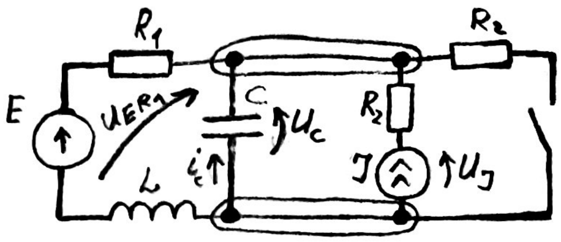
Вариант 14



Исходные данные:

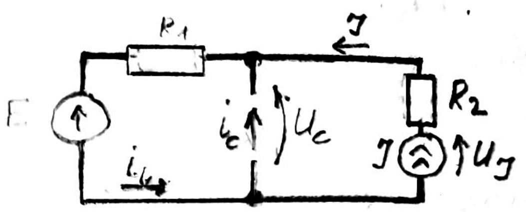
$E = 104\,В$; $J = 1{,}04\,В$; $L = 4\cdot10^{-3}\,Гн$;

$R_1 = 2\ Ом$; $R_2 = 50\ Ом$; $C = 40\cdot10^{-6}\,Ф$.

ТЗ: $U_c(t),\ i_c(t),\ U_J(t),\ U_{ER_1}(t),\ \tau$ - ?

1. Определение начальных условий ($t=0_-$):

Т.к. вх. воздействие постоянное, конденсатор → разрыв; катушка → закоротка.



$i_c(0_-) = 0$,

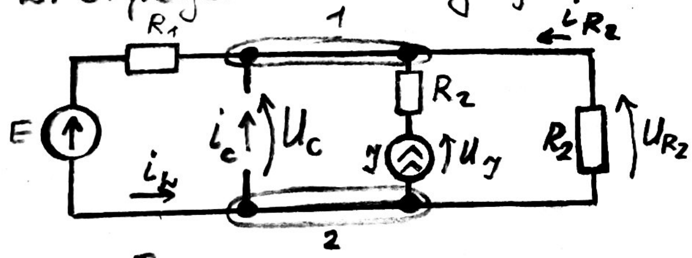
$U_c(0_-) = U_{R_2J}(0_-)$

$J(R_1+R_2) = U_J - E \Rightarrow U_J(0_-) = J(R_1+R_2) + E = 1{,}04\cdot52+104 =$
$= 158{,}08\,В$

$U_c(0_-) = U_{R_2J}(0_-) = JR_2 + U_J(0_-) = 1{,}04\cdot50 + 158{,}08 = 210{,}08\,В$

$i_L(0_-) = J = 1{,}04\,А$.

2. Определение вынужденной составляющей ($t=\infty$):



$\underbrace{i_c(\infty)} = 0$,

$$\underbrace{U_c(\infty)} = \frac{\sum \frac{E_i}{R_i} + \sum J_i}{\sum \frac{1}{R_i}} =$$

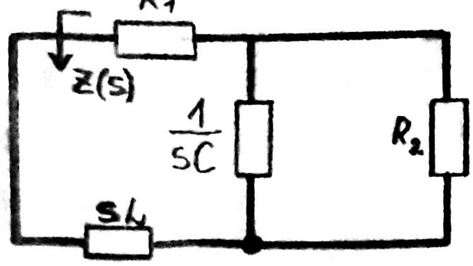
$$= \frac{\frac{E}{R_1} + J}{\frac{1}{R_1} + \frac{2}{R_2}} = \frac{\frac{104}{2} + 1{,}04}{\frac{1}{2} + \frac{2}{50}} = 98{,}2\,В$$

$i_L = J + i_{R_2}$; $i_{R_2}(\infty) = \frac{U_{R_2}(\infty)}{R_2} = \frac{U_c(\infty)}{R_2} = \frac{98{,}2}{50} = 1{,}964\,А$

$\underbrace{i_L(\infty)} = 1{,}04 + 1{,}964 = 3{,}004\,А$

$U_{R_2}(\infty) = JR_2 + U_J(\infty) \Rightarrow \underbrace{U_J(\infty)} = U_{R_2}(\infty) - JR_2 = 98{,}2 - 1{,}04\cdot50 =$
$= 46{,}2\,В.$

3. Определение вида переходного процесса:



$$Z(s) = R_1 + \frac{\frac{1}{c\cdot s}\cdot R_2}{\frac{1}{c\cdot s}+R_2} + sL = 0$$

$$s^2 + s\cdot\left(\frac{R_1}{L}+\frac{1}{R_2C}\right) + \frac{R_1+R_2}{LR_2C} = 0$$

$$s^2 + 1000s + 6500000 = 0$$

$$D = -25000000 < 0$$

$$s_{1,2} = \delta \pm j\omega = -500 \pm 2500j$$

$$s(t) = s(\infty) + e^{\delta t}(A_1\cos\omega t + A_2\sin\omega t)$$

$$U_c(t) = 98,2 + e^{-500t}(A_1\cos 2500t + A_2\sin 2500t)$$

4. Нахождение коэффициентов A_1 и A_2:

Законы коммутации:

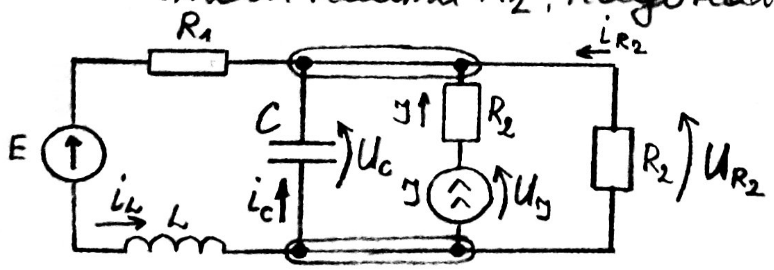
$$U_c(0_-) = U_c(0_+);\quad i_L(0_-) = i_L(0_+).$$

$$U_c(0_+) = 98,2 + e^{-500\cdot 0}(A_1\cos 2500\cdot 0 + A_2\sin 2500\cdot 0) = U_c(0_-) = 210,08\ \text{В}$$

$$98,2 + A_1 = 210,08$$

$$A_1 = 111,88$$

Чтобы найти A_2, надо найти $i_c(0_+)$:



$$i_c(0_+) + J + i_{R_2}(0_+) = i_L(0_+)$$

$$i_c(0_+) = i_L(0_-) - J - \frac{U_c(0_-)}{R_2} =$$

$$= 1,04 - 1,04 - \frac{210,08}{50} = -4,202\ \text{A}$$

$$i_{R_2}(0_+) = \frac{U_{R_2}(0_+)}{R_2} = \frac{U_c(0_+)}{R_2} = \frac{U_c(0_-)}{R_2}$$

$$i_L(0_+) = i_L(0_-)$$

$$\frac{dU_c(t)}{dt} = -500\, e^{-500}\left(A_1 \cos 2500t + A_2 \sin 2500t\right) +$$

$$+ e^{-500t} \cdot \left[A_1 \cdot 2500 \cdot (-\sin 2500t) + A_2 \cdot 2500 \cdot \cos 2500t \right] = \frac{i_c(t)}{c}$$

$$\frac{i_c(0_+)}{c} = -500 \cdot 1 (111{,}88 \cdot 1 + A_2 \cdot 0) + 1 \cdot (A_1 \cdot 0 + A_2 \cdot 2500 \cdot 1) = \frac{-4{,}202}{40 \cdot 10^{-6}}$$

$$A_2 = -19{,}644$$

$$U_c(t) = U_c(\infty) + e^{\delta t} \sqrt{A_1^2 + A_2^2}\, \sin\left(\omega t + \operatorname{arctg} \frac{A_2}{A_1}\right)$$

- $$\underline{U_c(t)} = 98{,}2 + e^{-500t} \cdot 113{,}591 \sin(2500t - 80{,}041)$$

$$i_c(t) = \frac{dU_c(t)}{dt} \cdot c$$

- $$\underline{i_c(t)} = e^{-500t}\left(-105050 \cos 2500t - 269878 \sin 2500t\right)$$

$$JR_2 + U_J = U_c$$

$$U_J(t) = U_c(t) - JR_2$$

- $$\underline{U_J(t)} = 46{,}2 + e^{-500t} \cdot 113{,}591 \sin(2500t - 80{,}041)$$

$$U_{ER_1}(\infty) = E - i_L(\infty) R_1 = 104 - 3{,}004 \cdot 2 = 97{,}992.$$

- $$\underline{U_{ER_1}(t)} = 97{,}992 + e^{-500t} \cdot 113{,}591 \sin(2500t - 80{,}041)$$

- $$\tau = \frac{1}{|\delta|} = \frac{1}{500}$$