

פתרון מבחן מה"ט

תורה
החשמל
קיץ 2016

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כל הזכויות שמורות

1

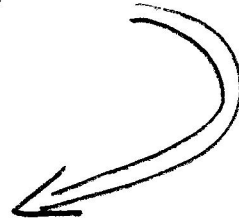
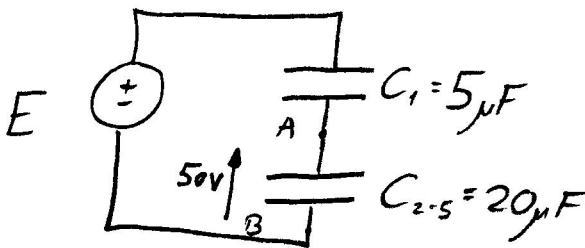
$$\textcircled{e} C_{4,5} = C_4 \parallel C_5 = C_4 + C_5 = 40 \mu F$$

$\begin{matrix} \text{р.д.н.} \\ \text{н.р.н.} \\ \text{р.д.н.} \end{matrix}$

$$U_{C_3} = U_{AB} \cdot \frac{C_{4,5}}{C_3 + C_{4,5}} = 50 \cdot \frac{40}{40 + 10} = 40V$$

$$Q_{C_3} = C_3 \cdot U_{C_3} = 10 \cdot 10^{-6} \cdot 40 = 400 \mu C$$

$$\textcircled{2} C_{2-5} = (C_3 \rightarrow C_{4,5}) \parallel C_2 = \left(\frac{1}{40} + \frac{1}{10} \right)^{-1} + 12 = 8 + 12 = 20 \mu F$$



$\begin{matrix} \text{р.д.н.} \\ \text{н.р.н.} \\ \text{р.д.н.} \end{matrix}$

$$U_{AB} = E \cdot \frac{C_1}{C_1 + C_{2-5}}$$

$$50 = E \cdot \frac{5}{5 + 20} \Rightarrow E = 250V$$

$$\textcircled{2} C_T = C_1 \rightarrow C_{2-5} = \left(\frac{1}{5} + \frac{1}{20} \right)^{-1} = 4 \mu F$$

\Downarrow

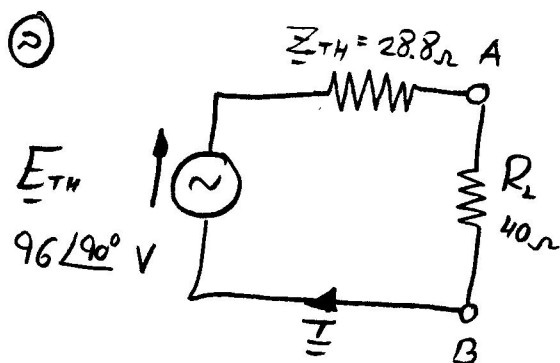
$$W_{CT} = \frac{C_T \cdot E^2}{2} = 0.5 \cdot 4 \cdot 10^{-6} \cdot 250^2 = 0.125 J$$

2

$$\begin{aligned} \textcircled{E} \quad \underline{Z}_{TH} &= (R_1 \parallel \underline{X}_1) + (R_2 + \underline{X}_2) = \\ &= \left(\frac{1}{40} + \frac{1}{j30} \right)^{-1} + \left(\frac{1}{40} + \frac{1}{-j30} \right)^{-1} = \\ &= 14.4 + j19.2 + 14.4 - j19.2 = \\ &= 28.8 \Omega \end{aligned}$$

$$\begin{aligned} \underline{E}_{TH} &= \underline{U}_{AB_0} = \underline{\dot{V}}_A - \underline{\dot{V}}_B = \underline{U}_{X_1} - \underline{U}_{X_2} = \\ &= \underline{U} \cdot \frac{\underline{X}_1}{\underline{X}_1 + R_1} - \underline{U} \cdot \frac{\underline{X}_2}{R_2 + \underline{X}_2} = \\ &= \underline{U} \cdot \left(\frac{\underline{X}_1}{\underline{X}_1 + R_1} - \frac{\underline{X}_2}{R_2 + \underline{X}_2} \right) = \\ &= 100 \angle 0^\circ \cdot \left(\frac{j30}{40 + j30} - \frac{-j30}{40 - j30} \right) = \\ &= 96 \angle 90^\circ \text{ V} \end{aligned}$$

⇓



$$\underline{I} = \frac{\underline{E}_{TH}}{\underline{Z}_{TH} + R_L} = \frac{96 \angle 90^\circ}{28.8 + 40} = 1.395 \angle 90^\circ \text{ A}$$

$$P_{R_L} = I^2 \cdot R_L = 1.395^2 \cdot 40 = 77.88 \text{ W}$$

3

$$\textcircled{b} R = \frac{\Delta u}{\Delta I} = \frac{60-0}{24 \cdot 10^{-3}-0} = 2.5 \text{ k}\Omega //$$

$$\textcircled{a} E = 25 \angle 0^\circ \text{ V}$$

$$\Downarrow \\ \underline{I}_R = \frac{E}{R} = \frac{25 \angle 0}{2500} = 0.01 \angle 0^\circ \text{ A} = 10 \angle 0^\circ \text{ mA}$$

$$\Downarrow \\ i_R(t) = \sqrt{2} \cdot 10 \cdot \sin(1000t) [\text{mA}] //$$

$$\textcircled{c} X_L = \omega L = 1000 \cdot 0.25 = 250 \Omega$$

$$\Downarrow \\ \underline{Z} = (2500 + j250) \Omega = 2512.469 \angle 5.7^\circ \Omega$$

$$\Downarrow \\ \underline{I}_Z = \frac{E}{Z} = \frac{25 \angle 0}{2500 + j250} = 9.95 \angle -5.7^\circ [\text{mA}]$$

$$\Downarrow \\ i_Z(t) = \sqrt{2} \cdot 9.95 \cdot \sin(1000t - 5.71^\circ) [\text{mA}] //$$

$$\textcircled{3} \quad \omega_0 = \frac{1}{\sqrt{LC}}$$

$$1000 = \frac{1}{\sqrt{0.25 \cdot C}}$$

$$C = 4 \mu\text{F} //$$

④

$$l_{\text{нас}} = l_1 + l_2 + l_3 = 160 + 120 + 160 = 440 \cdot 10^{-3} \text{ m}$$

$$A_{\text{нас}} = 800 \cdot 10^{-6} \text{ m}^2$$

$$\mu_{r_{\text{нас}}} = 2500$$

⇓

$$\begin{aligned} R_{m_1} = R_{m_{\text{нас}}} &= \frac{1}{\mu_0 \cdot \mu_{r_{\text{нас}}}} \cdot \frac{l_{\text{нас}}}{A_{\text{нас}}} = \frac{1}{2500 \mu_0} \cdot \frac{440 \cdot 10^{-3}}{800 \cdot 10^{-6}} = \\ &= 0.175 \cdot 10^6 \frac{1}{\text{H}} \end{aligned}$$

$$l_{\text{сир}} = l_4 = 120 \cdot 10^{-3} \text{ m}$$

$$A_{\text{сир}} = 800 \cdot 10^{-6} \text{ m}^2$$

$$\mu_{r_{\text{сир}}} = 500$$

⇓

$$\begin{aligned} R_{m_2} = R_{m_{\text{сир}}} &= \frac{1}{\mu_0 \cdot \mu_{r_{\text{сир}}}} \cdot \frac{l_{\text{сир}}}{A_{\text{сир}}} = \frac{1}{500 \mu_0} \cdot \frac{120 \cdot 10^{-3}}{800 \cdot 10^{-6}} = \\ &= 0.238 \cdot 10^6 \frac{1}{\text{H}} \end{aligned}$$

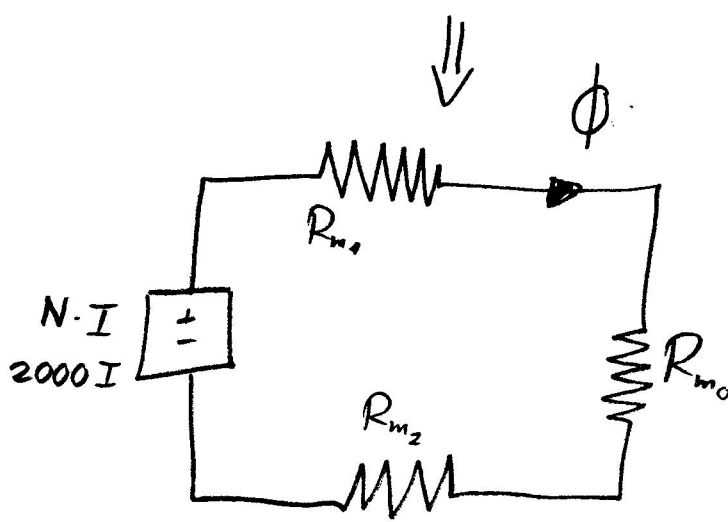
$$l_{\text{тик}} = 2 \cdot l_5 = 4 \cdot 10^{-3} \text{ m}$$

$$A_{\text{тик}} = 800 \cdot 10^{-6} \text{ m}^2$$

$$\mu_{r_{\text{тик}}} = 1$$

⇓

$$\begin{aligned} R_{m_0} = R_{m_{\text{тик}}} &= \frac{1}{\mu_0 \cdot \mu_{r_{\text{тик}}}} \cdot \frac{l_{\text{тик}}}{A_{\text{тик}}} = \frac{1}{\mu_0} \cdot \frac{4 \cdot 10^{-3}}{800 \cdot 10^{-6}} = \\ &= 3.978 \cdot 10^6 \frac{1}{\text{H}} \end{aligned}$$



$$\textcircled{a} R_{mT} = R_{m1} + R_{m0} + R_{m2} = 4.391 \cdot 10^6 \frac{1}{H} //$$

⇓

$$\textcircled{b} L = \frac{N^2}{R_{mT}} = \frac{2000^2}{4.391 \cdot 10^6} = 0.91 H //$$

$$\textcircled{c} B = 1.5 T \Rightarrow \Phi_{1.7T} = B \cdot A_{1.7T} = 1.5 \cdot 800 \cdot 10^{-6} = 1.2 \text{ mWb}$$

מח' המגנטוסיון
= מח' הזרם

$$\Phi_{1.7T} = \frac{N \cdot I}{R_{mT}}$$

$$1.2 \cdot 10^{-3} = \frac{2000 I}{4.391 \cdot 10^6}$$

לכל המרה המיוצגת
הנכונה, ניתן להשתמש
בנוסחה הקבועה י"י להב
DC הממוצע שלה וזה
הוא

$$\rightarrow I = 2.634 A //$$

⇓

$$\textcircled{3} W_L = \frac{L \cdot I^2}{2} = 0.5 \cdot 0.91 \cdot 2.634^2 = 3.158 J //$$

5

$$\begin{aligned} \textcircled{1} \underline{Z}_{2-5} &= (\underline{Z}_2 + \underline{Z}_3) \parallel (\underline{Z}_4 + \underline{Z}_5) = \\ &= (12 + j5 + 12 - j12) \parallel (6 + j10 + 6 - j5) = \\ &= \left(\frac{1}{24 - j7} + \frac{1}{12 + j5} \right)^{-1} = \\ &= (8.89 + j1.494) \Omega = 9.013 \angle 9.54^\circ \Omega \end{aligned}$$

$$\begin{aligned} \textcircled{2} \underline{I}_T &= \frac{\underline{U}}{\underline{Z}_1 + \underline{Z}_{2-5}} = \frac{200 \angle 0}{15 + j10 + 9.013 \angle 9.54} = \\ &= 7.544 \angle -25.7^\circ \text{ A} \end{aligned}$$

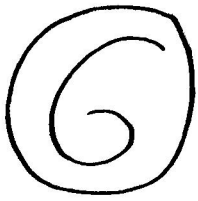
P₂₃ p₄₅ "82"

$$\begin{aligned} \textcircled{3} \underline{I}_{45} &= \underline{I}_T \cdot \frac{\underline{Z}_{2,3}}{\underline{Z}_{2,3} + \underline{Z}_{4,5}} = 7.544 \angle -25.7^\circ \cdot \frac{24 - j7}{24 - j7 + 12 + j5} = \\ &= 5.23 \angle -38.7^\circ \text{ A} \end{aligned}$$

$$\begin{aligned} \textcircled{3} \underline{S}_T &= \underline{I}_T^* \cdot \underline{U} = 7.544 \angle 25.7^\circ \cdot 200 \angle 0 = \\ &= \underbrace{(1359.545)}_{P_T \text{ [W]}} + j \underbrace{(654.3)}_{Q_T \text{ [VAR]}} \text{ VA} = 1508.8 \angle 25.7^\circ \text{ VA} \end{aligned}$$

$$P_T \approx 1360 \text{ W}$$

$$S_T \approx 1509 \text{ VA}$$



$$\textcircled{a} T = 10 \text{ m sec} \Rightarrow f = \frac{1}{T} = 100 \text{ Hz}$$

$$\textcircled{b} U_{\text{דמיונית}} = 15 \text{ V}$$

$$I_{\text{דמיונית}} = \frac{U_{\text{דמיונית}}}{R} = \frac{15}{50} = 0.3 \text{ A}$$

$$I_{\text{av}} = \frac{1}{T} \int_0^T i(t) dt$$
 אפקט אמצעי של הזרם הממוצע באמצעות:

 אק דפס בק יע אמצעי של סוקציות תכנס הרגעי,

 כי שנית ערפוע בטוחה מקוצרות המיוצרת ערע ארע:

$$I_{\text{av}} = \frac{I_1 + I_2}{2} = \frac{0.3 - 0.3}{2} = 0 \text{ A}$$

$$U_{\text{RMS}} = \sqrt{\frac{1}{T} \int_0^T [u(t)]^2 dt}$$
 בכז' אמצעי של היספק יע אמצעי של הזרם היזע של כל

 המחה ניתן ערעור זמא באמצעות:

 ואלה רצותק אמצעי של סוקציות

 המחה הרגעי, כי שנית ערפוע בטוחה מקוצרות המיוצרת

 ערע ארע:

$$U_{\text{RMS}} = \sqrt{\frac{(U_2 - U_1)^2}{3} + U_1 \cdot U_2} =$$

$$= \sqrt{\frac{[15 - (-15)]^2}{3} - 15^2} = \sqrt{75} = 8.66 \text{ V}$$

$$P = \frac{U_{\text{RMS}}^2}{R} = \frac{75}{50} = 1.5 \text{ W}$$

7

$$\textcircled{1} \quad \underline{U}_{z_1} = 65 \angle 0^\circ \text{ V} \quad \Rightarrow \quad \underline{I}_T = \frac{\underline{U}_{z_1}}{\underline{Z}_1} = \frac{65 \angle 0}{13 \angle 22.62} = 5 \angle -22.62^\circ \text{ A} //$$
$$\underline{Z}_1 = 13 \angle 22.62^\circ \Omega$$

$$\textcircled{2} \quad \underline{U}_{z_2} = 85 \angle -84.55^\circ \text{ V} \quad \underline{I}_T = 5 \angle -22.62^\circ \text{ A}$$

$$\Downarrow$$
$$\underline{Z}_2 = \frac{\underline{U}_{z_2}}{\underline{I}_T} = \frac{85 \angle -84.55}{5 \angle -22.62} = (8 - j15) \Omega = 17 \angle -61.93^\circ \Omega //$$

$$\textcircled{3} \quad \underline{U} = \underline{U}_{z_1} + \underline{U}_{z_2} = 65 \angle 0 + 85 \angle -84.55 =$$
$$= (73.073 - j84.615) \text{ V} =$$
$$= 111.8 \angle -49.18^\circ \text{ V} //$$

$$\textcircled{3} \quad \underline{S}_T = \underline{I}_T^* \underline{U} = 5 \angle +22.62 \cdot 111.8 \angle -49.18 =$$
$$= \underbrace{(500)}_{P_T [\text{W}]} - j \underbrace{250}_{Q_T [\text{VAR}]} \text{ VA} = 560 \angle -26.56^\circ \text{ VA} //$$

התוצאה היא $Q_c = -14.123 \text{ kVAR}$ (כלומר, התוצאה היא 14.123 kVAR של קונדנצטור) C

$$[1] P_T' = 21 \text{ kW (וע' כח)} \Rightarrow Q_T' = P_T \cdot \tan \phi' = 21 \cdot \tan 20 = 7.643 \text{ kVAR}$$

$$\phi' = 20^\circ$$

$$\Downarrow$$

$$Q_c = Q_T' - Q_T = 7.643 - 21.766 =$$

$$= (-)14.123 \text{ kVAR,,}$$

$$[2] P_T' = 21 \text{ kW}$$

$$\phi' = 20^\circ \Rightarrow S_T' = \frac{P_T'}{\cos \phi'} = \frac{21}{\cos 20} = 22.347 \text{ kVA}$$

$$\Downarrow$$

$$S_T' = 22.347 \angle 20 = (21 + j 7.643) \text{ kVA}$$

$$\Downarrow$$

$$Q_c = Q_T' - Q_T = 7.643 - 21.766 = (-)14.123 \text{ kVAR,,}$$

$$[3] Q_c = P_T \cdot (\tan \phi - \tan \phi') =$$

$$= 21 \cdot (\tan 46 - \tan 20) = 14.102 \text{ kVAR,,}$$

$$\text{C} \quad Q_c = \frac{U^2}{X_c} \quad \Downarrow \quad X_c = \frac{1}{2\pi f C}$$

$$14.123 \cdot 10^3 = \frac{231^2}{X_c} \quad 3.778 = \frac{1}{2\pi \cdot 50 \cdot C}$$

$$X_c = 3.778 \Omega \quad C = 842.467 \mu\text{F,,}$$