→ nalaz poglavlja 52

◆ **Tr - 1**

Odredite gornju i donju graničnu frekvenciju mrežnog transformatora omjera transformacije 1, zaključenog na sekundarnoj strani trošilom 600Ω, ako je na primar priključen izvor izlaznog (unutarnjeg) otpora 50Ω. Induktivitet primara je 1H, a koeficijent magnetskog vezanja namota 0.95. Serijski radni otpori namota su zanemarivo mali u odnosu na otpore trošila i izvora.

[Rj: $f_d = 7.35\text{Hz}, f_g = 1035\text{Hz}$]

◆ **Tr - 2**

Sekundar mrežnog transformatora zaključen je punovalnim ispravljačem i C filtrom. Srednja vrijednost napona na kondenzatoru je 20V, uz faktor valovitosti 10%. Projektirajte RC filtar između kondenzatora u C filtru i trošila, tako da napon na trošilu bude 12V, faktora valovitosti 0.1%, pri struji trošila 10mA. Odredite stupanj korisnog djelovanja filtra.

[Rj: $R = 800\Omega$, $C = 331.6\mu\text{F}$, $\eta = 0.6$]

◆ **Stb - 1**

Punovalni kapacitivno opterećeni ispravljač zaključen je trošilom otpora 20Ω. Srednja vrijednost napona na trošilu je 20V, uz efektivnu vrijednost napona valovitosti 4V. Koliko puta se smanji napon valovitosti na trošilu ako se između kapacitivno opterećenog punovalog ispravljača i trošila spoji LC filtar (L= 100mH, C= 1000μF)? Radni otpor zavojnice je zanemarivo malen.

[Rj: $\dfrac{U_{C1,V,ef}}{U_{T,V,ef}} = 39.5$]

◆ **Stb - 2**

Punovalni ispravljač zaključen je LC filtrom. Izlaznom naponu filtra srednja vrijednost mora biti 350V, a efektivna vrijednost napona valovitosti manja od 10V pri opteretnoj struji 100mA. Odredite induktivitet zavojnice i kapacitet kondenzatora u filtru. Radni otpor zavojnice je zanemarivo malen.

[Rj: $L_{min} = 3.714\text{H}$ $C_{min} = 11.3\mu\text{F}$]

◆ **Stb - 3**

U stabilizatoru napona koristi se Zener dioda slijedećih značajki: $U_{Z0} = 15\text{V}$, $\Delta U_{Z0} = \pm 0.1 \cdot U_{Z0}$, $I_{Zmin} = 5\text{mA}$, $r_d = 10\Omega$, $P_{max} = 0.5\text{W}$.

a) Odredite najveću vrijednost otpora serijskog otpornika u stabilizatoru tako da stabilizator ispravno radi uz ulazni napon 20V i priključeno trošilo 3kΩ.

b) Uz tako određen serijski otpor, koliki se najveći istosmjerni napon smije priključiti na ulaz stabilizatora a da ne dođe do preopterećenja diode?

c) Odredite faktor naponske i strujne stabilizacije uz uvjete iz **a)** dijela zadatka.

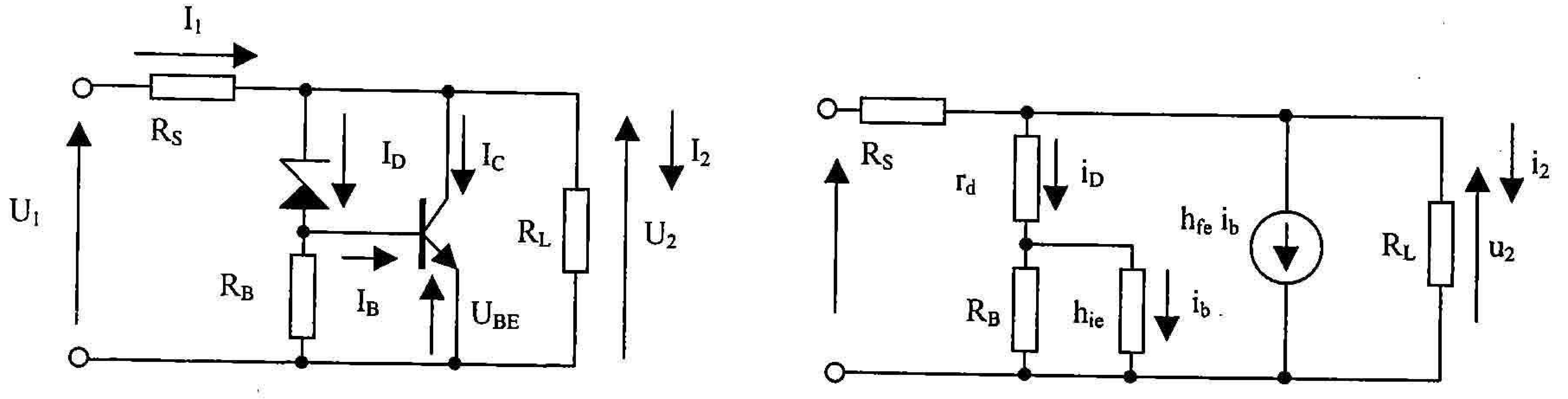
[Rj: a) $R_{S,MAX} = 333\Omega$]
[Rj: b) $U_{I,MAX} = 26.5\text{V}$]
[Rj: c) $K_U = 25.81$, $K_i = 310$]]

◆ **Stb - 4**

Izvedite jednadžbu potiskivanja ulaznog napona valovitosti (faktor naponske stabilizacije) za paralelni i serijski tranzistorski stabilizator. Navedite temeljne prednosti serijske izvedbe.

a) PARALELNI STABILIZATOR

Električka shema paralelnog stabilizatora prikazana je slikom 1:



Slika 1: Električka shema paralelnog tranzistorskog stabilizatora

$\boxed{\text{AUD - Tr}}$

Tr-1

$f_g, f_d = ?$

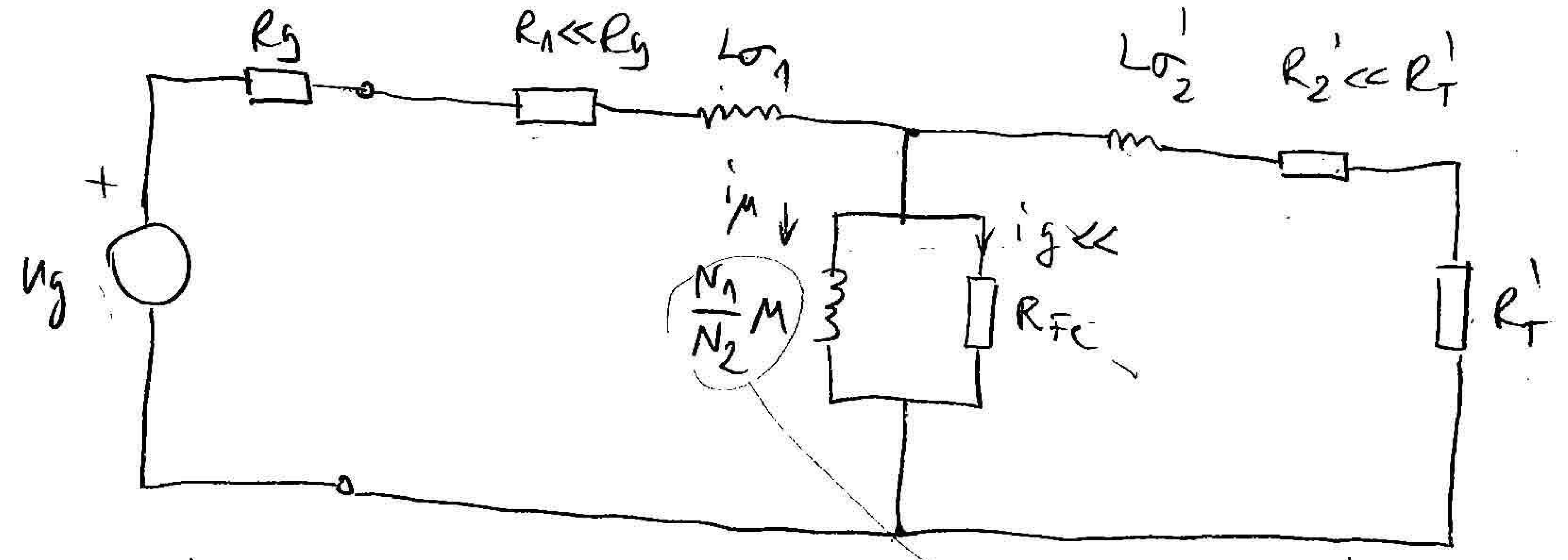
$n = 1 \qquad n = \frac{N_1}{N_2}$

$R_T = 600\ \Omega$

$R_g = 50\ \Omega$

$L_p = 1H \qquad R_S <<$

$k = 0{,}95$



$R_T' = n^2 R_T = R_T$

$L_{\sigma_2}' = n^2 L_{\sigma_2} = L_{\sigma_2}$

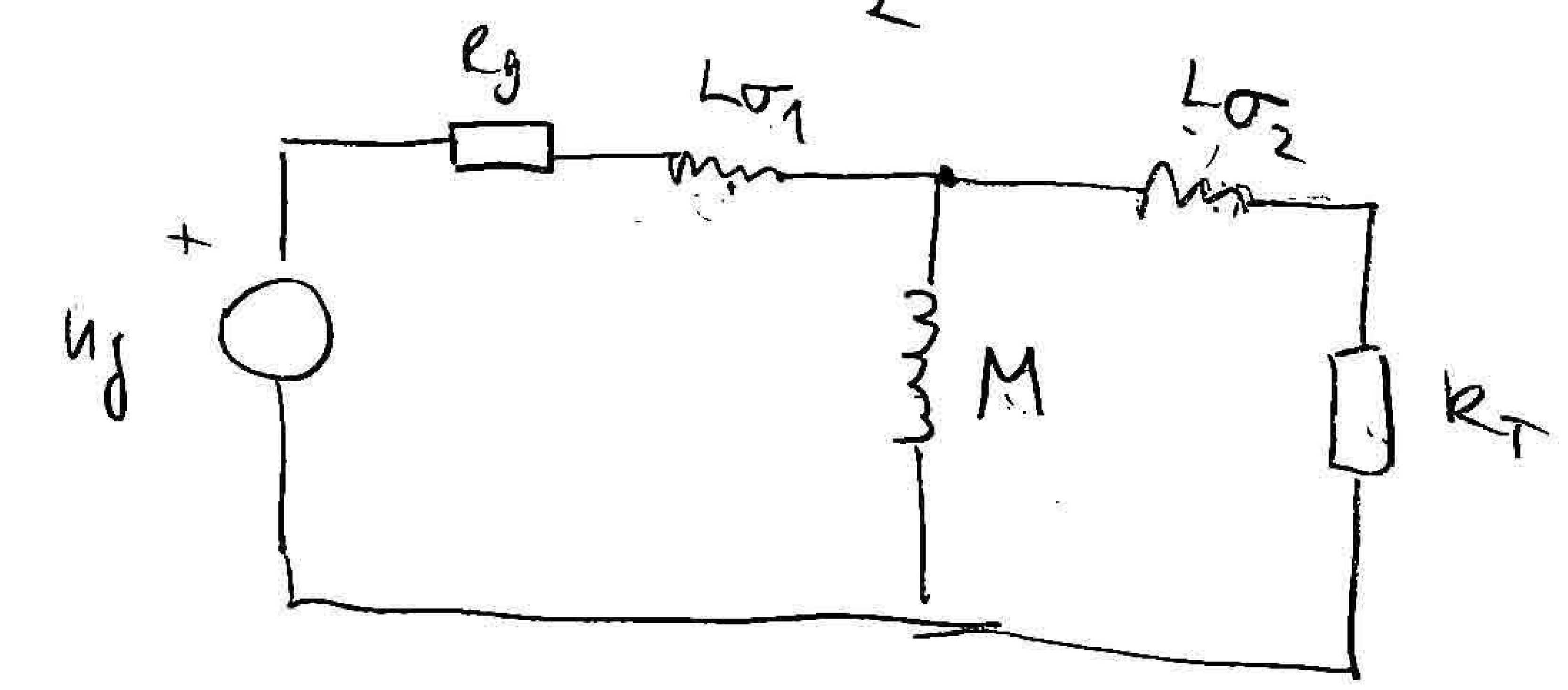
⇒ zbog: $u_1 = i_1 R_1 + j\omega i_1 L_p + j\omega i_2 M$

↳ $i_2 = n i_1$

⇒ M ↓ nM!

(u p kngm)

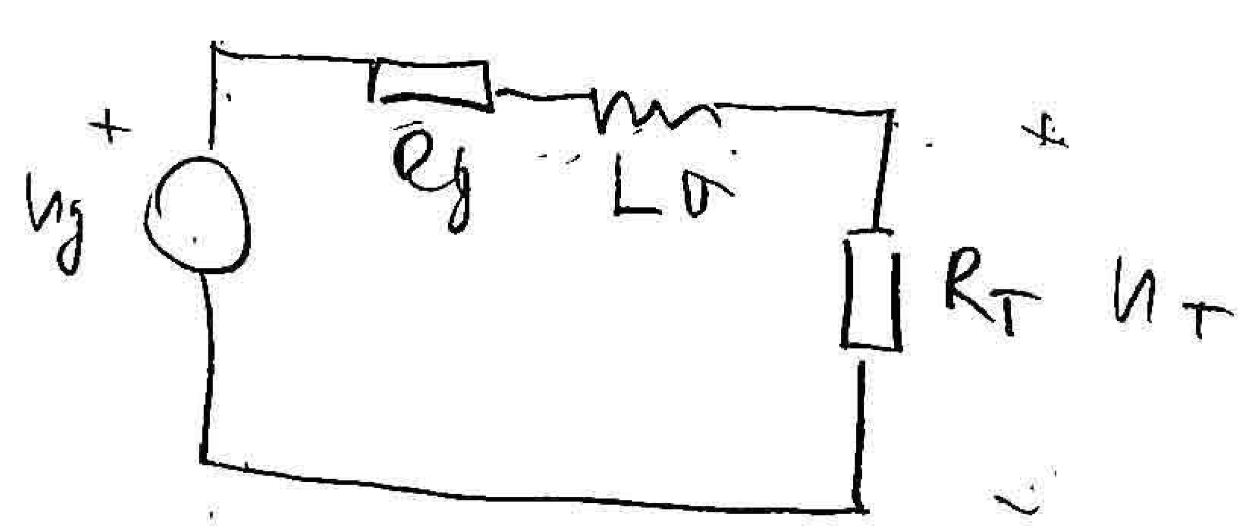
⇒



$\boxed{\text{VF}}$

$$\omega M >> \sqrt{(\omega L_{\sigma_2})^2 + R_T^2}$$

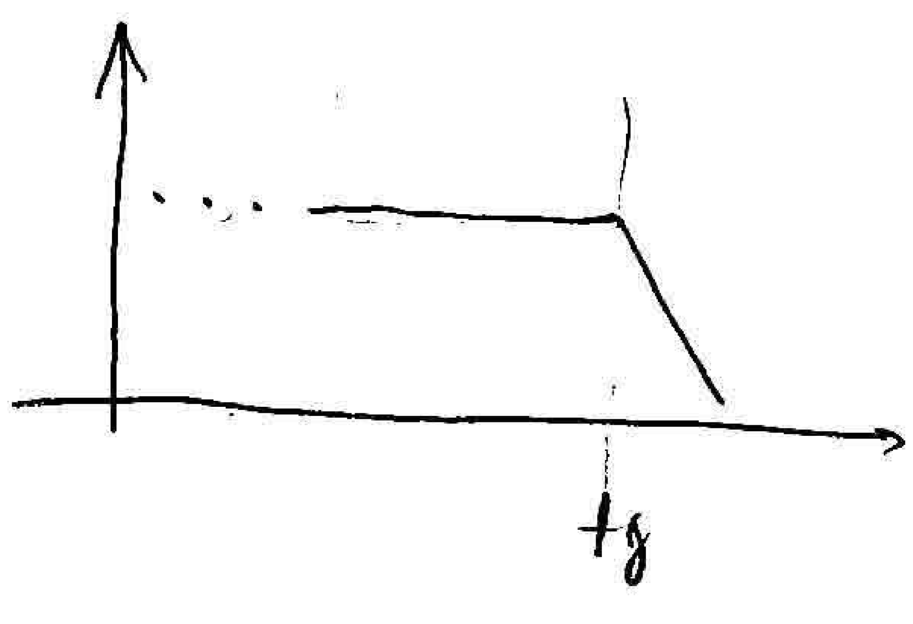
⇒



$$L_\sigma = L_{\sigma_1} + L_{\sigma_2}' = L_{\sigma_1} + L_{\sigma_2}$$

$$\frac{u_T}{u_g} = \frac{R_T}{\sqrt{(R_T + R_g)^2 + (\omega L_\sigma)^2}}$$

$$\left.\frac{u_T}{u_g}\right|_{\substack{f \to 0 \\ (zn\ f >> f_d)}} = \frac{R_T}{R_T + R_g}$$



$$\left.\frac{U_T}{U_g}\right|_{f=f_g} = \frac{1}{\sqrt{2}} \left.\frac{U_T}{U_g}\right|_{\substack{f\to 0 \\ (f\to f_d)}}$$

$$\frac{R_T^2}{(R_T+R_g)^2+(\omega_g L_\sigma)^2} = \frac{1}{2}\,\frac{R_T^2}{(R_T+R_g)^2}$$

$$R_T+R_g = \omega_g L_\sigma$$

$$\omega_g = \frac{R_T+R_g}{L_\sigma} \Rightarrow \boxed{f_g=\frac{1}{2\pi}\,\frac{R_T+R_g}{L_\sigma}} \qquad f_g\downarrow \text{ s } L_\sigma\uparrow$$

$L_\sigma = ?$

⇒ vrijede definicije: $M = k\sqrt{L_pL_s} = \left| L_p=\frac{N_1^2}{R_m},\ L_s=\frac{N_2^2}{R_m}\right| = k\,\frac{N_1N_2}{R_m}$

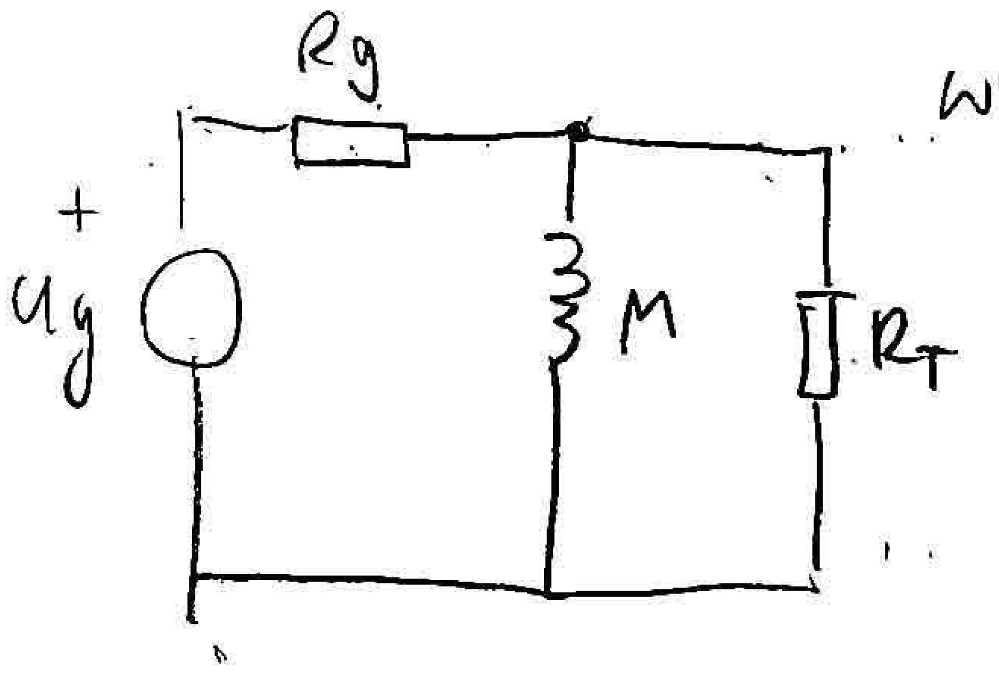
$$L_{\sigma1} = (1-k)L_p = L_p - kL_p = L_p - \frac{M R_m}{N_1N_2}\cdot\frac{N_1^2}{R_m} = L_p - \frac{N_1}{N_2}M$$

$$L_{\sigma2} = L_s - \frac{N_2}{N_1}\cdot M$$

- za $N_1=N_2 \Rightarrow L_p=L_s \Rightarrow L_{\sigma1}=L_{\sigma2}=(1-k)L_p=(1-0{,}95)\cdot 1H = 50\,mH$

$$\boxed{f_g} = \frac{1}{2\pi}\,\frac{600+50}{2\cdot 0{,}05} = \boxed{1{,}035\,kHz}$$

NF



$\omega L_{\sigma1} \ll R_g$, $\omega L_{\sigma2} \ll R_T$

$$\left|\frac{U_T}{U_g}\right|_{f=f_d} = \frac{1}{\sqrt{2}}\left|\frac{U_T}{U_g}\right|_{f_d\ll f\ll f_g}$$

$$\frac{R_T \| j\omega M}{R_g + R_T\| j\omega M} = \frac{\frac{j\omega M R_T}{R_T+j\omega M}}{R_g+\frac{j\omega M R_T}{R_T+j\omega M}} \cdot \frac{\frac{R_T+j\omega M}{j\omega M}}{-\|-} = \frac{R_T}{R_T+\frac{R_g(R_T+j\omega M)}{j\omega M}} =$$

$(M=L_p)$!

$$f_d = \frac{1}{2\pi}\,\frac{600\,\|\,50}{1} = \boxed{7{,}35\,Hz}$$

AND-Tr

$\boxed{NF\ldots}$

$$\left|\left|\frac{U_T}{U_g}\right|\right|_{f=f_d} = \frac{1}{\sqrt{2}}\left|\left|\frac{U_T}{U_g}\right|\right|_{f_d \ll f \ll f_g}$$

$$\frac{R_T \| j\omega M}{R_g + R_T \| j\omega M} = \frac{\frac{j\omega R_T M}{R_T + j\omega M}}{R_g + \frac{j\omega R_T M}{R_T + j\omega M}} \cdot \frac{(j\omega M + R_T)}{j\omega M (R_T + R_g)} =$$

$$= \frac{\frac{R_T}{R_g + R_T}}{\frac{R_T}{R_g + R_T} + \frac{R_g(R_T + j\omega M)}{j\omega M (R_g + R_T)}} = \frac{\frac{R_T}{R_g + R_T}}{\frac{j\omega M R_T + R_g R_T + j\omega M R_g}{j\omega M (R_g + R_T)}} =$$

$$= \frac{\frac{R_T}{R_g + R_T}}{1 + \frac{R_g R_T}{R_g + R_T} \cdot \frac{1}{j\omega M}} = \frac{\frac{R_T}{R_g + R_T}}{1 + \frac{R_g \| R_T}{j\omega M}} = \frac{U_T}{U_g}$$

$$\left|\left|\frac{U_T}{U_g}\right|\right|_{f=f_d} = \frac{\frac{R_T}{R_T + R_g}}{\sqrt{1 + \left(\frac{R_g \| R_T}{\omega_d M}\right)^2}} = \frac{1}{\sqrt{2}}\left|\left|\frac{U_T}{U_g}\right|\right|_{f_d \ll f \ll f_g} = \frac{1}{\sqrt{2}} \frac{\cancel{R_T}}{\cancel{R_T} + R_g}$$

$$1 + \left(\frac{R_g \| R_T}{\omega_d M}\right)^2 = 2 \Rightarrow \omega_d M = R_g \| R_T$$

$$\Rightarrow \boxed{f_d = \frac{R_g \| R_T}{2\pi M}}$$

$$\Rightarrow \cancel{f_d = \frac{1}{2\pi} \frac{600 \| 50}{1} = \boxed{7{,}35\,Hz}} \qquad f_d = \frac{1}{2\pi} \frac{600 \| 50}{0{,}95 \cdot 1} = 7{,}74\,Hz$$

$$M = k\sqrt{L_s L_p} = 0{,}95\sqrt{1 \cdot 1}$$

VÝSPRAVKE:

Tr-1:

$$f_d = \frac{1}{2\pi}\sqrt{\frac{600150}{0{,}95}} = 7{,}74\ Hz$$

AUD-Tr

Tr-2

punovalni ispr.

C-filtar (C₁ na shemi)

$U_{C1,AV} = 20V$

$r_{C1} = 10\%$

$RC = ?$

$U_{TAV} = 12V$

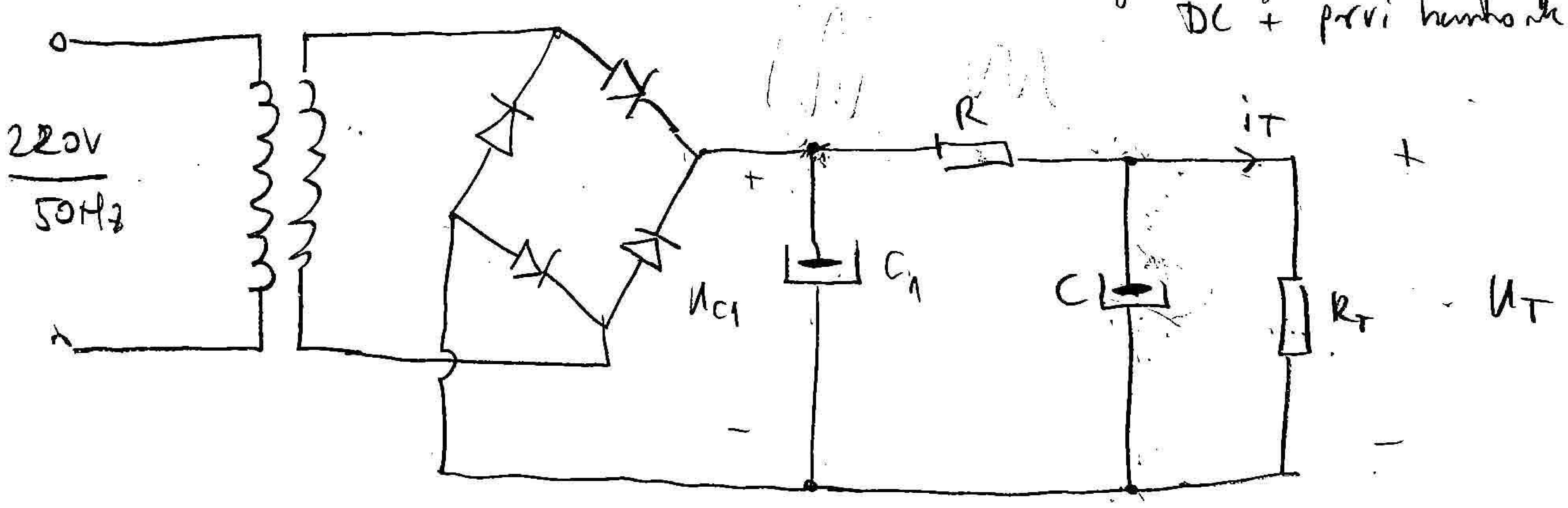
$r_T = 0,1\%$

$I_{TAV} = 10mA$

$\eta = ?$

VIDI DRUGU STRANU (2.1.) OBJASNI SMADEA!

- navodno kad ne bi bilo RC filtra, iz Smadea (A-32) se to dobije
- gledano 2nd, kao superpot DC + prvi harmonik



$$R_T = \frac{U_{TAV}}{I_{TAV}} = \frac{12}{0,01} = \boxed{1,2k\Omega} \quad \text{(opterećni otpor)}$$

$$\boxed{R =} \frac{U_{C1AV} - U_{TAV}}{I_{TAV}} = \frac{20-12}{0,01} = \boxed{800\Omega}$$

$$r_{C1} = \frac{U_{C1VRMS}}{U_{C1AV}}$$

U_{C1VRMS} - ef. napon valovitosti na C_1

U_{C1AV} - sred. vrijednost napona na C_1

$$r_T = \frac{U_{TVRMS}}{U_{TAV}}$$ - traženo

$$\Rightarrow \frac{U_{TVRMS}}{U_{C1VRMS}} = \frac{r_T}{r_{C1}} \frac{U_{TAV}}{U_{C1AV}} = \frac{0,001}{0,1} \frac{12}{20} = 0,006$$

$$\frac{U_{TVRMS}}{U_{C1VRMS}} \doteq \frac{R_T \parallel X_C(f=100Hz)}{R + R_T \parallel X_C(f=100Hz)}$$ → pravilno ispr.!

približna vrijednost par nakon punovalnog ispr. osim komp. sa 100 Hz postoje i viši harmonici

– ~~nog~~ uz pretp.: $R_T \gg X_C(f=100Hz)$

(inače filter nije dobar; izmj. komp. se mora zatvarati kroz C!)

$$\frac{U_{TVRMS}}{U_{C1VRMS}} \doteq \frac{\frac{1}{\omega C}}{\sqrt{R^2+\left(\frac{1}{\omega C}\right)^2}} = \frac{1}{\sqrt{1+(\omega RC)^2}}$$

– uz pretp.: $\omega CR \gg 1$

(tj. $R \gg \frac{1}{\omega C}$) glavnina napona valovitosti ostaje na otporniku RC filtra (inače bi r_T bio loš (valovitost na C))

$$\frac{U_{TVRMS}}{U_{C1VRMS}} \approx \frac{1}{\omega RC}$$

$$\boxed{C \approx} \frac{U_{C1VRMS}}{U_{TVRMS}} \cdot \frac{1}{2\pi f R} = \frac{1}{0{,}006} \frac{1}{2\pi\, 100 \cdot 800} = \boxed{331{,}6\,\mu F}$$

Provjera pretp.:

$$X_C(f=100Hz) = \frac{1}{2\pi f C} = 4{,}8\,\Omega \ll R_T = 1{,}2k$$

$$\omega CR = 166{,}7 \gg 1$$

OK.

$$\boxed{\eta =} \frac{U_{TAV} \cdot I_{TAV}}{U_{TAV} I_{TAV} + I_{TAV}^2 R} = \frac{1}{1+\frac{I_{TAV} R}{U_{TAV}}} = \frac{1}{1+\frac{R}{R_T}} = \frac{1}{1+\frac{800}{1200}} = \boxed{0{,}6}$$

↓

uz zanemarenje AC gubitaka $I_{TVRMS}^2 R \ll I_{TAV}^2 R$

AUD – STB

STB – 1

punovalni ispr.

$R_T = 20\Omega$

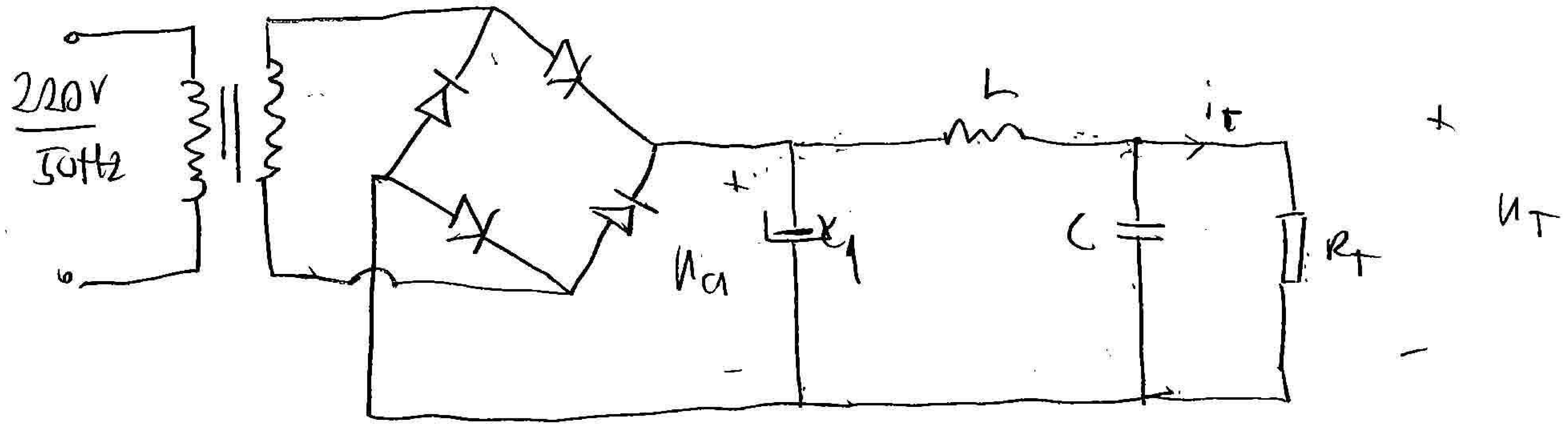
$U_{TAV} = 20V$

$U_{TV} = 4V_{eff}$

$k = ?$ $k = \frac{U_{TV}}{U_{TV}'}$

LC => $L = 100mH$ → $R_s = \varnothing$

$C = 1000\mu F$



$$I_{TAV} = \frac{U_{TAV}}{R_T} = \frac{20}{20} = 1A$$

$$\frac{U_{TVRMS}}{U_{CAVRMS}} = \frac{U_{TV}}{U_{CAV}} \approx \frac{X_C \parallel R_T}{(X_C \parallel R_T) + X_L}$$

promj. oznaka

– uz pretp.: $R_T \gg X_C$ (dobar LC filter; izmj. struja ide kroz C)

$$\frac{U_{TV}}{U_{CAV}} = \frac{\frac{1}{j\omega C}}{\frac{1}{j\omega C} + j\omega L} = \frac{1}{1 - \omega^2 LC}$$

– uz pretp $\omega^2 LC \gg 1$ (većina izmj. napona na L-u, zbog dobrog r_T (mala valovitost na C))

$$\frac{U_{TV}}{U_{CAV}} = \frac{1}{\omega^2 LC} = \boxed{25{,}3 \cdot 10^{-3}}$$

$\Rightarrow \quad \frac{u_{C1V}}{u_{TV}} = \boxed{39,5}$ tolika se smanji valovitost C_1 putem LC filtra

- LC filter je bolji od RC (bolji η) jer nema istosmjernog pada napona na L
- provjera pretp:

$$\frac{1}{2\pi f C} \doteq 1,6\,\Omega << R_T = 20\,\Omega$$

$$\omega^2 LC = 39,5 >> 1$$

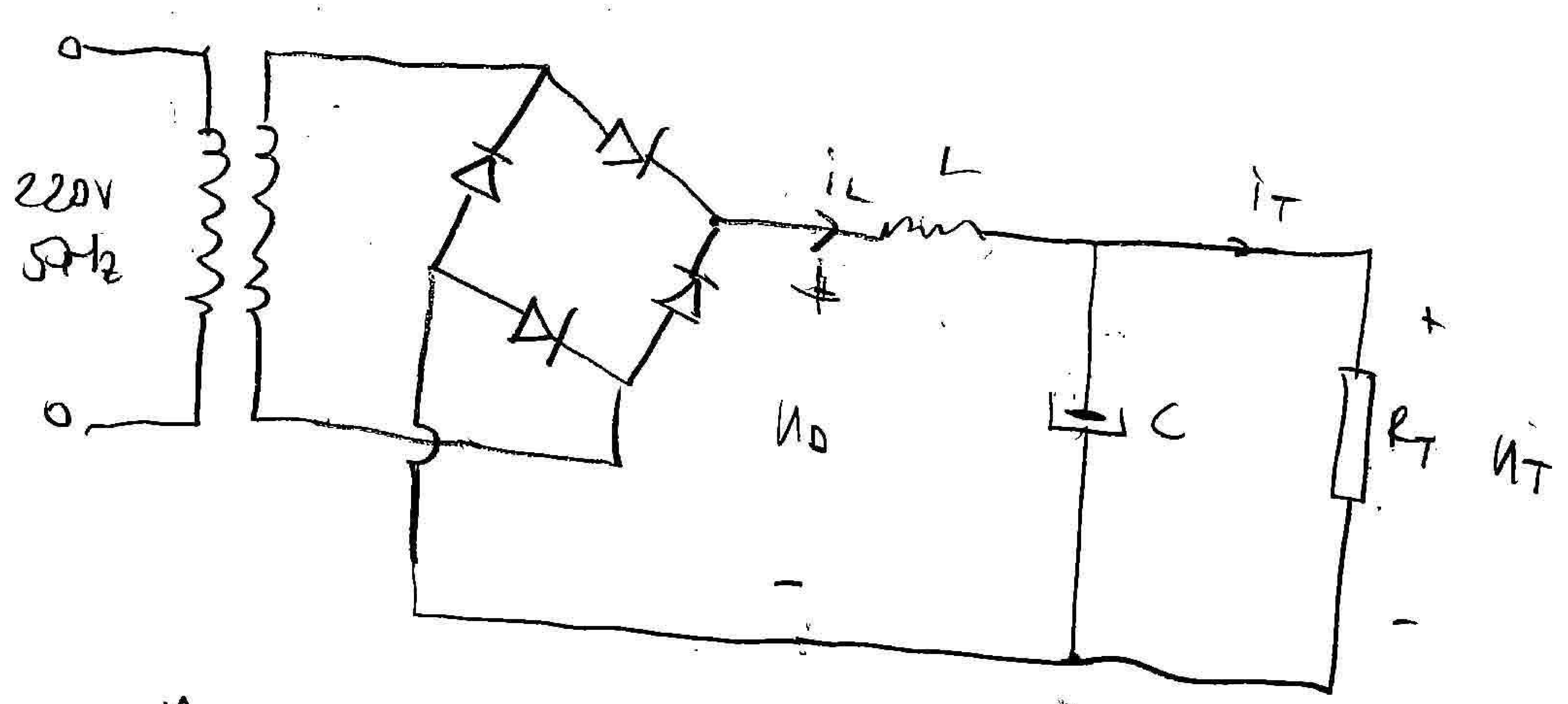
$\boxed{\text{STB-2}}$ punovalni ispr.
LC filter

$U_{TAV} = 350V$

$U_{TV} \leq 10 V_{ef}$

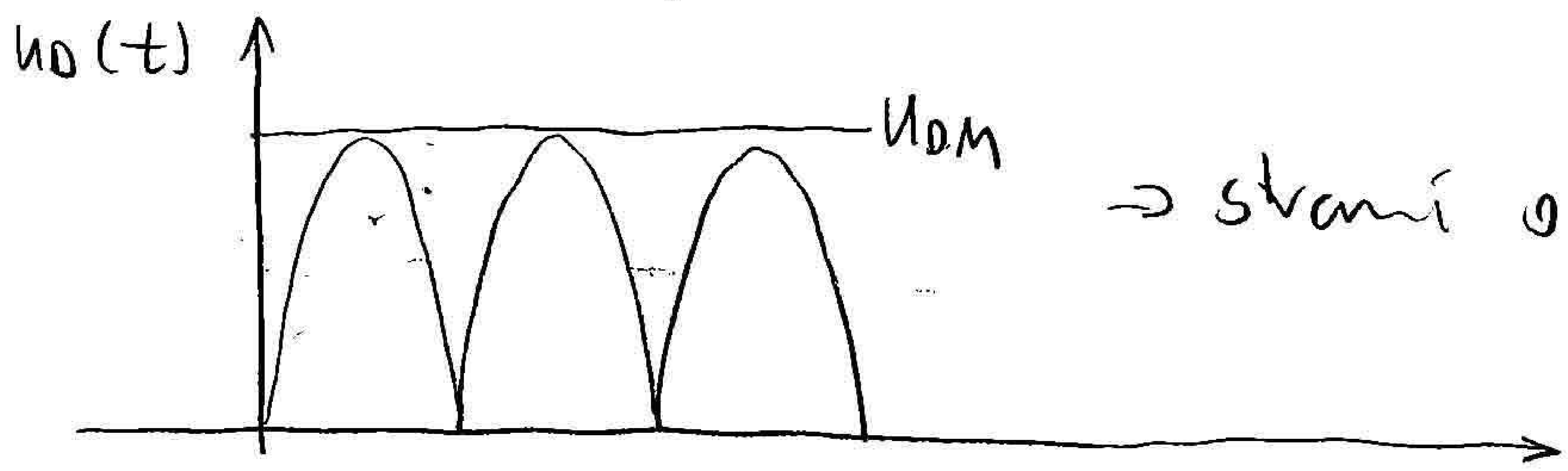
$I_{TAV} = 100\,mA$

$L, C = ?$



$$R_T = \frac{U_{TAV}}{I_{TAV}} = \frac{350}{0,1} = \boxed{3,5k}$$

$$r_T = \frac{U_{TV}}{U_{TAV}} = \frac{10}{350} \doteq \boxed{2,86\%}$$

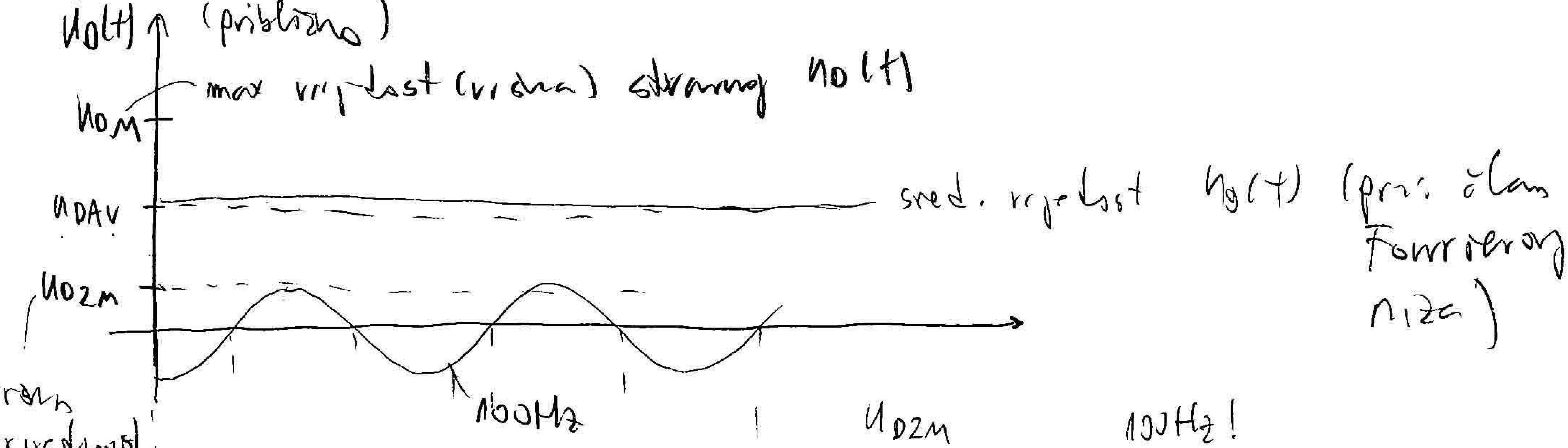


→ stvarni oblik

AND - STB

②

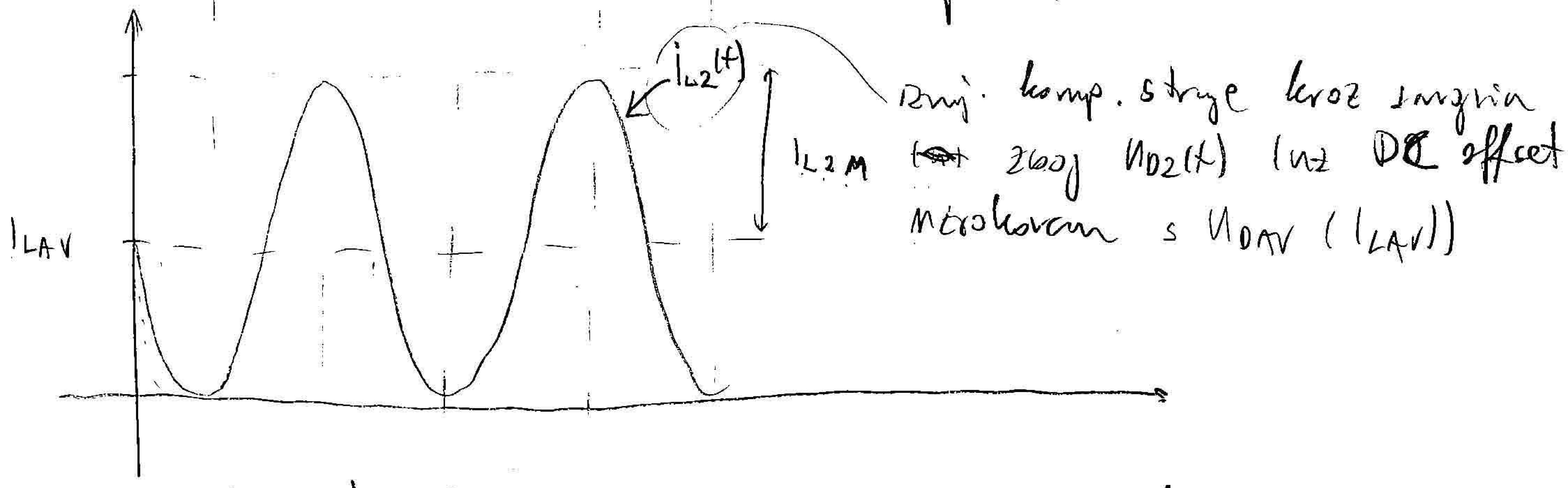
- radi lakšeg proračuna LC filtra, razvit ćemo $u_D(t)$ u Fourierov red samo sa DC komponentom i vrijednošću najnižeg harmonika!



U_{D2M} 100Hz!

$$u_D(t) = \underbrace{\frac{2}{\pi}U_{DM}}_{U_{DAV}} - \underbrace{\frac{4}{3\pi}U_{DM}\cos 2\omega_0 t}_{u_{D2}(t)} - \dots$$

$\hat{u}_D(t) = U_{DAV} + u_{D2}(t)$ (bez viših harm.) (aprox.)



- uvjet je da struja kroz zavojnicu teče neprekidno (kod "rezanja" L ne bi dobili prenizak vrijednost kondenzatora C)

$\hat{u}_D(t) = U_{DAV} - U_{D2M} \cos 2\omega_0 t$

za punovalni ispr.

$$U_{D2\,rms} = \frac{U_{D2M}}{\sqrt{2}} = \frac{4}{3\pi} \frac{1}{\sqrt{2}} U_{DM} = \frac{1}{3\pi} \frac{1}{\sqrt{2}} \frac{\pi}{2} U_{DAV}$$

$$\boxed{U_{D2\,rms} = \frac{\sqrt{2}}{3} U_{DAV}}$$

– RMS vrijednost harm. kojeg želimo potisnuti izražena pomoću sred. vrijednosti punovalno ispr. napona (U_{DAV})

pomak za $\varphi = 90°$

$$i_L \doteq I_{LAV} + i_{L2} = I_{LAV} - I_{L2M} \sin 2\omega_0 t =$$
$$= I_{LAV} - \sqrt{2} I_{L2rms} \sin 2\omega_0 t$$

– za dobro projektirani LC filter vrijedi:

$X_C(2\omega_0) << R_T \Rightarrow$ izmj. komp. struje teče uglavnom kroz C (~~kroz~~)

$X_C(2\omega_0) << X_L(2\omega_0) \Rightarrow$ gotovo sav izmj. pad napona je na L

$$I_{L2rms} \doteq \frac{U_{D2rms}}{X_L(2\omega_0)}$$ (jer je X_C praktički K.S. prema GND za AC)

– struja kroz L mora nepr. teći (vidi prije):

$$I_{L2M} \leq I_{LAV} \Rightarrow I_{L2\,rms} \leq \frac{I_{LAV}}{\sqrt{2}}$$

$\Rightarrow X_{Lmin}$:

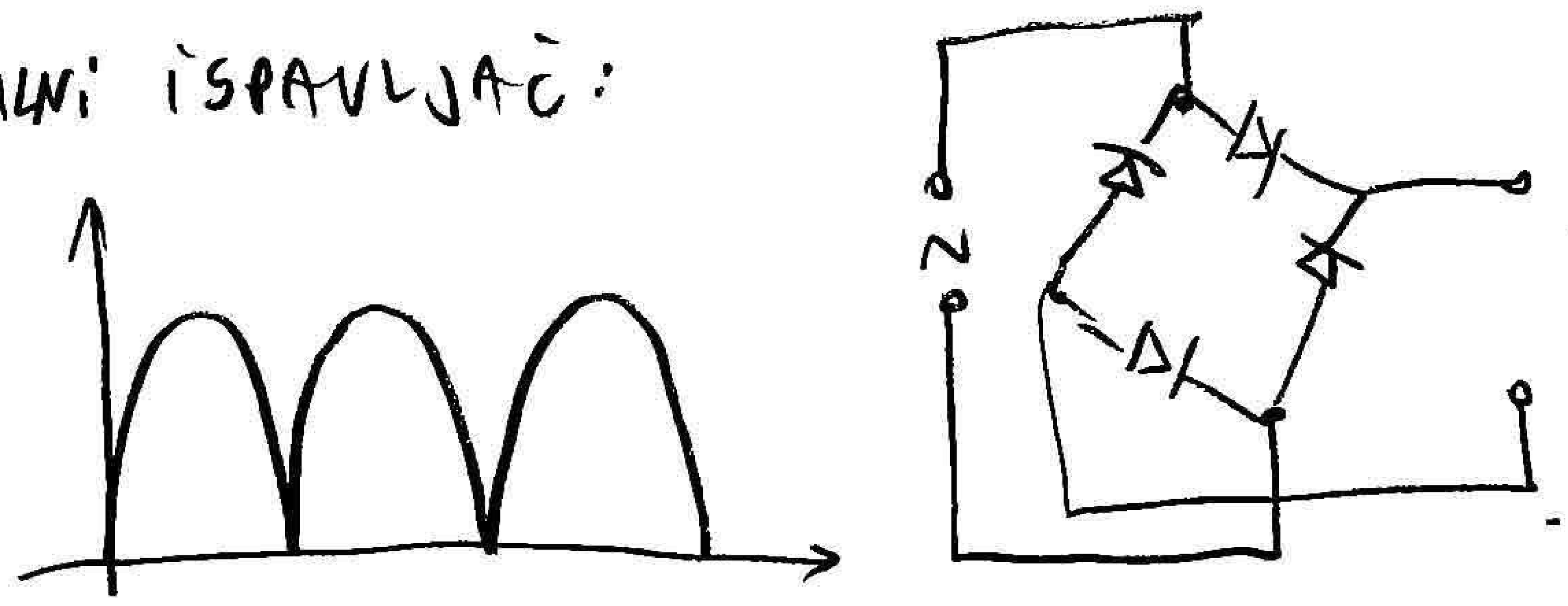
$$\frac{U_{D2rms}}{X_L(2\omega_0)} \leq \frac{I_{LAV}}{\sqrt{2}}$$

$$\Rightarrow X_L \geq \frac{U_{D2rms}}{I_{LAV}} \sqrt{2} = \frac{\sqrt{2}}{3} U_{DAV} \frac{\sqrt{2}}{I_{LAV}} =$$
$$= \frac{2}{3} \frac{U_{DAV}}{I_{LAV}}$$

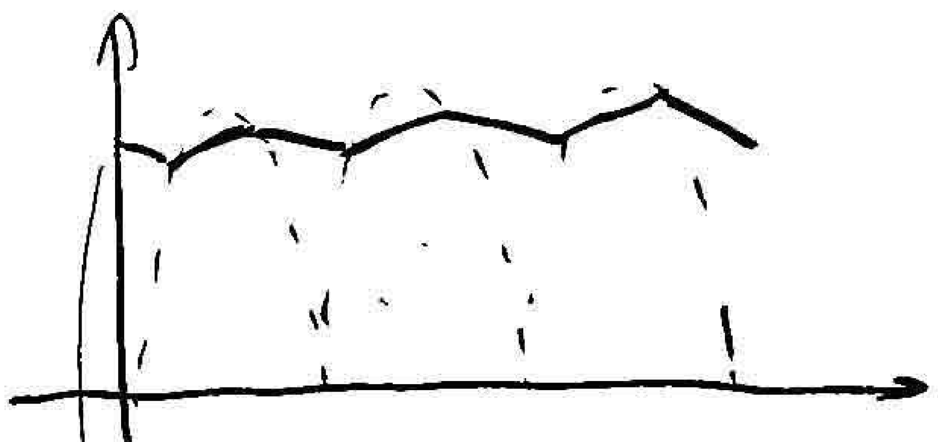
$X_L \geq \frac{2}{3} R_T$ $\quad X_L = 2\omega_0 L$

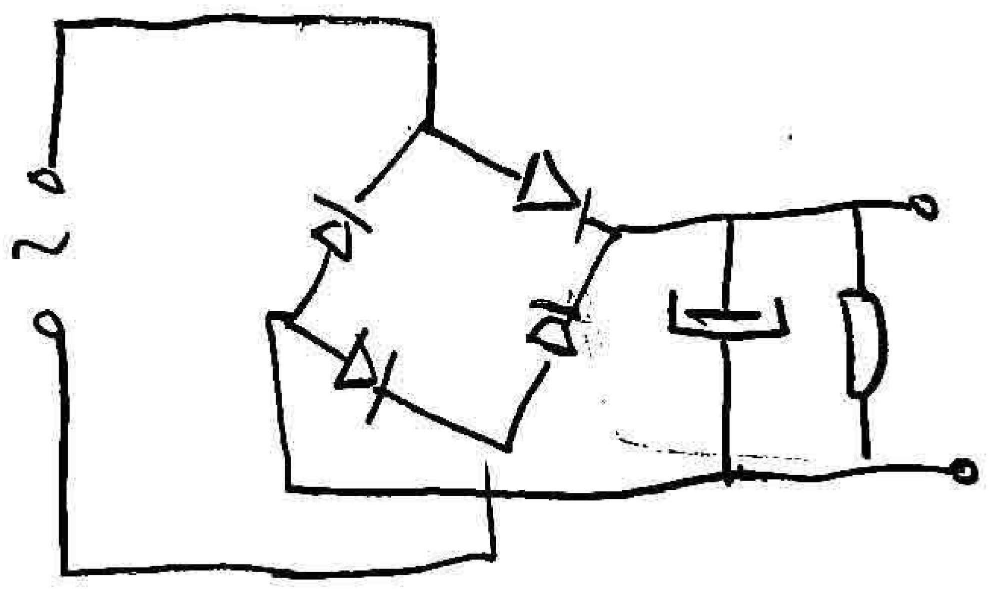
$$\boxed{L \geq} \frac{2}{3} \frac{R_T}{2\omega_0} = \frac{2}{3} \frac{3500}{2 \cdot 2\pi \cdot 50} = \boxed{3{,}714\,H}$$

→ PUNOVALNI ISPRAVLJAČ:



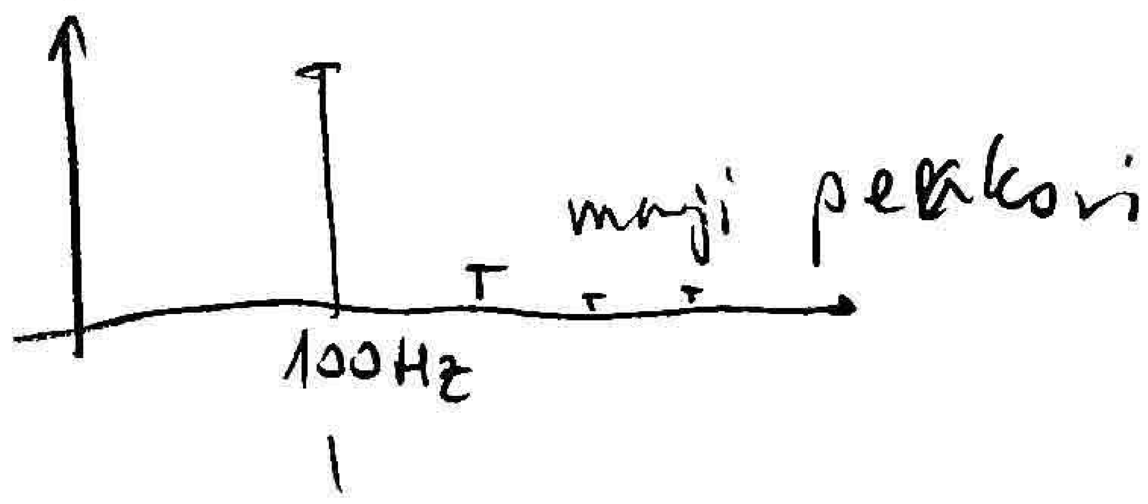
→ PUNOVALNI, KAPACITIVNO OPT. ISPRAVLJAČ:





"trokutni" napon:

spektar:

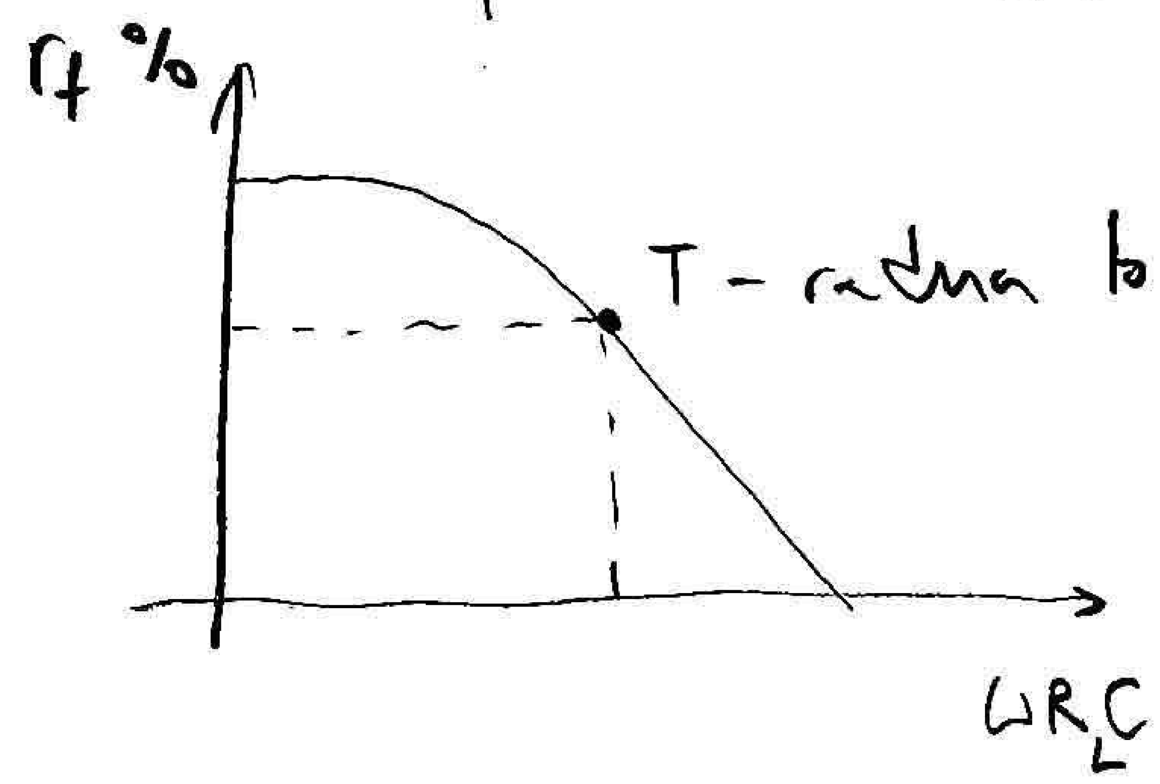


dominantno! (50Hz za poluvalne)

U_{VRMS} = efektivna vrijednost napona valovitosti (true-RMS, mjerenja)

SHADE-ovi dijagrami (str. A-33)

r_f vs $\omega R_L C$



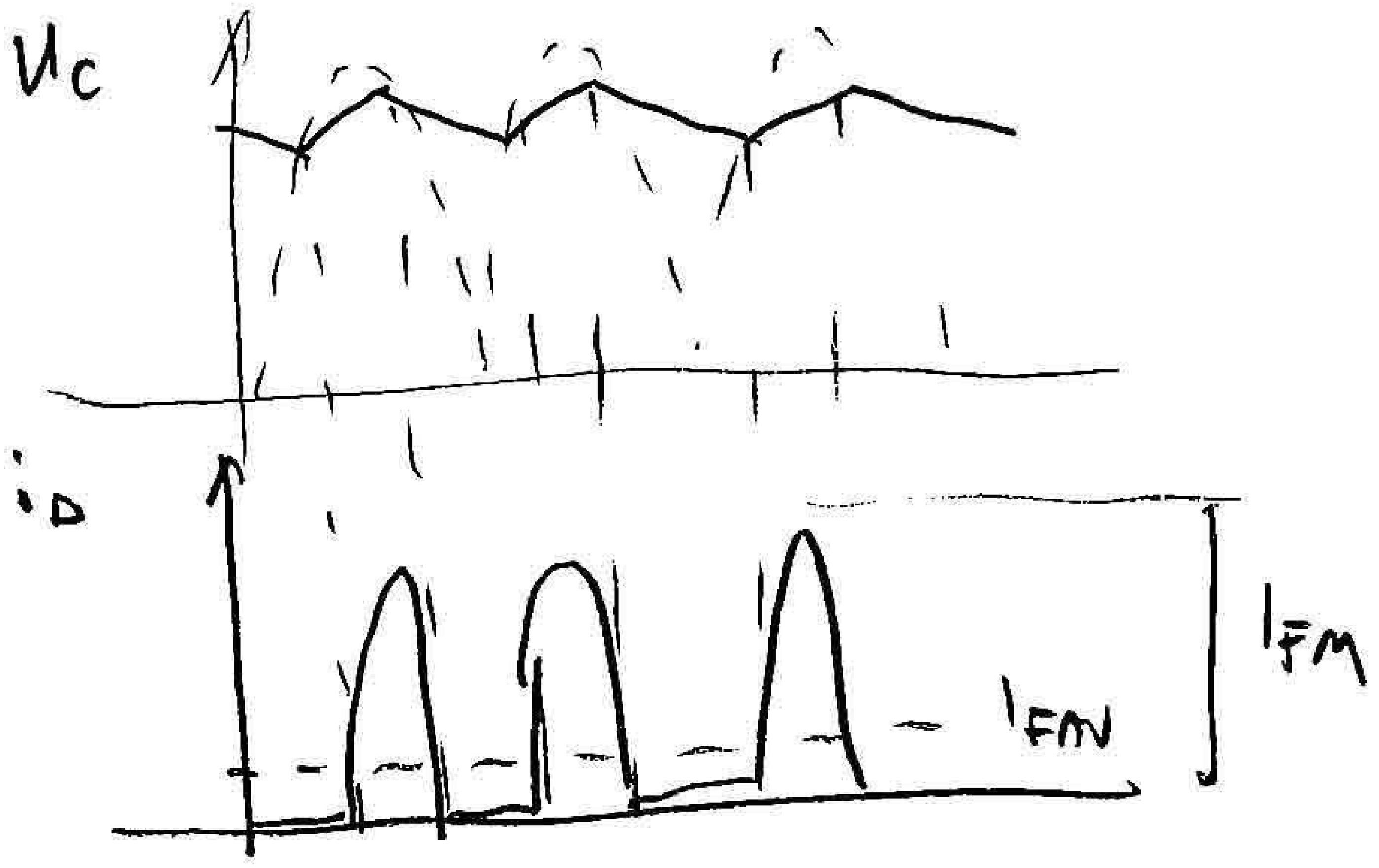
T - radna točka (ovisi o tome da li je:
→ punovalni/poluvalni ispr.!
→ ω gradske mreže (50/60Hz)
→ C - filtra
→ R - opt.

- eksperimentalne vrijednosti!
da se na temelju parametara sklopa može procijeniti valovitost

- slično → i drugi SHADE-ovi dijagrami

=)

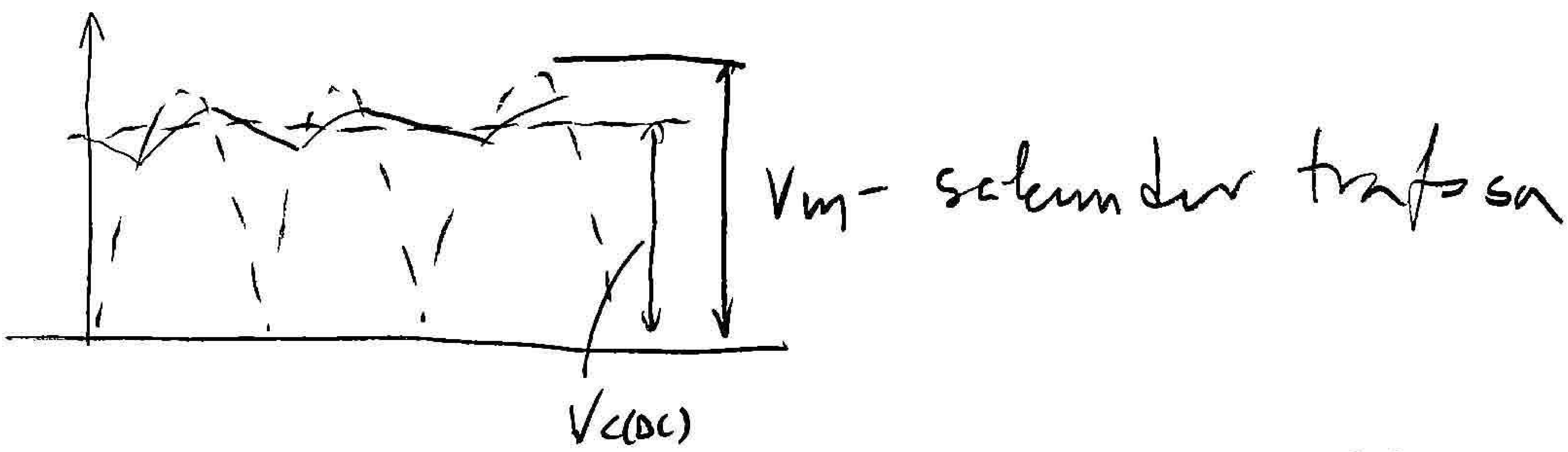
$\frac{I_{FM}}{I_{FAV}}$ vs $n\omega R_L C$



→ kako raste $n\omega R_L C$ → raste i špic struje

→ bitno kod određivanja I_{FM} da bi se znala procijeniti RATED struja ispravljačke diode

$\frac{V_{C(DC)}}{V_m}$ vs $\omega R C_L$ (polu/punovalni)



kako $\omega R_L C$ raste, tako se i $V_{C(DC)}$ približava V_m!

(VRATITI SE NA ZADATAK!)

AUD - STB

③

$\boxed{\text{STB}-2\ldots}$

$$\frac{u_{TV}}{u_{DV}} \doteq \frac{1}{\omega^2 LC}$$ (vidi razmatranje u preth. zad.)

$$r_T = \frac{U_{TV}}{U_{TAV}} = \frac{U_{TV}}{U_{DAV}} = \frac{U_{TV}}{U_{D2RMS}}\frac{\sqrt{2}}{3} = \frac{U_{TV}}{U_{DV}}\frac{\sqrt{2}}{3}$$

$$\Rightarrow r_T = \frac{\sqrt{2}}{3}\frac{1}{\omega^2 LC}$$

$$C \geq C_{min} = \frac{\sqrt{2}}{3}\frac{1}{\omega^2 L r_T} = \frac{\sqrt{2}}{3}\frac{1}{(2\pi 100)^2 3{,}714 \cdot 0{,}0286}$$

$$\boxed{C \geq 11{,}3\,\mu F}$$

- uz izbor $\boxed{L = 5H}$ $(> L_{min})$

$$\Rightarrow C_{min} = 8{,}4\,\mu F \rightarrow \boxed{C = 10\,\mu F}$$

$\boxed{\text{STB}-3}$

$U_{Z0} = 15\,V$

$\Delta U_Z = \pm 0{,}1 U_{Z0}$

$I_{Zmin} = 5\,mA$

$r_d = 10\,\Omega$

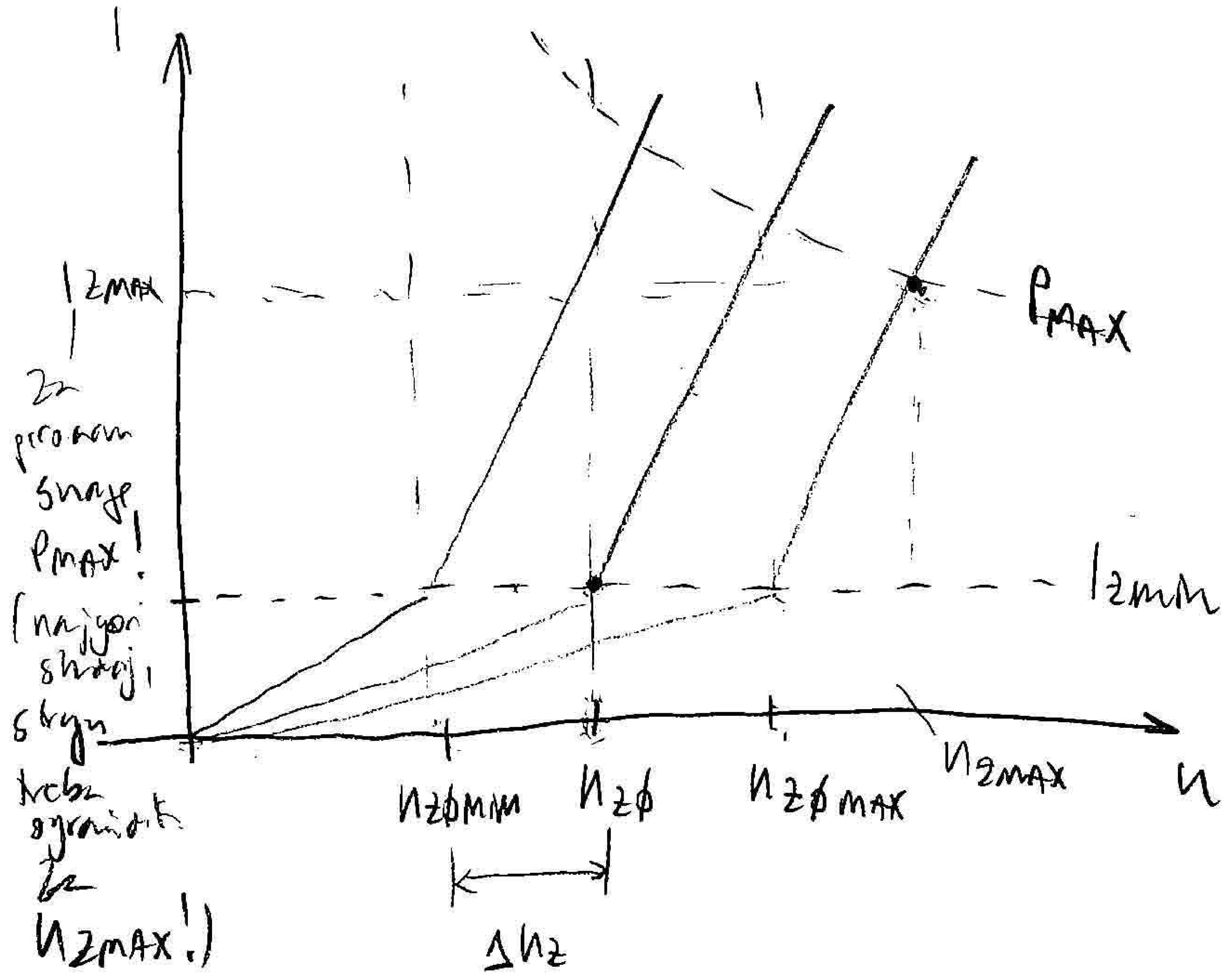
$P_{MAX} = 0{,}5\,W$

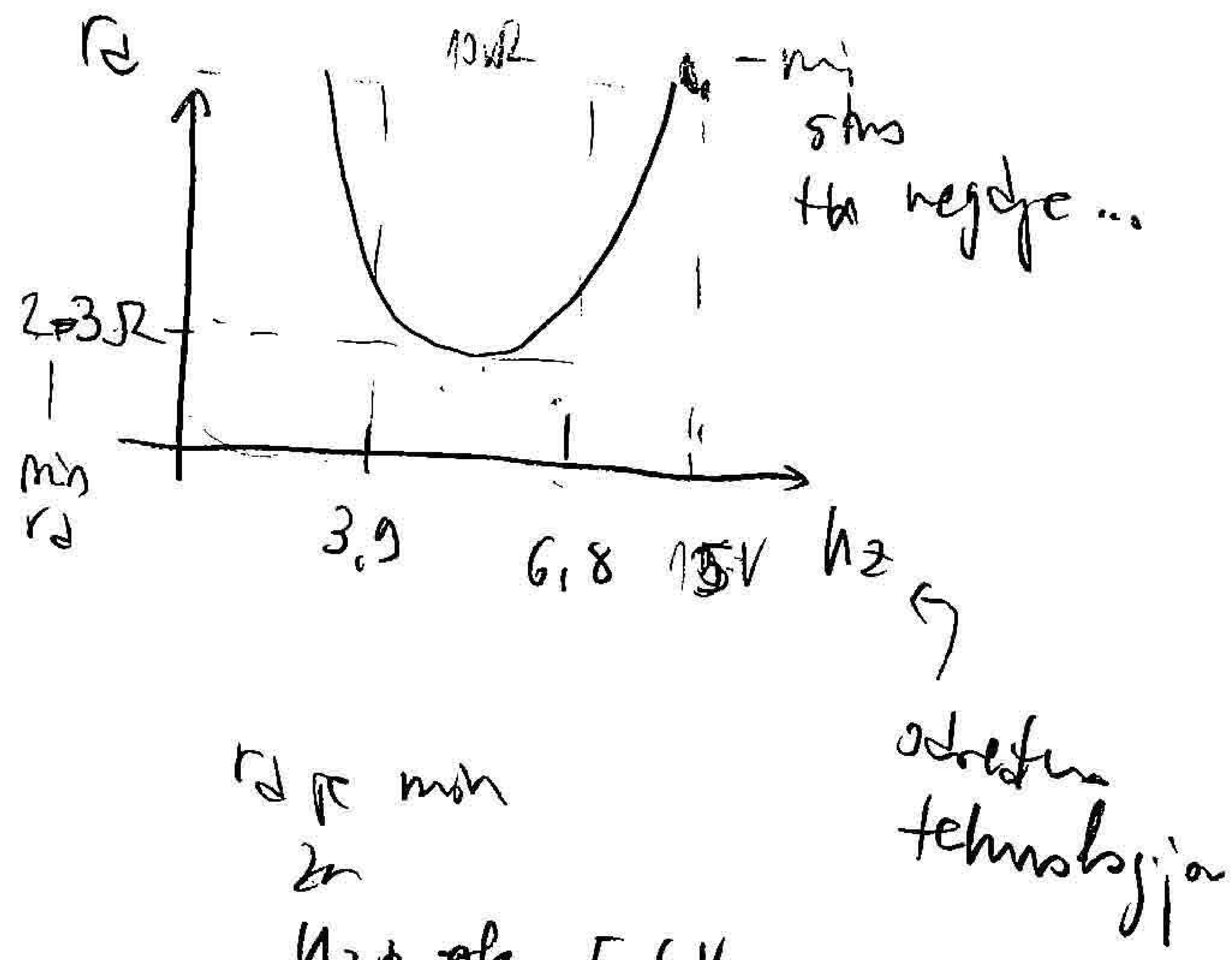
a) $R_{SMAX} = ?$ $\quad U_{UL} = 20\,V$, $R_T = 3\,k\Omega$

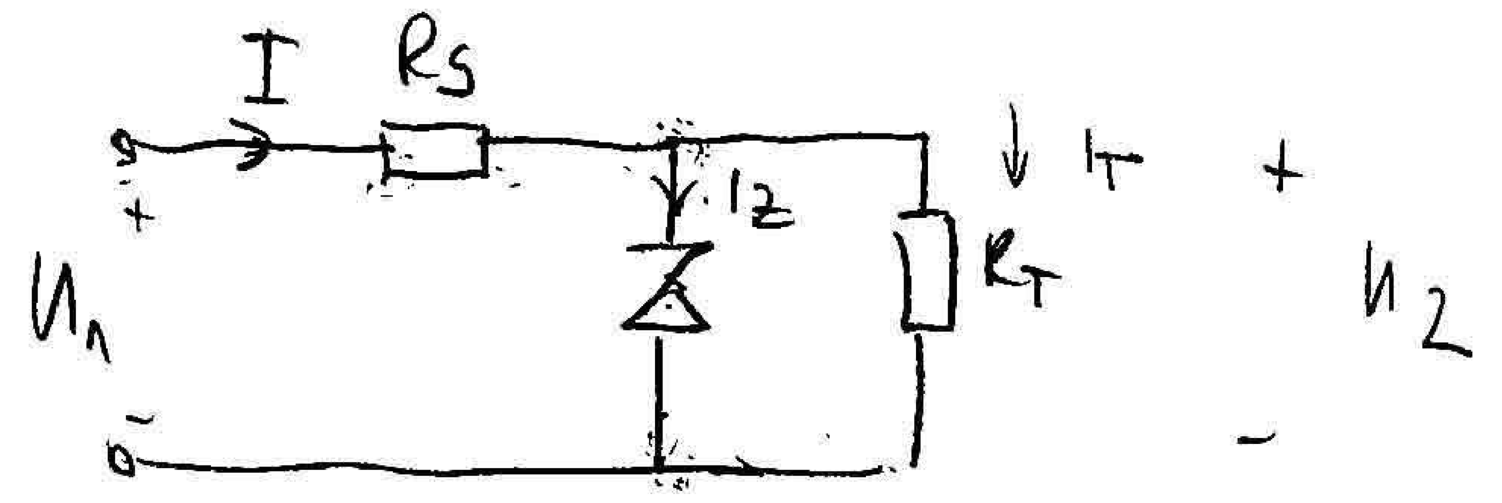
b) uz R_{SMAX}

$U_{1MAX} = ?$

c) K_u, K_I (za a))







typ. izgled stab. s zenerovom diodom

$\boxed{R_{SMAX}}$ određen s I_{Zmin} (da bi uopće ZD proradila)

→ najmanja struja I (max R_S, max U_Z, uz U_1 = konst) mora biti dovoljna za max $I_T = \frac{\max U_Z}{R_T = konst}$; barem min I_Z

R_{Smin} određen sa I_{Zmax} →

→ razlika max I (min R_S) i min I_T (min U_Z) R_T = konst ne smije biti veća od max I_Z (određen s P_{MAX} na U_{Zmax})

a) PRORAČUN R_S

općenito $U_{1min} = R_{SMAX}(I_{Zmin} + I_{TMAX}) + U_{Z0MAX}$

(konst u ovom slučaju)

$$\rightarrow \boxed{R_{SMAX}} = \frac{U_{1min} - U_{Z0MAX}}{I_{Zmin} + \frac{U_{Z0MAX}}{R_T}} = \frac{20 - 1{,}1 \cdot 15}{5 + \frac{1{,}1 \cdot 15}{3}} = \boxed{0{,}333K}$$

b) PRORAČUN U_{1max}

$U_Z = U_{Z0} + r_d (I_Z - I_{Zmin})$ (pravac na U–I karakt. ZD)

$P_{MAX} = I_{ZMAX} U_{ZMAX}$

$U_{ZMAX} = U_{Z0MAX} + r_d (I_{ZMAX} - I_{Zmin})$

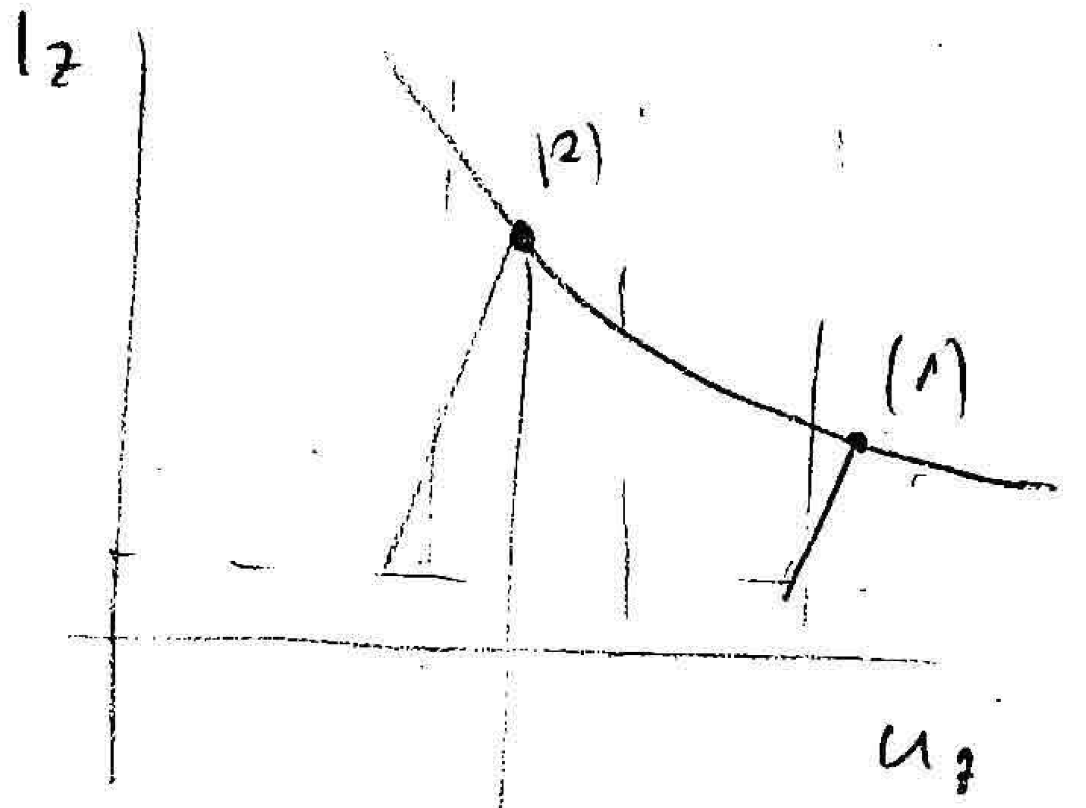
} kvadratna j-džba po I_{ZMAX}

(5) – nastavak

– iako ima logike da se R_{Smax} određuje iz I_{ZMIN} (U_{ZMAX}) kada se traži R_{Smin} ide se suprotnim putem (zbog disipacije kao kriterija, a ne mogućnosti rada); tada se uzima U_{Zmin} i I_{ZMAX}

– dugim računom, kvadratna j-džba za P_{MAX} uz pretpostavku $U_{Z0MAX} = U_{Zd}$ da je porošnje povećanje, tj. veći U_1 uz isti R_S!

– ako se postavi:
$$\begin{cases} P_{max} = U_{ZMAX} \cdot I_{ZMAX} \\ U_{Zmax} = U_{Z0,MIN} + r_d (I_{Zmax(min)} - I_{Zmin}) \end{cases}$$



dobije se:

$$\Rightarrow U_{Zmax} = \frac{P_{max}}{I_{Zmax}} = 13,81\,V$$

$I_{ZMAX} = 36,2\,mA$ ($I_{Zmax} = 29,85\,mA$)

→ uz takve uvjete (odabrana ZD s $U_{Z0\,min}$), max. dozv. napon na ulazu je (uz konst R_S):

$$U_{1max} = R_S (I_{Zmax} + \underbrace{\not{I}}_{I_{TMIN}}) + \overset{13,81\,V}{U_{Zmax}} =$$

$$= R_S\, 0,33\,k\Omega \cdot 36,2\,mA + 0,5 \cdot 15\,V =$$
$$= \boxed{25,86\,V}$$ → to je max. dozv. napon

AUD-5TB[3]

$$P_{MAX} = I_{ZMAX}\left[U_{Z0MAX} + r_d\left(I_{ZMAX} - I_{Zmin}\right)\right]$$

$$P_{MAX} - I_{ZMAX}U_{Z0MAX} - I_{ZMAX}^2 r_d + r_d I_{ZMAX} I_{Zmin} = 0$$

$$\vdots$$

$$I_{ZMAX_{1,2}} = \frac{U_{Z0MAX} - r_d I_{Zmin} \pm \sqrt{\left(U_{Z0MAX} - r_d I_{Zmin}\right)^2 + 4P_{MAX} r_d}}{-2r_d}$$

$$= \frac{16{,}5 - 10\cdot 5\cdot 10^{-3} \pm \sqrt{16{,}45^2 + 4\cdot 0{,}5\cdot 10}}{-2\cdot 10}$$

$$I_{ZMAX_{1,2}} = \frac{16{,}45 \pm 17{,}047}{-2\cdot 10}$$

$$\boxed{I_{ZMAX} = 29{,}85\,mA}$$ (neg. rj. nema. fiz. smisla!)

– u slučaju da su tol. napona U_{Z0} zanemarive tj. $U_{Z0MAX} \gg r_d(I_{ZMAX} - I_{Zmin})$ može se račun pojednostaviti:

$$P_{MAX} = I_{ZMAX}\cdot U_{Z0MAX}$$

$$\Rightarrow I_{ZMAX} = \frac{P_{MAX}}{U_{Z0MAX}} = \underline{\underline{30{,}3\,mA}} \quad (\approx 29{,}85\,mA)$$

$$U_{1MAX} = R_S\left(I_{ZMAX} + I_{Tmin}\right) + U_{Z0MAX}$$

U_{ZMAX} ii $P_{MAX}/I_{ZMAX} = 16{,}75V$

U_1 je promjenjiv u gl!

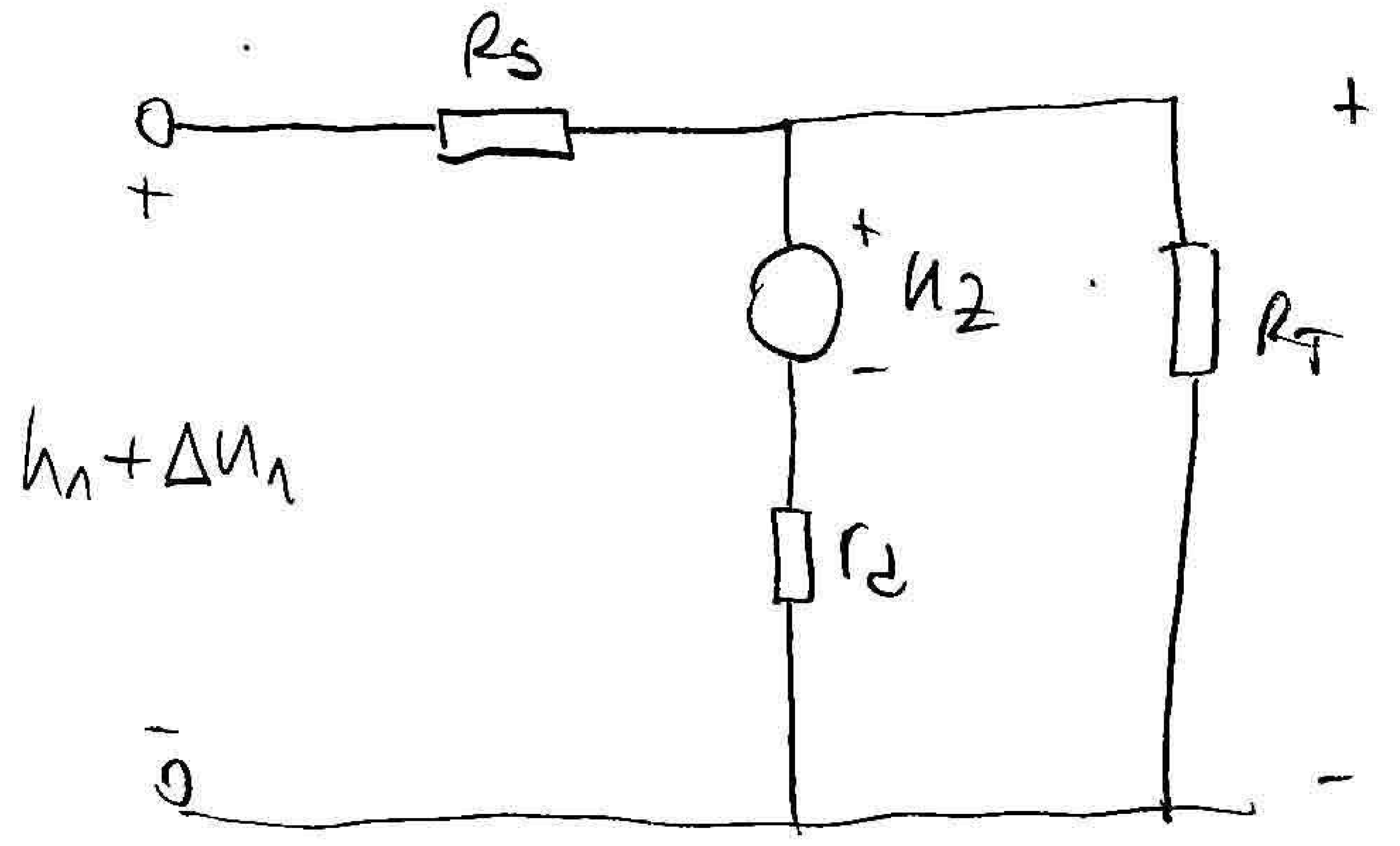
$I_{Tmin} = 0$ (teret nije priklj!)

$$\Rightarrow \boxed{U_{1MAX}} = 0{,}33\cdot 29{,}85 + 16{,}75 = \boxed{26{,}7V}$$

(VIDI DODATAK 4.1*)

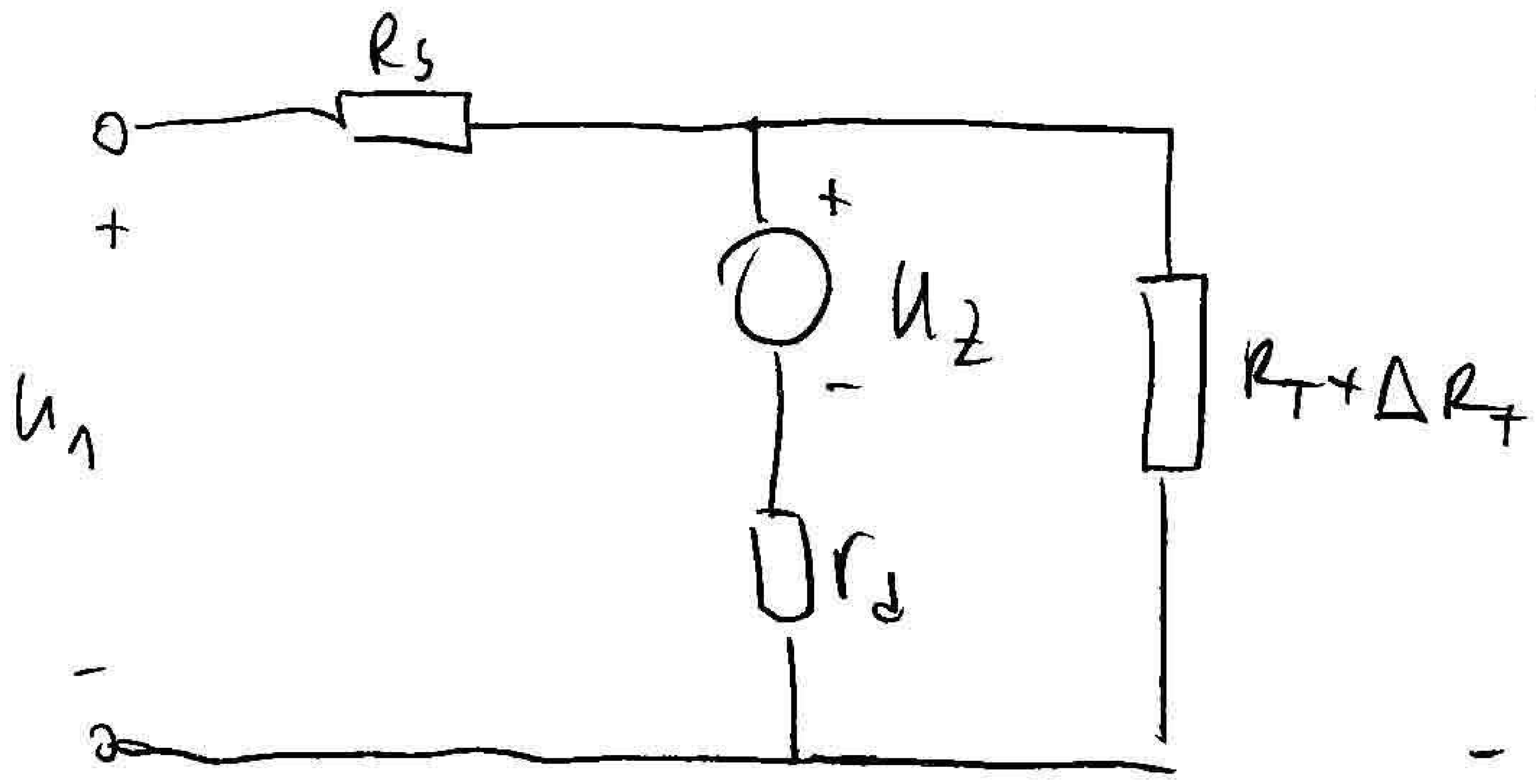
c) definicije faktora stabilizacije

NAPONSKA STAB.



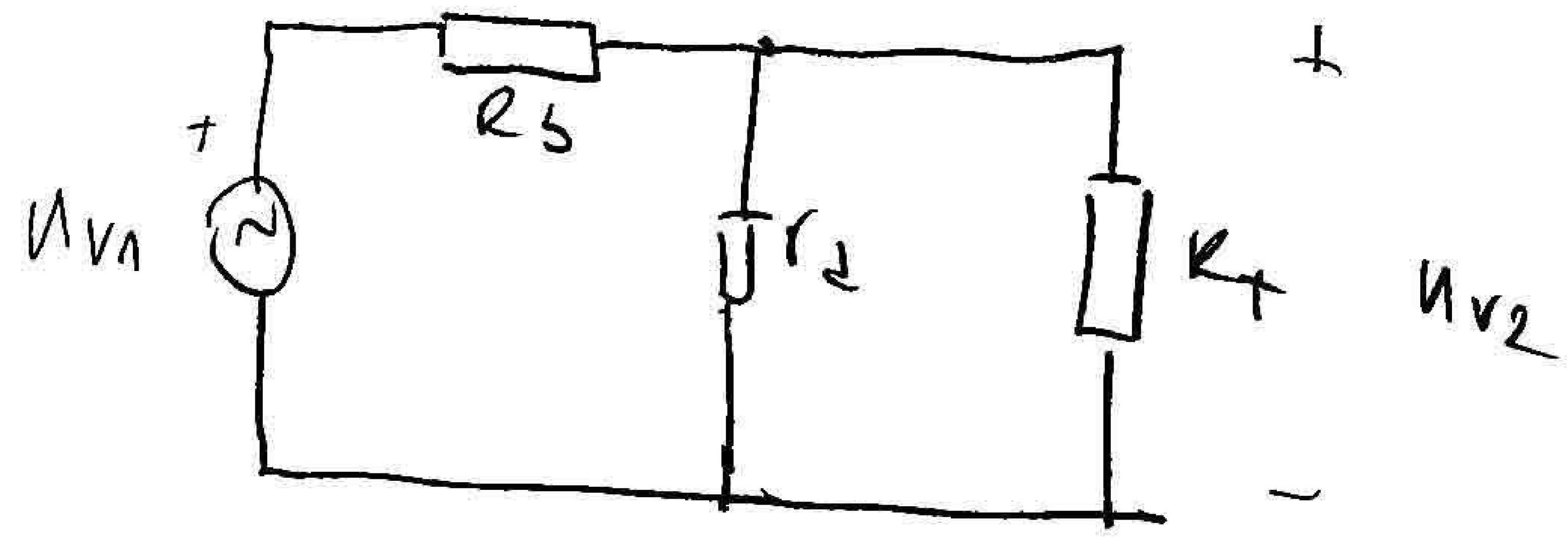
$$K_u = \frac{\frac{du_1}{u_1}}{\frac{du_2}{u_2}}$$

STRUJNA STAB.



$$\boxed{K_i = \frac{\frac{dR_T}{R}}{\frac{du_2}{u_2}}}$$

GUŠENJE NAPONA VALOVITOSTI



$K_V =$

$$K_u = \frac{\frac{\Delta u_1}{u_1}}{\frac{\Delta u_2}{u_2}}$$ – koliko je relativna promj. stabiliziranog izl. napona u_2 manja od promj. ulaznog napona u_1

$K_u = ?$

(1) $$\frac{u_1-u_2}{R_S} = \frac{u_2-u_Z}{r_d} + \frac{u_2}{R_T} \quad / \, d \quad \text{(tot. dif.)} \; (u_1, u_2 \text{ var})$$

$$\frac{du_1}{R_S} - \frac{du_2}{R_S} = \frac{du_2}{r_d} + \frac{du_2}{R_T}$$

STB-3...

$$\frac{dU_1}{R_S} = dU_2\left(\frac{1}{r_d}+\frac{1}{R_T}+\frac{1}{R_S}\right)$$

$$\frac{dU_1}{dU_2} = \left(1+\frac{R_S}{r_d}+\frac{R_S}{R_T}\right) \quad / \frac{U_2}{U_1}$$

$$K_u = \frac{\frac{dU_1}{U_1}}{\frac{dU_2}{U_2}} = \frac{U_2}{U_1}\left(1+\frac{R_S}{r_d}+\frac{R_S}{R_T}\right) = \frac{15}{20}\left(1+\frac{333}{10}+\frac{333}{3000}\right) = \boxed{25{,}81}$$

$$K_i = \frac{\frac{\Delta R_T}{R_T}}{\frac{\Delta U_2}{U_2}}$$

– koliko je rel. promj. ~~stab~~ stab. izl. napona puta manja od rel. promj. tereta (R_T)

$\Rightarrow$ (1) / d (tot. dif.)
(U_2, R_T var.)

$$-\frac{dU_2}{R_S} = \frac{dU_2}{r_d} + \frac{dU_2 R_T - U_2\, dR_T}{R_T^2}$$

$$dU_2\left(\frac{1}{r_d}+\frac{1}{R_S}+\frac{1}{R_T}\right) = \frac{U_2}{R_T^2}\, dR_T$$

$$K_i = \frac{\frac{dR_T}{R_T}}{\frac{dU_2}{U_2}} = \frac{R_S R_T}{R_S}\left(\frac{1}{r_d}+\frac{1}{R_S}+\frac{1}{R_T}\right) =$$

$$= \frac{R_T}{R_S}\left(1+\frac{R_S}{r_d}+\frac{R_S}{R_T}\right)$$

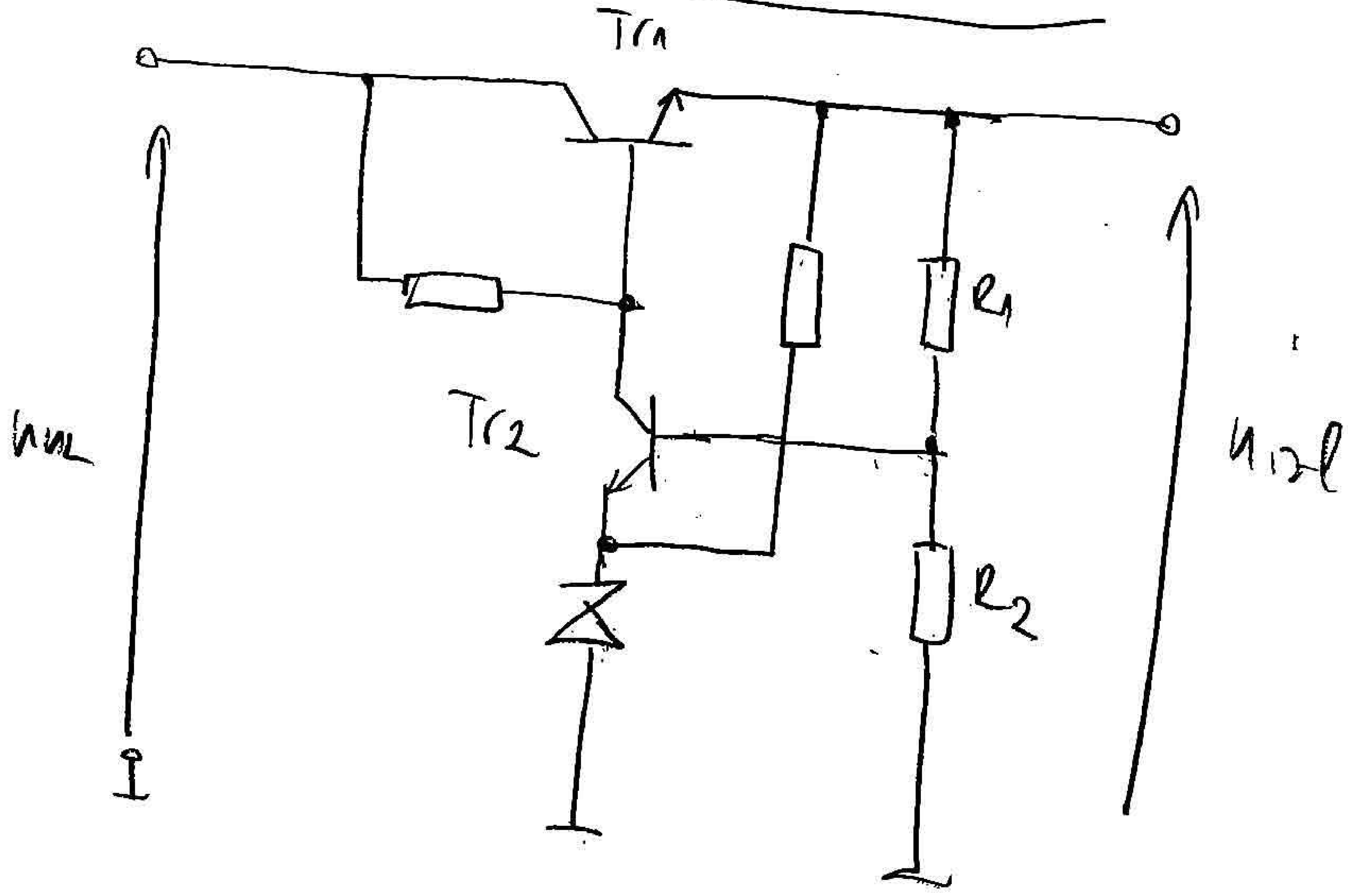
$$= \frac{3000}{333}\left(1+\frac{333}{10}+\frac{333}{3000}\right) = \boxed{310}$$

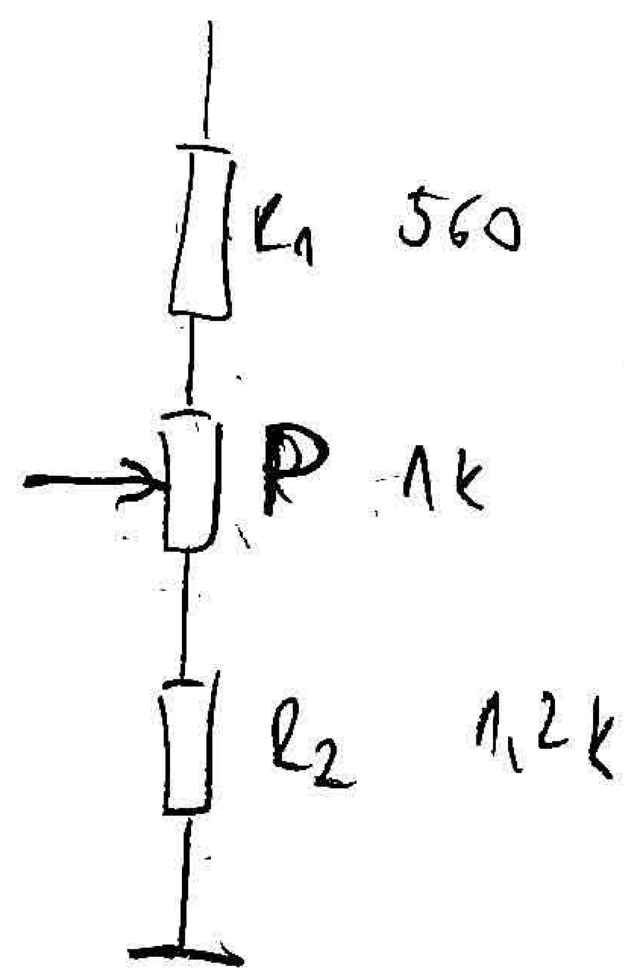
STB-4

Serijski stab. napona prikazan slikom koristi ZD nazivnog napona 5,6V kao izvor ref. napona.

a) Odredite omjer R_1/R_2 da bi U_{izl} bio 8V

b) odredite max i min vrijednost izlaznog napona ako se na bazu tranzistora Tr_2 dovede napon s klizača potenciometra $P = 1k\Omega$, spojenog između $R_1 = 560\Omega$ i $R_2 = 1,2k$





$$U_{izl} = U_Z + U_{BE_2} + \frac{R_1}{R_1+R_2} U_{izl}$$

$$U_{izl} = \frac{U_Z + U_{BE2}}{1 - \frac{R_1}{R_1+R_2}} = \frac{(U_Z + U_{BE2})(R_1+R_2)}{R_2}$$

a) $$\frac{R_2}{R_1+R_2} = \frac{U_Z + U_{BE2}}{U_{izl}}$$

$$\boxed{\frac{R_1}{R_2}} = \frac{U_{izl}}{U_Z+U_{BE2}} - 1 = \frac{8}{5,6+0,7} - 1 = \boxed{0,27}$$

b) $$\boxed{U_{izl\,MAX}} = (U_Z + U_{BE2}) \frac{R_1+R_2+P}{R_2} = \boxed{14,49V}$$

$$\boxed{U_{izl\,min}} = (U_Z + U_{BE2}) \frac{R_1+R_2+P}{R_2+P} = \boxed{7,9V}$$