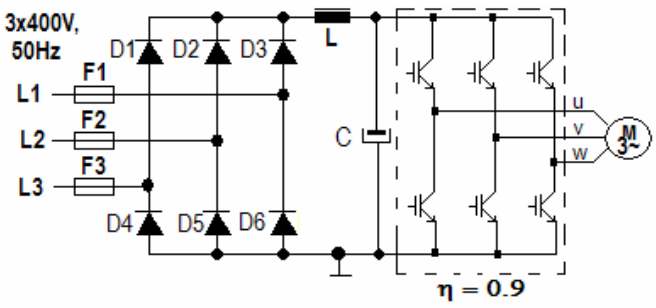
VISER- PEEP Master studije(elektrotehničko inženjerstvo) REŠENJA zadataka ISPIT JAN 2019

1. ZADATAK: Trofazni AC/AC pretvarač na Slici 1 se koristi za frekventnu regulaciju elektromotora čiji su podaci: 400V, 50Hz, 150A, 1485 ob/min, η =92%, $cos\varphi$ = 0.82. Stepen iskorišćenja trofaznog tranzistorskog pretvarača je η_p =90%. Za ulazni ispravljač su na raspolaganju diodni moduli SKKD100 čiji su tehnički podaci dati u Prilogu 1.

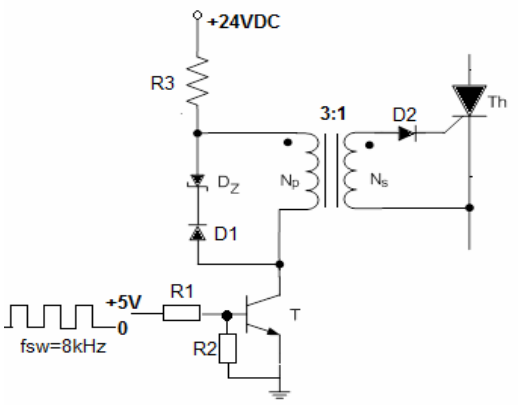


Slika 1- Trofazni AC/AC pretvarač

(a) Projektovati LC filtar u DC međukolu ako je zahtevana talasnost DC napona ≤ 1% i talasnost DC struje ≤ 20% .
(b) Projektovati sistem hlađenja diodnog ispravljača za temperaturni opseg okoline -25ºC...+40ºC, ako se pretpostavi da su svi moduli montirani na istom hladnjaku. Na raspolaganju je hladnjak tipa P3 i ventilator SKF-3-230-1 čiji su tehnički podaci dati u Prilogu 2. Za tako izabrani sistem hlađenja odrediti temperaturu na kućištu modula i temperaturu hladnjaka.
(c) Izvršiti izbor ulaznih osigurača ako su na raspolaganju osigurači dati u Tabeli 1.

Tabela 1

Osigurač	I^2t (A^2s)	I (A)	AC napon (V)	Vrsta prema brzini
Tip 1	16000	150	690	ultra brzi
Tip 2	15800	150	400	standardni
Tip 3	15500	200	690	ultrabrzi
Tip 4	10000	200	690	standardni
Tip 5	8000	200	440	standardni
Tip 6	30000	250	690	ultrabrzi
Tip 7	62000	315	690	ultrabrzi
Tip 8	2000	125	690	ultrabrzi



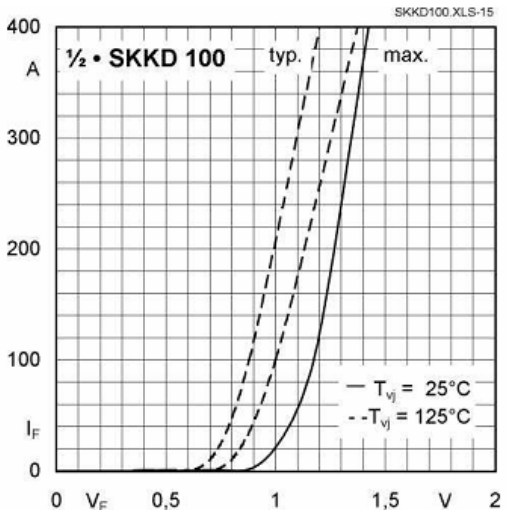
Slika 2-Pobudno kolo SCR

2. ZADATAK: Dimenzionisati pobudno kolo tiristora prikazano na Slici 2 (R1, R2, R3, Vz) , uz pretpostavku da je u kolu gejta tiristora potrebno ostvariti struju od 1.5A pri naponu gejt-katoda od 3V.
Usvojiti da je pad napona na diodama 0.7V, napon V_{bes}=0.75V, napon V_{ces}=0.2V, pojačanje tranzistora h_{fe}=360. Induktivnost magnećenja impulsnog transformatora je 30mH, dok je njegova rasipna induktivnost zanemarljiva.

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 110V ±10%, (2) izlazni napon 48VDC, (3) izlazna snaga 1kW, (4) talasnost struje prigušnice ≤ 10%, (5) talasnost izlaznog napona ≤ 0.1%, (6) radna učestanost 100kHz. (a) Odrediti kritičnu induktivnost. (b) Dimenzionisati pasivne (L i C) elemente i 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.

4. 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 600VDC, (3) izlazna snaga 4kW, (4) talasnost struje prigušnice ≤ 10%, (5) talasnost izlaznog napona ≤ 0.1%, (6) radna učestanost 100kHz. (a) Odrediti kritičnu induktivnost. (b) Dimenzionisati prekidačke elemente prema MAX naponu koji moraju izdržati i prema srednjoj vrednosti struje. 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.

PRILOG 1-Karakteristike dioda

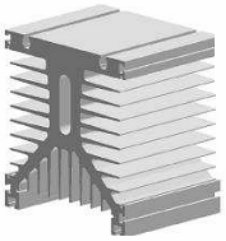


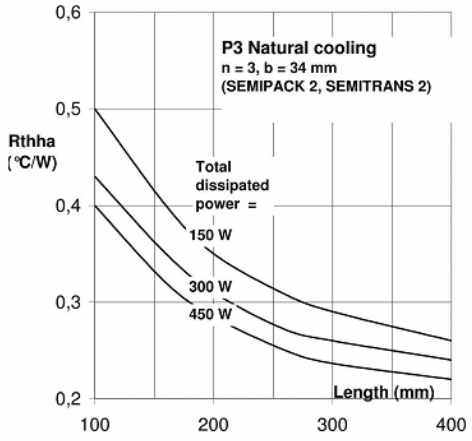
V_{RSM} V	V_{RRM} V	I_{FRMS} = 175 A (maximum value for continuous operation) I_{FAV} = 100 A (sin. 180; T_c = 85 °C)		
500	400	SKKD 100/04		
900	800	SKKD 100/08		
1300	1200	SKKD 100/12		
1500	1400	SKKD 100/14		
1700	1600	SKKD 100/16		
1900	1800	SKKD 100/18		

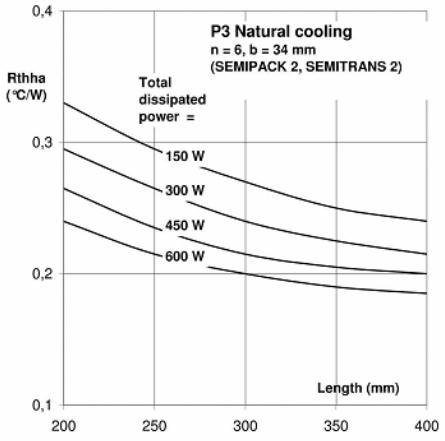
Symbol	Conditions	Values	Units
I_{FAV}	sin. 180; T_c = 85 (100) °C	100 (67)	A
I_D	P3/180; T_a = 45 °C; B2 / B6	73 / 91	A
	P3/180F; T_a = 35 °C; B2 / B6	150 / 190	A
I_{FSM}	T_{vj} = 25 °C; 10 ms	2500	A
	T_{vj} = 125 °C; 10 ms	2000	A
i^2t	T_{vj} = 25 °C; 8,3 ... 10 ms	31250	A^2s
	T_{vj} = 125 °C; 8,3 ... 10 ms	20000	A^2s
$R_{th(j-c)}$	per diode / per module	0,35 / 0,175	K/W
$R_{th(c-s)}$	per diode / per module	0,2 / 0,1	K/W
T_{vj}		- 40 ... + 125	°C
T_{stg}		- 40 ... + 125	°C

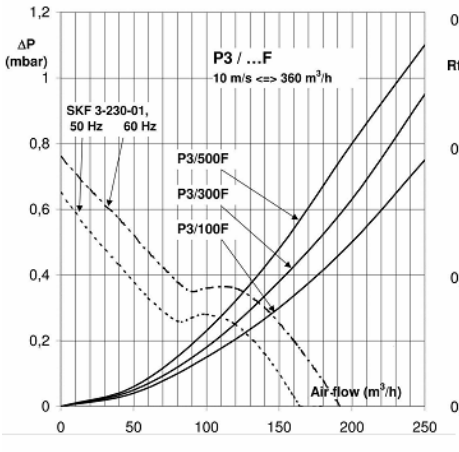
PRILOG 2- Karakteristike hladnjaka i ventilatora

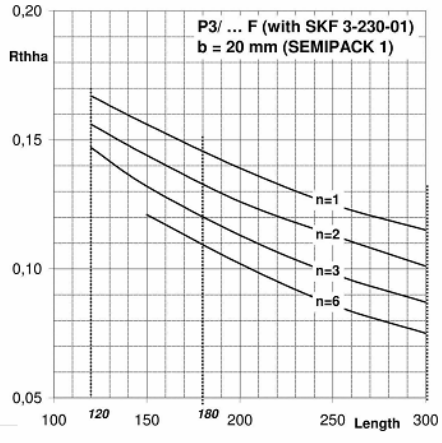
Standard lengths	n	b / d Ø mm	R_{thha} natural cooling K/W	R_{thha} with Fan SKF 3-230-01 K/W	w kg
P 3/120	1	20	0,55 (100W)	0,167	2,1
	3		0,43 (150W)	0,147	
P 3/180	2	20	0,39 (150W)	0,132	3,1
	3		0,36 (180W)	0,12	
	6		0,33 (200W)	0,108	
	1	34		0,144	
	3			0,118	
P 3/300	3	34		0,0847	5,3

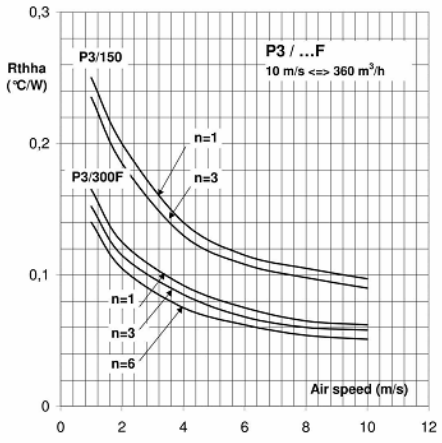




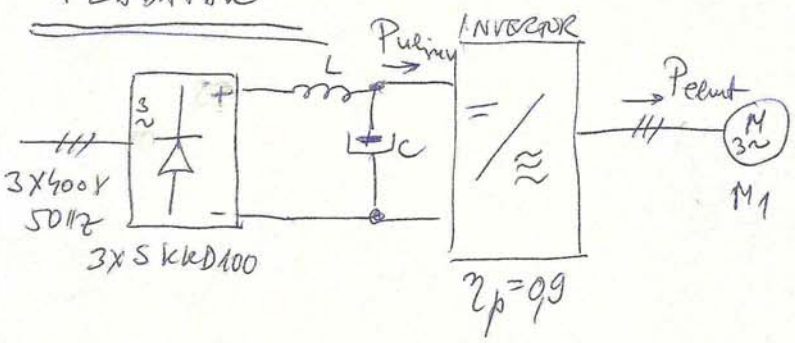








1 ZADATAK

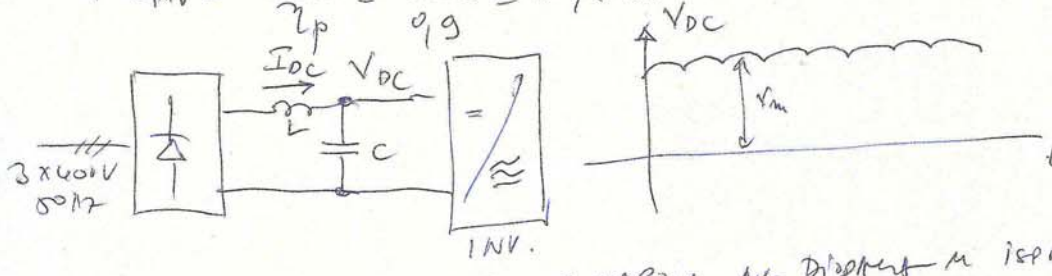


$\eta_p = 0{,}9$

M_1:
$U_n = 400\,V$
$f_n = 50\,Hz$
$I_n = 150\,A$
$n_n = 1485$ o/min
$\eta_n = 92\,\%$
$\cos\varphi_n = 0{,}92$

$P_{elmt} = \sqrt{3}\,U_n I_n \cos\varphi_n = \sqrt{3}\cdot 400\cdot 150\cdot 0{,}92 = 85{,}1\,kW$ $\quad P_{MOT} = \eta_n \cdot P_{elmt} = 78\,kW$

$P_{ul\,inv} = \dfrac{P_{elmt}}{\eta_p} = \dfrac{85{,}11}{0{,}9} = 94{,}6\,kW$



$V_{DC} = \dfrac{3V_m}{\pi}$

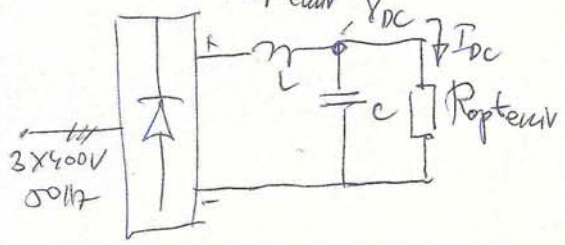
$V_{DC} = \dfrac{3\cdot\sqrt{2}\cdot 400\,V}{\pi}$

$V_{DC} = 538{,}85\,V$

Ako se uzme u obzir pad napona na diodama u ispravljaču $V_D = 2 \times V_{D1} =$

$V_D = 2 \times 1{,}2\,V \approx 2{,}4\,V \Rightarrow V_{DC}^* = \dfrac{3(\sqrt{2}\cdot 400 - 2\cdot 1{,}2\,V)}{\pi} = \dfrac{3\cdot 561{,}6}{\pi} = 536{,}56\,V$

$I_{DC} = \dfrac{V_{DC}^*}{R_{optemV}} \Rightarrow \dfrac{536{,}56\,V}{1763\,A} = R_{optemV}$ $\quad P_{DC} = P_{ul\,inv} = 94{,}6\,kW$



$P_{DC} = (V_{DC}^*)\cdot I_{DC} \Rightarrow I_{DC} = \dfrac{P_{DC}}{V_{DC}^*} = \dfrac{94{,}6\,k}{536{,}56\,V}$

$I_{DC} = 176{,}3\,A$

$R_{optemV} = \dfrac{536{,}56}{176{,}3} = 3{,}043\,\Omega$

$U_{ispr.} = V_{DC}^* + \dfrac{6V_m}{35}\cos 6\omega t - \dfrac{6V_m}{143\pi}\cos 12\omega t - \ldots$

$U_{ispr} \approx V_{DC}^* + \underbrace{\dfrac{6V_m}{35\pi}}_{U_m^{(6)}}\cos 6\omega t$

$V_{DC}^* = 536{,}56\,V$

$U_m^{(6)} = \dfrac{6V_m}{35\pi} = \dfrac{6\cdot(\sqrt{2}\cdot 400\,V - 2{,}4\,V)}{35\pi}$

$U_m^{(6)} = 30{,}66\,V$

a) * IZBOR kondenzatorja C v "LC" FILTRU

$$C \geq \frac{1}{\eta \cdot \omega \cdot R_{potenc}} \cdot \frac{\delta_i}{\delta_u}$$

$\eta = 6$ (šestpulzno vezje)

$\omega = 2\pi f = 2\pi \cdot 50Hz = 314\ rad/s$

$R_{potenc} = 3{,}043\,\Omega$

$\delta_i\% = 20\% \Rightarrow \delta_i = 0{,}2$

$\delta_u\% = 1\% \Rightarrow \delta_u = 0{,}01$

$$C \geq \frac{1}{6 \cdot 314 \cdot 3{,}043} \cdot \frac{20}{1}$$

$C \geq 3488{,}56\,\mu F$

Mi izberemo $\boxed{C^* = 3600\,\mu F / 800\,V_{DC}}$

kritična induktivnost: $L_{kr} = \frac{R_{potenc}}{105\omega} = \frac{3{,}043}{105 \cdot 314} = 92{,}3\,\mu H$

* IZBOR INDUKTIVNOSTI FILTRA

$L \gg L_{kr}$

$$\frac{\Delta I_L^{(6)}}{I_{DC}} = \frac{4 R_{potenc}}{3\sqrt{5}} \cdot \frac{6\omega C^*}{(6\omega)^2 L C^* - 1} \leq 0{,}2 \quad \text{oziroma}$$

$$L \geq \frac{1}{(6\omega)^2 C^*} \cdot \frac{4 R_{potenc} \cdot 6\omega C^*}{3\sqrt{5} \cdot 0{,}2} + \frac{1}{(6\omega)^2 C^*}$$

$$L \geq \frac{4 R_{potenc}}{3\sqrt{5}} \cdot \frac{1}{6\omega} \cdot \frac{1}{0{,}2} + \frac{1}{(6\omega)^2 \cdot C^*}$$

$$L \geq \frac{4 \cdot 3{,}043}{3\sqrt{5}} \cdot \frac{1}{6 \cdot 314} \cdot \frac{1}{0{,}2} + \frac{1}{(6 \cdot 314)^2 \cdot 3{,}6 \cdot 10^{-3}}$$

$L \geq 0{,}000922\,H + 0{,}000078259$

$L \geq 0{,}922\,mH + 0{,}078\,mH \approx 1\,mH \rightarrow$ Mi izberemo $L^* = 1\,mH$

$I_{DC} = 176{,}3\,A \qquad \Delta I_{DC} = 0{,}2 \cdot 176{,}3 = 35{,}26\,A$

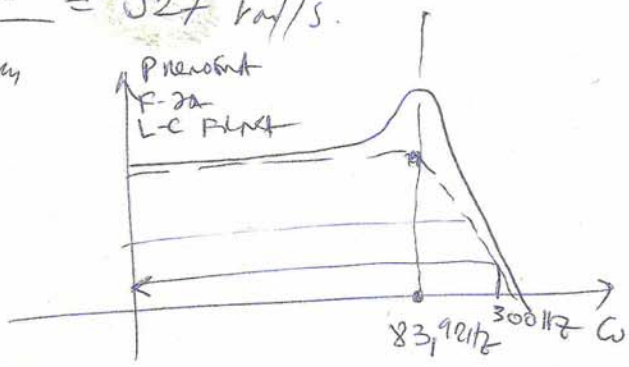
$I_{Lmax} = I_{DC} + \frac{\Delta I_{DC}}{2} = 176{,}3\,A + 17{,}63 = 194\,A \rightarrow 200\,A$

$\boxed{L^* = 1\,mH / 200\,A}$

Rezonantna učest. „LC" filtra

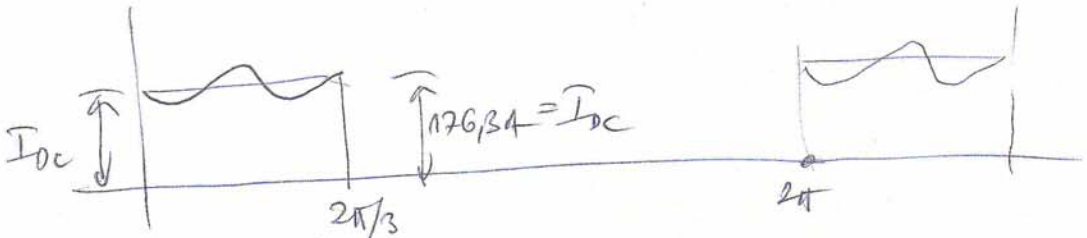
$$\omega_{rez} = \frac{1}{\sqrt{L^* \cdot C^*}} = \frac{1}{\sqrt{1m \cdot 3{,}6m}} = 527 \text{ rad/s}$$

$$f_{rez} = \frac{\omega_{rez}}{2\pi} = \frac{527}{6{,}28} = 83{,}92\text{Hz}$$



Filtar propušta niske učestanosti

b) Talasni oblik struje diode u kratkom



Srednja vrednost struje diode:

$$I_{DSR} = \frac{I_{DC}}{2\pi} \cdot \frac{2\pi}{3} = \frac{I_{DC}}{3} = \frac{176{,}3}{3} = 58{,}76\text{A}$$

Efektivna vrednost struje diode:

$$I_{Deff} = \sqrt{\frac{1}{2\pi} I_{DC}^2 \cdot \frac{2\pi}{3}} = \frac{I_{DC}}{\sqrt{3}} = \frac{176{,}3}{\sqrt{3}} = 102\text{A}$$

Disipacija na jednoj diodi:

$$P_{D1} = V_{T0} \cdot I_{DSR} + r_d \cdot I_{Deff}^2$$

r_D – dinamička otpornost diode

Sa grafika na I-V karakteristici (prilog-1) za karakteristiku MAX i pri MAX temp. $T_j = +125°C$ se očitava da je

$$V_{T0} = 1\text{V} \qquad r_D = \frac{1{,}4 - 1}{400 - 0} = 1\text{m}\Omega$$

$$P_{D1} = 1 \cdot 58{,}76 + 1m \cdot 102^2 = 58{,}76\text{W} + 10{,}4\text{W} = 69{,}16\text{W} \approx 70\text{W}$$

Ukupna disipacija svih 6 dioda

$$\Sigma P_D = 6 \cdot 70\text{W} = 420\text{W}$$

(4)

$T_{j\,max} = +125°C$ J – JUNCTION (spoj)

C – case (kućište)

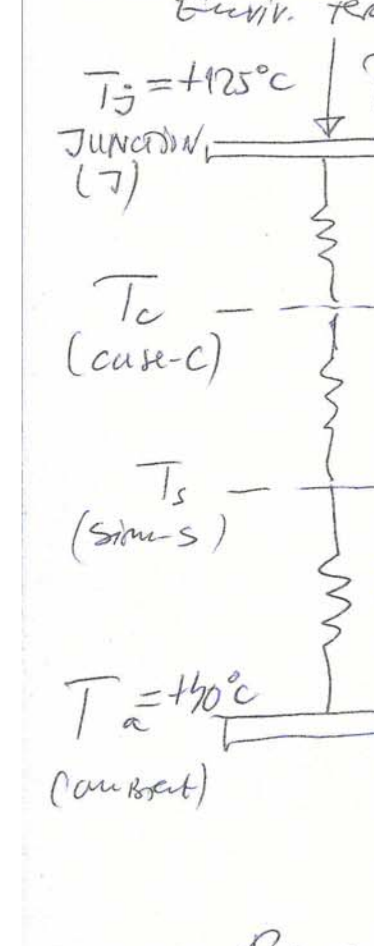
$T_{a\,max} = +40°C$ (MAX TEMP. OKOLINE) S – sink (hladnjak)

IZ PRILOGA-1 ZA TERMIČKE OTPORNOSTI KUĆIŠTA DIODA JE DOBIJENO

$R_{th(j-c)_1} = 0,35\,\frac{K}{W}$ (ZA JEDNU DIODU) – TERM. OTP. J–C

$R_{th(c-s)_1} = 0,2\,\frac{K}{W}$ (ZA JEDNU DIODU) – TERM. OTPOR. C–S

EKVIV. TERMIČKA ŠEMA:



$$\Sigma R_{th} = R_{th(j-c)e} + R_{th(c-s)e} + R_{th(s-a)}$$

$$\frac{R_{th(j-c)_1}}{6} = \frac{0,35}{6} = 0,0583\,\frac{K}{W} = R_{th(j-c)e}$$

$$\frac{R_{th(c-s)_1}}{6} = \frac{0,2}{6} = 0,0333\,\frac{K}{W} = R_{th(c-s)e}$$

$$\Sigma R_{th} \leq \frac{T_{j\,max} - T_{a\,max}}{P_{TOT}}$$

$$\Sigma R_{th} \leq \frac{125-40}{420} = 0,2\,\frac{K}{W}$$

$$R_{th(j-c)e} + R_{th(c-s)e} + R_{th(s-a)} \leq 0,2\,\frac{K}{W}$$

$$R_{th(s-a)} \leq 0,2 - 0,0583 - 0,0333 = 0,1084\,\frac{K}{W}$$

$$R^{*}_{th(s-a)} \leq 0,1\,\frac{K}{W}$$

PRIMENJUJE SE FORSIRANO HLAĐENJE I USVAJA SE HLADNJAK P3/300F I ZA USVOJENI VENTILATOR SKF 3-230-01/50HZ JE DOBIJEN RADNI PROTOK VAZDUHA OD $120\,\frac{m^3}{h} \rightarrow 3,3\,m/s$

ZA $n=3$ (3 MODULA) I ZA $3,3\,m/s$ ZA P3/300F JE DOBIJENO

$$R_{th(s-a)} = 0,09\,\frac{K}{W} \leq 0,1\,\frac{K}{W}$$

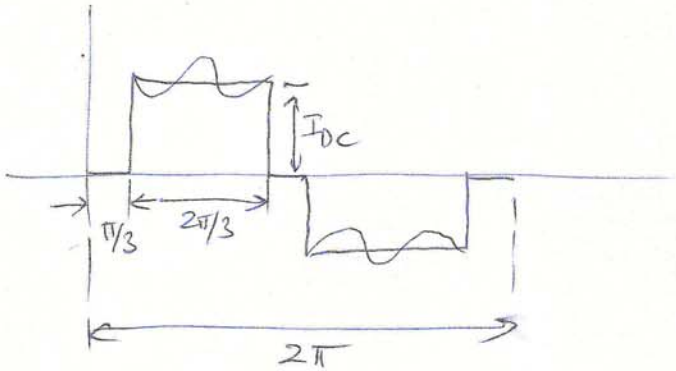
temperatura hladnjaka

$$T_s = T_{amax} + R_{th(s-a)} \cdot P_{TOT} = 40°C + 0{,}09\frac{K}{W} \cdot 420W = 77{,}8°C$$

temperatura ućišta

$$T_c = T_s + R_{th(c-s)e} \cdot P_{TOT} = 77{,}8°C + 0{,}033 \cdot 420 = 91{,}8°C$$

c) Efektivna vrednost linijske struje.



$$I_{Leff} = \sqrt{\frac{2 \cdot I_{DC}^2 \cdot \frac{2\pi}{3}}{2\pi}}$$

$$I_{Leff} = \sqrt{\frac{2}{3}}\, I_{DC}$$

$$I_{Leff} = 0{,}8164 \cdot 176{,}3A = 144A$$

Usvaja se osigurač za 150A (ULTRA-BRZI)

UBO – ULTRA BRZI osigurač

$$I^2 t_{(Dione)} \geq I^2 t_{(UBO)}$$

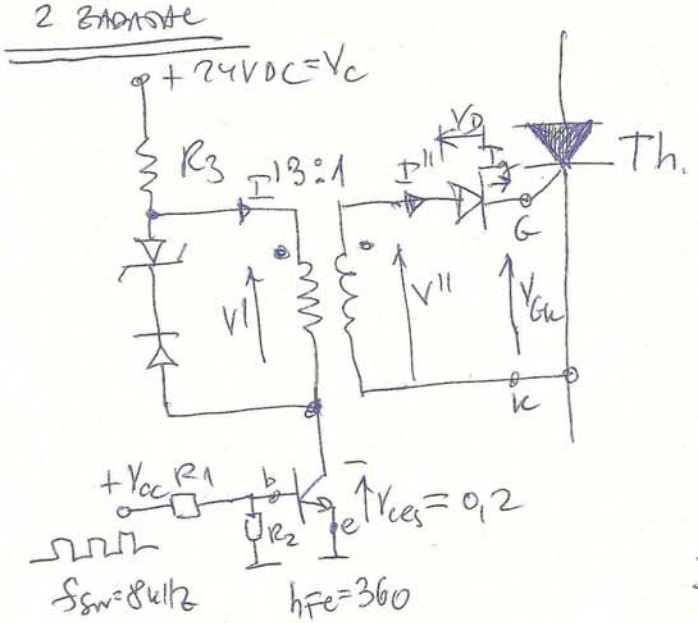
Pretpostavimo

$$I^2 t_{(Dione)} \approx 2\, I^2 t_{(UBO)} \Rightarrow I^2 t_{(UBO)} = \frac{1}{2} \cdot I^2 t_{(Dione)}$$

$$I^2 t_{(UBO)} = \frac{1}{2} \cdot \underbrace{20000\, A^2 s}_{\text{podatak iz tabele za diode (prilog-1) i pri } +125°C} \approx 10\,000\, A^2 s < 16\,000\, A^2 s ?$$

Usvaja se ULTRA BRZI osigurač TIP 1: 150A/16 000 $A^2 s$/690V~

2 STADIATE



$I_J = 1,5A$ $\quad V_D = 0,7V$

$V_{GK} = 3V$ $\quad V_{BES} = 0,75V$

$V_{CES} = 0,2V$

$L_m = 30mH$

$V'' = V_D + V_{GK} = 0,7 + 3 = 3,7V$

$I'' = I_J = 1,5A$

$V' = 3V'' = 11,1V$

$I' = \frac{I''}{3} = \frac{1,5}{3} = 0,5A$

$T = \frac{1}{f_{sw}} = \frac{1}{8kHz} = 125\mu s$

$t_{on} = t_{off} = \frac{1}{2}T = 62,5\mu s$

$V_c = R_3 I' + V' + V_{CES} \Rightarrow R_3 = \frac{V_c - V' - V_{CES}}{I'} = \frac{24 - 11,1 - 0,2}{0,5}$

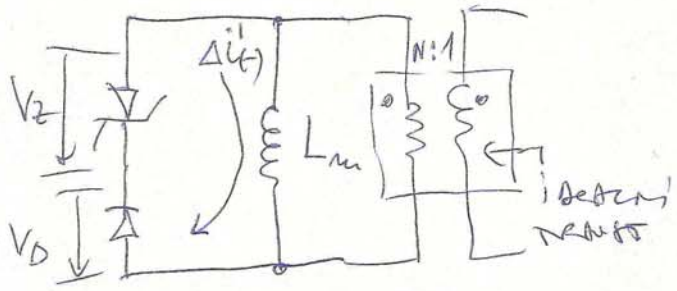
$R_3 = 25,4\Omega \rightarrow$ misura di $R_3^* = 25\Omega$

Effettivamente serve $I_{R3eff} = \frac{I''}{\sqrt{2}} = \frac{0,5}{\sqrt{2}} = 0,35A$

$P_{R3} = R_3 I_{R3eff}^2 = 25 \cdot 0,35^2 = 3,06W \rightarrow$ misura di $\boxed{R_3^* = 25\Omega / 3W}$

$L_m \cdot \Delta i' = V' \cdot t_{on} \Rightarrow \Delta i'_{(+)} = \frac{V' \cdot t_{on}}{L_m}$ (PORTA SERVE PER MAGNETIZZ.)

Per demagnetizzarsi $\Delta i'_{(-)} \approx \Delta i'_{(+)} = \frac{11,1V \cdot 62,5\mu s}{30mH} = 23,1mA$



$L_m \Delta i'_{(-)} = (V_Z + V_D) \cdot t_{off}$

$\frac{L_m \Delta i'_{(-)}}{V_Z + V_D} \leq t_{off}$

$\Delta i'_{(-)} = \frac{V' \cdot t_{on}}{L_m}$

$\frac{V' \cdot t_{on}}{V_Z + V_D} \leq t_{off} \Rightarrow V_Z + V_D \geq \frac{V' \cdot t_{on}}{t_{off}}$

$V_Z \geq V' \cdot \frac{t_{on}}{t_{off}} - V_D$

$t_{on} \approx t_{off} = \frac{T}{2} = \frac{1}{2f_{sw}} = \frac{1}{2 \cdot 8kHz} = 62,5\mu s$

$V_Z \geq 11,1 - 0,7 = 10,4V$

Usvajam se $V_Z^* = 11V$

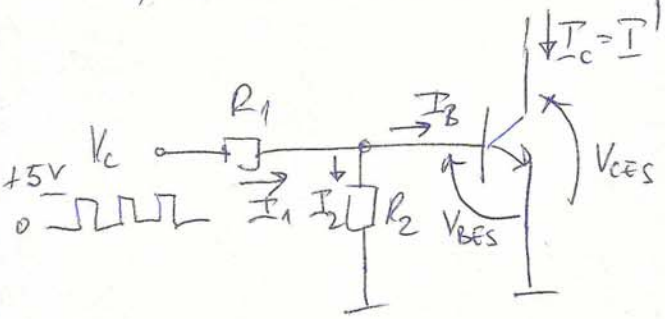
$$t_{off}^* = \frac{L_m \cdot \Delta i'}{V_Z^* + V_D} = \frac{30mH \cdot 23,1mA}{11 + 0,7} = 59,2\mu s < 62,5\mu s \quad \text{OK}$$

Disipacija na Zener diodi

$$P_D = V_Z \cdot \Delta i' \cdot \frac{t_{off}}{T} = 11 \cdot 23,1mA \cdot \frac{59,2\mu}{125\mu} = 0,12W$$

$$\boxed{V_Z^* = 11V / 0,25W}$$

Pobuda tranzistora:



$I_1 = I_2 + I_B$

$I_1 = \frac{V_C - V_{BES}}{R_1}$

$I_2 = \frac{V_{BES}}{R_2}$

$I_B \geq \frac{I_C}{h_{FE=}} = \frac{I'}{h_{FE}}$

$I_B \geq \frac{0,5}{360}$

$I_B \geq 1,388mA$

$I_B^* = 2mA$

$R_2 \gg R_1$ i usvajamo $R_2 = 10K$.

$$I_2 = \frac{V_{BES}}{R_2} = \frac{0,75}{10K} = 0,075mA$$

$I_1 = I_2 + I_B$

$I_B^* = I_1 - I_2 = 2mA$

$I_1 = 2mA + 0,075mA = 2,075mA$

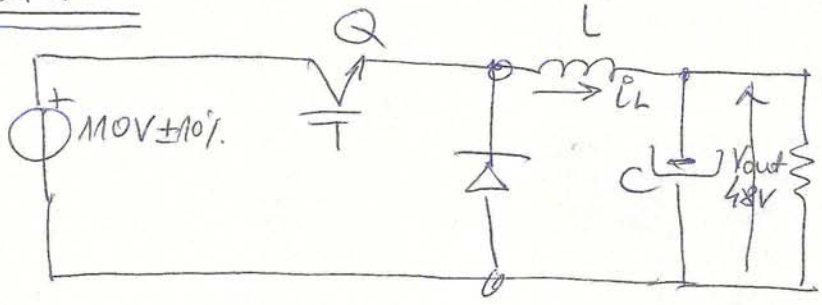
$$R_1 = \frac{V_C - V_{BES}}{R_1} = \frac{5 - 0,75}{2,075} \cdot 10^3 = 2K\Omega$$

$$P_{R1} = R_1 \cdot I_{R1}^2 = 2K \cdot 2,075m^2 = 8,6mW$$

$\boxed{R_1^* = 2K;\ 1/4W}$

$\boxed{R_2^* = 10K\ 1/4W}$

3 Zadatak



$P_{out} = 1kW$

$R_{out} = \frac{48V}{20,83A} = 2,3\Omega$

$\Delta i_{L/1} \leq 10\%$ $\quad f_{sw} = 100kHz$ $\quad I_{out} = \frac{P_{out}}{V_{out}} = \frac{1000W}{48V}$

$\Delta V_{out} \leq 0,1\%$ $\quad T = \frac{1}{f_{sw}} = \frac{1}{100k} = 10\mu s$

$I_{out} = 20,83A$

$\delta_{nom} = \frac{V_{out}}{V_{in\,nom}} = \frac{48}{110} = 0,436 \Rightarrow 43,6\%$ $\quad I_{L_{SR}} = I_{out} = 20,83A$

$\Delta i_L = 0,1 \cdot 20,83A = 2,083A$

$\delta_{max} = \frac{V_{out}}{V_{in\,min}} = \frac{48}{110 - 0,1 \cdot 110} = \frac{48}{110 - 11} = 0,4848 \Rightarrow 48,48\%$

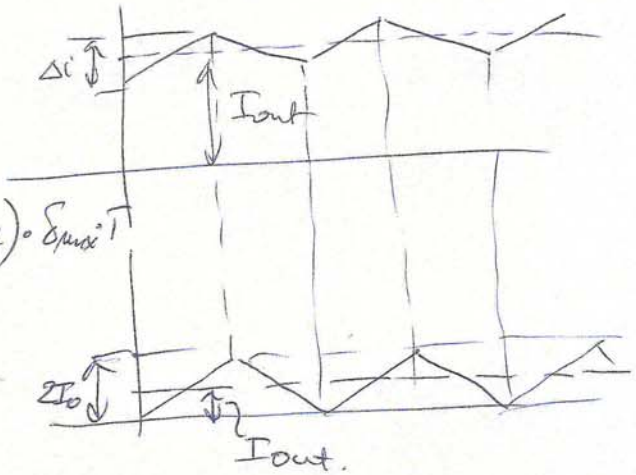
$\delta_{min} = \frac{V_{out}}{V_{in\,max}} = \frac{48}{110 + 0,1 \cdot 110} = \frac{48}{110 + 11} = \frac{48}{121} \Rightarrow 0,396 \Rightarrow 39,6\%$

a) L_c - kritična induktivnost

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

$L_c \cdot 2I_{out} = (V_{in\,min} - V_{out}) \cdot \delta_{max} \cdot T$

$L_c = \frac{(V_{in\,min} - V_{out}) \cdot \delta_{max} \cdot T}{2I_{out}}$



$L_c = \frac{99 - 48}{2 \cdot 20,83} \cdot 0,4848 \cdot 10\mu$

$L_c = 5,93\mu H.$ $\quad L \gg L_c$

* Dimenzionisanje L

$$L \geq \frac{t_{on\,min}(V_{in\,max} - V_{out})}{\Delta i} = \frac{\delta_{min}}{f_{sw}} \cdot \frac{V_{in\,max} - V_{out}}{\Delta i}$$

$$L \geq \frac{0{,}396}{100k} \cdot \frac{121 - 48}{2{,}083} = 138{,}78\mu H \rightarrow \text{usvaja se } L^* = 140\mu H$$

$$I_{Lmax} = I_L + \frac{\Delta i_L}{2} = I_{out} + \frac{\Delta i_L}{2} = 20{,}83 + \frac{2{,}083}{2} = 21{,}87A$$

$$\boxed{L^* = 140\mu H / 25A}$$

Za usvojeno $L^* = 140\mu H$ talasnost struje pri minim. ul. naponu je:

$$\Delta i = \frac{\delta_{max} \cdot T_o \cdot (V_{in\,min} - V_{out})}{L^*} = \frac{0{,}4848 \cdot 10\mu}{140\mu}(99 - 48)$$

$$\Delta i = 1{,}766A < 2{,}083A \quad \text{u}$$

* Dimenzionisanje C

$$C \geq \frac{1 - \delta_{min}}{8 L^* \cdot f^2 \left(\frac{\Delta V_o}{V_o}\right)}$$

$\delta_{min} = 0{,}396$ $\quad \frac{\Delta V_o}{V_o} = \frac{0{,}1}{100} = 0{,}001$

$L^* = 140\mu H$

$f = 100kHz$ $\quad \frac{\Delta V_o}{V_o} = 1m$

$$C \geq \frac{1 - 0{,}396}{8 \cdot 140\mu \cdot (100 \cdot 10^3)^2 \cdot 0{,}001}$$

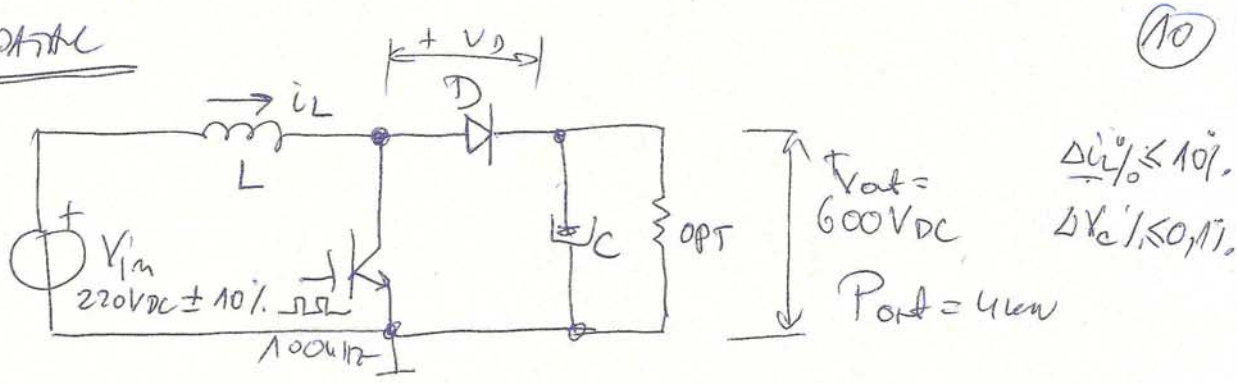
$$C \geq 89 \cdot 10^6 \cdot 0{,}604 = 53{,}756\mu F \rightarrow \text{usvaja se } \boxed{C^* = 100\mu F / 100V=}$$

Talasnost napona ne zavisi od $C^* = 100\mu F$

$$\frac{\Delta V_o}{V_o} = \frac{1 - \delta_{min}}{8 \cdot L^* \cdot C^* f^2} = \frac{1 - \delta_{min}}{8 \cdot 140\mu \cdot 100\mu \cdot (100 \cdot 10^3)^2} = \frac{1 - 0{,}396}{8 \cdot 140 \cdot 100\mu \cdot 10^4}$$

$$\frac{\Delta V_o}{V_o} = 0{,}00054 = 0{,}054\% < 0{,}1\%. \quad \text{u}$$

4 ZADATAK



$V_{in\,max} = 220 + 0{,}1 \cdot 220 = 220 + 22 = 242\,V_{DC}$

$V_{in\,min} = 220 - 0{,}1 \cdot 220 = 220 - 22 = 198\,V_{DC}$

$\Rightarrow 198\,V_{DC} \leq V_{in} \leq 242\,V_{DC}$

$f = 100\,kHz \Rightarrow T = \frac{1}{f} = \frac{1}{100k} = 10\,\mu s.$

$I_{out} = \frac{4000W}{600V} = 6{,}66A \qquad R_{out} = \frac{V_{out}}{I_{out}} = \frac{600}{6{,}66} = 90\Omega$

$P_{in} \approx P_{out} = V_{in} \cdot I_{in} = V_{in} \cdot I_{LSR} = 4000W$

$I_{LSR} \approx \frac{4000}{V_{in}} \qquad I_{LSR\,max} = \frac{4000}{V_{in\,min}} = 20{,}20A$

$I_{LSR\,min} = \frac{4000}{V_{in\,max}} = 16{,}52A$

$16{,}52A \leq I_{LSR} \leq 20{,}20A$

$V_{in} \cdot t_{on} = L \Delta i_L \qquad L_C = \frac{V_{in\,min} \cdot t_{on\,max}}{2 I_o}$

$t_{on\,max} = ? \qquad V_{out} = \frac{V_{in}}{1-\delta} \Rightarrow 1 - \delta = \frac{V_{in}}{V_{out}}$

$\delta = 1 - \frac{V_{in}}{V_{out}} \qquad \delta_{max} = 1 - \frac{V_{in\,min}}{V_{out}} = 1 - \frac{192}{600}$

$t_{on\,max} = \delta_{max} \cdot T \qquad \delta_{max} = 0{,}68$

$t_{on\,max} = 0{,}68 \cdot 10\,\mu s \qquad \delta_{min} = 1 - \frac{V_{in\,max}}{V_{out}} = 1 - \frac{242}{600}$

$t_{on\,max} = 6{,}8\,\mu s. \qquad \delta_{min} = 0{,}5966$

$L_C = \frac{198 \cdot 6{,}8\mu}{2 \cdot 2920} = 33{,}33\,\mu H$

$\boxed{L_C = 33{,}33\,\mu H}$

b) * izbor L

$$L \geq \frac{V_{in\,max} \cdot t_{on\,min}}{\Delta i_{Lmin}} = \frac{242 \cdot 5{,}966\mu}{1{,}652A} = 880\mu H$$

$t_{on\,min} = \delta_{min} \cdot T = 0{,}5966 \cdot 10\mu s$

$t_{on\,min} = 5{,}966\mu s.$

$\Delta i_{Lmin} = 0{,}1 \cdot I_{Lmin} = 91 \cdot 16{,}52$

$= 1{,}652A$

$I_{Lmax} = 20{,}70A + \frac{\Delta i_L}{2}$

$= 20{,}70A + \frac{91 \cdot 2070}{2}$

$= 20{,}70A + \frac{2{,}070}{2}$

$= 20{,}70 + 1{,}010$

$I_{Lmax} = 21{,}71A$

Usvajamo $\boxed{L^* = 900\mu H / 25A}$

* izbor C

$$C \geq \frac{I_{out}}{V_{out}} t_{on} \cdot \frac{1}{\frac{\Delta V_{out}}{V_{out}}}$$

$t_{on} \rightarrow t_{on\,max} = 6{,}8\mu s$

$\frac{\Delta V_{out}}{V_{out}} = \frac{0{,}1}{100} = 0{,}001$

$$C \geq \frac{6{,}66A}{600} \cdot \frac{6{,}8\mu}{0{,}001}$$

$C \geq 75{,}48\mu F \rightarrow$ usvaja se $\boxed{C^* = 100\mu F / 1000V\,DC}$

MAX NAPON prekidača Q je 600VDC → usvaja se prekidač za 1000 V DC.

MAX STRUJA prekidača Q je 22A → usvaja se prekidač za struju 25A (50A)

MAX NAPON diode D je 600VDC → usvaja se dioda za 1000V

MAX STRUJA diode D je 22A → usvaja se dioda za 25A (50A)