

המרות - חלק 1 - עקרונות כלליים

1

$$R_{AB} = \left\{ \left[(R_3 + R_4) \parallel R_5 \right] + R_2 \right\} \parallel R_1$$

$$R_{AB} = \left\{ \left[\left(\frac{140}{60+80} \right) \parallel 50 \right] + 40 \right\} \parallel 10 =$$

$$R_{AB} = \frac{292}{33} = 8.848 \Omega$$

$$R_{AC} = (R_1 + R_2) \parallel R_5 \parallel (R_3 + R_4)$$

$$R_{AC} = \left(\frac{50}{10+40} \right) \parallel 50 \parallel \left(\frac{140}{60+80} \right)$$

$$R_{AC} = \frac{700}{33} = 21.212 \Omega$$

$$R_{BC} = \left\{ \left[(R_3 + R_4) \parallel R_5 \right] + R_1 \right\} \parallel R_2$$

$$R_{BC} = \left\{ \left[\left(\frac{140}{60+80} \right) \parallel 50 \right] + 10 \right\} \parallel 40$$

$$R_{BC} = 21.575 \Omega$$

$$R_{DC} = \left\{ \left[(R_1 + R_2) \parallel R_5 \right] + R_3 \right\} \parallel R_4$$

$$R_{DC} = \left\{ \left[\left(\frac{50}{10+40} \right) \parallel 50 \right] + 60 \right\} \parallel 80$$

$$R_{DC} = \frac{1360}{33} = 41.212 \Omega$$

R_{DB} :

המרת $\Delta \leftarrow Y$

$$R_{1,5} = \frac{R_1 \cdot R_5}{R_1 + R_2 + R_5} = \frac{10 \cdot 50}{10 + 40 + 50} = 5 \Omega$$

$$R_{1,2} = \frac{R_1 \cdot R_2}{R_1 + R_2 + R_5} = \frac{10 \cdot 40}{10 + 40 + 50} = 4 \Omega$$

$$R_{2,5} = \frac{R_2 \cdot R_5}{R_1 + R_2 + R_5} = \frac{40 \cdot 50}{10 + 40 + 50} = 20 \Omega$$

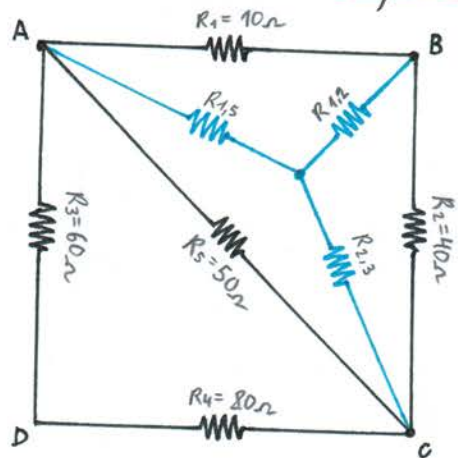


$$R_{DB} = R_{1,2} + (R_{1,5} + R_3) \parallel (R_{2,5} + R_4)$$

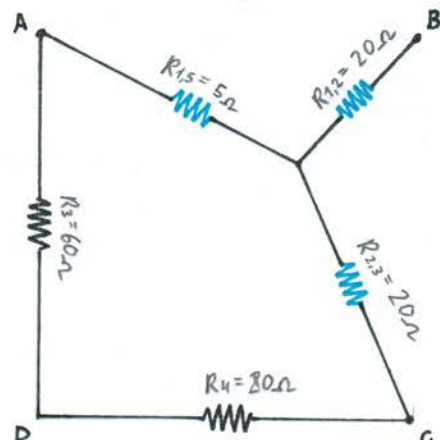
$$R_{DB} = 4 + \left(\frac{65}{5+60} \right) \parallel \left(\frac{100}{20+80} \right)$$

$$R_{DB} = 43.333 \Omega$$

המרת $\Delta \leftarrow Y$



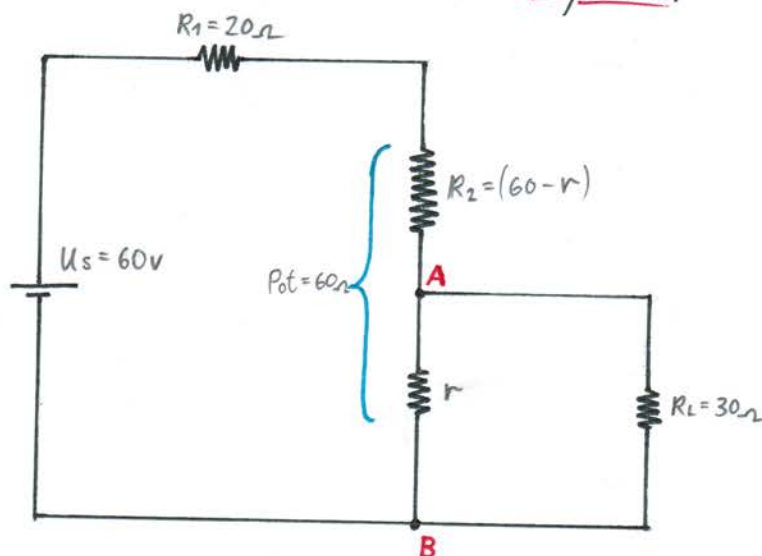
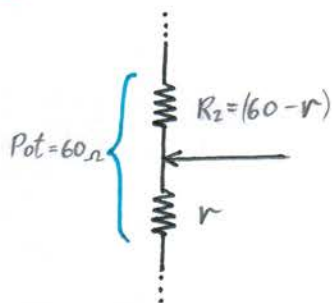
המרת $\Delta \leftarrow Y$



1

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נסימן את הפוטנציאל
באינר הבא:



מאזן שקול:

$$U_{AB} = U_r = U_{R_L}$$

$$P_{R_L} = \frac{U_{R_L}^2}{R_L}$$

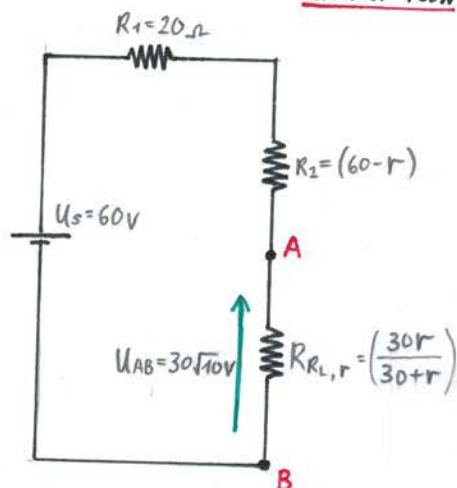
$$3 = \frac{U_{R_L}^2}{30}$$

$$U_{R_L} = \sqrt{3 \cdot 30}$$

$$U_{R_L} = 3\sqrt{10} \text{ V}$$

$$R_{R_L, r} = \frac{R_L \cdot r}{R_L + r} = \frac{30r}{30 + r}$$

מאזן תאורה:



חוק מחלקת המתח במעגל תאורה:

$$U_{AB} = U_s \cdot \frac{R_{R_L, r}}{R_1 + R_2 + R_{R_L, r}}$$

$$3\sqrt{10} = 60 \cdot \frac{\left(\frac{30r}{30+r}\right)}{20 + (60-r) + \left(\frac{30r}{30+r}\right)} \quad / : 60$$

השלב הזה ניתן
לפתור באמצעות
סולב
במחשבון.

$$\frac{\sqrt{10}}{20} = \frac{\left(\frac{30r}{30+r}\right)}{80 - r + \left(\frac{30r}{30+r}\right)} \quad / \cdot \frac{30+r}{\sqrt{10}}$$

$$\frac{20 \cdot 30r}{30+r} = 80\sqrt{10} - \sqrt{10}r + \frac{\sqrt{10} \cdot 30r}{30+r} \quad / \cdot (30+r)$$

$$600r = 2400\sqrt{10} + 80\sqrt{10} \cdot r - 30\sqrt{10}r - \sqrt{10}r^2 + 30\sqrt{10}r$$

$$\sqrt{10}r^2 + 600r - 80\sqrt{10}r - 2400\sqrt{10} = 0 \quad / : \sqrt{10}$$

$$r^2 - \frac{600}{\sqrt{10}} \cdot r - 80r - 2400 = 0$$

$$r^2 - 109.736r - 2400 = 0$$

$$r_1 = 18.687 \Omega \quad \checkmark$$

$$r_2 = -128.42$$

אין חשיבות
לחתיכות
שליליות

חשוב אחרי הגזרת המעגל:

$$\frac{r}{P_{ot}} \cdot 100\% = \frac{18.687}{60} \cdot 100\% = 31.146\%$$

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$$\Delta U_{AB} = 0V$$

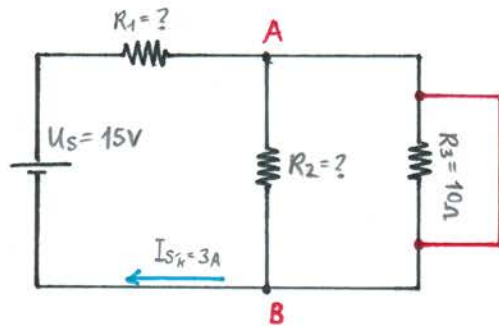
: I_{S_k} $\rightarrow$ I_{S_k}

$$U_{R_3} = U_{R_2} = U_{AB} = 0V$$

$$\underline{I_{R_1}} = I_{S_k} = \underline{3A} \quad \text{/: } I_{S_k}$$

$$R_1 = \frac{U_S}{I_{R_1}} = \frac{15}{3} = \underline{5\Omega} \quad \blacksquare$$

: K $\rightarrow$ 10Ω



$$I_{S_2} = I_{R_1} = I_{R_2} = \underline{1A} \quad \text{/: } I_{S_2}$$

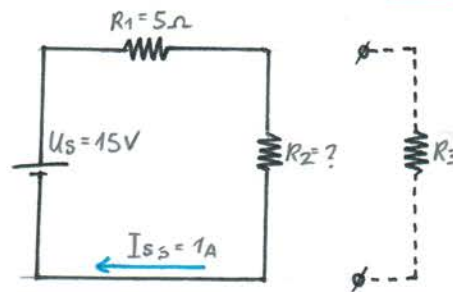
$$R_T = \frac{U_S}{I_{S_2}} = \frac{15}{1} = \underline{15\Omega}$$

$$R_T = R_1 + R_2$$

$$15 = 5 + R_2$$

$$\underline{R_2 = 10\Omega} \quad \blacksquare$$

: S $\rightarrow$ 10Ω



$$R_T = R_1 + R_2 \parallel R_3$$

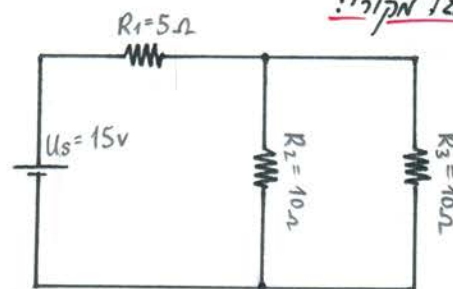
$$R_T = 5 + 10 \parallel 10$$

$$\underline{R_T = 10\Omega} \quad \blacksquare$$

$$I_S = \frac{U_S}{R_T} = \frac{15}{10}$$

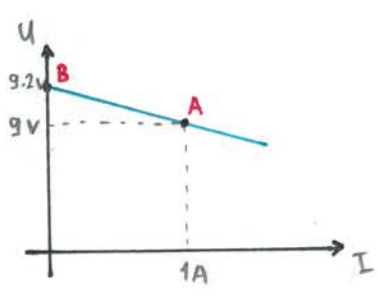
$$\underline{I_S = 1.5A} \quad \blacksquare$$

: N $\rightarrow$ 10Ω



3

4



נתון מתחיל

$$E = 9.2 \text{ V}$$

$$A \left(1, \frac{U}{I} \right)$$

$$B (0, 9.2)$$

סיומן נקודות:

$$r = \left(\frac{\Delta U}{\Delta I} \right)$$

סיבוס הישר:

$$r = \frac{U_B - U_A}{I_B - I_A} = \frac{9.2 - 9}{0 - 1} = -0.2$$

משוואת הישר:

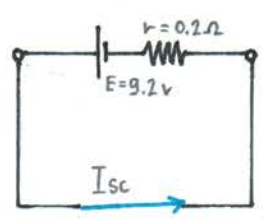
$$U = rI + E$$

$$U = (-0.2)I + 9.2$$

מתקבל:

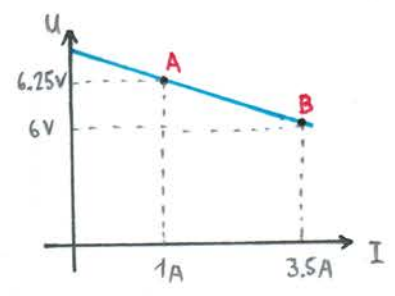
$$r = 0.2 \Omega$$

$$E = 9.2 \text{ V}$$



$$I_{sc} = \frac{E}{r} = \frac{9.2}{0.2}$$

$$I_{sc} = 46 \text{ A}$$



סיומן נקודות:

$$A \left(1, \frac{U}{I} \right)$$

$$B (3.5, 6)$$

סיבוס הישר:

$$r = \frac{U_B - U_A}{I_B - I_A} = \frac{6 - 6.25}{3.5 - 1} = -0.1$$

משוואת הישר (מנק' B):

$$U - U_B = r(I - I_B)$$

$$U - 6 = (-0.1)(I - 3.5)$$

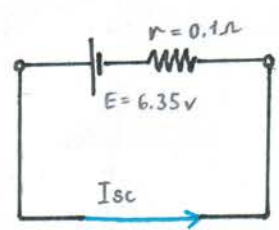
$$U = -0.1I + 0.35 + 6$$

$$U = -0.1I + 6.35$$

מתקבל:

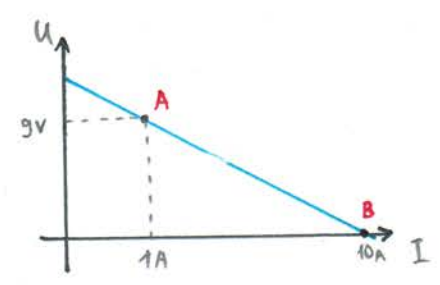
$$r = 0.1 \Omega$$

$$E = 6.35 \text{ V}$$



$$I_{sc} = \frac{E}{r} = \frac{6.35}{0.1}$$

$$I_{sc} = 63.5 \text{ A}$$



סיומן נקודות:

$$A \left(1, \frac{U}{I} \right)$$

$$B (10, 0)$$

סיבוס הישר:

$$r = \frac{U_B - U_A}{I_B - I_A} = \frac{0 - 9}{10 - 1} = -1$$

משוואת הישר (מנק' B):

$$U - U_B = r(I - I_B)$$

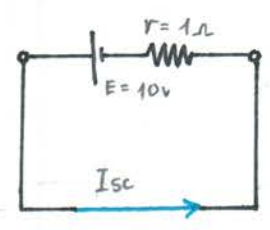
$$U - 0 = (-1)(I - 10)$$

$$U = -I + 10$$

מתקבל:

$$r = 1 \Omega$$

$$E = 10 \text{ V}$$



$$I_{sc} = \frac{E}{r} = \frac{10}{1}$$

$$I_{sc} = 10 \text{ A}$$

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החירף הנדרש

5

$$I'_S = \frac{U_S}{R_1} = \frac{9}{3} = \boxed{3A}$$

$$I'_{ST} = I_S + I'_S$$

$$I'_{ST} = 2 + 3$$

$$\boxed{I'_{ST} = 5A}$$

$$I_{R_L} = I'_{ST} \cdot \frac{R_{1,2}}{R_{1,2} + R_L}$$

$$I_{R_L} = 5 \cdot \frac{2}{2 + 45} = \frac{10}{47}$$

$$\boxed{I_{R_L} = 212.76mA}$$

$$P_{R_L} = I_{R_L}^2 \cdot R_L = 0.212^2 \cdot 45$$

$$\boxed{P_{R_L} = 2.037W}$$

$$U_{AB} = U_{R_L} = I_{R_L} \cdot R_L = 0.212 \cdot 45 = \frac{450}{47} = \boxed{9.574V}$$

$$P_{U_S} = I_{U_S} \cdot U_S = 0.1914 \cdot 9 = \frac{81}{47} = \boxed{1.723W}$$

$$P_{I_S} = I_S \cdot U_{AB} = 2 \cdot 9.574 = \frac{900}{47} = \boxed{19.148W}$$

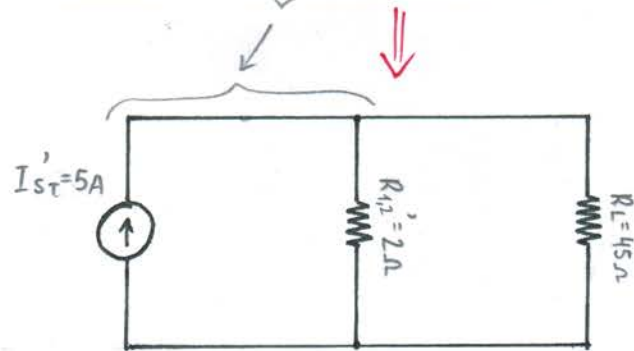
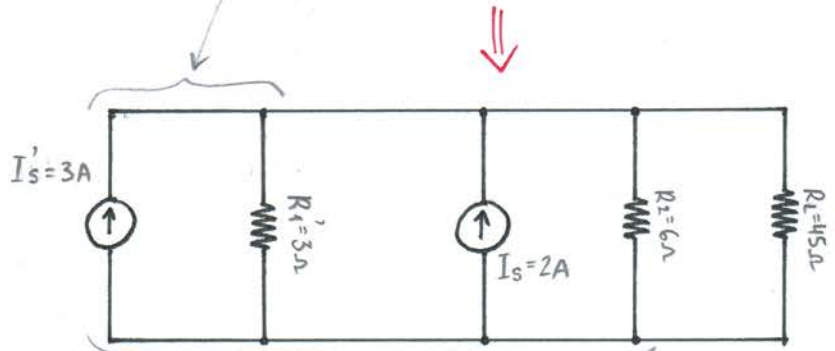
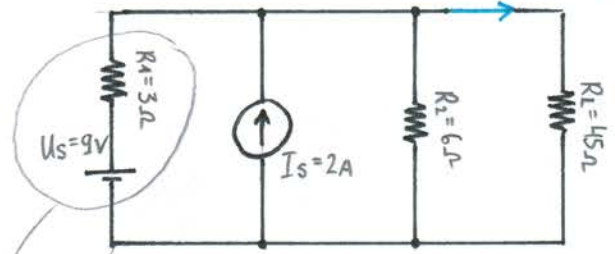
$$P = P_{I_S} - P_{U_S} = 19.148 - 1.723 = \frac{819}{47} = \boxed{17.425W}$$

$$P_{R_L} = \boxed{2.037W}$$

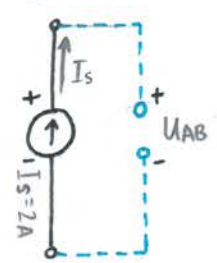
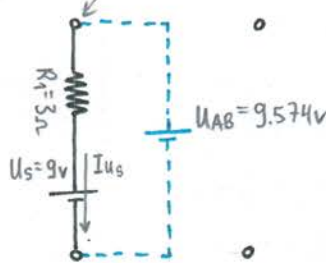
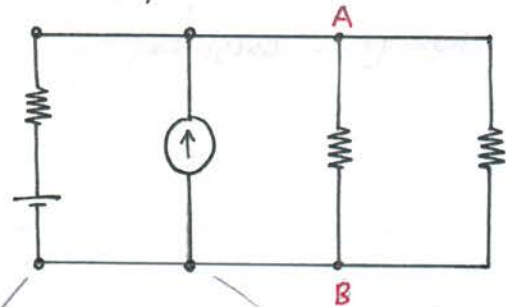
$$\eta = \frac{P_{R_L}}{P} \cdot 100 = \frac{2.037}{17.425} \cdot 100$$

$$\boxed{\eta = 11.69\%}$$

מקור: $\sqrt{28W}$



חישוב הנוכח - מקור: $\sqrt{28W}$

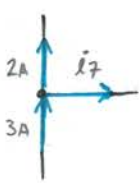


$$I_{U_S} = \frac{U_{AB} - U_S}{R_1} = \frac{9.57 - 9}{3}$$

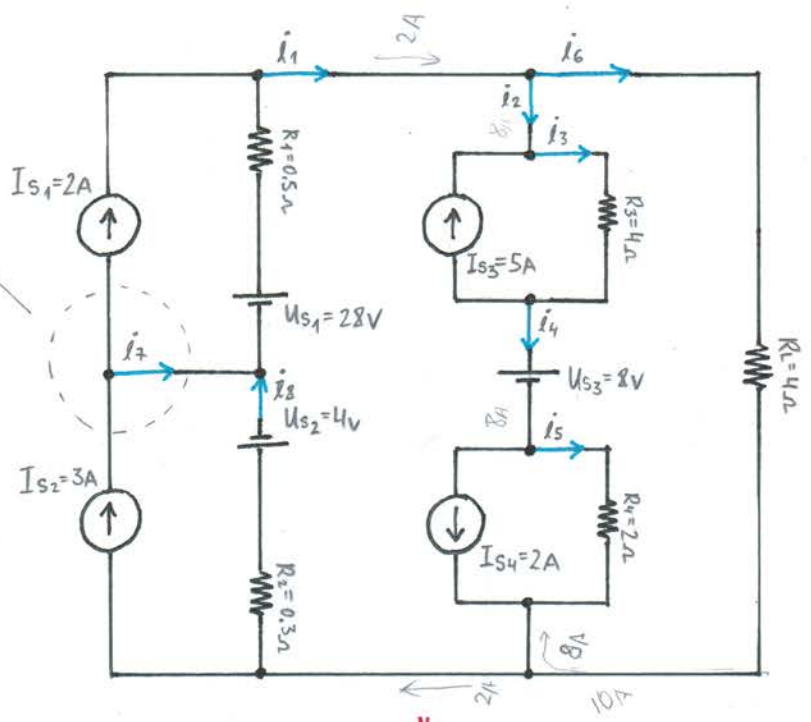
$$\boxed{I_{U_S} = 0.1914A}$$

5

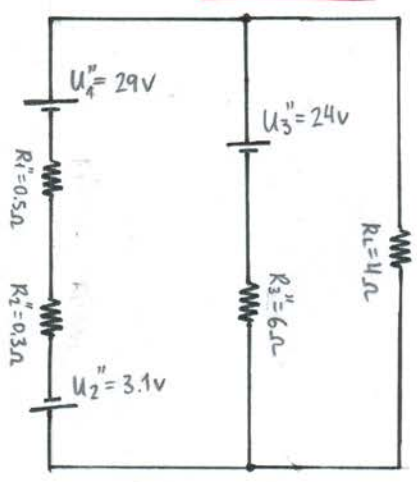
6



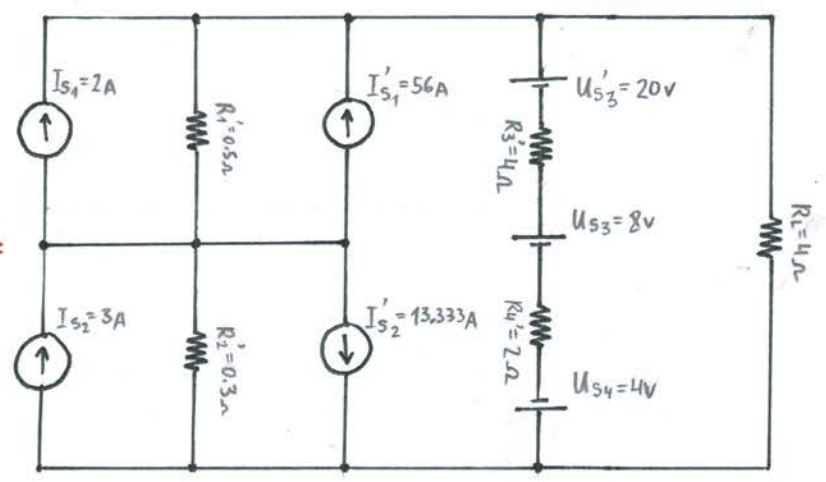
כחלק [KLV] נ"ס



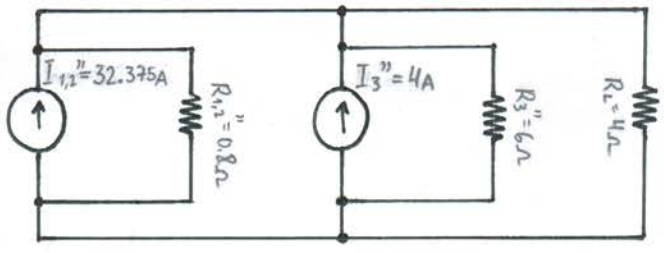
תהליך מס' 2



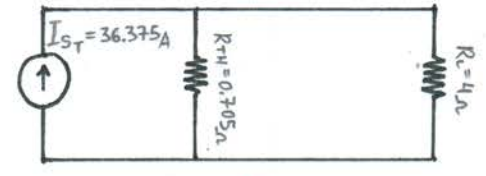
תהליך מס' 1



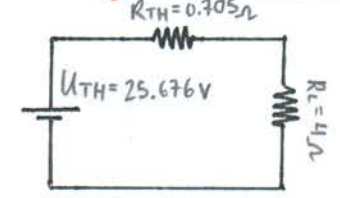
תהליך מס' 3



תהליך מס' 4



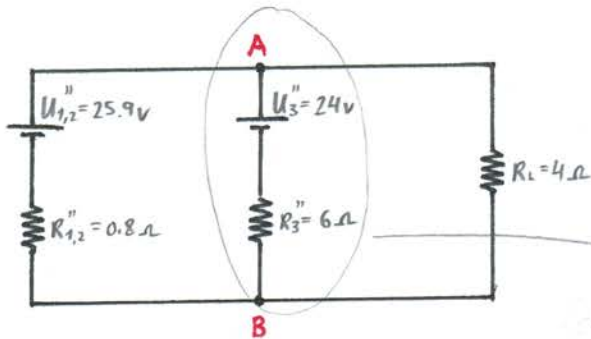
תהליך מס' 5



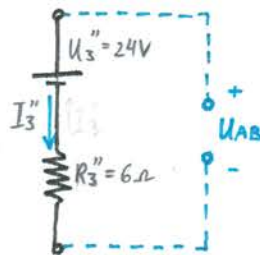
$$U_{RL} = U_{TH} \cdot \frac{R_L}{R_L + R_{TH}} = 25.676 \cdot \frac{4}{0.705 + 4} = 21.825V$$

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חישוב הזרמים במעגל: בהנחת משפט מילמן על מעגל תחילה מס' 2
ובהמשך לחישוב המתח על נקודת הוואס (U_{RL})
בסעיף הקודם מתקבל:



$$U_{AB} = U_{RL} = 21.825V$$



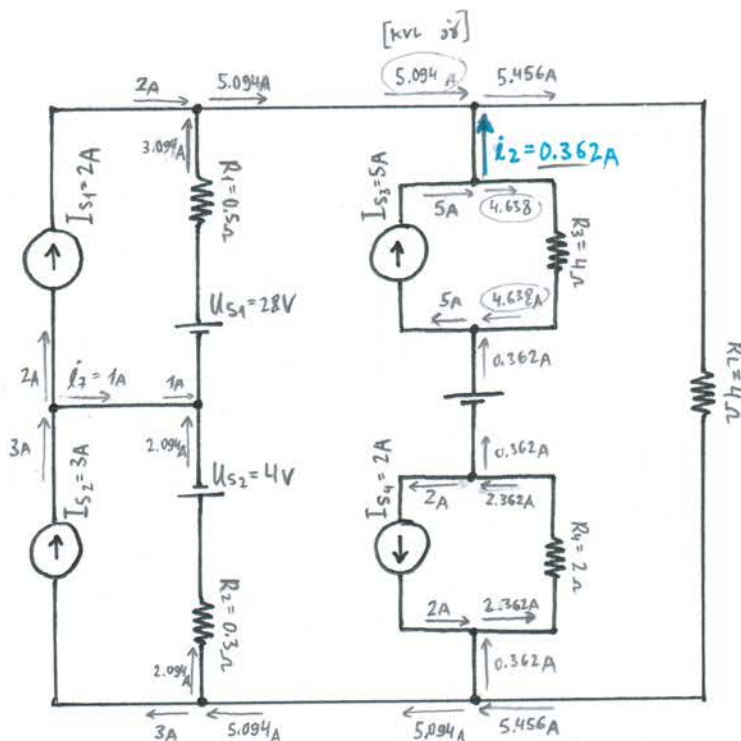
$$I_3'' = \frac{U_{AB} - U_3''}{R_3''} =$$

$$I_3'' = \frac{21.825 - 24}{6}$$

$$I_3'' = (-0.3625)A$$

$$I_2 = I_3'' = (-0.3625)A$$

הזרם במעגל המקורי



לאחר הצבת הזרם I_2
במעגל, והשלמת יתרת הזרמים
עם KCL במעגל המקורי, מתקבל:

$$I_1 = 5.094A$$

$$I_2 = (-0.362)A$$

$$I_3 = 4.638A$$

$$I_4 = (-0.362)A$$

$$I_5 = (-2.362)A$$

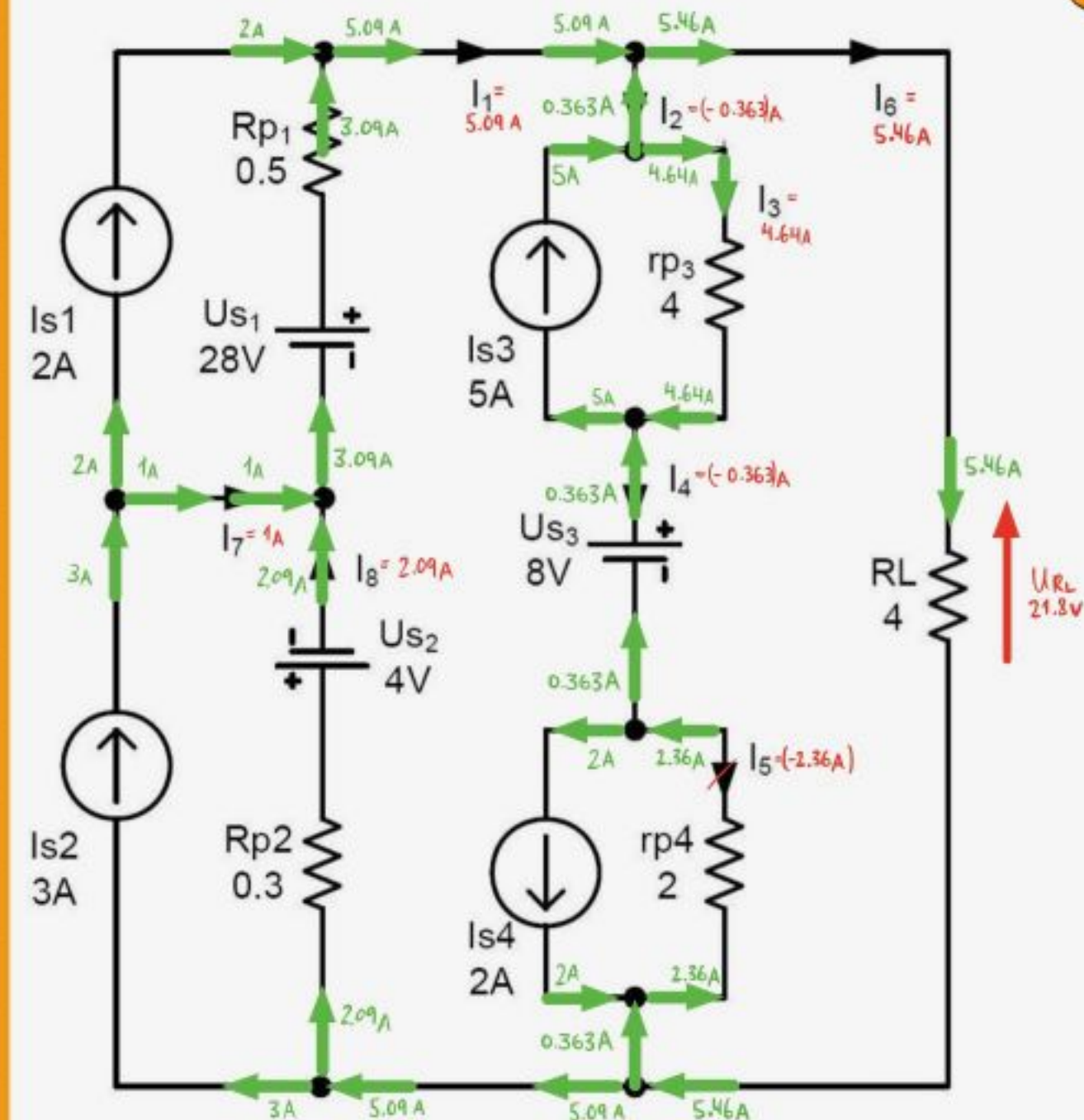
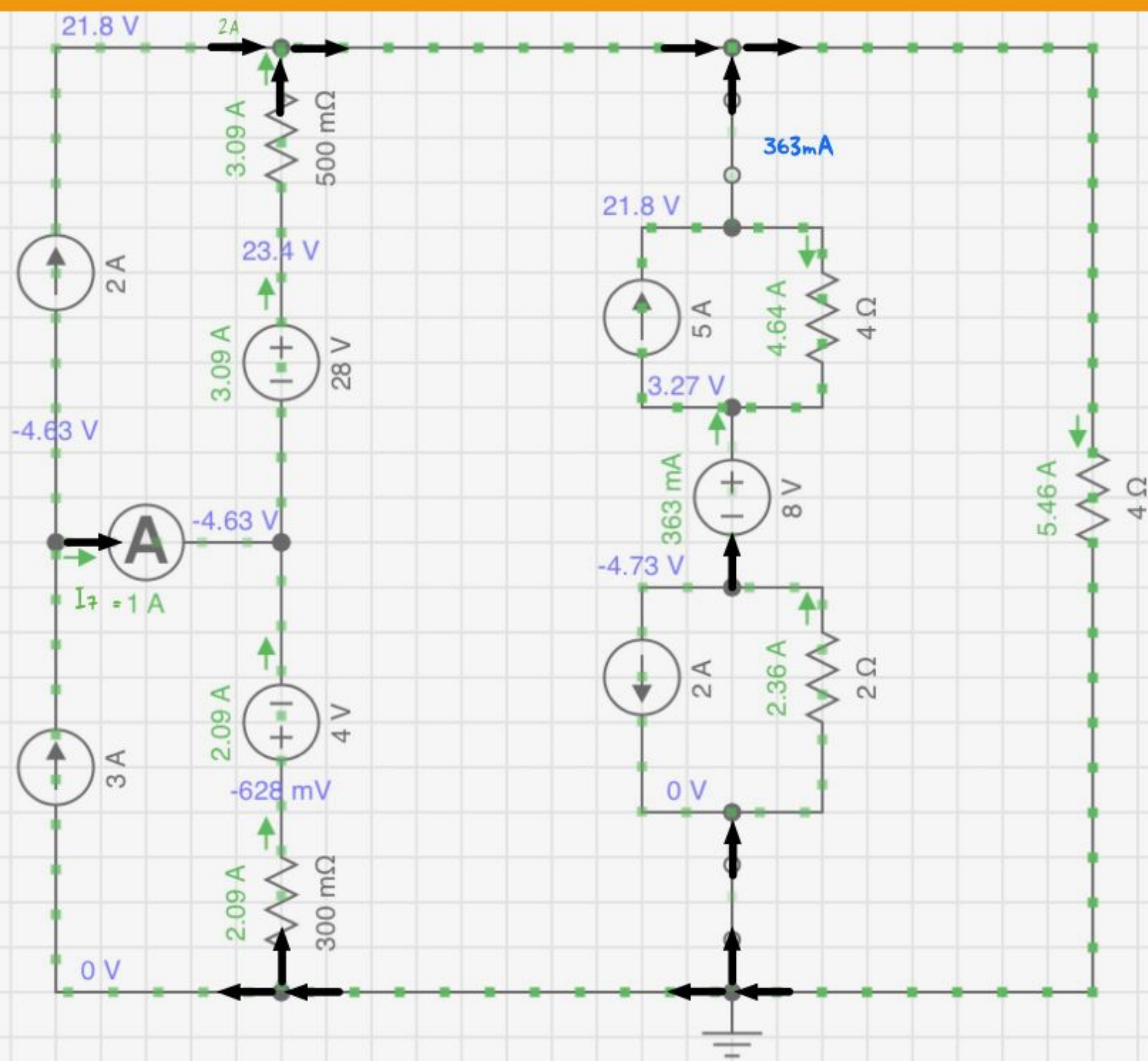
$$I_6 = 5.456A$$

$$I_7 = 1A$$

$$I_8 = 2.094A$$

חשב את מתח נגד העומס.

תשובה: 21.824V



סעיף רשות (למתקדמים בלבד): חשב את הזרמים שמסומנים במעגל.

תשובות:

$$I_1 = 5.093A, I_2 = 0.362A, I_3 = -5.362A$$

$$I_4 = -0.362A, I_5 = -2.362A, I_6 = 5.456A$$

$$I_7 = 1A, I_8 = 2.093A$$