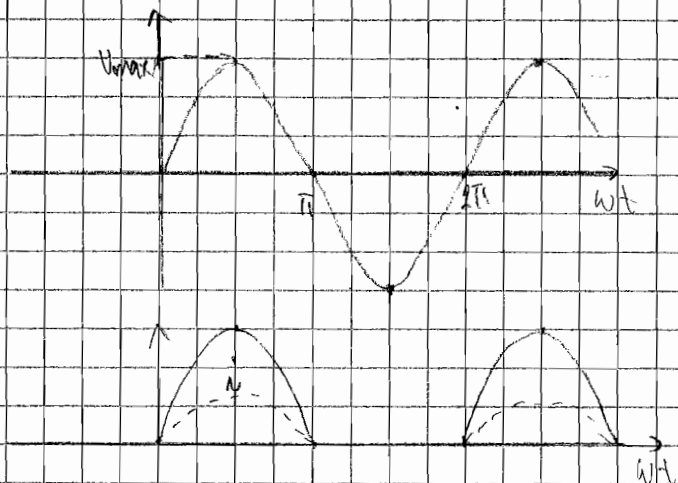
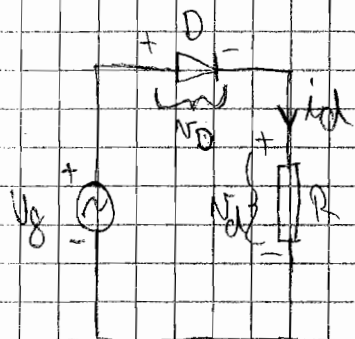


ISPRAVLJAČI

POLNIVNI ISPRAVLJAČI - NEUPRAVLJIVI

R-TROŠILO:



$$U_g = U_D = \sqrt{2} U_D \sin(\omega t) = U_{max} \sin(\omega t) - \text{NAPON IZVORA}$$

$$U_{D,av} = \frac{\int_0^\pi U_D dt}{\pi} = \frac{U_{max}}{\pi} - \text{SREDNJA VREDNOST NAPONA NA TROŠILU}$$

$$U_D = U_D \cdot R - \text{TREKUTNA VREDNOST NAPONA NA TROŠILU}$$

$$I_D = \frac{U_{D,av}}{R} - \text{SREDNJA VREDNOST STRUJE TROŠILA}$$

$$U_{RMS} = \frac{U_{max}}{2} - \text{EFEKTIVNA VREDNOST NAPONA NA TROŠILU}$$

$$I_{RMS} = \frac{U_{RMS}}{R} = \frac{U_{max}}{2R} - \text{EFEKTIVNA VREDNOST STRUJE NA TROŠILU}$$

$$P = I_{RMS} \cdot U_{RMS} [W] - \text{EFEKTIVNA VREDNOST SNAGE NA TROŠILU}$$

$$S = U_D \cdot I_D [VA] - \text{MAXIMALNA VREDNOST SNAGE NA TROŠILU}$$

$$\eta = \frac{P}{S} [\%] - \text{FAKTOR SNAGE}$$

R-L-TROŠILO:

$$U_g = U_D = U_{max} \sin(\omega t) = R \cdot i(t) + \frac{d}{dt} i(t) L - \text{NAPON IZVORA}$$

$$i_A(t) = \left(\frac{U_{max}}{Z} \right) \sin(\omega t - \varphi) - \text{STRUJA KROZ IMPEDANCIJU ZA VRIJEME POZITIVNE POLUPERIODE}$$

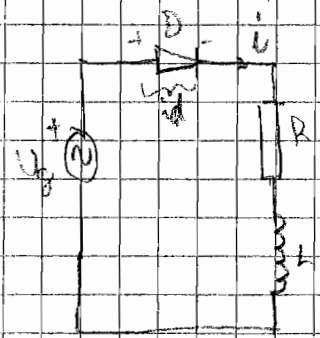
$$i_m(t) = A e^{\frac{-t}{\tau}} - \text{STRUJA PRIGUŠENJA IZ ZAVOJNICE ZA VRIJEME NEGATIVNE POLUPERIODE}$$

$$i_u(t) = i_p(t) + i_m(t) = \frac{V_m}{Z} \sin(\omega t - \varphi) + A e^{-\frac{t}{\tau}} - \text{UKUPNA STRUJA}$$

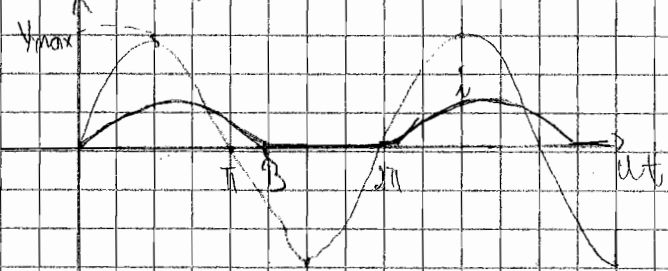
$$Z = \sqrt{R^2 + (\omega L)^2} - \text{IMPEDANCIJA}$$

$$\varphi = \tan^{-1}\left(\frac{\omega L}{R}\right) - \text{KUT } \varphi$$

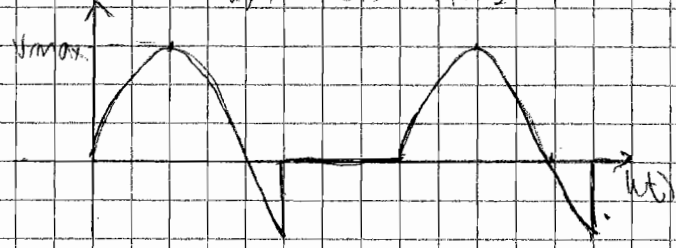
$$A = \frac{\sqrt{2} V_0 \omega L}{Z^2} ; \tau = \frac{L}{R}$$



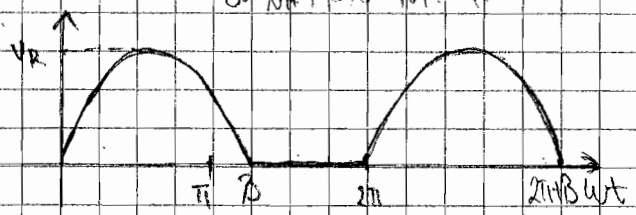
1) NAPON IZVORA I UKUPNA STRUJA



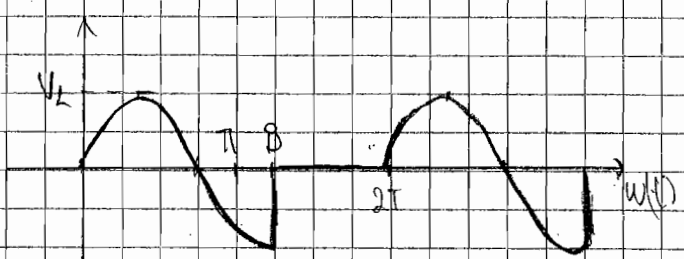
2) NAPON NA Z:



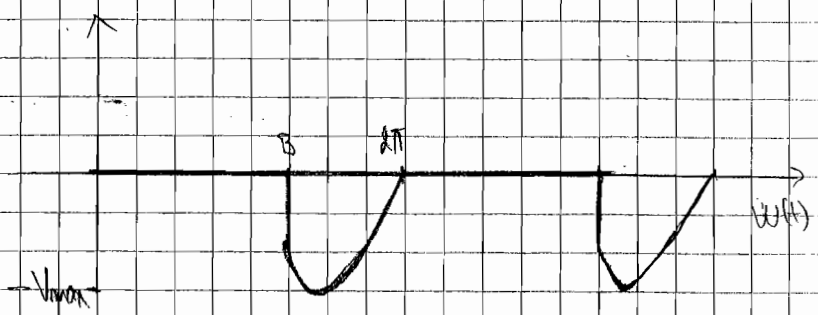
3) NAPON NA R:



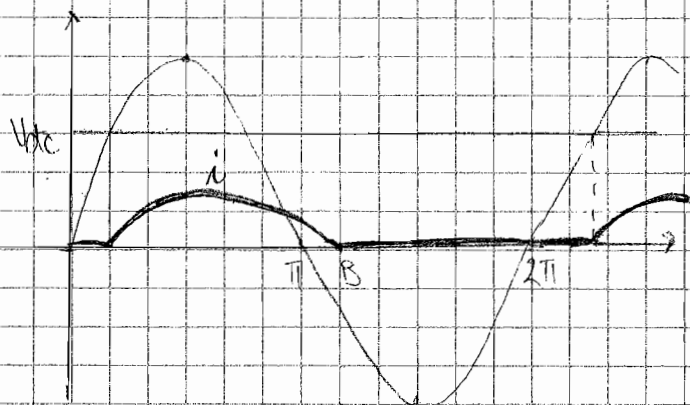
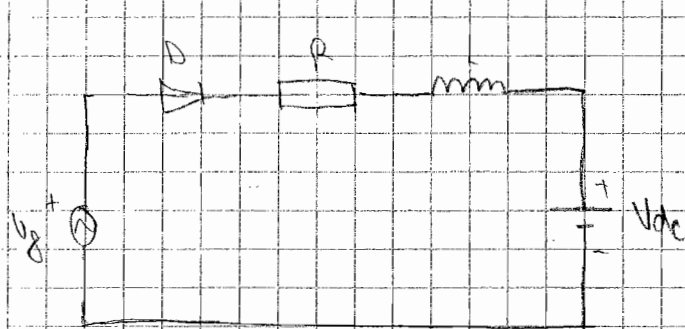
4) NAPON NA L:



5) NAPON NA DIODI:



R-L-E - TROŠILO:



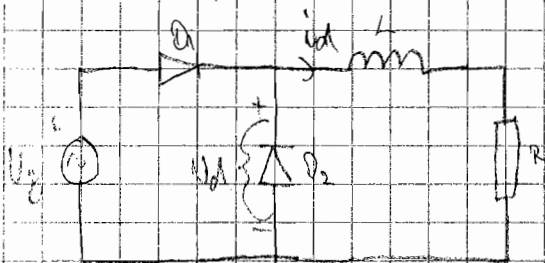
$$U_g = U_0 = V_{max} \sin(\omega t) = U_{dc} + R i(t) + \frac{d\psi}{dt} \quad \text{-- NAPON IZVORA}$$

$$V_{max} \sin(\omega t) = U_{dc} \quad \text{-- TRENUTAK KAD DIODA PROVEDE}$$

$$i_{dl}(t) = \frac{V_{max}}{2} (\sin \omega t - 1) - \frac{U_{dc}}{R} + A e^{-\frac{t}{L}} \quad \text{-- UKUPNA STRUJA}$$

$$P_{ac} = I_{RMS}^2 R + I U_{dc} \quad \text{-- SNAGA KRUGA}$$

POREDNA DIODA:



$$i_{d1}(t) \approx I_0 = \frac{U_0}{R} = \frac{V_{max}}{\pi R} \quad \text{-- SREDNJA VREDNOST STRUJE NA 2D}$$

$$V_1 = \frac{V_{max}}{2} \quad \text{-- AMPLITUDA OSMOVNOG HARMONIKA 1D}$$

$$I_1 = \frac{I_0}{\sqrt{2}} \quad \text{-- STRUJA OSMOVNOG HARMONIKA -- KARAKTERISTIKA ZA JAKO INDUKTIVNO TROŠILO}$$

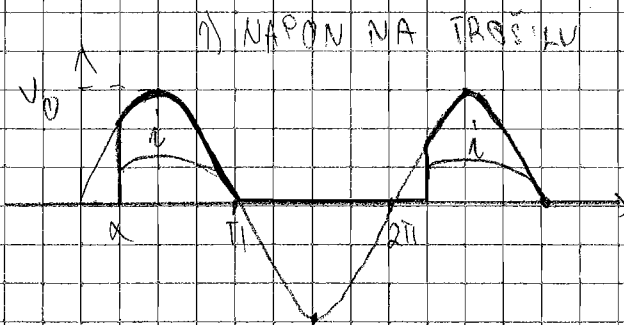
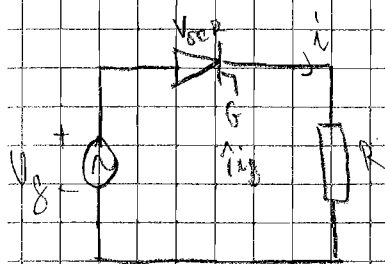
$$Z_1 = \frac{V_1}{I_1} \quad \text{-- IMPEDANCIA TROŠILA NA OSMOVNOJ FREKVENCIJI}$$

$$Z_1 = R + j\omega L$$

$$L = \frac{Z}{\omega}$$

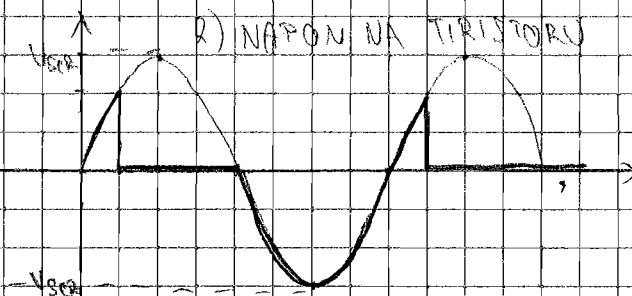
POKROVNÍ ISPRAVLJACÍ - VPRAVLJIVÍ

R-TROJÍK:



VPRAVLJÁČKA KARAKTERISTIKA:

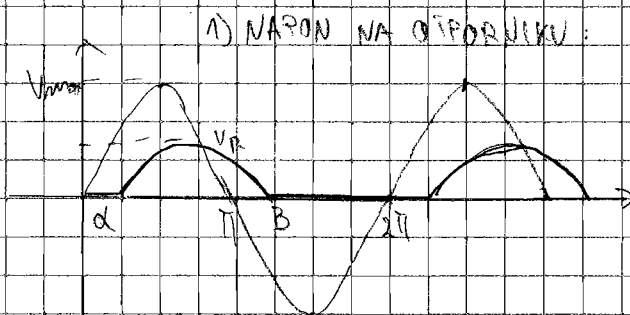
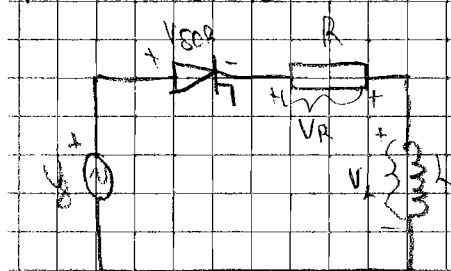
$$V_D = \frac{V_{max}}{2\pi} [1 + \cos \alpha] = \text{SREDNJA VRSNOST NAPONA NA TROJÍKU}$$



$$V_{RMS} = \frac{V_{max}}{2} \sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}}$$

- EFEKTIVNA VRSNOST NAPONA NA TROJÍKU

R-L-TROJÍK:

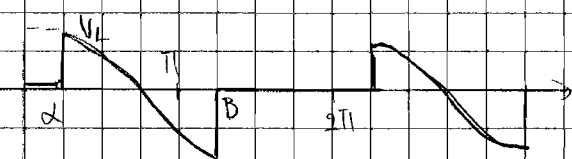


2) NAPON NA INDUKTIVITU:

$$i(t) = i_p(t) + i_m(t) \quad \text{STRUJA TROJILA}$$

$$i(t) = \left(\frac{V_{max}}{2} \right) \sin(\omega t - \varphi) + A e^{-\frac{t}{\tau}}$$

$$i(t) = 0 = \left(\frac{V_{max}}{2} \right) \sin(\alpha - \varphi) + A e^{-\frac{\alpha}{\omega \tau}} \quad \text{STRUJA TIRISTORA}$$



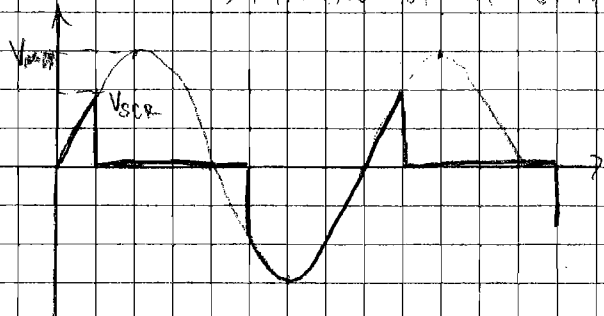
$$i(\omega t) = \left(\frac{V_{max}}{2} \right) [\sin(\omega t - \varphi) - \sin(\alpha - \varphi)] e^{\frac{\alpha - \omega t}{\omega \tau}}$$

- UKUPNA STRUJA $\alpha \leq \omega t \leq \beta$

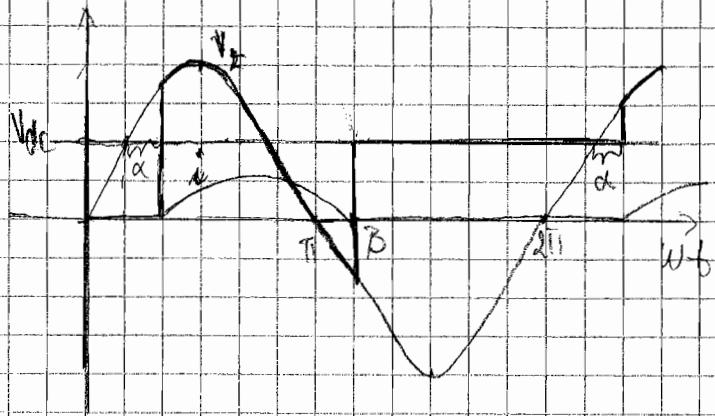
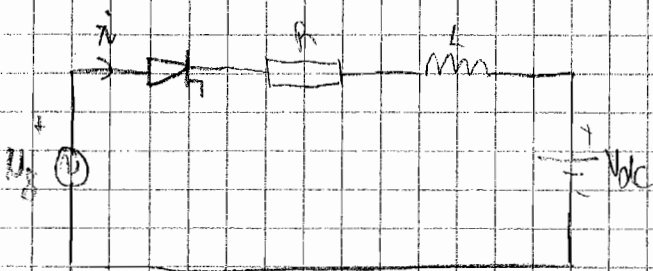
$$A = \left[- \left(\frac{V_{max}}{2} \right) \sin(\alpha - \varphi) \right] e^{\frac{\alpha}{\omega \tau}}$$

$$i(\beta) = 0 = \left(\frac{V_{max}}{2} \right) [\sin(\beta - \varphi) - \sin(\alpha - \varphi)] e^{\frac{\alpha - \beta}{\omega \tau}} \quad \text{STRUJA}$$

3) NAPON NA TIRISTORU



R-2-E - TROJÍLO:



$$I_{min} = \sin^{-1} \left(\frac{V_{dc}}{V_{max}} \right) - \text{MINIMÁLNÍ KÚT VÁNĚSE JSA TIRISTORA}$$

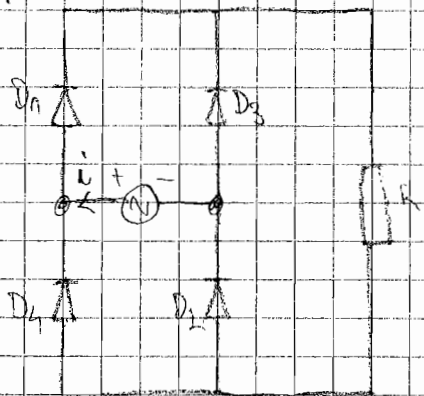
$$i(\omega t) = \left(\frac{V_{max}}{Z} \right) \sin(\omega t - \varphi) = \frac{V_{dc}}{R} + A e^{-\frac{\omega t}{\tau}} - \text{UKUPNÁ ZPRŮSA}$$

$$A = \left[- \frac{V_{max}}{Z} \sin(\alpha - \varphi) \right] e^{\frac{\alpha}{\omega \tau}}$$

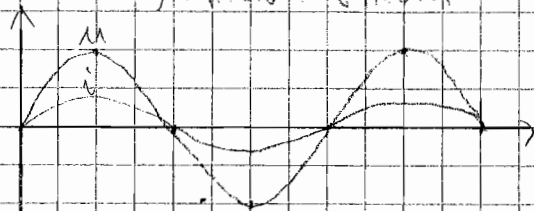
PUNOVÁLNÍ ISPRAVKAČÍ - NEUPRAVKOVNÍ

JEDNOFÁZNÍ MOŠNÍ SPOJ - R-TROJÍLO:

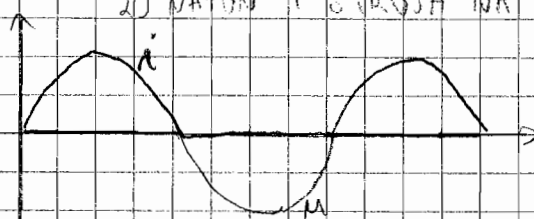
GRETE:



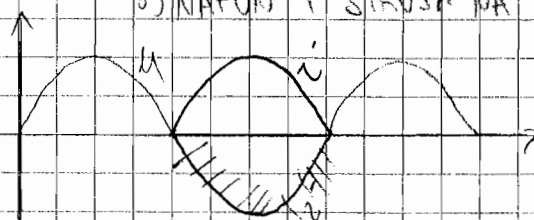
1) NAPON I STROVA NA D1-D2



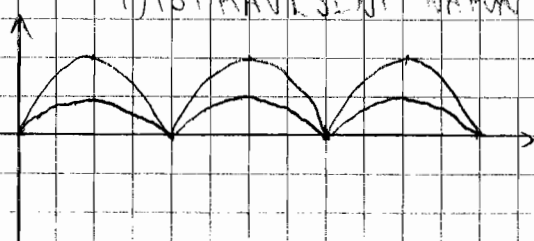
2) NAPON I STROVA NA D3-D4



3) NAPON I STROVA NA D1-D3



4) ISPRAVLENÍ NAPON I STROVA



$$V_0(\omega t) = V_{max} \sin(\omega t)$$

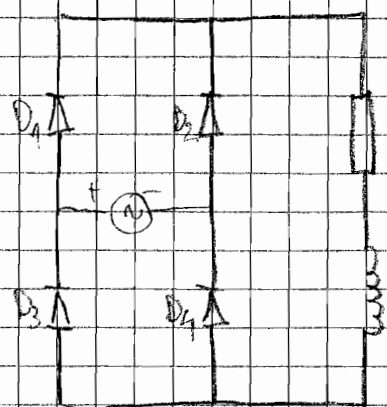
- SREDNÍ VŘEDNOSTI NAPONA
VÝSTRA

$$V_0 = \frac{2 V_{max}}{\pi} - \text{SREDNÍ VŘEDNOSTI NAPONA TROJÍLA}$$

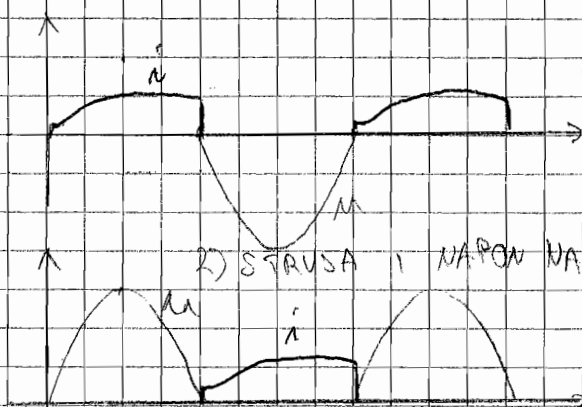
$$I_0 = \frac{V_0}{R} = \frac{2 V_{max}}{\pi R}$$

$$I_{RMS} = \frac{I_{max}}{\sqrt{2}}$$

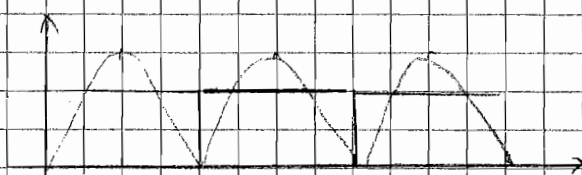
JEDNOFAZNI MOSNI SPOJ - R-L-TROŠILO:



1) STRUJA I NAPON NA D_1-D_2



2) STRUJA I NAPON NA D_3-D_4



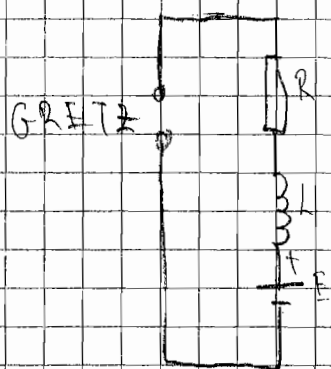
$$V_0 = \frac{2V_{max}}{\pi} \text{ - SREDNJA VRSNOST}$$

$$I_0 = \frac{V_0}{R}$$

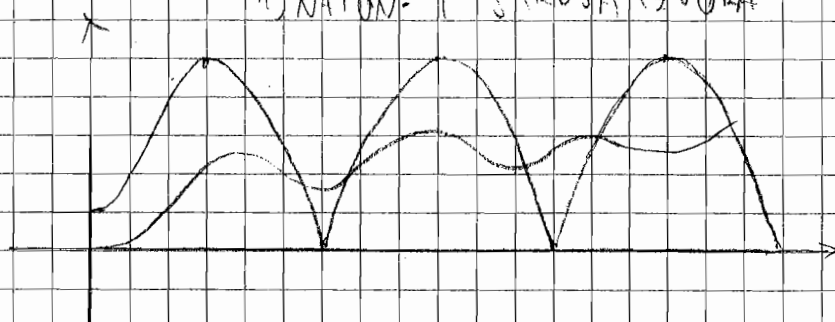
$$V_m = \frac{2V_m}{\pi} \left[\frac{1}{m-1} - \frac{1}{m+1} \right]$$

$$I_m = \frac{V_m}{Z_m} = \frac{V_m}{R + j\omega L}$$

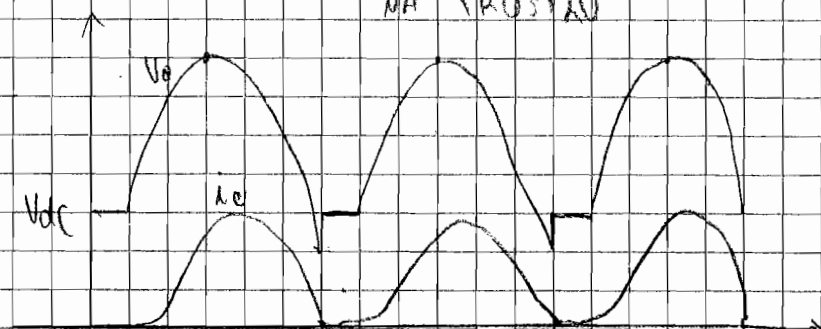
JEDNOFAZNI MOSNI SPOJ - R-L-E-TROŠILO:



1) NAPON I STRUJA IZVORA



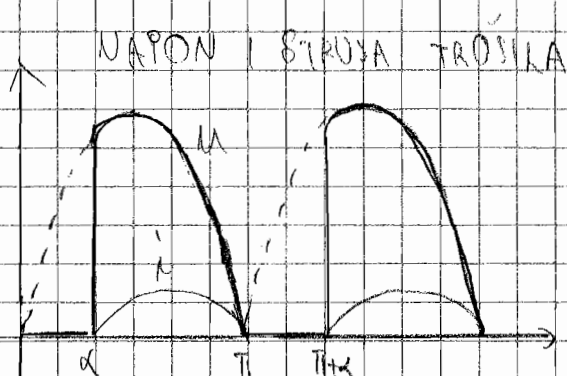
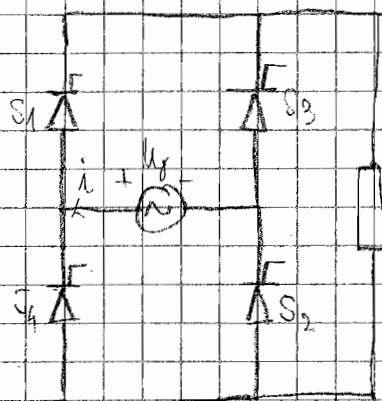
2) SREDNJA VRSNOST NAPONA I STRUJE NA TROŠILU



$$I_0 = \frac{V_0 - V_{dc}}{R} = \frac{\frac{2V_{max}}{\pi} - V_{dc}}{R}$$

PROVODNI ISPRAVLJAČI - UPRAVLJIVI:

R-TROŠILO:



$$\dot{V}_0 = \frac{V_{max}}{\pi} (1 + \cos \alpha)$$

$$\dot{I}_0 = \frac{V_0}{R} = \frac{V_{max}}{\pi R} (1 + \cos \alpha)$$

SREDNJA VREDNOST

NAPONA I STRUJE NA TROŠILU

2L-TROŠILO:

ISPRAKIDANA STRUJA:

$$i_0(\omega t) = \frac{V_{max}}{Z} \left[\sin(\omega t - \varphi) - \sin(\alpha - \varphi) e^{\frac{\alpha - \omega t}{\omega T}} \right]$$

$$\beta = \alpha + \pi$$

NEISPRAKIDANA STRUJA

$$\alpha = \tan^{-1} \left(\frac{\omega L}{R} \right)$$

$$V_0 = \frac{2 V_{max}}{\pi} \cos \alpha$$

$$I_0 = \frac{V_0}{R}$$

$$V_m = \sqrt{a_m^2 + b_m^2}$$

$$a_m = \frac{2 V_{max}}{\pi} \left[\frac{\cos(m+1)\alpha}{m+1} - \frac{\cos(m-1)\alpha}{m-1} \right]$$

$$b_m = \frac{2 V_{max}}{\pi} \left[\frac{\sin(m+1)\alpha}{m+1} - \frac{\sin(m-1)\alpha}{m-1} \right]$$

$m=2, 4, 6, \dots$

$$I_m = \frac{V_m}{Z_m} = \frac{V_m}{R + j\omega L}$$

R-L-E - TROŠILO:

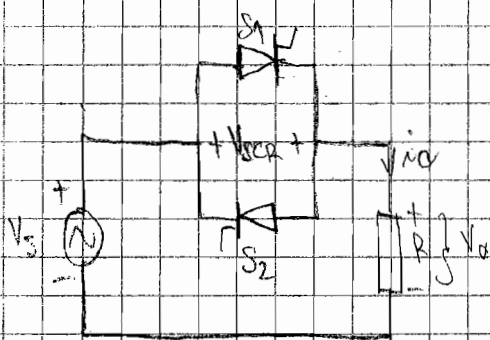
$$V_0 = \frac{2V_{max}}{\pi} \cos \alpha \quad \Rightarrow \quad \cos \alpha = \frac{V_0 \pi}{2V_{max}}$$

$$I_0 = \frac{V_0 - V_{de}}{R}$$

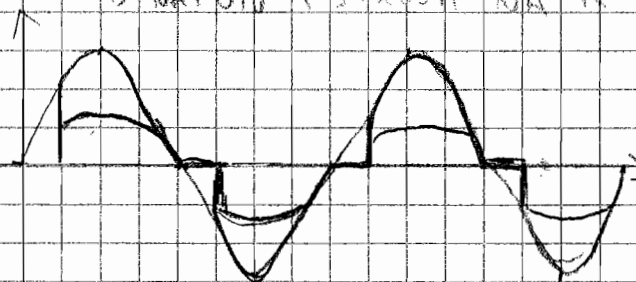
IZMENIČNI PRETVARAČI (AC/AC)

JEDNOFAZNI REGULATOR NAPONA:

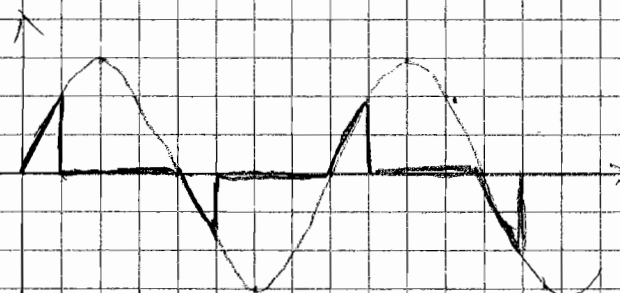
R-TROŠILO:



1) NAPON I STRUJA NA R



2) NAPON NA TIRISTORIMA



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

$$I_{RMS} = \frac{V_{RMS}}{R}$$

$$I_{OSCR} = \frac{V_{max}}{2\pi R} (1 + \cos \alpha)$$

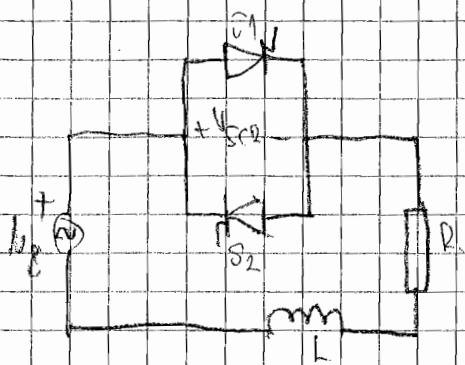
$$I_{SCR RMS} = \frac{I_{RMS}}{\sqrt{2}}$$

$$PF = \frac{P}{S} = \frac{P}{V_{SRMS} \cdot I_{SRMS}} = \frac{\frac{V_{RMS}^2}{R}}{V_{SRMS} \cdot \left(\frac{V_{RMS}}{R}\right)}$$

$$PF = \sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}}$$

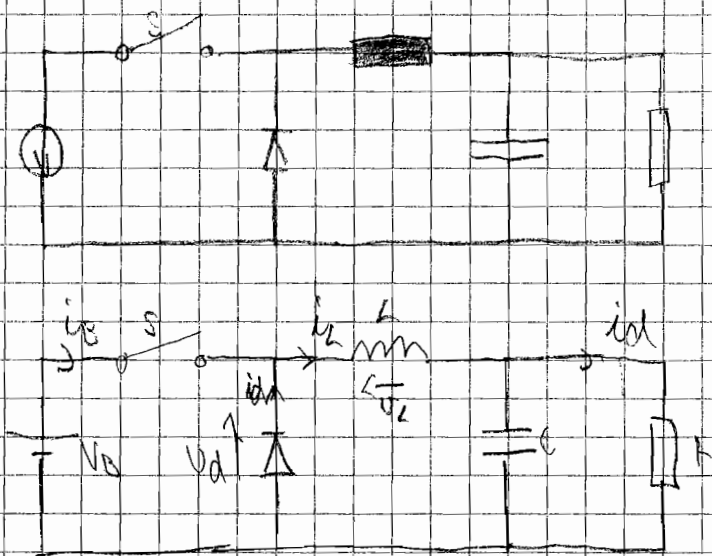
FAKTOR SNAGE

R-L-TROŠILO:



DC/DC - PRETVORBA

1) SILAZNI ISTOSMJERNI PRETVARAC (BUCK, STEP-DOWN):



- NEISPREKIDANI NAČIN RADA:

$$V_d = D V_B \text{ - NAPONSKA TRANSFORMATORSKA UJEDNAŽENJA}$$

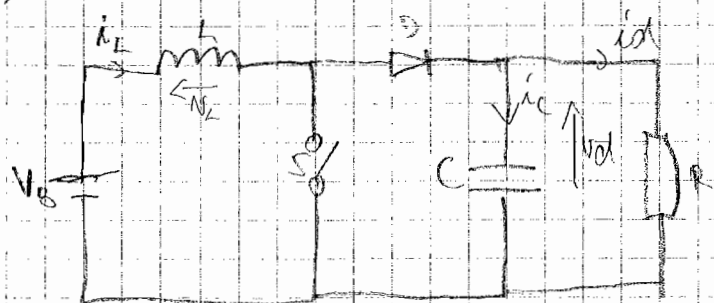
$$I_d = \frac{1}{D} I_B \text{ - STRUJNA}$$

$$I_d = I_L$$

- ISPREKIDANI NAČIN RADA:

$$\frac{V_d}{V_B} = \frac{D}{D+1} = \frac{D^2}{D^2 + \frac{1}{\eta} \frac{I_d}{I_{dmax}}} = \frac{D^2}{D^2 + \frac{1}{\eta} \left(\frac{I_0}{I_{LBmax}} \right)}$$

2) VZLAZNI ISTOSMERNI PRETVARAČ (BOOST, STEP-UP):

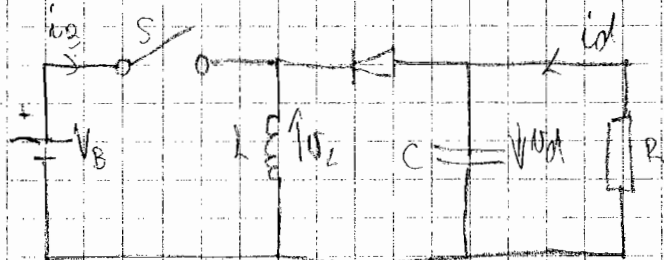


NEISPREKIDANI REŽIM:

$$\frac{V_O}{V_B} = \frac{1}{1-D} \quad - \text{NAPONSKA TRANSF. JED.}$$

$$\frac{I_O}{I_B} = \frac{V_B}{V_O} = 1-D \quad - \text{STRUJNA TRANSF. JED.}$$

3) SILAZNO-VZLAZNI PRETVARAČ (BUCK-BOOST):



$$\frac{V_O}{V_B} = \frac{D}{1-D} \quad - \text{NEISPREKIDANI REŽIM}$$

$$\frac{I_O}{I_B} = \frac{1-D}{D}$$