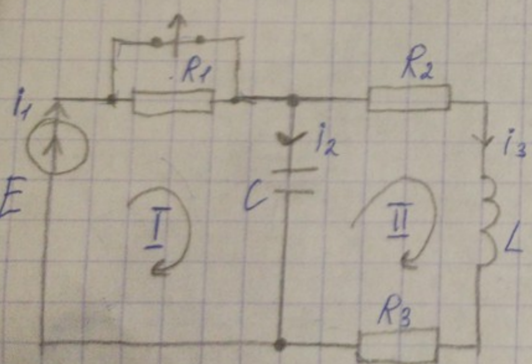
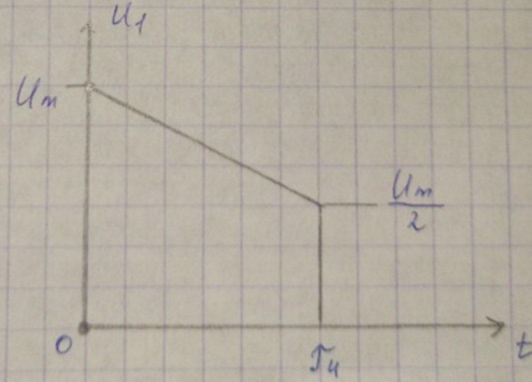
ВИу 19-01 АСУ   Таран. Д   69 в.

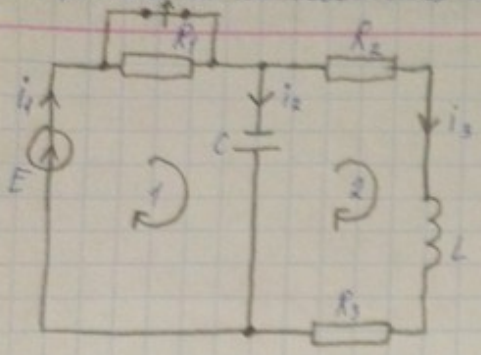
№ рис.	E, B.	L, мГн.	C, мкФ	R_1	R_2	R_3	R_4	опред. параметр.	частота, Гц.	Фаза, град
4	100	1	10	50	30	20	0	i_1	1600	45

Напр. рис с граф. $U_1(t)$	U_m, B.
21	100





Классическим метод:



Нач. услов. до коммутации:

$U_{c0} = i_2(0) \cdot (R_2 + R_3) = 2 \cdot 50 = 100\ В$

$i_2(0) = \frac{E}{R_2 + R_3} = \frac{100}{30+20} = 2\ А$

Система урав. после коммутации:

$$\begin{cases} E = R_1 i_1 + \frac{1}{C}\int i_2\,dt \\ 0 = -\frac{1}{C}\int i_2\,dt + (R_2 + R_3) i_3 + L\frac{di_3}{dt} \\ 0 = i_1 - i_2 - i_3 \end{cases}$$

$$\begin{cases} 0 = R_1 i_{1св} + \frac{1}{PC} i_{2св} \\ 0 = -\frac{1}{PC} i_{2св} + (R_2 + R_3 + LP) i_{3св} \\ 0 = i_{1св} - i_{2св} - i_{3св} \end{cases}$$

$$\begin{vmatrix} R_1 & \frac{1}{PC} & 0 \\ 0 & -\frac{1}{PC} & R_2+R_3+L \\ 1 & -1 & -1 \end{vmatrix} = \frac{R_1}{PC} + \frac{R_2+R_3+LP}{PC} + R_1(R_2+R_3+LP) =$$

$$= R_1 + R_2 + R_3 + LP + R_1R_2PC + R_1R_3PC + R_1LCP^2 =$$

$$= R_1LCP^2 + P(L + R_2R_1C + R_1R_3C) + R_1 + R_2 + R_3 = 0$$

$$50 \cdot 10^{-3} \cdot 10^{-5} P^2 + (10^{-3} + 50 \cdot 30 \cdot 10^{-5} + 50 \cdot 20 \cdot 10^{-5}) P + 100 = 0$$

$$5 \cdot 10^{-8} P^2 + 0{,}026 P + 100 = 0$$

$$D = 0{,}026^2 - 4 \cdot 5 \cdot 10^{-7} \cdot 100 = 0{,}000476 = 0{,}0218174$$

$$P_{1,2} = \frac{-0{,}026 \pm 0{,}0218174}{2 \cdot 5 \cdot 10^{-7}} = \begin{cases} P_1 = -418 \\ P_2 = -47817 \end{cases}$$

Принужденная состав. тока:

$$i_{1\,пр} = \frac{E}{R_1 + R_2 + R_3} = \frac{100}{50+30+20} = 1A$$

Определим $\frac{i_1}{dt}$ из 1 уравнения от $t=0$:

$$R_1 i_1(0) + \frac{1}{C}\int i_2(0)\,dt = 0$$

$$U_c = -R_1 i_1(0) \Rightarrow i_1(0) = -2A$$

$$\frac{i_1(0)}{dt} = \frac{i_2(0)}{R_1 C} = -4000\ \frac{A}{сек.}$$

$$\begin{cases} i_1(t) = i_{1\,пр} + A_1 e^{p_1 t} + A_2 e^{p_2 t} \\ \frac{di_1}{dt} = \frac{i_{1\,пр}}{dt} + p_1 A_1 e^{p_1 t} + p_2 A_2 e^{p_2 t} \end{cases}$$

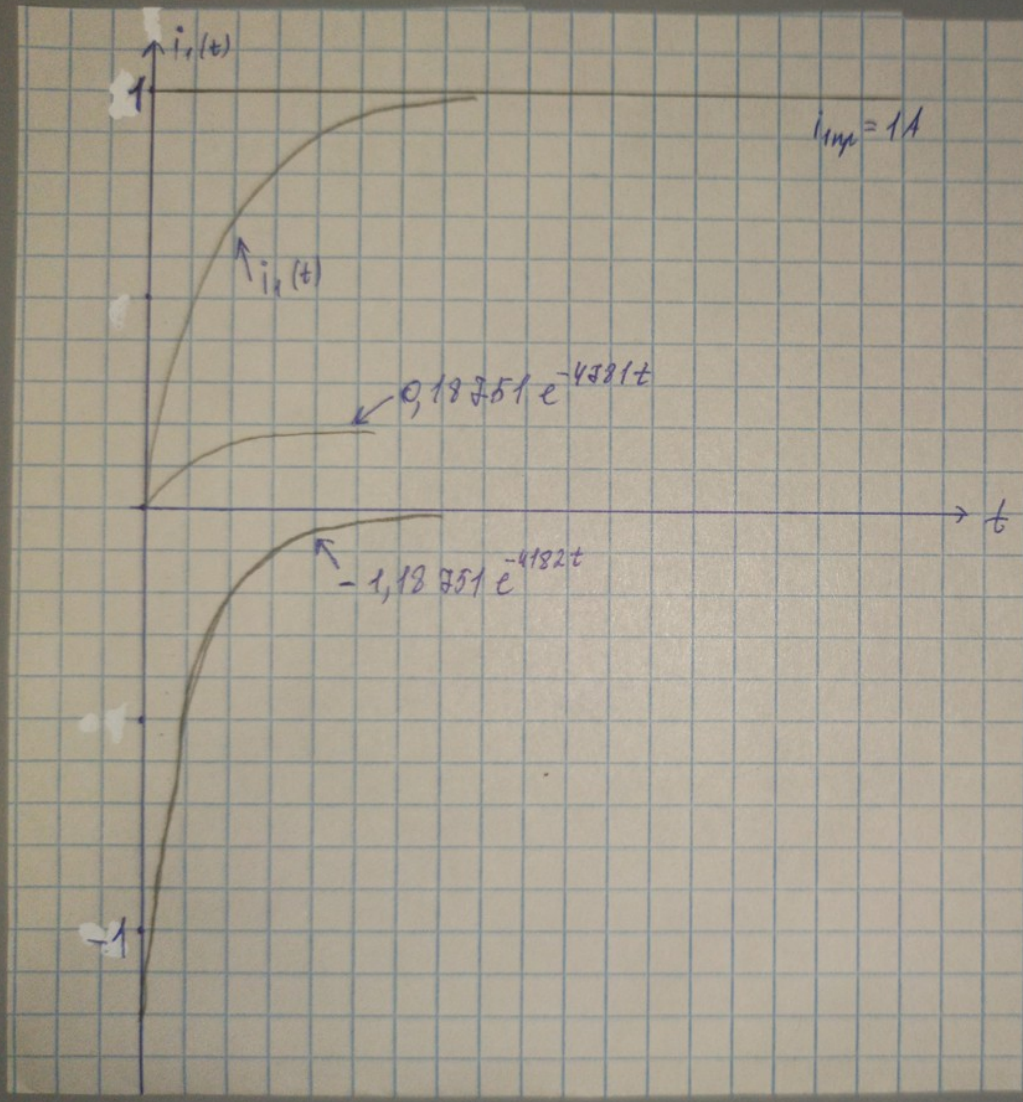
$$\begin{cases} i_1(0) = i_{1\,пр} + A_1 + A_2 \\ \frac{di_1(0)}{dt} = p_1 A_1 + p_2 A_2 \end{cases}$$

$$\begin{cases} -1 = A_1 + A_2 \\ -4000 = -4182 A_1 - 47817 A_2 \end{cases}$$

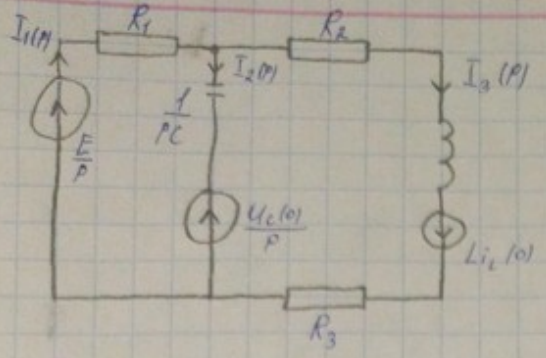
$$A_1 = -1,18751$$

$$A_2 = 0,18751$$

$$i_1(t) = 1 - 1,18751\, e^{-4182t} + 0,18751\, e^{-47817t}$$


$i_1(t)$
1
$i_{1пр} = 1A$
$i_2(t)$
$0,18751\,e^{-4381t}$
t
$-1,18751\,e^{-4182t}$
-1

Операторный метод:



$$\begin{cases} \frac{E}{P} - \frac{U_c(P)}{P} = R_1 I(P) + \frac{1}{PC} I_2(P) \\ \frac{U_c(P)}{P} + Li_L(0) = -\frac{1}{PC} I_2(P) + (R_2 + R_3 + PL) I_3(P) \\ 0 = I_1(P) - I_2(P) - I_3(P) \end{cases}$$

$$\begin{vmatrix} \frac{E}{P} - \frac{U_c(0)}{P} & \frac{1}{PC} & 0 \\ \frac{U_c(0)}{P} - Li_L(0) & -\frac{1}{PC} & R_2+R_3+PL \\ 0 & -1 & -1 \end{vmatrix} = \left(\frac{E}{P} - \underbrace{\frac{U_c(0)}{P}}_{=0}\right)\frac{1}{PC} + \left(\frac{E}{P} - \underbrace{\frac{U_c(0)}{P}}_{=0}\right)(R_2+R_3+PL) +$$

$$+ \left(\frac{U_c(0)}{P} - Li_L(0)\right)\frac{1}{PC} = \frac{U_c(0) - Li_L(0)P}{P^2C}$$

$$I_1(P) = \frac{\begin{vmatrix} \frac{E}{P} - \frac{U_c(0)}{P} & \frac{1}{PC} & 0 \\ \frac{U_c(0)}{P} - Li_L(0) & -\frac{1}{PC} & R_2+R_3+PL \\ 0 & -1 & -1 \end{vmatrix}}{\begin{vmatrix} R_1 & \frac{1}{PC} & 0 \\ 0 & -\frac{1}{PC} & R_2+R_3+PL \\ 1 & -1 & -1 \end{vmatrix}} =$$

$$\begin{vmatrix} R_1 & \frac{1}{PC} & 0 \\ 0 & -\frac{1}{PC} & R_2+R_3+PL \\ 1 & -1 & -1 \end{vmatrix} = \frac{R_1}{PC} + \frac{R_2+R_3+LP}{PC} + R_1(R_2+R_3+LP)\frac{PC}{PC} =$$

$$= \frac{R_1+R_2+R_3+LP+R_1R_2PC+R_1R_3PC+LCP^2}{PC}$$

$$= \frac{U_c(0) - Li_L(0)P}{R_1+R_2+R_3+P(L+R_1R_2C+R_1R_3C)+R_1LCP^2)} = \frac{F_1(P)}{F_2(P)}$$

$F_1(P) = 100 - 2\cdot 10^{-3}P$

$F_2'(P) = 15\cdot 10^{-7}P^2 + 0{,}0052P + 100$

$P_1 = 0 \qquad F_1 = 100 \qquad F_2' = 100$

$P_2 = -4132 \qquad F_1 = 108{,}364 \qquad F_2' = -91{,}230314$

$P_3 = -47917 \qquad F_1 = 195{,}634 \qquad F_2' = 1043{,}21423$

$i_1(t) = 1 - 1{,}18731\, e^{-4132t} + 0{,}18753\, e^{-47917t}$

Для одной ЭДС

$e(t) = 100\cos(3200\pi t + 45°)$

$E(p) = \frac{100(p\cos 45° - \omega \sin 45°)}{p^2 - \omega^2}$

Начальные условия

$\dot{U}_c(0-) = \frac{\dot{E}}{R_2 + R_3 + \dot{Z}} \cdot \dot{Z} = \frac{100 e^{45i} \cdot 10{,}14 e^{-1{,}38i}}{50 + 10{,}14 e^{-1{,}38i}} = \frac{1014 e^{-0{,}36i}}{50 + 10{,}14 e^{-1{,}38i}} = 19{,}18 e^{-0{,}173i}$

$\dot{Z} = \frac{R_1 + j\omega L}{1 + (R_1 + j\omega L) j\omega C} = \frac{50 + 3200\pi \cdot 10^{-3} \cdot j}{1 + (50 + 3200\pi \cdot 10^{-3} \cdot j) \cdot 3200\pi \cdot 10^{-5} \cdot j} = \frac{50 + 10i}{-0{,}011 + 5{,}03i} =$

$= 10{,}14 e^{-1{,}38i}$

$\dot{I}_L(0-) = \frac{\dot{U}_c(0-)}{R_2 + j\omega L} = \frac{19{,}18 e^{-0{,}173i}}{30 + 3200\pi \cdot 10^{-3} \cdot i} = 0{,}606 e^{-0{,}5}$

$U_c(0) = 19{,}18\cos(-0{,}173) = 18{,}18\ В \qquad I_L(0) = 0{,}606\cos(-0{,}5) = 16{,}8\ А$

$$I_1(0) = \frac{\begin{vmatrix} \frac{E(p)}{p} - \frac{U_c(0)}{p} & \frac{1}{pC} & 0 \\ \frac{U_c(0)}{p} - Li_L(0) & -\frac{1}{pC} & R_2 + R_3 + pL \\ 0 & -1 & -1 \end{vmatrix}}{\begin{vmatrix} R_1 & \frac{1}{pC} & 0 \\ 0 & -\frac{1}{pC} & R_2 + R_3 + pC \\ 1 & -1 & -1 \end{vmatrix}} = \frac{E(p) - i_L(0)(p^2 - \omega^2) + ((-U_c(0)(p^2 - \omega^2))(R_2 + R_3 + p^2 L) + E(p) p (R_2 + R_3 + pL))C}{(R_1 LCp^2 + p(L + R_1 R_2 C + R_1 R_3 C) + R_1 + R_2 + R_3} =$$

$$= \frac{50\sqrt{2}p - 16 \cdot 10^4 \pi\sqrt{2} - 16{,}8(p^2 - (3200\pi)^2) + ((-19{,}18(p^2 - (3200\pi)^2)(50 \cdot 10^{-3} p^2) + (5 \cdot 10^{-3} p^2 + 0{,}026p + 100)(p^2 - (3200\pi)^2)}{+(50\sqrt{2}p - 16 \cdot 10^4 \pi\sqrt{2}) \cdot p \cdot (50 + 10^{-3} p)) \cdot 10^{-5}} = \frac{F_1}{F_2}$$

5

Корни F_2:

$F_1 = 50\sqrt{2}P - 16\cdot 10^{-3}\pi\sqrt{2} \cdot [-16{,}91(P^2 - (3200\pi)^2)] + [(-19{,}12(P^2 - (3200\pi)^2)\cdot (50\cdot 10^{-3}P^2) + (50\sqrt{2}P - 16\cdot 10^{-3}\pi\sqrt{2})P \cdot (50 + 10^{-3}P)]\cdot 10^{-5}$

$F_2' = 2\cdot 10^{-6}P^3 + 0{,}0378P^2 + 93{,}04P - 10109125020$

$p_1 = -4182$

$p_2 = -47817$

$p_{3,4} = \pm j3200\pi$

$p_1 = -4182 \quad F_1 = 1{,}54\cdot 10^{10} \quad F_2' = -10108321332$

$p_2 = -47817 \quad F_1 = -480367\cdot 10^8 \quad F_2' = -10154180348$

$p_3 = j3200\pi \quad F_1 = 1024\cdot 10^7 e^{-3{,}14159j} \quad F_2' = 10117\cdot 10^6 e^{-3{,}14159j}$

$p_4 = -j3200\pi \quad F_1 = 10209\cdot 10^7 e^{3{,}14159} \quad F_2' = 10117\cdot 10^6 e^{3{,}14159j}$

$$i(t) = \frac{1021\cdot 10^9 e^{-3{,}14159j}}{10117\cdot 10^6 e^{-3{,}14159j}} e^{100\pi j t} + \frac{10209\cdot 10^7 e^{3{,}14159}}{10117\cdot 10^6 e^{3{,}14159j}} \cdot e^{-100\pi j t} +$$

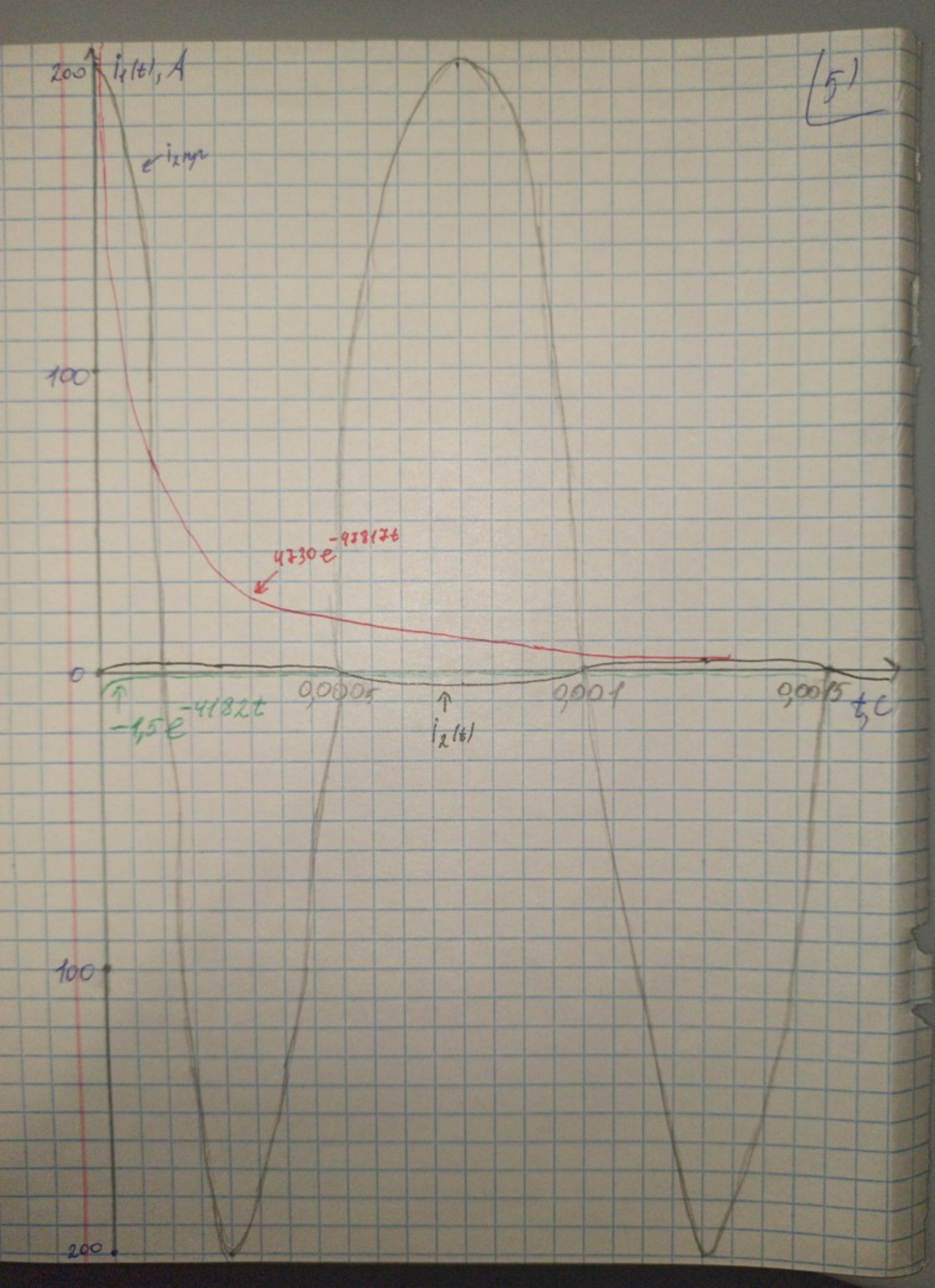
$$+ \frac{1{,}54\cdot 10^{10}}{-10108321332} \cdot e^{-4182t} + \frac{480367\cdot 10^8}{10154180348} \cdot e^{-47817t} =$$

$$= 100{,}92\, e^{-0{,}0001j} \cdot e^{100\pi j t} + 100{,}92\cdot e^{0{,}0001j} \cdot e^{-100\pi j t} - 1{,}5\cdot e^{-4182t} +$$

$$+ 4730\, e^{-47817t} = 100{,}92\,[\cos(3200\pi t - 0{,}0001) + j\sin(3200\pi t - 0{,}0001) +$$

$$+ \cos(3200\pi t - 0{,}0001) - j\sin(3200\pi t - 0{,}0001j)) - 1{,}5\, e^{-4182t} + 4730\, e^{-47817t} =$$

$$= 201{,}84\cos(3200\pi t + 0) - 1{,}5\, e^{-4182t} + 4730\, e^{-47817t}$$


(5)
200
$i_1(t)$, A
$e^{i_1 \cdot \ln}$
100
$4730e^{-93817t}$
0
$-1,5e^{-4182t}$
0,0005
$i_2(t)$
0,001
0,0015
t, c
100
200

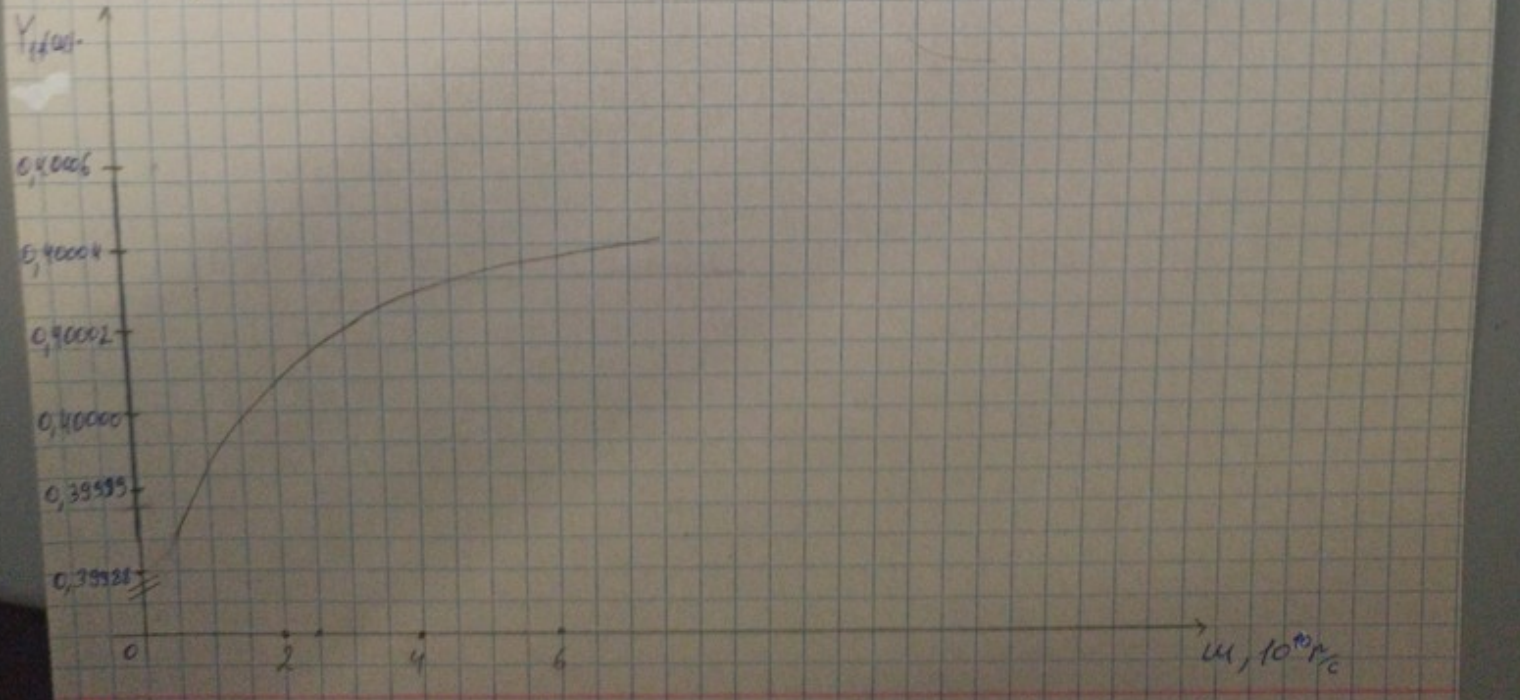
Для электрической цепи определим комплексную передаточную проводимость характеристики, используя операторную характеристику.

$$Y_{11}(P) = \frac{I_1(P)}{E_1(P)} = \frac{\Delta_{11}(P)}{\Delta z} = \frac{\begin{vmatrix} -\frac{1}{PC} & R_2+R_3+PL \\ -1 & -1 \end{vmatrix}}{\begin{vmatrix} R_1 & \frac{1}{PC} & 0 \\ 0 & -\frac{1}{PC} & R_2+R_3+PL \\ 1 & -1 & -1 \end{vmatrix}} = \frac{\frac{1}{PC}+R_2+R_3+PL}{\frac{R_1}{PC}+\frac{R_2+R_3+LP}{PC}+R_1(R_2+R_3+LP)} =$$

$$= \frac{1+PC(R_2+R_3+PL)}{R_1+R_2+R_3+P(L+R_1R_2C+R_1R_3C)+R_1LCP^2} = \frac{1+10^{-5}P(50+10^{-3}P)}{5\cdot10^{-7}P^2+0{,}026P+100}$$

$$Y_{11}(j\omega) = \frac{1+10^{-5}(j\omega)(50+10^{-3}(j\omega))}{5\cdot10^{-7}(j\omega)^2+0{,}026(j\omega)+100} = \frac{1+50\cdot10^{-5}j\omega+10^{-8}(j\omega)^2}{5\cdot10^{-7}(j\omega)^2+0{,}026(j\omega)+100}$$

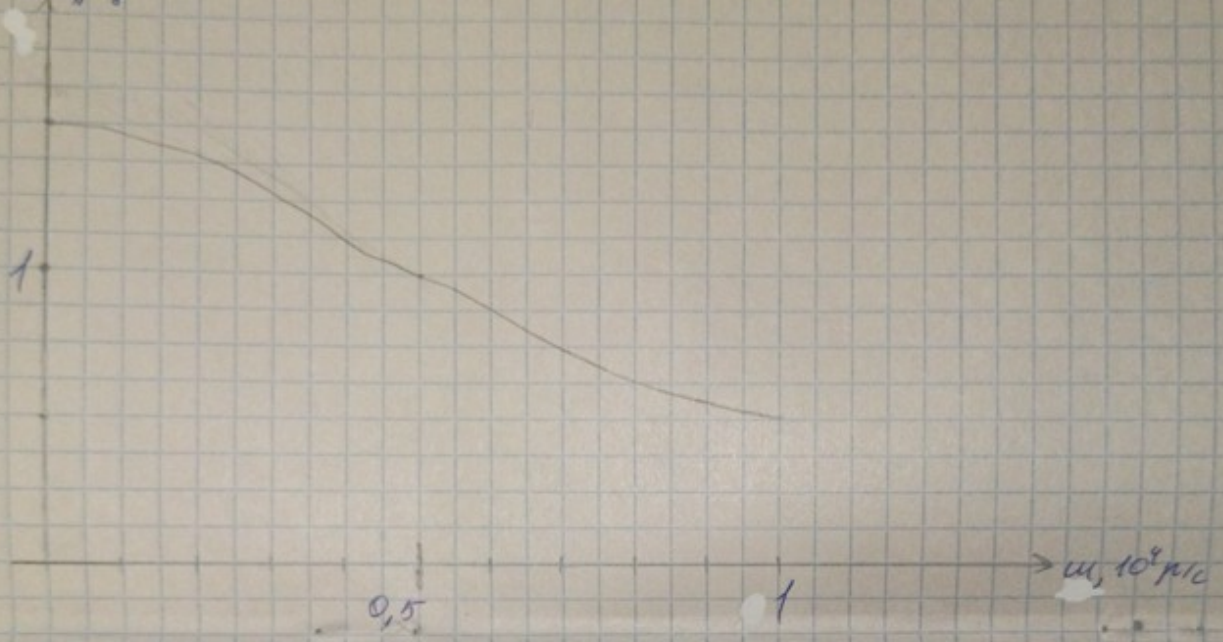
$$Y_{11}(\omega) = \sqrt{\frac{(1+5\cdot10^{-9}\omega)^2+(10^{-8}\omega^2)^2}{(5\cdot10^{-7}\omega^2)^2+(0{,}026\omega+100)^2}}$$



$$\varphi(\omega) = \operatorname{arctg}\left(\frac{1+5\cdot10^{-4}}{10^{-8}\omega}\right) - \operatorname{arctg}\left(\frac{0{,}026\omega+100}{5\cdot10^{-7}\omega^2}\right) =$$

$$= \operatorname{arctg}\left(\frac{1}{10^{-8}\omega}+\frac{5\cdot10^{4}}{\omega}\right) - \operatorname{arctg}\left(\frac{0{,}026\omega+100}{5\cdot10^{-7}\omega^2}\right) =$$

$$= \operatorname{arctg}\left(\frac{100050000}{x}\right) - \operatorname{arctg}\left(\frac{13\cdot10^{7}+500\cdot10^{9}x^2}{2500}\right)$$



$$h(t) = \frac{Y_{11}(P)}{P} = \frac{1+10^{-5}P(50+10^{-3}P)}{5\cdot10^{-7}P^3+0{,}026P^2+100P} = \frac{F_1(P)}{F_2(P)}$$

$$F_2' = 15\cdot10^{-7}P^2+0{,}052P+100$$

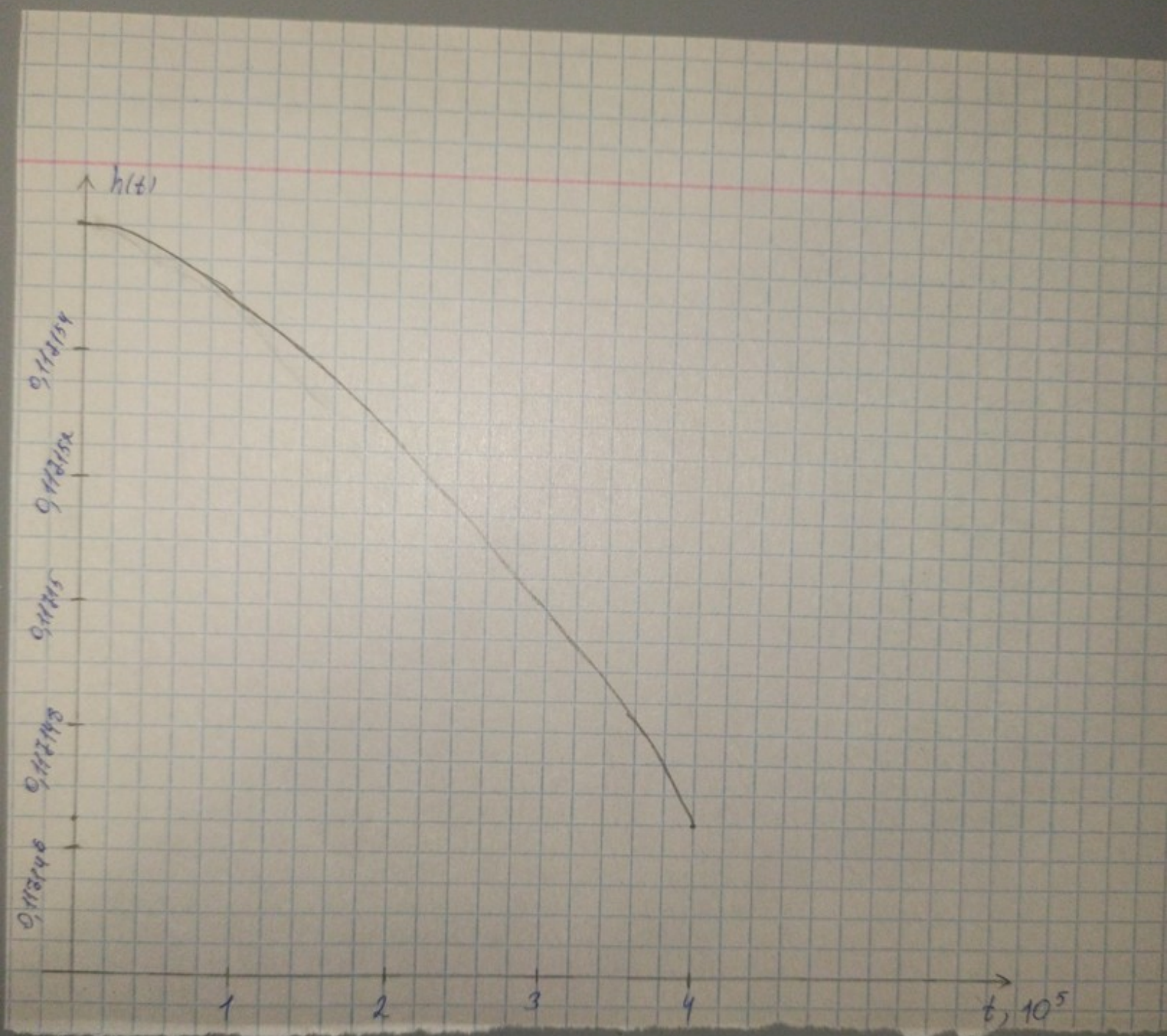
Корни:

$P_1 = 0$ $\quad F_1 = 1$ $\quad F_2' = 100$

$P_2 = -4182$ $\quad F_1 = 3{,}744562$ $\quad F_2' = -91{,}230314$

$P_3 = -47817$ $\quad F_1 = 1144{,}23274$ $\quad F_2' = 1043{,}21423$

$$h(t) = 0{,}01 - 0{,}106313\cdot e^{-4182t} + 1{,}09633\, e^{-47817t}$$


h(t)
0,11815
0,11815
0,11815
0,11815
0,11815
1
2
3
4
t, 10^5

$$g(t) = h'(t) = \frac{d\,h(t)}{dt} = p_1 A_1 e^{p_1 t} + p_2 A_2 e^{p_2 t} = 447\,e^{-4182t} - 52447\,e^{-47317t}$$