(k)

1

$$\begin{cases} +G_{11}V_1 - G_{12}V_2 - G_{13}V_3 = I_{sc_1} \\ -G_{21}V_1 + G_{22}V_2 - G_{23}V_3 = I_{sc_2} \\ -G_{31}V_1 - G_{32}V_2 + G_{33}V_3 = I_{sc_3} \end{cases}$$

$$G_{11} = \frac{1}{R_6} + \frac{1}{R_2} + \frac{1}{R_1} = \frac{1}{8} + \frac{1}{6} + \frac{1}{3} = \frac{5}{8}\,S$$

$$G_{22} = \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_5} = \frac{1}{6} + \frac{1}{10} + \frac{1}{1} = \frac{19}{15}\,S$$

$$G_{33} = \frac{1}{R_1} + \frac{1}{R_5} + \frac{1}{R_4 + R_7} = \frac{1}{3} + \frac{1}{1} + \frac{1}{11} = \frac{47}{33}\,S$$

$$G_{12} = G_{21} = \frac{1}{R_2} = \frac{1}{6}\,S$$

$$G_{23} = G_{32} = \frac{1}{R_5} = \frac{1}{1} = 1\,S$$

$$G_{13} = G_{31} = \frac{1}{R_1} = \frac{1}{3}\,S$$

$$I_{sc_1} = \frac{E_2}{R_2} + \frac{E_1}{R_1} = \frac{10}{6} + \frac{12}{3} = 5.666A$$

$$I_{sc_2} = -\frac{E_3}{R_3} - \frac{E_2}{R_2} - I = -\frac{2}{10} - \frac{10}{6} - 6 = -7.866A$$

$$I_{sc_3} = -\frac{E_1}{R_1} + I + \frac{E_4}{R_4 + R_7} = -\frac{12}{3} + 6 + \frac{12}{11} = 3.091A$$

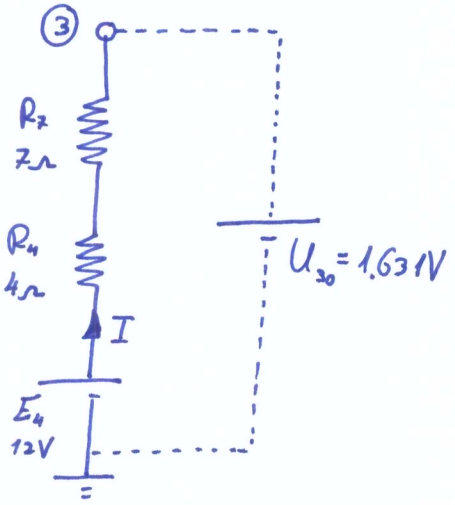
$$\Downarrow$$

$$\begin{cases} +\frac{5}{8}V_1 - \frac{1}{6}V_2 - \frac{1}{3}V_3 = 5.666 \\ -\frac{1}{6}V_1 + \frac{19}{15}V_2 - 1 \cdot V_3 = -7.866 \\ -\frac{1}{3}V_1 - 1 \cdot V_2 + \frac{47}{33}V_3 = 3.091 \end{cases}$$

$V_1 = 8.937V$ $\quad V_2 = -3.746V$ $\quad V_3 = 1.631V$

② $U_{AC} = V_A - V_C = V_1 - V_3 = 8.937 - 1.631 = 7.306V$

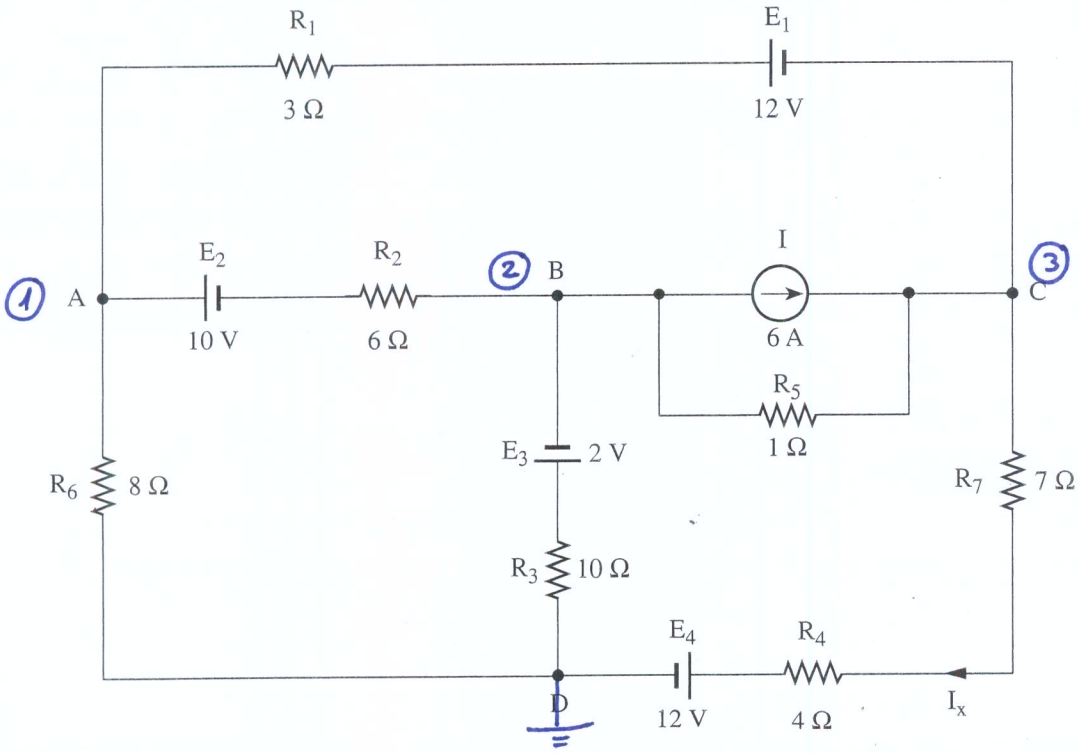
③



$$I = \frac{E_4 - U_{30}}{R_4 + R_7} = \frac{12 - 1.631}{4+7} = 0.942A$$

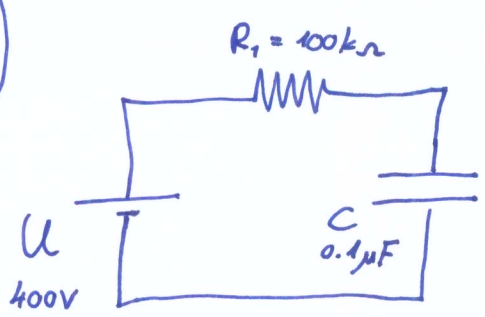
שים לב! הזרם I_x נמדד בכיוון ההפוך, כלומר:

$$I_x = -I = -0.942A$$



2

טעינה



$0 < t < 15msec$

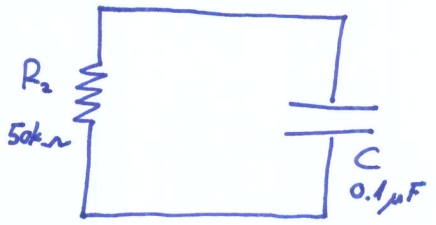
$\tau_1 = R_1 C =$

$= 100 \cdot 10^3 \cdot 0.1 \cdot 10^{-6} =$

$= 10msec$

$u_c(\infty) = 400V$

פריקה



$15msec \leq t$

$\tau_2 = R_2 C =$

$= 50 \cdot 10^3 \cdot 0.1 \cdot 10^{-6} =$

$= 5msec$

$u_c(\infty) = 0V$

ב) $u_c(0^+) = 0V$ (נתון)

$$u_c(t) = u_c(\infty) - [u_c(\infty) - u_c(0^+)]e^{-\frac{t}{\tau_1}} =$$

$$= 400 - [400 - 0]e^{-\frac{t}{10}} =$$

$$= 400 - 400e^{-\frac{t}{10}} \ [V]_{//}$$

$$u_c(t = 15msec) = 400 - 400e^{-\frac{15}{10}} = 310.748V$$

$$\Downarrow$$

$$u_c(0^+) = 310.748V \quad \left(\begin{array}{c}\text{סוף קשר הטעינה}\\ \text{הוא התחלת קשר}\\ \text{הפריקה}\end{array}\right)$$

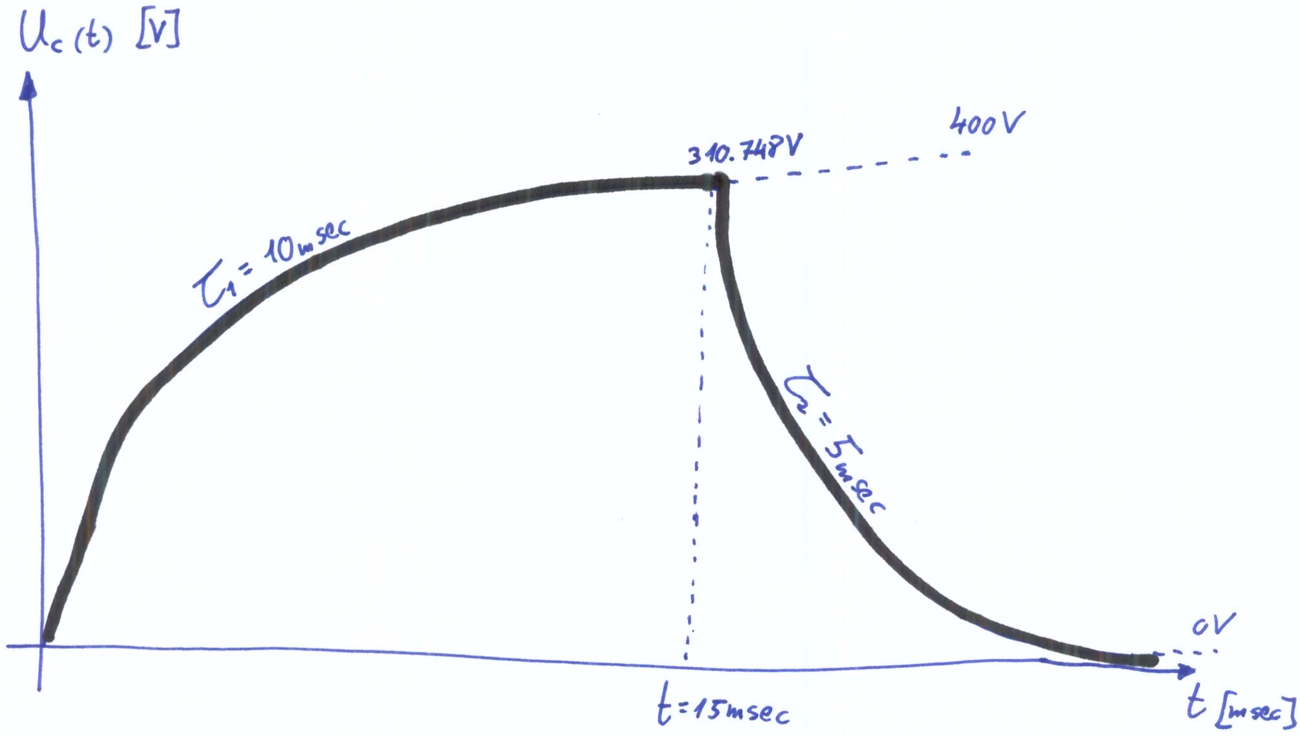
$$u_c(t) = u_c(\infty) - [u_c(\infty) - u_c(0^+)]e^{-\frac{t}{\tau_2}} =$$

$$= 0 - [0 - 310.748]e^{-\frac{t}{5}} =$$

$$= 310.748e^{-\frac{t}{5}} \ [V]_{//}$$

$$u_c(t = 30msec) = 310.748e^{-\frac{15}{5}} = 15.471V_{//}$$

(d)



③ ניתן לראות הן מהמשוואות שקבלנו והן מהגרף שמתח הקבל יגיע ל-200V פעם אחת בטעינה ופעם אחת בפריקה:

טעינה

$$200 = 400 - 400e^{-\frac{t_1}{10}}$$

$$-200 = -400e^{-\frac{t_1}{10}}$$

$$0.5 = e^{-\frac{t_1}{10}} \quad /\ln$$

$$-0.693 = -\frac{t_1}{10}$$

$$\boxed{t_1 = 6.931\,msec}$$

פריקה

$$200 = 310.748e^{-\frac{t'}{5}}$$

$$0.643 = e^{-\frac{t'}{5}} \quad /\ln$$

$$-0.44 = -\frac{t'}{5}$$

$$t' = 2.203\,msec$$

שים לב!

$$\boxed{t_2 = t' + 15 = 17.203\,msec}$$

(3) $\omega_0 = 10^5 \frac{rad}{sec} \Rightarrow f_0 = \frac{\omega_0}{2\pi} = \frac{10^5}{2\pi} = 15.915\,kHz$

$BW' = 0.15\omega_0 = 0.15 \cdot 10^5 = 15 \cdot 10^3 \frac{rad}{sec} \Rightarrow BW = \frac{BW'}{2\pi} = 2.387\,kHz$

(t) $BW = \frac{f_0}{Q_0}$

$2.387 \cdot 10^3 = \frac{15.915 \cdot 10^3}{Q_0} \Rightarrow Q_0 = 6.666_{..}$

(2) $P = 30W \quad (\text{נתון})$

$\frac{U^2}{R} = 30$

$\frac{120^2}{R} = 30 \Rightarrow R = 480\Omega_{..}$

$\Downarrow$

$Q_0 = \frac{\omega_0 L}{R}$

$6.666 = \frac{10^5 \cdot L}{480} \Rightarrow L = 32mH_{..}$

$\Downarrow$

$\omega_0 = \sqrt{\frac{1}{LC}}$

$10^5 = \sqrt{\frac{1}{32 \cdot 10^{-3} C}} \Rightarrow C = 3.125nF_{..}$

(d) $\underline{I} = \frac{\underline{U}}{\underline{Z}_T} = \frac{\underline{U}}{R} = \frac{120\angle 0^\circ}{480} = 0.25\angle 0^\circ A_{..}$

$X_L = X_C = \omega_0 L = 10^5 \cdot 32 \cdot 10^{-3} = 3200\Omega$

$\Downarrow$

$$\Downarrow$$

$$\underline{X}_L = jX_L = j3200\,\Omega$$

$$\underline{X}_C = -jX_C = -j3200\,\Omega$$

$$\Downarrow$$

$$\underline{U}_R = \underline{U} = 120\angle 0^\circ\ V$$

$$\underline{U}_L = \underline{I}\cdot\underline{X}_L = 0.25\angle 0^\circ \cdot j3200 = 800\angle 90^\circ\ V$$

$$\underline{U}_C = \underline{I}\cdot\underline{X}_C = 0.25\angle 0^\circ \cdot (-j3200) = 800\angle -90^\circ\ V$$

✿ דרך נוספת:

המתח הן על הסליל והן על הקבל יהיה גדול ממתח הנגד פי גורם הט"ב, כלומר:

$$U_L = U_C = Q_0 \cdot U_R = Q_0 \cdot U = 6.666 \cdot 120 = 800V$$

במעגל שלנו זווית המופע של הזרם היא 0°, ולכן לפי כללי המופע ("CIVIL") נקבל:

$$\underline{U}_L = 800\angle 90^\circ V$$

$$\underline{U}_C = 800\angle -90^\circ V$$