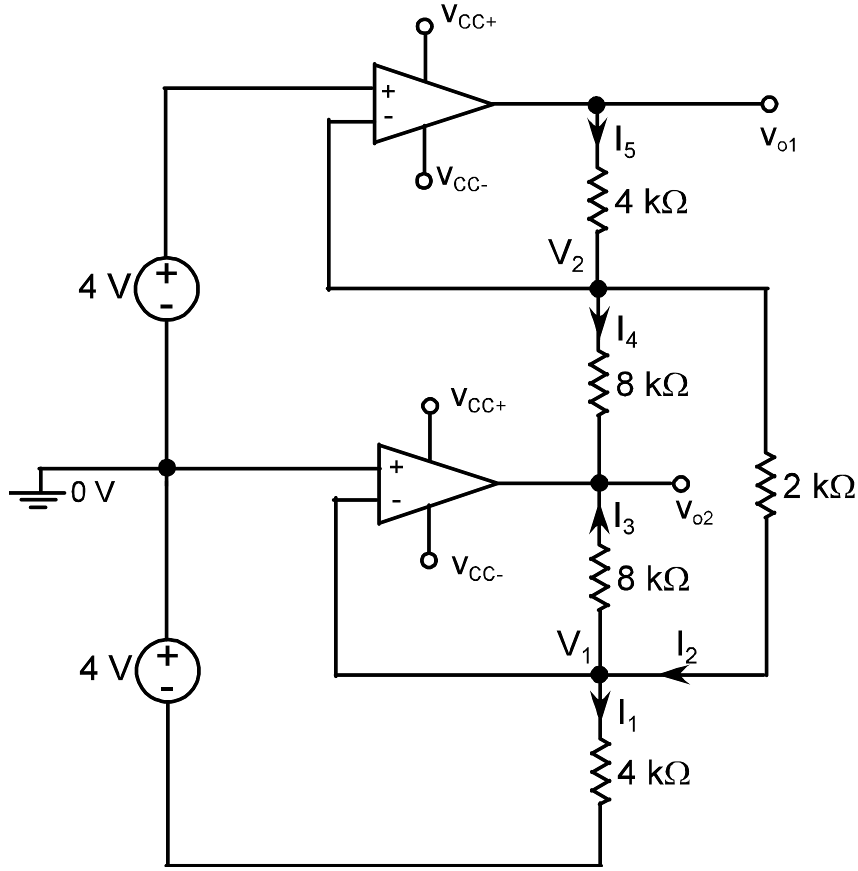
ROSE-HULMAN INSTITUTE OF TECHNOLOGY

ECE203 DC Circuits Spring 2016-2017

Homework Set #23
DUE Tuesday, May 9, 2017

1. Determine :
   a) V_{o1} & V_{o2}.
   b) The minimum absolute values of V_{CC+} and V_{CC-}.



Since V_1 = 0 V, $I_1 = \frac{4}{4} = 1$ mA. Since V_2 = 4 V, $I_2 = \frac{4}{2} = 2$ mA.

This gives: I_3 = 1 mA, and $V_{o2} = 0 - 8 \times 1 = -8$ V

$I_4 = \frac{4 - (-8)}{8} = 1.5$ mA, and $I_5 = 1.5 + 2 = 3.5$ mA.

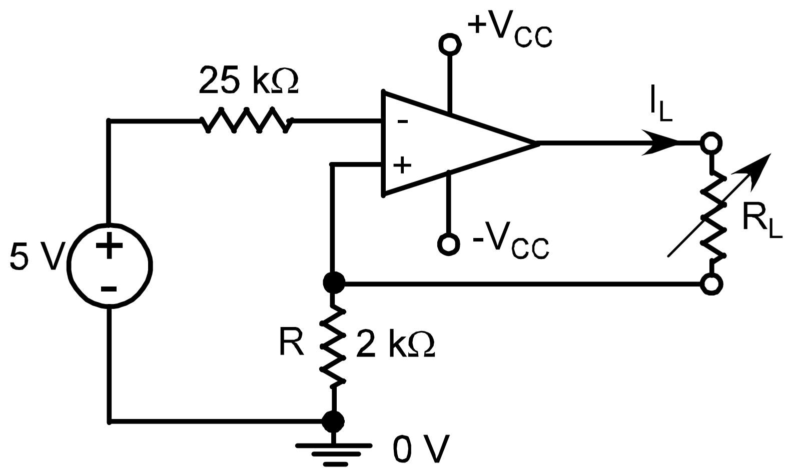
This gives: $V_{o1} = 4 + 4 \times 3.5 = 18$ V

If no allowance is made for distortion: $V_{CC+} = 18$ V, $V_{CC-} = -8$ V

Allowing for distortion: $V_{CC+} = 19.5$ V, $V_{CC-} = -9.5$ V

Either of the above are OK.

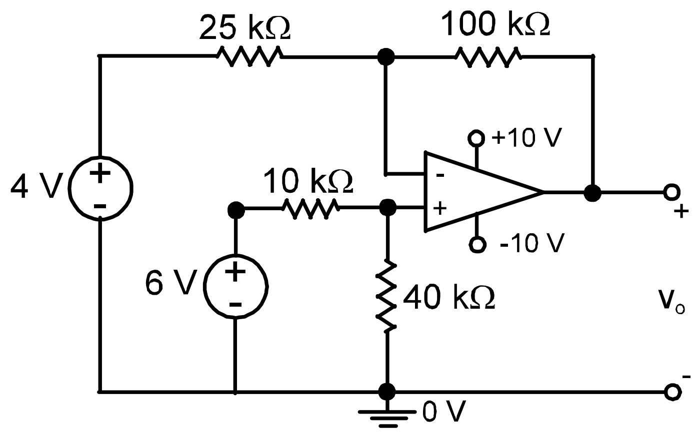
2. Design (i.e. draw the diagram and insert all parameter values) a constant current amplifier that will output 2.5 mA over its operating range and is driven from a signal that has a Thevenin equivalent of 5 V and 25 kΩ. Assume the op amp is ideal and operates in its linear range. Specify the smallest value of $\pm V_{CC}$ if the largest load resistance is 5 kΩ.



Load current is 2.5 mA: ∴ $R = \dfrac{V_S}{I_L} = \dfrac{5}{2.5} = 2\ k\Omega$

At onset of saturation: $V_{CC+} = V_S + I_L \times R_{Lsat} = 5 + 2.5 \times 5 = 17.5$ V

3. a) Determine v_o for the following circuit. Assume the op amp and power supplies are ideal.



b) Determine CMRR if the worst-case values of the resistors are:
22.5 kΩ for 25 kΩ, 90 kΩ for 100 kΩ, 11 kΩ for 10 kΩ, 36 kΩ for 40 kΩ.

a) The gain on each channel is 4 so:

$$v_o = 4(6 - 4) = 8 \text{ V}$$

b) The CMRR gets worse as ε gets larger. The worst-case (largest ε) occurs for:

$$R_{2-} = 90 \text{ k}\Omega,\ R_{1-} = 22.5 \text{ k}\Omega,\ R_{2+} = 36 \text{ k}\Omega,\ R_{1+} = 11 \text{ k}\Omega$$

This gives:

$$\varepsilon = 1 - \frac{R_{1-}R_{2+}}{R_{2-}R_{1+}} = 1 - \frac{22.5 \times 36}{90 \times 11} = 0.1818$$

Which results in:

$$CMRR = \left| \frac{1 + R_{2-}/R_{1-}}{-\varepsilon} \right| = \left| \frac{1 + 90/22.5}{-0.1818} \right| = 27.5$$