

פתרון תרגיל חצי שנה (חלק א')

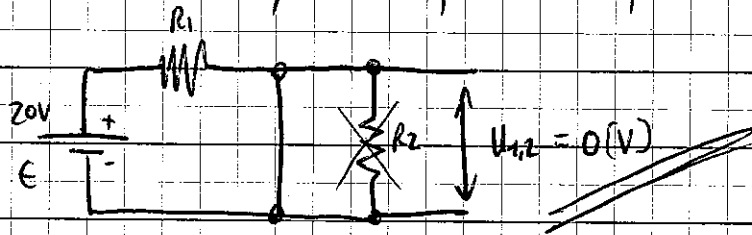
מספר קריק - 2013

תאריך

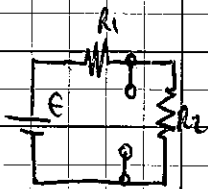
שאלה 1

בדיקה ראשונית
מבדל המכילה

א) חזר $t=0$ הקולט ממונח קצר ואכן:

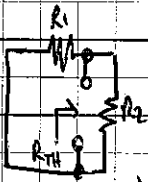


ב) (???) SW מנע (???) :



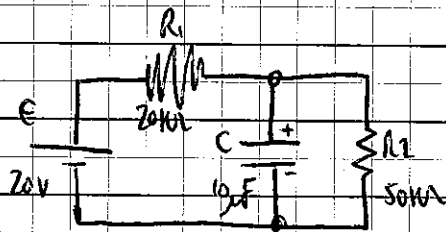
$$U_C(\infty) = \frac{E \cdot R_2}{R_1 + R_2}$$

$$U_C(\infty) = \frac{20 \cdot 50}{70} = 14.285 \text{ V}$$



$$\tau = C \cdot (R_1 \parallel R_2) = 10 \cdot 10^{-6} \cdot (20 \parallel 50) \cdot 10^3$$

$$\tau = 0.142 \text{ sec}$$

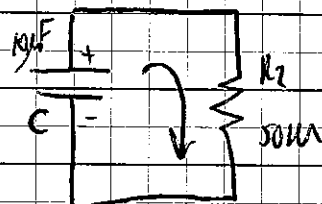


ב) (???) SW מנע OFF (פתיקת קולט) :

$$\tau = C \cdot R_2 = 10 \cdot 10^{-6} \cdot 50 \cdot 10^3$$

$$\tau = 0.5 \text{ sec}$$

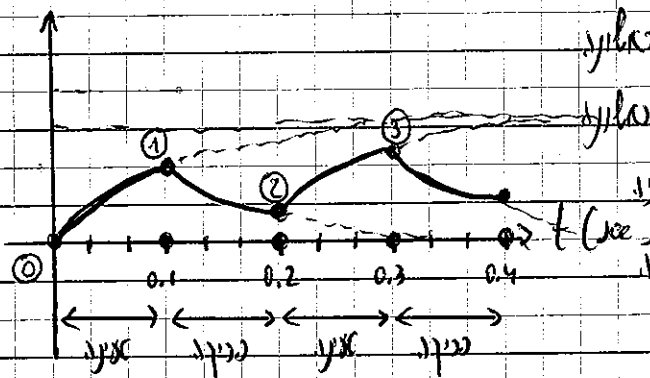
$$U_R(t) = U_C(t)$$



ג) (???) חזר ממונח על הקולט כחצי שנה :

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מכתב הפכפכה

$$U_C(V) = U_{12}(V)$$



- ① - סגירת מנורה
- ② - פתיחת מנורה
- ③ - סגירת מנורה

17) זמן $t = 0.1 \text{ sec}$ (קריאה):

$$U_C(t) = U_C(\infty) - (U_C(\infty) - U_C(0))e^{-\frac{t}{\tau}}$$

$$U_C(t=0.1 \text{ sec}) = 14.285 - (14.285 - 0)e^{-\frac{0.1}{0.142}} = 7.221(V)$$

18) זמן $t = 0.2 \text{ sec}$ (פתיחה):

$$U_C(t=0.2 \text{ sec}) = 0 - (0 - 7.221)e^{-\frac{0.1}{0.142}} = 5.912(V)$$

ב. זמן של 0.1 sec, זמן של 0.1 sec
($\Delta t = 0.2 - 0.1 = 0.1 \text{ sec}$)

19) זמן $t = 0.3 \text{ sec}$ (קריאה):

$$U_C(t=0.3 \text{ sec}) = 14.285 - (14.285 - 5.912)e^{-\frac{0.1}{0.142}} = 10.144(V)$$

זמן של 0.1 sec, זמן של 0.1 sec
($\Delta t = 0.3 - 0.2 = 0.1 \text{ sec}$)

2. יחיד

$$\bar{U}_{1,2} = \bar{U}_A + \bar{U}_B$$

(C)

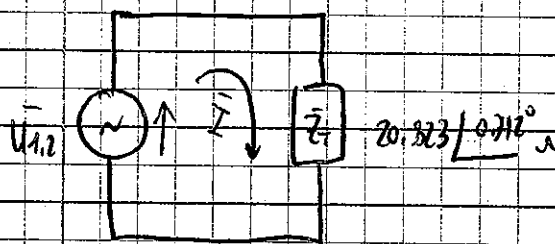
$$\bar{U}_{1,2} = 30 \angle 30^\circ + 40 \angle -40^\circ = 57.626 \angle -10.712^\circ \text{ (V)}$$

החזרה למערכת
המקור

החזרה למערכת המקור: 1.7 מ"מ (C)

$$\bar{Z}_T = \bar{Z}_1 \parallel \bar{Z}_2 = \left(\frac{1}{30 \angle 30^\circ} + \frac{1}{40 \angle -40^\circ} \right)^{-1} = 20.823 \angle 0.712^\circ \Omega$$

$$\text{P.F.} = \cos \phi_{Z_T} = \cos(0.712^\circ) = 0.999$$



$$\bar{I}_T = \frac{\bar{U}_{1,2}}{\bar{Z}_T}$$

(C)

$$\bar{I}_T = \frac{57.626 \angle -10.712^\circ}{20.823 \angle 0.712^\circ} = 2.76 \angle -11.424^\circ \text{ (A)}$$

$$\bar{S}_A = \bar{U}_A \cdot \bar{I}_A^* = 30 \angle 30^\circ \cdot 2.76 \angle 11.424^\circ = 83.01 \angle 41.424^\circ \text{ (VA)}$$

3. יחיד

$$U_0 = 230 \text{ V}$$

$$f_0 = 50 \text{ Hz}$$

$$B_{\text{max}} = 1.2 \text{ T}$$

$$X_L = 8000 \Omega$$

$$X_L = \omega L$$

$$L = \frac{X_L}{\omega} = \frac{8000}{2\pi \cdot 50} = 25.464 \text{ mH}$$

החזרה למערכת המקור: 1.7 מ"מ (C)

$$A = 4 \text{ cm}^2 = 4 \cdot 10^{-4} \text{ m}^2$$

$$l_{av} = 20 \text{ cm}$$

החומר הוא ברזל (Iron)

1K

$$\epsilon \approx U_n = 4.44 \cdot f \cdot N \cdot \phi_{max}$$

$$\phi_{max} = \frac{U_n}{4.44 \cdot f \cdot N} = \frac{230}{4.44 \cdot 50 \cdot 2159} = 0.48 \text{ mT}$$

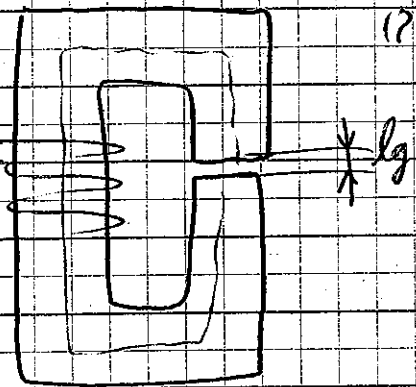
$$N = \frac{U_n}{4.44 \cdot f \cdot \phi_{max}} = \frac{230}{4.44 \cdot 50 \cdot 0.48 \cdot 10^{-3}} = 2158.408$$

$$N = 2159 \text{ (Turns)}$$

$$L = \frac{N^2}{R_{mT}}$$

$$R_{mT} = \frac{N^2}{L} = \frac{2159^2}{25.464} = 183.053 \cdot 10^3 \left(\frac{\text{AT}}{\text{wb}} \right)$$

$$R_{mT} = R_m + R_g$$



1.2) להימנע מהאובדן של הזרם (המגנט) להימנע מהאובדן של הזרם (המגנט) להימנע מהאובדן של הזרם (המגנט)

$$|B| = \mu \cdot |H|$$

$$\mu = \frac{dB}{dH} = \frac{1}{100} = 0.01$$

$$R_m = \frac{l_{av}}{\mu \cdot A} = \frac{20 \cdot 10^{-2}}{0.01 \cdot 4 \cdot 10^{-4}} = 50 \cdot 10^3 \left(\frac{\text{AT}}{\text{wb}} \right)$$

$$R_g = R_{mT} - R_m = 183.053 - 50 = 133.053 \left(\frac{\text{AT}}{\text{wb}} \right)$$

$$R_g = \frac{l_g}{\mu_0 \cdot A}$$

$$l_g = R_g \cdot \mu_0 \cdot A = 133.053 \cdot 10^3 \cdot 4\pi \cdot 10^{-7} \cdot 4 \cdot 10^{-4} = 6.68 \cdot 10^{-5} \text{ (m)}$$

$$L_2 = \frac{N_2^2}{n_{mT}} = \frac{1000^2}{133.0340^3} = 5.462 \text{ (Hz)} \quad (8)$$

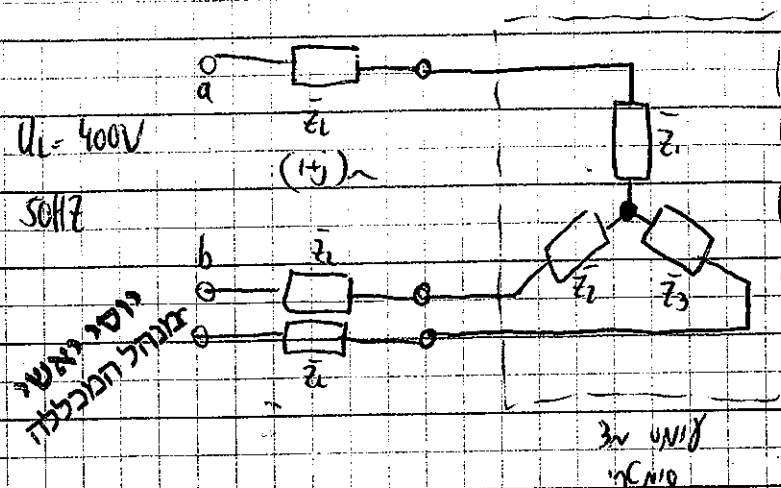
1955 2015 2128 2128

(3) היות ונממן לשתים (3) חזק, וזהו שכל

$$E_2 = 4.44 \cdot f \cdot N_2 \cdot \phi_{2max}$$

$$E_2 \approx U_2 = 4.44 \cdot 50 \cdot 1000 \cdot 0.48 \cdot 10^{-3} = 106.56 \text{ (V)}$$

העומס הנדרש (C) : $U_L = 400V$ $50Hz$



$$P_T = 20kW, \cos \phi = 0.7 (\text{lag})$$

$$U_L = 400V$$

העומס הנדרש (C) : $\bar{Z}_1 = \bar{Z}_2 = \bar{Z}_3$ $U_L = 400V$ $50Hz$

$$|U_L| = \sqrt{3} \cdot |U_{PH}|$$

$$|U_{PH}| = \frac{|U_L|}{\sqrt{3}} = \frac{400}{\sqrt{3}} = 230.94 V$$

$$P_T = \sqrt{3} |I_L| |U_L| \cos \phi$$

$$|I_L| = \frac{P_T}{\sqrt{3} |U_L| \cos \phi} = \frac{20 \cdot 10^3}{\sqrt{3} \cdot 400 \cdot 0.7} = 41.239 A$$

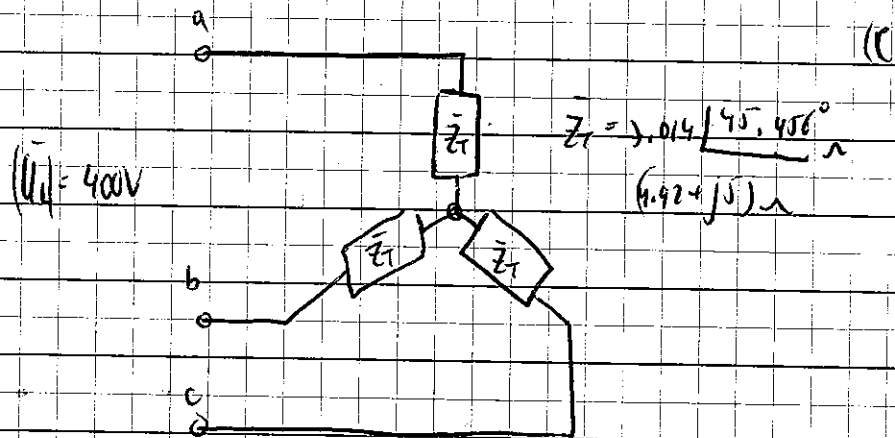
$$|I_L| = |I_{PH}| = 41.239 A$$

$$|Z_{PH}| = \frac{|U_{PH}|}{|I_{PH}|} = \frac{230.94}{41.239} = 5.6 \Omega$$

$$\bar{Z}_{PH} = 5.6 \angle 45.572^\circ \Omega = (3.92 + j4) \Omega$$

העומס הנדרש (C) : $\bar{Z}_1 = \bar{Z}_2 = \bar{Z}_3$ $U_L = 400V$ $50Hz$

$$\bar{Z}_T = \bar{Z}_{PH} + \bar{Z}_L = 5.6 \angle 45.572^\circ + (1 + j) = (4.92 + j5) \Omega = 7.014 \angle 45.572^\circ \Omega$$



$$|\bar{U}_{PH}| = \frac{U_{LL}}{\sqrt{3}} = 230.94V$$

$$|\bar{I}_{PH}| = \frac{|\bar{U}_{PH}|}{|\bar{Z}_L|} = \frac{230.94}{7.014} = 32.925 A$$

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מכאן המכנה

$$|\bar{I}_L| = |\bar{I}_{PH}| = 32.925 (A)$$

$$P_T = \sqrt{3} \cdot |\bar{I}_L| \cdot |\bar{U}_L| \cdot \cos \phi_{Z_T}$$

$$P_T = \sqrt{3} \cdot 32.925 \cdot 400 \cdot \cos(45.456) = 16001 (W)$$

(2) נתון: $f = 60Hz$ (הזרם הזורם) (הקו)

$X = \omega L$ (הקו) $f = 50Hz$ (הזרם הזורם) (הקו)

$$L = \frac{X}{\omega} = \frac{5}{2\pi \cdot 50} = 15.915 mH \quad ; \quad L_T = \frac{4}{2\pi \cdot 50} = 12.732 mH$$

(הקו) $f = 60Hz$ (הזרם הזורם) (הקו)

$$X = \omega L = 2\pi \cdot 60 \cdot 15.915 \cdot 10^{-3} = 6 \Omega$$

$$\bar{Z}_T = (4.92 + j6) \Omega = 7.759 / 50.648^\circ \Omega$$

$$|\bar{I}_{PH}| = \frac{|\bar{U}_{PH}|}{|\bar{Z}_T|} = \frac{230.94}{7.759} = 29.642 A$$

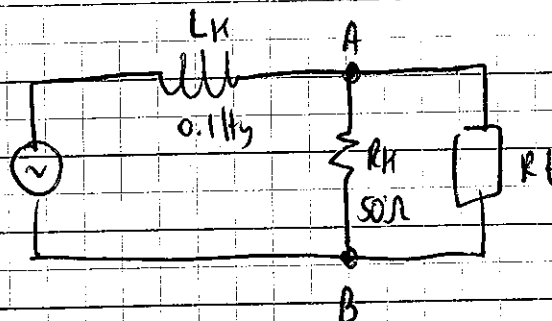
$$P_T = 3 \cdot |\bar{I}_{PH}|^2 \cdot R_L = 3 \cdot 29.642^2 \cdot 3.92 = 10337.902 (W)$$

↑
הזרם הזורם

$$\bar{Z}_1 = R_1 + jX_L = (3.92 + j28.60 \cdot 12.732 \cdot 10^{-3}) = (3.92 + j4.8) \Omega = 6.19 \angle 50.76^\circ \Omega$$

$$|\bar{U}_{PH1}| = |\bar{Z}_{PH1}| \cdot |\bar{I}_1| = 29.642 \cdot 6.19 = 183.483 \text{ V}$$

$$|U_L| = \sqrt{3} |\bar{U}_{PH1}| = \sqrt{3} \cdot 183.483 = 317.803 \text{ (V)}$$



ינסי יאשי
מוכר ומכר

5 mV

$$\omega = 0.0044 \left(\frac{1}{s} \right)$$

$$|\bar{U}_{AB}| = 231 \text{ V}$$

$$|\bar{I}_T| = 11 \text{ A}$$

$$\leftarrow T_1 = 24^\circ \text{ מדר}$$

$$|\bar{U}_{AB}| = 231 \text{ V}, |\bar{I}_T| = 9 \text{ A}$$

$$\leftarrow T_2 = 33^\circ \text{ מדר}$$

$$X_{LH} = \omega L = 28.60 \cdot 0.1$$

$$\leftarrow T_2 = 33^\circ \text{ מדר}$$

$$X_{LH} = 31.415 \Omega$$

$$|\bar{U}_{LH}| = X_{LH} \cdot |\bar{I}_T| = 31.415 \cdot 9 = 282.743 \text{ V}$$

$$|\bar{U}_T| = \sqrt{|\bar{U}_{LH}|^2 + |\bar{U}_{AB}|^2}$$

חישוב המאמץ בין קצוות א ו ב
בין נאמס נאמס
בין נאמס
90°

$$|\bar{U}_T| = \sqrt{282.743^2 + 231^2} = 365.109 \text{ (V)}$$

$$|\bar{I}_{RL}| = |\bar{I}_T| - |\bar{I}_{RH}| = 9 - \frac{|\bar{U}_{AB}|}{R_H} = 9 - \frac{231}{50} = 4.38 \text{ A}$$

אשר (מחזור)

בין (מדר)

לפני המאמס

לפי הנגדים ומקור!

$$R_{L2} = \frac{|\bar{U}_{AB}|}{|\bar{I}_{RL}|} = \frac{231}{4.38} = 52.739 \Omega$$

$$\leftarrow T_1 = 24^\circ \text{ מדר}$$

$$|\bar{U}_{LH}| = |\bar{I}_T| \cdot X_{LH} = 11 \cdot 31.415 = 345.565 \text{ V}$$

$$|\bar{U}_{AB}| = \sqrt{|\bar{U}_T|^2 - |\bar{U}_{LH}|^2}$$

$$|\bar{U}_{AB}| = \sqrt{365.109^2 - 345.565^2} = 117.853 \text{ V}$$

$$R_{t1} = \frac{|\bar{U}_{AB}|}{|\bar{I}_{A1}|} = \frac{117.853}{8.642} = 13.635 \Omega$$

$$|\bar{I}_{A1}| = \frac{|\bar{U}_{AB}|}{R_{t1}} = \frac{117.853}{50} = 2.357 \text{ A}$$

$$|\bar{I}_{A1}| = |\bar{I}_T| - |\bar{I}_{A1}| = 11 - 2.357 = 8.642 \text{ A}$$

הזרם הזורם
בין המוליכים
הפנימיים

$$R_{t2} = R_{t1} (1 - \alpha_T (T_2 - T_1))$$

קוסי יאנשי
מכפול המכפלה

$$\frac{R_{t2}}{R_{t1}} - 1 = \alpha_T (T_2 - T_1)$$

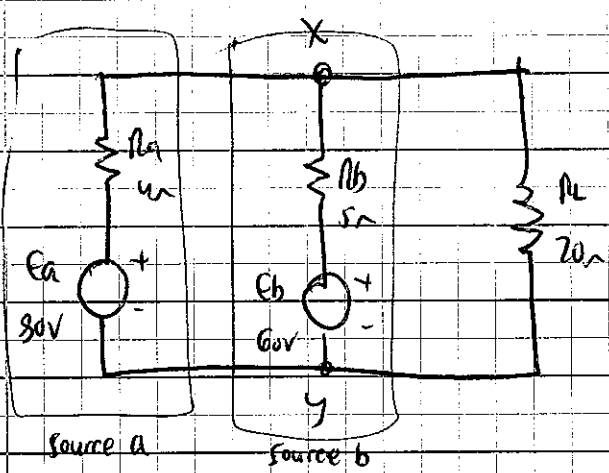
$$T_2 = \frac{\frac{R_{t2}}{R_{t1}} - 1}{\alpha_T} + T_1 = \frac{\frac{52.139}{13.635} - 1}{0.0044} + 24 = 675.798 (^{\circ}\text{C})$$

$$P = |\bar{I}_{A1}|^2 \cdot R_{t1} = 8.642^2 \cdot 52.139 = 1011.366 \text{ W} = 1.011 \text{ kW}$$

$$W_{\text{Therm}} = P \cdot t = 1.011 \cdot 24 = 24.264 \text{ (kWh)}$$

24 = 1 kWh

6 מילי



הזרם הזורם

$$U_{xy} = \frac{\frac{E_a}{R_a} + \frac{E_b}{R_b}}{\frac{1}{R_a} + \frac{1}{R_b} + \frac{1}{R_c}}$$

$$U_{xy} = \frac{\frac{80}{4} + \frac{60}{5}}{\frac{1}{4} + \frac{1}{5} + \frac{1}{20}} = 64 \text{ V}$$

כיוון המכונה

$$I_{Ea} = \frac{E_a - U_{xy}}{R_a} = \frac{80 - 64}{4} = 4 \text{ (A)}$$

$$I_{Eb} = \frac{U_{xy} - E_b}{R_b} = \frac{64 - 60}{5} = 0.8 \text{ (A)}$$

$$U_{xy} = 64 \text{ (V)}$$

$$P_R = \frac{U_{xy}^2}{R_c} = \frac{64^2}{20} = 204.8 \text{ (W)}$$

$$E_a > U_{xy} \quad \text{כיוון הזרם הוא מ-} E_a \quad (1)$$

$$E_b < U_{xy} \quad \text{כיוון הזרם הוא מ-} E_b \quad (2)$$

$$\eta = \frac{P_{Ea} - P_R}{P_{Ea}} \cdot 100 =$$

$$P_{Ea} = E_a \cdot I_{Ea} = 80 \cdot 4 = 320 \text{ W}$$

$$P_R = I_{Rc}^2 \cdot R_c = 4^2 \cdot 20 = 320 \text{ W}$$

$$\eta = \frac{320 - 320}{320} \cdot 100 = 0 \text{ (0\%)}$$

$$\bar{Z}_X = \left[(\bar{Z}_X + \bar{Z}_S) \parallel \bar{Z}_P \right] + \bar{Z}_S \quad (10)$$

$$\bar{Z}_X - \bar{Z}_S = \frac{(\bar{Z}_X + \bar{Z}_S) \bar{Z}_P}{\bar{Z}_X + \bar{Z}_S + \bar{Z}_P}$$

נוסחה
מיוחדת למעגלים

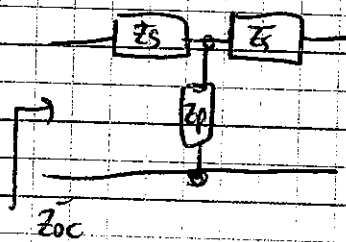
$$(\bar{Z}_X - \bar{Z}_S)(\bar{Z}_X + \bar{Z}_S + \bar{Z}_P) = \bar{Z}_X \bar{Z}_P + \bar{Z}_S \bar{Z}_P$$

$$\bar{Z}_X^2 + \bar{Z}_X \bar{Z}_S + \bar{Z}_X \bar{Z}_P - \bar{Z}_S \bar{Z}_X - \bar{Z}_S^2 - \bar{Z}_S \bar{Z}_P = \bar{Z}_X \bar{Z}_P + \bar{Z}_S \bar{Z}_P$$

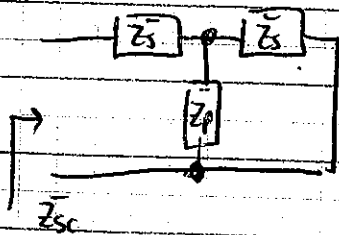
$$\bar{Z}_X^2 = \bar{Z}_S^2 + 2\bar{Z}_S \bar{Z}_P$$

$$\bar{Z}_X = \sqrt{\bar{Z}_S^2 + 2\bar{Z}_S \bar{Z}_P}$$

$$\bar{Z}_X = \sqrt{\bar{Z}_{oc} \cdot \bar{Z}_{sc}} \quad (?)$$



$$\bar{Z}_{oc} = \bar{Z}_S + \bar{Z}_P$$



$$\bar{Z}_{sc} = (\bar{Z}_S \parallel \bar{Z}_P) + \bar{Z}_S$$

$$\bar{Z}_{sc} = \frac{\bar{Z}_S \cdot \bar{Z}_P}{\bar{Z}_S + \bar{Z}_P} + \bar{Z}_S$$

$$\bar{Z}_X = \sqrt{(\bar{Z}_S + \bar{Z}_P) \left[\frac{\bar{Z}_S \cdot \bar{Z}_P}{\bar{Z}_S + \bar{Z}_P} + \bar{Z}_S \right]}$$

$$\bar{Z}_X^2 = (\bar{Z}_S + \bar{Z}_P) \left[\frac{\bar{Z}_S \cdot \bar{Z}_P}{\bar{Z}_S + \bar{Z}_P} + \bar{Z}_S \right]$$

$$\frac{\bar{Z}_X^2}{\bar{Z}_S + \bar{Z}_P} - \bar{Z}_S = \frac{\bar{Z}_S \cdot \bar{Z}_P}{\bar{Z}_S + \bar{Z}_P} \quad | \cdot (\bar{Z}_S + \bar{Z}_P)$$

i.m.m.11

$$\bar{z}_x^2 - \bar{z}_s(\bar{z}_s + \bar{z}_p) = \bar{z}_s \bar{z}_p$$

$$\bar{z}_x^2 - \bar{z}_s^2 - \bar{z}_s \bar{z}_p = \bar{z}_s \bar{z}_p$$

$$\bar{z}_x^2 = \bar{z}_s^2 + 2\bar{z}_s \bar{z}_p$$

$$\bar{z}_x = \sqrt{\bar{z}_s^2 + 2\bar{z}_s \bar{z}_p}$$

הצבה
על ה-100

הצבה
על ה-100

$$\bar{z}_x = \sqrt{20 \angle 30^\circ \cdot 20 \angle 30^\circ + 2 \cdot 20 \angle 30^\circ \cdot 40 \angle -60^\circ}$$

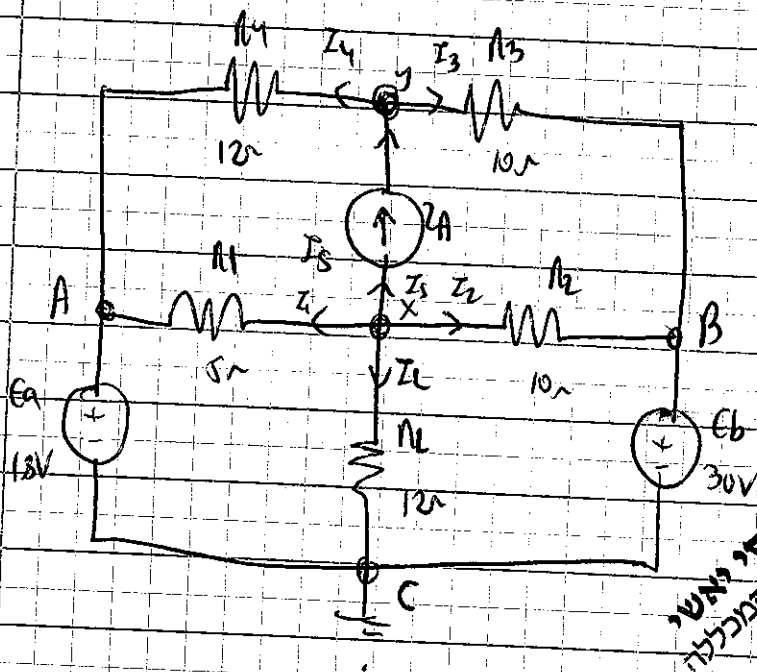
$$\bar{z}_x = \sqrt{1649.242 \angle -15.463^\circ} = \sqrt{1649.242} \angle \frac{-15.463^\circ}{2}$$

$$\bar{z}_x = 40.61 \angle -7.731^\circ \Omega = (40.216 - j5.638) \Omega$$

↑
R X_C

$$X_C = \frac{1}{\omega C}$$

$$C = \frac{1}{\omega X_C} = \frac{1}{100\pi \cdot 5.638} = 0.564 \text{ (mF)}$$



8 נדק

$$U_C = 0$$

$$U_A = E_A = 18V$$

$$U_B = E_B = 30V$$

$$U_x = ?$$

$$U_y = ?$$

$$9) I_S = I_3 + I_4$$

$$I_S = \frac{U_y - U_B}{R_3} + \frac{U_y - U_A}{R_4}$$

$$2 = \frac{U_y - 30}{10} + \frac{U_y - 18}{12} \quad | \cdot 24$$

$$48 = 24U_y - 72 + 24U_y - 36$$

$$4.4U_y = 156$$

$$U_y = 35.454 V$$

$$X) I_5 + I_2 + I_L + I_1 = 0$$

$$2 + \frac{U_x - U_B}{R_2} + \frac{U_x - U_C}{R_L} + \frac{U_x - U_A}{R_1} = 0$$

$$2 + \frac{U_x - 30}{10} + \frac{U_x}{12} + \frac{U_x - 18}{5} = 0 \quad | \cdot 60$$

$$120 + 6U_x - 180 + 5U_x + 12U_x - 216 = 0$$

$$23U_x = 276$$

$$U_x = 12V$$

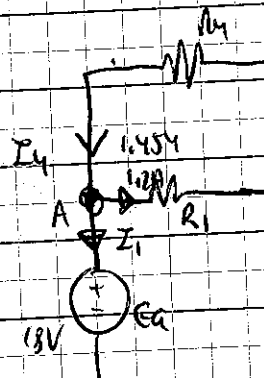
$$U_{RL} = U_x = 12 (V)$$

$$U_{xy} = U_x - U_y = 12 - 35.454 = -23.454 \text{ (V)} \quad (?)$$

(1)

$$I_4 = \frac{U_y - U_A}{R_4} = \frac{35.454 - 18}{12} = 1.454 \text{ A}$$

$$I_1 = \frac{U_A - U_x}{R_1} = \frac{18 - 12}{5} = \frac{6}{5} = 1.2 \text{ A}$$



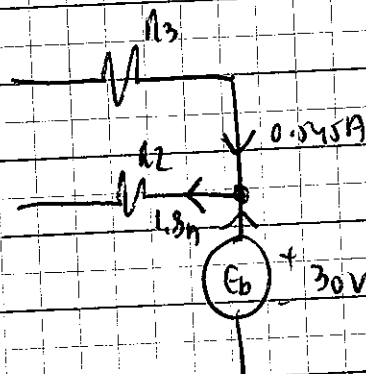
יחסי נאש
במקור המכילה

$$I_{Ea} = I_4 - I_1 = 1.454 - 1.2 = 0.254 \text{ A}$$

$$P_{Ea} = I_{Ea} \cdot E_a = 0.254 \cdot 18 = 4.581 \text{ (W)} \quad (\text{Watt})$$

$$I_{A2} = \frac{U_B - U_x}{R_2} = \frac{30 - 12}{10} = \frac{18}{10} = 1.8 \text{ A}$$

$$I_{A3} = \frac{U_y - U_B}{R_3} = \frac{35.454 - 30}{10} = 0.5454 \text{ A}$$



$$I_{Eb} = I_{A2} - I_{A3} = 1.8 - 0.545 = 1.254 \text{ A}$$

$$P_{Eb} = I_{Eb} \cdot E_b = 1.254 \cdot 30 = 37.638 \text{ (W)} \quad (\text{Watt})$$