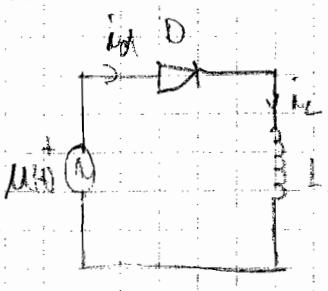
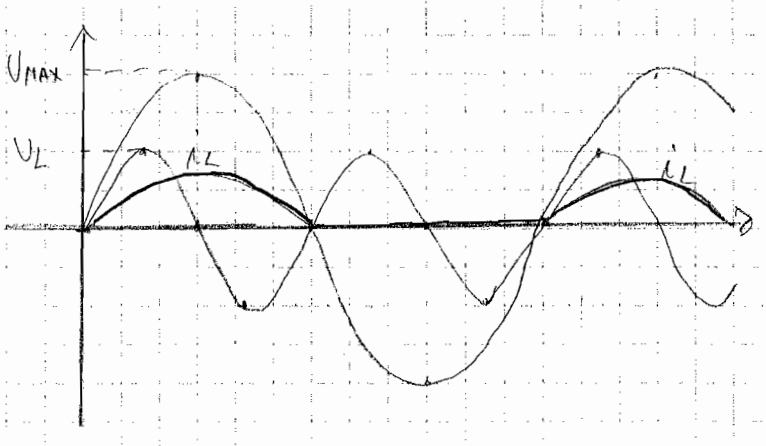
① POLUVALNI NEUPRAVLJIVI ISPRAVLJAČ - L - TROŠILO





$u(t) = 100 \sin(314t)$

$I_{Dmax} = 10\,A$

$L = ?$

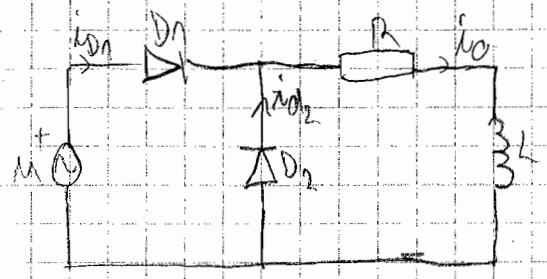
$I_{Dmax} = \frac{2U_{max}}{\omega L}$ - MAKSIMALNA STRUJA NA DIODI V_0

$L = \frac{2U_{max}}{\omega I_{Dmax}}$

$u(t) = U_{max} \sin(\omega t) \Rightarrow U_{max} = 100\,V \; ; \; \omega = 314\,s^{-1}$

$L = \frac{2 \cdot 100}{314 \cdot 10} = 63.7\,mH$

1) POLUVALNI ISPRAVLJAČ S POVRATNOM DIODOM: - R-L-TROŠILO



$V_{S_{RMS}} = 240V$

$f = 60 Hz$

$R = 8 \Omega$

$L \to \infty$

) FAKTOR SNAGE P_f, SKICA VALNIH OBLIKA NAPONA NA I STRUJA NA D_1 I D_2

) SREDNJA VRIJEDNOST STRUJE KROZ D_1 I D_2

) ODREDI L TAKAV DA VALOVITOST STRUJE TROŠILA NE IZNOSI VIŠE OD 10% SREDNJE VRIJEDNOSTI STRUJE TROŠILA ?

108.034

) $P_f = \frac{P}{S}$

$V_{max} = \sqrt{2}\, V_{S_{RMS}} = \sqrt{2} \cdot 240 = 339.41\ V$ - MAKSIMALNI NAPON IZVORA

$i_o = \frac{V_{max}}{\pi R} = 13.5\ A$ - SREDNJA VRIJEDNOST STRUJE NA TROŠILU $\approx I_{RMS}$

$I_{S_{RMS}} = \frac{I_{RMS}}{\sqrt{2}} = \frac{13.5}{\sqrt{2}} = 9.55A$ - EFEKTIVNA VRIJEDNOST STRUJE IZVORA

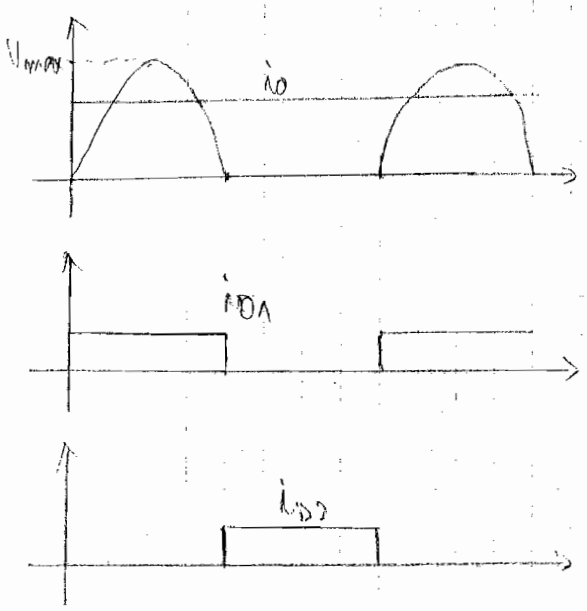
$P = I^2_{RMS} \cdot R = 13.5^2 \cdot 8 = 1458\ [W]$ - SNAGA NA TROŠILU

ILI

$P = I_0 \cdot V_0 = 13.5 \cdot \frac{V_{max}}{\pi} = 13.5 \cdot 108.034 = 1459\ [W]$

$S = V_{S_{RMS}} \cdot I_{S_{RMS}} = 240 \cdot 9.55 = 2292\ [VA]$

$P_f = \frac{1459}{2292} = 0.637$



b) $I_{D1} = I_{D2} = \frac{I_O}{2} = \frac{13,5}{2} = 6,75\ A$ - CORRENTE MÉDIA EM CADA DIODO

c) $V_1 = \frac{V_{max}}{2} = 170\ V$ - AMPLITUDE DA COMPONENTE FUNDAMENTAL V_O

$\Delta I_O = \frac{I_O}{10} = 1,35\ A$ - VALOR DE PICO DA COMPONENTE FUNDAMENTAL I_O

$I_1 = \frac{\Delta I_O}{2} = 0,675\ A$ - AMPLITUDE DA COMPONENTE FUNDAMENTAL I_O

$Z_1 = \frac{V_1}{I_1} = \frac{170}{0,675} = 252\ \Omega$ - IMPEDÂNCIA DA COMPONENTE FUNDAMENTAL V_O

$|Z|$

$Z_1 = \frac{V_{max}}{\Delta I_O}$

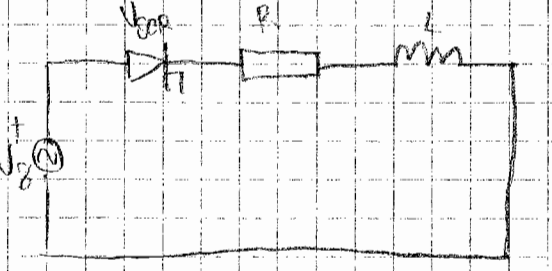
$Z_1 = \sqrt{R^2 + \omega L^2} \Rightarrow Z^2 = R^2 + \omega^2 L^2$

$Z^2 = Z'^2 + (\omega L)^2 \quad / \omega$

$L^2 = \frac{Z^2 + R^2}{\omega^2}$

$L = \sqrt{\frac{Z^2 + R^2}{\omega^2}} = \sqrt{\frac{252^2 + 5^2}{377^2}} = 0,67\ H$

) UPRAVLJIVI POLUVALNI ISPRAVLJAČ – R-L-TROŠILO



$V_0 = 120\,V$
$f = 60\,Hz$
$R = 20\,\Omega$
$L = 0{,}04\,H$
$\alpha = 45°\,[el]$

a) ANALITIČKI IZRAZ ZA STRUJU U OBLIKU $i(\omega t) = ?$
b) SREDNJU VRIJEDNOST STRUJE KROZ T1
c) SREDNJU SNAGU NA TROŠILU
d) FAKTOR SNAGE

) $i(\omega t) = \frac{U_{max}}{Z}\sin(\omega t - \varphi) + A\,e^{-\frac{t}{\tau}}$

$U_{max} = \sqrt{2}\cdot V_0 = \sqrt{2}\cdot 120 = 169{,}7\,V$

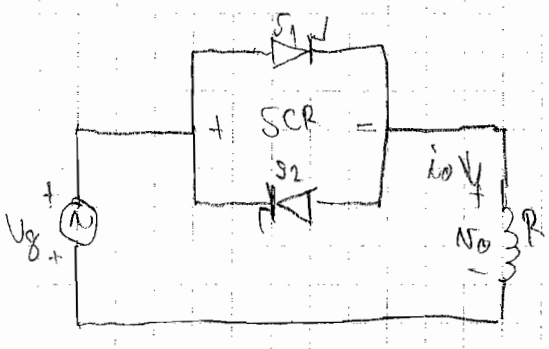
$Z = \sqrt{R^2+(\omega L)^2} = \sqrt{20^2+(2\cdot\pi\cdot f\cdot L)^2} = \sqrt{20^2+(2\cdot\pi\cdot 60\cdot 0{,}04)^2} = 25\,\Omega$

$\varphi = tg^{-1}\left(\frac{\omega L}{R}\right) = 37° \Rightarrow \varphi = 37\cdot\frac{\pi}{180}\,[rad] = 0{,}646\,rad$

$\tau = \frac{L}{R} = \frac{0{,}04}{20} = 0{,}002$

$A = \frac{\sqrt{2}\,V_0\,\omega L}{Z^2} = \frac{U_{max}\,\omega L}{Z^2} = 4{,}09$

④ IZMJENIČNI PRETVARAČ (AC/AC) – JEDNOFAZNI REGULATOR NAPONA



$V_S = 120V$
$f = 60Hz$
$R = 15\,\Omega$
$P = 500\,W$

a) KUT UPRAVLJANJA TIRISTORA – α
b) EFEKTIVNA VRIJEDNOST STRUJE IZVORA
c) EFEKTIVNA I SREDNJA VRIJEDNOST STRUJE TIRISTORA
d) FAKTOR SNAGE IZVORA
e) UKUPNO HARMONIČKO IZOBLIČENJE STRUJE IZVORA – THD

a)
$$P = \frac{V_{ORMS}^2}{R} \Rightarrow V_{ORMS} = \sqrt{PR} = 86.6V$$ – EFEKTIVNA VRIJEDNOST NAPONA NA TROŠILU

$$V_{ORMS} = V_S \cdot \sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}}$$

$$V_{ORMS} - V_S \sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}} = 0 \Rightarrow \text{NUMERIČKI} \Rightarrow \alpha = 88.1°$$

b) $$I_{ORMS} = \frac{V_{ORMS}}{R} = \frac{86.6}{15} = 5.77A$$

c) $$I_{SCR_{RMS}} = \frac{I_{ORMS}}{\sqrt{2}} = \frac{5.77}{\sqrt{2}} = 4.08A$$ – EFEKTIVNA STRUJA TIRISTORA

$$I_{SCR_{AV}} = \frac{\sqrt{2}V_0}{2\pi R}(1+\cos\alpha) = \frac{\sqrt{2}\cdot 120}{2\pi \cdot 15}(1+\cos 88.1) = 1.86A$$ – SREDNJA STRUJA TIRISTORA

d) $$PF = \frac{P}{S} = \frac{500}{V_S \cdot I_{ORMS}} = 0.72$$ ILI $$PF = \sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}}$$

c) $I_{RMS} = \frac{U_{SRMS}}{R} = \frac{120}{15} = 8A$

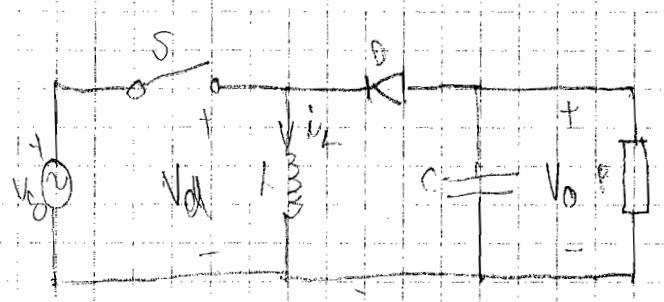
SLIKA $\Rightarrow$ $C_1 = 0.61$ - FAKTOR OSNOVNOG HARMONIKA

$I_{1RMS} = C_1 \cdot I_{RMS} = 0.61 \cdot 8 = 4,9\,A$ - EFEKTIVNA VRIJEDNOST OSNOVNOG HARMONIKA

$THD = \frac{\sqrt{I_{RMS}^2 - I_{1RMS}^2}}{I_{1RMS}} = \frac{\sqrt{5,77^2 - 4,9^2}}{4,9} = 0.63 \Rightarrow 63\,\%$

5)

a) SILAZNO - NIZLAZNI PRETVARAČ:



$f = 20\ kHz$

$L = 0.05\ mH$

$V_i = V_d = 15V$

$V_0 = 10\ V$

$P = 10\ W$

$D = ?$

$$I_0 = \frac{P_0}{V_0} = \frac{10\ W}{10\ V} = 1\ A$$

$$\frac{D}{1-D} = \frac{V_0}{V_i} = \frac{10}{15}$$ } PRETPOSTAVLJENI OBRAZNI REŽIM RADA

$$D = 0.4$$

$$I_{0B} = \frac{T_s \cdot V_0}{2L}(1-D)^2$$ - GRANIČNA VRIJEDNOST STRUJE

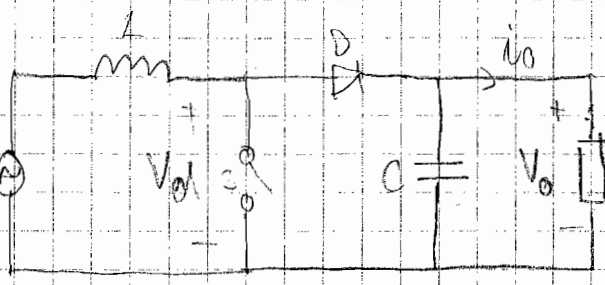
$$I_{0B_{max}} = (D=1) = \frac{T_s \cdot V_0}{2L} = \frac{50\mu \cdot 10}{2 \cdot 0.05m} = 5\ A$$

$$I_{0B} = I_{0B_{max}}(1-D)^2 = 5 \cdot (1-0.4)^2 = 1.2\ A$$ - GRANIČNA STRUJA VRIJEDNOST NAPONA

$I_0 < I_{0B}$ - ISPREKIDANI REŽIM RADA

$$D = \frac{V_0}{V_i}\sqrt{\frac{I_0}{I_{0B_{max}}}} = \frac{10}{15}\sqrt{\frac{1}{5}} = 0.3$$

) U ZAVISNOSTI OD PREKIDAČA:



- RAD U ISPREKIDANOM REŽIMU
- RADA U_d

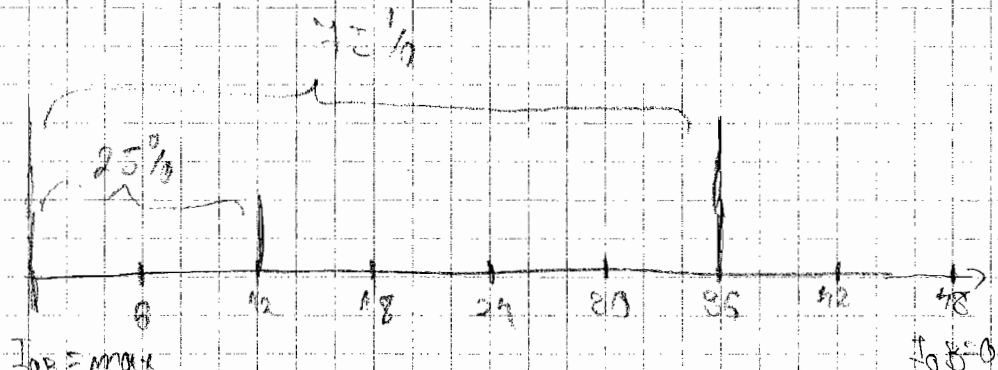
$U_d = 48\,V$

$12\,V < U_i < 36\,V$

$P_{omax} = 120\,W$

$f_c = 50kHz$

$L = ?$



$$I_{omax} = \frac{P_{omax}}{V_o} = 2,5\,A$$

$$0,25 < D < 0,75$$

$$T = \frac{1}{f} = 20\mu s$$

$$I_{OBmax} = \frac{T_s V_o}{2L} D(1-D)^2 \Rightarrow L = \frac{I_o V_o}{2 I_{OBmax}} D(1-D)^2$$

$$L = \frac{20\mu \cdot 48}{2 \cdot 2,5} 0,75\,(1-0,75) = 9\mu H$$

⑥ PWM

- TREBA DIZAJNIRATI PWM - IZMJENJIVAČ KOJI ĆE NA IZLAZU DAVATI NAPON EFEKTIVNE VRIJEDNOSTI 75 V I 60 Hz. IZMJENJIVAČ JE SPOJEN NA IZTOSMJERNI IZVOR 150 V. TERET JE SERIJSKA KOMBINACIJA R-L TROŠILA, R = 12 Ω, L = 60 mH. ODREDI SKLOPNU FREKVENCIJU TAKVU DA JE THD ≤ 10%

$$m_a = \frac{V_1}{V_{dc}} = \frac{75\sqrt{2}}{150} = 0{,}707 \quad \text{- INDEKS AMPLITUDNE MODULACIJE}$$

$$I_1 = \frac{V_1}{Z_1} = \frac{75\sqrt{2}}{\sqrt{R^2 + (2\pi f L)^2}} = 4{,}14\ A$$

THD ≤ 10%:

$$THD = \frac{\sqrt{\sum_{m=2}^{\infty} (I_{mRMS})^2}}{I_{1RMS}} \Rightarrow \frac{\sqrt{\sum_{m=2}^{\infty} (I_{mRMS})^2}}{I_{1RMS}} \leq 0{,}1 \Rightarrow \sqrt{\sum_{m=2}^{\infty} (I_{mRMS})^2} \leq 0{,}1\, I_{1RMS}$$

$$\sqrt{\sum_{m=2}^{\infty} (I_{mRMS})^2} \leq 0{,}1 \cdot \frac{4{,}14}{\sqrt{2}} = 0{,}293$$ - EFEKTIVNA VRIJEDNOST CIJE HARMONIKA

$$\sqrt{\sum_{m=2}^{\infty} (I_{mRMS})^2} \approx I_{mfRMS} = \frac{I_{mf}}{\sqrt{2}} \Rightarrow I_{mf} < 0{,}1 \cdot 4{,}14 = 0{,}414\ A$$

- IZ TABLICE:

$$m = m_f \ ; \ m_a = 0{,}7 \Rightarrow \frac{V_m}{V_{dc}} = \frac{V_{mf}}{V_{dc}} = 0{,}92 \Rightarrow V_{mf} = 150 \cdot 0{,}92 = 138\ V$$

- $f = f_s$:

$$Z_{mf} = \frac{V_{mf}}{I_{mf}} = \frac{138}{0{,}414} = 333\ \Omega$$

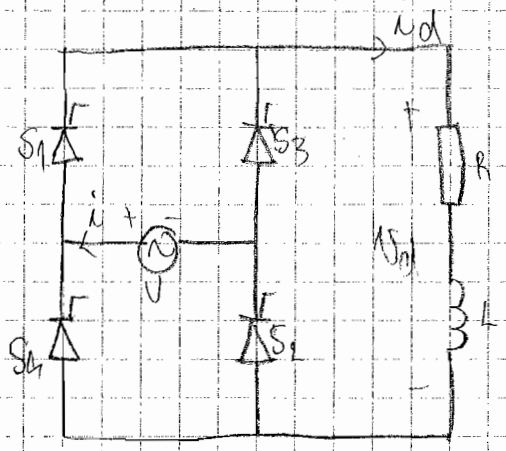
- PRETPOSTAVKA:

$$Z_{mf} \approx \omega L = m_f \cdot \omega_1 \cdot L$$

$$m_f \cdot \omega_1 \cdot L > 333 \Rightarrow m_f > \frac{333}{377 \cdot 0{,}08} = 14{,}7 \approx 15 \Rightarrow \text{ODABIREMO } (17)$$

$$f_c = m_f \cdot A \cdot f_{mod} = 17 \cdot A \cdot 60 = 17 \cdot 1 \cdot 60 = \underline{1020\ Hz}$$

D2.



$R = 20\ \Omega$

$L = 100\ mH = 0.1\ H$

$V_{PRMS} = 70\ V$

$I_d = 2\ A$

$\alpha = ?$

$$U_d = \frac{2V_P}{\pi}\cos\alpha \quad i \quad V_{RMS} = \frac{V_{max}}{2} = \frac{V_P\sqrt{2}}{2} \Rightarrow V_P = \sqrt{2}\,V_{PRMS} = 99\ V$$

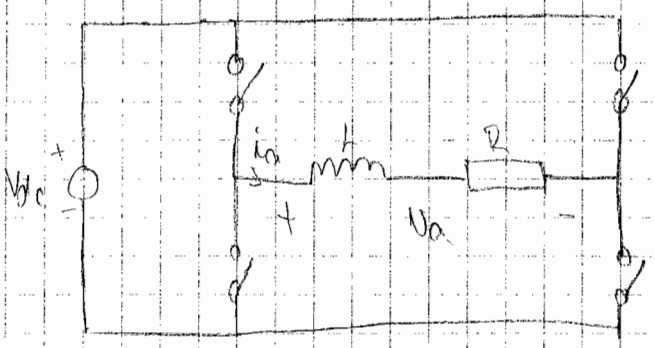
$$I_d = \frac{U_d}{R} \Rightarrow U_d = i_d \cdot R = 2 \cdot 20 = 40\ V$$

$$\cos\alpha = \frac{U_d\,\pi}{2V_P} = \frac{40\pi}{2 \cdot 99} = 0{,}63 \Rightarrow \alpha = 50{,}6^\circ$$

STRUJA ĆE BITI ISPREKIDANA PRI KUTU : $\alpha \geq tg^{-1}\left(\frac{\omega L}{R}\right)$

$$tg^{-1}\ \alpha = tg^{-1}\left(\frac{2\pi f L}{R}\right) = tg^{-1}\left(\frac{2 \cdot \pi \cdot 50 \cdot 0{,}1}{20}\right) = 57{,}5^\circ$$

2.D2 - ⑥



$R = 20\ \Omega$

$L = 80\ mH$

$f = 200\ Hz \Rightarrow \omega = 2\pi f = 1256{,}64\ s^{-1}$

$V_{dc} = 50\ V$

I_{0RMS} 2A PARA QUE AMPLITUDE =?

$$V_m = \frac{4}{\pi}\frac{V_{dc}}{m}$$

$$V_1 = \frac{4}{\pi}\frac{V_{dc}}{1} = \frac{4}{\pi}V_{dc} = 63{,}66\ V \qquad Z_1 = \sqrt{R^2 + (\omega m L)^2} = \sqrt{R^2 + (\omega L)^2} = 102{,}3\ \Omega$$

$$V_2 = \frac{4}{\pi}\frac{V_{dc}}{2} = 31{,}78\ V \qquad Z_2 = \sqrt{R^2 + (\omega 2L)^2} = 202{,}5\ \Omega$$

$$V_3 = \frac{4}{\pi}\frac{V_{dc}}{3} = 21{,}22\ V \qquad Z_3 = \sqrt{R^2 + (\omega 3L)^2} = 302\ \Omega$$

$$I_1 = \frac{V_1}{Z_1} = 0{,}62\ A$$

$$I_2 = \frac{V_2}{Z_2} = 0{,}154\ A$$

$$I_3 = \frac{V_3}{Z_3} = 0{,}074\ A$$

$$I_0 = \frac{I_1 + I_2 + I_3}{3} = 0{,}282\ A$$

$$I_{0RMS} = \frac{I_0}{\sqrt{2}} = 0{,}1996\ A$$