N 14.1 (17)

$$F_1(s) = \frac{s^2-3s-1}{(s+4)(s+1)^2}$$

$$i_L(0+) = \lim_{s\to\infty} sF_1(s) = \lim_{s\to\infty} \frac{s^3-3s^2-s}{(s+4)(s+1)^2} = 1$$

$$U_L(s) = sF_1(s) - Li_L(0+) = \frac{s^3-3s^2-s}{(s+4)(s+1)^2} - 1 =$$

$$= -\frac{9s^2+10s+4}{(s+1)^2(s+4)}$$

$$U_L(0+) = \lim_{s\to\infty} sU_L(s) = \lim_{s\to\infty}\left(-\frac{9s^3+10s^2+4s}{(s+1)^2(s+4)}\right) = -9$$

$$\frac{s^2-3s-1}{(s+4)(s+1)^2} = \frac{A}{s+4} + \frac{B}{s+1} + \frac{C}{(s+1)^2}$$

$$A = \frac{s^2-3s-1}{(s+1)^2}\Big|_{s=-4} = \frac{16+12-1}{9} = 3$$

$$B = \left(\frac{s^2-3s-1}{s+4}\right)'\Big|_{s=-1} = \frac{(2s-3)(s+4)-s^2+3s+1}{(s+4)^2}\Big|_{s=-1} =$$

$$= \frac{3(-5)-1-3+1}{9} = -2$$

$$C = \frac{s^2-3s-1}{s+4}\Big|_{s=-1} = \frac{1+3-1}{3} = 1$$

$$i_L(t) = 3e^{-4t} - 2e^{-t} + te^{-t},\quad t>0$$

$$-\frac{9s^2+10s+4}{(s+1)^2(s+4)} = \frac{A}{s+4} + \frac{B}{s+1} + \frac{C}{(s+1)^2}$$

$$A = -\frac{9s^2+10s+4}{(s+1)^2}\Big|_{s=-4} = -\frac{144-40+4}{9} = -12$$

$$B = \left(-\frac{9s^2+10s+4}{s+4}\right)'\Big|_{s=-1} = -\frac{(18s+10)(s+4)-(9s^2+10s+4)}{(s+4)^2}\Big|_{s=-1} =$$

$$= \frac{(-8)\cdot 3-(9-10+4)}{9} = 3$$

$$C = -\frac{(9s^2+10s+4)}{s+4}\Big|_{s=-1} = -\frac{9-10+4}{3} = -1$$

$u_L(t) = -12e^{-4t} + 3e^{-t} - 6e^{-t}, \; t>0$

$F_2(s) = \dfrac{5\sqrt{2}(s+5)}{s^2+2s+17}$

$i_L(0+) = \lim\limits_{s\to\infty} sF_2(s) = \lim\limits_{s\to\infty} \dfrac{5\sqrt{2}(s^2+5s)}{s^2+2s+17} = 5\sqrt{2}$

$U_2(s) = sF_2(s) - Li_2(0+) = \dfrac{5\sqrt{2}(s^2+5s)}{s^2+2s+17} - 5\sqrt{2} =$

$= \dfrac{5\sqrt{2}(3s-17)}{s^2+2s+17}$

$U_L(0+) = \lim\limits_{s\to\infty} sU_2(s) = \lim\limits_{s\to\infty} \dfrac{5\sqrt{2}(3s^2-17s)}{s^2+2s+17} = 15\sqrt{2}$

$s^2+2s+17=0 \quad D=-16 \quad s_{1,2} = -1 \pm j4$

$\dfrac{5\sqrt{2}(s+5)}{s^2+2s+17} = \dfrac{\dot{A}_1}{s+1-j4} + \dfrac{\dot{A}}{s+1+j4}$

$\dot{A}_1 = \dfrac{5\sqrt{2}(s+5)}{s+1+j4}\Big|_{s=-1+j4} = \dfrac{5\sqrt{2}(-1+j4+5)}{j8} = \dfrac{5\sqrt{2}(1+j)}{j2} = 5e^{-j45^\circ}$

$\dot{A}_2 = \dot{A}_1^* = 5e^{j45^\circ}$

$i_L(t) = 10e^{-t}\cos(4t-45^\circ), \; t>0$

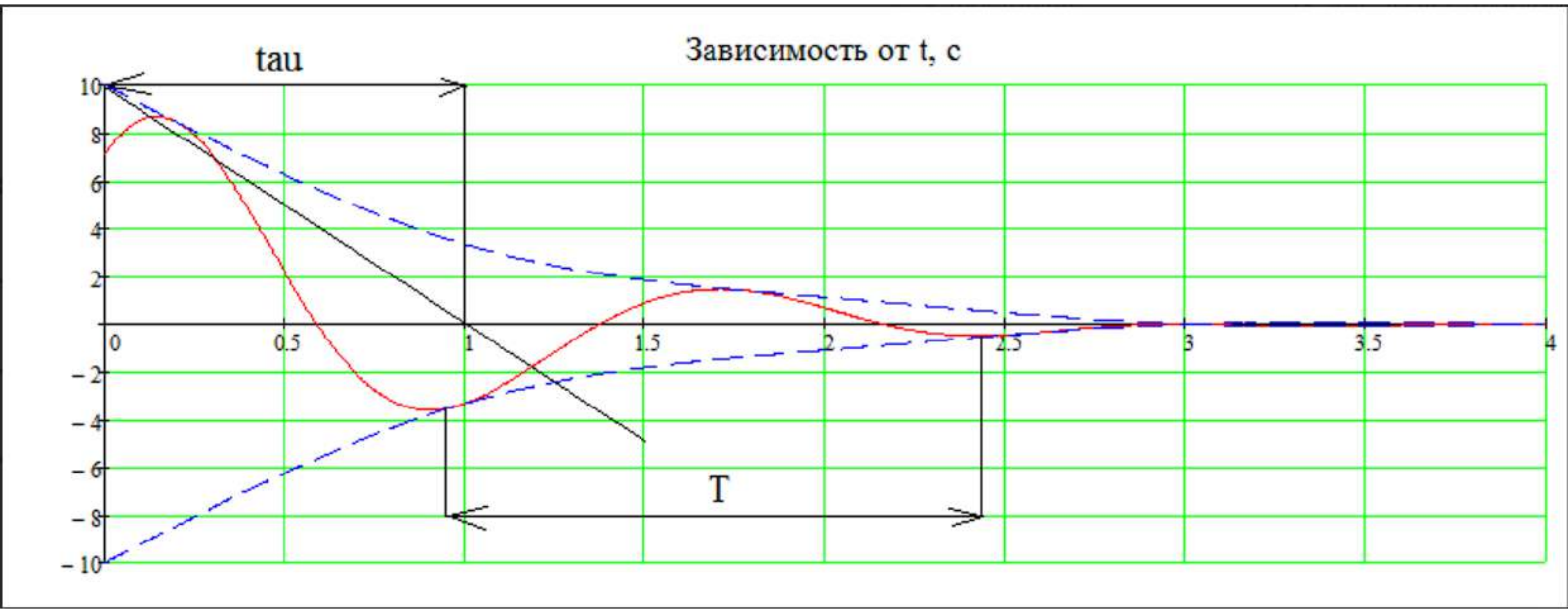
$\dfrac{5\sqrt{2}(3s-17)}{s^2+2s+17} = \dfrac{\dot{A}_1}{s+1-j4} + \dfrac{\dot{A}_2}{s+1+j4}$

$\dot{A}_1 = \dfrac{5\sqrt{2}(3s-17)}{s+1+j4}\Big|_{s=-1+j4} = 5\sqrt{17}e^{j59^\circ}$

$\dot{A}_2 = \dot{A}_1^* = 5\sqrt{17}e^{-j59^\circ}$

$U_L(t) = 10\sqrt{17}e^{-t}\cos(4t+59^\circ), \; t>0$

$\tau = \dfrac{1}{\sigma} = \dfrac{1}{1} = 1 \qquad T = \dfrac{2\pi}{\omega} = \dfrac{2\pi}{4} = \dfrac{\pi}{2}$


Зависимость от t, c
tau
T
10
8
6
4
2
0
0.5
1
1.5
2
2.5
3
3.5
4
− 2
− 4
− 6
− 8
− 10

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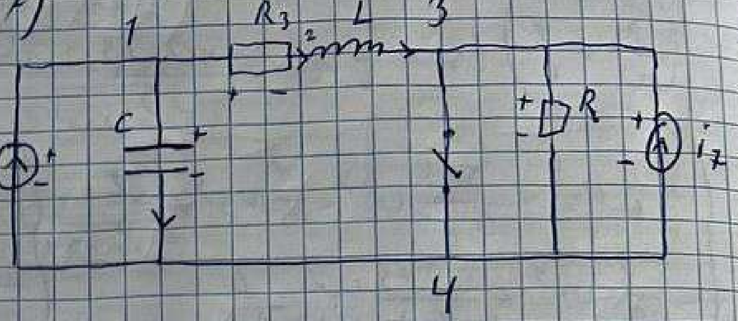
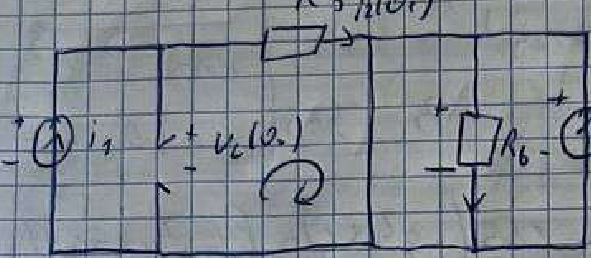


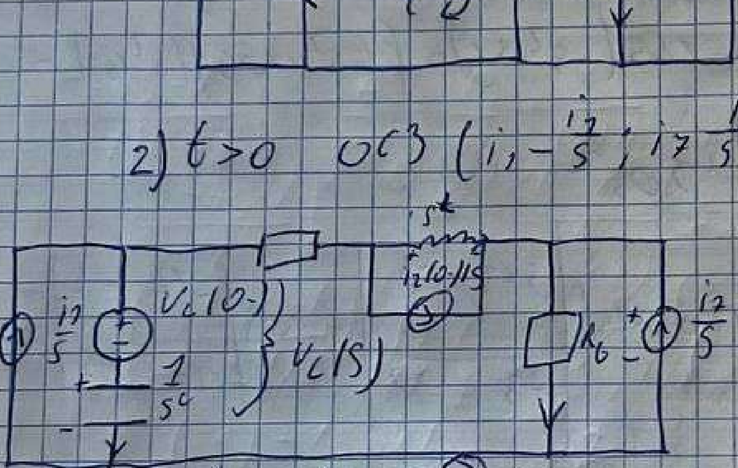
$i_1 = 2$
$C = 0{,}1$
$R_3 = 6$
$L = 2$
$R_6 = 6$
$i_7 = 4$
$U_C - ?$
$i_L - ?$

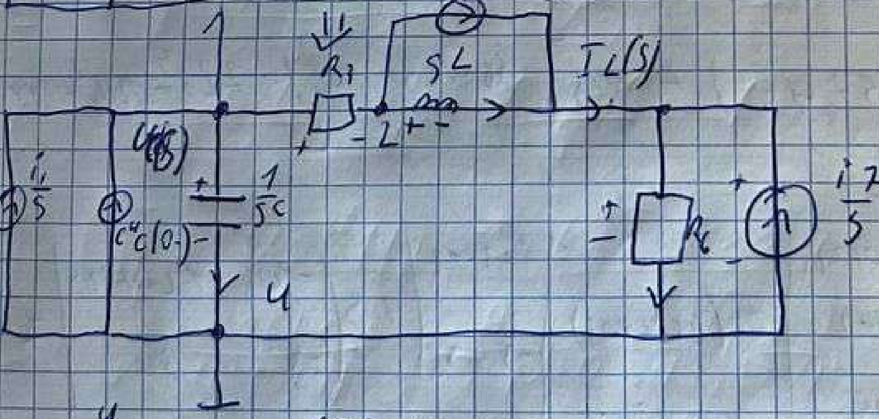
1) $t = 0^-$ $L \equiv$ к.з. $C \equiv$ х.х., „К" = замкнут



$i_L(0^-) = i_1 = 2$
ЗНК: $-U_C(0^-) + i_2(0^-) R_3 \Rightarrow$
$\Rightarrow U_C(0^-) = R_3 i_2(0^-) =$
$= 6 \cdot 2 = 12$

2) $t > 0$ ОСЗ $\left(i_1 - \frac{i_1}{s};\ i_7 - \frac{i_7}{s}\right)$, „К" - разомкнут





$U_4^y = 0$ МУН

$G_{11} = sC + \frac{1}{R_3} = \frac{s}{10} + \frac{1}{6}$ $\quad G_{12} = -\frac{1}{R_3} = -\frac{1}{6}$ $\quad G_{13} = 0$

$G_{21} = G_{12} = -\frac{1}{6}$ $\quad G_{22} = \frac{1}{R_3} + \frac{1}{sL} = \frac{1}{6} + \frac{1}{2s} = \frac{s+3}{6s}$ $\quad G_{23} = -\frac{1}{sL} = -\frac{1}{2s}$

$G_{31} = G_{13} = 0$ $\quad G_{32} = G_{23} = -\frac{1}{2s}$ $\quad G_{33} = \frac{1}{sL} + \frac{1}{R_6} = \frac{1}{2s} + \frac{1}{6} = \frac{3+s}{6s}$

$I_2^y = \frac{(0^-)}{s} - \frac{2}{s}$, $I_3^y = \frac{i_7}{s} + \frac{i_L(0^-)}{s} = \frac{6}{s}$

$$\begin{cases} \left(\dfrac{s}{10}+\dfrac{1}{6}\right)u_1^y - \dfrac{1}{6}u_2^y = \dfrac{10+6s}{5s} \\ -\dfrac{1}{6}u_1^y + \dfrac{s+3}{6s}u_2^y - \dfrac{1}{15}u_3^y = -\dfrac{2}{5} \\ -\dfrac{1}{15}u_2^y + \dfrac{3+s}{6s}u_3^y = \dfrac{6}{s} \end{cases} \Rightarrow \begin{cases} (6s^2+10s)u_1^y - 10su_2^y = 120+72s \\ -5u_1^y + (s+3)u_2^y - 3u_3^y = -12 \\ -3u_2^y + (3+s)u_3^y = 36 \end{cases}$$

$$\Delta = \begin{vmatrix} 6s^2+10s & -10s & 0 \\ -5 & s+3 & -3 \\ 0 & -3 & 3+s \end{vmatrix} = (6s^2+10s)\begin{vmatrix} s+3 & -3 \\ -3 & 3+s \end{vmatrix} + 10s\begin{vmatrix} -5 & -3 \\ 0 & 3+s \end{vmatrix} =$$

$$= (6s^2+10s)(s^2+6s+9-9) + 10s(-s^2-3s) = (6s^2+10s)(s^2+6s) -$$

$$-10s^3 - 30s^2 = 6s^4+36s^3+30s^2$$

$$\Delta_1 = \begin{vmatrix} 120+72s & -10s & 0 \\ -12 & s+3 & -3 \\ 36 & -3 & 3+s \end{vmatrix} = (120+72s)\begin{vmatrix} s+3 & -3 \\ -3 & s+3 \end{vmatrix} + 10s\begin{vmatrix} -12 & -3 \\ 36 & 3+s \end{vmatrix} =$$

$$= (120+72s)(s^2+6s+9-9) + 10s(-36-12s+108) = 72s^3+432s^2+1440s$$

$$\Delta_2 = \begin{vmatrix} 6s^2+10s & -10s & 120+72s \\ -5 & s+3 & -12 \\ 0 & -3 & 36 \end{vmatrix} = (6s^2+10s)\begin{vmatrix} s+3 & -12 \\ -3 & 36 \end{vmatrix} + 5\begin{vmatrix} -10s & 120+72s \\ -3 & 36 \end{vmatrix} =$$

$$= (6s^2+10s)(36s+108-36) + 5(-360s+360+216s) = 216s^3+648s^2+1080s$$

$$U_1^y = \frac{\Delta_1}{\Delta} = \frac{72s^3+432s^2+1440s}{6s^4+36s^3+30s^2} = \frac{12s^2+72s+240}{s^3+6s^2+5s}$$

$$U_2^y = \frac{\Delta_2}{\Delta} = \frac{648s^2+1080s}{6s^4+36s^3+30s^2} = \frac{108s+180}{s^3+6s^2+5s}$$

$$U_3^y = \frac{\Delta_3}{\Delta} = \frac{216s^3+648s^2+1080s}{6s^4+36s^3+30s^2} = \frac{36s^2+108s+180}{s^3+6s^2+5s}$$

$$U_c(s) = U_1^y - U_4^y = \frac{12s^2+72s+240}{s(s^2+6s+5)} = \frac{A_1}{s} + \frac{A_2}{s+1} + \frac{A_3}{s+5}$$

$$A_1 = \frac{12s^2+72s+240}{s^2+6s+5}\bigg|_{s=0} = 48 \qquad A_2 = \frac{12s^2+72s+240}{s(s+5)}\bigg|_{s=-1} = -45$$

$$A_3 = \frac{12s^2+72s+240}{s(s+1)}\bigg|_{s=-5} = 9$$

$$\underline{U_c(t) = 48 - 45e^{-t} + 9e^{-5t},\ t>0}$$

$$I_L(s) = \frac{U_2^y - U_3^y}{sL} + \frac{i_L(0-)}{s} = \frac{1}{2s}\left(\frac{108s+180}{s^3+6s^2+5s} - \frac{36s^2+108s+180}{s^3+6s^2+5s}\right) + \frac{2}{s} =$$

$$= \frac{2s^2-6s+10}{s(s^2+6s+5)} = \frac{A_1}{s} + \frac{A_2}{s+1} + \frac{A_3}{s+5}$$

$$A_1 = \frac{2s^2-6s+10}{s^2+6s+5}\bigg|_{s=0} = 2 \qquad A_2 = \frac{2s^2-6s+10}{s(s+5)}\bigg|_{s=-1} = -\frac{9}{2}$$

$$A_3 = \frac{2s^2-6s+10}{s(s+1)}\bigg|_{s=-5} = \frac{9}{2}$$

$$I_L(s) = \frac{2}{s} - \frac{9/2}{s+1} + \frac{9/2}{s+5}$$

$$i_2(t) = 2 - \frac{4}{2}e^{-t} + \frac{4}{2}e^{-5t}, \quad t>0$$

TOH 30

$$U_C(0+) = 48 - 45e^{-0} + 4e^{-0} = 48 - 45 + 4 = 12$$

$$U_C(0+) = \lim_{s\to\infty} sU_C(s) = \lim_{s\to\infty} \frac{0s^2 + 2s + 240}{s^2 + 6s + 5} = 12$$

$$i_2(0+) = 2 - \frac{4}{2}e^{-0} + \frac{4}{2}e^{-0} = 2$$

$$i_2(0+) = \lim_{s\to\infty} sI_2(s) = \lim_{s\to\infty} \frac{2s^2 + 6s + 10}{s^2 + 6s + 5} = 2$$

TOK 30

$$U_C(\infty) = \lim_{t\to\infty} \left(48 - 45e^{-t} + 4e^{-5t}\right) = 48$$

$$U_C(\infty) = \lim_{s\to 0} \left(sU_C(s)\right) = \lim_{s\to 0} \frac{12s^2 + 72s + 240}{s^2 + 6s + 5} = 48$$

$$i_2(\infty) = \lim_{s\to\infty} \left(2 - \frac{4}{2}e^{-t} + \frac{4}{2}e^{-5t}\right) = 2$$

$$i_2(\infty) = \lim_{s\to 0} sI_2(s) = \lim_{s\to 0} \frac{2s^2 - 6s + 10}{s^2 + 6s + 5} = 2$$