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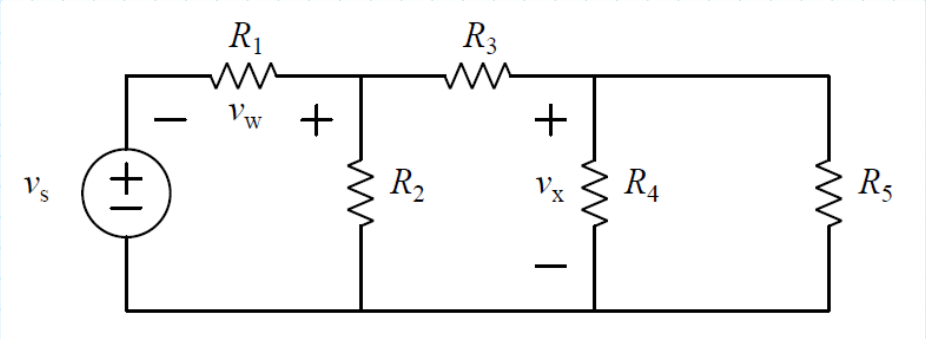
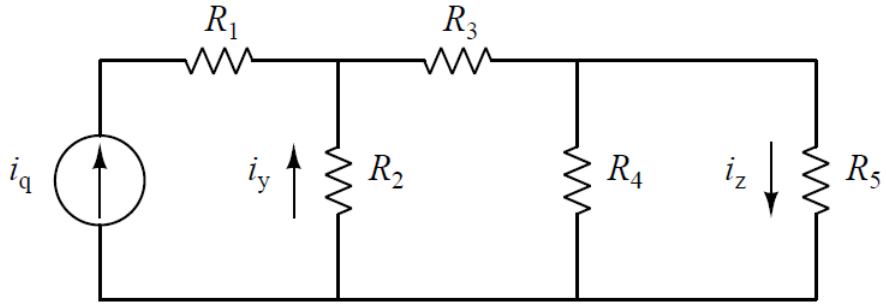
(1)



$R_{45} = R_4 \| R_5 \quad R_{345} = R_3 + R_{45} \quad R_{2345} = R_2 \| R_{345}$

$v_w = -\dfrac{v_s R_1}{R_1 + R_{2345}} \qquad v_x = \dfrac{v_s R_{2345}}{R_1 + R_{2345}} \dfrac{R_4 \| R_5}{R_3 + R_4 \| R_5}$

(2)

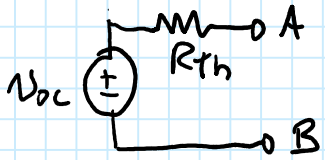


$R_{45} = R_4 \| R_5 \quad R_{345} = R_3 + R_{45} \quad R_{2345} = R_2 \| R_{345}$

NOTE: R_1 NOT INVOLVED IN DIVISION!

$i_y = -\dfrac{i_g (R_2 \| R_{345})}{R_2} \qquad i_z = \dfrac{i_g (R_2 \| R_{345})}{R_{345}} \dfrac{R_4 \| R_5}{R_5}$

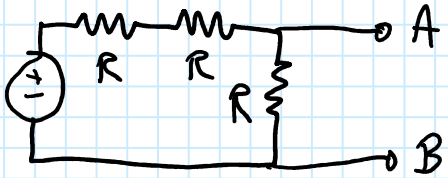
(3) $v_{oc} = 0.5\,V \quad i_{sc} = 375\,mA, \quad R_{Th} = \dfrac{v_{oc}}{i_{sc}} = 1333.\overline{3}\,\Omega$



(4) $R_L = R_{Th} = 1333.\overline{3}\,\Omega$

$P_{del} = v_{oc}^2 / 4R_L = 46.88\,\mu W$

(5) v_s



$R_{eq} = R \| 2R = \dfrac{2R}{3}$ ✓

$v_{oc} = \dfrac{v_s R}{3R}$ ✓

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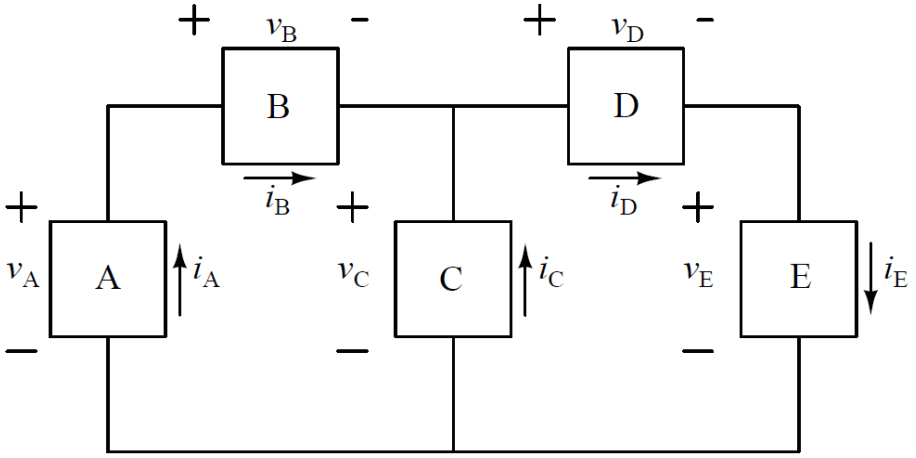

Element	Conv.	Voltage v, V	Current i, A	Power Absorbed p_{abs}, W
A	A	15	$i_A = i_B$ 3	$p = -vi$ −45
B	P	$-v_A + v_B = 0$ 5	3	$p = vi$ 15
C	A	$v = -p/i$ 10	$i_C = i_D - i_B$ −1	10
D	P	$-v_C + v_D = 0$ 12	2	$p = vi$ 24
E	P	-2	$i_E = i_D$ 2	$p = vi$ −4

CHECK: $\Sigma p_{abs} = -45 + 15 + 10 + 24 - 4 = 0$ ✓

KVL, left: $-v_A + v_B + v_C = -15 + 5 + 10 = 0$ ✓

KVL, right: $-v_C + v_D + v_E = -10 + 12 - 2 = 0$ ✓

KCL, top middle: $-i_B - i_C + i_D = -3 + 1 + 2 = 0$ ✓

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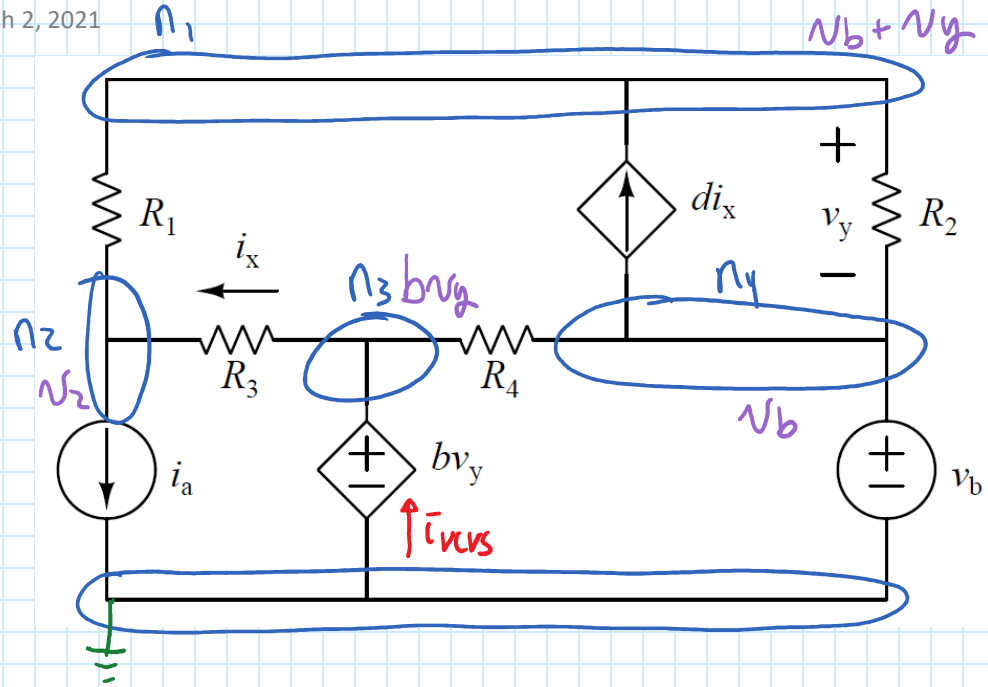

REALLY SMART:
$bV_y - R_3 i_x$
AND NO
NEED FOR

KCL = nodes − 1 − v.src = 5 − 1 − 2 = 2

UNK: V_2 V_y i_x (LAZY LABELS MAY ADD V_1, V_3, V_4)

KCL, n_1: $\frac{V_b + V_y - V_2}{R_1} - di_x + \frac{V_y}{R_2} = 0$

KCL, n_2: $\frac{V_2 - (V_b + V_y)}{R_1} - i_x + i_a = 0$

MEAS, i_x: $i_x = \frac{bV_y - V_2}{R_3}$

IF LAZY LABELS,
SRC, v_b: $V_b = V_4 - 0$
SRC, vcvs: $bV_y = V_3 - 0$
MEAS, V_y: $V_y = V_1 - V_4$

$P_{abs,R_4} = (bV_y - V_b)^2 / R_4$

$P_{del,ccvs} = di_x V_y$

$P_{del,vcvs} = i_{vcvs} \cdot bV_y$

KCL, n_3: $i_x + \frac{(bV_y - V_b)}{R_4} - i_{vcvs} = 0$

$i_{vcvs} = i_x + \frac{(bV_y - V_b)}{R_4}$

4 -MCM

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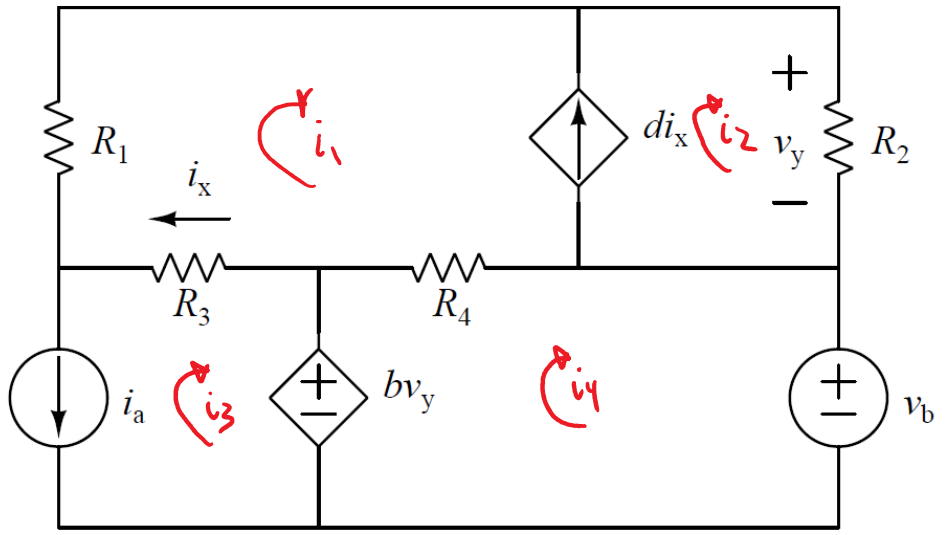

KVL = mesh − i.src = 4 − 2 = 2

UNK: i_1 i_2 i_3 i_4 i_x v_y

KVL, sl$_{12}$: $R_1 i_1 + R_2 i_2 + R_4(i_1 - i_4) + R_3(i_1 - i_3) = 0$

KVL, l$_4$: $-bv_y + R_4(i_4 - i_1) + v_b = 0$

SRC, i_a: $i_a = -i_3$

SRC, dix: $dix = i_2 - i_1$

MEAS, ix: $ix = i_1 - i_3$

MEAS, v_y: $v_y = R_2 i_2$

$p_{abs,R_4} = (i_1 - i_4)^2 R_4$

$p_{del,CCCS} = dix\, v_y$

$p_{del,VCVS} = bv_y (i_4 - i_3)$

4 -BCM

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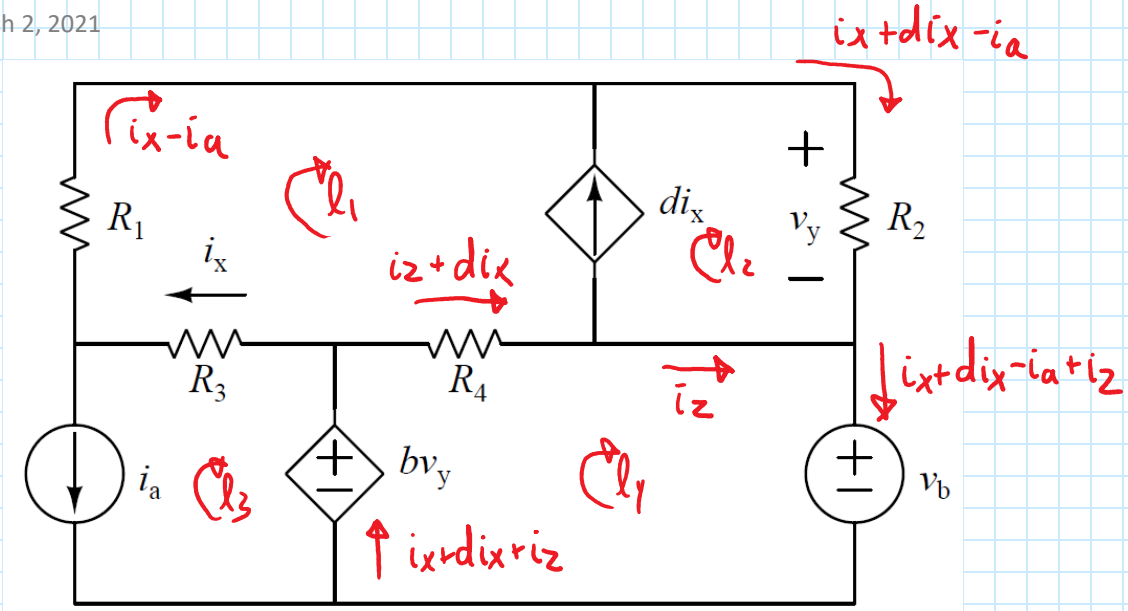

UNK: i_x, i_z, v_y

KVL, sl_{12}: $R_1(i_x - i_a) + R_2(i_x + di_x - i_a) - R_4(i_z + di_x) + R_3 i_x = 0$

KVL, l_4: $-bv_y + R_4(i_z + di_x) + v_b = 0$

MEAS, v_y: $v_y = R_2(i_x + di_x - i_a)$

$$P_{abs,R_4} = (i_z + di_x)^2 R_4$$

$$P_{del,CCCS} = di_x v_y$$

$$P_{del,VCVS} = (i_x + di_x + i_z)\, bv_y$$

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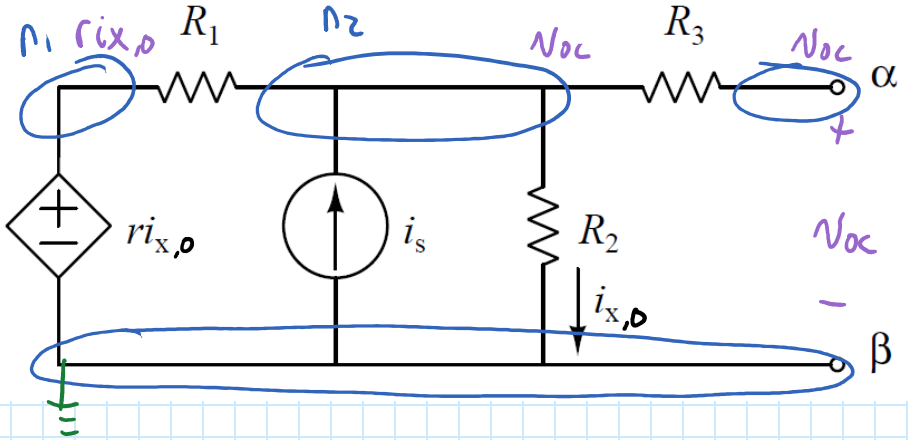
INDEP + DEP → FIND V_{oc}, i_{sc}, $R_{Th} = V_{oc}/i_{sc}$

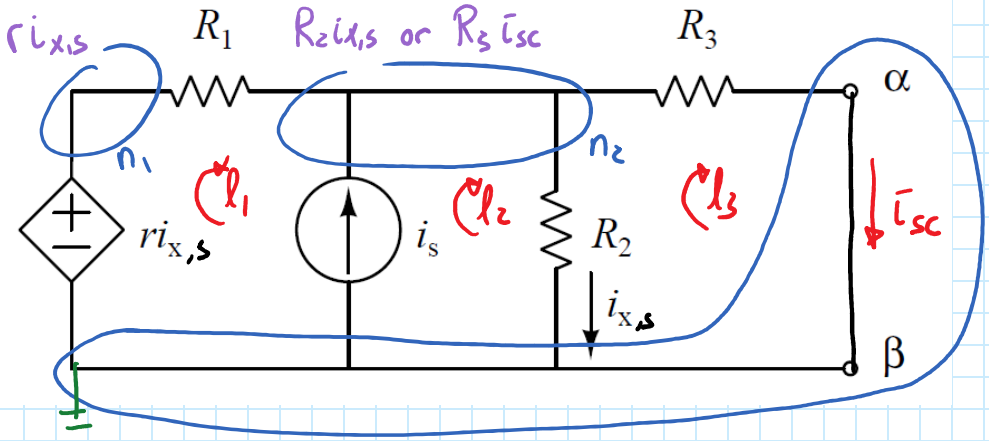


OHM'S LAW ON R_2: $R_2 i_{x,0} = V_{oc}$

KCL, n_2: $\dfrac{V_{oc} - r i_{x,0}}{R_1} - i_s + i_{x,0} = 0$ (SUBS & x R_1)

$R_2 i_{x,0} - r i_{x,0} - R_1 i_s + R_1 i_{x,0} = 0$

$i_{x,0} = \dfrac{R_1 i_s}{R_1 + R_2 - r}$ $\qquad V_{oc} = \dfrac{R_1 R_2 i_s}{R_1 + R_2 - r}$



KVL, l_3: $-R_2 i_{x,s} + R_3 i_{sc} = 0$ $\qquad i_{sc} = \dfrac{R_2 i_{x,s}}{R_3}$

KCL, n_2: $\dfrac{R_2 i_{x,s} - r i_{x,s}}{R_1} - i_s + i_{x,s} + \dfrac{R_2 i_{x,s}}{R_3} = 0$

5 - continued

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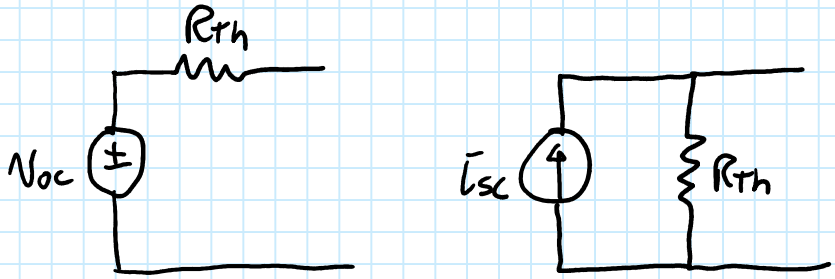
$$i_{x,s} = \frac{i_s}{\frac{R_2}{R_1} - \frac{r}{R_1} + 1 + \frac{R_2}{R_3}} = \frac{R_1 R_3 i_s}{R_2 R_3 - r R_3 + R_1 R_3 + R_1 R_2} \qquad i_{sc} = \frac{R_2 i_{x,s}}{R_3} = \frac{R_1 R_2 i_s}{R_1 R_2 + R_1 R_3 + R_2 R_3 - r R_3}$$

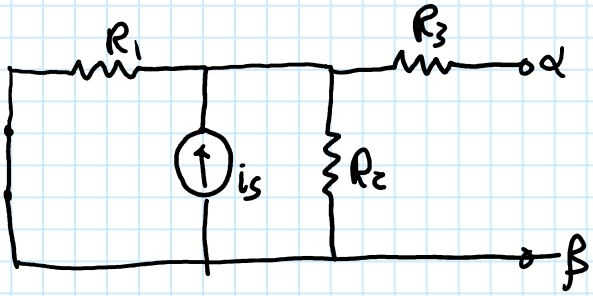
$$v_{oc} = \frac{R_1 R_2 i_s}{R_1 + R_2 - r} \qquad i_{sc} = \frac{R_1 R_2 i_s}{R_1 R_2 + R_1 R_3 + R_2 R_3 - r R_3}$$

$$R_{Th} = \frac{v_{oc}}{i_{sc}} = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3 - r R_3}{R_1 + R_2 - r} = R_3 + \frac{R_1 R_2}{R_1 + R_2 - r}$$



$$R_L = R_{Th} \qquad p_{del} = \frac{v_{oc}^2}{4 R_{Th}} = \frac{i_{sc}^2 R_{Th}}{4}$$

Check: if $r = 0$,



$$v_{oc} = \frac{R_1 R_2 i_s}{R_1 + R_2} = (R_1 \| R_2) i_s \quad \checkmark$$

$$i_{sc} = \frac{R_1 R_2 i_s}{R_1 R_2 + R_1 R_3 + R_2 R_3} = \frac{(R_1 \| R_2 \| R_3) i_s}{R_3} \quad \checkmark$$

$$R_{Th} = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_1 + R_2} = R_3 + \frac{R_1 R_2}{R_1 + R_2} = R_3 + (R_1 \| R_2) \quad \checkmark$$