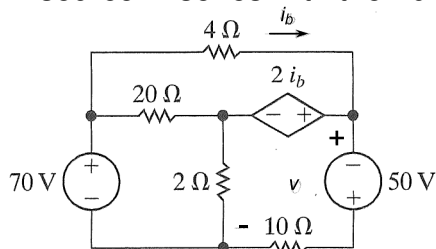


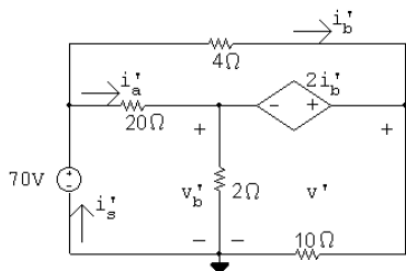
### Homework Set #18

#### DUE Friday, April 28, 2017

1. Use superposition to find the voltage  $V$  in the following circuit. Note that it's the voltage across the 50 V source in series with the 10  $\Omega$  resistor.



70-V source acting alone:



$$v' = 70 - 4i'_b$$

$$i'_s = \frac{v'_b}{2} + \frac{v'}{10} = i'_a + i'_b$$

$$70 = 20i'_a + v'_b$$

$$i'_a = \frac{70 - v'_b}{20}$$

$$\therefore i'_b = \frac{v'_b}{2} + \frac{v'}{10} - \frac{70 - v'_b}{20} = \frac{11}{20}v'_b + \frac{v'}{10} - 3.5$$

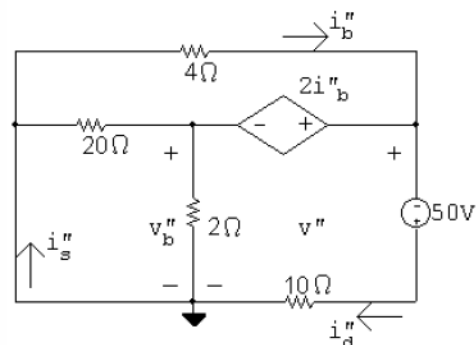
$$v' = v'_b + 2i'_b$$

$$\therefore v'_b = v' - 2i'_b$$

$$\therefore i'_b = \frac{11}{20}(v' - 2i'_b) + \frac{v'}{10} - 3.5 \quad \text{or} \quad i'_b = \frac{13}{42}v' - \frac{70}{42}$$

$$\therefore v' = 70 - 4\left(\frac{13}{42}v' - \frac{70}{42}\right) \quad \text{or} \quad v' = \frac{3220}{94} = \frac{1610}{47} \text{ V} = 34.255$$

50-V source acting alone:



$$v'' = -4i''_b$$

$$v'' = v''_b + 2i''_b$$

$$v'' = -50 + 10i''_d$$

$$\therefore i''_d = \frac{v'' + 50}{10}$$

$$i''_s = \frac{v''_b}{2} + \frac{v'' + 50}{10}$$

$$i''_b = \frac{v''_b}{20} + i''_s = \frac{v''_b}{20} + \frac{v''_b}{2} + \frac{v'' + 50}{10} = \frac{11}{20}v''_b + \frac{v'' + 50}{10}$$

$$v''_b = v'' - 2i''_b$$

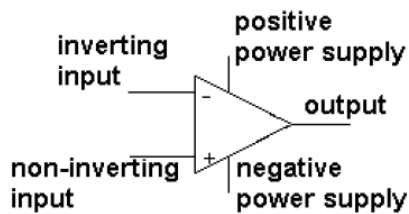
$$\therefore i''_b = \frac{11}{20}(v'' - 2i''_b) + \frac{v'' + 50}{10} \quad \text{or} \quad i''_b = \frac{13}{42}v'' + \frac{100}{42}$$

$$\text{Thus, } v'' = -4\left(\frac{13}{42}v'' + \frac{100}{42}\right) \quad \text{or} \quad v'' = -\frac{200}{47} \text{ V} = -4.255 \text{ V}$$

$$\text{Hence, } v = v' + v'' = \frac{1610}{47} - \frac{200}{47} = \frac{1410}{47} = 30 \text{ V}$$

2. Problem 5.1 in Nilsson.

[a] The five terminals of the op amp are identified as follows:



[b] The input resistance of an ideal op amp is infinite, which constrains the value of the input currents to 0. Thus,  $i_n = 0$  A.

[c] The open-loop voltage gain of an ideal op amp is infinite, which constrains the difference between the voltage at the two input terminals to 0. Thus,  $(v_p - v_n) = 0$ .

[d] Write a node voltage equation at  $v_n$ :

$$\frac{v_n + 3}{5000} + \frac{v_n - v_o}{15,000} = 0$$

But  $v_p = 0$  and  $v_n = v_p = 0$ . Thus,

$$\frac{3}{5000} - \frac{v_o}{15,000} = 0 \quad \text{so} \quad v_o = 9 \text{ V}$$

3. Problem 5.3 in Nilsson.

$$v_p = \frac{5000}{5000 + 10,000}(6) = 2 \text{ V} = v_n$$

$$\frac{v_n + 5}{3000} + \frac{v_n - v_o}{6000} = 0$$

$$2(2 + 5) + (2 - v_o) = 0$$

$$v_o = 16 \text{ V}$$

$$i_L = \frac{v_o}{8000} = \frac{16}{8000} = 2000 \times 10^{-6}$$

$$i_L = 2 \text{ mA}$$