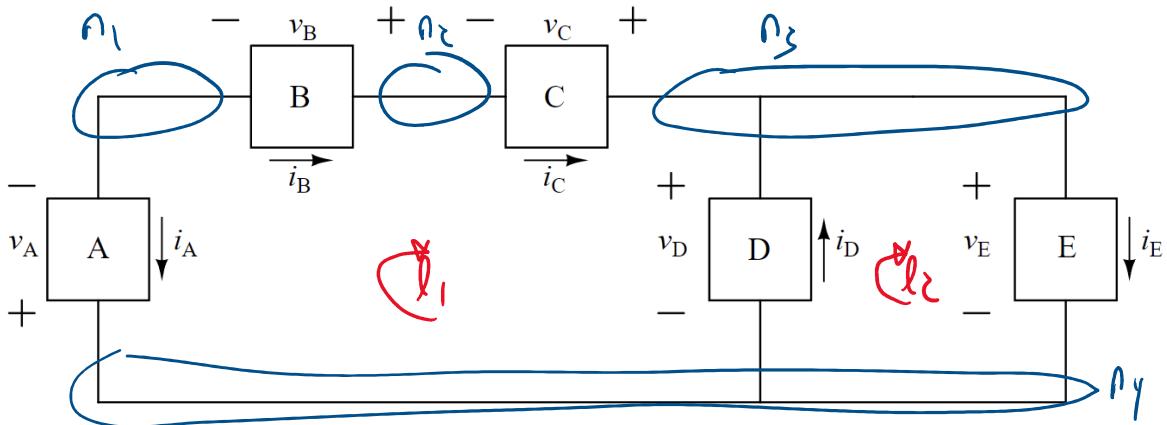


Name	Variable	Units	Equation
power	P	W	$v_i, \frac{dw}{dt}$
conductance	G	S, Σ	N/R
resistance	R	Ω	$\frac{\rho L}{A}, \frac{V}{I}$
work/energy	w	J	N/R
voltage	v	V	$\frac{dw}{dq}, iR$
charge	q	C	N/R
current	i	A	$\frac{dq}{dt}$

OK IF V^2/R or $i^2 R$

only one can
use $v = Ri$



Element	Conv.	Voltage v , V	Current i , A	Power Absorbed p_{abs} , W
A	A	10	-2	① 20 ②
B	A	23 ③	2	-46 ④
C	A	-8 ⑤	2	16 ⑥
D	A	5	-1 ⑦	5 ⑧
E	P	5 ⑨	1	5 ⑩

① BRANCH CURRENTS EQUAL: $i_A = -i_B$ $i_C = i_B$

② POWER EQUATIONS: $p_{abs,A} = -v_A i_A = 20$ $v_C = -p_{abs,C} / i_C = -8$

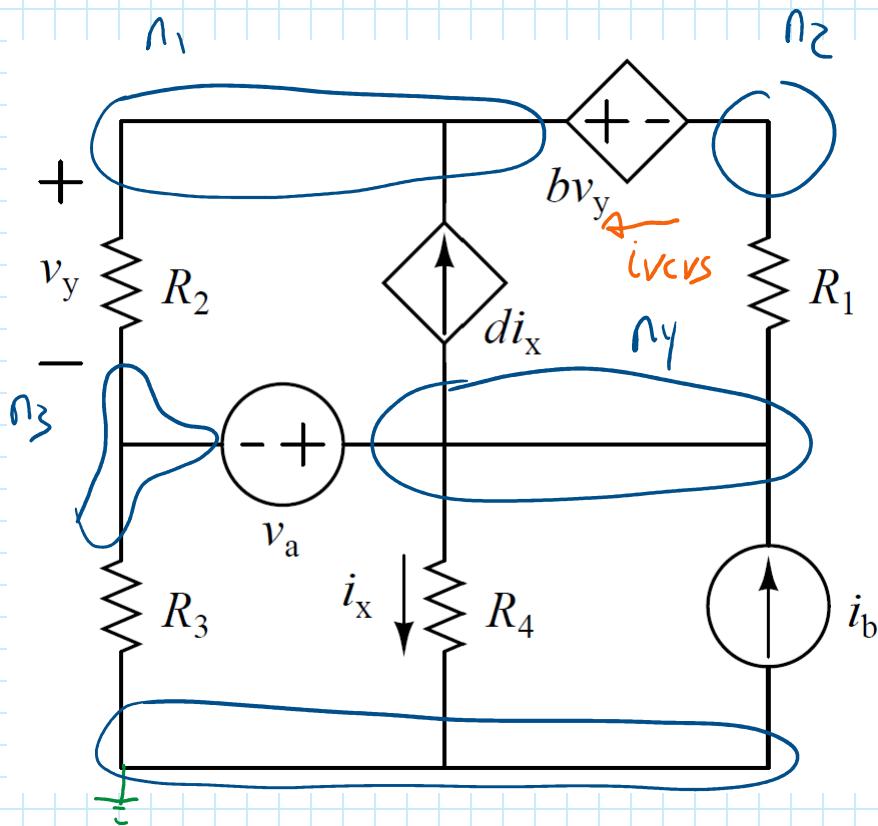
③ PARALLEL VOLTAGES ARE EQUAL: $v_B = v_D$

④ KCL, R_3 : $-i_C - i_D + i_E = 0$ $i_D = i_E - i_C = -1$

⑤ KVL, R_1 : $v_A - v_B - v_C + v_D = 0$ $v_B = v_A - v_C + v_D = 10 + 8 + 5 = 23$

⑥ $p_{abs,B} = -v_B i_B = -46$ $p_{abs,D} = -v_D i_D = 5$ $p_{abs,E} = v_E i_E = 5$

(CHECK: $\sum p_{abs} = 20 - 46 + 16 + 5 + 5 = 0 \checkmark$)



	n_1	n_2	n_3	n_4	UNK:
VLL / LL	V_{n_1}	V_{n_2}	V_{n_3}	V_{n_4}	$V_{n_1}, V_{n_2}, V_{n_3}, V_{n_4}, i_x, V_y$
SL	$V_{n_3} + V_y$	$V_{n_3}V_y - bV_y$	V_{n_3}	$V_{n_3} + V_a$	V_{n_3}, i_x, V_y
RSL	$R_{ix} - V_a + V_y - bV_y$	$R_{ix} - V_a + V_y - bV_y$	$R_{ix} - V_a$	$R_{ix}i_x$	i_x, V_y

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

$$\text{KCL}_{n_1, n_2}: \frac{V_{n_1} - V_{n_3}}{R_2} - di_x + \frac{V_{n_2} - V_{n_4}}{R_1} = 0$$

$$\text{KCL}_{n_3, n_4}: \frac{V_{n_3} - V_{n_1}}{R_2} + \frac{V_{n_3}}{R_3} + di_x + i_x + \frac{V_{n_4} - V_{n_2}}{R_1} - i_b = 0$$

$$\text{alt: KCL}_{n_1, n_2, n_3}: \frac{V_{n_3}}{R_3} + i_x - i_b = 0$$

$$\text{SRC, } V_a: V_a = V_{n_4} - V_{n_3}$$

$$\text{SRC, } V_{CVS}: bV_y = V_{n_1} - V_{n_2}$$

$$\text{MEAS, } V_y: V_y = V_{n_1} - V_{n_3}$$

$$\text{MEAS, } i_x: i_x = V_{n_4}/R_y \quad \rightarrow \text{FOR SL, VLL/LL}$$

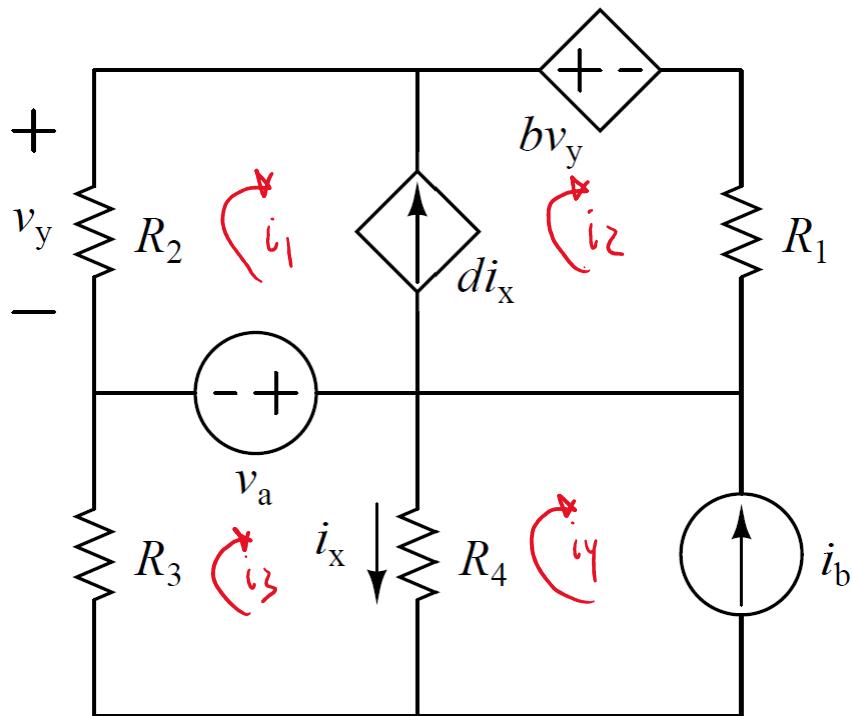
$$P_{abs, R_1} = \frac{(V_{n_2} - V_{n_4})^2}{R_1}$$

$$P_{diss, CCS} = di_x(V_{n_1} - V_{n_4})$$

$$P_{diss, V_{CVS}} = bV_y i_{CVS}$$

$$i_{CVS} = \frac{V_{n_4} - V_{n_2}}{R_1} \text{ or}$$

$$\frac{V_y}{R_2} - di_x$$



UNK: $i_1, i_2, i_3, i_4, i_x, V_y$

KVL = 4 mesh - 2 src = 2

$$\text{KVL}_1, \text{sk}_1: R_2 i_1 + bV_y + R_1 i_2 + V_a = 0$$

$$\text{KVL}_2, \text{lk}_3: R_3 i_3 - V_a + R_4 (i_3 - i_4) = 0$$

$$\text{SRC } i_b: i_b = -i_4$$

$$\text{SRC, cccs: } di_x = i_2 - i_1$$

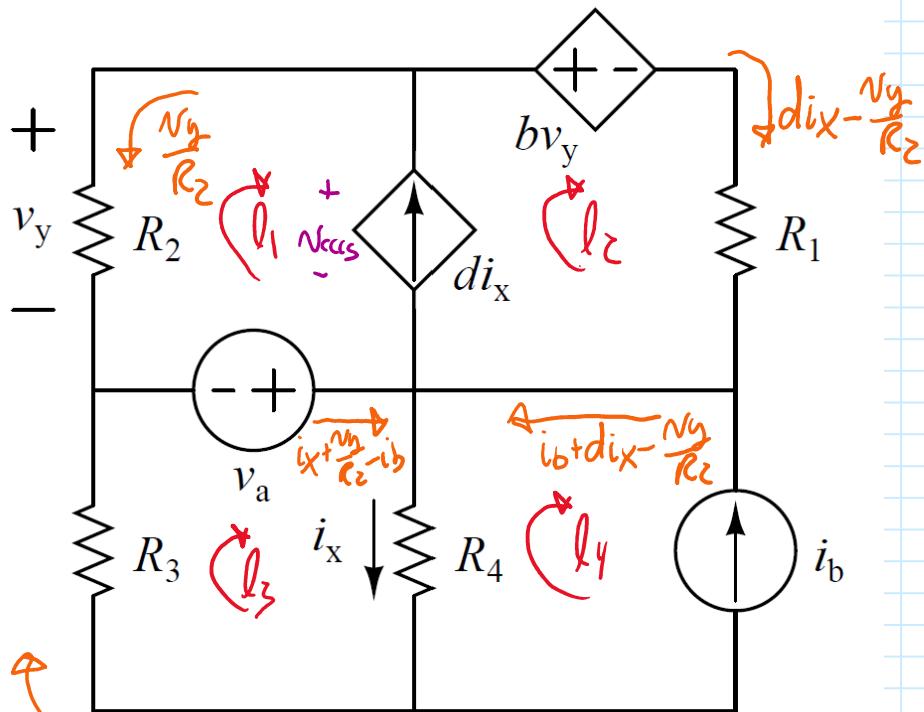
$$\text{MEAS, } i_x: i_x = i_3 - i_4$$

$$\text{MEAS, } V_y: V_y = -R_2 i_1$$

$$P_{abs, R_1} = (i_2)^2 R_1$$

$$P_{del, \text{cccs}} = di_x (V_y - V_a) = di_x (bV_y + R_1 i_2)$$

$$P_{del, \text{Vcvs}} = -bV_y i_2$$

 $i_x - i_b$ unk: i_x, v_y

mesh -> i_src = 2 KVL

$$\text{KVL}_1, l_3: R_3(i_x - i_b) - v_a + R_4 i_x = 0$$

$$\text{KVL}_2, l_2: -v_y + b v_y + R_1(dix - \frac{v_y}{R_2}) + v_a = 0$$

$$P_{\text{abs}, R_1}: (dix - \frac{v_y}{R_2})^2 R_1$$

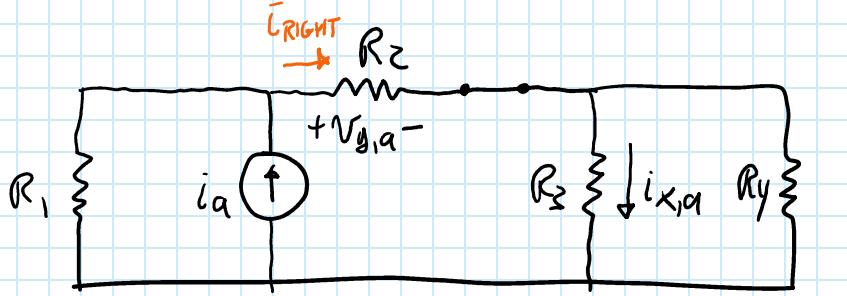
$$P_{\text{abs}, \text{CCCS}}: dix v_{\text{CCCS}}$$

$$\text{KVL}_3, l_1: -v_y + v_{\text{CCCS}} + v_a = 0 \quad \text{or} \quad -v_{\text{CCCS}} + b v_y + R_1(dix - \frac{v_y}{R_2}) = 0$$

$$v_{\text{CCCS}} = v_y - v_a \quad v_{\text{CCCS}} = b v_y + R_1(dix - \frac{v_y}{R_2})$$

$$P_{\text{abs}, \text{VCVS}}: v_a (i_x + \frac{v_y}{R_2} - i_b)$$

5

 i_a :

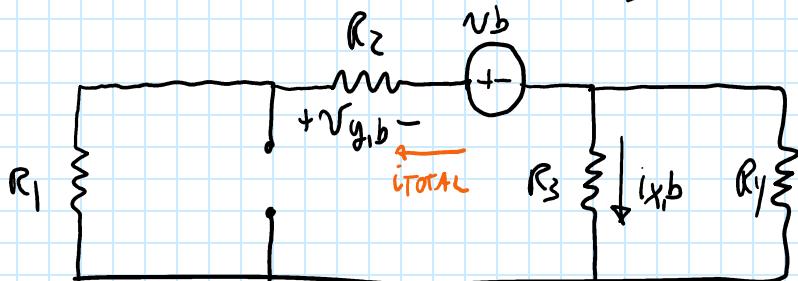
$$i_{me} = i_{tot} \frac{R_{eg}}{R_{me}} \text{ or}$$

$$\frac{i_{tot} R_{eg}}{R_{me} + R_{other}}$$

$$R_{34} = R_3 \parallel R_y \quad R_{234} = R_2 + R_{34} \quad R_{eg} = R_1 \parallel R_{234}$$

$$i_{RIGHT} = \frac{i_a R_1}{R_{234}} = \frac{i_a R_1}{R_1 + R_{234}}$$

$$V_{g,a} = R_2 i_{RIGHT} \quad i_{x,a} = \frac{i_{RIGHT} R_{34}}{R_3} = \frac{i_{RIGHT} R_4}{R_3 + R_y}$$

 V_b :

$$R_{34} = R_3 \parallel R_y \quad R_{eg} = R_1 + R_2 + R_{34}$$

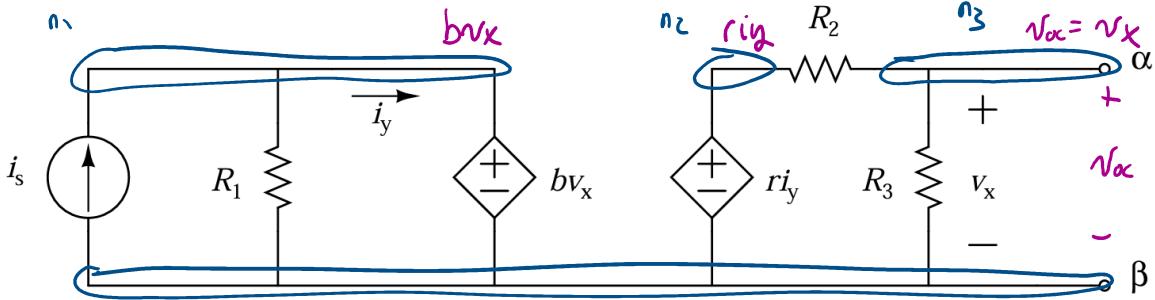
$$V_{g,b} = -\frac{V_b R_2}{R_{eg}}$$

$$i_{TOTAL} = \frac{V_b}{R_{eg}}$$

$$i_{x,b} = -\frac{i_{TOTAL} R_{34}}{R_3} = \frac{-i_{TOTAL} R_4}{R_3 + R_y}$$

$$\text{or: } \underbrace{\frac{-V_b (R_3 \parallel R_y)}{R_{eg}}}_{\text{VOLTAGE ACROSS } R_3 \parallel R_y} \cdot \underbrace{\frac{1}{R_3}}_{\text{OHM'S LAW}}$$

VOLTAGE ACROSS $R_3 \parallel R_y$ OHM'S LAW



$$\text{KCL at } n_1: -i_s + \frac{b v_x}{R_1} + i_y = 0$$

$$\text{KCL at } n_3: \frac{v_x - r i_y}{R_2} + \frac{v_x}{R_3} = 0 \quad \text{or use division:}$$

$$(R_2 + R_3) v_x = r R_3 i_y$$

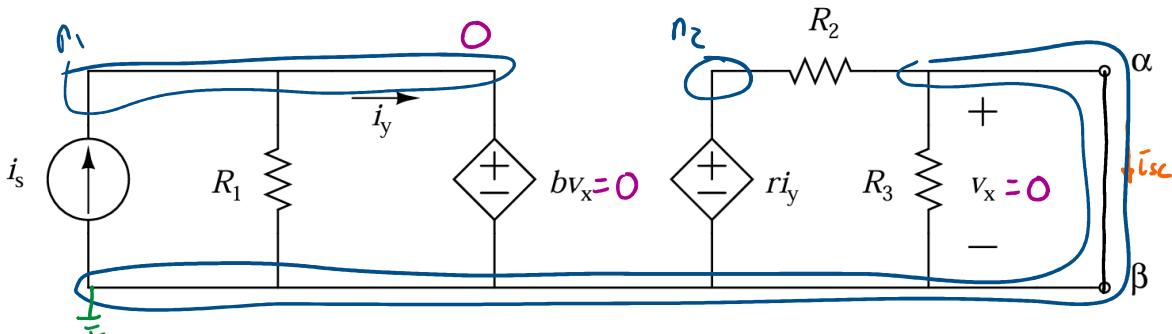
$$i_y = \frac{(R_2 + R_3) v_x}{r R_3}$$

$$v_x = \frac{r R_3 i_s}{(R_2 + R_3) + r R_3}$$

$$-i_s + \frac{b v_x}{R_1} + \frac{(R_2 + R_3) v_x}{r R_3} = 0$$

$$(b r R_3 + R_1 R_2 + R_1 R_3) v_x = r R_1 R_3 i_s$$

$$v_x = V_{OC} = \frac{r R_1 R_3 i_s}{b r R_3 + R_1 R_2 + R_1 R_3}$$



$$\text{KCL at } n_1: -i_s + \frac{i_y}{R_1} + i_y = 0 \quad i_y = i_s$$

$$\text{Ohm's } R_2: \frac{r i_y}{R_2} = i_{sc} \quad i_{sc} = \frac{r i_s}{R_2}$$

* $v_x = 0$ DUE TO SHORT CIRCUIT

$$R_{Th} = \frac{V_{OC}}{i_{sc}} = \frac{r R_1 R_3 i_s}{b r R_3 + R_1 R_2 + R_1 R_3} \quad \frac{R_2}{r i_s} = \frac{R_1 R_2 R_3}{b r R_3 + R_1 R_2 + R_1 R_3}$$

$$\text{Max p: } R_L = R_{Th} \quad P_{max} = \frac{V_{OC}^2}{4 R_{Th}} = \frac{i_{sc}^2 R_{Th}}{4}$$

