

לדג' 1

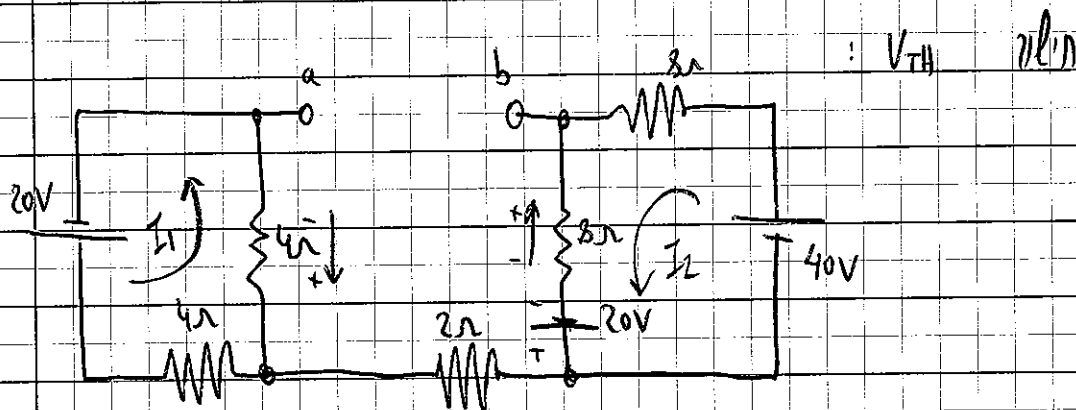
ניסוי יחסי
 מודול המכילה

$$R_{ab} = 4 \parallel 4 + 2 + 8 \parallel 8$$

תילת : R_{TH} (K)

$$R_{ab} = 8\Omega$$

$$R_{TH} = 8\Omega$$



$$I_1 = \frac{20}{8} = 2.5A$$

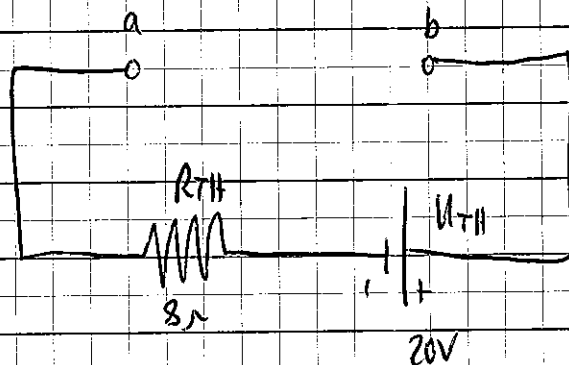
$$I_2 = \frac{40+20}{16} = 3.75A$$

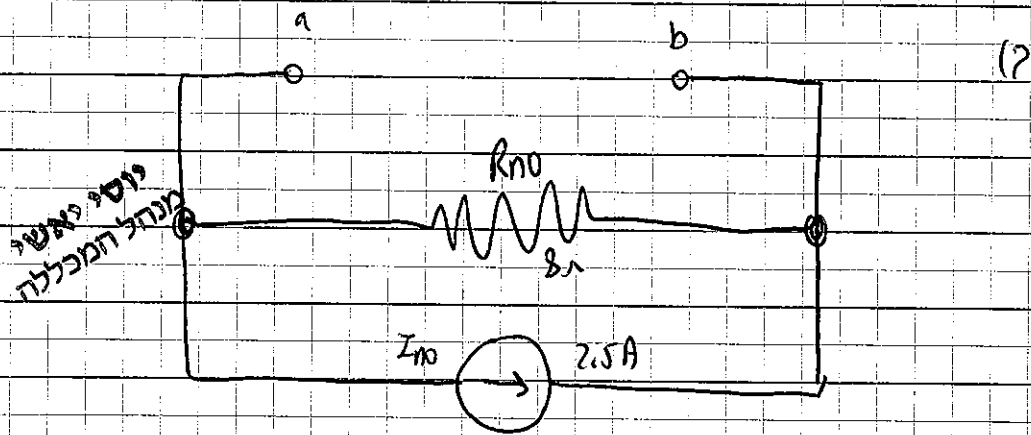
$$U_{ab} = -4 \cdot I_1 + 20 - 8I_2$$

$$U_{ab} = -4 \cdot 2.5 + 20 - 8 \cdot 3.75 = -20V$$

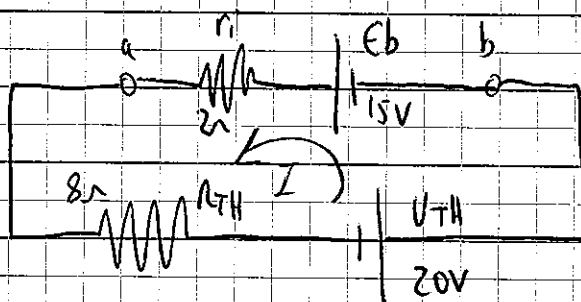
$$U_{TH} = 20V$$

660 אלף תזנין :





$$I_{no} = \frac{U_{TH}}{R_{TH}} = \frac{20}{8} = 2.5 \text{ A} ; \quad G_{no} = \frac{1}{R_{no}} = \frac{1}{8} = 0.125 \text{ (S)}$$



$$I = \frac{U_{TH} + E_b}{r_i + R_{TH}} = \frac{35}{10} = 3.5 \text{ (A)}$$

~~פריקו 77N7 77N7~~

2 אדל

$$P = \frac{U^2}{R}$$

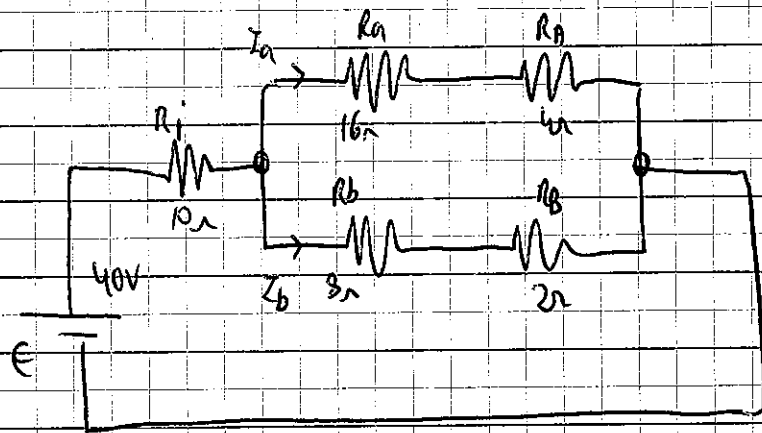
$$R = \frac{U^2}{P}$$

$$R_A = \frac{6^2}{9} = 4 \text{ (A)}$$

$$R_B = \frac{4^2}{8} = 2 \text{ (A)}$$

(K)

בסעיף זה
מחשבים את ההכחה



$$R_T = [(R_a + R_b) \parallel (R_a + R_b)] + R_i$$

$$R_T = (20 \parallel 10) + 10 = 16.667 \Omega$$

$$I_T = \frac{\epsilon}{R_T} = \frac{40}{16.667} = 2.4A$$

$$I_a = \frac{I_T \cdot (R_b + R_b)}{R_b + R_b + R_a + R_a} = \frac{2.4 \cdot 10}{10 + 20} = 0.8A$$

$$I_b = I_T - I_a = 2.4 - 0.8 = 1.6A$$

$$P = I^2 \cdot R$$

$$P_{RA} = 0.8^2 \cdot 4 = 2.56(W)$$

$$P_{RB} = 1.6^2 \cdot 2 = 5.12(W)$$

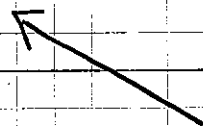
17 : 170 S 178 (1

$$R_T = (R_a \parallel R_b) + (R_a \parallel R_b) + R_i$$

$$R_T = 16 \parallel 8 + 4 \parallel 2 + 10$$

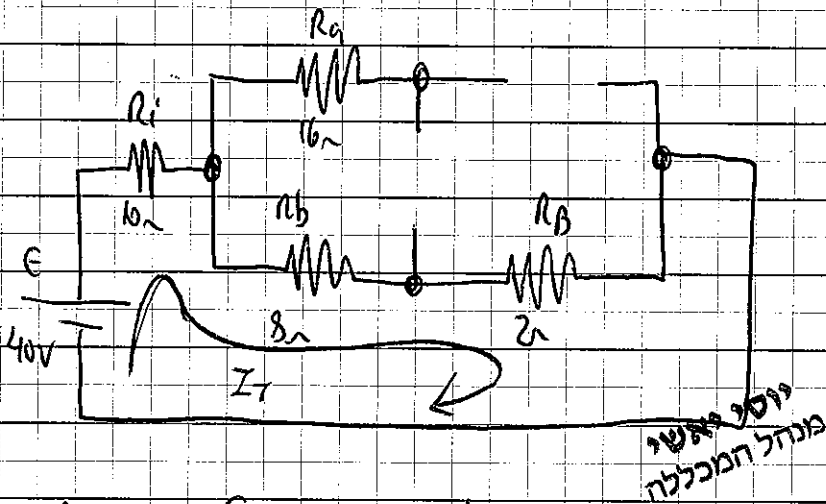
$$R_T = 16.667 \Omega$$

$$I_T = \frac{\epsilon}{R_T} = 2.4A$$



התקדם מזה של ה"מחשבים" !
מקומו של ה"מחשבים" של ה"מחשבים" :

$$P_{RA} = 2.56(W) ; P_{RB} = 5.12(W)$$



$$I_T = \frac{E}{R_i + R_b + R_B} = \frac{40}{20} = 2A$$

$$P_{R_B} = I_T^2 \cdot R_B = 2^2 \cdot 2 = 8 [W]$$

3. א.ל.ל.

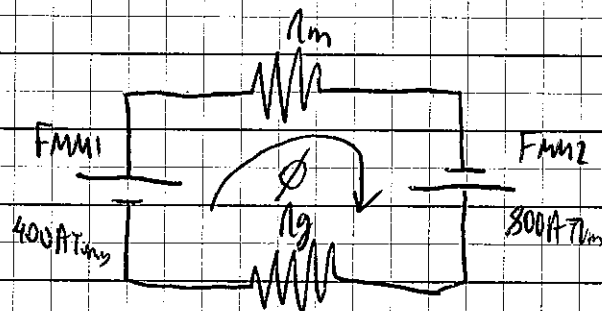
(ג) א.ל.ל. חלול (אנדרט) סגור:

$$F_{M1} = N_1 \cdot I_1$$

$$F_{M1} = 400 \cdot 1 = 400 \text{ ATurns}$$

$$F_{M2} = N_2 \cdot I_2$$

$$F_{M2} = 400 \cdot 2 = 800 \text{ ATurns}$$



$$R_m = \frac{l_{av}}{A \cdot \mu_0 \cdot \mu_r}$$

(K)

$$R_m = \frac{325 \cdot 10^{-3}}{2000 \cdot 10^{-6} \cdot 4\pi \cdot 10^{-7} \cdot 10000} = 12931.339 \frac{\text{ATurn}}{\text{Wb}}$$

$$R_g = \frac{l_g}{A_g \cdot \mu_0} = \frac{2 \cdot 10^{-3}}{2000 \cdot 10^{-6} \cdot 4\pi \cdot 10^{-7}} = 795.774715 \frac{\text{ATurn}}{\text{Wb}}$$

$$R_{mT} = R_m + R_g = 12931.339 + 795.774715 = 808.706 \cdot 10^3 \frac{\text{AT}}{\text{Wb}}$$

$$\Phi = \frac{F_{M1} + F_{M2}}{R_{mT}} = \frac{1200}{808.706 \cdot 10^3} = 1.483 (\text{mWb})$$

$$L_1 = \frac{N_1 \Phi_1}{Z_1} = \frac{400 \cdot 1.483 \cdot 10^{-3}}{1} = 0.593 \text{ (H)} \quad (7)$$

חשבוני
מכנה המכונה

$$L_2 = \frac{N_2 \Phi_2}{Z_2} = \frac{400 \cdot 1.483 \cdot 10^{-3}}{2} = 0.2966 \text{ H} \quad (8)$$

$$X_L = \omega L = 2\pi f L$$

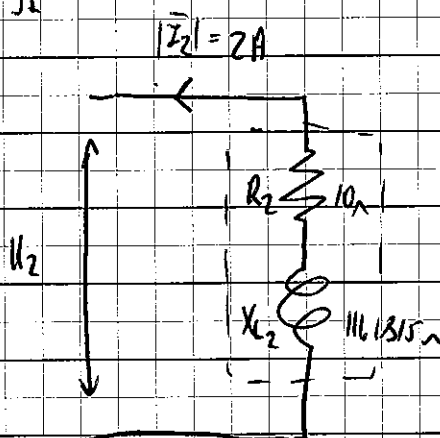
$$X_{L2} = 2\pi \cdot 60 \cdot 0.2966 = 111.815 \Omega$$

$$|\bar{U}_2| = |\bar{I}_2| \cdot |\bar{Z}_2|$$

$$|\bar{U}_2| = |\bar{I}_2| \cdot \sqrt{R_2^2 + X_{L2}^2}$$

$$|\bar{U}_2| = 2 \cdot \sqrt{10^2 + 111.815^2}$$

$$|\bar{U}_2| = 224.523 \text{ (V)} \quad \text{---}$$



$$U_1 = R_1 \cdot I_1 = 10 \cdot 1 = 10 \text{ (V)} \quad \text{---} \quad (9)$$

4.10Kp

$$f = 1000 \text{ Hz} \quad \text{מח} \quad (K)$$

$$X_L = \omega L = 2\pi \cdot 1000 \cdot 1 \cdot 10^{-3} = 6.283 \Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi \cdot 1000 \cdot 10^{-6}} = 15.915 \Omega$$

$$\bar{Z}_T = R_i + R_L + \left(\frac{1}{jX_L} + \frac{1}{-jX_C} \right)^{-1} = 40 + \left(\frac{1}{j6.283} + \frac{1}{-j15.915} \right)^{-1}$$

$$\bar{Z}_T = (40 + j10.381) \Omega = 41.325 / 14.548^\circ \Omega$$

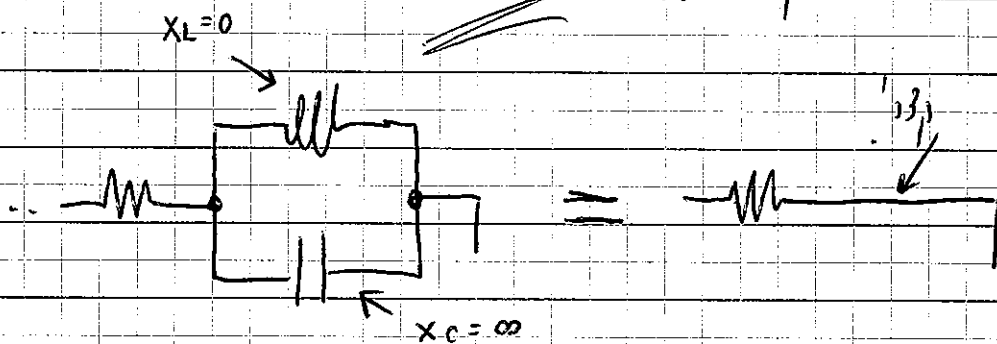
$$\bar{I}_L = \frac{\bar{E}}{\bar{Z}_T} = \frac{20 \angle 0^\circ}{41.325 \angle 14.548^\circ} = 0.483 \angle -14.548^\circ \text{ A}$$

$$P_{Li} = |\bar{Z}_T|^2 \cdot R_i = 0.483^2 \cdot 15 = 3.5 \text{ (W)}$$

יוסי יאשי
מנהל המכללה

(?) כפי שיתקף שרס מנר קצוות R_L , עכנו המסד
3 כינוי אהיו מני' אסיו, קרי' $X_{LC} = 0$ (קצו)

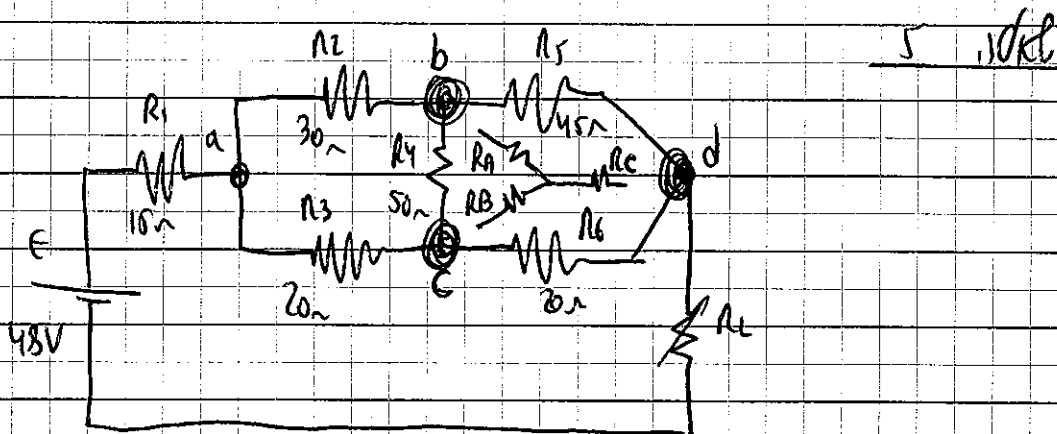
מקרה, לו יתקף עקו $f = 0$



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

$$|U_{RL}| = \frac{|\bar{E}| \cdot R_L}{R_i + R_L} = \frac{20 \cdot 25}{40} = 12.5 \text{ V}$$

$$P_{RL} = \frac{12.5^2}{25} = 6.25 \text{ (W)}$$

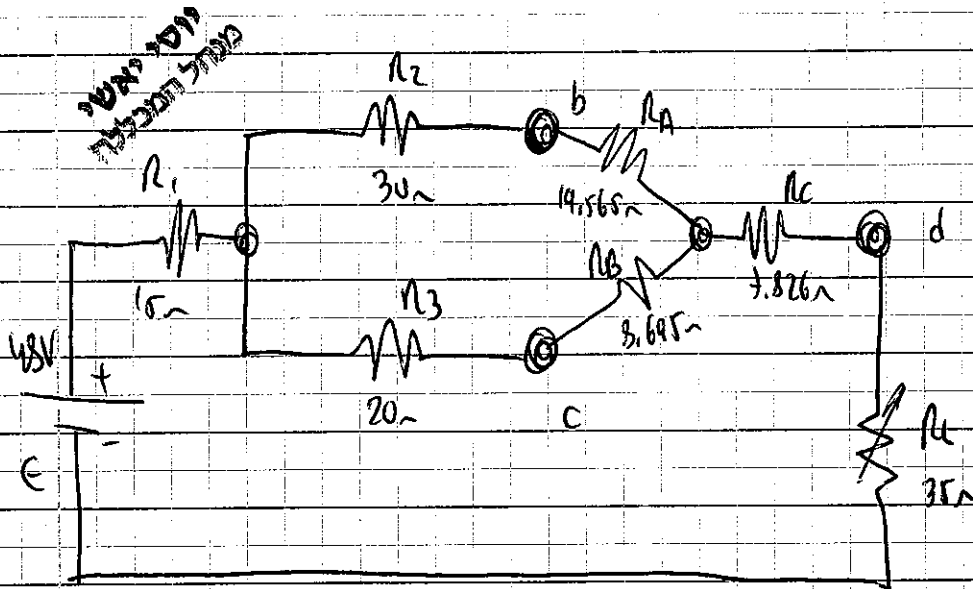


$$R_A = \frac{R_4 \cdot R_5}{R_4 + R_5 + R_6} = \frac{45 \cdot 50}{115} = 19.565 \Omega$$

(K)

$$R_B = \frac{R_4 \cdot R_6}{R_4 + R_5 + R_6} = \frac{50 \cdot 20}{115} = 8.695 \Omega$$

$$R_C = \frac{R_5 \cdot R_6}{R_4 + R_5 + R_6} = \frac{45 \cdot 20}{115} = 7.826 \Omega$$



$$R_T = [(R_2 + R_A) \parallel (R_3 + R_B)] + R_1 + R_C + R_L$$

$$R_T = (49.565 \parallel 28.695) + 15 + 7.826 + 35 = 76 \Omega$$

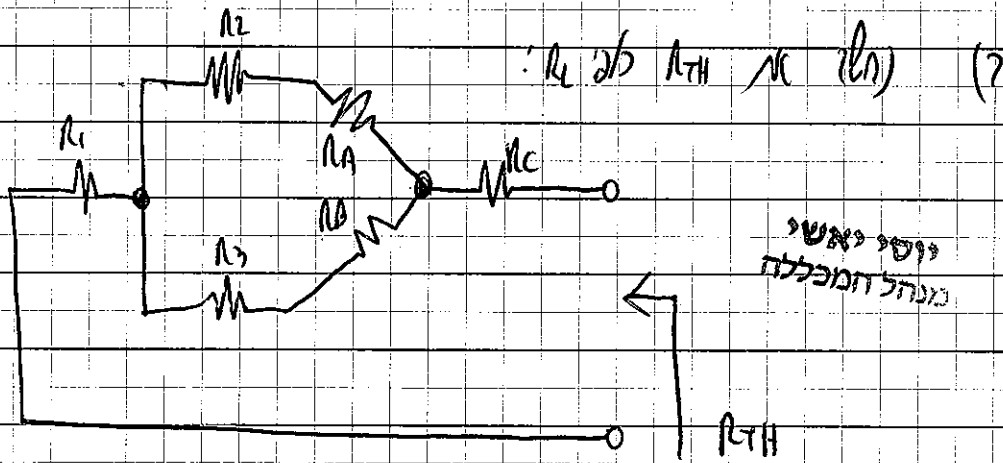
$$I_T = \frac{E}{R_T} = \frac{48}{76} = 0.631 \text{ A}$$

$$P_{RL} = I_T^2 \cdot R_L = 0.631^2 \cdot 35 = 13.961 \text{ (W)}$$

$$P_E = I_T \cdot E = 0.631 \cdot 48 = 30.288 \text{ W}$$

$$\eta = \frac{P_{RL}}{P_E} \cdot 100 = \frac{13.961}{30.288} \cdot 100 = 46.098 \%$$

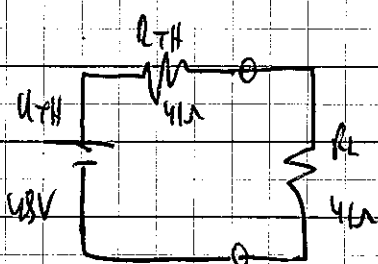
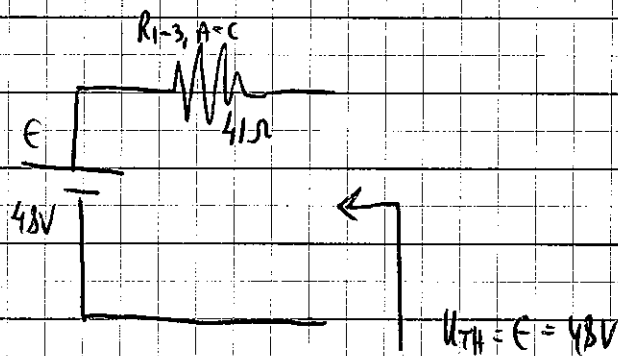
התוצאה נכונה
התוצאה נכונה



$$R_{TH} = (R_2 + R_A) \parallel (R_3 + R_B) + R_1 + R_C$$

$$R_{TH} = 41\Omega$$

$P_{R_L \max}$ | $R_L = R_{TH} = 41\Omega$



כל R_L R_{TH}

$$P_{R_L} = \frac{U_{R_L}^2}{R_L} = \frac{\left(\frac{1}{2} U_{TH}\right)^2}{R_L} = \frac{24^2}{41} = 14.048 (W)$$

$$I_{RL} = \frac{U_{RL}}{R_L} = \frac{\frac{1}{2} U_{TH}}{R_L} = \frac{24}{41} = 0.585 \text{ A}$$

$$I_{RL} = I_T = 0.585 \text{ A}$$

פוטנציאל
מנוחל המכללה

$$W = P \cdot t$$

$$P_T = I_T^2 \cdot R_T = 0.585^2 \cdot \overbrace{(R_L + R_{1-3, A-C})}^{82 \Omega} = 28.097 \text{ W}$$

$$W_T = 28.097 \cdot \underbrace{2 \cdot 60 \cdot 60}_{\substack{\text{הזמן הדרוש} \\ \text{לעבוד}}} = 202302.439 \text{ (J)}$$

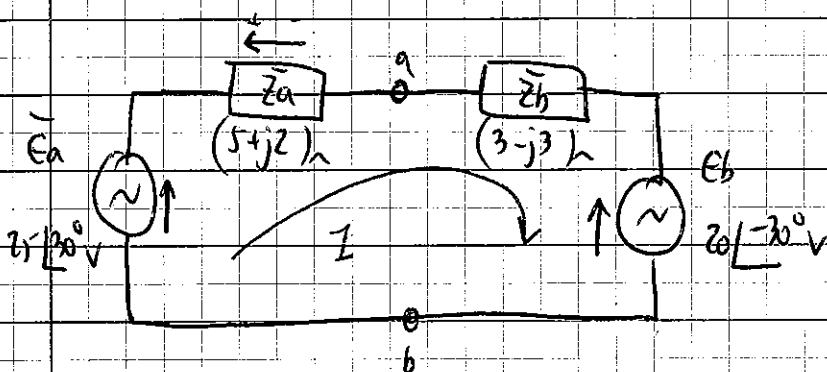
ג. דבור

$$\bar{Z}_{th} = \bar{Z}_a \parallel \bar{Z}_b$$

: $\bar{Z}_{th}$ תלות (K)

$$\bar{Z}_{th} = \left(\frac{1}{5+j2} + \frac{1}{3-j3} \right)^{-1} = (2.723 - j0.784) \Omega = 2.833 \angle -16.033^\circ \Omega$$

: $\bar{U}_{th}$ תלות



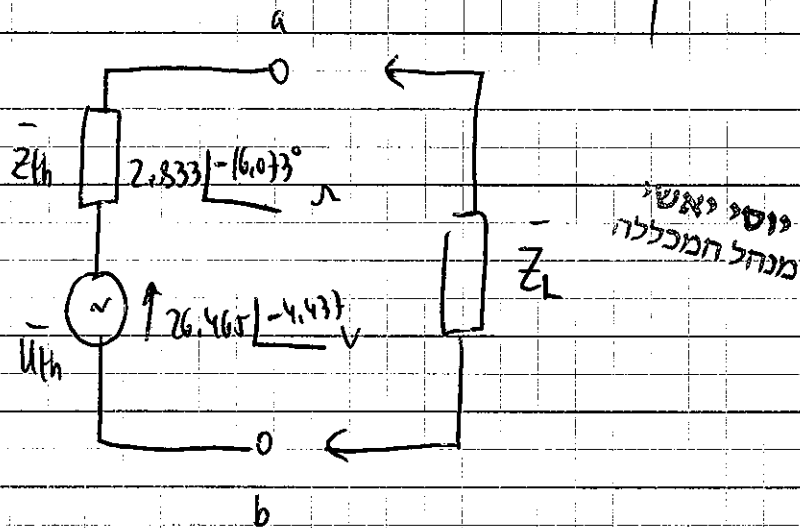
$$\bar{I} = \frac{\bar{E}_a - \bar{E}_b}{\bar{Z}_a + \bar{Z}_b} = \frac{25 \angle 30^\circ - 20 \angle -30^\circ}{5+j2 + 3-j3} = 2.841 \angle 86.231^\circ \text{ A}$$

$$\bar{U}_{ab} = -U_{Z_a} + \bar{E}_a$$

$$\bar{U}_{ab} = -(5+j2) \cdot 2.841 \angle 86.231^\circ + 25 \angle 30^\circ$$

$$\bar{U}_{ab} = \bar{U}_{th} = 26.465 \angle -4.433^\circ \text{ V}$$

160 נלח תנ"ן :



$$P_{L \max} \mid \bar{Z}_L = \bar{Z}_{Th}^* = 2.833 / 16.033^\circ [\Omega] = (2.722 + j0.784) \Omega$$

$$\bar{Z}_T = 2 \cdot 2.722 = 5.444 \Omega$$

$$\bar{I}_T = \frac{\bar{U}_{Th}}{\bar{Z}_T} = \frac{26.465 / -4.433}{5.444} = 4.861 / -4.433^\circ \text{ A}$$

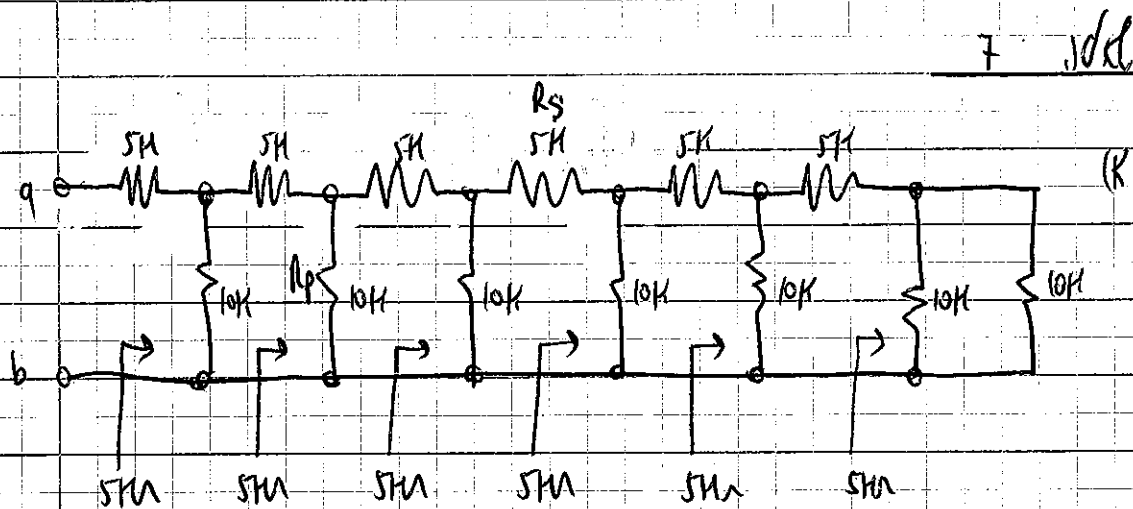
$$P_{L \max} = |\bar{I}_T|^2 \cdot 2.722 =$$

$$P_{L \max} = 4.861^2 \cdot 2.722 = 64.33 \text{ (W)}$$

$$P_{L \max} \mid R_L = |\bar{Z}_{Th}| = 2.833 \Omega \quad (?)$$

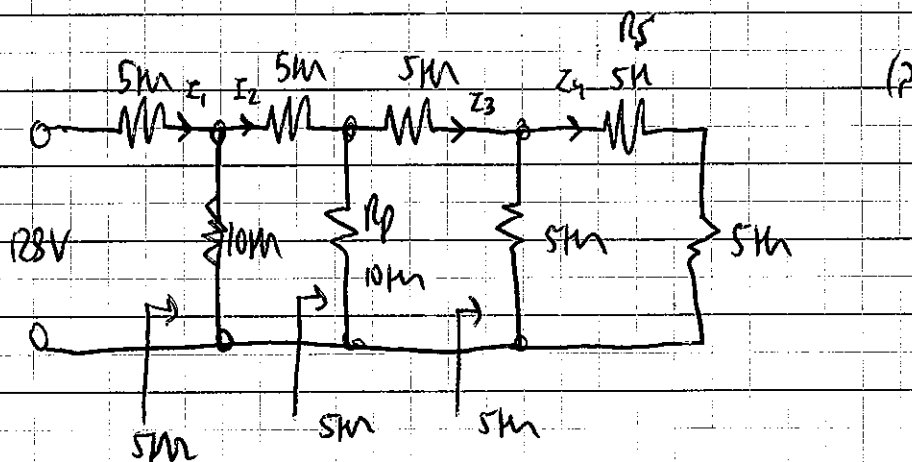
$$\bar{I}_T = \frac{\bar{U}_{Th}}{\bar{Z}_{Th} + R_L} = \frac{26.465 / -4.433}{2.833 / -16.033 + 2.833} = 4.711 / 3.6^\circ \text{ A}$$

$P_{R_1} = I_H^2 \cdot R_L = 4.11^2 \cdot 2.833 = 63.034 \text{ (W)}$



$R_{ab} = 5k$

! מנסה נאמרון נדמן



$I_1 = \frac{128}{5k + 5k} = 12.8 \text{ mA}$

$I_2 = \frac{1}{2} I_1 = \frac{12.8}{2} = 6.4 \text{ mA}$

$I_3 = \frac{1}{2} I_2 = \frac{6.4}{2} = 3.2 \text{ mA}$

$I_{Rp} = I_2 - I_3 = 6.4 - 3.2 = 3.2 \text{ mA}$

$U_{Rp} = I_{Rp} \cdot R_p = 3.2 \cdot 10 = 32 \text{ (V)}$

$$I_4 = \frac{1}{2} I_3 = \frac{1}{2} \cdot 3.2 = 1.6 \text{ mA}$$

(C)

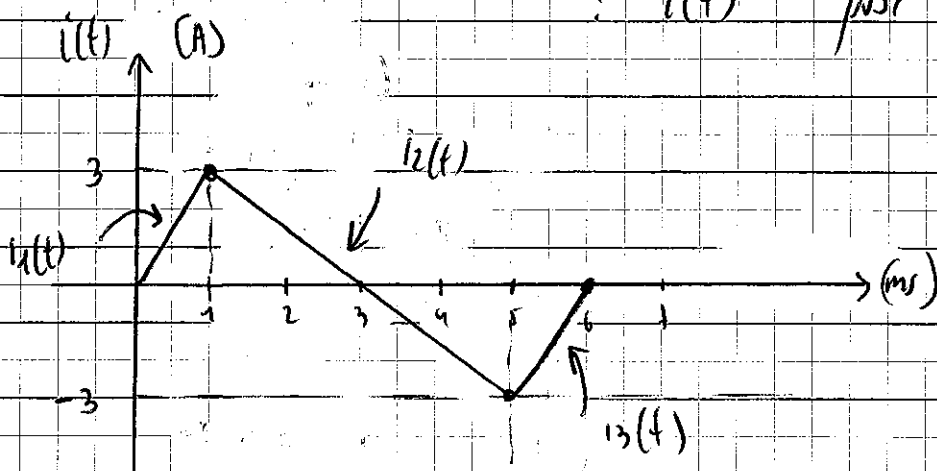
$$P_{RS} = I_4^2 \cdot R_S = (1.6 \cdot 10^{-3})^2 \cdot 5 \cdot 10^3 = 12.8 \text{ (mW)}$$

יחס חשמלי
מנהל המכללה

8 שאלות

האם ניתן להשתמש בטרנספורמטור? (כן/לא)

$i(t)$ נא?



$$a_1 = \frac{\Delta i}{\Delta t} = \frac{3-0}{1 \cdot 10^{-3}} = 3000$$

$$i_1(t) = at + b_1$$

$$i_1(t) = 3000t$$

$$0 \leq t \leq 1$$

$$a_2 = \frac{-3-3}{(5-1) \cdot 10^{-3}} = \frac{-6}{4 \cdot 10^{-3}} = -1500$$

$$i_2(t) = -1500t + b_2$$

$$3 = -1500 \cdot (1 \cdot 10^{-3}) + b_2$$

$$3 = -1.5 + b_2$$

$$b_2 = 4.5$$

$$i_2(t) = -1500t + 4.5$$

$$1 \leq t \leq 5$$

$$a_3 = \frac{0-(-3)}{(6-5) \cdot 10^{-3}} = 3000$$

$$5 \leq t \leq 6$$

$$i_3(t) = 3000t + b_3$$

$$0 = 3000 \cdot 6 \cdot 10^{-3} + b$$

$$b = -18$$

כיוון חיובי
במועד המכונה

$$i_3(t) = 3000t - 18$$

ל: $(t = 1_{\text{ms}})$ R נק' ו 128

$$i_{R_{\text{max}}} = 3000t = 3000 \cdot 1_{\text{ms}} = 3A$$

$$i_{R_{\text{max}}} = 3A$$

$$U_{R_{\text{max}}} = i_{R_{\text{max}}} \cdot R = 3 \cdot 1 = 3(V)$$

ל: L נק' ו 128

$$V_L = L \frac{di}{dt}$$

$$0 < t \leq 1$$

$$V_L = 1 \cdot 10^{-3} \cdot 3000 = 3(V)$$

$$V_{L_{\text{max}}} = 3(V)$$

$$1 < t \leq 5$$

$$V_L = 1 \cdot 10^{-3} \cdot (-1500) = -1.5(V)$$

$$5 < t \leq 6$$

$$V_L = 1 \cdot 10^{-3} \cdot 3000 = 3(V)$$

ל: C נק' ו 128

$$V_C(t) = \frac{1}{C} \int_0^t i_C(t) dt$$

$$0 < t \leq 1$$

$$V_C(t) = \frac{1}{1500 \cdot 10^{-6}} \int_0^{1m} 3000t dt = 1V$$

$$1 < t < 3$$

$$V_C(t) = V_C(0) + \frac{1}{C} \int_0^t Z_C(t) dt$$

$$V_C(t) = 1 + \frac{1}{1500 \cdot 10^{-6}} \int_{3m}^{3m} (-1000t + 4.5) dt$$

$$V_C(t) = 3V$$

פסוקי ראשי
מנחל חמכלה

$$3 < t < 5$$

$$V_C(t) = V_C(0) + \frac{1}{C} \int_0^t Z_C(t) dt$$

$$V_C(t) = 3 + \frac{1}{1500 \cdot 10^{-6}} \int_{3m}^{5m} (-1000t + 4.5) dt = 1V$$

$$5 < t < 6$$

$$V_C(t) = V_C(0) + \frac{1}{C} \int_0^t Z_C(t) dt$$

$$V_C(t) = 1 + \frac{1}{1500 \cdot 10^{-6}} \int_{5m}^{6m} (3000t - 18) dt$$

$$V_C(t) = 0$$

$$U_{Cmax} = 3 [V]$$

$$W_L = \frac{1}{2} L \cdot Z_{Lmax}^2 = \frac{1}{2} \cdot 1 \cdot 10^{-3} \cdot 3^2 = 4.5 (mJ)$$

(?)

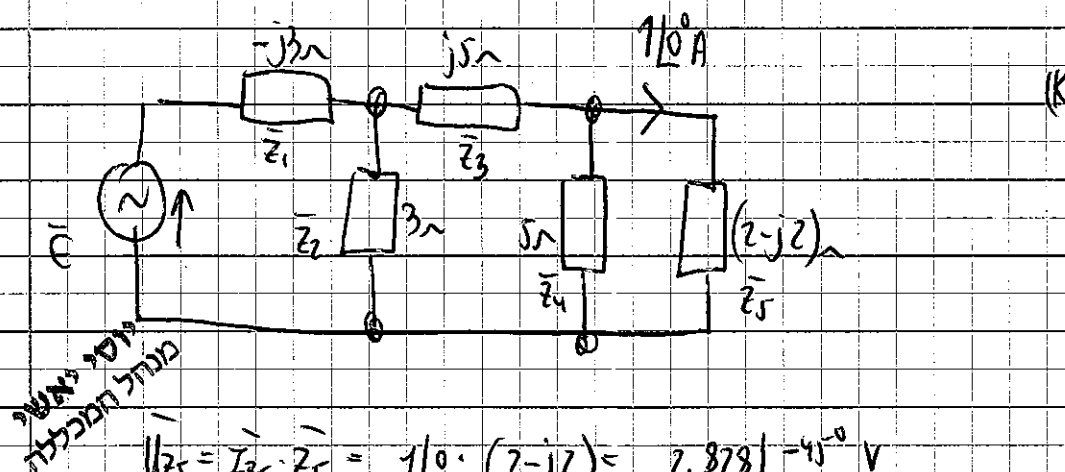
$$W_C = \frac{1}{2} \cdot C \cdot U_{Cmax}^2 = \frac{1}{2} \cdot 1500 \cdot 10^{-6} \cdot 3^2 = 6.75 (mJ)$$

$$U_R(t=6msec) = 0V$$

$$U_L(t=6msec) = 3V$$

$$U_C(t=6msec) = 0$$

$$U_{source}(t=6msec) = U_R(t) + U_C(t) + U_L(t) = 3 [V]$$



$$\tilde{U}_{Z5} = \tilde{I}_{Z5} \cdot \tilde{Z}_5 = 1\angle 0^\circ \cdot (2-j2) = 2.828\angle -45^\circ \text{ V}$$

$$\tilde{U}_{Z5} = \tilde{U}_{Z4}$$

$$\tilde{I}_{Z4} = \frac{\tilde{U}_{Z4}}{\tilde{Z}_4} = \frac{2.828\angle -45^\circ}{5\angle 0^\circ} = 0.565\angle -45^\circ \text{ A}$$

$$\tilde{Z}_{Z3} = \tilde{Z}_{Z4} + \tilde{Z}_{Z5} = 0.565\angle -45^\circ + 1\angle 0^\circ = 1.455\angle -15.932^\circ \text{ A}$$

$$\tilde{U}_{Z3} = \tilde{Z}_{Z3} \cdot \tilde{I}_{Z3} = 1.455\angle -15.932^\circ \cdot 5\angle 90^\circ = 7.275\angle 74.068^\circ \text{ V}$$

$$\tilde{U}_{Z2} = \tilde{U}_{Z3} + \tilde{U}_{Z4} = 7.275\angle 74.068^\circ + 2.828\angle -45^\circ$$

$$\tilde{U}_{Z2} = 6.397\angle 51.34^\circ \text{ V}$$

$$\tilde{I}_{Z2} = \frac{\tilde{U}_{Z2}}{\tilde{Z}_2} = \frac{6.397\angle 51.34^\circ}{3\angle 0^\circ} = 2.132\angle 51.34^\circ \text{ A}$$

$$\tilde{I}_T = \tilde{I}_{Z2} + \tilde{I}_{Z3} = 2.132\angle 51.34^\circ + 1.455\angle -15.932^\circ$$

$$\tilde{I}_T = 3.009\angle 24.861^\circ \text{ A}$$

$$\tilde{U}_{Z1} = \tilde{I}_T \cdot \tilde{Z}_1 = 3.009\angle 24.861^\circ \cdot 3\angle -90^\circ = 9.027\angle -65.139^\circ \text{ V}$$

$$\tilde{E} = \tilde{U}_{Z1} + \tilde{U}_{Z2} = 9.027\angle -65.139^\circ + 6.397\angle 51.34^\circ = 8.421\angle -22.298^\circ \text{ (V)}$$

$$\tilde{Z}_T = \frac{\tilde{E}}{\tilde{I}_T} = \frac{8.421\angle -22.298^\circ}{3.009\angle 24.861^\circ} = (1.402 - j2.052) \text{ (}\Omega\text{)}$$

$$\tilde{Z}_T = 2.498\angle -47.159^\circ \text{ (}\Omega\text{)}$$

$$P_{Z4} = |\tilde{I}_{Z4}|^2 \cdot R_4 = 0.565^2 \cdot 5 = 1.596 \text{ (W)}$$

