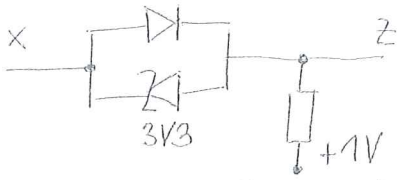
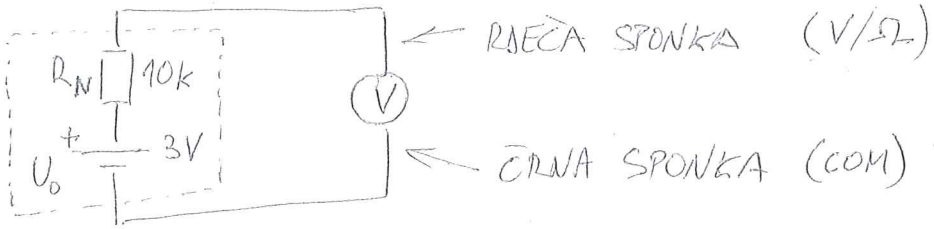
1. kolokvij Elektronike v fiziki (FMT)
4. april 2018

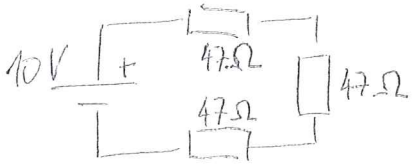
1. Narišite graf z odvisnostjo izhodne napetosti z od vhodne napetosti x, za vrednosti x med -5V in 5V.



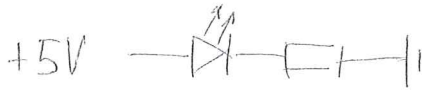
2. Koliko pokaže narisani merilnik napetosti z notranjo upornostjo 1MΩ?

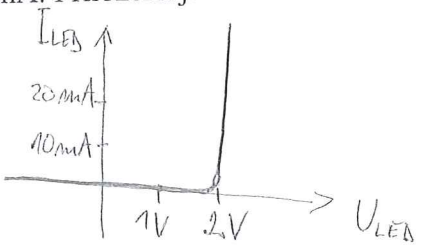


3. Narišite popravljeno shemo, kjer je v vezje vezan tudi ampermeter tako, da meri tok skozi ostale elemente. Kolikšen tok pokaže? Upornost ampermetra je 10Ω. Označite, kako ste razporedili rdečo in črno sponko instrumenta.

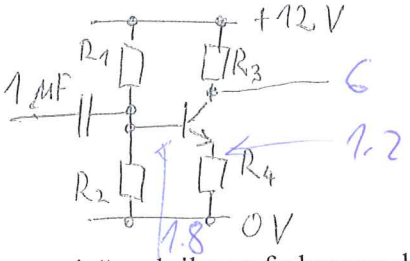


4. Izračunajte vrednost R, pri kateri skozi LED teče 20mA. Priložena je karakteristika LED.

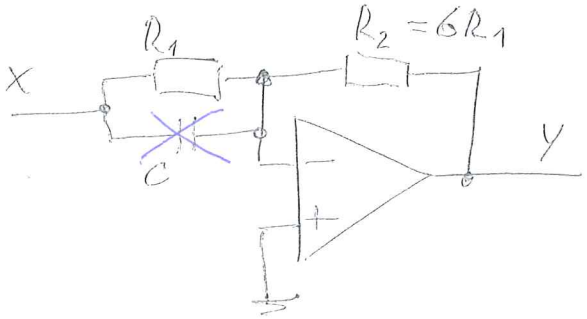




5. Izberite vrednosti upornikov tako, da bo velikost ojačenja 5 in delovna točka izhoda pri 6V. Poraba vezja naj ne bo večja od 2mA.

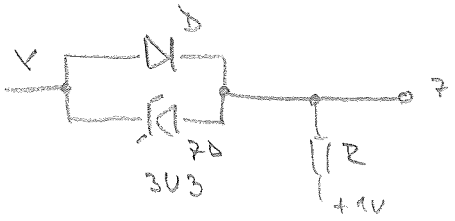


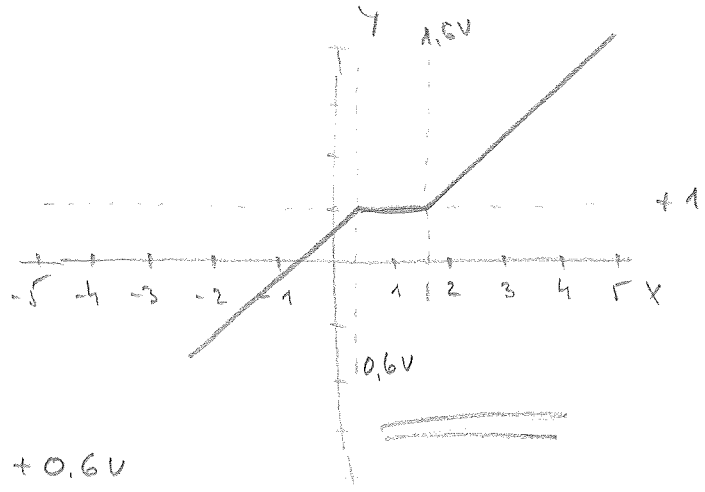
6. Kolikšno je ojačenje narisanega ojačevalnika za frekvence, ki so mnogo nižje od $1/R_1C$?



1. kolokvij Elektronike 1 za FIZ, 4. april 2018

① Graf y/x $[-5, +5]$

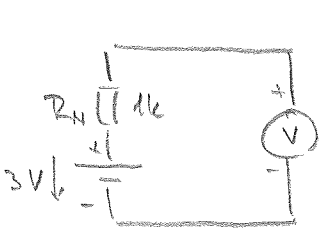




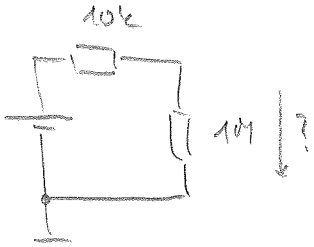
- D prevaja, ko je $x \geq 1V + 0.6V$
- ZD prevaja v prevodni smeri, ko je $x \leq 1V - 0.6V$
- ZD prevaja v zaporni smeri, ko je $x \geq 1V + 3.3V$, ker se ne more sprožiti zaporedni D

---

② odčitek ?



$R_{NV} = 1M$ ≡



$$\text{odčitek} = 3V \cdot \frac{1M\Omega}{1M\Omega + 1k\Omega} = \underline{2.997V}$$ ali cca. 1‰ premalo

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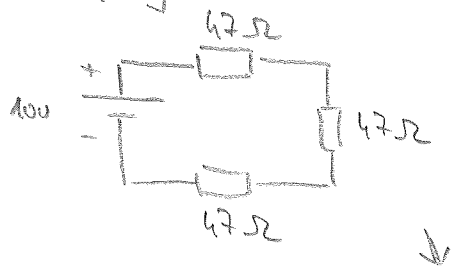
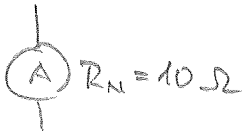
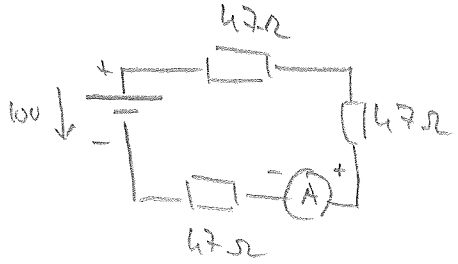
③ Merjenje toka

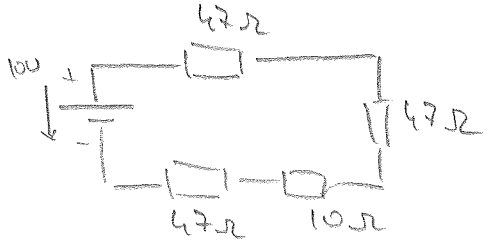


& 

↓ neti kamorkoli v tokokrog, npr. prekini žico in na prekinjeno mesto vstavi A-meter



⇒



b)

$$I = \frac{10\,V}{47\,\Omega + 47\,\Omega + 47\,\Omega + 10\,\Omega} = \frac{10\,V}{151\,\Omega} = \underline{66{,}22\,mA}$$

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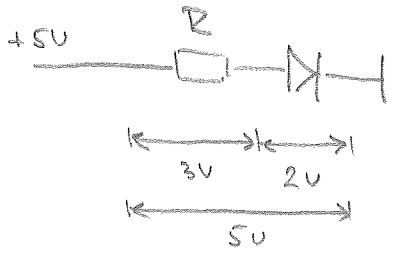
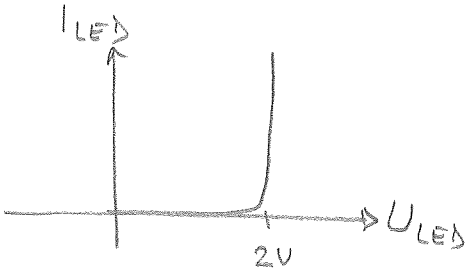
④ določi R za $I = 20mA$





$$I = \frac{3V}{R} \Rightarrow R = \frac{3V}{20mA} = \underline{150\,\Omega}$$

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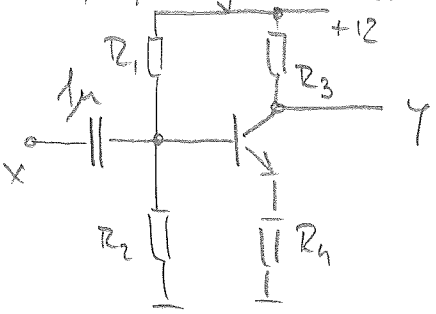
⑤ TR, ojačenje in debelina kocka: $q = 5$, $\langle y \rangle = 6V$

$I = 2mA$



približno računanje: $q = 5 \Rightarrow \underline{R_3/R_4 = 5}$

$I_c \doteq I = 2mA \Rightarrow$ na R_3 je 6V

$$\Downarrow$$

$$R_3 = \frac{6V}{2mA} = \underline{3k}$$

$$R_4 = R_3/5 = \underline{600\,\Omega}$$

zato je na R_4 napetost: $U_{R4} = R_4 \cdot I_c$

$= 600\,\Omega \cdot 2mA = \underline{1{,}2V}$

kar zahteva $U_B = 1{,}2V + 0{.}6V = \underline{1{,}8V}$

v bazo teče I_B, ki tipično znaša $I_c/B = I_c/100 = 20\mu A$

zato izberemo I_B skozi R_1 in $R_2 \Rightarrow I_{R12} = 10 \cdot I_B = 200\mu A$

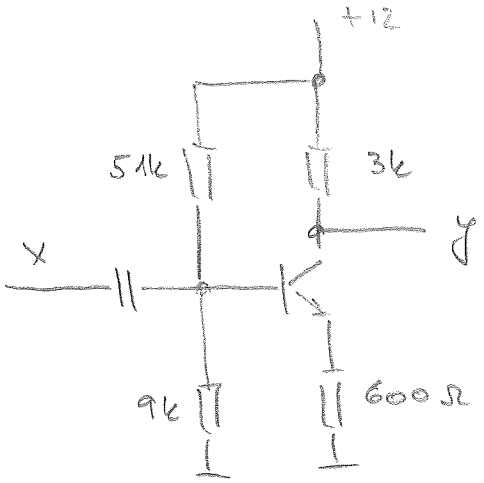
iz tega določimo R_2: na njem je 1.8V, skozenj teče 200µA, torej:

c)

$R_2 = \frac{1.8V}{200\mu A} = \underline{\underline{9k}}$

ma R_1 je napetost $U_{R1} = (12 - 1.8)V = 10.2V$, tok je $200\mu A$:

$R_1 = \frac{10.2V}{200\mu A} = \underline{\underline{51k}}$



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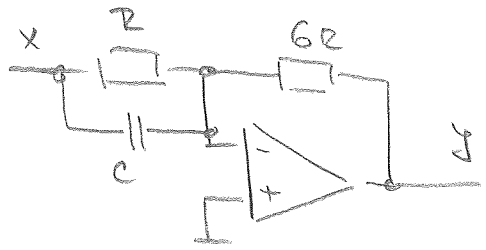
⑥



pišì vozliščno enačbo

$I_R + I_C + I_{6R} = 0$

$\frac{x}{R} + \frac{x}{\frac{1}{i\omega C}} + \frac{y}{6R} = 0$

torej: $y = -x\left[\frac{6R}{R} + i\omega 6RC\right]$; $\omega \ll \frac{1}{RC}$

tole lahko zanemarimo

$y = -6x \Rightarrow$ ojačenje je $\underline{\underline{-6}}$

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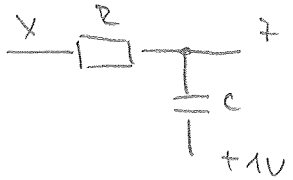
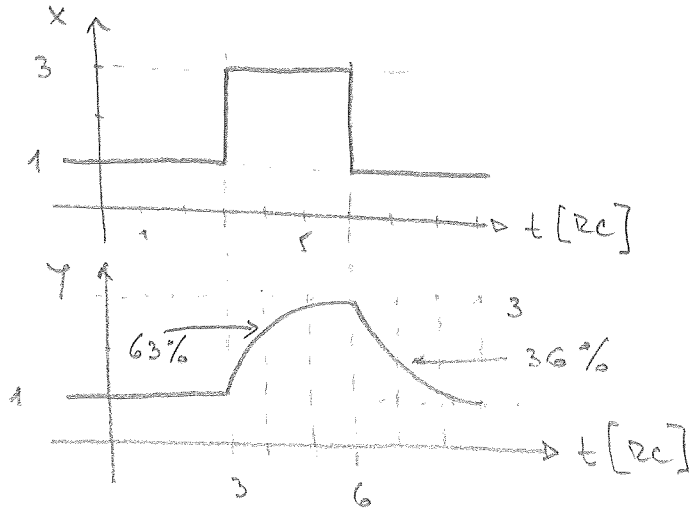
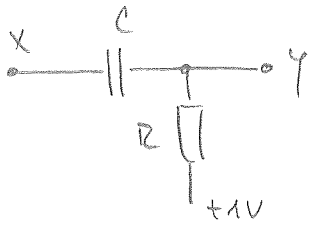
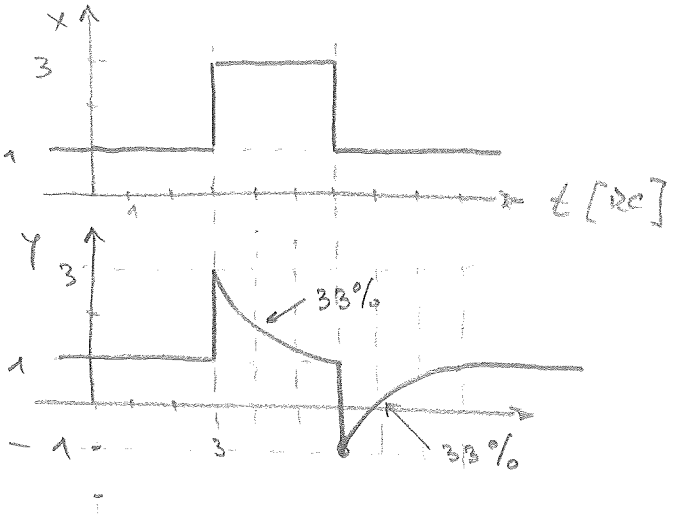
⑦





(8)





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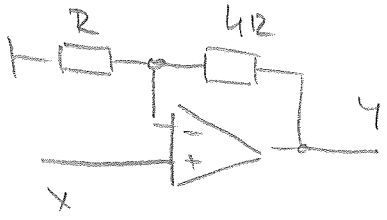
(9)



$x = 2 \sin \omega t \ [V]$

$SR = 100 V/\mu s$

$$y = x\left[1 + \frac{4R}{R}\right] = 5$$

$$= 2 \cdot \sin \omega t \cdot 5 = \underline{10 \sin \omega t}$$

max. zahtevana hitrost naraščanja $\leq$ SR omejevalnika

$$\max\left[\frac{dy}{dt}\right] = \max\left[10\omega \underbrace{\cos \omega t}_{\max = 1}\right] = 10\omega < SR$$

$$\omega < \frac{SR}{10} = \frac{10^8}{10^{-1} \cdot 10^{-6}} = \underline{10 MHz}$$

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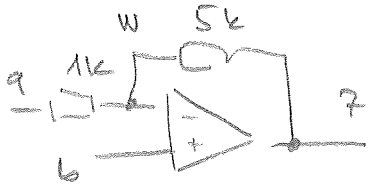
(10)



a) idealni OP $\Rightarrow$ razlika med vhodoma je enaka 0

b) zapišči vozliščno enačbo za $w = b$

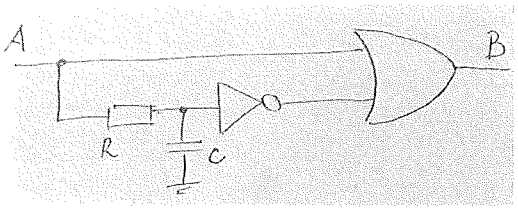
$$I_{1k} + I_{5k} = 0$$

$$\frac{w-a}{1k} + \frac{w-z}{5k} = 0 \Rightarrow 5b - 5a + b = z$$

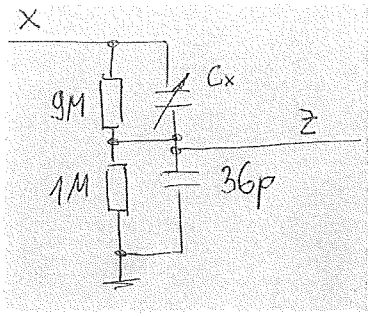
$$\underline{z = 6b - 5a}$$

2. kolokvij iz Elektronike (FMT)
5. junij 2018

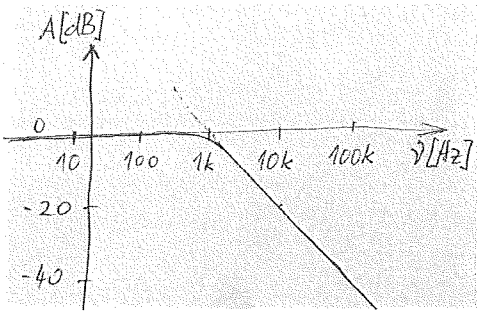
1. Vhod A alternira med logičnima 0 in 1 s periodo 100ms. Narišite grafa vsaj dveh period časovnega poteka vhodnega stanja A in izhodnega B. Produkt RC je 10ms.



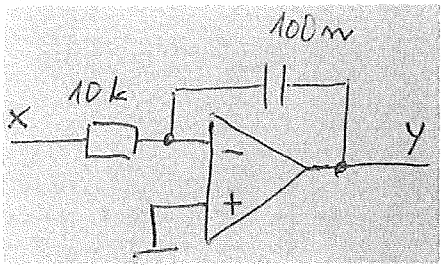
2. Narisan je električni model osciloskopske sonde in vhodnega dela osciloskopa. Nastavljivi kondenzator C_X nastavimo na 4pF. Na vhod x vodimo harmonske signale različnih frekvenc. Narišite Bodejev diagram za ojačenje in za fazni zamik za izhod z.



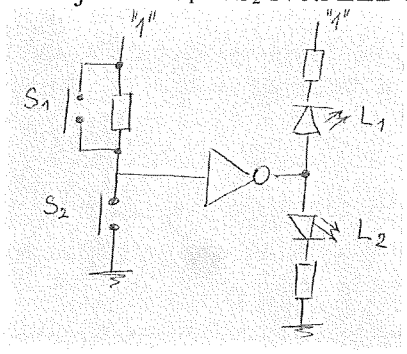
3. Na vhod vezja z narisano ojačevalno karakteristiko je priključen sinusni signal s frekvenco 100kHz in amplitudo 10V. Ocenite amplitudo izhodnega signala.



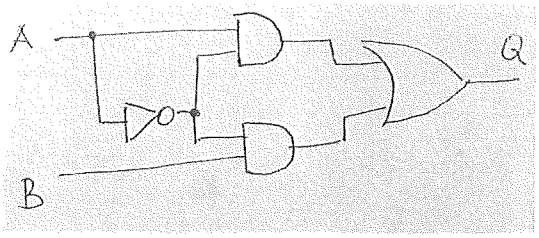
4. Ob času $t = 0$ je kondenzator prazen in vhodna napetost x je -2V. Ob času $t = 2$ms napetost x dvignemo na 2V, ob času $t = 3$ms pa jo spustimo na 0V. Narišite potek izhodne napetosti y za odbobje od $t = 0$ do $t = 5$ms.



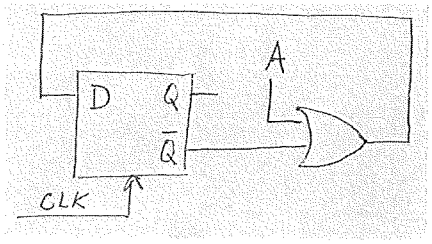
5. Pri katerih kombinacijah stanj stikal S_1 in S_2 sveti LED L_1 in kdaj L_2?



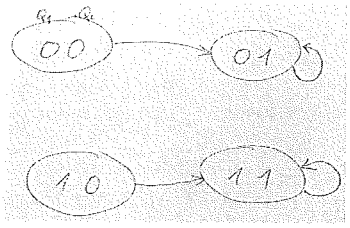
6. Zapiši tabelo izhodnih vrednosti Q za vse možne kombinacije A in B.



7. Narišite diagram stanj Q za narisani avtomat, z označenimi odvisnostmi prehodov od vrednosti vhoda A.



8. Narišite sinhroni avtomat, ki implementira narisani diagram stanj.

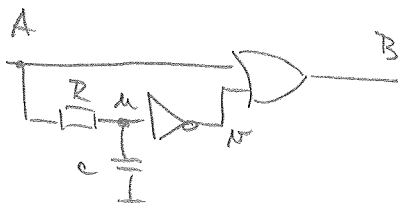


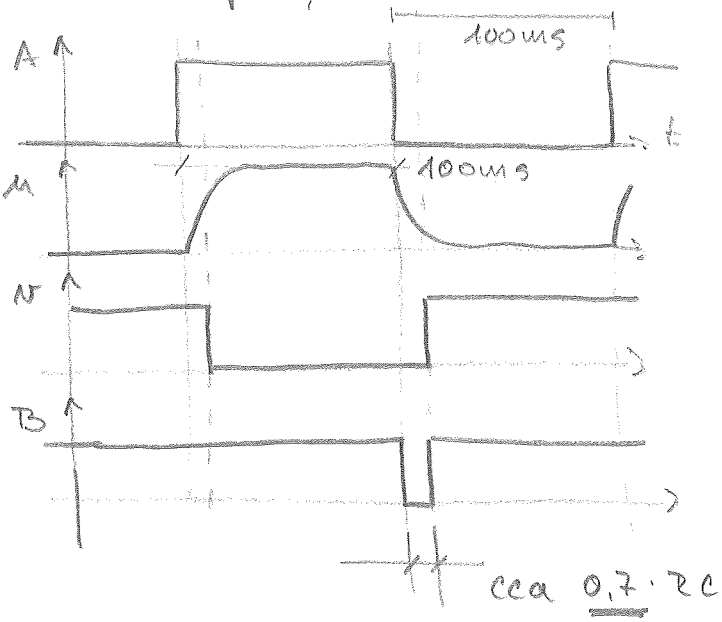
9. Z najmanjšim možnim multiplekserjem in negacijskimi vrati realizirajte vezje, ki med števili od $000_{(2)}$ do $111_{(2)}$ (torej od nič do sedem) z logično »1« označi praštevila.

10. Poenostavite Boolov izraz $Z = C\,B + C\,\overline{B} + B + A\,(B + \overline{B})$.

Časa za reševanje je 60 minut, zapiskov ne uporabljamo. Srečno! M.V.

2. kolokvij Elektronika v fiziki, 5. junij 2018 e)

① 



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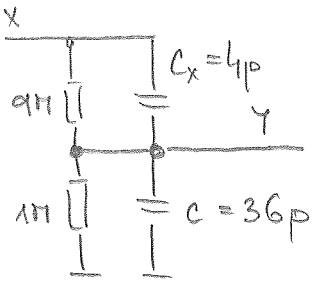
② 

vozliščna enačba:

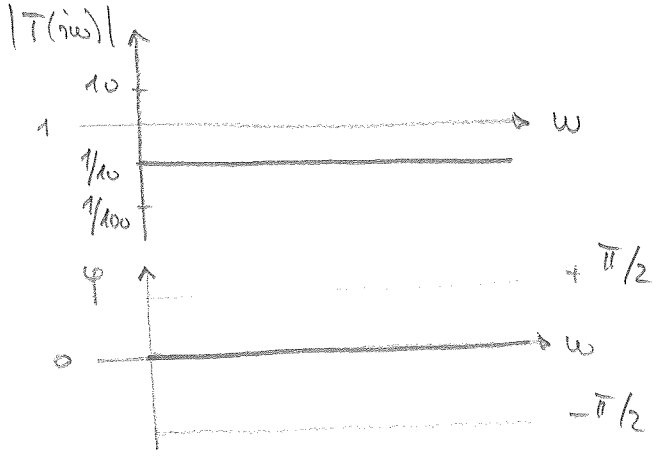
$$I_{9M} + I_{1M} + I_{Cx} + I_C = 0$$

$$\frac{y-x}{9M} + \frac{y}{1M} + \frac{y-x}{\frac{1}{i\omega \cdot 4p}} + \frac{y}{\frac{1}{i\omega 36p}} = 0$$

$$y - x + 9y + (y-x)\cdot i\omega \cdot 4\cdot 10^{-6}\cdot 9 + y\cdot i\omega \cdot 36\cdot 10^{-6}\cdot 9 = 0$$

$$10y + i\omega y \cdot 9\cdot 10^{-6}(4+36) = x\left(1 + 36\, i\omega \cdot 10^{-6}\right)$$

$$y = \frac{x}{10}\,\frac{1 + 36\cdot i\omega\cdot 10^{-6}}{1 + 36\cdot i\omega\cdot 10^{-6}} = \frac{x}{10}$$ ✓ pravilno kompenzirana sonda

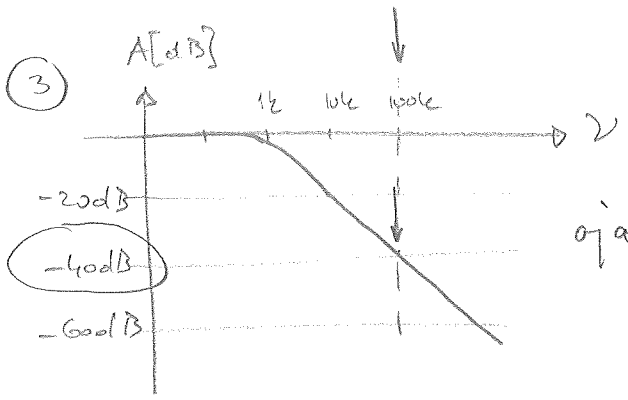


$$|T(i\omega)| = \frac{1}{10}$$

$$\varphi = 0°$$

f)

③



ojačenje pri $f = 100\,kHz$ je $1/100$

torej:

$10[V] \rightarrow \boxed{1/100} \rightarrow \underline{1/10\,[V]}$

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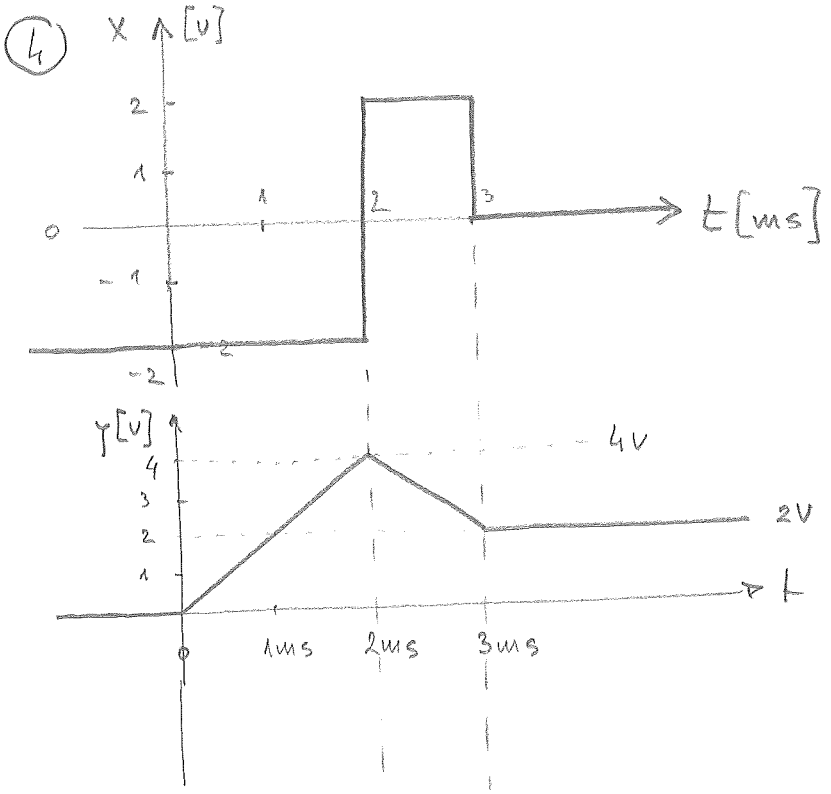
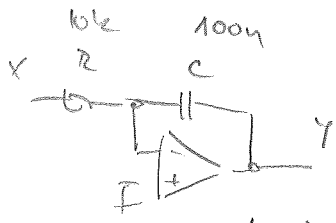
④





$$y = -\frac{1}{RC}\int x\,dt$$

$$= -\frac{1}{10^4 \cdot 10^{-7}}\int x\,dt$$

$$= -10^3 \int x\,dt$$

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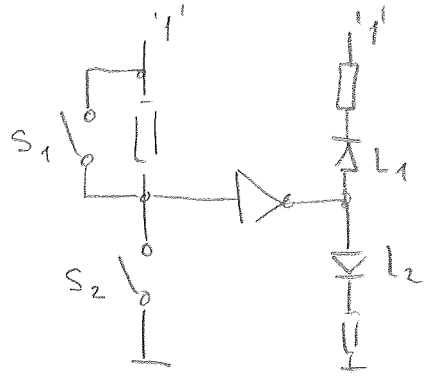
⑤



L_1 ne sveti, ker na njej ne more biti napetosti, ki bi povzela tok

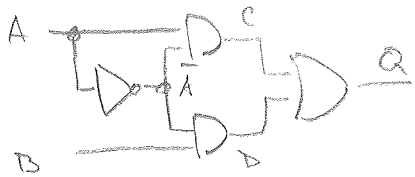
L_2:

S_1	S_2	L_2
0	0	ne sveti
0	1	sveti
1	0	ne sveti
1	1	ne sveti

možnosti kratkega stika: S_1/S_2

g)

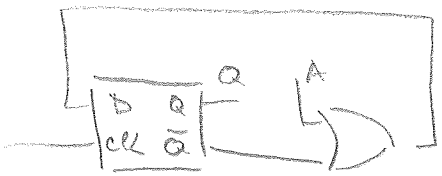
(6)



A	B	$\bar{A}$	C	D	Q
0	0	1	0	0	0
0	1	1	0	1	1
1	0	0	0	0	0
1	1	0	0	0	0

---

(7)



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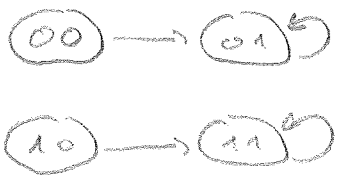
(8)

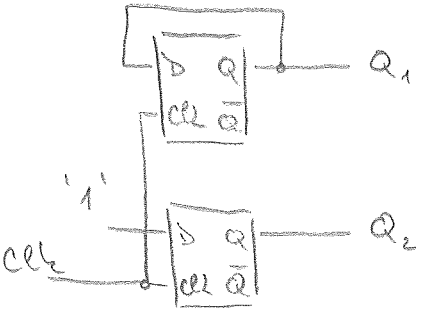


⇒

$Q_1 Q_2$	$Q_1^+ Q_2^+$	D_1	D_2
0 0	0 1	0	1
0 1	0 1	0	1
1 0	1 1	1	1
1 1	1 1	1	1

$D_1 = Q_1$

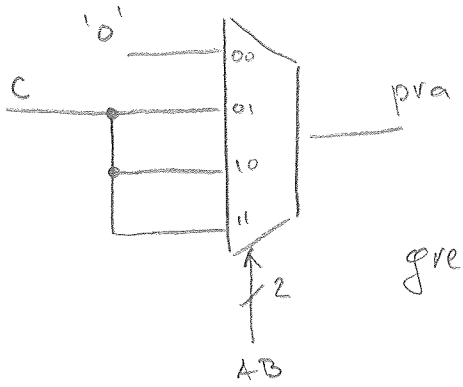
$D_2 = '1'$



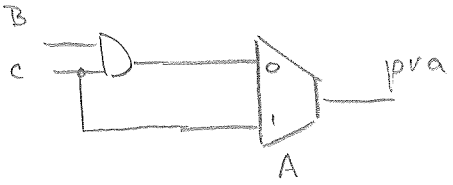
h)

(9)

A	B	C	prva
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1



gre še manj!



ampak zahteva AND!

---

(10) $z = CB + C\overline{B} + B + A(B + \overline{B})$

$= C(B + \overline{B}) + B + A(B + \overline{B})$

$= C + B + A$

ali pa

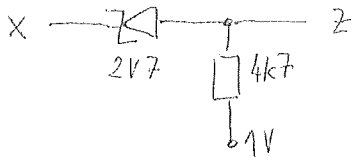
C \ AB	00	01	11	10
0	0	1	1	1
1	1	1	1	1

$z = \overline{A} \cdot \overline{B} \cdot \overline{C}$

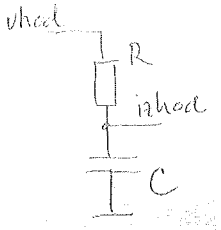
1. pismeni izpit iz Elektronike v fiziki (FMT)
2. julij 2018

V vseh nalogah napajamo operacijske ojačevalnike s +5V in -5V.

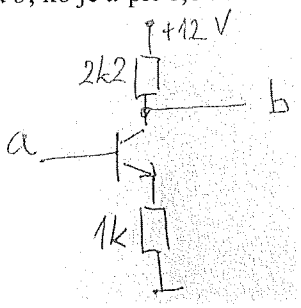
1. Narišite graf odvisnosti potenciala z od potenciala x.



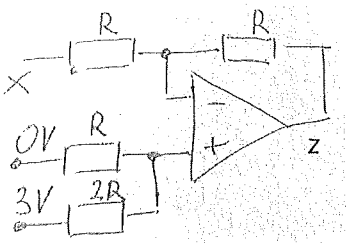
2. Narišite Bodejev diagram za fazni zamik spodnjega frekvenčnega filtra z $RC = 10\text{ms}$.



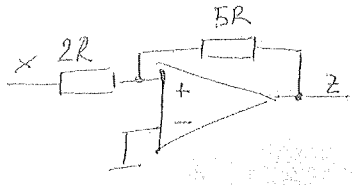
3. Kolikšno je ojačenje vezja za majhne signale ob optimalni delovni točki ojačevalnika? Kakšen je potencial v vozlišču b, ko je a pri 1,6V?



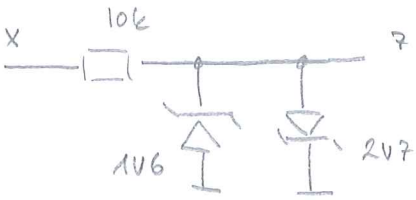
4. Za katere vrednosti napetosti x je napetost z negativna?



5. Narišite histerezno karakteristiko $z(x)$ za naslednji komparator.



2. pisni izpit Elektronika v fiziki 23.8.2018 MM)

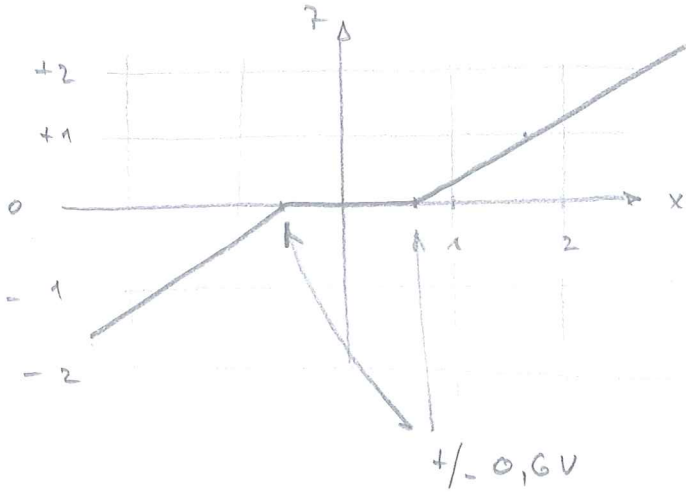
① 

Z ▷ 1V6 prevaja za: $-0{,}6V > Z > 1{,}6V$

Z ▷ 2V7 prevaja za: $-2{,}7V > Z > 0.6V$

ena od diod prevaja za

$-0.6 > Z > +0.6$



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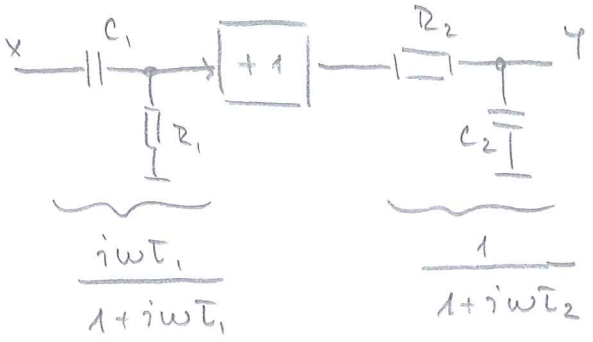
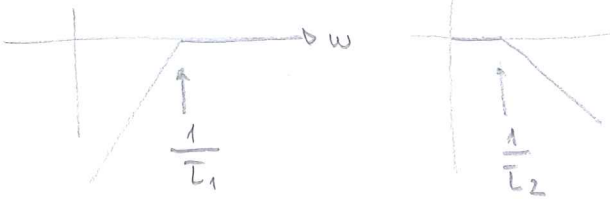
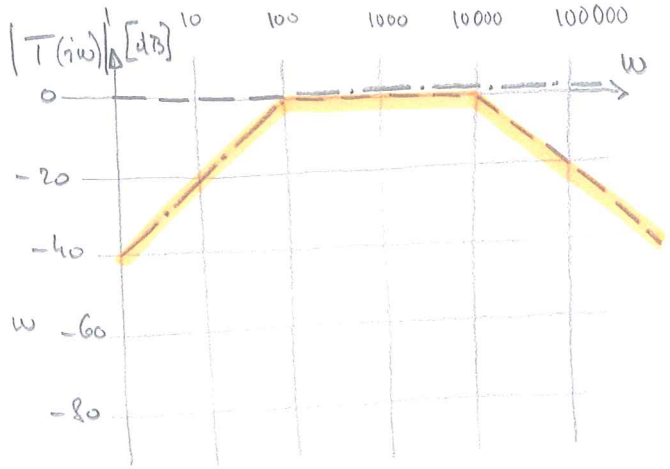
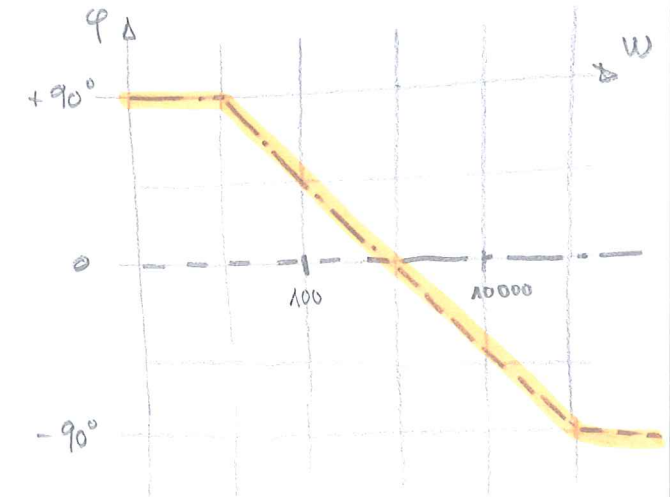
② 

$\frac{i\omega\tau_1}{1+i\omega\tau_1}$ $\frac{1}{1+i\omega\tau_2}$

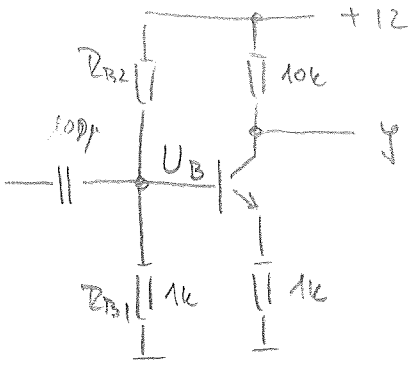






skupaj za dva RC člena

(3)



ojačenje: $-\frac{R_C}{R_E} = -\frac{10k}{1k} = \underline{-10}$

delovna točka: $\langle y \rangle = 6V$

zato: $U_{RC} = 12V - 6V = 6V$

in $I_{RC} = U_{RC}/R_C = 6V/10k = \underline{0.6mA}$

isti tok (~) teče skozi R_E, zato: $U_{RE} = I_{RC} \cdot R_E = 0.6mA \cdot 1k = \underline{0.6V}$

napetost na B je za 0.6V večja od U_{RE}, zato $U_B = \underline{1.2V}$

pri tem teče skozi R_{B1} tok: $I_{RB1} = U_B/R_{B1} = 1.2/1k = \underline{1.2mA}$

ta tok priteka skozi R_{B2} (tok v bazo je zanemarljiv proti toku skozi R_{B1}), na njem je padec napetosti

$+12 - U_B = U_{RB2} = +12 - 1.2 = \underline{10.8V}$

njegova vrednost pa mora zato biti $R_{B2} = U_{RB2}/I_{RB1}$

$R_{B2} = 10.8V/1.2mA = \underline{9k}$

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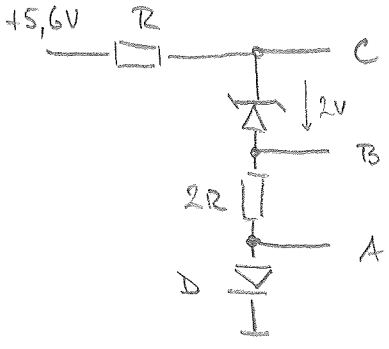
(4)

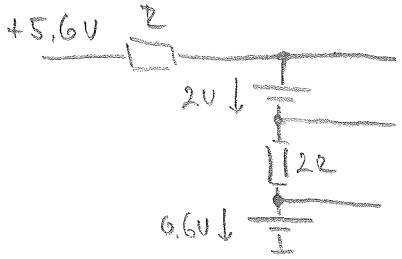


A: skozi vezje teče tok, diodaD prevaja, zato je na njej padec napetosti 0.6V

$\Downarrow$

$A = \underline{0.6V}$

ZD: prevaja v zaporni smeri, zato je na njej padec napetosti 2V $\Rightarrow$ B in C sta razmaknjena za $\underline{2V}$

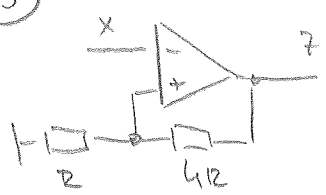


$+5.6V = U_R + 2V + U_{2R} + 0.6V$; $U_{2R} = 2U_R$

$3U_R = (5.6 - 2 - 0.6)V = 3V$

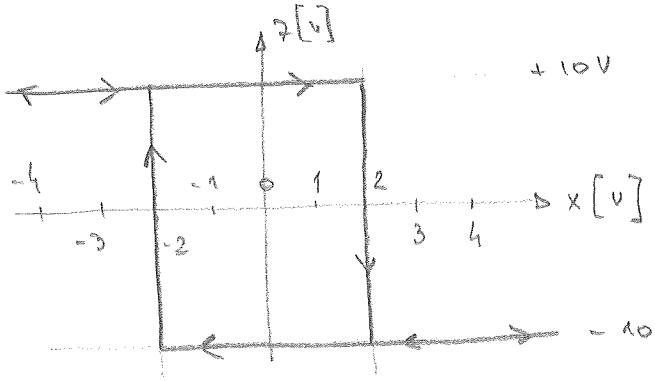
$U_R = \underline{1V}$

(5)



napajanje: +/- 10 V

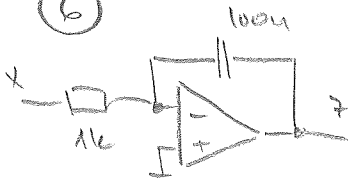
preklopni bločki: $x = \pm z \frac{R}{R+4R} = \pm \frac{z}{5} = \pm 2V$



⇐ pozor: vhodni signal je vezan na inv. vhod, kjer se predznaki obrnejo!

---

(6)



$$z = -\frac{1}{RC}\int x\,dt$$

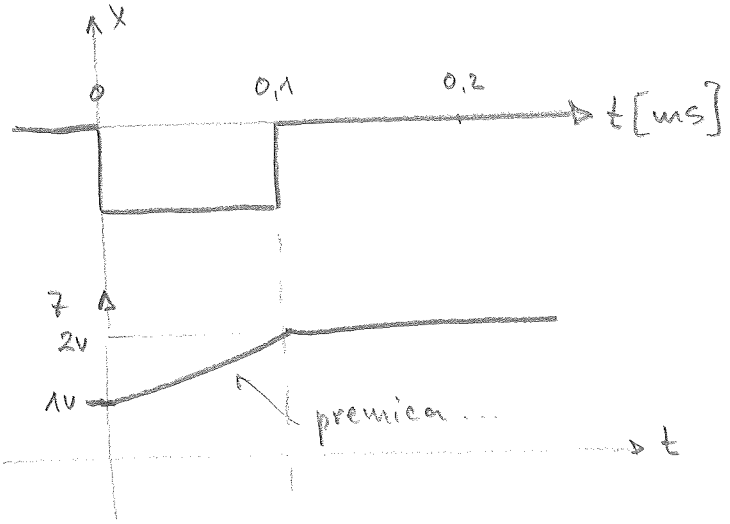
$$= -10^4 \int x\,dt$$

$$\Downarrow$$

$$z = 1V - 10^4 \cdot x \cdot t$$

$$= 1V + 10^4 \cdot 10^{-4} V = \underline{\underline{2V}}$$

} pri $t = 0.1ms$



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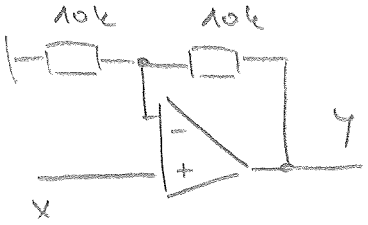
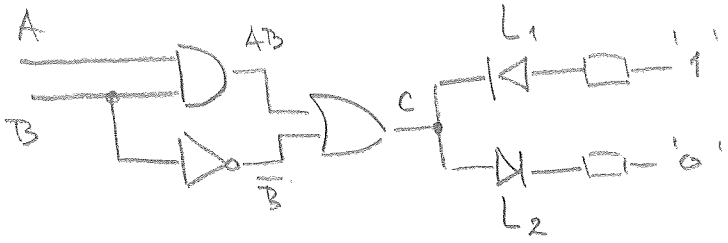
(7) ojačenje $6dB = G = 20 \cdot \log \frac{y}{x} \Rightarrow \frac{y}{x} = 10^{6/20} \doteq \underline{\underline{2}}$ (1.999)

$\frac{y}{x} = +2 \Rightarrow$



$$y = x\left(1 + \frac{R_F}{R_1}\right) = \underline{\underline{2x}}$$

(8)



A	B	$\bar{B}$	AB	C	L_1	L_2
0	0	1	0	1	x	✓
0	1	0	0	0	✓	x
1	0	1	0	1	x	✓
1	1	0	1	1	x	✓

L_1 sveti za $\bar{A}B$

L_2 sveti za sve ostale kombinacije ulaznih A, B

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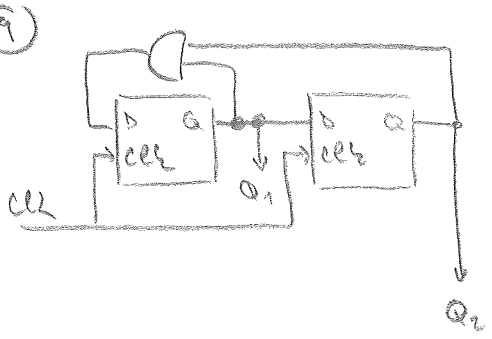
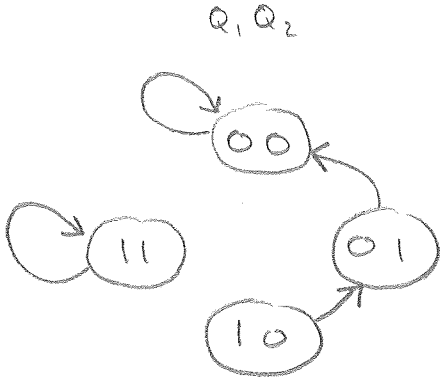
(9)



Q_1	Q_2	Q_1^+	Q_2^+
0	0	0	0
0	1	0	0
1	0	0	1
1	1	1	1



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(10)

$$\left(P\bar{Q} + \left(Q + Q\bar{Q}\right)P\right) + \left(P\left(\bar{Q}\bar{P}\right) + Q\cdot\left(\bar{P} + P\right)\right) =$$

$$= \left(P\bar{Q} + QP\right) + \left(P\bar{Q}\bar{P} + Q\right) =$$

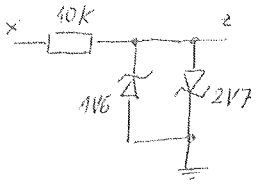
$$= P\left(\bar{Q} + Q\right) + Q =$$

$$= P + Q = R$$

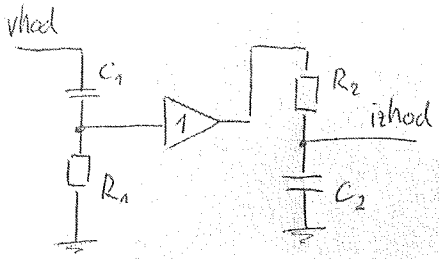
2. pismeni izpit iz Elektronike v fiziki (FMT)
23. avgust 2018

V vseh nalogah napajamo operacijske ojačevalnike s +5V in -5V.

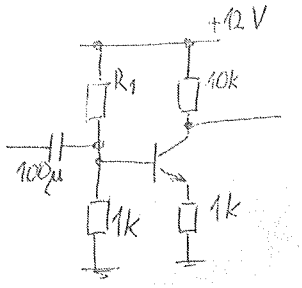
1. Narišite graf odvisnosti potenciala z od potenciala x, za x med -3V in 3V.



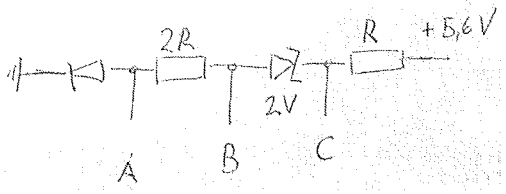
2. Narišite Bodejev diagram za ojačenje spodnjega frekvenčnega filtra z $1/R_1C_1 = 100/s$ in $1/R_2C_2 = 10000/s$.



3. Izberite vrednost R_1 tako, da bo delovna točka ojačevalnika optimalno nastavljena. Kolikšno je ojačenje vezja?

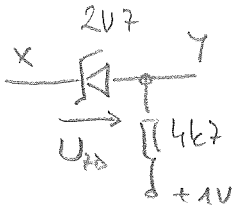


4. Izračunajte potenciale v točkah A, B in C.

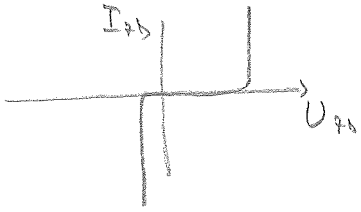


1. pisni izpit Elektronika v fiziki 2.7.2018

①



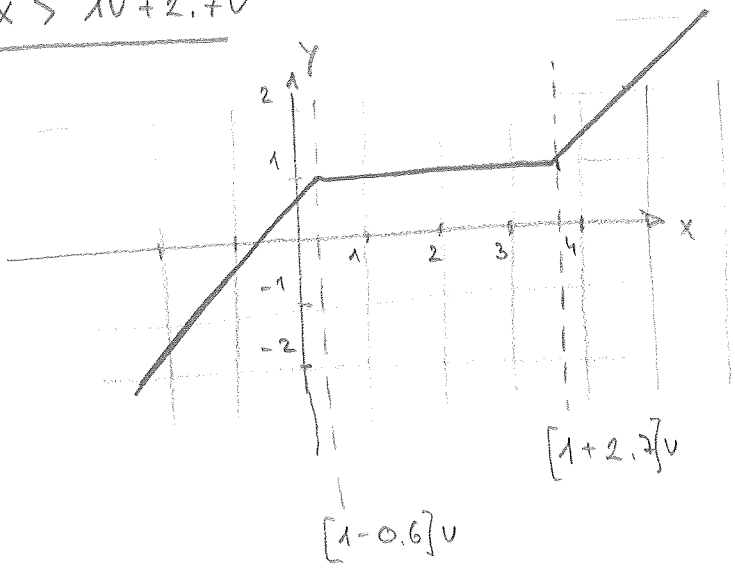
7D: prevaja, ko je na njej več kot 2,7 V ali manj kot −0.6 V



pazi: predznak!

torej: 7D prevaja za

$$1V - 0{,}6V > X > 1V + 2{,}7V$$



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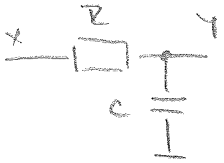
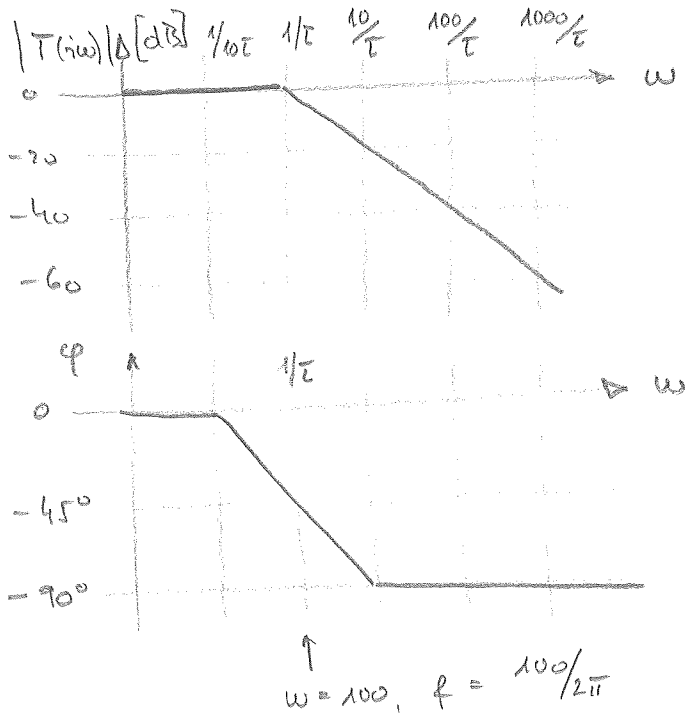
②

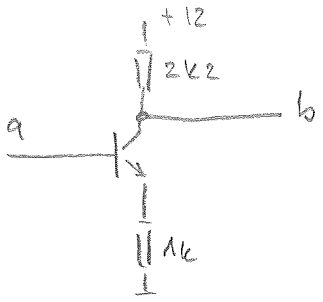


$RC = 10\,ms$

$$T(p) = \frac{1}{1+\tau p} \Rightarrow T(i\omega) = \frac{1}{1+i\omega RC}$$



③



ojačanje : $-\frac{R_c}{R_e} = -\frac{2k2}{1k} = \underline{\underline{-2.2}}$

$a = 1,6V \Rightarrow U_{RE} = 1,6V - U_{BE}$

$= 1,6V - 0,6V = \underline{\underline{1V}}$

$I_{RE} = U_{RE}/1k = \underline{\underline{1mA}} \doteq I_c$

$U_{Rc} = I_c \cdot 2k2 = 2,2V$

$b = +12V - 2,2V = +12V - U_{Rc} = \underline{\underline{9,8V}}$

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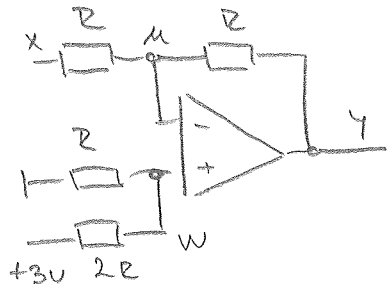
④



a) w : $w = +3\,\frac{R}{R+2R} = \underline{\underline{+1V}}$

b) idealni OP : $u = w = \underline{\underline{+1V}}$

c) vozliščna enačba za u

$$\frac{u-x}{R} + \frac{u-y}{R} = 0 \Rightarrow y = -x + 2u$$

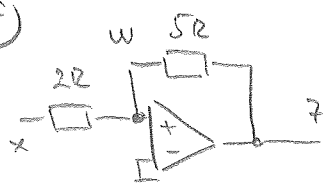
d) iščemo x za $y < 0 \Rightarrow \quad -x + 2u < 0$

$x > 2u = 2V$

$\underline{\underline{x > 2V \Rightarrow y < 0}}$

---

⑤



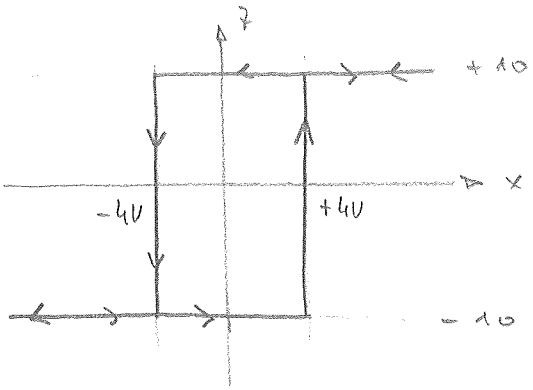
napajanje : $\pm 10V$

meje zanke: vozliščna enačba za $w = 0$

$\frac{x}{2R} + \frac{z}{5R} = 0 \; ; \; z = \pm 10V$

$\boxed{x = -\frac{2}{5}z = \mp 4V}$ tole sta meji zanke

k)



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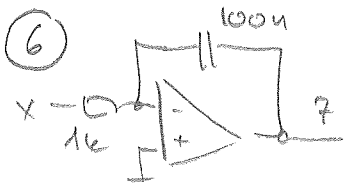
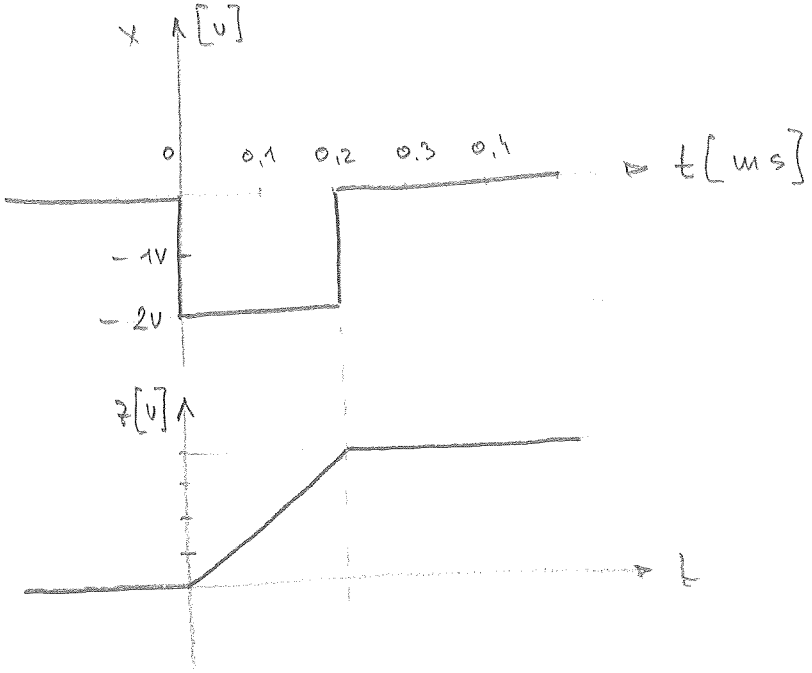
(6)





$$z = -\frac{1}{RC}\int x\,dt$$

$$RC = 1k \cdot 100 \cdot 10^{-9}\,s = 10^{-4}\,s$$

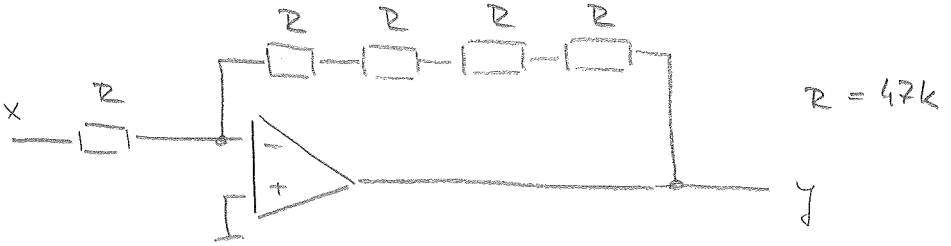
$$z = -10^4 \cdot x \cdot t \quad za \quad 0 < t < 0.2\,ms$$

$$z\Big|_{t=0.2\,ms} = -10^4 \cdot (-2) \cdot 2 \cdot 10^{-4} = 4V$$

---

(7) pojačanje $= +12\,dB = G = 20 \cdot \log \frac{y}{x}$

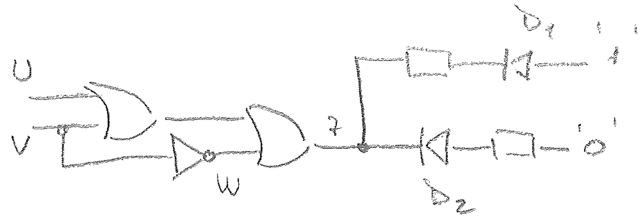
$$\frac{y}{x} = 10^{12/20} \doteq 4 \qquad (3,981)\ ;\ \text{negativno}$$



$R = 47k$

e)

(8)



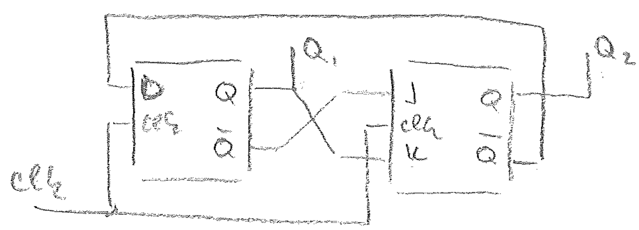
U	V	W	Z	D_1
0	0	1	1	X
0	1	0	1	X
1	0	1	1	X
1	1	0	1	X

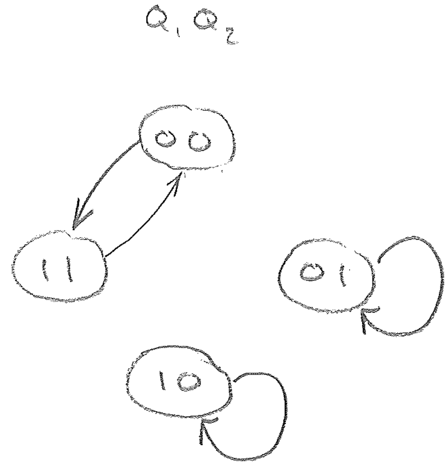
D_2 : ne sveti, je narobe obrnjena

D_1 : ne sveti, Z ni nikoli '0'

---

(9)





J	K	Q^+
0	0	Q
0	1	0
1	0	1
1	1	$\bar{Q}$

(rows 0 1 and 1 0: } samo tole)

Q_1	Q_2	Q_1^+	Q_2^+
0	0	1	1
0	1	0	1
1	0	1	0
1	1	0	0

---

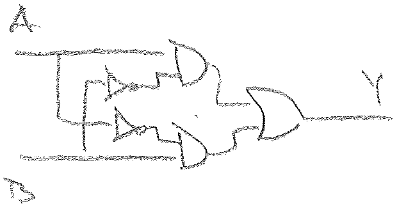
(10)

$$\left((A\cdot\bar{A}) + (B + A\bar{B})\cdot(\bar{B}+B)\right)\cdot(A\bar{B} + B\bar{A}) =$$

$$= (B + A\bar{B})\cdot(A\bar{B}+B\bar{A}) =$$

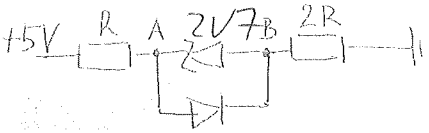
$$= \underbrace{B\cdot A\cdot\bar{B}}_{0} + B\cdot\bar{A} + \underbrace{A\bar{B}\cdot A\bar{B}}_{A\bar{B}} + \underbrace{A\bar{B}B\bar{A}}_{0}$$

$$= A\bar{B} + B\bar{A} = A\oplus B$$

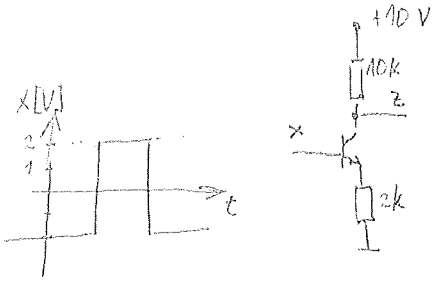


3. pismeni izpit iz Elektronike v fiziki (FMT)
12. september 2018

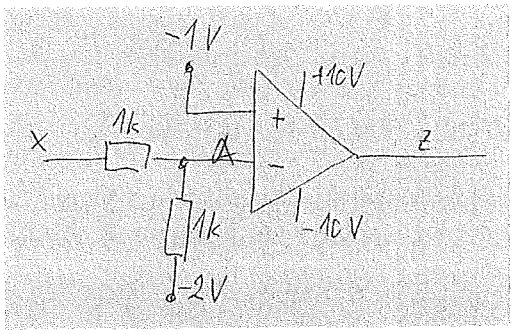
1. Izračunajte napetosti v točkah *A* in *B*.



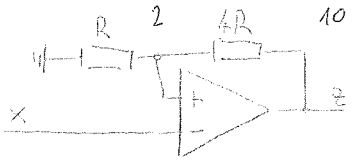
2. Narišite graf poteka izhodne napetosti *z*.



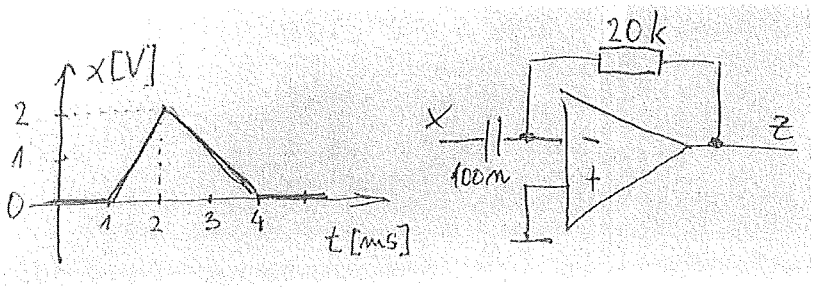
3. Za katere vrednosti napetosti *x* je napetost *z* negativna?

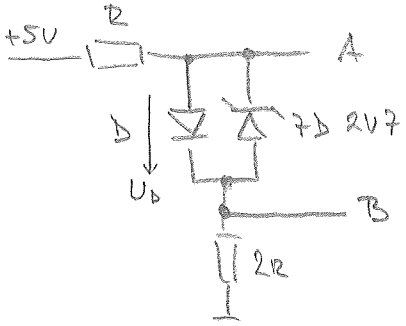


4. Narišite histerezno karakteristiko $z(x)$ za naslednji komparator. ±10 V



5. Narišite potek izhodnega signala *z*.

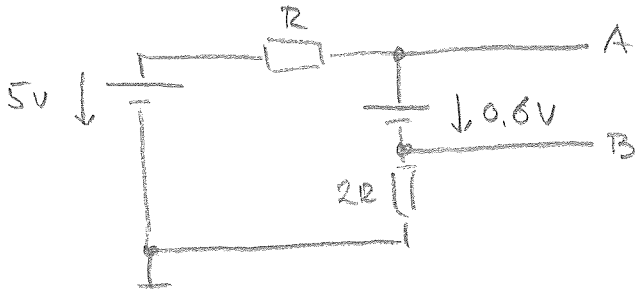


① 

D prevaja, zato je na njej padec napetosti 0,6V = U_D

ZD ne prevaja, saj je na njej le 0,6V; prevajala bi šele pri $U_D > 2,7V$ ali za $U_D < -0,6V$

⇓ zato



mešja: $5V = U_R + 0,6V + U_{2R}$

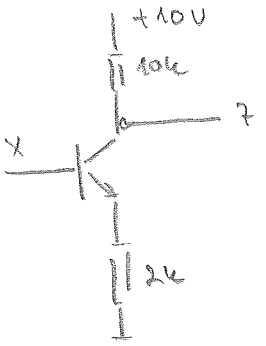
$5V = 0,6V + 3U_R$

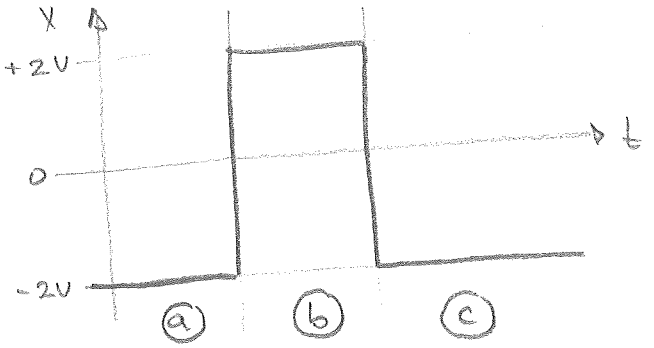
$$\begin{cases} U_R = \frac{4,4V}{3} = 1,46V \\ U_{2R} = 2U_R = 2,93V \end{cases}$$

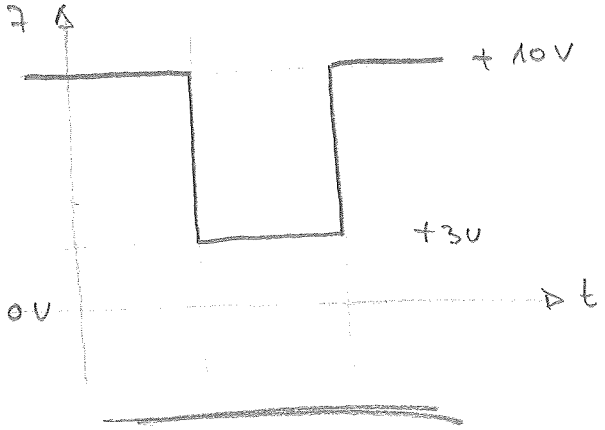
$B = 2,93V$

$A = 3,53V$

---

② 





ⓐ & ⓒ: meg. X ⇒ TR ne prevaja ⇓ $Z = +10$

ⓑ $X = +2V \Rightarrow U_{BE} = +2V - 0,6V = 1,4V$

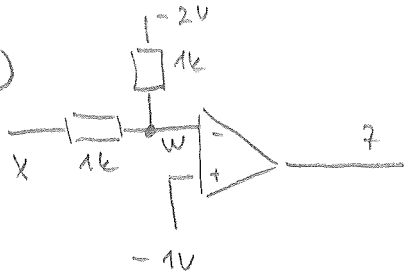
$I_E = I_C = 1,4V / 2k = 0,7mA$

$U_{RC} = I_C \cdot R_C = 0,7mA \cdot 10k = 7V$

$Z = +10 - U_{RC} = 3V$

r)

③



vezje je komparator

$\Downarrow$

$z = -10V$ za $\underline{W > -1V}$

vozliščna enačba za W:

$$\frac{W - x}{1k} + \frac{W - (-2V)}{1k} = 0$$

$$2W = x - 2V \Rightarrow \underline{W = \frac{x - 2V}{2} > -1V}$$

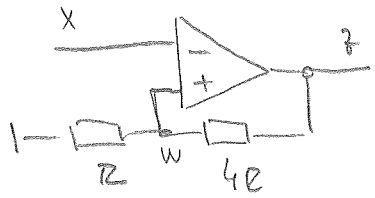
$$x - 2V > -2V$$

$$\underline{x > 0V} \Rightarrow z < 0$$

---

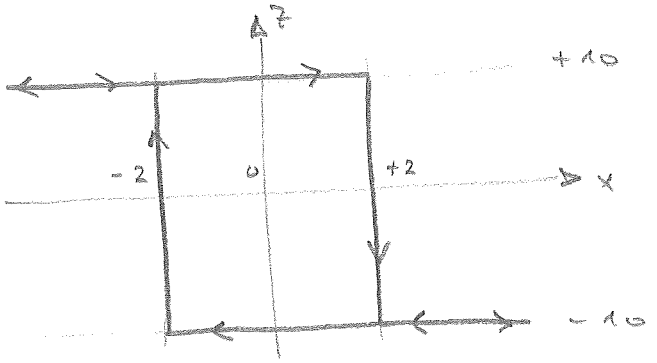
④

napajanje $\pm 10V$



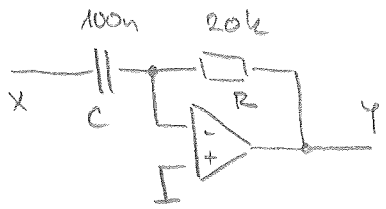
prelom pri: $x = z \frac{R}{R+4R} = \pm 10 \frac{1}{5} V$

$= \pm 2V$



<u>pozor</u>: vhodni signal je vezan na inv. vhod, zato so predznaki drugačni

(5)

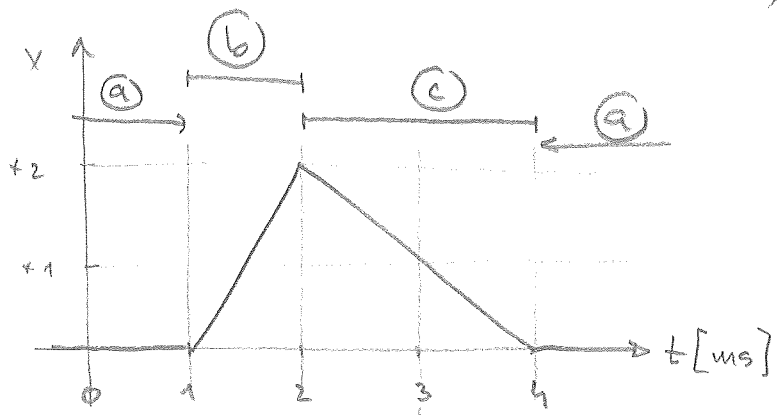


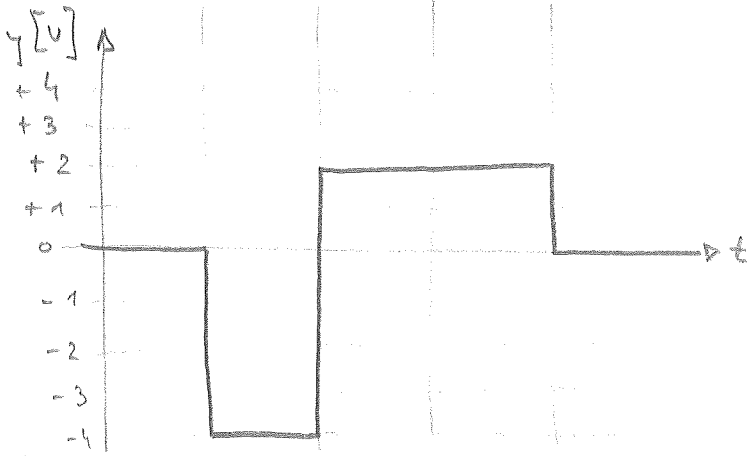
diferenciator

$$y = -RC\frac{dx}{dt}$$

$$= -10^{-7}\cdot 20\cdot 10^{3}\frac{dx}{dt}$$

$$= -2\cdot 10^{-3}\frac{dx}{dt}$$





a) odvod $x = 0 \Rightarrow y = 0$

b) odvod je konstanten in znaša: $\frac{dx}{dt} = \frac{2V}{10^{-3}s} = 2\cdot 10^{3} V/s$

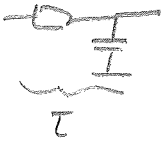
zato: $y = -2\cdot 10^{-3}\cdot 2\cdot 10^{3} = \underline{\underline{-4V}}$

c) odvod je konstanten in znaša $\frac{dx}{dt} = \frac{-2V}{2\cdot 10^{-3}s} = -10^{3} V/s$

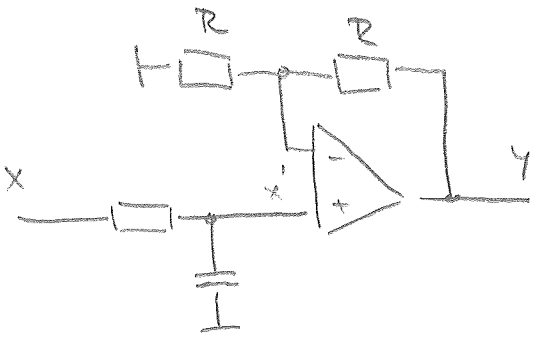
zato: $y = -2\cdot 10^{-3}\cdot(-10^{3}) = \underline{\underline{+2V}}$

---

(6) ojačanje $6dB = 20\log\frac{y}{x} \Rightarrow \underline{y = 2x}$ do $f = 10^{3}Hz$

ojačanje med 1kHz pade z 20dB/dekado $\Rightarrow$ 

torej:



: ojačevalnik : $\underline{y = x'\cdot 2}$

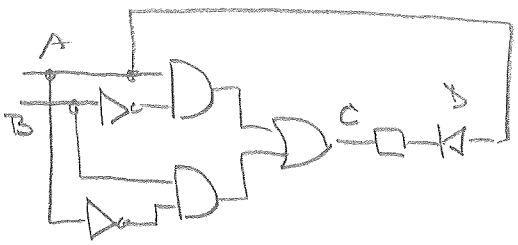
RC: prelomna frekvenca pri 1000Hz $\Rightarrow$ $\omega_p = 2\pi\cdot 1000Hz = \frac{1}{RC}$

na primer: izberi $\underline{C = 10nF}$

izračunaj $R = \frac{1}{2\pi\cdot 10^{3}\cdot 10^{-8}}$

$\underline{\underline{R = 15.9k}}$

(7) t)



vzpostavitev 1 : D lahko sveti le, če je A = '1' in C = '0'

vezavanje se povezuje v izhodje levega B, za katerega je C = '0' pri A = '1', torej D sveti za B = '1' in A = '1'

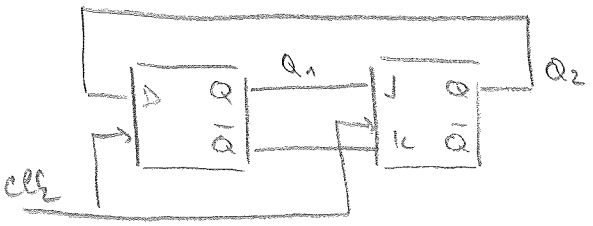
daljša pot:

A	B	$\bar{A}$	$\bar{B}$	$A\bar{B} + \bar{A}B$	D : sveti za A=1 in A⊕B=0
0	0	1	1	0	x
0	1	1	0	1	x
1	0	0	1	1	x
1	1	0	0	0	sveti

X⊙Z

---

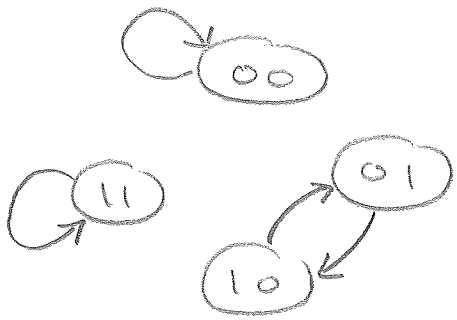
(8)



J	K	Q^+	
0	0	Q	} tle pride v poštev
0	1	0	
1	0	1	
1	1	$\bar{Q}$	

Q_1	Q_2	Q_1^+	Q_2^+
0	0	0	0
0	1	1	0
1	0	0	1
1	1	1	1

⇒



(9)

$$F = \Big(P\,(\bar{Q}\cdot\bar{P}) + Q\cdot(\bar{P}+P)\Big) + \Big((Q + Q\cdot\bar{Q})P + (P\cdot\bar{Q})\Big) =$$

$$F = P\bar{Q}\bar{P} + Q + QP + P\bar{Q} =$$

$$F = Q + P\bar{Q}$$

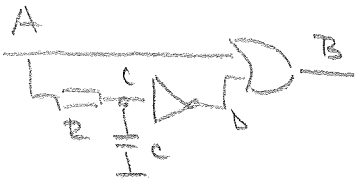
P	Q	$Q + P\bar{Q}$
0	0	0
0	1	1
1	0	1
1	1	1

tonej

$\underline{F = P + Q}$

---

(10)



RC = 10 ms