& $\sum_a i = 0 = \frac{v_i}{24k} - \frac{A v_i}{R_o} - I_{sc} = 0 \quad \Rightarrow I_{sc} = -41.1$ A so $R_T = \frac{V_T}{I_{sc}} = 321\text{m}\Omega$



(b) What is output resistance? Find by applying V_{test}, I_{test} @ output -- equiv to Thevenin calc.
$\boxed{\text{so } R_{OUT} = 321\text{m}\Omega}$

(c) If $R_L = 330\,\Omega$, find input resistance seen by source.

Now $\sum_c i = \frac{.88 - v_i}{1.6k} - \frac{v_i}{R_i} - \frac{v_i - v_o}{24k} = 0$ & $\sum_a i = \frac{v_i - v_o}{24k} - \frac{v_o - A v_i}{R_o} - \frac{v_o}{R_L = 330} = 0$

Plug in again for A, R_i, R_o & solve simultaneously for $v_i = .942$mV $\Rightarrow i_g = \frac{.88 - .000942}{1.6k} \cong 550\mu A$
& $\boxed{R_{IN} = \frac{v_g}{i_g} \cong 1.602\,k\Omega}$