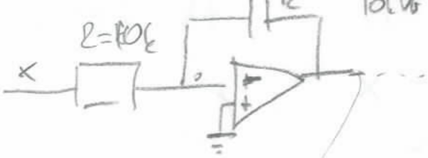
② Sestavite vezje s prenosno funkcijo $\frac{1}{Tp}$ vhodno upornost naj bo 10 kΩ časovna konstanta pa 2 ms. Ob času t=0 sta vhodna in izhodna napetost 0, nato pa se vhodna napetost spremenja, kot je narisano. Narišite potek izhodne napetosti

$T_R = \frac{2\,ms}{10\,k\Omega} = 0{,}2\,\mu F$



$T = RC$
$C = \frac{T}{R}$

$$\frac{z}{\frac{1}{pC}} + \frac{x}{R} = 0$$

$$\boxed{z = -\frac{x}{pT}}$$

integrator → obrniti moramo še predznak

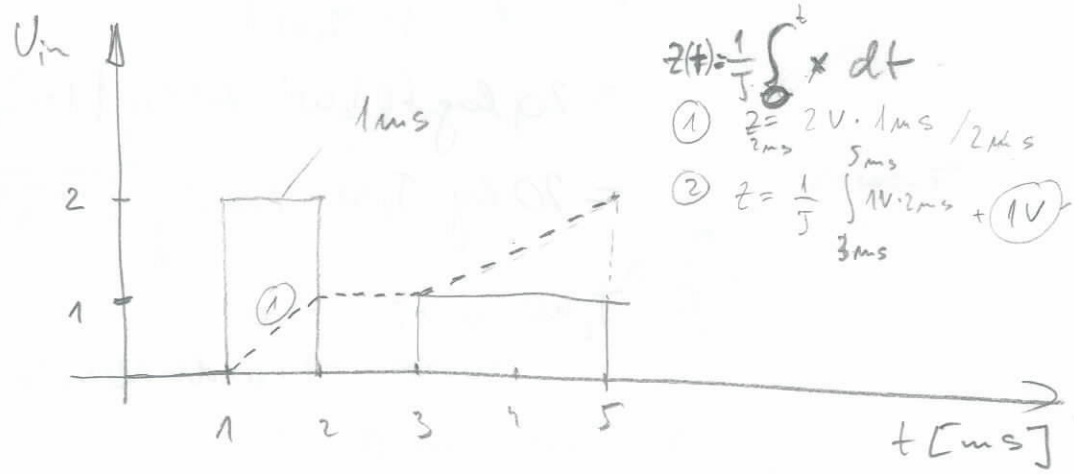
$$\frac{z}{R} + \frac{x}{R} = 0$$

$$\underline{z = -x}$$

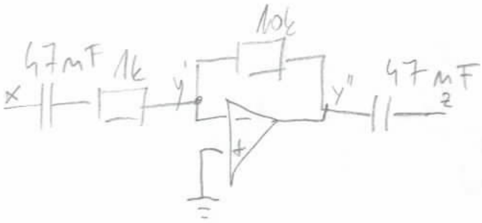
$$z(t) = \frac{1}{T}\int^{t} x\,dt$$

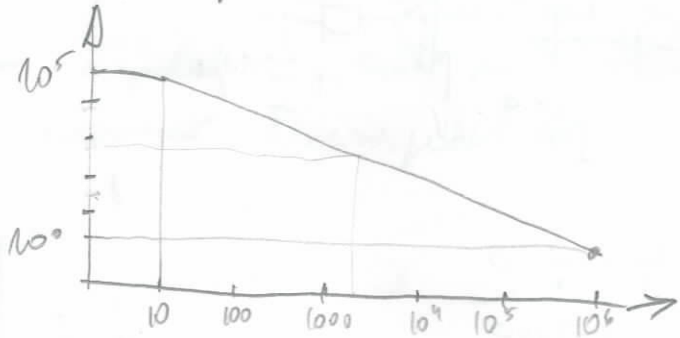
① $z_{2ms} = 2V \cdot 1ms / 2ms$

② $z = \frac{1}{T}\int_{3ms}^{5ms} 1V \cdot 2ms + 1V$ od (1)



④ Nariši frekvenčno odvisnost ojačanja naslednjega filtra. Na desni je narisana frekvenčna karakteristika ojačanja.




$$\frac{x-y'}{R_1+\frac{1}{i\omega C}} + \frac{y''-y'}{R_2} = 0$$

$$\frac{y'-y''}{R_2} + \frac{z-y''}{\frac{1}{i\omega C}} = 0 \Rightarrow y' + Ay' + i\omega T_2 (z + Ay') = 0$$

$$A(0-y') = y''$$

$$-Ay' = y''$$

$$y'(1+A+i\omega T_2 A) = -i\omega T_2 z$$

$$\boxed{y' = \frac{-i\omega T_2 z}{(1+A+i\omega T_2 A)}}$$

$$x - y' - \left[\frac{R_1}{R_2}+\frac{1}{i\omega T_2}\right](1+A)y' = 0$$

$$\boxed{x = y'\left[1+\left(\frac{R_1}{R_2}+\frac{1}{i\omega T_2}\right)(1+A)\right]}$$

$$x = \frac{-i\omega T_2 z\left(1+\left(\frac{R_1}{R_2}+\frac{1}{i\omega T_2}\right)(1+A)\right)}{(1+A+i\omega T_2 A)}$$

$\omega_c = \frac{1}{T_2}$ = 47 nF · 10 kΩ = 2'13 kHz

$A(\omega_c) \geq 1000$

pod $\omega_c$

$$\frac{z}{x} = -\frac{1+i\omega T_2}{+i\omega T_2 \frac{R_1}{R_2}+1}$$

$$20\log\left|\frac{z}{x}\right| = 20\log\sqrt{1+\omega^2 T_2^2} - 20\log\sqrt{1+\omega^2 T^2 \frac{R_1}{R_2}^2}$$

$$T\cdot\frac{R_1}{R_2} = 10^{-2}T \Rightarrow \omega_{c1} = 100\,\omega_c$$

$$\frac{z}{x} = \frac{1+A+i\omega T_2 A}{-i\omega T_2\left[1+\left(\frac{R_1}{R_2}+\frac{1}{i\omega T_2}\right)(1+A)\right]}$$

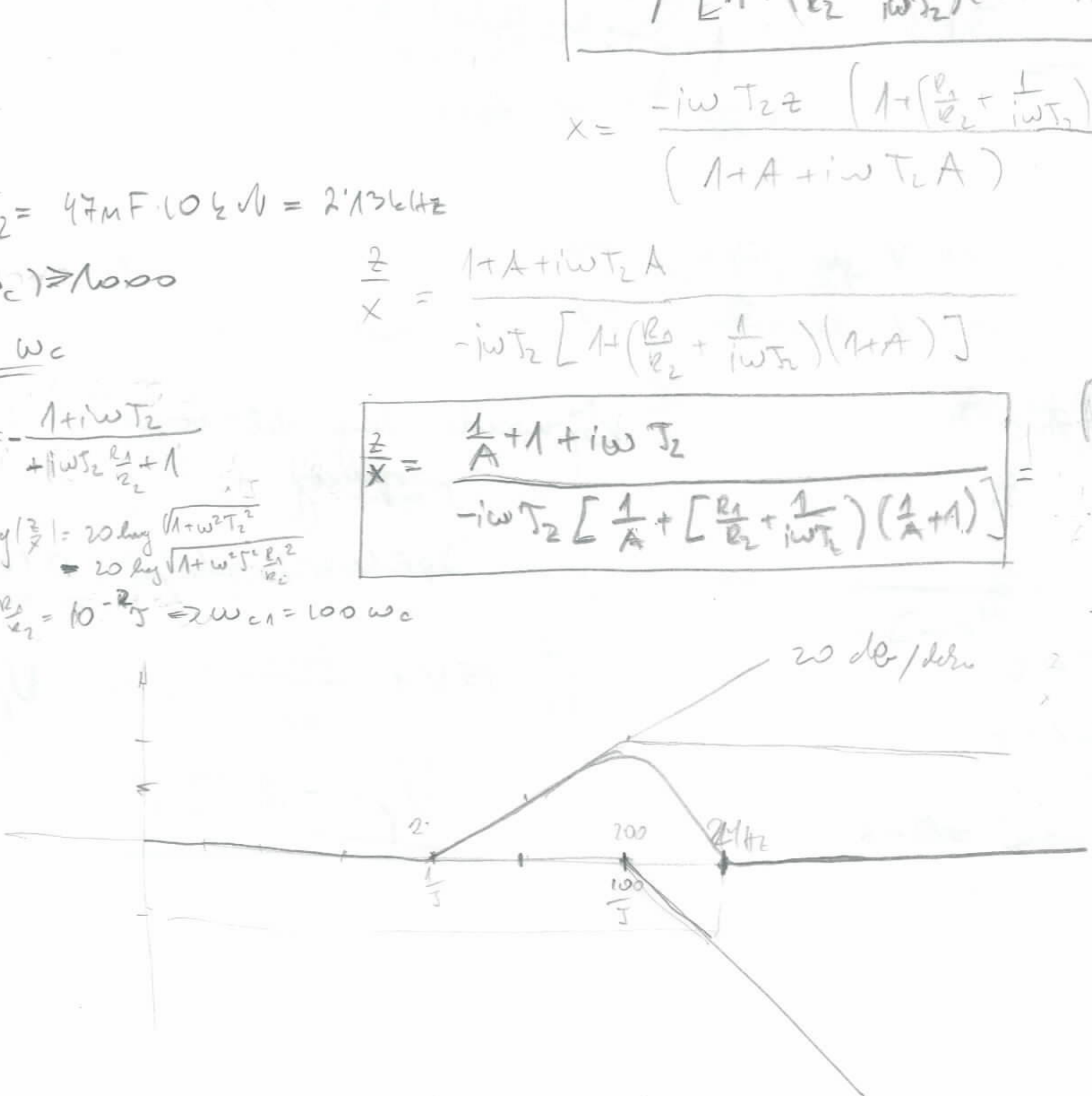
$$\boxed{\frac{z}{x} = \frac{\frac{1}{A}+1+i\omega T_2}{-i\omega T_2\left[\frac{1}{A}+\left[\frac{R_1}{R_2}+\frac{1}{i\omega T_2}\right)\left(\frac{1}{A}+1\right)\right]}} =$$

$\boxed{\omega > 1\,MHz}$ $A \to 1$

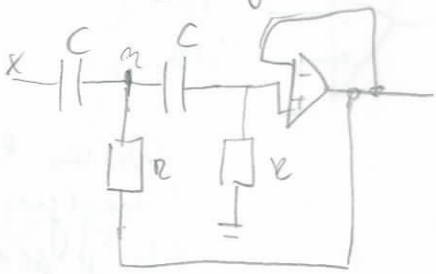
$$\frac{2+i\omega T_2}{-i\omega T_2\left[1+\left[\frac{R_1}{R_2}+\frac{1}{i\omega T_2}\right)\cdot 2\right.}$$

$$= -\frac{2+i\omega T_2}{+1'02\, i\omega T_2 + 2}$$

20 log



3) Zapišite, kakšno je ojačanje spodnjega vezja odvisno od frekvence vhodnega sinusnega signala.




$$i\omega C(x-\eta) + \frac{z-\eta}{R} + (z-\eta)i\omega C = 0$$

$$i\omega C(\eta - z) + \frac{0-z}{R} = 0$$

$$i\omega\tau(\eta - z) - z = 0$$

$$i\omega\tau\eta - z(1+i\omega\tau) = 0$$

$$\eta = \frac{z(1+i\omega\tau)}{i\omega\tau}$$

$$i\omega\tau(x-\eta) + z - \eta + i\omega\tau(z-\eta) = 0$$

$$-\eta(2i\omega\tau + 1) + z(1+i\omega\tau) + x = 0$$

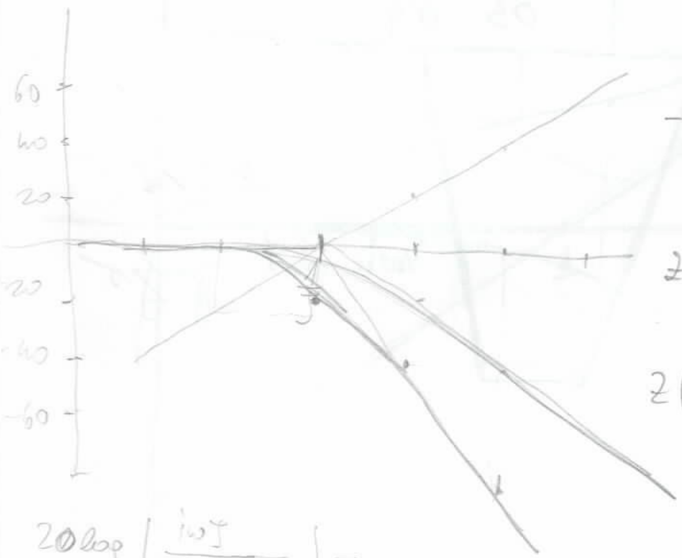
$$-\frac{z(1+i\omega\tau)(2i\omega\tau+1)}{i\omega\tau} + z(1+i\omega\tau) + x = 0$$

$$z(1+i\omega\tau)\left[1 - \frac{(2i\omega\tau+1)}{i\omega\tau}\right] + x = 0$$

$$z(1+i\omega\tau)\left[\frac{i\omega\tau - 2i\omega\tau - 1}{i\omega\tau}\right] + x = 0$$

$$z(1+i\omega\tau)\cdot\frac{-(1+i\omega\tau)}{i\omega\tau} + x = 0$$

$$\boxed{\frac{z}{x} = \frac{i\omega\tau}{(1+i\omega\tau)^2}}$$




$$20\log\left|\frac{i\omega\tau}{(1+i\omega\tau)^2}\right| =$$

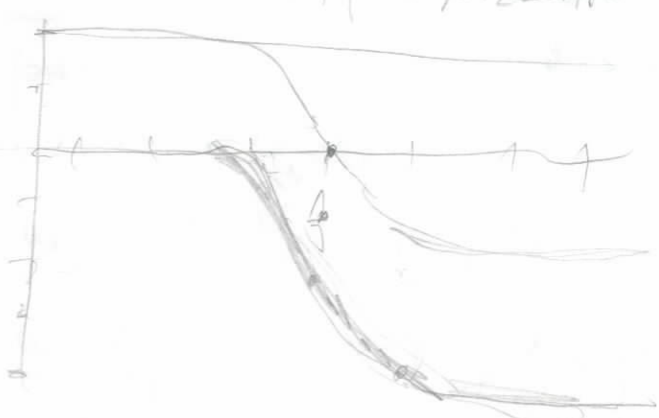
$$20\log \omega\tau - 40\log\sqrt{1+(\omega\tau)^2}$$

$$\mathrm{tg}\,\varphi = \frac{\mathrm{Im}\,A}{\mathrm{Re}\,A} \Rightarrow \varphi \to 90^\circ$$

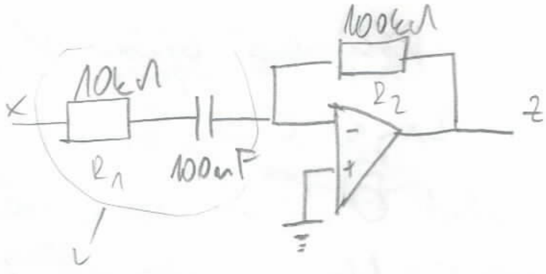
$$\Rightarrow \omega \to 0 \,;\ \varphi \to 0$$

$$\omega = \frac{1}{\tau} \,;\ \varphi = -45\cdot 2 = -90$$

$$\omega \to \infty \,;\ \varphi = -90\cdot 2 = -180$$



V log skali narišite v odvisnost gainja in faznega zamika za filter



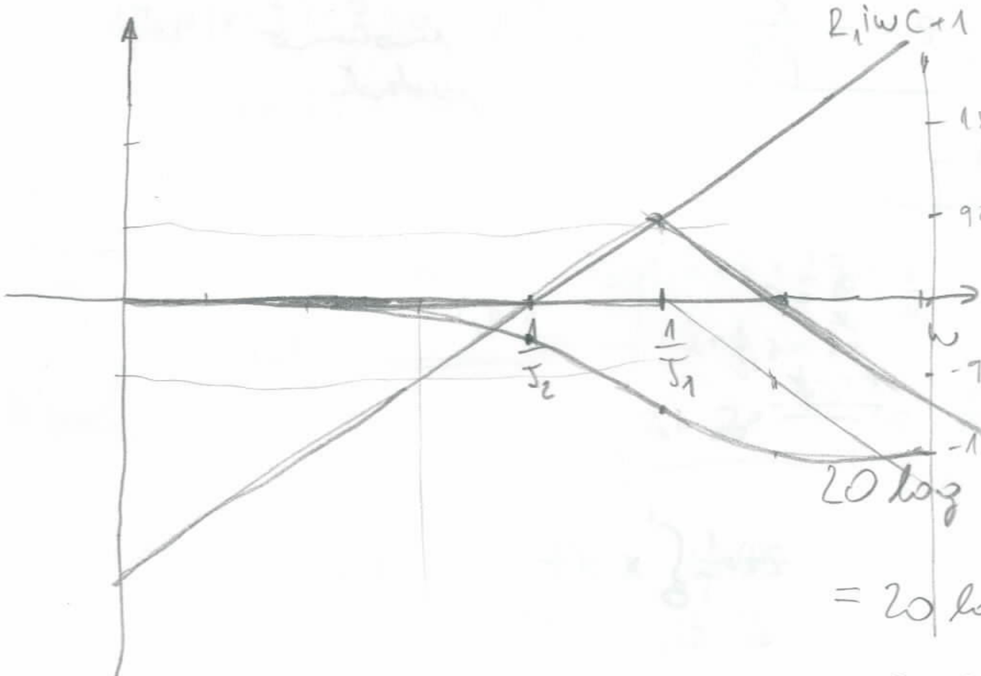

$$Z_s = R_1 + \frac{1}{i\omega C}$$

$$\frac{x}{R_1 + \frac{1}{i\omega C}} + \frac{z}{R_2} = 0$$

$$z = -\frac{R_2}{R_1 + \frac{1}{i\omega C}}\, x$$

$$z = -\frac{R_2\, i\omega C}{R_1 i\omega C + 1}\, x$$

$$= -\frac{R_2 C\, i\omega}{R_1 i\omega C + 1}\, x = \frac{-iT_2\omega}{1 + iT_1\omega}\, x$$




$T_2$ -

$$20 \log \left| \frac{-iT_2\omega}{1 + iT_1\omega} \right| =$$

$$= 20 \log |iT_2\omega| - 20 \log |1 + iT_1\omega| =$$

$$= 20 \log T_2\omega - 20 \log \sqrt{1 + T_1^2\omega^2}$$

Faze:

$$\mathrm{tg}\,\varphi = \frac{\mathrm{Im}\, A}{\mathrm{Re}\, A}$$

$$\mathrm{arctg} \frac{\mathrm{Im}\, A}{\mathrm{Re}\, A} = \varphi$$

1. $T_2\omega$: $\omega \to 0$, $\to \infty$
   $\omega \to \infty \to 20$ db/dekado
2. $T_1\omega$: $\omega \to 0$ $0$
   $\omega \to \infty$ $-20$ db/dekado

---

Vsote faz:

1. $\omega \to 0 \to \varphi_1 \to 0,\ \varphi_2 \to 0$
2. $\omega \to \infty \to \varphi_1 \to -90°,\ \varphi_2 = -90°$ $\quad \varphi = \varphi_1 + \varphi_2 = -180°$
3. $\omega = \frac{1}{T_2} \to \varphi_1 = -45°,\ \varphi_2 = \mathrm{arctg} - \frac{T_1}{T_2} = -56°$
   $\omega = \frac{1}{T_1} \to \varphi_1 = \mathrm{arctg} - \frac{T_2}{T_1} = -84°,\ \varphi_1 = -45°$

③ Starejši op. amp. uporabljen v sodnjem vezju ima vhodni tok $I_B = 0{,}1\mu A$ v vsak vhod, drsitna hitrost pa $SR = 0{,}5\, V/\mu s$. Narišite potek izhodne napetosti če je $C\,(t=0)$ prazen potem pa...!

$$\frac{x}{R} + I_b + Cpz = 0 \qquad\qquad \frac{x}{R} + Cpz = 0$$

$$x = -Tpz$$

$$x + I_b R + Tpz = 0$$

$$z = -\frac{1}{T}\int x\,dx$$

Drsitna hitrost ne igra vloge ker je še vedno dovolj hitra!

$$z = \frac{1}{T}\int(-x - I_b R)\,dt$$

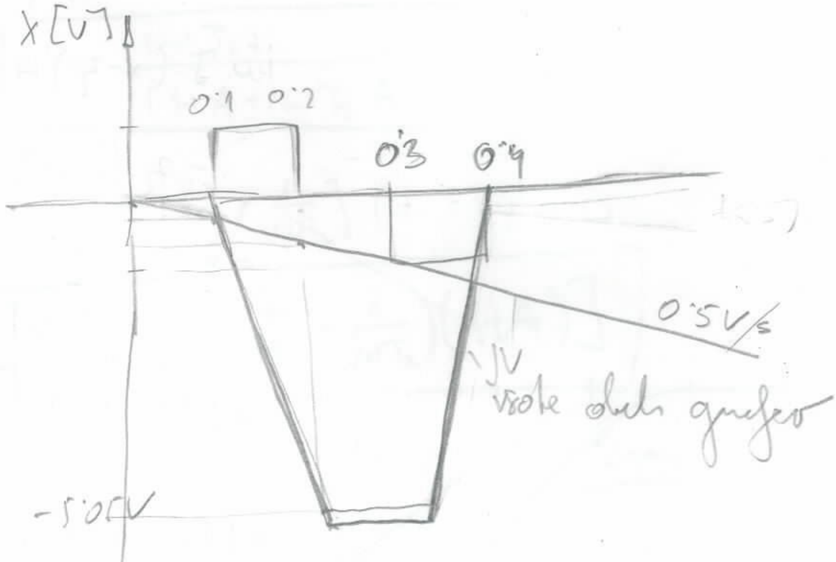
$$z = -\frac{1}{T}\int(x + I_b R)\,dt$$

$$T = 0{,}02\,s$$

$$I_b \cdot R = 0{,}01\,V = 10\,mV$$

$$z = -\frac{1}{T}[x_0 + I_b \cdot R]\cdot t$$

$$z = -[x_0 + I_b \cdot R]\,\frac{t}{T}$$




$$z = 1{,}01V \cdot \frac{0{,}1s}{0{,}02s}$$

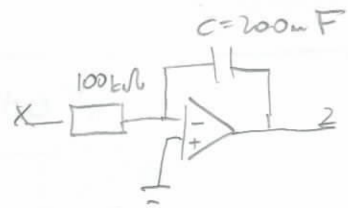
$$z = -5{,}05V$$

$$z = -0{,}99 \cdot V \cdot \frac{0{,}1s}{0{,}02s}$$

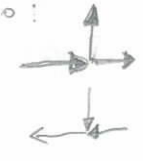
$$= 4{,}95V$$

$$z = 0{,}01 \cdot \frac{0{,}1s}{0{,}02s} =$$

$$0{,}05V$$

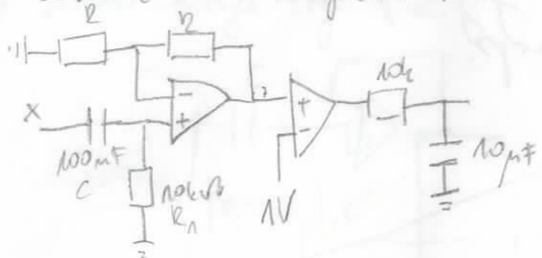


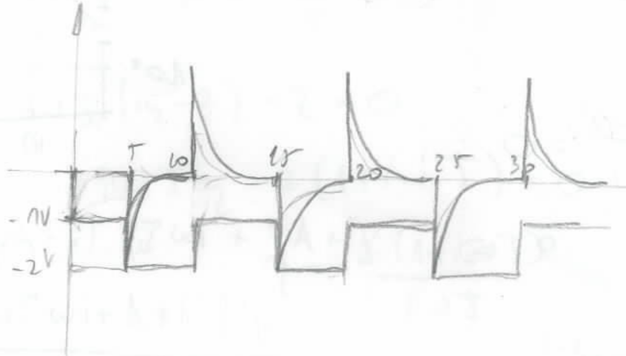

x>0 :



PONAVLJANJE I

1) Na vhod spodnjega vezja vodimo pravokotni periodični signal, kakšna je po dolgem času izhodna napetost? DEC 2004




$$\frac{z-y}{R} + \frac{-y}{R} = 0$$

$$z - 2y = 0$$

$$y = \frac{z}{2}$$

$$Cp\left(x - \frac{z}{2}\right) + -\frac{z}{2R_1} = 0$$

$$2T_1 p\left(x - \frac{z}{2}\right) - z = 0$$

$$T_1 p(2x - z) - z = 0$$

$$-z(T_1 p + 1) + 2T_1 p x = 0$$

prenosne f. CR člena z → $z = \frac{2T_1 p x}{T_1 p + 1}$ ⇒ $T_1 \dot z + z = 2T_1 \dot x$

$\dot z + \frac{1}{T_1} z = 2\dot x$ → kako bi videli da je to res 2x, če bi poznali CR člene

$T_1 = 10k\Omega \cdot 100nF = 1ms$

$z_h = z_0 e^{-\frac{1}{T_1}t}$ → $z_0 = 2V$

A(z-1): z > 1 V da dobimo +15V

z < 1 V da dobimo -15V

$$z = z_0 e^{-\frac{t}{T_1}}$$

$$\frac{z}{z_0} = e^{-\frac{t}{T_1}}$$

$$\ln\frac{z}{z_0} = -\frac{t}{T_1}$$

$$T_1 \ln\frac{z_0}{z} = t$$

$$T_1 \ln 2 = t$$

Kaj naredi drugi del vezja: povprečenje

$T_p = 10k\Omega \cdot 10\mu F = 0.1s \gg$

$$\frac{t}{t_0}\cdot 15V + \frac{(t_0 - t)}{t_0}(-15V) = U_p$$

$$U_p = -12'9V$$

dolžina periode $t_0$ = 10ms

$$\frac{t}{t_0}$$