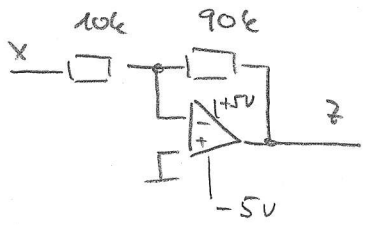
13a

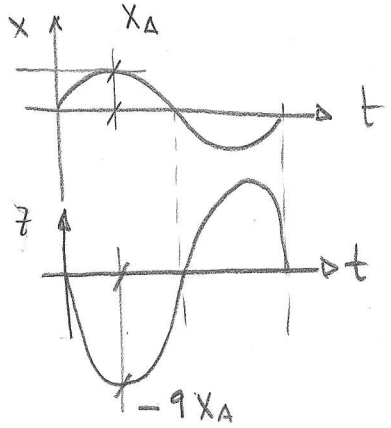


idealni op: $G \to \infty$

$I_B \to 0$

$$A = -\frac{90k}{10k} = -9$$

izh. signal je po velikosti devet-kratnik vhodnega, obrnjen je oblika in frekvenca



kdr gre izh. napetost lahko le do napajanj (+/- 5V), bo izh. signal popačen, če bo njegova ampl. postavila bili > ±5V

⇓

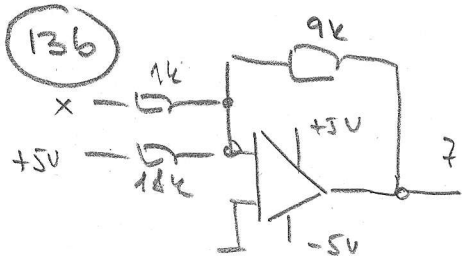
Vhodni signal ima lahko amplitudo največ:

$$X_{AMAX} = 5V/9 = 0{,}555\,V$$

če je ampl x_A večja, je izhodni signal popačen, ker je več linearni ojačevalnik

---

13b

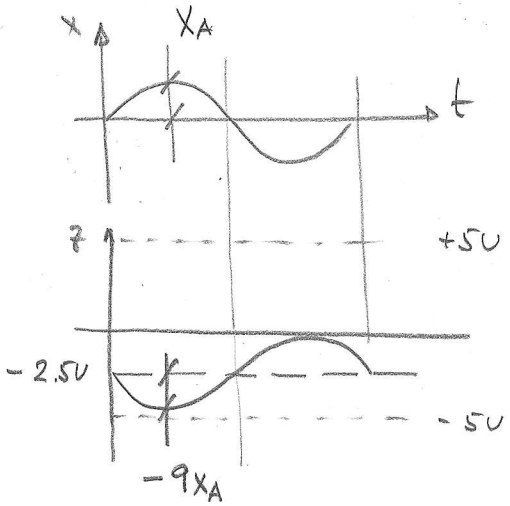


idealni op: $G \to \infty$

$I_B \to 0$

$$Z = -X\frac{9k}{1k} - (+5V)\frac{9k}{18k} =$$

$$= -9x - 2{,}5V$$



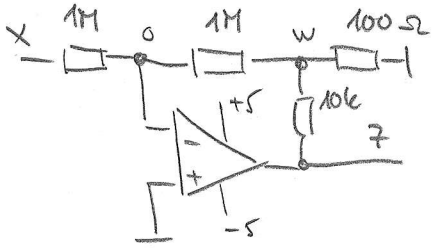
izh. signal gre lahko le do +/- 5V

- začnemo pri -2.5V in gremo navzdol x ne manj, vendar ne gre pod -5V

⇓

X_{AMAX} za lin. ojač $= \frac{2{,}5}{9} = 0{,}277V$

(13c)



natančno:

$$\frac{X}{1M} + \frac{W}{1M} = 0 \Rightarrow X = -W$$

$$\frac{W}{1M} + \frac{W-Z}{10k} + \frac{W}{100} = 0$$

$$-\frac{X}{1M} - \frac{X}{10k} - \frac{Z}{10k} - \frac{X}{100} = 0 \quad / \cdot 1M$$

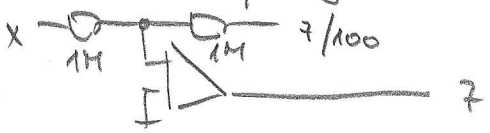
$$-X - 100X - 10000X = 100Z$$

$$Z = -X \cdot 100{,}101$$ ojačenje $\underline{A = -100{,}101}$

približno: upornika 10k in 100Ω sestavljata delilnik napetosti. Ker sta njuni upornosti mnogo manjši od upornosti R = 1M, ki je breme delilnika, lahko delilnik napetosti obremenevam ločeno. Dobim:

$$W = Z \frac{100}{10k + 100} \doteq \frac{Z}{100}$$

od tu naprej imam opravit le s preostankom mreža, ki ima ojačenje -1



Zato: $Z \doteq -\frac{X}{100}$

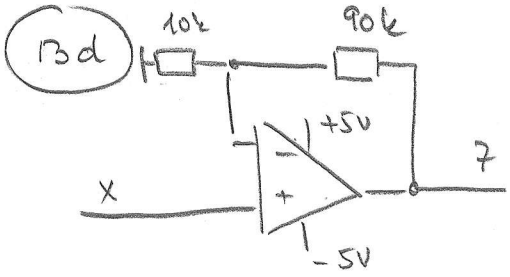
ostalo: največja amplituda izhodnega signala Z je lahko 5V, tako je tudi, ko je amplituda vhodnega signala $5/100 = \underline{50\,mV}$

predmosti : vhodna upornost v mreže 13a je 10k
– " – v mreže 13c je 1M

⇓

veliko ojačenje lahko dosežemo tudi takrat, ko ima vhodni upornik v invertirani ojači. veliko upornost

slabosti : ofsetna napetost OP bolj vpliva na izh. signal



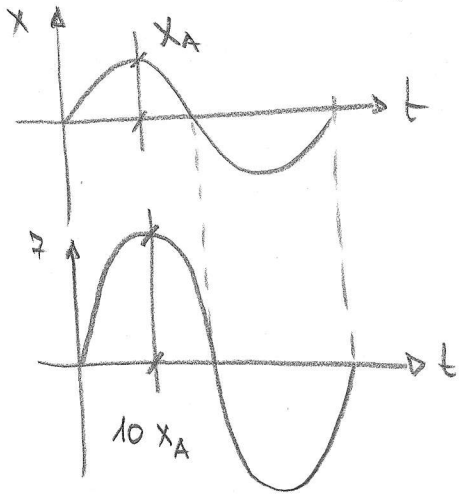
idealni OP: $G \to \infty$

$I_B \to 0$

⇓

$$A = 1 + \frac{90k}{10k} = 10$$

dopustna ampl. izhodnega signala je 5V, to pomeni izh. signal x z amplitudo 0.5V ⇒ največja amplituda vhodnega signala je 0.5V



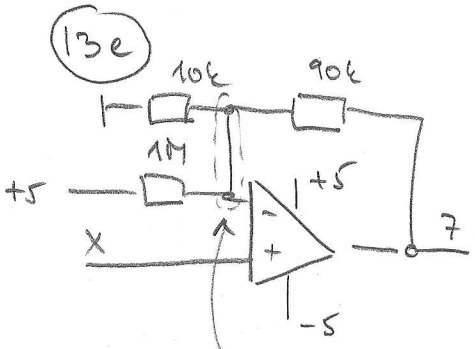
predmost: vhodni $I_B \equiv 0$

⇓

mreže ima neskončno veliko vhodno upornost

slabost : — (predznak?)

(13e)



idealni OP: $G \to \infty$, $I_B \to 0$ } napetost med vhodoma v OP $\equiv$ 0

$\Downarrow$

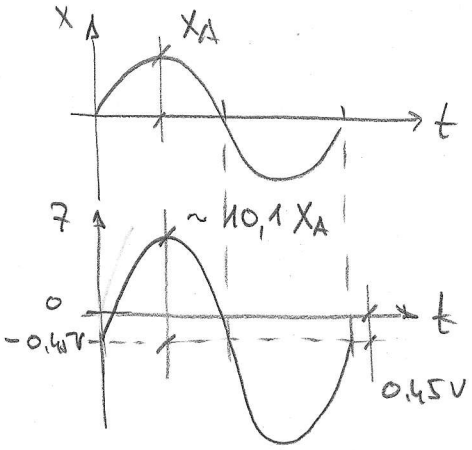
na inv. vhodu je prav tako signal x

Vozliščna enačba za:

$$\frac{x}{10k} + \frac{x-5}{1M} + \frac{x-z}{90k} = 0 \quad / \cdot 1M$$

$$100x + x + 11{,}1x - 5 = 11{,}1z$$

$$z = \frac{112{,}1}{11{,}1}x - \frac{5}{11{,}1} \Rightarrow \underline{z = 10{,}099x - 0{,}45V}$$



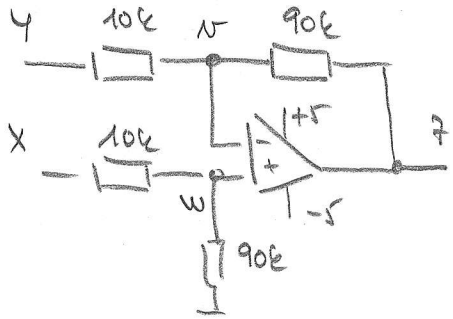
enak kot prej: izh. signal ne more pod -5V, torej je največja ampl. izh. signala 5V - 0,45V = 4,55V

ker je ojačanje vezja ~ 10,1

$\Downarrow$

$$x_{AMAX} = \frac{4{,}55V}{10{,}1} = 0{,}455V$$

(13f)



idealni OP: $G \to \infty$

$I_B \to 0$

neg. povratna vezava:

$v = w$

vh. tok v OP = 0 $\Rightarrow$ izračunaj $w = x \dfrac{90k}{10k + 90k} = x \dfrac{9}{10}$

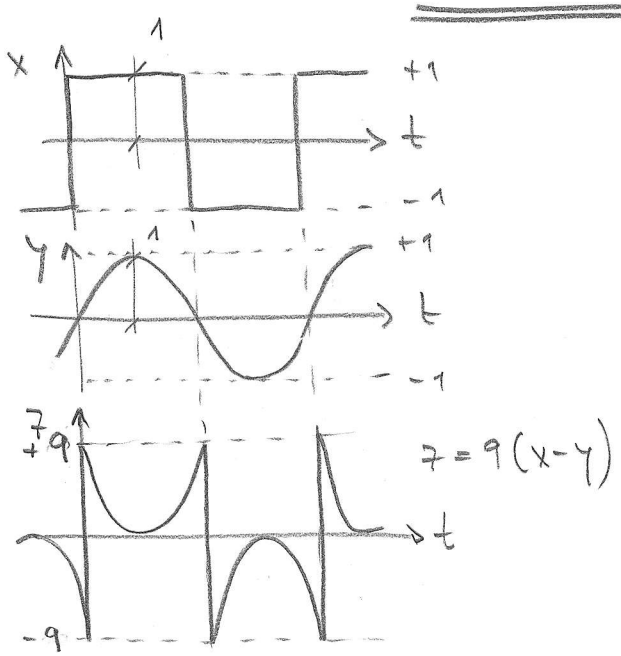
nato zapiši vozliščno enačbo za $v = w$

$$\frac{v - y}{10k} + \frac{v - z}{90k} = 0$$

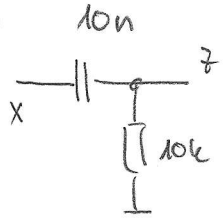
$$9v - 9y + v - z = 0$$

$$z = 10v - 9y = 10 \cdot \frac{9}{10} x - 9y =$$

$$\underline{\underline{z = 9(x - y)}}$$



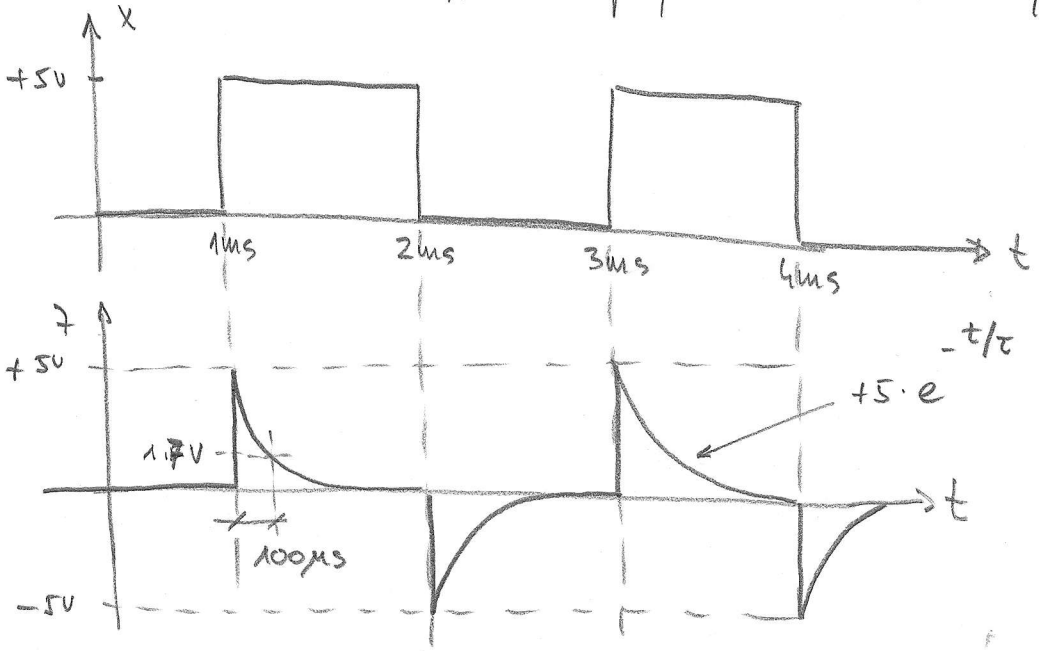
14a



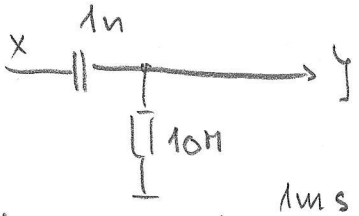
$\tau = R \cdot C = 10 \cdot 10^{-9} \cdot 10 \cdot 10^{3} = 100 \cdot 10^{-6} = 100\mu s$

v τ napetost pade na 36% začetne

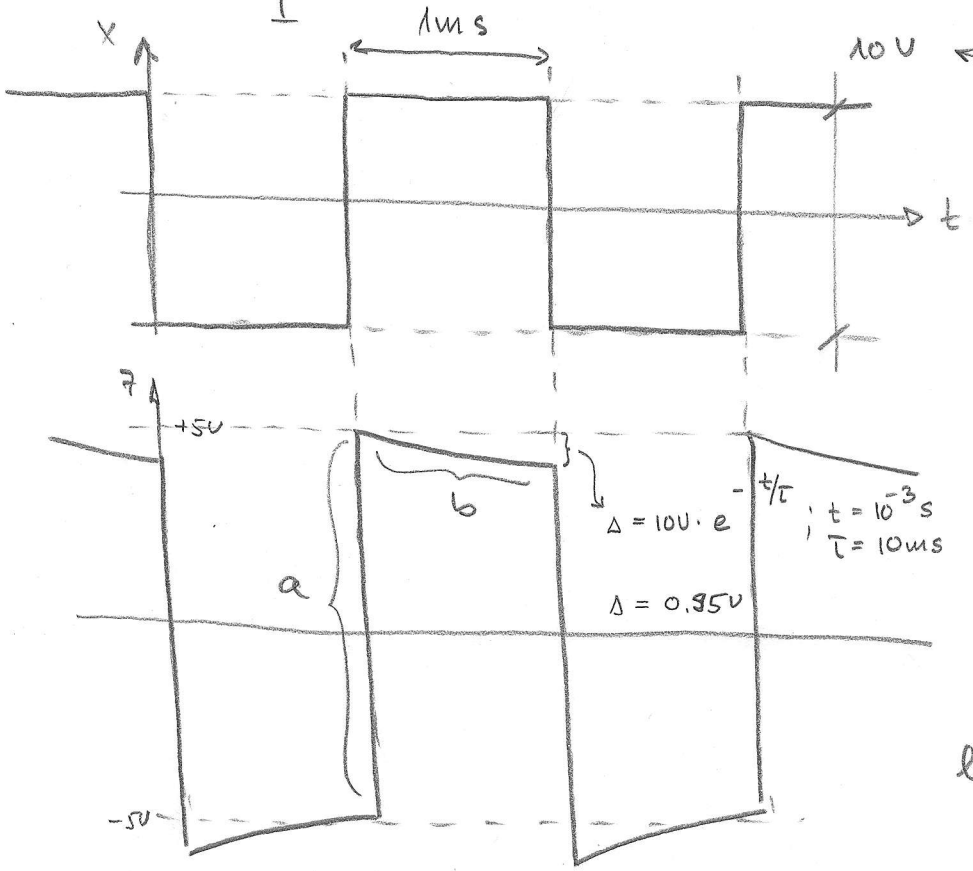
v 5τ pojav izzveni (skoraj)



14b'



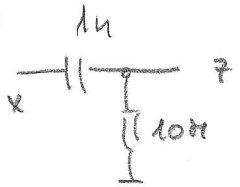
$\tau = R \cdot C = 10^{-9} \cdot 10 \cdot 10^{6} = 10 \cdot 10^{-3} = 10ms$



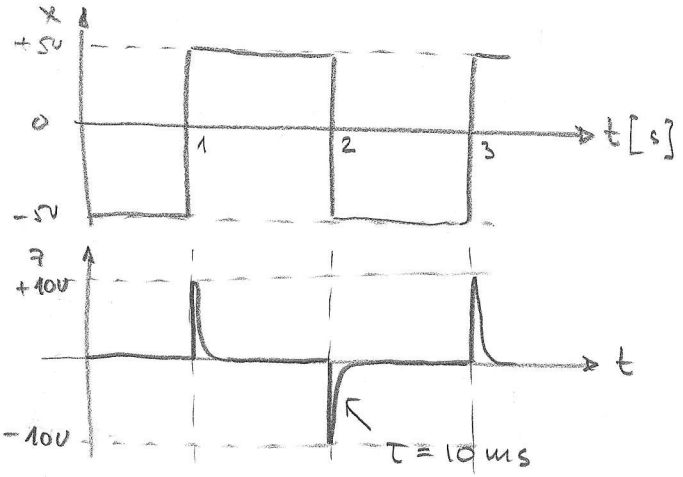
a) poskoš za 1

b) eksponentno upadanje, a le čisto začet del, saj je $\tau = 10ms$, gledamo pa le prvo ms!

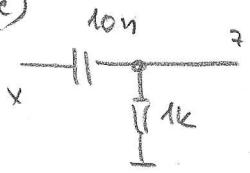
(14b)



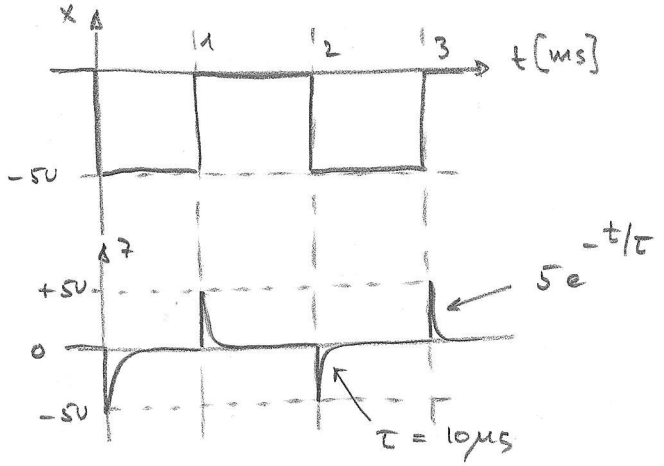
$\tau = R \cdot C = 10^{-9} F \cdot 10 \cdot 10^{6} \Omega = 10\,ms$



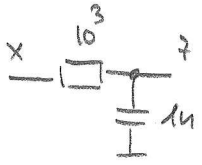
(14c)



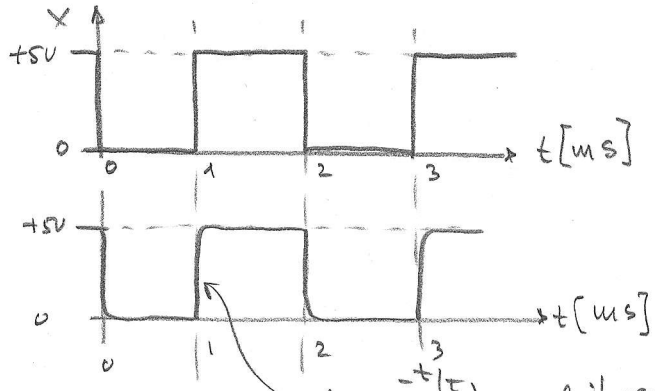
$\tau = RC = 10 \cdot 10^{-9} \cdot 10^{3} = 10\mu s$



14d

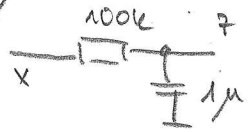


$\tau = RC = 10^3 \cdot 10^{-9} = 1\mu s$

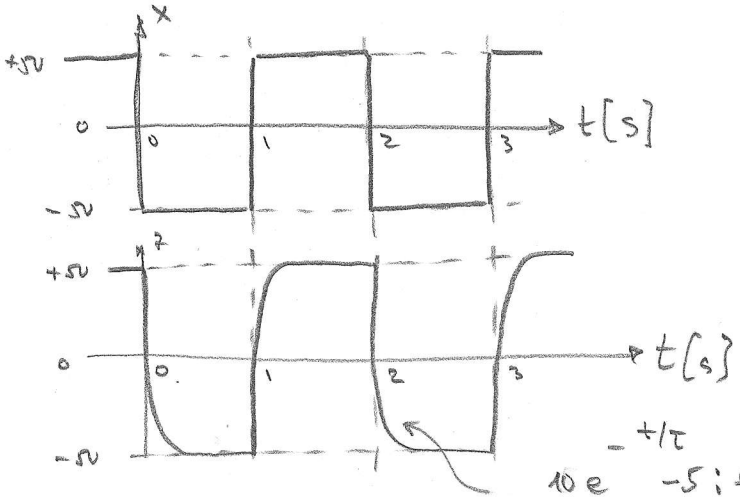


$5(1-e^{-t/\tau})$; hitro exp. naraščanje od 0V do +5V

14e

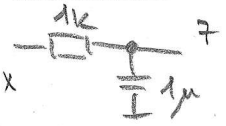


$\tau = RC = 100 \cdot 10^3 \cdot 10^{-6} = 100\,ms$

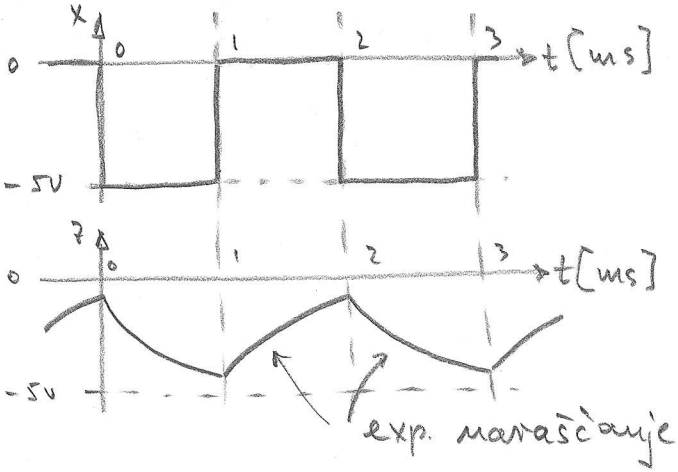


$10e^{-t/\tau} - 5$; exp. padanje od +5V proti -5V

14f



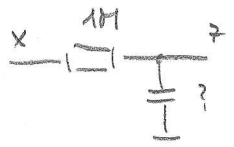
$\tau = RC = 10^3 \cdot 10^{-6} = 1ms$



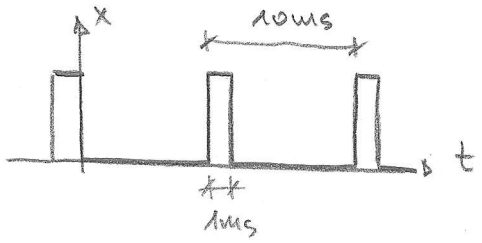
exp. naraščanje in padanje

ker je $\tau \approx$ polperiodi, se C ne napolni do konca, se pred tem se nh. napetost x spremeni

(15a)



potrebujemo povprečevalnik na spodnje sponke

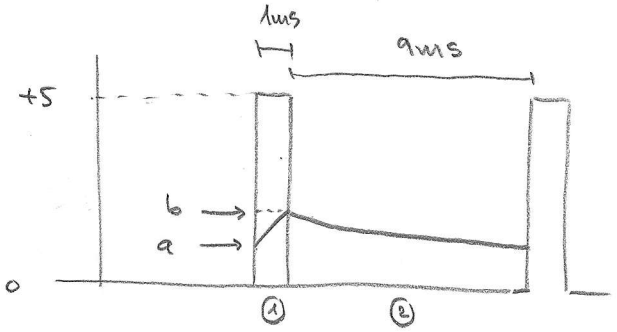


$$f = \frac{1}{10\,ms} = 100\,Hz$$

dovolj bo, če bo $\tau \gg (T = 10\,ms) \Rightarrow$

vzemimo $\tau = 10 \cdot 10\,ms = \boxed{100\,ms} \Rightarrow C =$

$$C = \tau / R = \frac{100 \cdot 10^{-3}}{10^6} = \underline{\underline{100\,nF}}$$



stacionarno stanje:

med ① se napolni od a do b

med ② se sprazni od b do a

$\Rightarrow$ en period je stanje enako

$$① \quad b = (5-a)\left(1 - e^{-1/100}\right) + a$$

$$② \quad a = b \cdot e^{-9/100} \Rightarrow b = a e^{9/100}$$

$$a e^{9/100} = (5-a)\left(1 - e^{-1/100}\right) + a$$

$$= 5 - 5e^{-1/100} - \cancel{a} + a e^{-1/100} + \cancel{a}$$

$$a\left[e^{9/100} - e^{-1/100}\right] = 5\left(1 - e^{-1/100}\right)$$

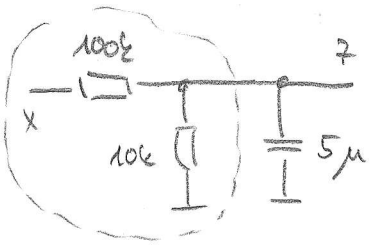
$$a = 5\,\frac{1 - e^{-1/100}}{e^{9/100} - e^{-1/100}} = 5 \cdot \frac{0,00995}{0,10412} = \underline{\underline{0,4778\,V}}$$

$$b = 0,4778\,V \cdot e^{9/100} = \underline{\underline{0,5228\,V}}$$

$$\Delta = b - a = \underline{\underline{45\,mV}}$$ dovolj dobro povprečenje

itn. napetost z se spreminja za $\underline{\underline{45\,mV}}$

15b



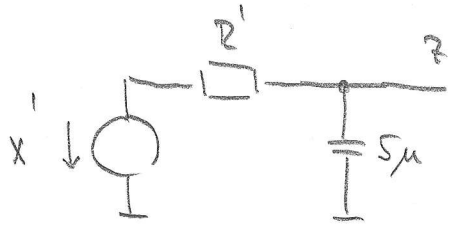
kombinirano vezje, ni enostavno Rc

⇓

Thevenin

⇓

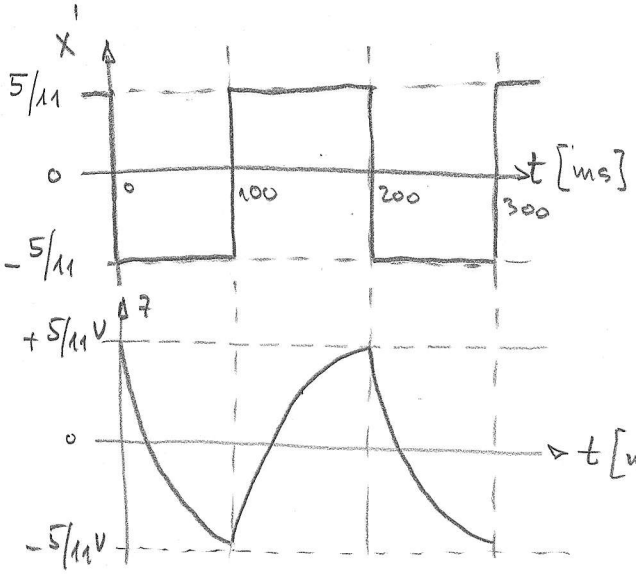
nadomesti dva elementa in vir x



$$x' = x\,\frac{10k}{10k+100k} = \frac{x}{11}$$

$$R' = 100k \parallel 10k = \frac{10\cdot 100}{10+100}\,k$$

$$= 9{,}091k$$



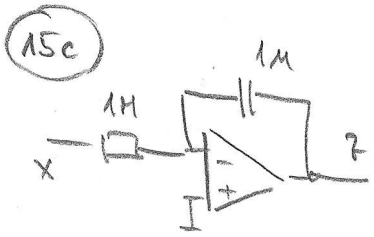
$$\tau = R'C = 9{,}091k \cdot 5\mu = 45ms$$

$$\tau \approx 10k \cdot 5\mu\ !$$

polperioda traja malo več od $2\tau \Rightarrow C$ se nekoliko ma $\approx 90\%$ končne vrednosti

---

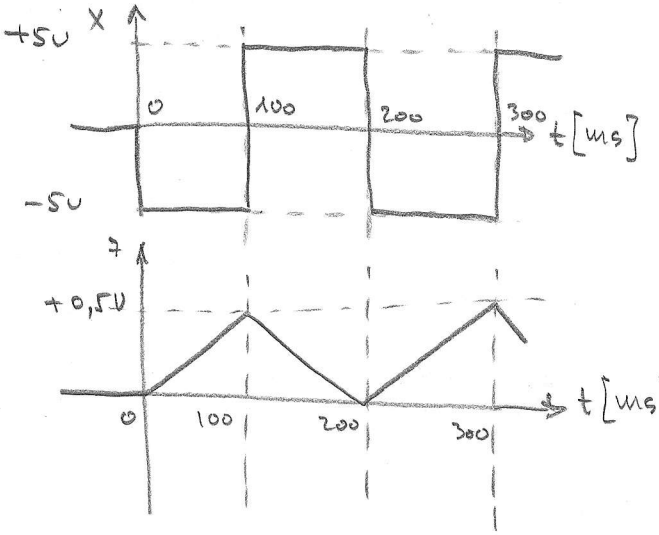
15c



vezje je integrator (z idealnim OP)

$$z = -\frac{1}{RC}\int_0^T x(t)\,dt$$

$$\tau = RC = 10^6 \cdot 10^{-6} = 1s$$



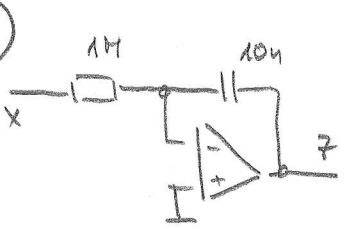
predpostavi: začnemo ob $t=0$! takrat je $z = 0$!

$x = 5V \Rightarrow$ konst !

zato

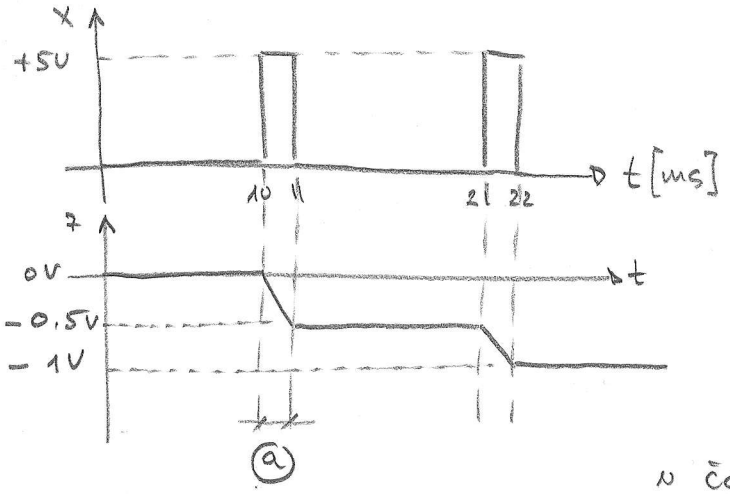
$$z = -\frac{1}{1}\cdot 5\int_0^T dt \quad ; \quad \tau = 0.1s$$

15d



vezje je integrator:

$$Z = -\frac{1}{RC}\int_0^T X(t)\,dt$$



na začetku je $Z = 0$ (reset)

kadar je $X = 0 \Rightarrow Z = konst$

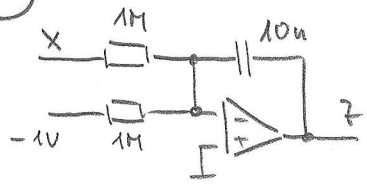
$X > 0 \Rightarrow Z$ pada

v času (a): $\Delta Z = -\frac{1}{RC}\int_0^{1ms} 5V\,dt$

$$= -\frac{5}{10^6 \cdot 10 \cdot 10^{-9}} \cdot 10^{-3}\,V$$

$$\Delta Z = -0.5V$$

15e



vezje je integrator z dvema vhodoma

↓

uporabi načelo superpozicije

a) $X \neq 0,\ (-1) = 0$

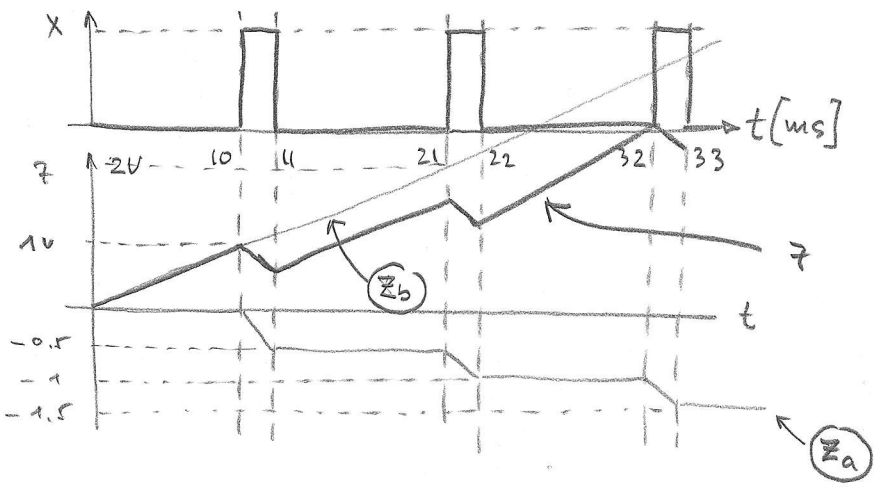
b) $X = 0,\ (-1) \neq 0$

$$Z = -\frac{1}{RC}\int_0^T vhod(t)\,dt, \quad RC = 10ms$$

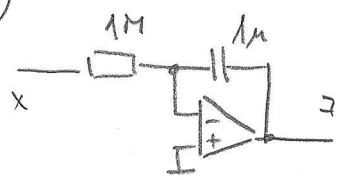
a) enako kot 15d

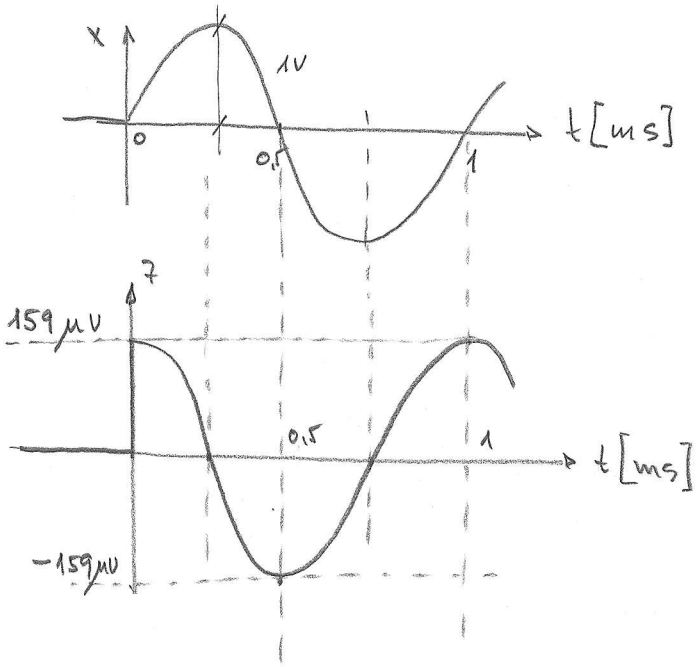
b) $$Z_b = -\frac{1}{10ms}\cdot\int_0^T (-1)\,dt$$

$$= 100 \cdot t = 1V/10ms$$



(15 f)





mreže je integrator z idealnim op

$$z = -\frac{1}{RC}\int x(t)\,dt \quad \underbrace{+C}_{\phi}$$

$$RC = 10^{6}\cdot 10^{-6} = 1\,s$$

$$z = -\int 1\cdot \sin 2\pi\cdot 10^{3} t\,dt$$

$$= +\cos 2\pi\cdot 10^{3} t\cdot \underbrace{\frac{1}{2\pi\cdot 10^{3}}}_{159\cdot 10^{-6}}$$

amplituda signala na izlazu