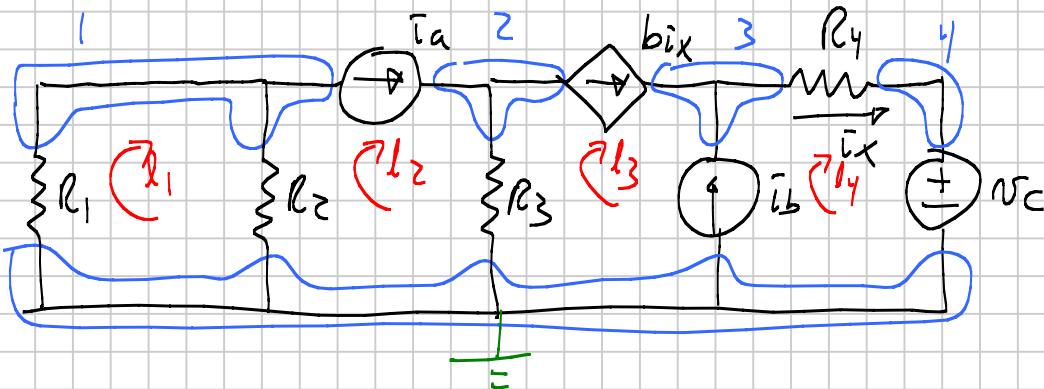


# BME 153 Test | Spring 2009

Note Title

1)



Need  $i_x$ ; can find at  $n_3$ :  $KCL_{n_3}$ :  $-b\bar{i}_x - \bar{i}_b + \bar{i}_x = 0$

Node voltages:

$$i_x = \frac{\bar{i}_b}{1-b}$$

$$v_{n_4} = v_c$$

$$v_{n_3} = v_c + R_4 i_x$$

$$v_{n_2} = R_3 (\bar{i}_a - b\bar{i}_x)$$

$$v_{n_1} = -\bar{i}_a (R_1 || R_2)$$

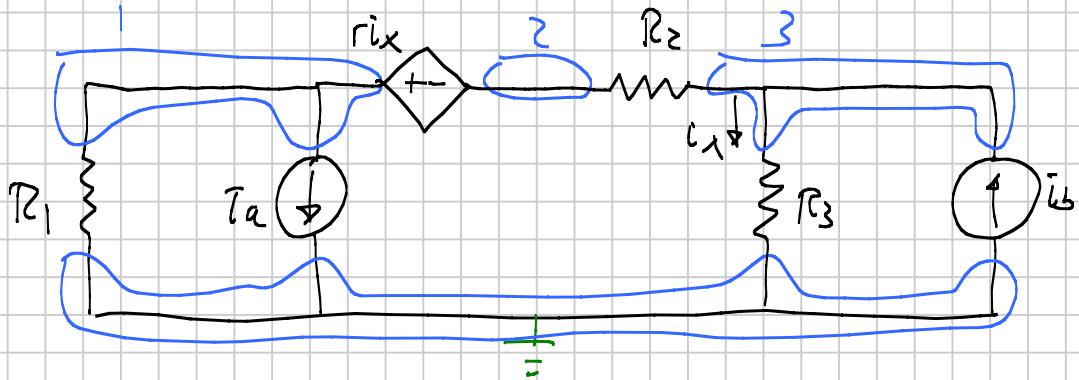
$$1) p_{abs, i_a} = (v_{n_1} - v_{n_2}) \bar{i}_a = (-\bar{i}_a (R_1 || R_2) - R_3 (\bar{i}_a - b\bar{i}_x)) \bar{i}_a$$

$$2) p_{abs, i_b} = -v_{n_3} \bar{i}_b = -[v_c + R_4 i_x] \bar{i}_b$$

$$3) p_{abs, v_c} = \bar{i}_x v_c$$

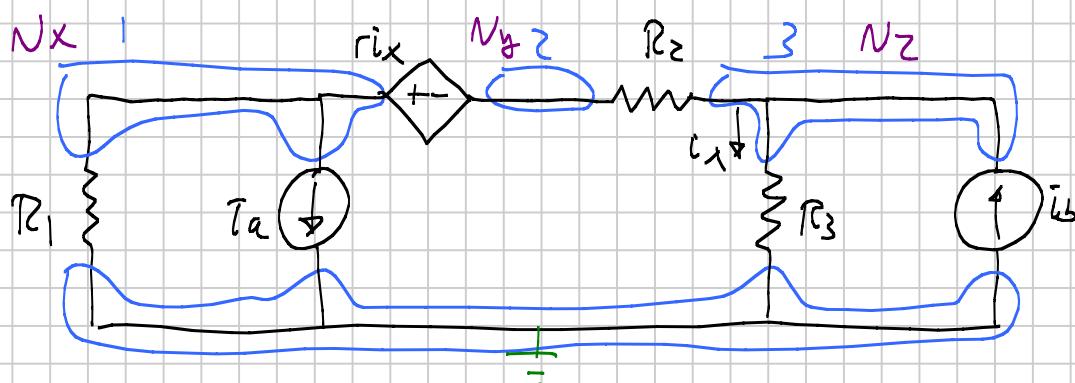
$$4) p_{abs, cccs} = (v_{n_2} - v_{n_3}) b\bar{i}_x = (R_3 (\bar{i}_a - b\bar{i}_x) - (v_c + R_4 i_x)) b\bar{i}_x$$

2)



- 1) GND
- 2) NODES
- 3) NODE VOLTAGES

Several options here; main choice is whether  $V_{n_3}$  is its own unknown or is  $R_3 i_x$   
 "most general" is



Unknowns:  $N_x, N_y, N_z, i_x$

Eqs:

Control:  $i_x = N_z / R_3$

AUX:  $N_x - N_y = r i_x$

PICK 2 of these 3

KCL,  $n_3$ :  $\frac{N_z - N_y}{R_2} + \frac{N_z}{R_3} - \bar{i}_b = 0$

KCL,  $s_{n_1 z}$ :  $\frac{N_x}{R_1} + T_a + \frac{N_y - N_z}{R_2} = 0$

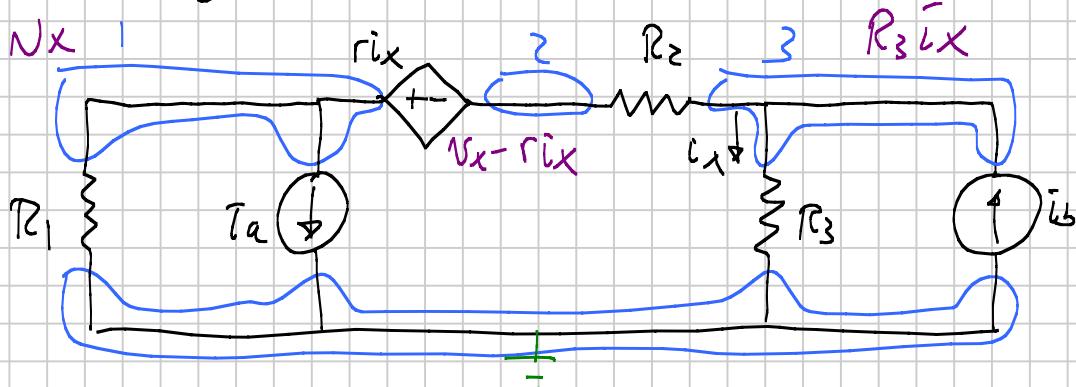
KCL,  $s_{n_1 z}$ :  $\frac{N_x}{R_1} + T_a + \frac{N_z}{R_3} - \bar{i}_b = 0$

$P_{abs, R_2} = (N_y - N_z)^2 / R_2$

$P_{del, CCVS} = N_{CCVS} \bar{i}_{CCVS} = (r i_x) \left( \frac{N_z - N_y}{R_2} \right)$

$= \left( \frac{r N_z}{R_3} \right) \left( \frac{N_z - N_y}{R_2} \right)$

Alternatively



Unknowns :  $N_x, i_x$

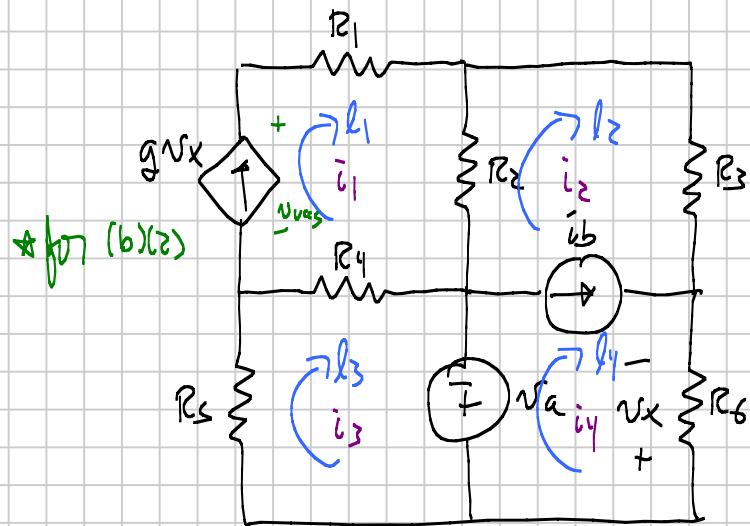
$$\left\{ \begin{array}{l} KCL, n_3 : R_3 i_x - \frac{N_x - r_i x}{R_2} + \bar{i}_x - \bar{i}_b = 0 \\ KCL, s_{n_12} : \frac{N_x}{R_1} + \bar{i}_b + \frac{(N_x - r_i x) - R_2 i_x}{R_2} = 0 \\ KCL, s_{n_123} : \frac{N_x}{R_1} + \bar{i}_a + \bar{i}_x - \bar{i}_b = 0 \end{array} \right.$$

Pick 2 out of

$$P_{abs, R_2} = (R_3 i_x - N_x + r_i x)^2 / R_2$$

$$P_{del, VCCS} = N_{VCCS} i_{VCCS} = r_i x \underbrace{(R_3 i_x - (N_x - r_i x)) / R_2}_{}$$

3)



1) Loops  
2) Mesh currents

Unknowns:  $i_1, i_2, i_3, i_4, v_x$

$$\text{Control: } v_x = -R_6 \bar{i}_4$$

$$\text{AVX: } \bar{i}_1 = g v_x$$

$$(\bar{i}_4 - \bar{i}_2) = \bar{i}_5$$

PICK 2 of 3

$$\left\{ \begin{array}{l} \text{KVL, l}_3: R_S(\bar{i}_3) + R_4(i_3 - \bar{i}_1) - v_a = 0 \\ \text{KVL, l}_2: v_a + R_2(i_2 - \bar{i}_1) + R_3 i_2 + R_6 \bar{i}_4 \\ \text{KVL, l}_3: R_S(i_3) + R_4(i_3 - \bar{i}_1) + R_2(i_2 - \bar{i}_1) + R_3(i_2) + R_6(i_4) \end{array} \right.$$

$$(1) P_{abs, R_2} = (\bar{i}_1 - \bar{i}_2)^2 R_2$$

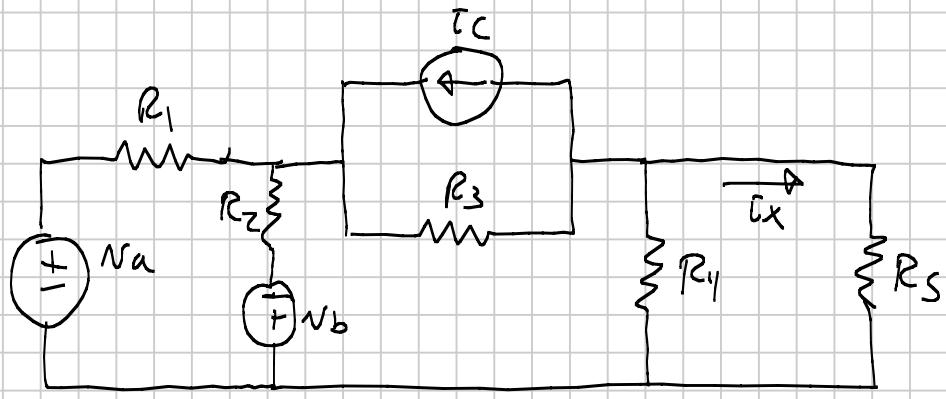
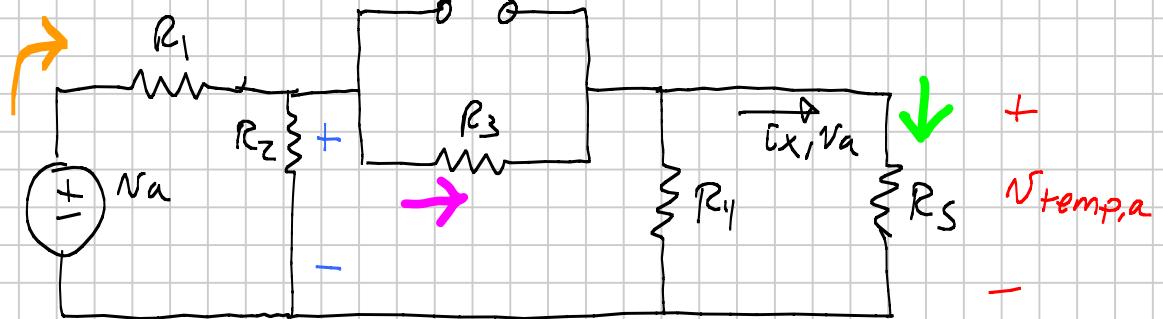
$$(2) P_{abs, VCCS} = \text{need to get } v_{VCCS}$$

$$\text{KVL, l}_1: -v_{VCCS} + R_1 \bar{i}_1 + R_2(\bar{i}_1 - \bar{i}_2) + R_4(\bar{i}_1 - i_3) = 0$$

$$v_{VCCS} = R_1 \bar{i}_1 + R_2(\bar{i}_1 - \bar{i}_2) + R_4(\bar{i}_1 - i_3)$$

$$P_{abs, VCCS} = v_{VCCS} \underline{\bar{i}_1}$$

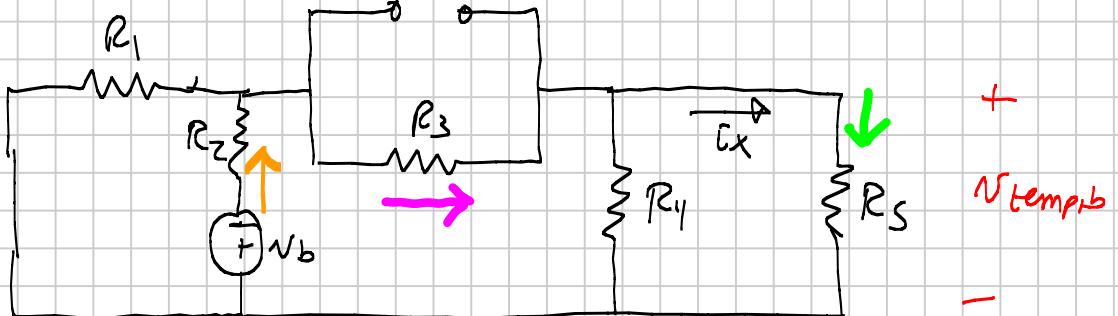
4)

 $V_a:$ 

$$V_{temp,a} = V_a \left( \frac{R_2 \parallel (R_3 + (R_4 \parallel R_S))}{R_1 + (R_2 \parallel (R_3 + (R_4 \parallel R_S)))} \right) \left( \frac{R_4 \parallel R_S}{R_4 + (R_4 \parallel R_S)} \right); i_{x,V_a} = \frac{V_{temp,a}}{R_S}$$

or, note  $R_{eq} = R_1 + (R_2 \parallel (R_3 + (R_4 \parallel R_S)))$  and use current division

$$i_{x,V_b} = \left( \frac{V_a}{R_1 + (R_2 \parallel (R_3 + (R_4 \parallel R_S)))} \right) \left( \frac{R_2}{R_2 + R_3 + (R_4 \parallel R_S)} \right) \left( \frac{R_4}{R_4 + R_S} \right)$$

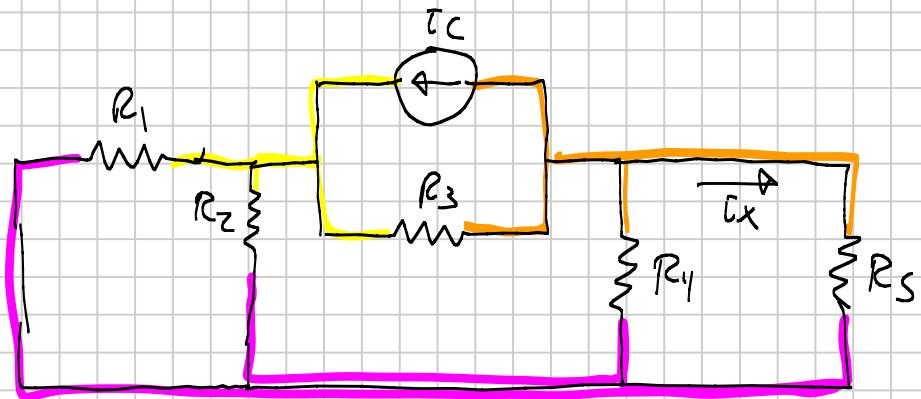
 $V_b:$ 

$$V_{temp,b} = -V_b \left( \frac{R_1 \parallel (R_3 + (R_4 \parallel R_S))}{R_2 + (R_1 \parallel (R_3 + (R_4 \parallel R_S)))} \right) \left( \frac{R_4 \parallel R_S}{R_2 + (R_4 \parallel R_S)} \right) i_{x,V_b} = \frac{V_{temp,b}}{R_S}$$

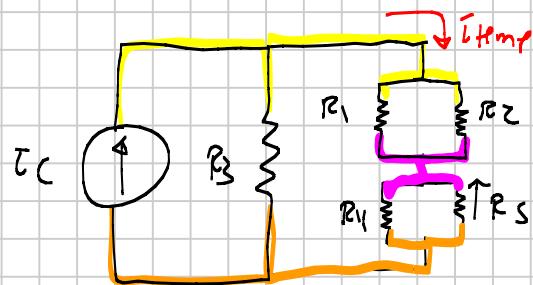
or, note  $R_{eq} = R_2 + (R_1 \parallel (R_3 + (R_4 \parallel R_S)))$  and use current division

$$i_{x,V_b} = \left( \frac{-V_b}{R_2 + (R_1 \parallel (R_3 + (R_4 \parallel R_S)))} \right) \left( \frac{R_1}{R_1 + R_2 + (R_4 \parallel R_S)} \right) \left( \frac{R_4}{R_4 + R_S} \right)$$

$T_C$



Redraw:



$$\bar{R}_{temp} = T_C \left( \frac{R_3}{R_3 + ((R_1 || R_2) + (R_4 || R_5))} \right)$$

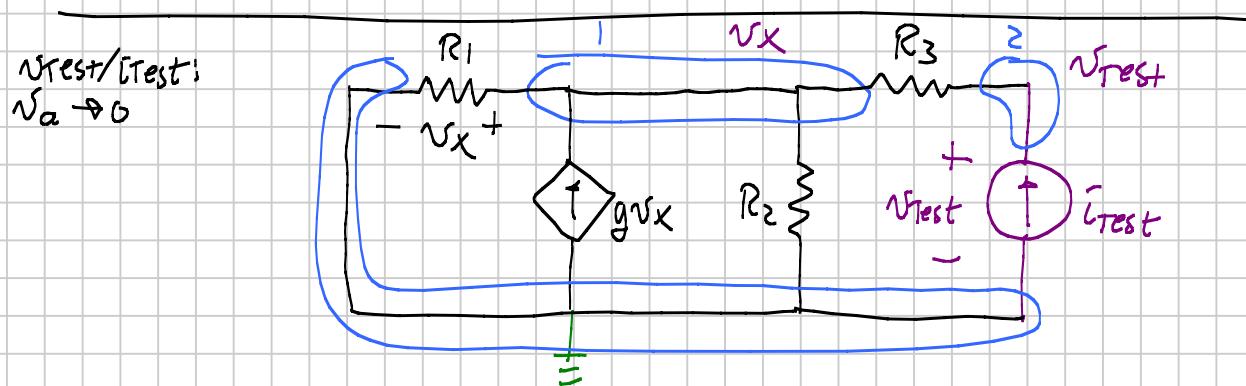
$$\bar{i}_{x_{eq}} = -\bar{i}_{temp} \left( \frac{R_4}{R_4 + R_5} \right) = -\bar{i}_{temp} \left( \frac{R_3}{R_3 + ((R_1 || R_2) + (R_4 || R_5))} \right) \left( \frac{R_4}{R_4 + R_5} \right)$$

$$\bar{i}_x = \bar{i}_{1,va} + \bar{i}_{1,vb} + \bar{i}_{x,T_C}$$

Since there is a dependent source, cannot use  $V_{oc}$  or  $I_{sc}$ .

Since there is an independent source, can either find  $V_{oc}$  or  $I_{sc}$  or

$V_{test}/I_{test}$



$$KCL_{in_1}: \frac{V_x}{R_1} - gV_x + \frac{V_x}{R_2} + \frac{(V_x - V_{test})}{R_3} = 0$$

$$KCL_{in_2}: \frac{V_{test} - V_x}{R_3} - I_{test} = 0 \quad V_x = V_{test} - R_3 I_{test}$$

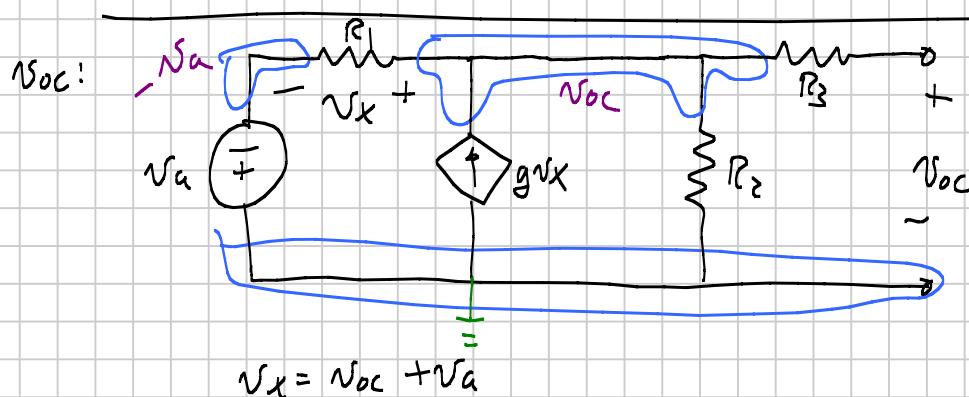
$$(V_{test} - R_3 I_{test}) \left( \frac{1}{R_1} - g + \frac{1}{R_2} \right) - I_{test} = 0$$

$$V_{test} = I_{test} \left( \frac{1}{R_1} + \frac{R_3}{R_1} + \frac{R_3}{R_2} - gR_3 \right) / \left( \frac{1}{R_1} + \frac{1}{R_2} - g \right)$$

$$\frac{V_{test}}{I_{test}} = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3 - g R_1 R_2 R_3}{R_1 + R_2 - g R_1 R_2} = R_T$$

$$\text{also, } R_3 + \frac{R_1 R_2}{R_1 + R_2 - g R_1 R_2}$$

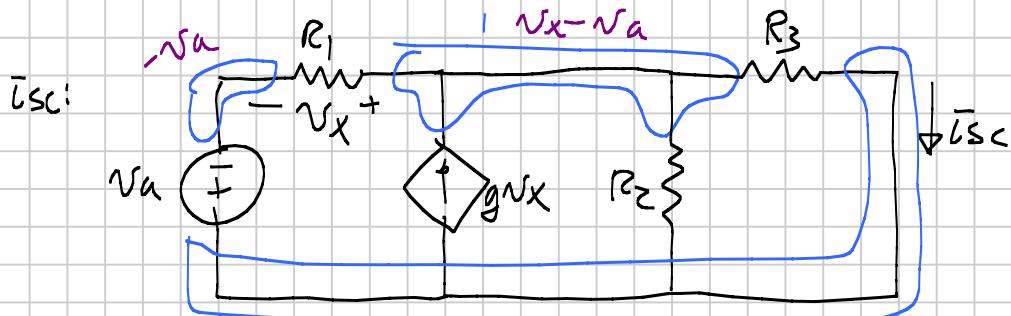
note - if  $g=0$ ,  
 $R_T = R_3 + (R_1 || R_2)$



$$KCL: \frac{V_{oc} + V_a}{R_1} - g(V_{oc} + V_a) + \frac{V_{oc}}{R_2} = 0$$

$$V_{oc} = -V_a \left( \frac{1}{R_1} - g \right) = -\frac{V_a (R_2 - g R_1 R_2)}{R_1 + R_2 - g R_1 R_2} = V_a \left( \frac{R_1}{R_1 + R_2 - g R_1 R_2} - 1 \right)$$

if  $g=0$ ,  
 $-V_a \left( \frac{R_2}{R_1 + R_2} \right)$



$$KCL_{n_1}: \frac{V_x}{R_1} - g V_x + \frac{V_x - V_a}{R_2} + \frac{V_x - V_a}{R_3} = 0$$

$$V_x = \frac{V_a \left( \frac{1}{R_2} + \frac{1}{R_3} \right)}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} - g} = \frac{V_a (R_1 R_2 + R_1 R_3)}{R_1 R_2 + R_1 R_3 + R_2 R_3 - g R_1 R_2 R_3}$$

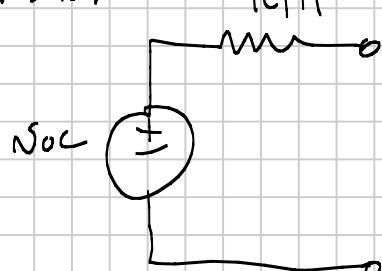
$$I_{SC} = \frac{V_x - V_a}{R_3} = -\frac{V_a}{R_3} \left( \frac{R_2 R_3 - g R_1 R_2 R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3 - g R_1 R_2 R_3} \right)$$

$$\text{if } g=0, \frac{V_a}{R_1 + (R_2 || R_3)} \frac{R_2}{R_2 + R_3} = \frac{V_a (R_2 + R_3)}{R_1 R_2 + R_1 R_3 + R_2 R_3} \frac{R_2}{R_2 + R_3} \quad \checkmark$$

Curr check:

$$\begin{aligned} \frac{V_{OC}}{I_{SC}} &= \frac{-V_a (R_2 - g R_1 R_2)}{R_1 + R_2 - g R_1 R_2} \frac{R_3 (R_1 R_2 + R_1 R_3 + R_2 R_3 - g R_1 R_2 R_3)}{-V_a (R_2 R_3 - g R_1 R_2 R_3)} \\ &= \frac{R_1 R_2 + R_1 R_3 + R_2 R_3 - g R_1 R_2 R_3}{R_1 + R_2 - g R_1 R_2} \end{aligned}$$

Thevenin:



Norton:

