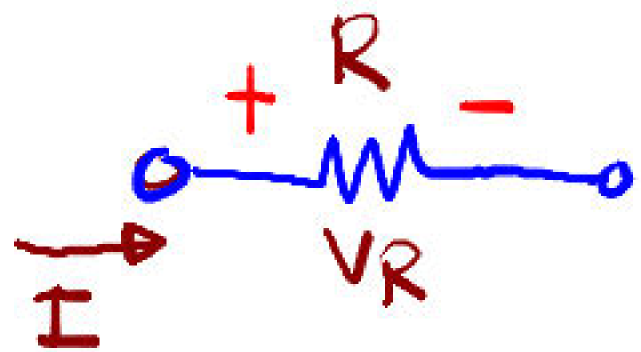
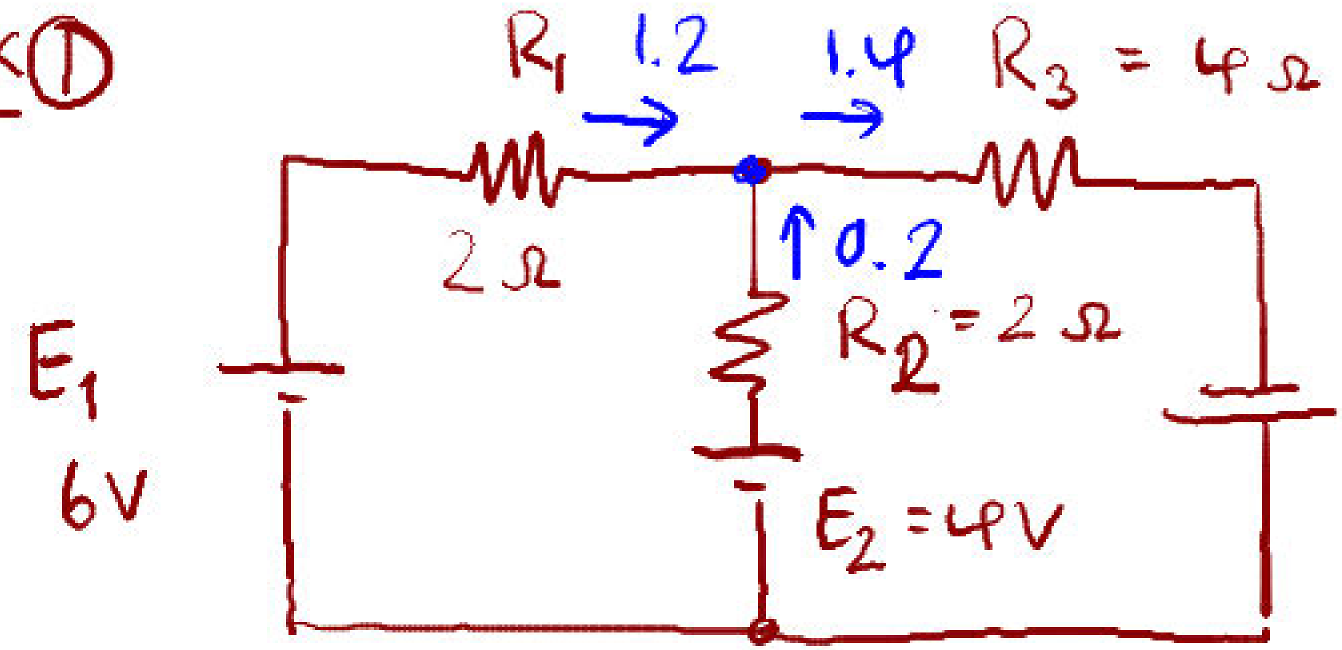
สรุป Loop Analysis

1. สมมติให้กระแสไหลตามเข็มนาฬิกา
2. กำหนดขั้วของแรงดันที่ตกคร่อมตัวต้านทานทุกตัว ตามทิศทางของกระแสที่ไหลผ่าน



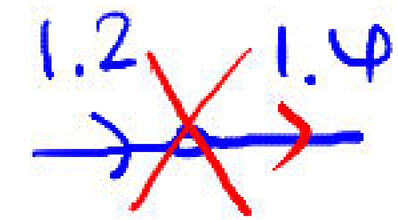
3. เขียนสมการ KVL ในแต่ละ Loop
4. สมการเส้นตรง (โดยใช้ Matrix)
5. ได้คำตอบ

Ex 1



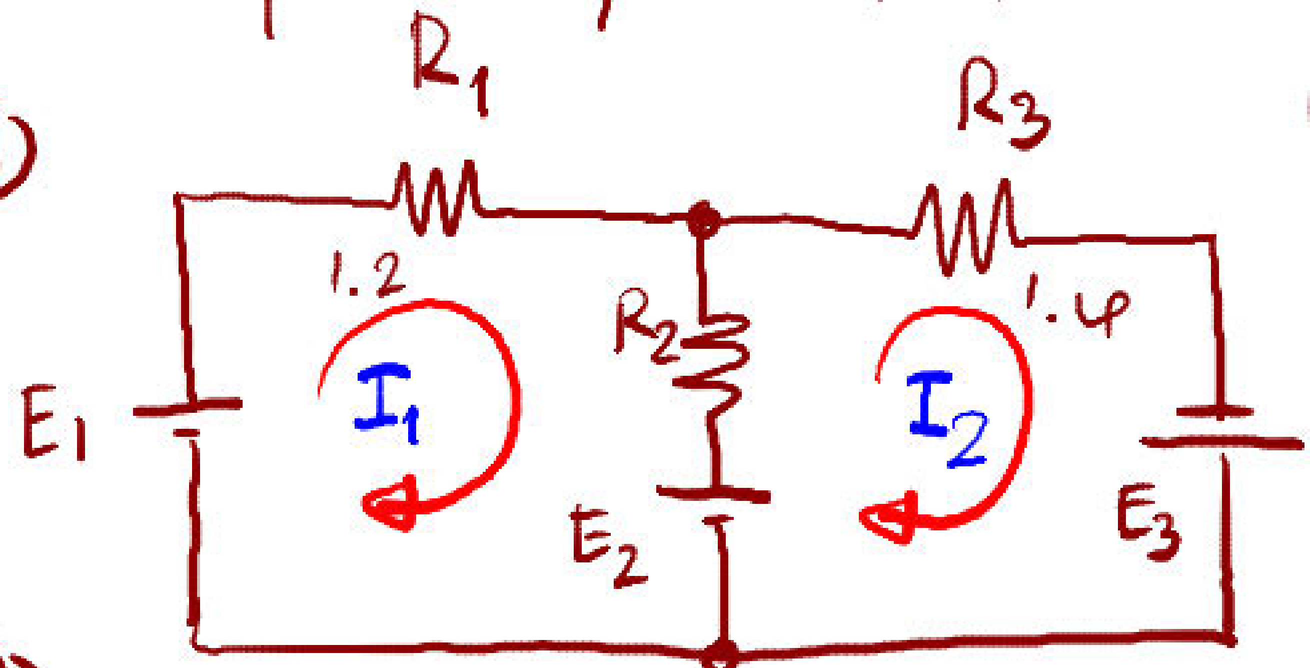
2

{ KVL ⇒ $\Sigma V = 0$
{ KCL ⇒ $\Sigma I = 0$

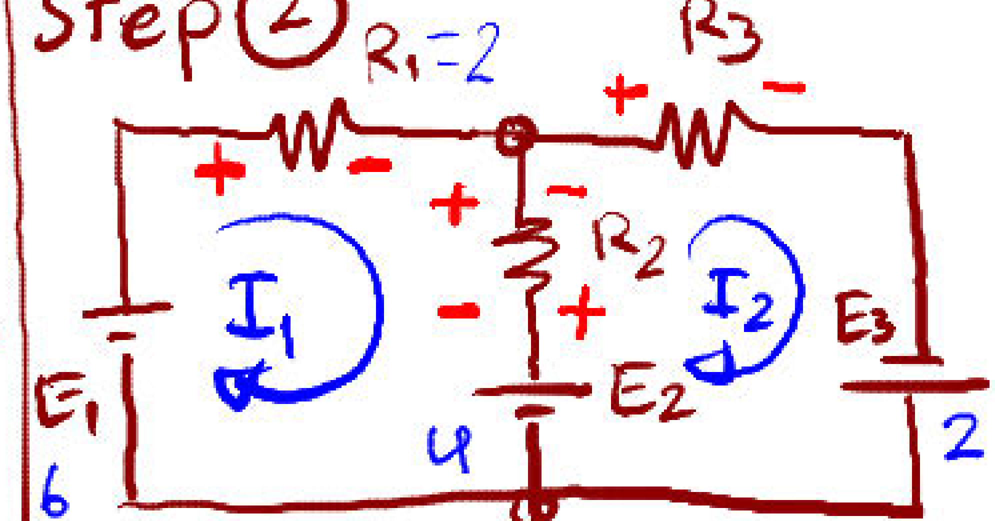


จงใช้ Loop Analysis เพื่อหา กระแสที่ไหลผ่าน R ทุกตัว

step 1



Step 2



step 3

Loop 1:

$6V - 2I_1 - 2I_1 + 2I_2 - 4V = 0$

Loop 2:

$4 + 2I_1 - 2I_2 - 4I_2 + 2 = 0$

Step 3

Loop 1:

$$4I_1 - 2I_2 = 2\ V \quad (1) \qquad \left\{ 6 - 2I_1 - 2I_1 + 2I_2 - 4 = 0 \right.$$

Loop 2:

$$-2I_1 + 6I_2 = 6\ V \quad (2) \qquad \left\{ 4 + 2I_1 - 2I_2 - 4I_2 + 2 = 0 \right.$$

Step 4 แก้สมการ 2 ตัวแปร

(คูณลง − คูณขึ้น)

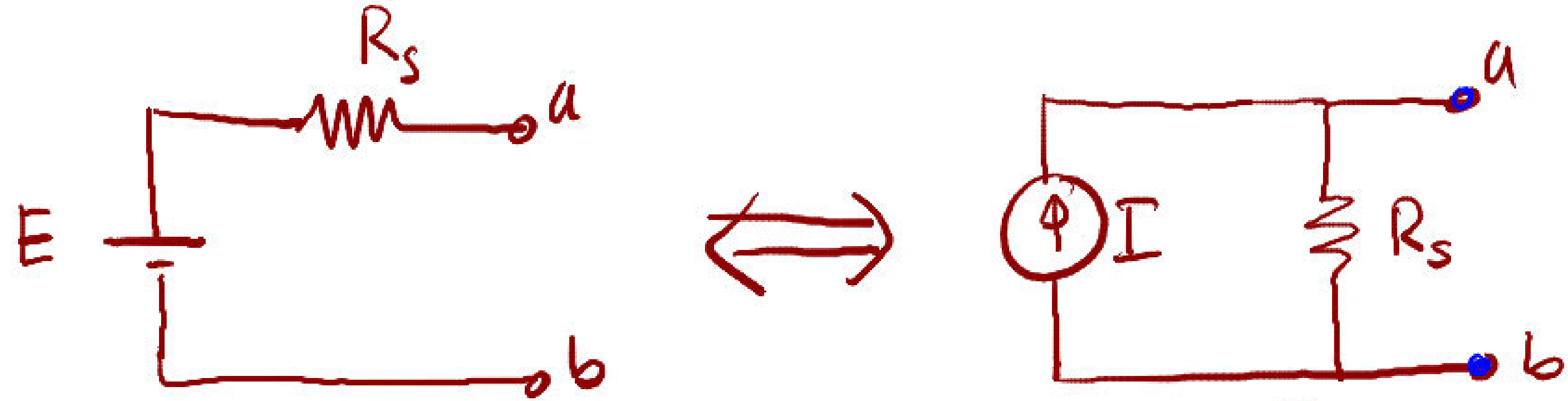
$$I_1 = \frac{\begin{vmatrix} 2 & -2 \\ 6 & 6 \end{vmatrix}}{\begin{vmatrix} 4 & -2 \\ -2 & 6 \end{vmatrix}} = \frac{12+12}{24-4} = 1.20\ A$$

$$I_2 = \frac{\begin{vmatrix} 4 & 2 \\ -2 & 6 \end{vmatrix}}{\begin{vmatrix} 4 & -2 \\ -2 & 6 \end{vmatrix}} = \frac{24+4}{24-4} = 1.40\ A$$

สรุป Node Analysis

1. กำหนด Reference (Ground)
2. ถ้ามี Voltage Source ให้เปลี่ยนเป็น * Current Source
3. กำหนด Node เพื่อหา $V_1, V_2 \ldots V_n$ ที่จุดอ้างอิง
4. กำหนดขั้วขวาแรงดันที่ตกคร่อม R ทุกตัว ตามทิศทางของกระแส
5. ใช้ KCL เขียนสมการ Node
6. แก้สมการ Node หา $V_1, V_2 \ldots V_n$

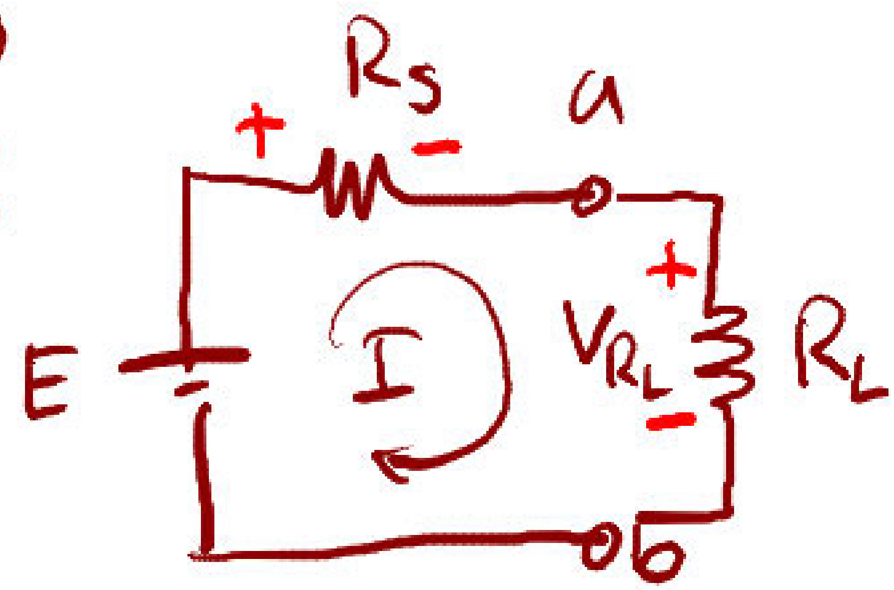
Source Conversion



$E = I R_s$

$I = \dfrac{E}{R_s}$

พิสูจน์

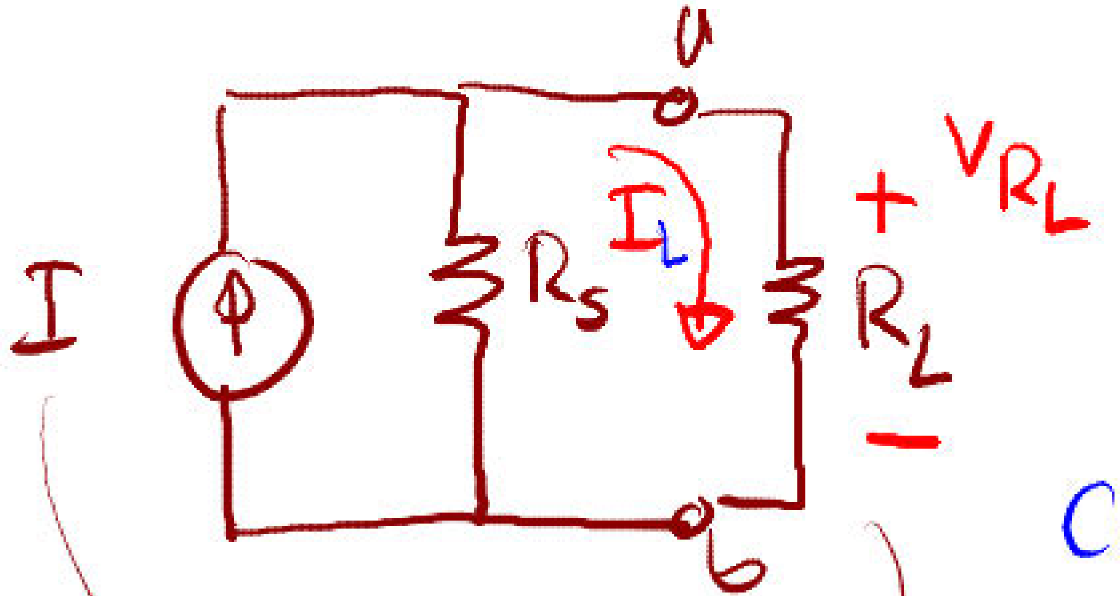


$$\boxed{V_{R_L} = \frac{R_L}{R_s + R_L} \cdot E}$$

voltage Divider

$$\boxed{I = \frac{E}{R_s + R_L}}$$

ohm's Law



$$\boxed{I_L = \frac{R_s}{R_s + R_L} \cdot I}$$

Current Divider

$$I = \frac{E}{R_s}$$

Ohm's Law

$$I_L = \left(\frac{\cancel{R_s}}{R_s + R_L} \right) \cdot \left(\frac{E}{\cancel{R_s}} \right)$$

$$\boxed{V_{R_L} = I_L \cdot R_L}$$

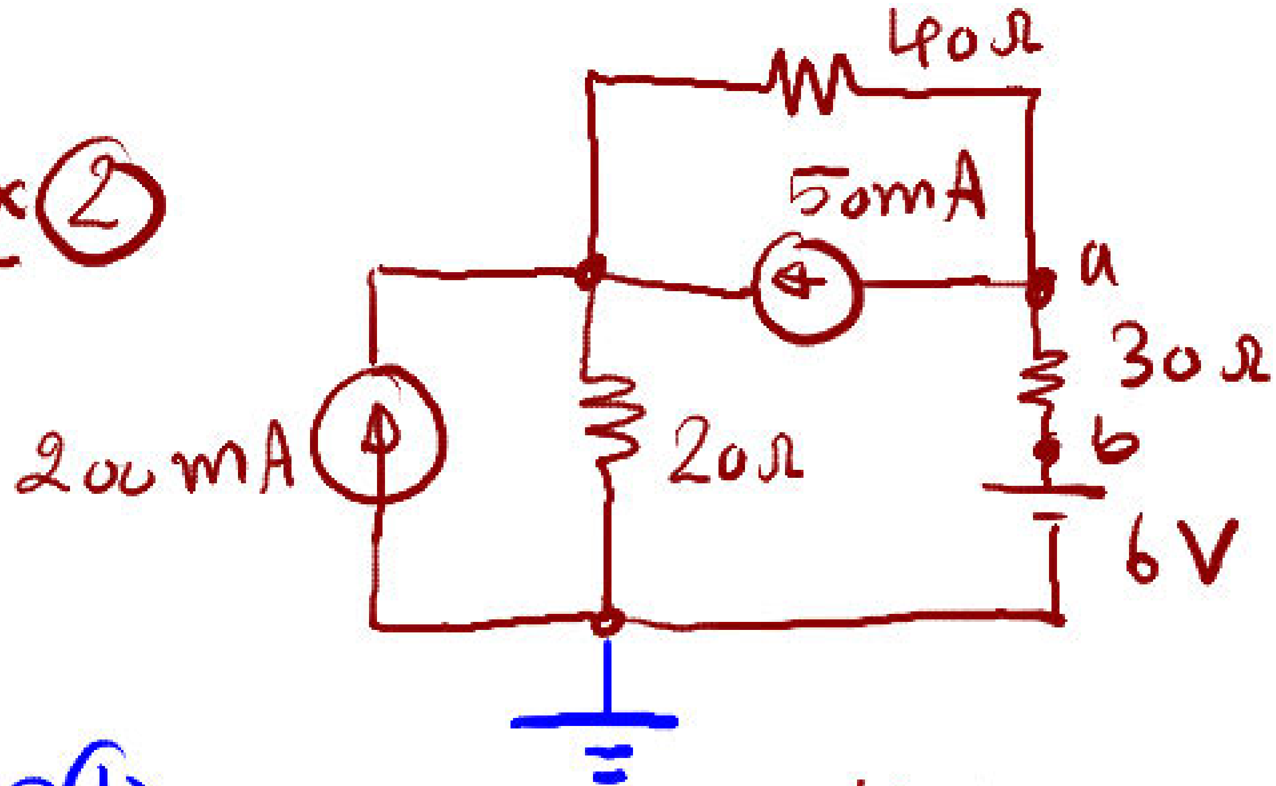
$$\boxed{I_L = \frac{E}{R_s + R_L}} \quad \checkmark$$

$$\boxed{V_{R_L} = \frac{E}{R_s + R_L} \cdot R_L} \quad \checkmark$$

Ex 2

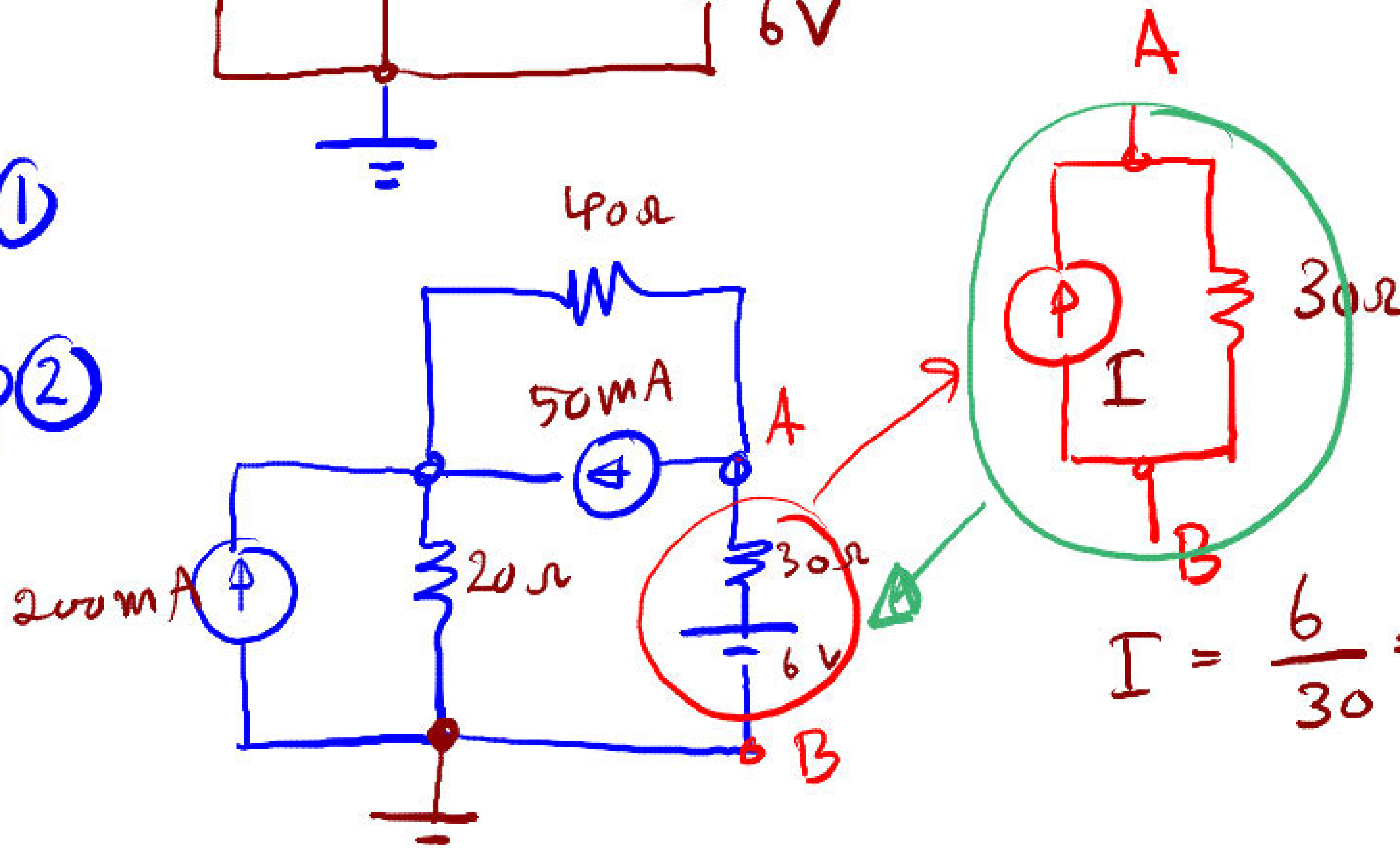
จงหา V_{ab}

ใช้ Node Analysis



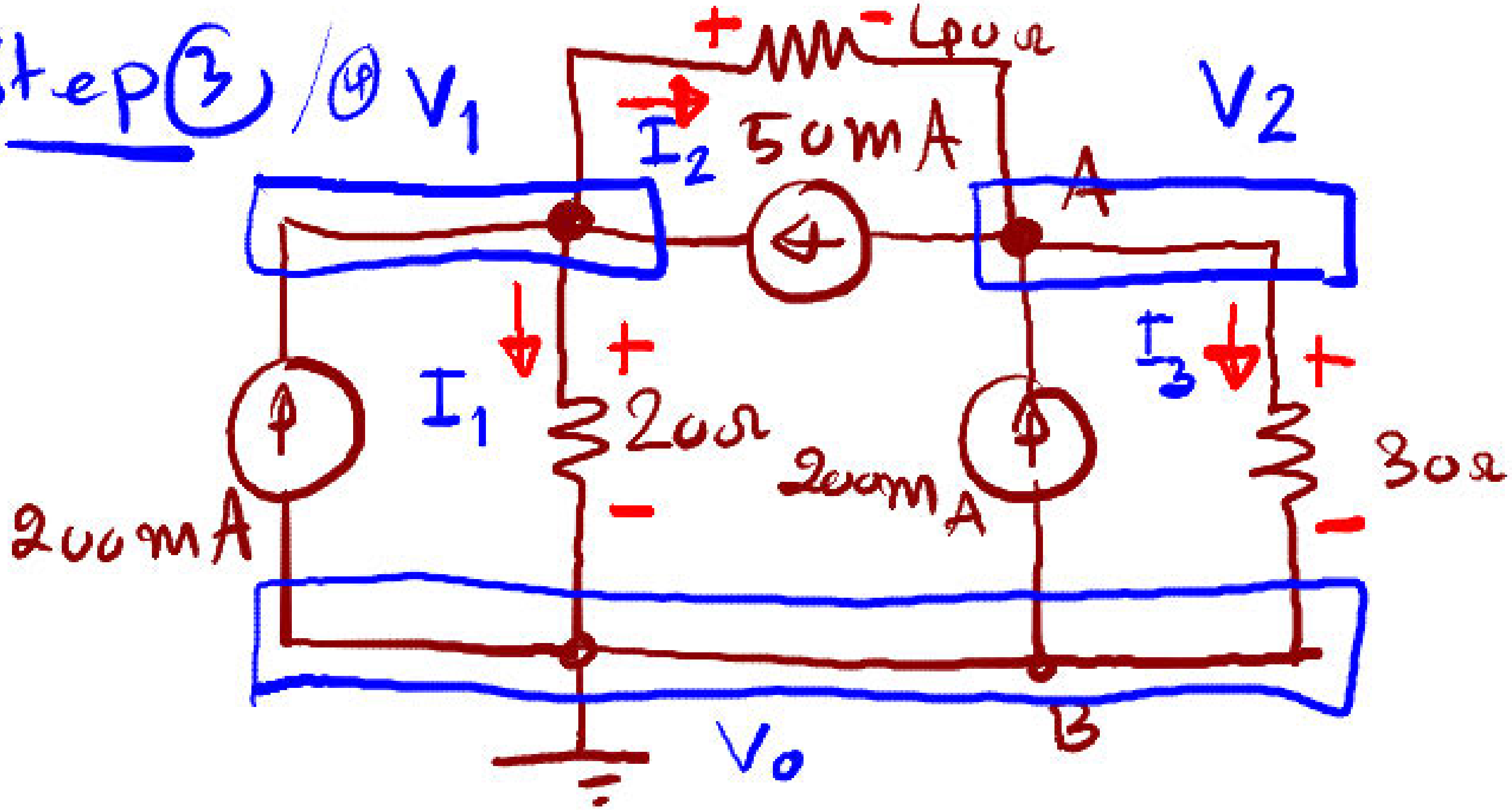
Step 1

Step 2



$$I = \frac{6}{30} = 200\,mA$$

Step 3 / 4



KCL = $\Sigma I = 0$

$I_{ไหลเข้า} = I_{ไหลออก}$

Step 5 ใช้ KCL กับ Node V1

Ohm's Law

$I_1 = \dfrac{V_1}{20}$

$I_2 = \dfrac{V_1 - V_2}{40}$

$I_3 = \dfrac{V_2}{30}$

$I_{เข้า} = I_{ออก}$

$200mA + 50mA = I_1 + I_2$ — ①

Node V2

$I_{เข้า} = I_{ออก}$

$200mA + I_2 = 50mA + I_3$ — ②

I_1, I_2, I_3 แทนใน ① และ ②

$$200\,mA + 50\,mA = \frac{V_1}{20} + \frac{V_1 - V_2}{40}$$

$$250\,mA = \frac{V_1}{20} + \frac{V_1}{40} - \frac{V_2}{40}$$

Node V_1

$$\boxed{250\,mA = \left(\frac{1}{20} + \frac{1}{40}\right)V_1 - \frac{V_2}{40}} \quad ③$$

Node V_2

$$200\,mA + \frac{V_1 - V_2}{40} = 50\,mA + \frac{V_2}{30}$$

$$150\,mA = -\frac{V_1}{40} + \frac{V_2}{40} + \frac{V_3}{30}$$

$$\boxed{150\,mA = -\frac{V_1}{40} + \left(\frac{1}{40} + \frac{1}{30}\right)V_2} \quad ④$$

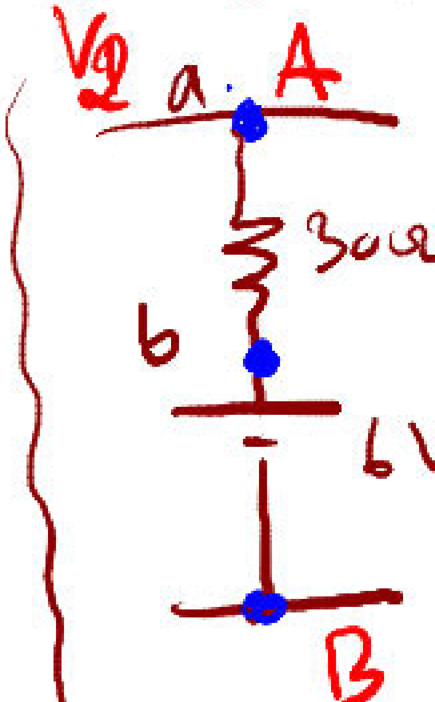
จาก③ $0.075V_1 - 0.025V_2 = 0.25$ — ⑤

จาก④ $-0.025V_1 + 0.0583V_2 = 0.15$ — ⑥

$$V_1 = \frac{\begin{vmatrix} 0.25 & -0.025 \\ 0.15 & 0.0583 \end{vmatrix}}{\begin{vmatrix} 0.075 & -0.025 \\ -0.025 & 0.0583 \end{vmatrix}} = 4.89\ V$$

$$V_2 = \frac{\begin{vmatrix} 0.075 & 0.25 \\ -0.025 & 0.15 \end{vmatrix}}{\begin{vmatrix} 0.075 & -0.025 \\ -0.025 & 0.0583 \end{vmatrix}} = 4.67\ V$$

โจทย์ถามหา V_{ab}

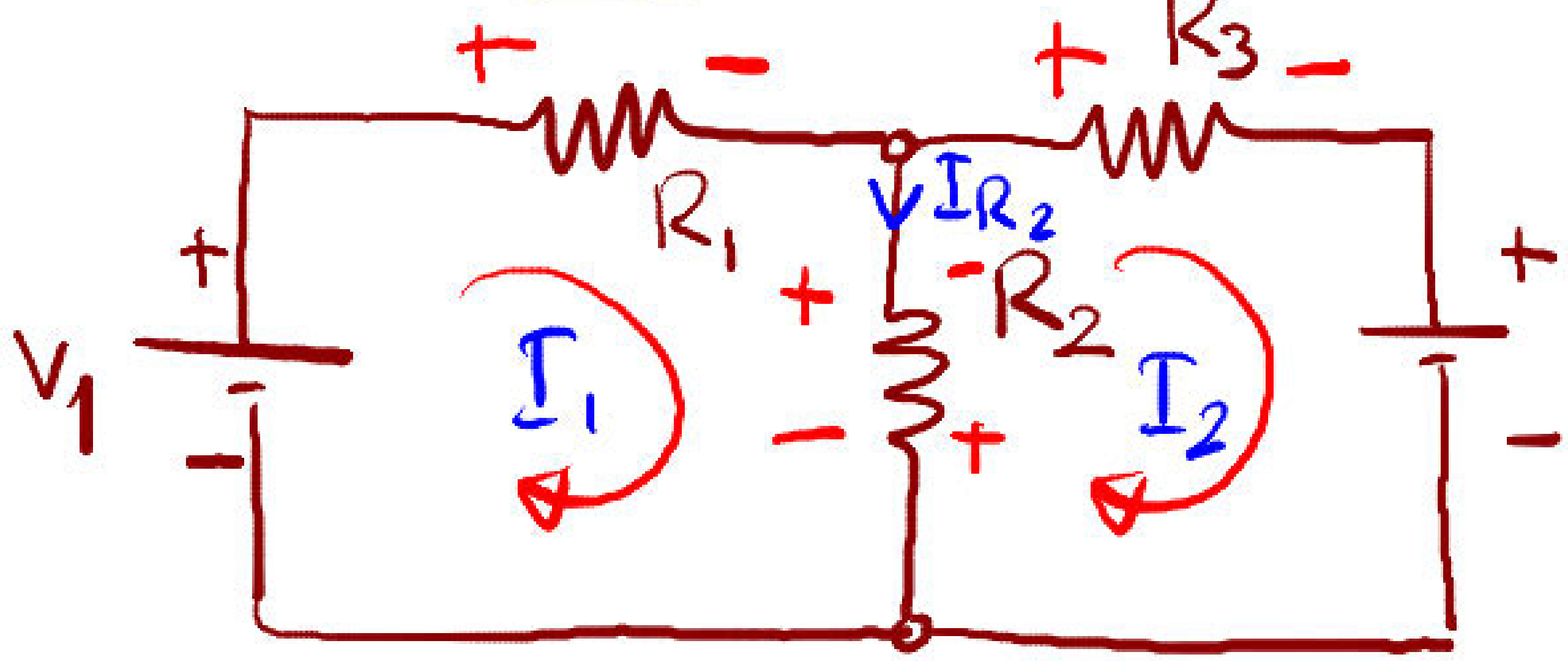


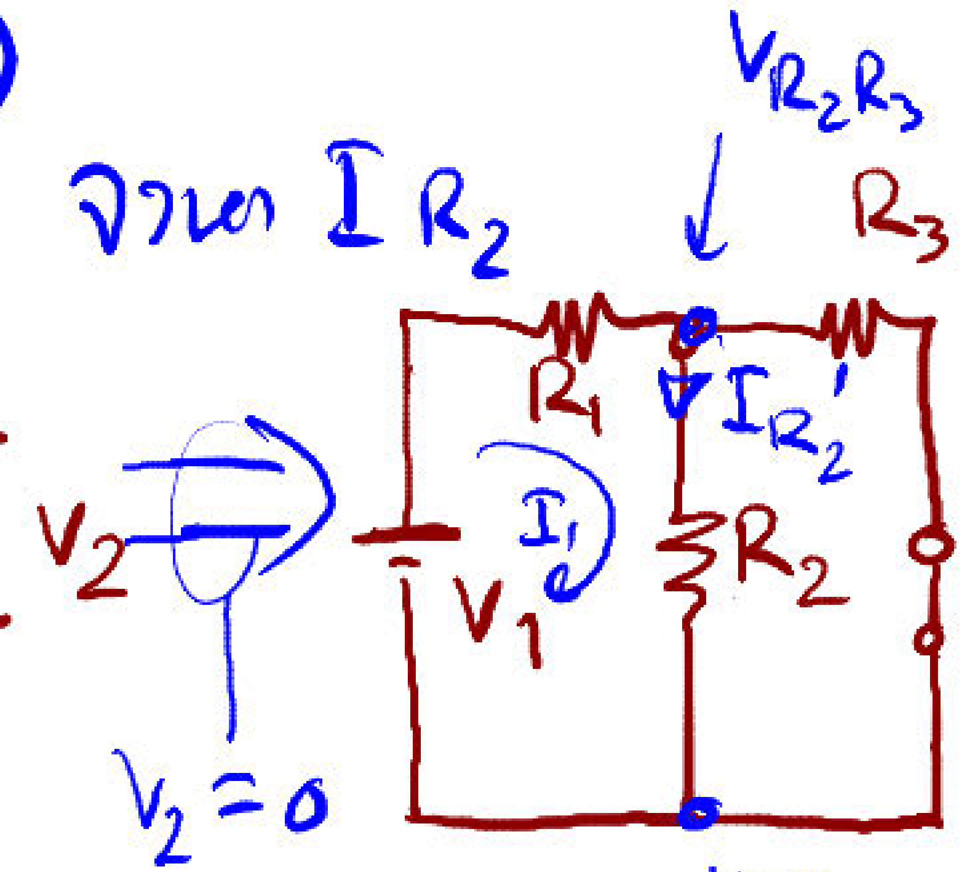
$V_2 = 4.67 = V_a$

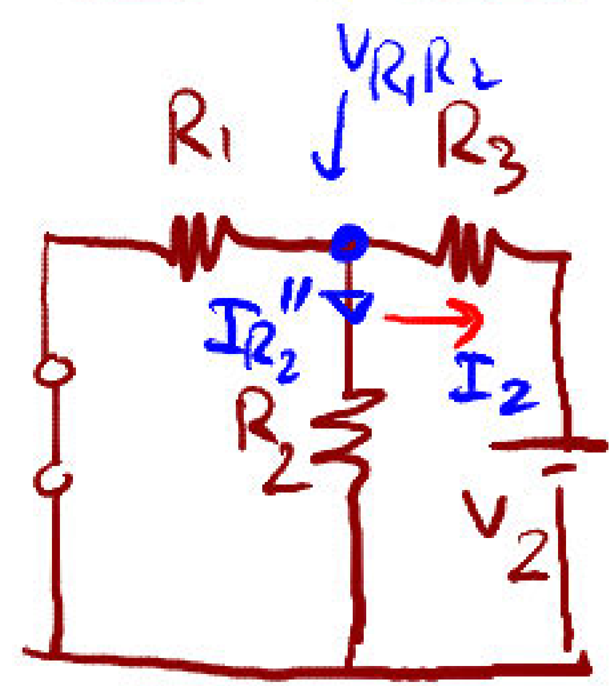
$V_{ab} = 4.67 - 6$

$= -1.33\ V$

Super position (การทับซ้อน)







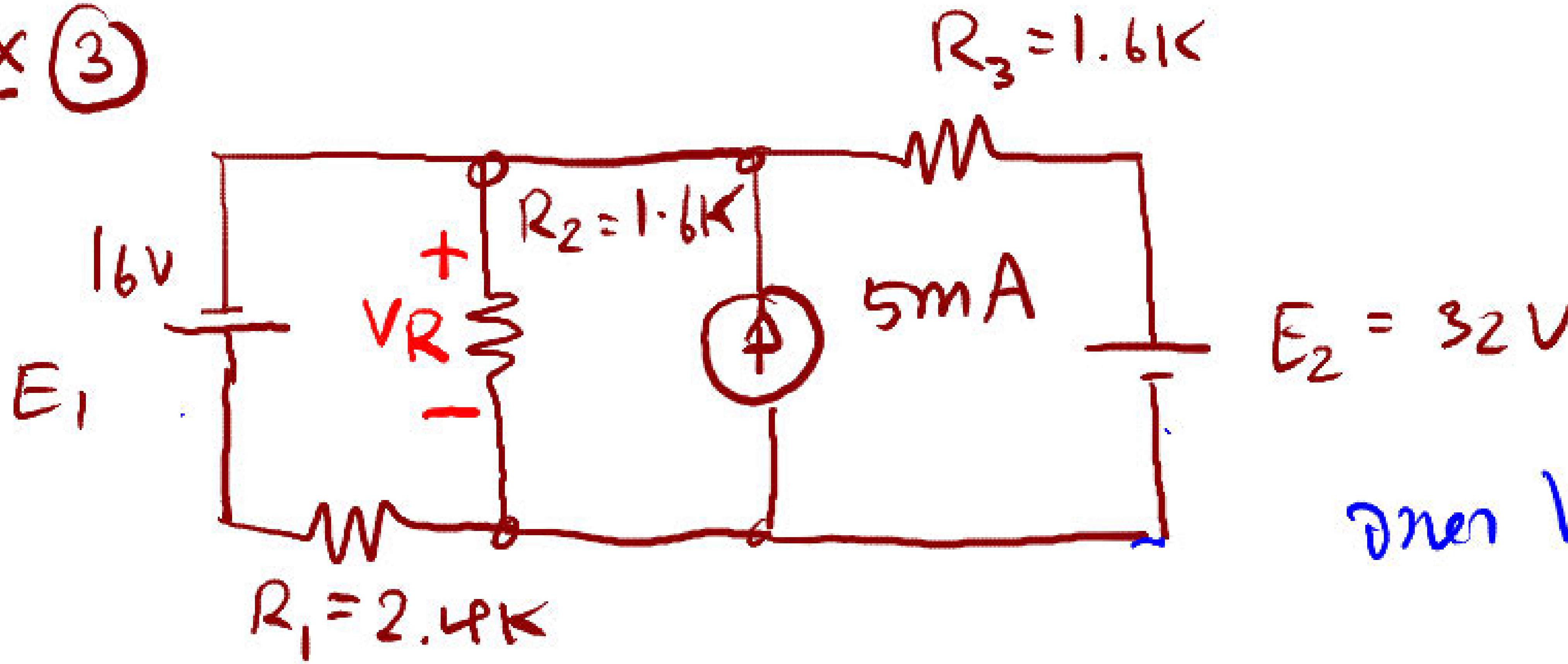
$$I_{R_2} = I_{R_2}' + I_{R_2}''$$

$$I_{R_2}' = \frac{V_{R_2R_3}}{R_2}, \quad V_{R_2R_3} = \frac{V_1 (R_2 // R_3)}{R_1 + (R_2 // R_3)}$$

$V_1 = 0$

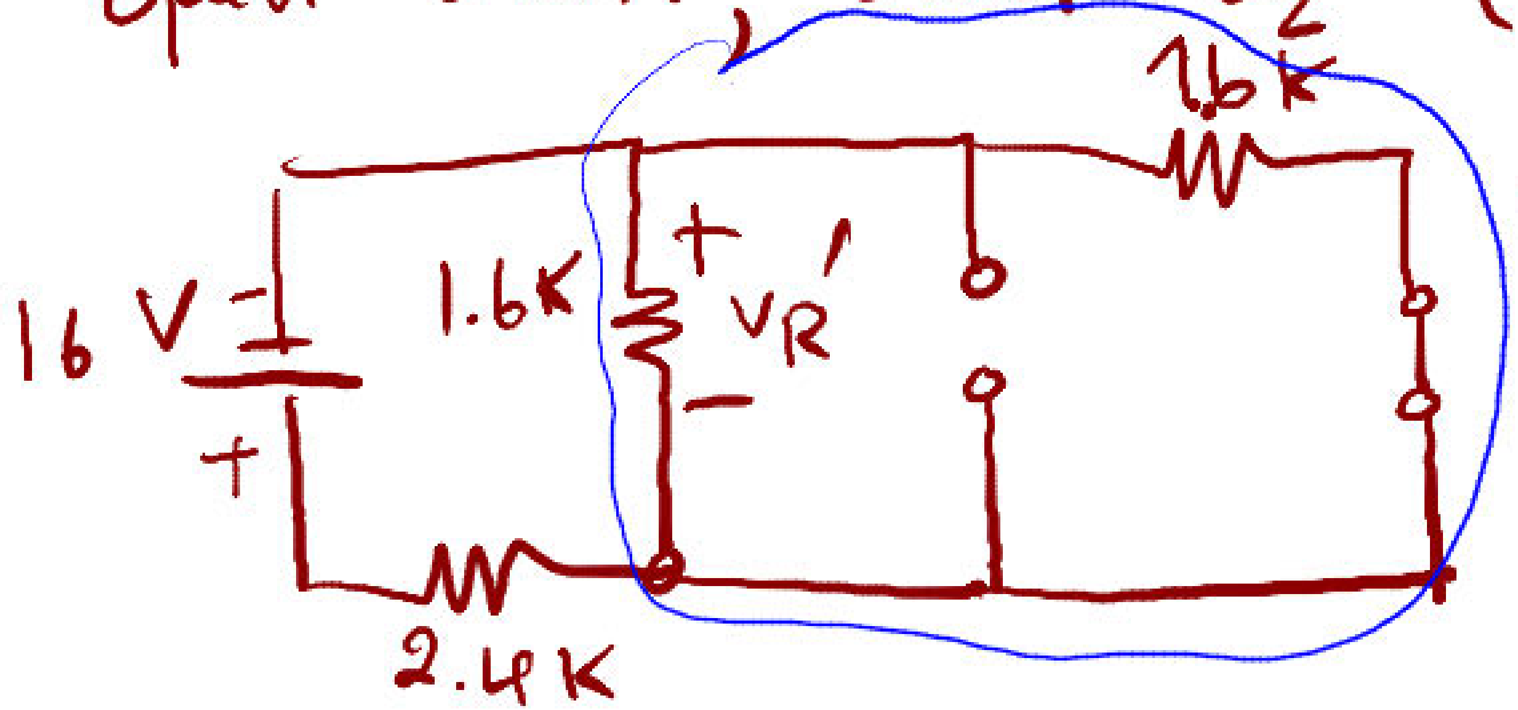
$$I_{R_2}'' = \frac{V_{R_1R_2}}{R_2}, \quad V_{R_1R_2} = \frac{V_2 \cdot (R_1 // R_2)}{R_3 + (R_1 // R_2)}$$

Ex 3



จงหา V_R

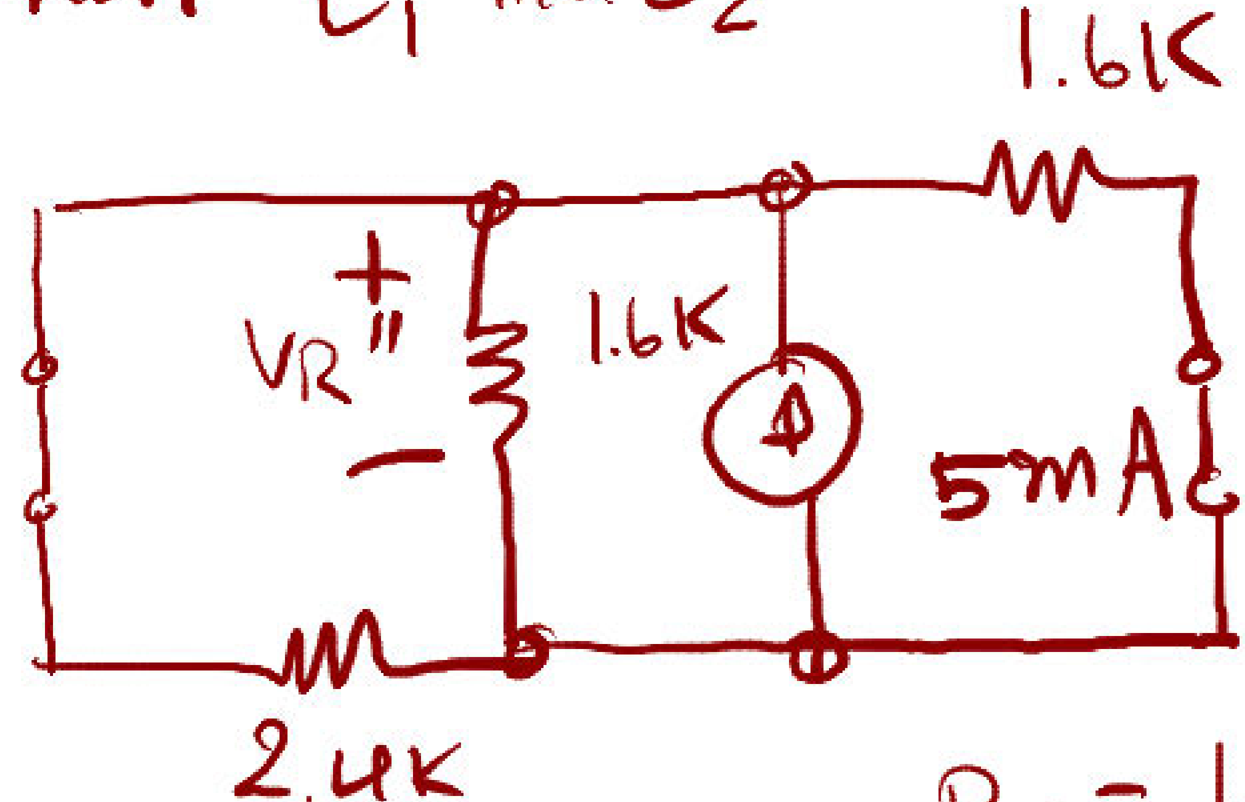
1. open 5mA, short E_2 (แหล่งจ่ายอื่นๆ = 0)

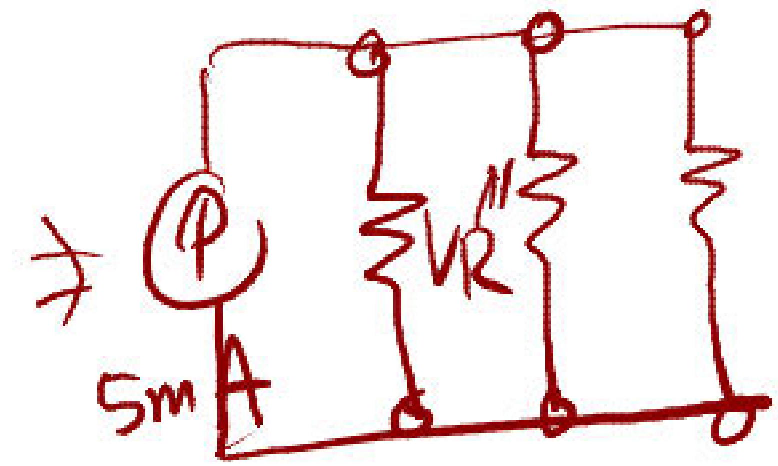


$$V_R' = -\frac{(0.8K)}{(0.8K + 2.4K)} \times 16$$

$$= -4 \text{ Volt}$$

2. Short E_1 และ E_2





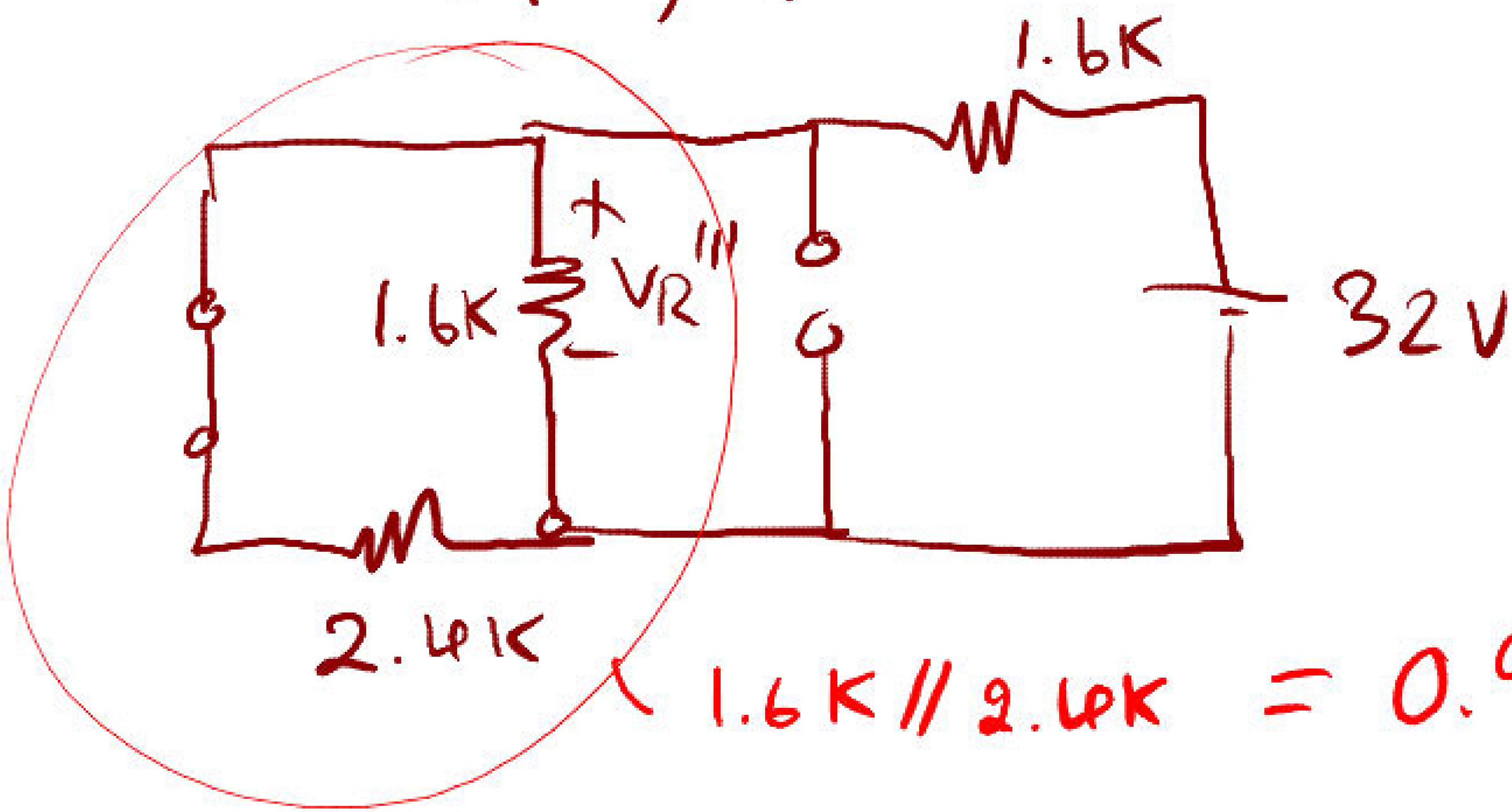
$$R_T = 1.6K \,//\, 1.6K \,//\, 2.4K$$

$$= 0.6\ K\Omega$$

$$\therefore V_R'' = I R_T = 5\cancel{m}A \times 0.6\cancel{K}$$

$$= 3\ \text{Volt}$$

(3) short E_1, open 5 mA



$\Rightarrow$

$(1.6K \,//\, 2.4K = 0.96\,K\Omega$

$$\therefore\ V_R''' = \left(\frac{0.96K}{0.96K + 1.6K}\right) \cdot 32\,V = 12 \text{ Volt}$$

$$\therefore\ V_R = V_R' + V_R'' + V_R''' = -4 + 3 + 12 = 11 \text{ Volt}$$