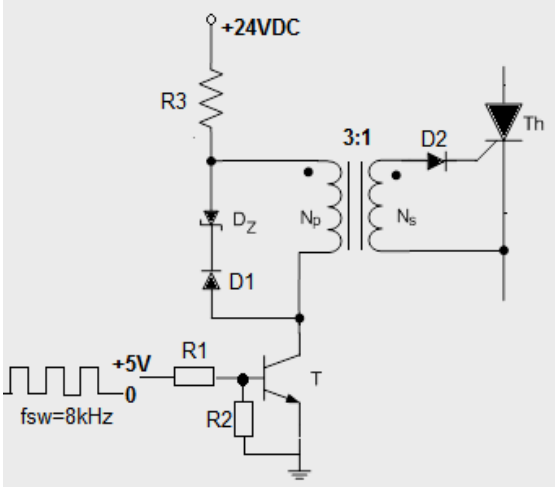
VISER- Master studije(elektrotehničko inženjerstvo) **predmet: PEEP 2018/2019**
REŠENJA ZADATAKA II kolokvijum

1 zadatak



Dimenzionisati pobudno kolo tiristora prikazano na slici (R1, R2, R3, V_Z) , uz pretpostavku da je u kolu gejta tiristora potrebno ostvariti struju od 1.8A pri naponu gejt-katoda od 4V.
Usvojiti da je pad napona na diodama 0.6V, napon V_{bes}=0.75V, napon V_{ces}=0.3V, pojačanje tranzistora h_{fe}=500. Induktivnost magnećenja impulsnog transformatora je 40mH, dok je njegova rasipna induktivnost zanemarljiva.

2 zadatak

Potrebno je projektovati DC/DC električni neizolovani pretvarač napona koji treba da radi u kontinualnom režimu za koji su dati ulazni podaci za projektovanje: (1) nominalni DC ulazni napon 220V ±10%, (2) izlazni napon 110VDC, (3) izlazna snaga 1kW, (4) talasnost struje prigušnice ≤ 20%, (5) talasnost izlaznog napona ≤ 0.1%, (6) radna učestanost 100kHz. Odrediti kritičnu induktivnost. Dimenzionisati prekidačke elemente prema MAX naponu koji moraju izdržati i prema srednjoj vrednosti struje. Zanemariti padove napona i komutacione gubitke na prekidačkim elementima, kao i unutrašnje otpornosti pasivnih elemenata. Smatrati da je opterećenje na izlazu približno konstantno

3 zadatak

Potrebno je projektovati DC/DC električni neizolovani pretvarač napona koji treba da radi u kontinualnom režimu, za koji su dati ulazni podaci za projektovanje: (1) nominalni DC ulazni napon 12V ±10%, (2) izlazni napon 24VDC, (3) izlazna snaga 500W, (4) talasnost struje prigušnice ≤ 5%, (5) talasnost izlaznog napona ≤ 0.1%, (6) radna učestanost 100kHz. Odrediti kritičnu induktivnost. Dimenzionisati prekidačke elemente prema MAX naponu koji moraju izdržati i prema srednjoj vrednosti struje. Za pad napona na diodi usvojiti da je V_γ= 0.6V. Zanemariti pad napona na prekidačkom tranzistoru i komutacione gubitke na prekidačkim elementima, kao i unutrašnje otpornosti pasivnih elemenata. Smatrati da je opterećenje na izlazu približno konstantno.

4 zadatak

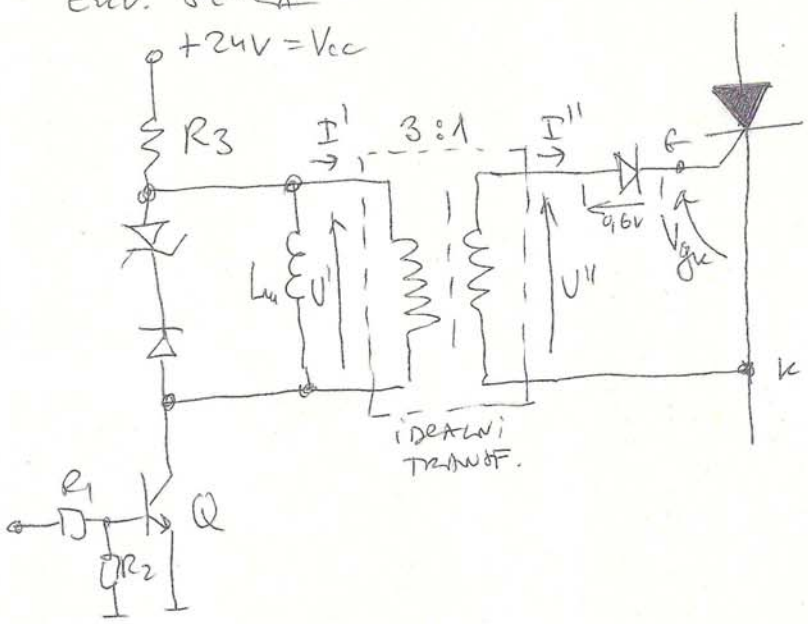
U kolu u zadatku 2 potrebno je LEM strujnim modulom meriti trenutnu vrednost struje prekidačkog tranzistora na osciloskopu. Na raspolaganju su LEM strujni senzori prenosnog odnosa 1:1000, napona napajanja ± 15V DC, ali različitih propusnih opsega 1MHz, 10MHz, 50MHz i 100MHz i opsega struja 0-10A, 25A, 50A, 100A. Povraćeno naelektrisanje diode kod isključenja je Qrr=500nC. Vreme oporavka diode je t_{rr} =25ns. Odabrati potreban LEM senzor, nacrtati šemu merenja struje i dimenzionisati merni otpornik na izlazu LEM modula tako da se na njemu obezbedi naponski signal 0-10VDC koji se vodi na ulaz osciloskopa radi merenja.

U Beogradu 26.01.2018, Predmetni profesor Dr Željko Despotović, dipl.el.nž.

1 ZADATAK:

$V_{gk} = 4V \quad I_{gk} = 1,8A$

Ekv. šema



$I'' = I_g$

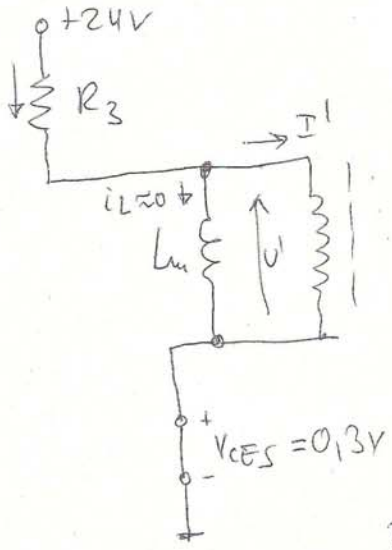
$U'' = V_D + V_{gk}$

$U'' = 0,6 + 4 = 4,6V$

$U' = 3 \cdot 4,6V = 13,8V$

$I' = \frac{1,8}{3} = 0,6A$

U INTERVALU kada je Q u stanju – „ON" Ekviv. šema je



$V_{cc} = R_3 I' + U' + V_{CES}$

$I' = I_g / N$

$V_{cc} = R_3 \frac{I_g}{N} + U' + V_{CES}$

$$\frac{V_{cc} - U' - V_{CES}}{\frac{R_3}{N}} > I_{g\,kr} = 1,8A$$

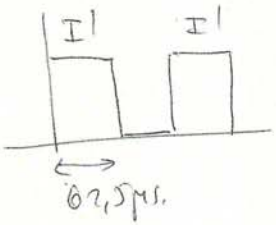
$$\frac{24 - 13,8 - 0,3V}{\frac{I_{g\,kr}}{N}} \geq R_3$$

$$\frac{24 - 13,8 - 0,3}{0,6} \geq R_3 \Rightarrow R_3 \leq \frac{9,9}{0,6} = 16,5\Omega$$

usvaja se $R_3^* = 16\Omega \Rightarrow I'^* = \frac{V_{cc} - U' - V_{CES}}{R_3^*}$

$$I'^* = \frac{24 - 13,8 - 0,3}{16} = 0,61875A$$

$I_{R3} \approx I^1$



$f_{sw} = 8\,kHz$

$T = \frac{1}{8000} = 125\,\mu s$

$T/2 = 62{,}5\,\mu s$

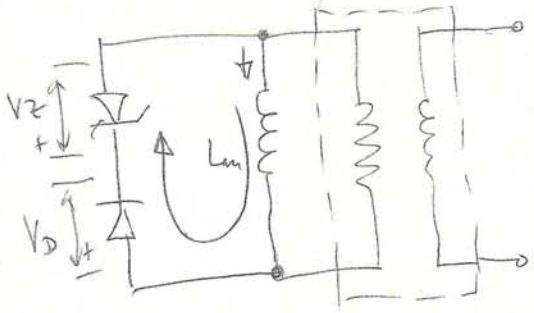
$I_{R3eff} = \frac{I^1}{\sqrt{2}} = \frac{0{,}6188}{1{,}41} = 0{,}4388\,A$

$P_{R3} = R_3 I_{R3eff}^2$

$P_{R3} = 16 \cdot 0{,}4388^2 = 3{,}08\,W \rightarrow$ Minimo $P_{R3} \geq 3\,W$

$\boxed{R_3 = 16\,\Omega / 3\,W}$

U interruttore quando Q (thyristor) "OFF" Equivalente

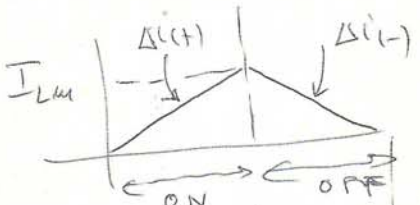


$L_m \cdot \Delta i_{(+)} = U^1 \cdot t_{on}$

$L_m = 40\,mH$

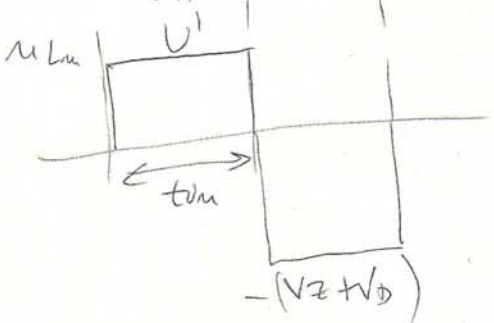
$\Delta i_{(+)} = I_{Lm} = \frac{U^1 \cdot t_{on}}{L_m}$

$I_{Lm} = \frac{13{,}8 \cdot 62{,}5\,\mu}{40\,m}$



$I_{Lm} = 0{,}02156\,A$

$\approx 21{,}56\,mA$



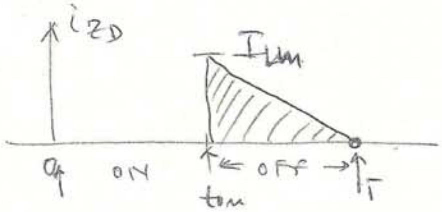
$L_m \Delta i_{(-)} = (V_z + V_D) \cdot t_{off}$

$t_{off} = \frac{L_m \Delta i_{(-)}}{V_z + V_D} \leq 62{,}5\,\mu s.$

$V_z + V_D \geq \frac{L_m \Delta i_{(-)}}{62{,}5\,\mu s}$

$V_z + V_D \geq \frac{40\,m \cdot 21{,}56\,m}{62{,}5\,\mu} \geq 13{,}7984\,V$

$V_z \geq 13{,}198\,V \qquad V_z^* = 15\,V$



$i_{ZDSR} = \frac{I_{Lm} \cdot t_{off}}{2 \cdot T} = \frac{I_{Lm}}{2} \delta$

$\delta = 0,5$

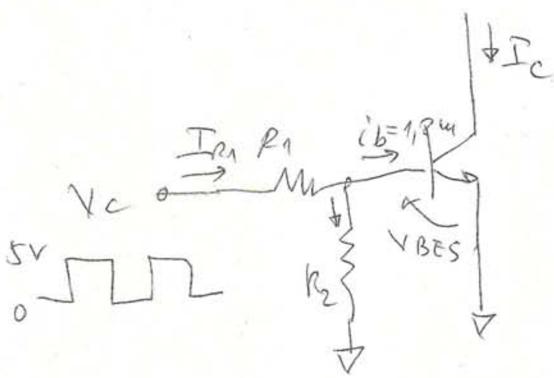
$I_{ZDSR} = \frac{I_{Lm}}{4} = \frac{21,56}{4} mA = 5,39 mA$

$P_{ZD} = V_{ZD} \cdot I_{ZDSR} = 15 \cdot 5,39 = 80,85 mW$

* Mora se odabrati 15V/100mW

Struja kolektora tranzistora $I_C \approx I' = 0,6A$ $\quad \beta_f = h_{FE} = 500$

Struja baze $i_b \geq \frac{I_C}{\beta_f} \Rightarrow i_b \geq \frac{0,6}{500} = 1,2 mA$



$\frac{V_C - V_{BES}}{I_{R1}} = R_1$

Za odabranu vrijednost $R_2 = 2k$

$I_{R2} = \frac{V_{BES}}{R_2}$

$I_{R1} = I_{R2} + i_b$

$\frac{V_C - V_{BES}}{R_1} = \frac{V_{BES}}{R_2} + i_b \Rightarrow i_b \geq 1,2 mA.$

$\frac{V_C - V_{BES}}{R_1} - \frac{V_{BES}}{R_2} \geq 1,2 mA \qquad \frac{V_{BES}}{R_2} = \frac{0,75V}{10k} = 0,075 mA$

$\frac{V_C - V_{BES}}{R_1} \geq 1,2 mA + 0,075 mA = 1,275 mA$

$R_1 \leq \frac{V_C - V_{BES}}{1,275 mA} = \frac{5 - 0,75}{1,275 \cdot 10^{-3}} = 3,333 k\Omega$

Usmerjač je $R_1 = 3k\Omega$

$I_{R1} = 1{,}275\,mA$ $\quad I_{R1ef} = \frac{1{,}275\,mA}{1{,}41} = 0{,}9\,mA$

$P_{R1} = R_1 I_{R1ef}^2 = 3000 \cdot (0{,}9)^2 \cdot 10^{-6} = 0{,}0243\,W$

$= 2{,}43\,mW$

Izaberemo vrednosti

$R_1 = 3k\Omega / 250\,mW$ $\quad R_2 = 10k / 250\,mW$ $\quad R_3 = 16\Omega / 3W$

2 TRADITAL

$V_{in} = 220V \pm 10\%$

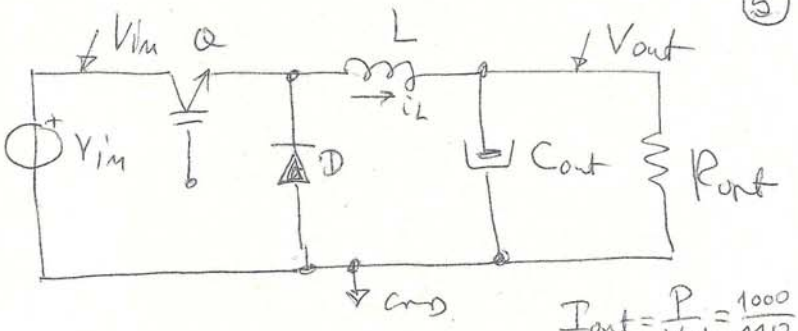
$V_{out} = 110V$

$P_{out} = 1000W$

$\Delta i_L\% \leq 5\%$

$\Delta u_c\% \leq 0,1\%$

$f_{sw} = 100kHz$



$I_{out} = \frac{P}{V_{out}} = \frac{1000}{110}$

$V_{in\,max} = 220 \cdot 1,1 = 242V$ $\quad V_{out} = 110V$

$V_{in\,min} = 220 \cdot 0,9 = 200V$ $\quad R_{out} = \frac{110V}{I_{out}}$

$I_{out} = 9,1A$

$R_{out} = \frac{110}{9,1} = 12,1\Omega$

$200Vdc \leq V_{in} \leq 242V\,dc$

$\delta = \frac{V_{out}}{V_{in}}$ $\quad V_{in} \to max$ $\quad \delta \to \delta_{min}$ $\quad V_{out} \approx cost.$

$V_{in} \to min$ $\quad \delta \to \delta_{max}$ $\quad V_{out} \approx cost$

$$0,55 \leq \delta \leq 0,4545$$

$\delta_{min} = \frac{V_{out}^{min}}{V_{in\,max}} = \frac{110}{242} = 0,4545$

$\delta_{max} = \frac{V_{out}^{max}}{V_{in\,min}} = \frac{110}{200} = 0,55$

Dimensionamento induttanza:

$L_c = \frac{(1-\delta)}{2 f_{sw}} \cdot R_{out}$ $\quad \delta \to \delta_{min}$

$L_c = \frac{(1-0,4545) \cdot 12,1}{2 \cdot 100 \cdot 10^3} = 33\mu H$

Dimensionamento induttanza L:

$L \cdot \Delta i_{(+)} = (V_{in} - V_{out})\, t_{on}$

$L\,\Delta i_{(-)} = -V_{out} \cdot t_{off}$

$I_{LSR} = I_{out} = 9,1A$

$\Delta i\% = \frac{\Delta i}{I_{LSR}} \cdot 100 \leq 20\%$

$\Delta i \leq \frac{20 \cdot I_{LSR}}{100} = 0,2\, I_{LSR}$

$\Delta i \leq 0,2 \cdot 9,1$

$\Delta i \leq 1,82A$

$$\Delta i = \frac{(V_{in} - V_{out}) \cdot t_{on}}{L} \leq 1{,}82\,A$$

$$V_{out} = \delta V_{in} \qquad t_{on} = \delta T \qquad T = \frac{1}{f_{sw}}$$

$$\Delta i = \frac{\left(\frac{V_{out}}{\delta} - V_{out}\right)\delta T}{L} = \frac{V_{out}(1-\delta)\delta T}{\delta \cdot L}$$

$$\Delta i = \frac{V_{out}(1-\delta)}{f_{sw} \cdot L} \leq 1{,}82\,A$$

$$L \geq \frac{V_{out}(1-\delta)}{f_{sw} \cdot \Delta i} = \frac{110 \cdot (1 - \delta_{min})}{f_{sw} \cdot \Delta i}$$

$$L \geq \frac{110\,(1 - 0{,}4545)}{100 \cdot 10^3 \cdot 1{,}82} = \frac{60}{100 \cdot 10^3 \cdot 1{,}82} = 329{,}6\,\mu H$$

$$L \geq 330\,\mu H \rightarrow \text{valore commerciale } L^* = 350\,\mu H$$

$$\Delta i^* = \frac{V_{out}(1-\delta)}{f_{sw} \cdot L^*} = \frac{110(1 - 0{,}4545)}{100 \cdot 10^3 \cdot 0{,}35m} = 1{,}71\,A < 1{,}82\,A$$

$$I_{max_L} = I_{Load} + \Delta i^* = 9{,}1 + 1{,}71 = 10{,}814\,A$$

- Uscita da principale $L^* = 350\,\mu H / 12\,A$

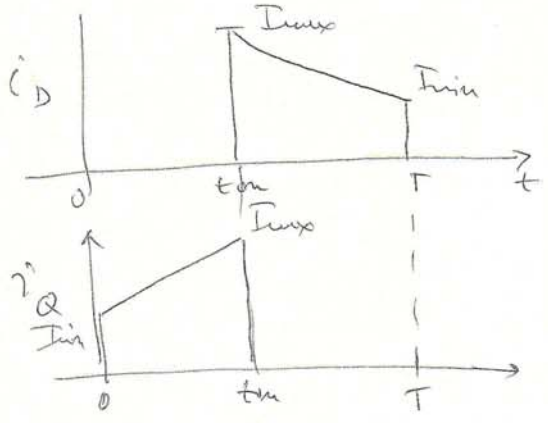
Dimensionamento condensatore:

$$C_{out} \geq \frac{1 - \delta_{min}}{8 \cdot L^* \cdot f_{sw}^2 \left(\frac{\Delta V_{out}}{V_{out}}\right)} \qquad \frac{\Delta V_{out}}{V_{out}} = \frac{9{,}1\%}{100} = 0{,}001$$

$$C_{out} \geq \frac{1 - 0{,}4545}{8 \cdot 350 \cdot 10^{-6} \cdot 100^2 \cdot 10^{-6} \cdot 10^{-3}} = \frac{1 - 0{,}5455}{28000}$$

$$C_{out} \geq 16{,}232\,\mu F \rightarrow \text{valore commerciale } C^* = 22\,\mu F$$

MAX, MYON condens. 160 i 200V $\rightarrow C^* = 22\,\mu F / 160\,V_{dc}$



$$T = \frac{1}{f_{sw}} = \frac{1}{100k} = 10\mu s$$

$$I_{DSR} = \frac{I_{max} + I_{min}}{2} \cdot t_{on} \cdot \frac{1}{T}$$

$$I_{DSR} = I_{LSR} \cdot (1-\delta) T \cdot \frac{1}{T}$$

$$I_{LSR} = 9,1A$$

$$I_{DSR_{max}} = I_{LSR}(1-\delta_{min}) \cdot T \cdot \frac{1}{T}$$

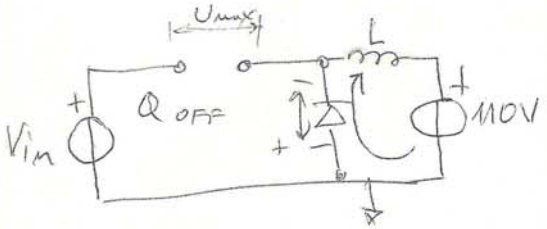
$$I_{DSR_{max}} = 9,1(1-0,4545)$$

$$I_{DSR_{max}} = 4,96A \rightarrow 5A$$

$$I_{QSR_{max}} = \delta I_{LSR} = \delta_{max} \cdot I_{LSR}$$

$$I_{QSR_{max}} = 0,55 \cdot 9,1 = 5,05 \rightarrow 5,1A$$

MAX NAPON NA KONDENZATORU JE JEDNAK KADA JE ON ISKLJUČEN (ODNOSNO U REŽIMU „OFF")

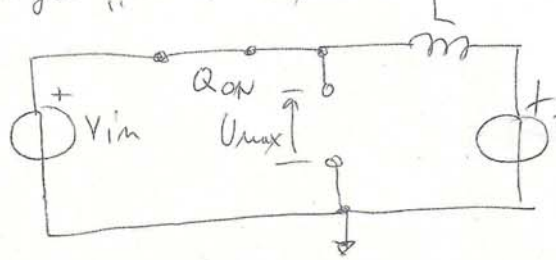


$$U_{max_Q} = V_{in} + V_D$$

$$U_{max\,Q} = 110 + 96 = 110,6V$$

IZABRATI KONDENZATOR 15A/300V

MAX NAPON NA DIODI JE JEDNAK KADA PROVODI KONDENZATOR (KRUG „ON - state")



$$U_{max_D} \approx V_{in} = V_{in_{max}}$$

$$= 242V$$

IZABRATI DIODU 15A/300V

3 GRANDEZZE:

$V_{in} = 12V \pm 10\%$

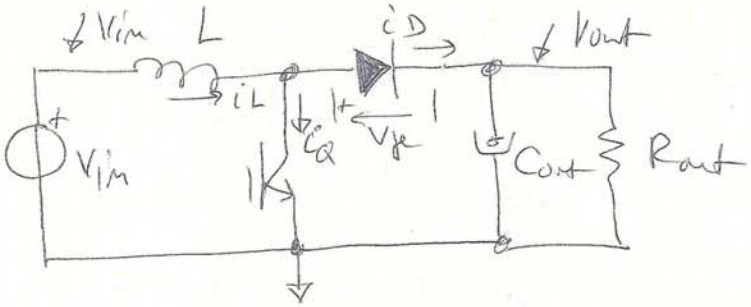
$V_{out} = 24V_{DC}$

$P_{out} = 500W$

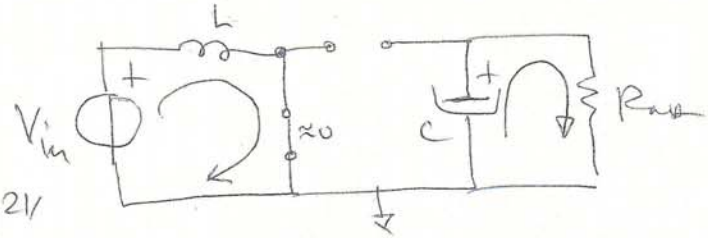
$\Delta i_L \% \leq 5\%$

$\Delta V_{out}\% \leq 0{,}1\%$

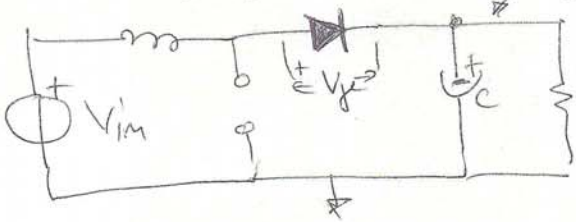
$f_{sw} = 100kHz$



stage "interval ton"



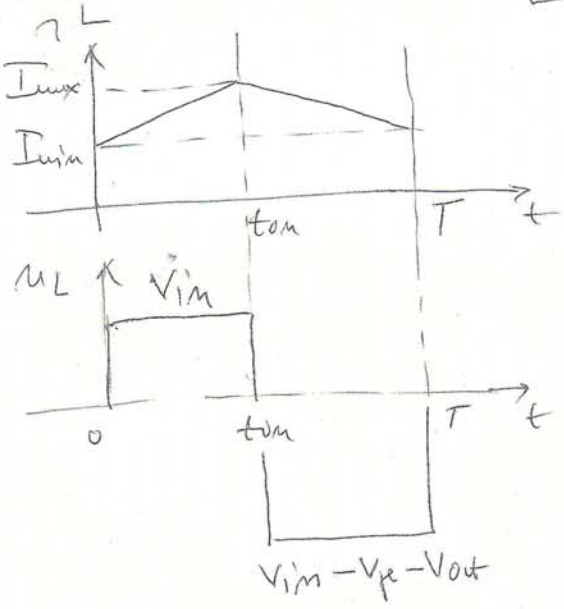
stage "interval toff"



$V_{in\,max} = 12 \cdot 1{,}1 = 13{,}2V$

$V_{in\,min} = 12 \cdot 0{,}9 = 10{,}8V$

$10{,}8V \leq V_{in} \leq 13{,}2V$



$L\Delta i_{(+)} = V_{in} \cdot t_{on}$

$L\Delta i_{(-)} = (V_{in} - V_F - V_{out})\, t_{off}$

$|\Delta i_{(+)}| = |\Delta i_{(-)}| = \Delta i$

$V_{in}\, t_{on} = (V_{out} + V_F - V_{in})\, t_{off}$

$V_{out} + V_F = V_{out}^*$

$V_{in} \cdot t_{on} = (V_{out}^* - V_{in})\, t_{off}$

$t_{on} + t_{off} = T$

$V_{in} \cdot \delta T = (V_{out}^* - V_{in})(1-\delta) T$

$V_{in} \cdot \delta = (V_{out}^* - V_{in})(1-\delta)$

$V_{out}^* = \dfrac{V_{in}}{1-\delta} \Rightarrow \boxed{V_{out} = \dfrac{V_{in}}{1-\delta} - V_F}$

$V_{out} = 24V$ $\quad V_{out} + V_f = 24,6V = V_{out}^*$

$V_{out}^* = \frac{V_{in}}{1-\delta} = cost$ $\quad V_{in} \to V_{in\,min}$ $\quad \delta \to \delta_{max}$

$V_{in} \to V_{in\,max}$ $\quad \delta \to \delta_{min}$.

$V_{in} = (1-\delta) \cdot cost.$

$V_{in} \uparrow \quad 1-\delta \uparrow \quad \delta \downarrow$

$V_{in} \downarrow \quad 1-\delta \downarrow \quad \delta \uparrow$

2A:

$V_{in\,min} = 10,8V$

$1-\delta = \frac{V_{in\,min}}{V_{out}^*} = \frac{10,8}{24,6}$

$\delta_{max} = 1 - \frac{10,8}{24,6} = 0,56$

2A: $V_{in\,max} = 13,2V$ $\quad 1-\delta = \frac{V_{in\,max}}{V_{out}^*} = \frac{13,2}{24,6}$

$\delta_{min} = 1 - \frac{13,2}{24,6} = 0,4634$

Sincrono mentre singolo diodo:

$I_{DSR} = I_{out}$ $\quad (I_{GSR} = 0)$

$I_{DSR} = \frac{P_{out}}{V_{out}} = \frac{500W}{24V} = 20,83A$

Ausiliario diodo:

$P_{jD} \simeq V_f \cdot I_{DSR} = 0,6 \cdot 20,833 = 12,5\,W$

$P_{in} = P_{out} + P_{jD} = 500 + 12,5 = 512,5W$

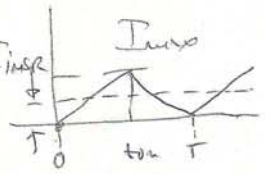
$V_{in} = \frac{P_{in}}{I_{in}}$ TD. $I_{in} = \frac{P_{in}}{V_{in}}$

$I_{in\,max} = \frac{P_{in}}{V_{in\,min}} = \frac{512,5W}{10,8V} = 47,45A$

$I_{in\,min} = \frac{P_{in}}{V_{max}} = \frac{512,5W}{13,2V} = 38,825A$

Verificare induttanza L_c:

$$I_{max} = I_{min} + \frac{V_{in} \cdot t_{on}}{L} \qquad I_{min} = 0$$



$$I_{max} = \frac{V_{in} \cdot t_{on}}{L_c} \qquad I_{max} = 2 I_{insr}$$

$$2 I_{insr} = \frac{V_{in} \cdot t_{on}}{L_c} \Rightarrow L_c = \frac{V_{in} \cdot t_{on}}{2 I_{insr}}$$

$$L_c = \frac{V_{in}\, t_{on}}{2 I_{insr}} = \frac{V_{in} \cdot \delta T}{2 I_{insr}} = \frac{V_{in} \cdot \delta}{2 f_{sw} \cdot I_{insr}}$$

- Za ul. napon $V_{in} = V_{inmin} = 10{,}8\,V$ $\delta = \delta_{max} = 0{,}56$
  i $I_{insr} = I_{in\,max}$ tamo da se

$$L_{c1} = \frac{10{,}8 \cdot 0{,}56}{2 \cdot 100 \cdot 10^3 \cdot 47{,}45\,A} = 0{,}63\,\mu H$$

- Za ul. napon. $V_{in} = V_{inmax} = 13{,}2\,V$, $\delta = \delta_{min} = 0{,}4634$
  $I_{in} = I_{in\,min}$

$$L_{c2} = \frac{13{,}2 \cdot 0{,}4634}{2 \cdot 100 \cdot 10^3 \cdot 38{,}875}$$

$$L_{c2} = 0{,}787\,\mu H$$

$$L_c = 0{,}787\mu \longrightarrow \underline{L_c^* = 1\,\mu H}$$

Dimenzionisanje prigušnice L

$$V_{in} \cdot t_{on} = L \Delta i \Rightarrow \Delta i = \frac{V_{in}\, t_{on}}{L} = \frac{V_{in} \cdot \delta T}{L}$$

$$\Delta i = \frac{V_{in}\,\delta}{f_{sw} \cdot L} \leq 2{,}37\,A \qquad \Delta i = \frac{5\%}{100} \cdot I_{in\,max}$$

$$\Delta i = 0{,}05 \cdot 47{,}45\,A$$

$$\Delta i = 2{,}37\,A$$

$$L \geq \frac{V_{in} \cdot \delta}{f_{sw} \cdot \Delta i}$$

$$L \geq \frac{V_{imin} \cdot \delta_{max}}{f_{sw} \cdot \Delta i_{max}} = \frac{10,8 \cdot 0,56}{100 \cdot 10^3 \cdot 2,37} = 75,5\mu H$$

$$L' = \frac{V_{imax} \cdot \delta_{min}}{f_{sw} \cdot \Delta i_{min}} \qquad \Delta i_{min} = 0,05 \cdot 38,875 = 1,94$$

$$L' = \frac{13,2 \cdot 0,4634}{100 \cdot 10^3 \cdot 1,94} = 31,5\mu H$$

usvaja se veće $L^* = 35\mu H$

za $L^* = 35\mu H$ $\quad \Delta i_{min} = \frac{V_{imax} \cdot \delta_{min}}{f_{sw} \cdot L^*} = \frac{13,2 \cdot 0,4634}{100k \cdot 35\mu}$

$$\Delta i_{min} = 1,74A$$

za $L^* = 35\mu H$ $\quad \Delta i_{max} = \frac{V_{imin} \cdot \delta_{max}}{f_{sw} \cdot L^*}$

$$\Delta i_{max} = \frac{10,8 \cdot 0,56}{100 \cdot 10^3 \cdot 35\mu}$$

$$\Delta i_{max} = 1,728A$$

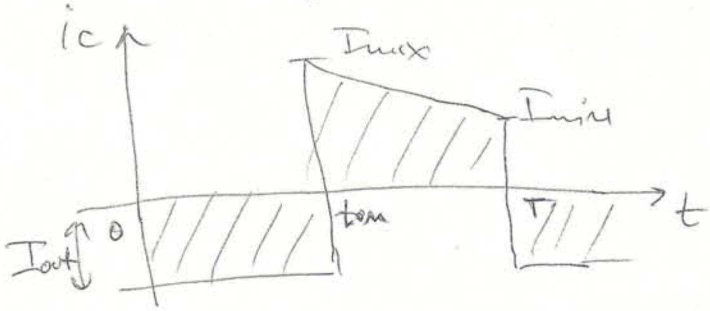
MAX struja prigušnice

$$I_{maxL} = I_{imax} + \frac{\Delta i_{max}}{2} = 47,45A + \frac{1,728}{2} = 48,3A$$

usvaja se prigušnica $I_{maxL} = 50A$

$$\boxed{L^* = 35\mu H / 50A}$$

Dimenzionisanje kond. C



$$I_{out}\cdot t_{on} = C\Delta V(t)$$

$$\frac{\Delta V}{V_{out}} = \frac{I_{out}\cdot t_{on}}{C\cdot V_{out}}$$

$$\frac{I_{out}\cdot t_{on}}{C\cdot V_{out}} \leq 0{,}001$$

kritični slučaj je kad je $t_{on}\to t_{onmax}$

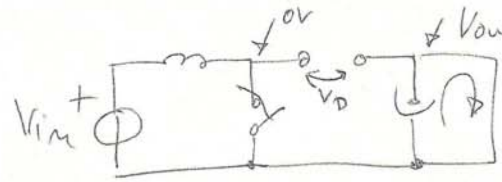
$t_{onmax} = \delta_{max}\cdot T = 5{,}6\mu s$

$$C \geq \frac{I_{out}\cdot t_{onmax}}{V_{out}\cdot 0{,}001} = \frac{20{,}83\cdot 5{,}6\mu}{24\cdot 0{,}001}$$

$$C \geq 4860\mu F \rightarrow 5600\mu F$$

- usvajamo $C^* = 5600\mu F/40V =$

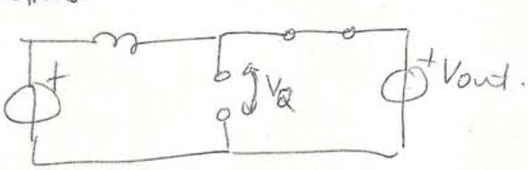
* maksimalna struja diode 30A (29,83A), max napon diode



$V_{Dmax} = V_{out} - 0 = V_{out}$

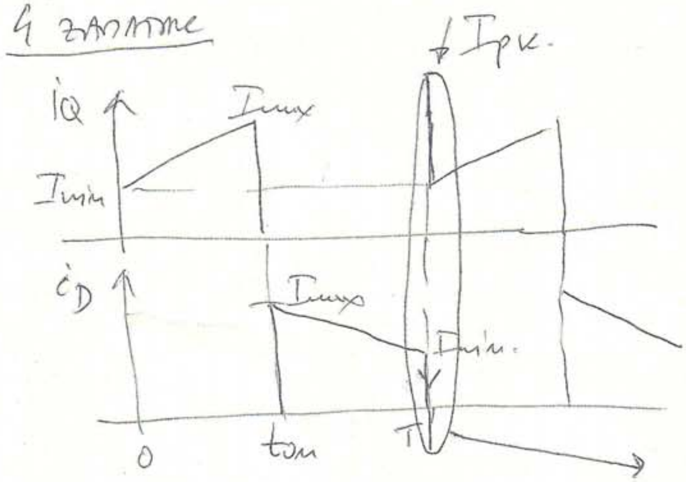
usvaja se dioda 30A/40V

* maks. struja tranzistora 50A, dok je max napon tranzistora V_{out}



usvaja se tranzistor 50A/40V

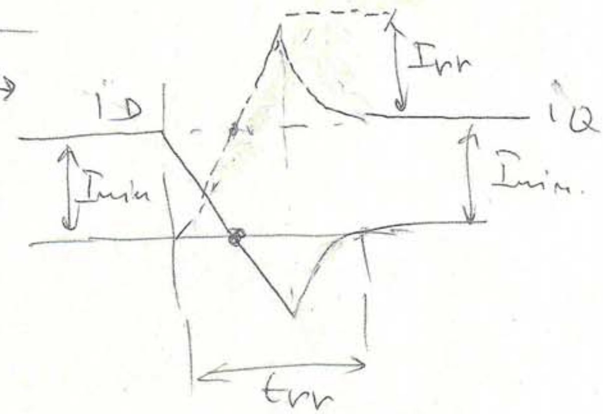
4 ZADATAK



$Q_{rr} = 500\mu C$

$t_{rr} = 25\mu s$

$\frac{1}{t_{rr}} = \frac{1}{25\mu s} \Rightarrow 40MHz.$



$I_{rr} = \frac{2Q_{rr}}{t_{rr}}$

$I_{rr} = \frac{2 \cdot 500mC}{25\mu s} = 40A$

$I_{Qmax} = I_{min} + I_{rr}$

$I_{min} = I_{max} - \Delta i$

$I_{min} = I_{sr} - \frac{\Delta i}{2}$
$= 9{,}1 - \frac{1{,}71}{2} = 8{,}245$

$I_{Qmax} = 8{,}245A + 40A$
$= 48{,}245A$

usvaja se LEM modul 50A/50MHz ili

LEM modul 100A/50MHz

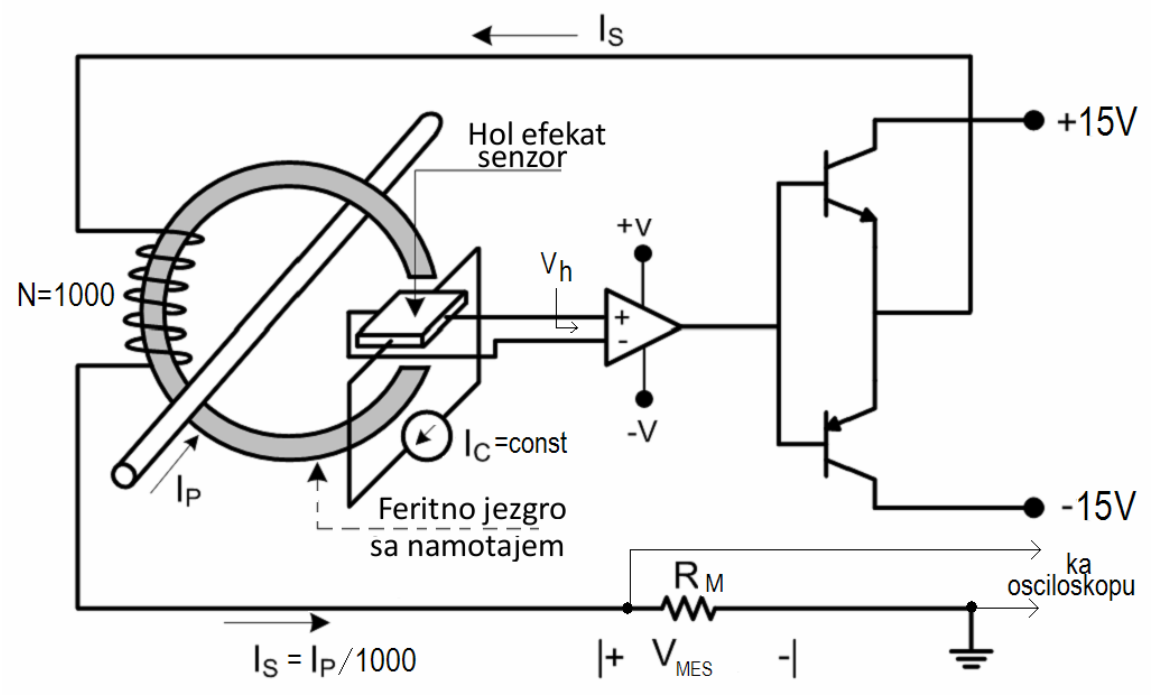
$V_{MES} = R_M \cdot \frac{I_p}{N_S} \Rightarrow R_M = \frac{V_{MES} \cdot N_S}{I_p} = \frac{10 \cdot 1000}{100}$

$R_M = 100\Omega \qquad \frac{I_p}{1000} = I_{mer} = \frac{100}{1000} = 100mA$

$P_{RM} = 100\Omega \cdot (100mA)^2 = 1W$ usvaja se $R_M = 100\Omega / 1W$ tačnost $< 0{,}5\%$

Za struju od 50A dobija se naponski signal $V_{MES} = 100 \cdot \frac{50}{1000} = 5V$ (signal 0–5V)

ELEKTRIČNA ŠEMA MERENJA



$$V_{MES} = R_M \cdot \frac{I_p}{1000} = 100\Omega \cdot \frac{50A}{1000} = 5V$$