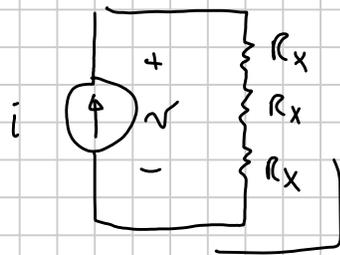


ERG 224 Test 1 Spring 2019

Note Title

I) (1) $i = 2 \text{ mA}$ $p_{del} = 36 \text{ mW} = v i$; $v = p_{del}/i = 18 \text{ V}$



$$R_{eq} = 3R_x$$

$$p_{abs} = i^2 R_{eq} = 3i^2 R_x$$

$$R_x = \frac{p_{abs}}{3i^2} = 3000 \Omega$$

2) $v = 12 \text{ V}$ $p_{del} = 36 \text{ mW} = v i$ $i = p_{del}/v = 3 \text{ mA}$



$$R_{eq} = \frac{1}{\frac{1}{R_y} + \frac{1}{R_y} + \frac{1}{R_y}} = R_y/3$$

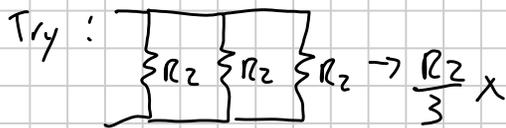
$$p_{abs} = \frac{v^2}{R_{eq}} \quad R_{eq} = \frac{v^2}{p_{abs}} \quad R_y = \frac{3v^2}{p_{abs}}$$

$$R_y = 12 \text{ k}\Omega$$

3) $R_2 = 6 \text{ k}\Omega$ $R_{eq} = 4 \text{ k}\Omega$ so some must be in parallel since $R_{eq} < R_2$

a) $p_{del} = i^2 R_{eq}$ $i = \sqrt{\frac{p_{del}}{R_{eq}}} = \sqrt{\frac{4 \cdot 10^{-1}}{4 \cdot 10^3}} = \sqrt{10^{-4}} = .01 \text{ A}$

b) $p_{del} = v i$ $v = p_{del}/i = .4 / .01 = 40 \text{ V}$



$$R_2 \parallel 2R_2 = \frac{2R_2^2}{R_2 + 2R_2} = \frac{2}{3} R_2 \quad \checkmark$$



$$p_{abs, R_1} = \frac{v^2}{R} = \frac{1600}{6000} = \frac{4}{15} \text{ W}$$

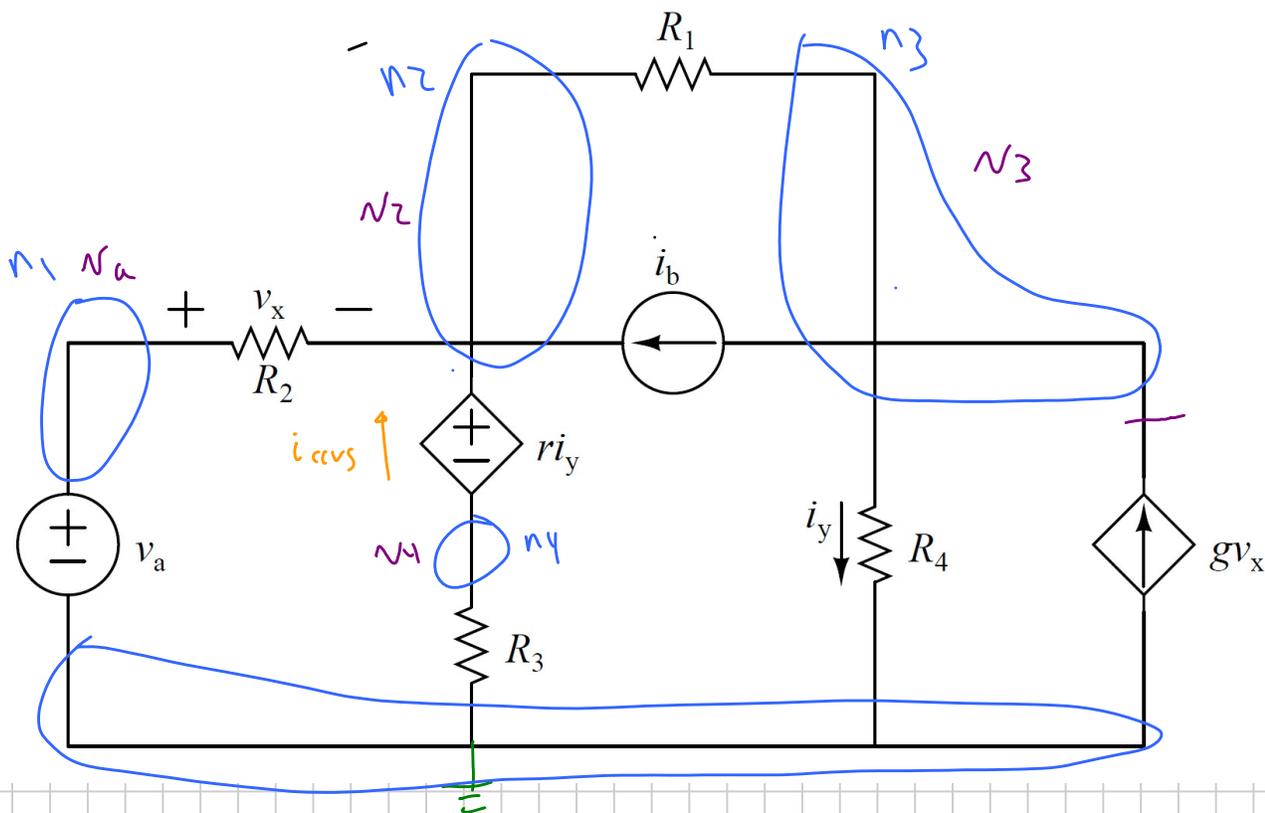
$$p_{abs, R_2} = p_{abs, R_3} = \frac{(v/2)^2}{R} = \frac{v^2}{4R} = \frac{1600}{24000} = \frac{1}{15} \text{ W}$$

Note: total $p_{abs} = \frac{4}{15} + \frac{1}{15} + \frac{1}{15} = \frac{6}{15} = 0.4 \checkmark$

4) $v_w = \frac{R_1}{R_1 + R_{234}} v_s$ $v_x = \frac{R_{234}}{R_1 + R_{234}} \frac{R_4}{R_2 + R_4} v_s$ $R_{234} = R_2 \parallel (R_3 + R_4)$

5) $i_y = \frac{R_3 \parallel (R_{145})}{R_{145}} i_p$ $i_z = \frac{R_2 \parallel (R_{145})}{R_4} i_p$ $R_{145} = (R_1 + R_5) \parallel R_4$
 or $-\frac{R_{145}}{R_4} i_y$

II



SEMI-LAZY LABELS; UNK: v_2 v_3 v_4 v_x i_b

KCL: 5 nodes - 1 - 2 v. src = 2

$$\text{KCL, } n_3: \frac{v_3 - v_2}{R_1} + i_b + \frac{v_3 - 0}{R_4} - g v_x = 0$$

$$\text{KCL, } n_2: \frac{v_2 - v_a}{R_2} + \frac{v_2 - v_3}{R_1} - i_b + \frac{v_4 - 0}{R_3} = 0$$

$$\text{SRC, } i_{ccvs}: r i_y = v_2 - v_4$$

$$\text{MEAS, } v_x: v_x = v_a - v_2$$

$$\text{MEAS, } i_y: i_y = \frac{v_3}{R_4}$$

$$(2) \quad p_{abs, R_3} = \frac{v_4^2}{R_3} = \frac{v_4^2}{R_3}$$

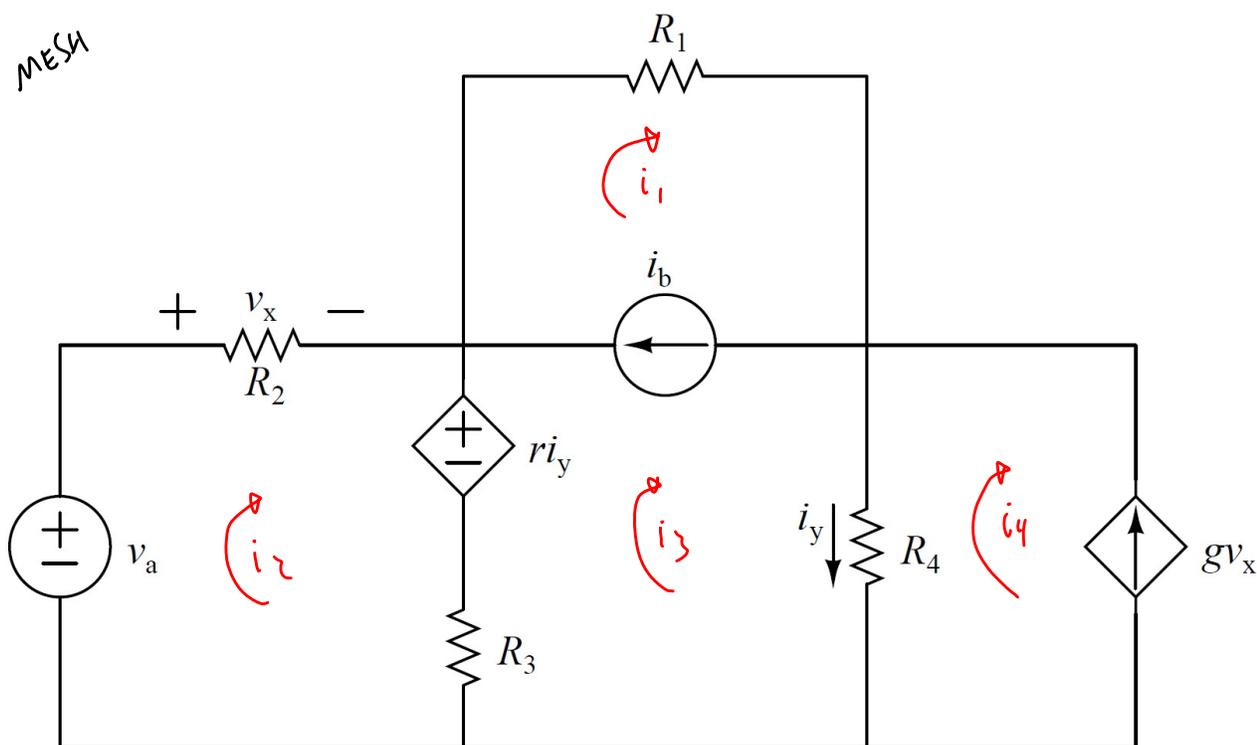
$p_{del, ccvs}$ need current through; KCL, n_4 easiest $i_{ccvs} = -v_4/R_3$

$$p_{del, ccvs} = (r i_y) (-v_4/R_3)$$

$$p_{del, vccs} = (v_3)(g v_x)$$

III

MESH



KVL: 4 mesh - 2 src = 2 KVL

Unk: $i_1, i_2, i_3, i_4, v_x, i_y$

KVL, i_2 : $-v_a + R_2 i_2 + r i_y + R_3 (i_2 - i_3) = 0$

KVL, i_3 : $R_3 (i_3 - i_2) - r i_y + R_1 i_1 + R_4 (i_3 - i_4) = 0$

SRC, i_b : $i_b = i_1 - i_3$

SRC, v_{ccs} : $g v_x = -i_y$

MEAS, v_x : $v_x = R_2 i_2$

MEAS, i_y : $i_y = i_3 - i_4$

(2) $P_{abs, R_3} = i^2 R = (i_2 - i_3)^2 R_3$

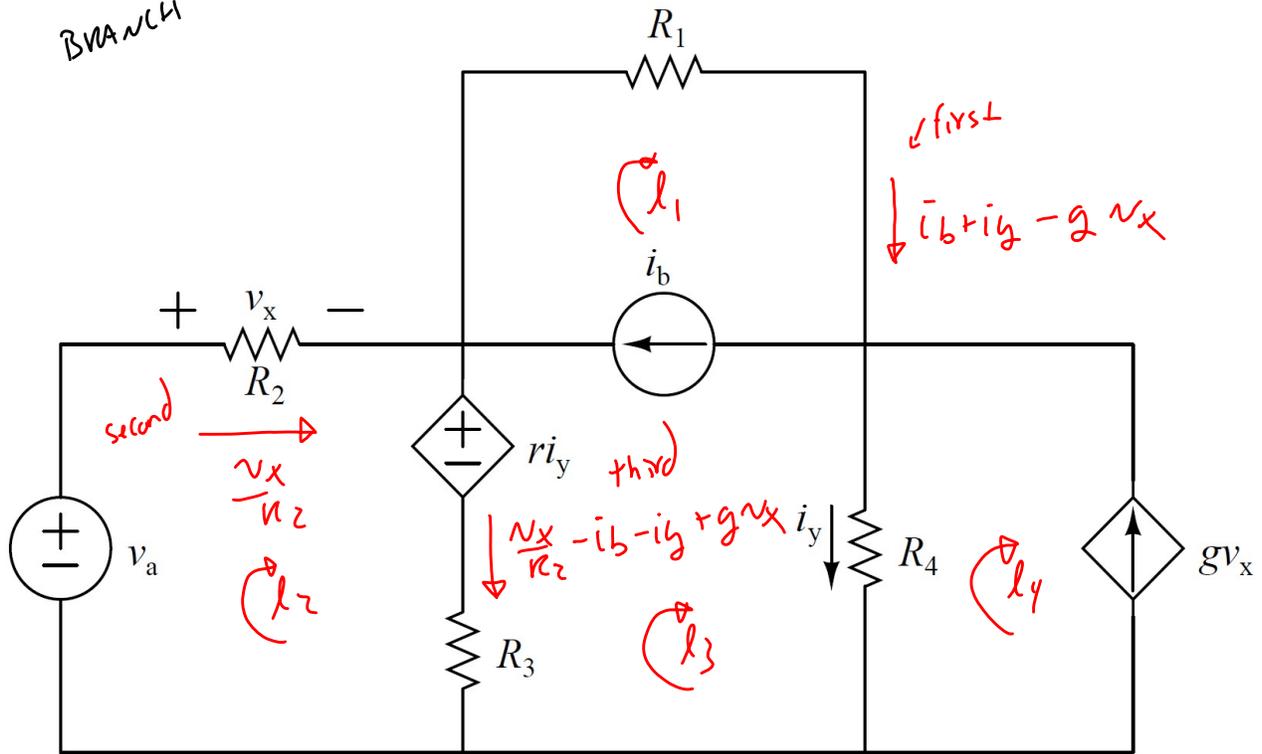
$P_{del, ccvs} = (r i_y)(i_3 - i_2)$

$P_{del, vccs}$ needs $v_{ccs} = R_4 i_y$ (in parallel w/ R_4)

$P_{del, vccs} = (R_4 i_y)(g v_x)$

III
alt

BRANCH



$$\# \text{KVL} = 4 \text{ mesh} - 2 \text{ isrc} = 2 \quad \text{unk: } i_y, v_x$$

$$\text{KVL, } l_2: -v_a + v_x + r i_y + R_3 \left(\frac{v_x}{R_2} - i_b - i_y + g v_x \right) = 0$$

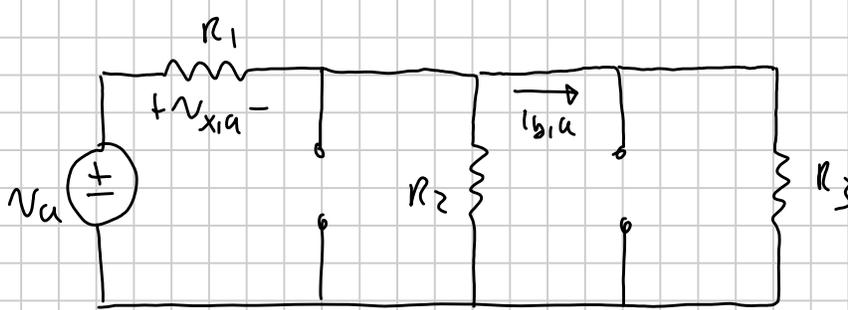
$$\text{KVL, } l_3: -R_3 \left(\frac{v_x}{R_2} - i_b - i_y + g v_x \right) - r i_y + R_1 (i_b + i_y - g v_x) + R_4 i_y = 0$$

$$P_{\text{abs}, R_3}: i^2 R = \left(\frac{v_x}{R_2} - i_b - i_y + g v_x \right)^2 R_3$$

$$P_{\text{del}, \text{cvcs}}: -r i_y \left(\frac{v_x}{R_2} - i_b - i_y + g v_x \right)^2$$

$$P_{\text{del}, \text{vcvs}}: R_4 i_y g v_x$$

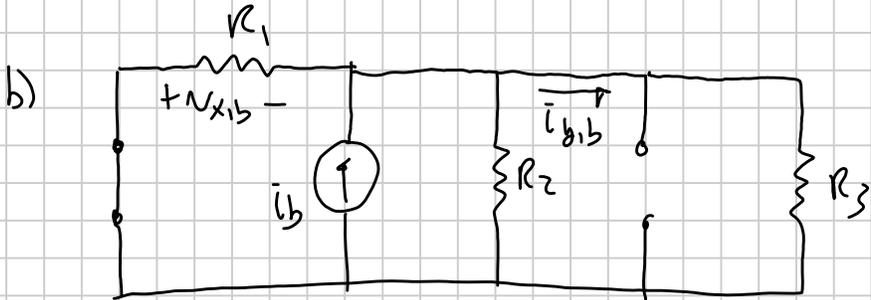
IV)



$$v_{x,a} = v_a \left(\frac{R_1}{R_1 + (R_2 \parallel R_3)} \right)$$

$$i_{y,a} = v_a \left(\frac{R_2 \parallel R_3}{R_1 + (R_2 \parallel R_3)} \right) \frac{1}{R_3}$$

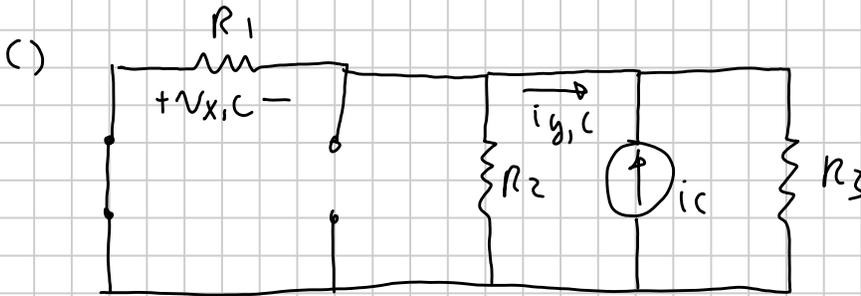
$$\text{or } \frac{v_a}{R_1 + (R_2 \parallel R_3)} \frac{R_2 \parallel R_3}{R_3}$$



(all in parallel)

$$v_{x,b} = -i_b (R_1 \parallel R_2 \parallel R_3)$$

$$i_{y,b} = i_b \frac{(R_1 \parallel R_2 \parallel R_3)}{R_3}$$



(all in parallel)

$$v_{x,c} = -i_c (R_1 \parallel R_2 \parallel R_3)$$

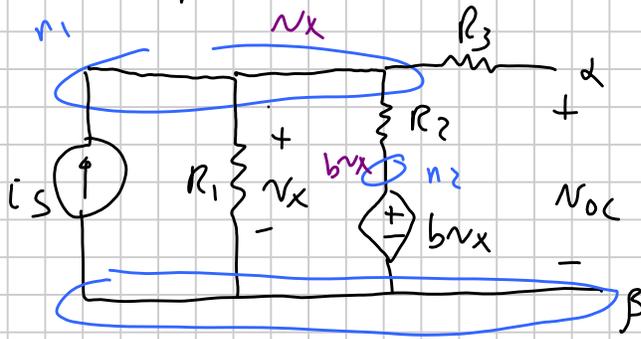
$$i_{y,c} = -i_c \frac{R_1 \parallel R_2 \parallel R_3}{R_3}$$

$$v_x = v_{x,a} + v_{x,b} + v_{x,c}$$

$$i_y = i_{y,a} + i_{y,b} + i_{y,c}$$

V) One indep. & one dep. var:

Find V_{oc} :

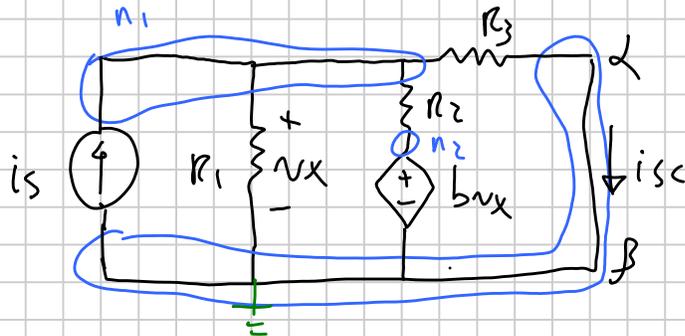


KCL, n_1 : $-i_s + \frac{v_x}{R_1} + \frac{v_x - b v_x}{R_2} = 0$ no current in R_3

$$v_x = \frac{i_s}{\frac{1}{R_1} + \frac{1-b}{R_2}} = \frac{R_1 R_2 i_s}{(1-b)R_1 + R_2}$$

$V_{oc} = v_x$ since no current in R_3 !

Find i_{sc}



KCL, n_1 : $-i_s + \frac{v_x}{R_1} + \frac{v_x - b v_x}{R_2} + \frac{v_x}{R_3} = 0$

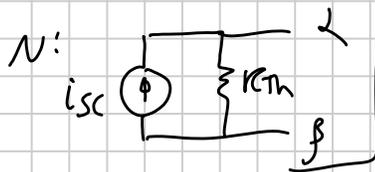
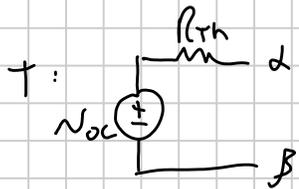
$$v_x = \frac{i_s}{\frac{1}{R_1} + \frac{1-b}{R_2} + \frac{1}{R_3}} = \frac{R_1 R_2 R_3 i_s}{R_1 R_2 + R_2 R_3 + R_1 R_3 (1-b)}$$

(note: different from above!)

$$i_{sc} = \frac{v_x}{R_3} = \frac{R_1 R_2 i_s}{R_1 R_2 + R_2 R_3 + R_1 R_3 (1-b)}$$

$$R_{th} = \frac{V_{oc}}{i_{sc}}$$

can leave this



(?) Max. pow. $R_L = R_{th}$, $P_{del} = \frac{(V_{oc}/2)^2}{R_L} = \frac{V_{oc}^2}{4R_{th}}$

Not Required, but:

$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{R_1 R_2 I_S}{(1-b)R_1 + R_2} \cdot \frac{R_1 R_2 + R_2 R_3 + R_1 R_3 (1-b)}{R_1 R_2 I_S}$$
$$= \frac{R_1 R_2 + R_2 R_3 + R_1 R_3 (1-b)}{(1-b)R_1 + R_2} = \frac{R_1 R_2}{(1-b)R_1 + R_2} + R_3$$

note - if $b=0$, $R_{th} = \frac{R_1 R_2}{R_1 + R_2} + R_3 = (R_1 || R_2) + R_3$

But ONLY if $b=0$