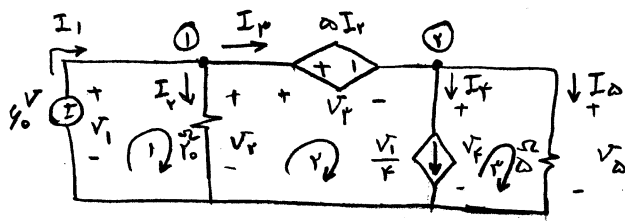


یاسف تعریفی در مدار I - در اول

(۱-۱) الف) رله ۲ رجول ساده



① درگاه KCL: $\sum_{k=1}^N I_k = 0 \Rightarrow I_1 - I_2 - I_3 = 0$

② درگاه KCL: $\sum_{k=1}^N I_k = 0 \Rightarrow I_2 - I_4 - I_5 = 0$

KVL در حلقه ۱: $-V_1 + V_2 = 0 \Rightarrow V_1 = V_2$

KVL در حلقه ۲: $-V_4 + V_3 + V_5 = 0 \Rightarrow V_4 = V_3 + V_5$

مقاومت ها: $V_1 = 4 \cdot I_2$, $V_3 = 5 \cdot I_4$, $I_5 = \frac{V_4}{2}$

KVL در حلقه اول: $-V_1 + V_2 = 0 \Rightarrow V_1 = V_2$

KVL در حلقه دوم: $-V_4 + V_3 + V_5 = 0 \Rightarrow V_4 = V_3 + V_5$

مقاومت ها: $V_2 = 4 \cdot I_2$, $V_5 = 5 \cdot I_5$

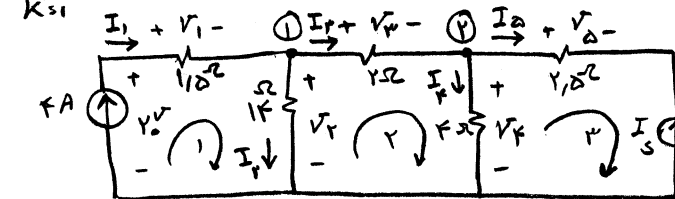
$4 = 4 \cdot I_2 \Rightarrow I_2 = 1A$, $V_3 = 5 \cdot I_4 = 10V$, $I_5 = \frac{V_4}{2} = \frac{4}{2} = 2A$, $V_2 = V_3 + V_5 \Rightarrow 4 = 10 + V_5 \Rightarrow V_5 = -6V$
 $\Rightarrow V_4 = 4V$, $V_5 = V_4 - V_3 = -6V$, $I_5 = \frac{V_5}{2} = -3A$, $I_4 = I_2 + I_5 = 1 - 3 = -2A$, $I_1 = I_2 + I_4 = 1 - 2 = -1A$

$P_1 = -(V_1 \times I_1) = -(4 \times 1) = -4W$

$P_2 = V_2 \times I_2 = 4 \times 1 = 4W$

$P_4 = V_4 \times I_4 = 4 \times (-2) = -8W$

$\sum_{k=1}^N P_k = -4 + 4 - 8 + 10 - 6 = 0$



KVL در حلقه اول: $-V_1 + V_2 + V_3 = 0 \Rightarrow V_2 = V_1 - V_3 = 1 - 1 = 0V \Rightarrow I_2 = \frac{V_2}{1} = 0A \Rightarrow P_2 = 1 \times 1 = 1W$

① درگاه KCL: $I_1 - I_2 - I_3 = 0 \Rightarrow I_3 = 1 - 0 = 1A \Rightarrow V_3 = 2 \times 1 = 2V \Rightarrow P_3 = 2 \times 1 = 2W$

KVL در حلقه دوم: $-V_2 + V_3 + V_4 = 0 \Rightarrow V_4 = 1 - 2 = -1V \Rightarrow I_4 = \frac{V_4}{2} = -0.5A \Rightarrow P_4 = 1 \times 2 = 2W$

② درگاه KCL: $I_3 - I_4 - I_5 = 0 \Rightarrow I_5 = 1 - (-0.5) = 1.5A \Rightarrow V_5 = 2 \times 1.5 = 3V \Rightarrow P_5 = 2 \times 1.5 = 3W$

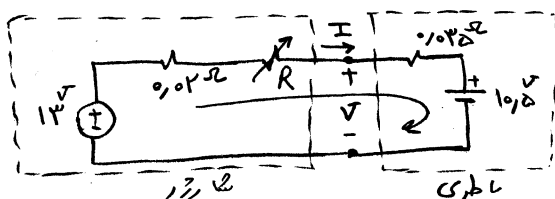
$I_5 = -I_4 = -1A$ KVL در حلقه سوم: $-V_4 + V_5 + V_6 = 0 \Rightarrow V_6 = 1 - 3 = -2V \Rightarrow P_6 = -(2 \times 1) = -2W$

$V_2 = 1 \cdot I_2$, KVL: $-V_1 + V_2 + 9 + 4 \cdot I_1 + 2 \cdot V_2 = 0$

$\Rightarrow 1 \cdot I_1 + 4 \cdot I_1 + 2 \cdot I_1 = -9 \Rightarrow I_1 = -1A$

KVL: $-V_1 + 1 \cdot I_1 + 9 + 4 \cdot I_1 - 10 \cdot I_1 = 0 \Rightarrow 3 \cdot I_1 = -9 \Rightarrow I_1 = -3A$

(۳-۱) الف) $2V_2$



$I = 1A \Rightarrow (0.5 + 0.5 + R) \times 1 = 13 - 10 = 3 \Rightarrow R = \frac{3}{1} - 0.5 = 2.5\Omega$

$V = 11V \Rightarrow 11 = 0.5 \cdot I + 10 \Rightarrow I = 14.2A$

$\Rightarrow -13 + 0.5 \cdot I + R \cdot I + 11 = 0 \Rightarrow R = \frac{13 - 11}{14.2 - 0.5} = 0.14\Omega$

(۴-۱) الف) اگر $I = 5A$

KVL: $-13 + 0.5 \cdot I + R \cdot I + 10.5 = 0$

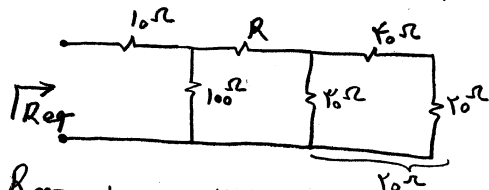
(ب) اگر $V = 11V$

$$R_{eq} = 100 + 200 + 100 = 400 \Omega$$

$$100 \parallel R_{eq} = \frac{100 \times 400}{500} = 80 \Omega$$

$$R_{eq_r} = 100 + 80 + 100 = 280 \Omega$$

$$R_{eq_r} = 100 + 80 + 100 = 280 \Omega$$



$$R_{eq} = 10 + 100 \parallel (R + 100) = 10 + 100 \parallel (10 + 100) = 10 + 100 \parallel 110 = 10 + 50 = 60 \Omega$$

$$R_{eq} = 10 \Rightarrow 10 = 10 + 100 \parallel (R + 100) \Rightarrow 100 \parallel (R + 100) = 0 \Rightarrow R = 210 \Omega$$

$$\Rightarrow \frac{100 \times (R + 100)}{100 + (R + 100)} = 0 \Rightarrow R = 210 \Omega$$

$$R_{eq} = R \Rightarrow R = 10 + 100 \parallel (R + 100) \Rightarrow \frac{100 \times (R + 100)}{100 + (R + 100)} + 10 = R \Rightarrow R^2 + 10R - 2100 = 0$$

$$\Rightarrow R = \frac{-10 \pm \sqrt{(-10)^2 - (1)(-2100)}}{1} \Rightarrow R_1 = 41.4 \Omega, R_2 = -41.4 \Omega \Rightarrow R_{eq} = R = 41.4 \Omega$$

$$R_1 = 10 \parallel 100 = \frac{10 \times 100}{110} = 9.09 \Omega$$

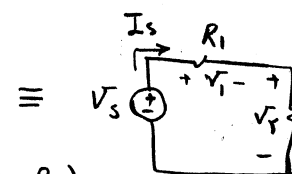
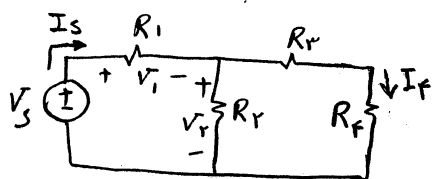
$$R_2 = 10 \parallel (10 + 100) = \frac{10 \times 110}{120} = 9.17 \Omega$$

$$R_3 = 10 \parallel 100 + 10 = 19.09 \Omega \Rightarrow I = \frac{V}{R} = \frac{100}{19.09} = 5.24 A$$

$$I_1 = \frac{(4 + 1)}{10 + (4 + 1)} \times 10 = \frac{5}{15} \times 10 = 3.33 A, I_2 = 10 - 3.33 = 6.67 A, I_3 = \frac{10}{10 + 10} \times 6.67 = 3.33 A, I_4 = 6.67 - 3.33 = 3.34 A$$

$$P_{10\Omega} = I^2 R = 10^2 \times 10 = 1000 \text{ watt}$$

$$P_{10\Omega} = 4^2 \times 10 = 160 \text{ W}, P_{10\Omega} = 1.1^2 \times 100 = 121 \text{ W}, P_{10\Omega} = 3.33^2 \times 10 = 111 \text{ W}, \Sigma P = 1000 + 121 + 111 + 160 = 1392 \text{ W}$$

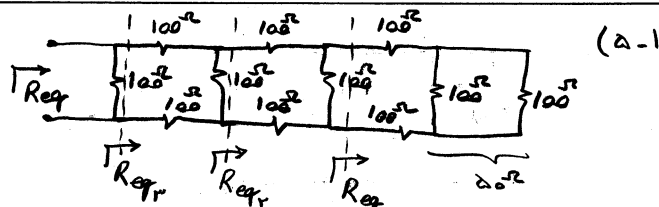


$$V_2 = \frac{R_{eq}}{R_1 + R_{eq}} V_s = \frac{\frac{R_2(R_3 + R_4)}{R_2 + R_3 + R_4}}{R_1 + \frac{R_2(R_3 + R_4)}{R_2 + R_3 + R_4}} V_s = \frac{R_2(R_3 + R_4)}{R_1 R_2 + (R_1 + R_2)(R_3 + R_4)} V_s$$

$$V_1 = \frac{R_1}{R_1 + R_{eq}} V_s = \frac{R_1}{R_1 + \frac{R_2(R_3 + R_4)}{R_2 + R_3 + R_4}} V_s = \frac{R_1(R_2 + R_3 + R_4)}{R_1 R_2 + (R_1 + R_2)(R_3 + R_4)} V_s$$

$$I_s = \frac{V_s}{R_1 + R_{eq}} = \frac{(R_2 + R_3 + R_4) V_s}{R_1 R_2 + (R_1 + R_2)(R_3 + R_4)}$$

$$I_4 = \frac{R_2}{R_2 + (R_3 + R_4)} I_s = \frac{R_2(R_2 + R_3 + R_4) V_s}{(R_2 + R_3 + R_4)(R_1 R_2 + (R_1 + R_2)(R_3 + R_4))} = \frac{R_2 V_s}{R_1 R_2 + (R_1 + R_2)(R_3 + R_4)}$$



$$100 \parallel R_{eq_r} = \frac{100 \times 280}{380} = 73.68 \Omega$$

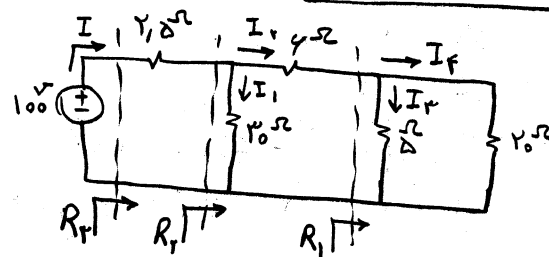
$$R_{eq} = 100 \parallel 73.68 = \frac{100 \times 73.68}{173.68} = 42.44 \Omega$$

$$10 \parallel (10 + 100) = \frac{10 \times 110}{120} = 9.17 \Omega$$

$$R_{eq} = ? , R = 10 \Omega$$

$$R_{eq} = 40 \Omega$$

$$R = ? , R_{eq} = 10 \Omega$$



$$\Sigma P = 1000 + 121 + 111 + 160 = 1392 \text{ W}$$

$$(1-1)$$

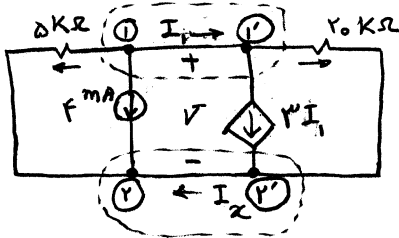
تقسیم ولتاژ

تقسیم ولتاژ

تقسیم جریان

باسف تقوینای مدار I - سرسوم

(۱-۲) مدار ۲ گره دارد. ولتاژ گره بالا را V و ولتاژ گره پایین را صفر در نظر می‌گیریم.



$$\sum_{k=1}^N I_k = 0 \Rightarrow -\frac{V}{5k} - 4mA - 3I_1 - \frac{V}{20k} = 0$$

$$\Rightarrow 4V + 10 + 40 I_1 \times 10^3 + V = 0, \text{ از طرف دیگر در گره ۱ داریم: } -\frac{V}{5k} - 4mA - I_1 = 0 \Rightarrow I_1 = -\frac{V+40}{5000}$$

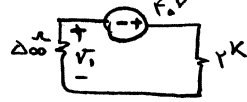
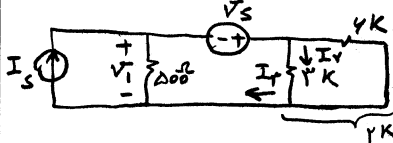
$$\Rightarrow 4V + 10 - \frac{40000}{5000} (V+40) + V = 0 \Rightarrow 5V - 12V = 40 - 10 = 30 \Rightarrow V = \frac{-30}{5} = -6V$$

$$\text{در گره ۲ داریم: } I_x = 3I_1 + \frac{V}{20k} = \frac{-3(V+40)}{5000} - \frac{2V}{20k} = \frac{-3(-6+40)}{5000} - \frac{2(-6)}{20k} = \frac{-3(-46)}{5000} - \frac{12}{20k} = 1.11mA - 0.6mA = 0.51mA$$



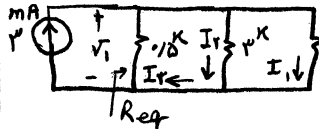
$$4V + 10 = 40 \Rightarrow 4V = 30 \Rightarrow V = 7.5V$$

$$5 + 19.4 = 24.4 \Rightarrow 20k \parallel 19.4k = 9.18k \Rightarrow R_{eq} = 10 + 9.18 = 19.18k$$



$$V_1 = -\frac{10k}{20k + 10k} \times 4V = -1V$$

(۴-۲) الف) $V_3 = 4V$ و $I_3 = ?$, $V_1 = ?$



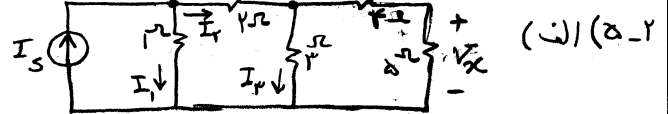
$$R_{eq} = 20k \parallel 10k = \frac{20 \times 10}{20 + 10} = 6.67k$$

ب) $V_3 = 4V$, $I_3 = ?$, $V_1 = ?$

$$V = 4mA \times R_{eq} = 4mA \times 6.67k = 26.68V \Rightarrow I_1 = \frac{1V}{4k} = 0.25mA, I_2 = \frac{1V}{2k} = 0.5mA$$

$$\Rightarrow I_3 = I_1 + I_2 = 0.75mA$$

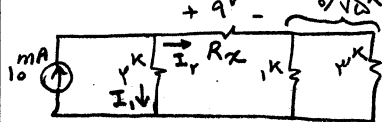
$$\begin{cases} V_2 = 10V \\ I_3 = ? \end{cases} \quad I_f = \frac{10}{20} = 0.5A \Rightarrow V_f = 4 \times 0.5 = 2V$$



$$I_3 = I_1 + I_2 = 0.25 + 0.5 = 0.75A \Rightarrow V_1 = 2 \times 0.75 = 1.5V \Rightarrow V_2 = 1.5 + 10 = 11.5V \Rightarrow I_1 = \frac{1.5}{4k} = 0.375mA \Rightarrow I_3 = 0.375 + 0.75 = 1.125mA$$

$$\frac{V_2}{I_3} = \frac{10}{0.75} = 13.33k$$

ب) $V_2 = 10V$, $I_3 = ?$, $V_1 = ?$



$$I_1 = 10mA \times \frac{2k}{2k + R_x + 10k} = \frac{20}{R_x + 12k}$$

(۶-۲)

$$\Rightarrow 20R_x = 9R_x + 24V \Rightarrow R_x = 2.4k \Rightarrow P_{R_x} = \frac{V^2}{R_x} = \frac{9 \times 9}{2.4k} = 3.375mW$$

$$V_{R_1} = V_S, V_{R_2} = \frac{R_2 \parallel (R_3 + R_4)}{R_2 + (R_3 + R_4)} V_S = V_{R_3} + V_{R_4}$$

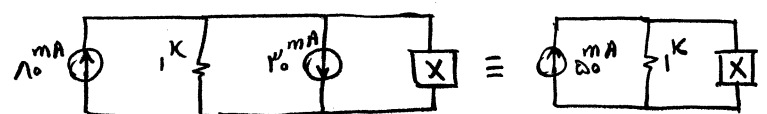
(۷-۲)

$$V_{R_3} = V_{R_4} = \frac{R_4}{R_3 + R_4} V_{R_2} = \frac{R_4}{R_3 + R_4} \cdot \frac{R_2 \parallel (R_3 + R_4)}{R_2 + (R_3 + R_4)} V_S = \frac{R_4}{R_2 + R_3 + R_4} V_S$$

$$\text{KCL در گره ۱: } 5 + V - \frac{V}{2} - \frac{V}{4} = 0 \Rightarrow 12 = \frac{4V}{4} \Rightarrow V = 12V \Rightarrow I_2 = \frac{12V}{4k} = 3mA$$

(۸-۲)

$$\text{KCL در گره ۲: } 2 + 2I_x = 5 - \frac{V_1}{1k} \Rightarrow 2 + (2 \times 3) - 5 = \frac{V_1}{1k} \Rightarrow V_1 = 1k \times 2 = 2V \Rightarrow P_{DA} = 5 \times (2 - 12) = -10W$$



(۹-۲) الف) X یک مقاومت است.

$$1k \parallel 4k = \frac{4}{5} = 0.8k \Rightarrow V = 50 \times 0.8k = 40V \Rightarrow P_{4k} = \frac{V^2}{R} = \frac{1600}{4k} = 0.4W$$

$$I_{1k} = \frac{40}{1k} = 40mA \Rightarrow I_{40V} = 40 - 50 = -10mA \Rightarrow P_{40V} = 10mA \times (-40V) = -0.4W$$