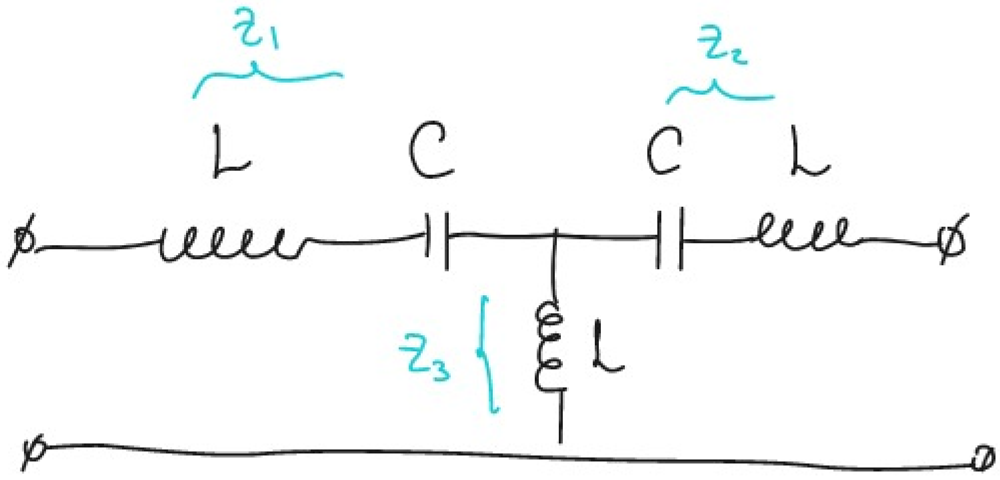
T2 prep



$$A = 1 + \frac{Z_1}{Z_3}$$

$$B = Z_1 + Z_2 + \frac{Z_1 Z_2}{Z_3}$$

$$C = \frac{1}{Z_3}$$

$$D = 1 + \frac{Z_2}{Z_3}$$

$$Z_1 = j\omega L + \frac{1}{j\omega C} = Z_2$$

$$Z_3 = j\omega L$$

$$A = 1 + 1 + j\omega C = 2 - \frac{1}{\omega^2 LC} = D$$

$$B = 2\left(j\omega L + \frac{1}{j\omega C}\right) + \frac{\left(j\omega L + \frac{1}{j\omega C}\right)^2}{j\omega L} =$$

$$= \frac{-2\omega^2 L^2 + 2\frac{L}{C} - \omega^2 L^2 + 2\frac{L}{C} - \frac{1}{\omega^2 C^2}}{j\omega L} =$$

$$= \frac{4\frac{L}{C} - 3\omega^2 L^2 - \frac{1}{\omega^2 C^2}}{j\omega L}$$

$$C = \frac{1}{j\omega L}$$

$$Z_c = \sqrt{\frac{B}{C}} = \sqrt{4\frac{L}{C} - 3\omega^2 L^2 - \frac{1}{\omega^2 C^2}}$$

A - действ. $\quad A = \operatorname{ch}\gamma = \cos\alpha \cdot \cos\beta + j\sin\alpha \cdot \sin\beta$

$\Downarrow$

$\alpha = 0$

$$2 - \frac{1}{\omega^2 LC} = \cos\beta \Rightarrow \quad -1 \le 2 - \frac{1}{\omega^2 LC} \le 1$$

$$\frac{1}{3} \le \omega^2 LC \le 1$$

$$\frac{1}{\sqrt{3LC}} \le \omega \le \frac{1}{\sqrt{LC}}$$

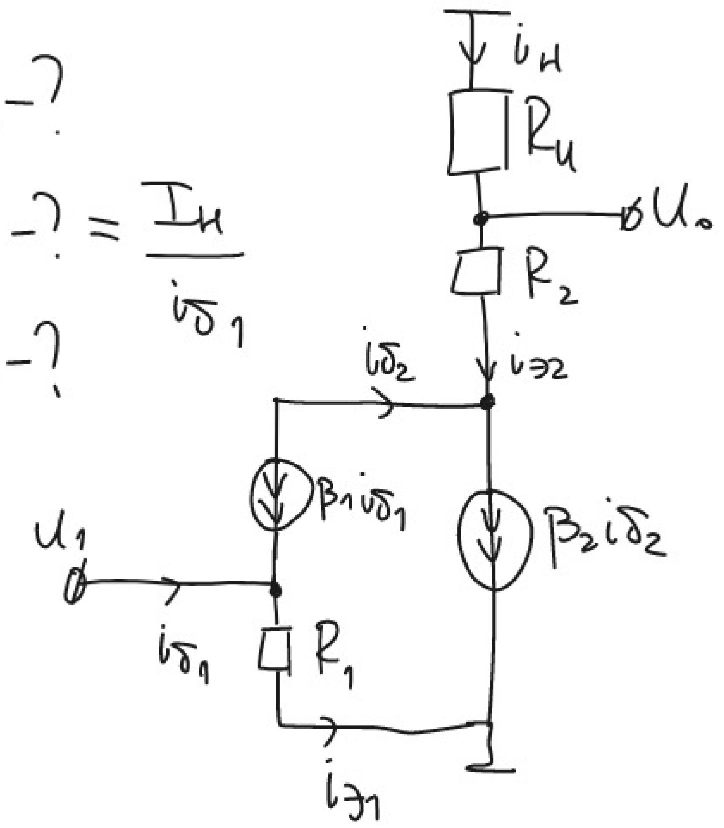
2

$$\begin{cases} i_{э_1} = i_{б_1} + i_{б_2} = i_{б_1}(1+\beta_1) \\ i_{э_2} = i_{б_2}(1+\beta_2) \end{cases}$$

K_u - ?

K_I - ? $= \dfrac{I_н}{i_{б_1}}$

$R_{вх}$ - ?



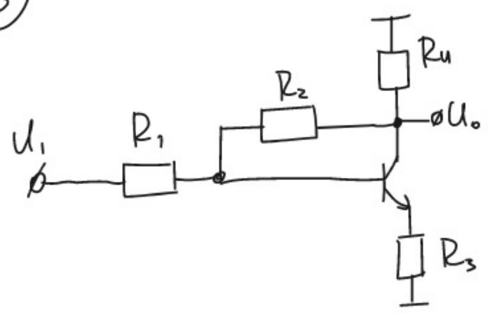
$$K_I = \frac{I_н}{i_{б_1}} = \frac{i_{э2}}{i_{б_1}} = \frac{i_{б_2}(\beta_2-1)}{i_{б_1}} =$$

$$= \frac{-\beta_1 i_{б_1}(\beta_2-1)}{i_{б_1}} = \beta_1(1-\beta_2)$$

$$K_u = \frac{U_o}{U_1} = \frac{-R_н \cdot i_н}{i_{э_1} R_1} = \frac{-R_н \beta_1 \cancel{i_{б_1}}(1-\beta_2)}{\cancel{i_{б_1}}(1+\beta_1) R_1} = \frac{\beta_1 R_н (\beta_2 - 1)}{(1+\beta_1) R_1}$$

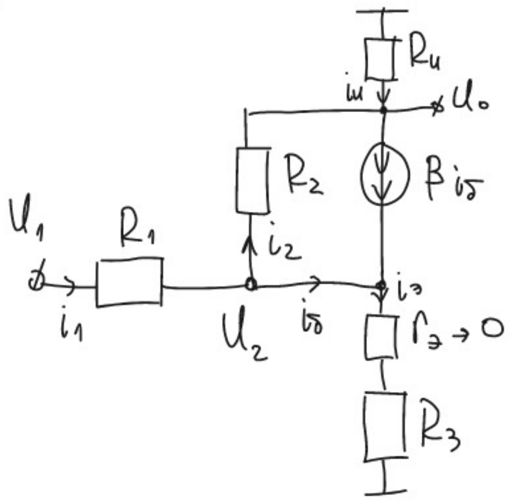
$$R_{вх} = \frac{U_1}{i_{б_1}} = \frac{i_{б_1}(1+\beta_1)R_1}{i_{б_1}} = (1+\beta_1)R_1$$

3



K_u-? $\quad r_э \to 0 \quad \beta \gg 1$

$\dfrac{U_o}{U_1} = ?$



$$U_o = i_н R_н$$

$$\begin{cases} i_1 = i_2 + i_б \\ \beta i_б = i_2 + i_н \\ i_э = i_б(1+\beta) \end{cases}$$

$$i_2 = \frac{U_2 - U_o}{R_2} = \frac{i_э(r_э + R_3) - U_o}{R_2} = \frac{i_б(1+\beta)(r_э+R_3) - U_o}{R_2}$$

$$i_3 = \frac{U_2}{r_3+R_3}$$

$$i_4 = \frac{0-U_0}{R_4}$$

$$i_1 R_1 = U_1 - U_2$$

$$(i_2+i_б)R_1 = U_1 - i_3(r_3+R_3)$$

$$(i_2+i_б)R_1 = U_1 - i_б(1+\beta)(r_3+R_3)$$

$$U_1 = (i_2+i_б) - i_б(1+\beta)(r_3+R_3) = \left(\frac{i_б(1+\beta)(r_3+R_3)-U_0}{R_2} + i_б\right) - i_б(1+\beta)(r_3+R_3) =$$

$$U_0 = -i_4 R_4 = (i_2 - \beta i_б)R_4 = \left(\frac{i_б(1+\beta)(r_3+R_3)-U_0}{R_2} - \beta i_б\right)R_4$$

$$U_0\left(1+\frac{R_4}{R_2}\right) = \left(\frac{i_б(1+\beta)(r_3+R_3)}{R_2} - \beta i_б\right)R_4$$

$$U_0 = \frac{R_2 R_4\left(\frac{i_б(1+\beta)(r_3+R_3)}{R_2} - \beta i_б\right)}{R_2+R_4} \overset{\substack{\beta\gg 1\\ r_3\to 0}}{=} \frac{R_4(i_б\cdot\beta\cdot R_3 - \beta i_б\cdot R_2)}{R_2+R_4}$$

$$= \left[\underbrace{\frac{i_б\beta R_3 - \frac{R_4(i_б\cdot\beta\cdot R_3-\beta i_б\cdot R_2)}{R_2+R_4}}{R_2}} + i_б\right] - i_б\beta\cdot R_3 = \frac{\beta i_б(R_3+R_4)}{R_2+R_4} + i_б - i_б\cdot\beta R_3 =$$

$$\frac{i_б\beta R_3(R_2+\cancel{R_4}) - \cancel{R_4 i_б\beta R_3} + \beta i_б R_2 R_4}{R_2\cdot(R_2+R_4)}$$

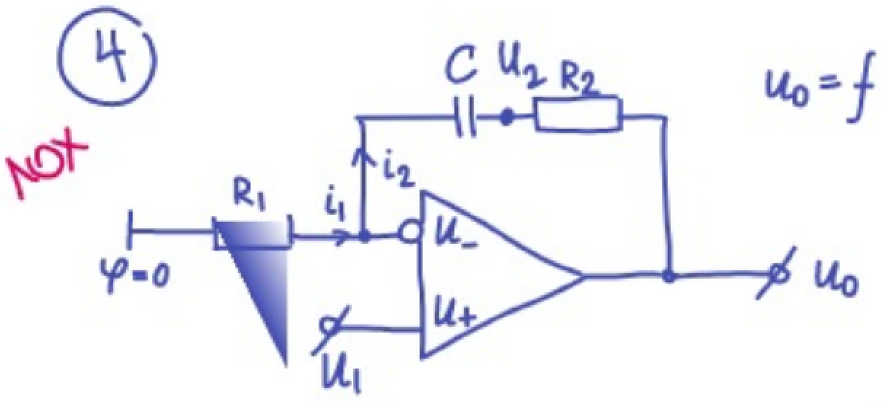
$$= \frac{i_б\beta R_2 R_3 + \beta i_б R_2 R_4}{R_2(R_2+R_4)} = \frac{\beta i_б(R_3+R_4)}{R_2+R_H}$$

$$= \frac{\beta i_б(R_3+R_H-R_2R_3-R_3R_4) + i_б(R_2+R_H)}{R_2+R_4}$$

$$K_u = \frac{R_4(i_б\cdot\beta\cdot R_3 - \beta i_б\cdot R_2)}{R_2+R_4}\cdot\frac{R_2+R_4}{\beta i_б(R_3+R_H-R_2R_3-R_3R_4)+i_б(R_2+R_H)} =$$

$$= \frac{R_4\beta(R_3-R_2)}{\beta(R_3+R_H-R_2R_3-R_3R_4)+(R_2+R_4)}$$

4



$u_0 = f(u_1) - ?$

Решение:

$u_1 = u_+ \qquad i_1 = i_2$

$i_1 = \frac{0 - u_1}{R_1} \qquad u_- = u_+$

$$i_c = C\frac{du}{dt}$$

$$i_1 = i_c$$

$$i_1 = -\frac{u_1}{R_1}\ ;\ i_2 = i_c$$

$$C\frac{d(u_1 - u_2)}{dt} = -\frac{u_1}{R_1}$$

+

$$C\,d(u_1 - u_2) = -\int\frac{u_1}{R_1}dt$$

$$i_1 = i_2 \quad v$$

$$C(u_1 - u_2) = -\int\frac{u_1}{R_1}dt$$

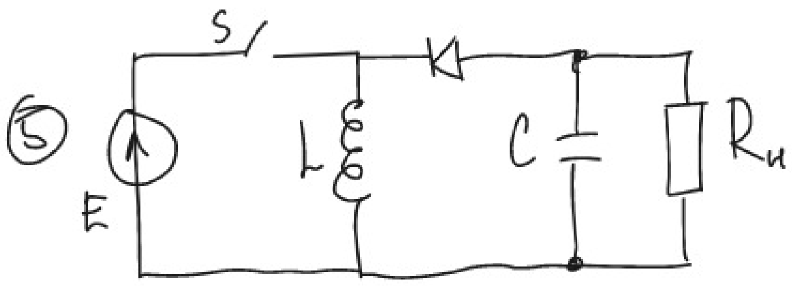
$$-\frac{u_1}{R_1} = \frac{u_2 - u_0}{R_2} \Rightarrow$$

$$-Cu_2 = -Cu_1 - \int\frac{u_1}{R_1}dt$$

$$\Rightarrow u_2 = \frac{-u_1 R_2}{R_1} + u_0$$

$$u_2 = u_1 + \frac{1}{CR_1}\int u_1 dt$$

Ответ: $u_0 = u_1\left(1 + \frac{R_2}{R_1}\right) + \frac{1}{CR_1}\int u_1 dt$



$U_{н\,ср}$?

$$S = on: \; E = L \cdot \frac{di_L}{dt} \Big| \cdot D \qquad S = off: \; U_{нс} = -\frac{L\,di_L}{dt} \Big| \cdot (1-D)$$

$$C\frac{dU_{нс}}{dt} = \frac{U_{нс}}{R_н} \Big| \cdot D \qquad C\frac{dU_{нс}}{dt} = -i_L + \frac{U_{нс}}{R_н} \Big| \cdot (1-D)$$

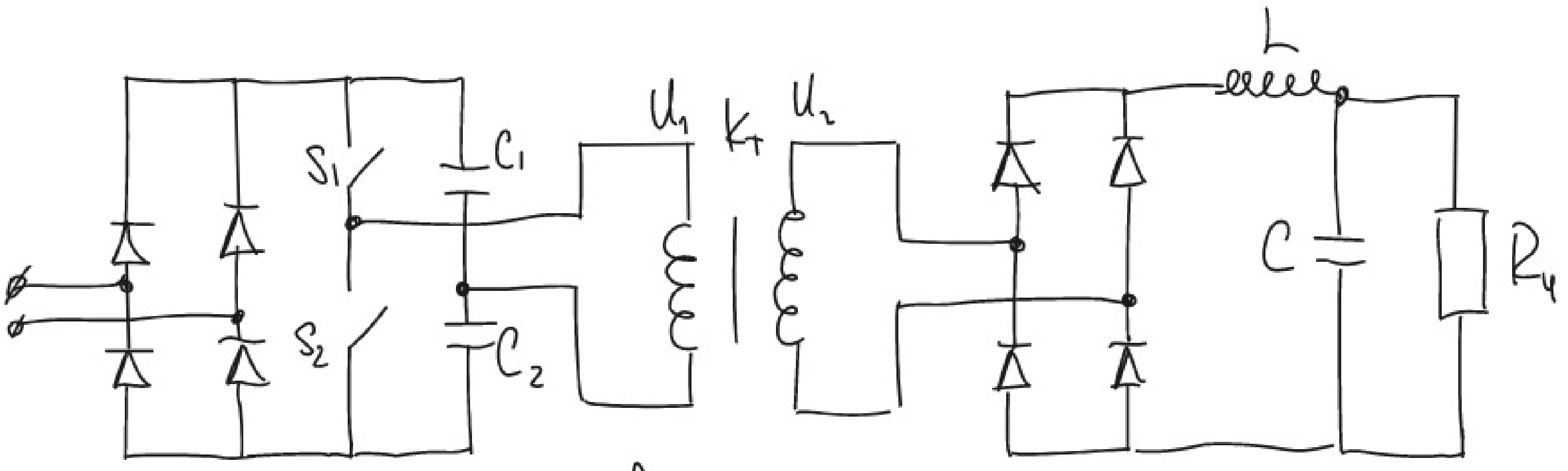
$$DL\frac{di_L}{dt} + (1-D)\frac{L\,di_L}{dt} = ED - (1-D)U_{нс}$$

$$\left[C\frac{dU_{нс}}{dt}D + C\frac{dU_{нс}}{dt}(1-D) = D\frac{U_{нс}}{R_н} + (1-D)\left(-i_L + \frac{U_{нс}}{R_н}\right) \right]$$

$\frac{di_L}{dt} = 0$ не учит. пульсации

$$ED = (1-D)U_{нс} \Rightarrow U_{нс} = \frac{ED}{(1-D)}$$

miro



$\tau = 5\mu s$ $\quad f_{sw} = 2 \cdot 10^4 T_y$

$E = 230\ V_{rms}$ $\quad K_T = \frac{1}{10}$ $\quad U_{Hcp} - ?$

$$U_d = 0{,}9\, U_{rms} = 0{,}9 \cdot 230V = 207V$$

$$U_1 = \frac{U_d}{2} = \frac{207}{2} = 103{,}5V$$

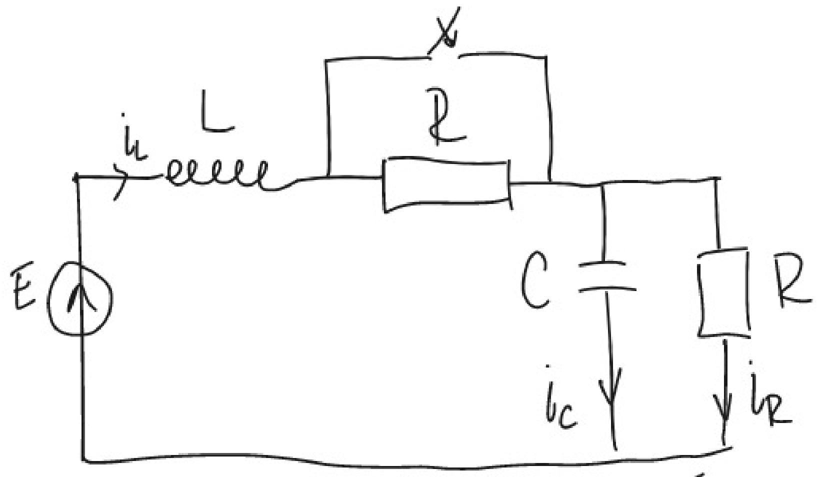
$$U_2 = K_T \cdot U_1 = \frac{1}{10} \cdot 103{,}5V = 10{,}35V$$

$$D = \frac{2\tau}{T} = 2\tau f = 2 \cdot 5 \cdot 10^{-6} \cdot 2 \cdot 10^4 = 2 \cdot 10^{-1} = \frac{1}{5}$$

$$U_H = D \cdot U_2 = \frac{10{,}35V}{5} = 2{,}07V$$

miro

7



$I_L(t)$ - ? $R = 2\,\Omega$ $E = 10V$

$L = 5 \cdot 10^{-4}$ Гн $C = 20\mu F$

Классич. метод:

$$pL + \frac{\frac{R}{pC}}{R + \frac{1}{pC}} = 0$$

$$pL + \frac{R}{1 + RpC} = 0$$

$$p^2 RCL + pL + R = 0$$

$$p^2 \cdot 2 \cdot 10^{-5} \cdot 2 \cdot 5 \cdot 10^{-4} + p \cdot 5 \cdot 10^{-4} + 2 = 0$$

$$p^2 \cdot 2 \cdot 10^{-8} + p \cdot 5 \cdot 10^{-4} + 2 = 0$$

$$p_{1,2} = \frac{-L \pm \sqrt{L^2 - 4R^2LC}}{2RLC}$$

$p_1 = -20000$ $p_2 = -5000$

miro

$$\begin{cases} U(t) = E + Ae^{p_1 t} + Be^{p_2 t} \\ U(0) = E + A + B = E/2 \\ U'(0) = \dfrac{I(0)}{C} = \dfrac{E}{2RC} = -p_1 A - p_2 B = -2\cdot 10^4 A - 5\cdot 10^3 B = 0 \end{cases} \Rightarrow \quad A + B = -\frac{E}{2}$$

$$\Downarrow$$

$$-20A = 5B$$

$$A = -4B = -4\left(-\frac{E}{2} - A\right)$$

$$A = 2E + 4A$$

$$A = -\frac{2}{3}E$$

$$B = +\frac{2}{3}E\frac{1}{4} = \frac{1}{6}E$$

$$U_c(t) = E - \frac{2}{3}Ee^{-2\cdot 10^4 t} + \frac{1}{6}Ee^{-5\cdot 10^3 t}$$

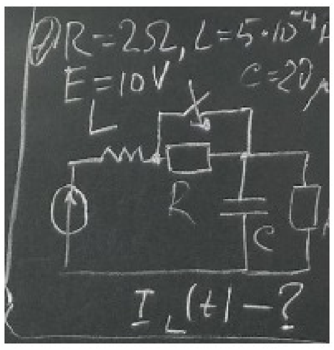
$$I_L = i_{np} + Ae^{p_1 t} + Be^{p_2 t}$$

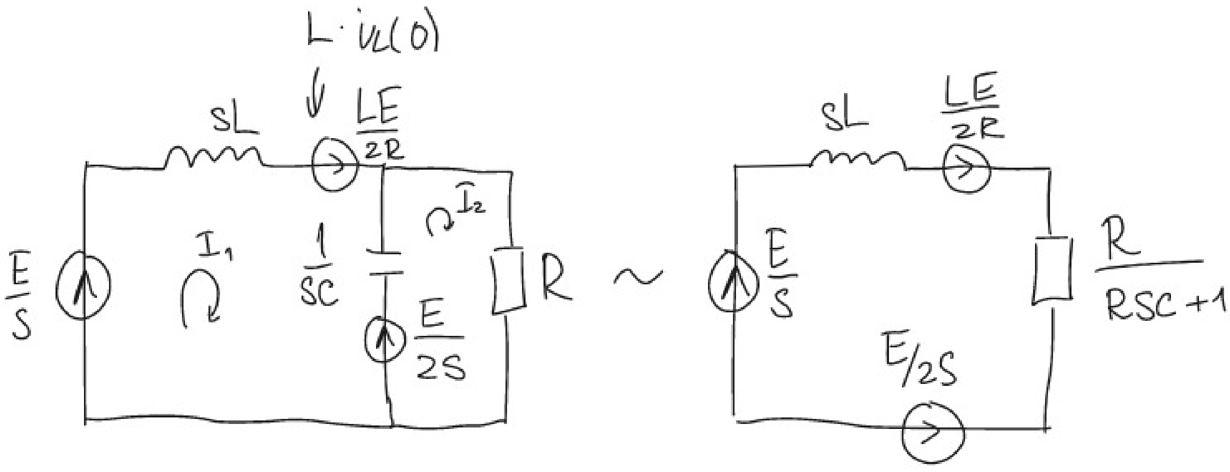
$$I_L'(0) = p_1 A + p_2 B = \frac{E}{2L}$$

$$I_L(0) = \frac{E}{R} + A + B = \frac{E}{2R}$$

$$\Rightarrow \begin{cases} p_1 A + p_2 B = \dfrac{E}{2L} \\ A + B = -\dfrac{E}{2R} \end{cases}$$

miro





A	A/s
e^{-at}	$\frac{1}{s+a}$
$\frac{1}{a}(1-e^{-at})$	$\frac{1}{s(s+a)}$
$\frac{1}{b-a}(e^{-at}-e^{-bt})$	$\frac{1}{(s+a)(s+b)}$

$$\frac{E}{2S}+\frac{LE}{2R}=I_L\cdot\left(SL+\frac{R}{RSC+1}\right)$$

$$\frac{ER+LES}{2SR}=I_L\left(\frac{S^2RLC+SL+R}{RSC+1}\right)$$

$$I_L=\frac{ER+LES}{2SR}\cdot\frac{(RSC+1)}{(S^2RLC+SL+R)}$$

$$=\frac{20+5\cdot10^{-3}S}{4S}\cdot\frac{4\cdot10^{-5}s+1}{(S^2\cdot2\cdot10^{-8}+5\cdot10^{-4}S+2)}=$$

$$=(S+25\cdot10^3)(S+4\cdot10^3)$$

$$\begin{cases} \dfrac{E}{s} + \dfrac{LE}{2R} - \dfrac{E}{2s} = I_1\left(sL + \dfrac{1}{sC}\right) - I_2 \dfrac{1}{sC} \\[2ex] \dfrac{E}{2s} = -I_1 \cdot \dfrac{1}{sC} + I_2\left(R + \dfrac{1}{sC}\right) \end{cases}$$

$$I_2 = \frac{\dfrac{E}{2s} + \dfrac{I_1}{sC}}{R + \dfrac{1}{sC}} = \frac{EC + 2I_1}{2\cancel{sC}} \cdot \frac{\cancel{sC}}{RsC+1} = \frac{EC+2I_1}{2(RsC+1)}$$

$$\frac{E}{2s} + \frac{LE}{2R} = I_1\left(sL + \frac{1}{sC}\right) - \frac{1}{sC}\,\frac{EC+2I_1}{2(RsC+1)}$$

$$I_1\left[sL + \frac{1}{sC} - \frac{1}{sC(RsC+1)}\right] = \frac{LE}{2R} + \frac{E}{2s}\left(1 + \frac{1}{RsC+1}\right)$$

$$I_1\left[s \cdot 5 \cdot 10^{-4} + \frac{1}{s \cdot 2 \cdot 10^{-5}}\left(1 - \frac{1}{4 \cdot 10^{-5} s + 1}\right)\right] = \frac{5 \cdot 10^{-3}}{4} + \frac{5}{s}\left(1 + \frac{1}{4 \cdot 10^{-5} s + 1}\right)$$

$$I_1 = \frac{25 s^2 + 725000 \cdot s + 5 \cdot 10^9}{10 s^3 + 250000 s^2 + 10^9 s} = \frac{(s + 11298)(s + 17701)}{(s+20000)(s+5000) \cdot s} =$$

miro