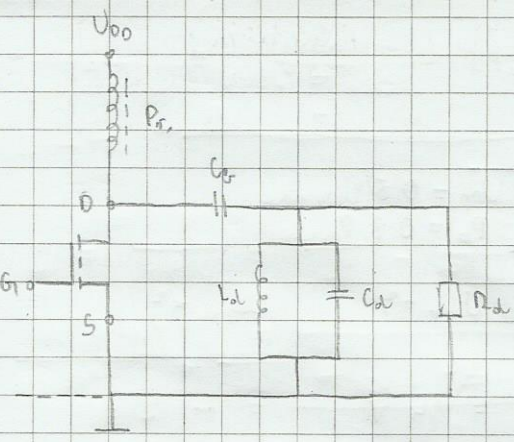
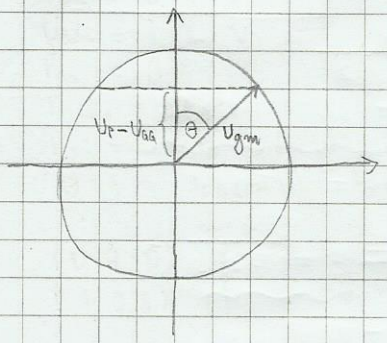
Zadaci:

3. $f = 1\ MHz = 10^6\ Hz$
$U_{DD} = 28\ V$
$U_{GG} = -1\ V$
$P_d = 39\ W$
$U_p = 1\ V$
$I_{d1m} = 1.1\ A$
$U_{gm} = 5.85\ V$
$U_{dsmin} = 4\ V$
$Q = 12$

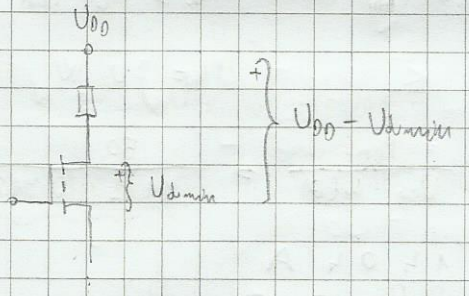
$\Theta = ?$ $\quad \eta_m = ?$ $\quad P_{DD} = ?$ $\quad P_h = ?$ $\quad R_d = ?$ $\quad L_d, C_d = ?$





$$\cos\Theta = \frac{U_p - U_{GG}}{U_{gm}} = \frac{1+1}{5.85} = 0.342$$

$$\Theta = 70°$$



$$\eta_m = \frac{U_{DD} - U_{dsmin}}{U_{DD}} = \frac{28-4}{28} = \frac{6}{7}$$

$$\eta_m = 0.857$$

jednosmjerna snaga: $P_{DD} = U_{DD} \cdot I_0 = U_{DD} \cdot I_{d1m} \cdot \gamma_0(\Theta) = 28 \cdot 1.1 \cdot 0.252$

$$P_{DD} = 7.7616\ W$$

korisna izlazna snaga: $P_h = \frac{U_{dsm} \cdot I_{d1m}}{2} = \frac{(U_{DD} - U_{dsmin}) \cdot I_{d1m} \cdot \gamma_1(\Theta)}{2} = \frac{(28-4) \cdot 1.1 \cdot 0.}{2}$

$$P_h = 5.7552\ W$$

$$R_d = \frac{U_{dsm}}{I_{d1m}} = \frac{U_{DD} - U_{dsmin}}{I_{d1m} \cdot \gamma_1(\Theta)} = \frac{28-4}{1.1 \cdot 0.436} = 50.04$$

$$R_d = 50\ \Omega$$

$$Q = \frac{R_d}{X_L} = \frac{R_d}{\omega L_d} \Rightarrow L_d = \frac{R_d}{\omega Q} = \frac{R_d}{2\pi f Q} = \frac{50}{2\pi \cdot 10^6 \cdot 12}$$

$$L_d = 0.66\ \mu H$$

$$Q = \frac{R_d}{X_C} = R_d \cdot \omega C_d \Rightarrow C_d = \frac{Q}{\omega R_d} = \frac{Q}{2\pi f R_d} = \frac{12}{2\pi \cdot 10^6 \cdot 50}$$

$$C_d = 38.2\ nF$$

9. Układ B

$U_{DSS} = 28\ V$
$P_d = 25\ W$
$\eta = 60\%$

$U_{DD} = ?$ albo $U_{DD} = 0.8\, U_{DD\,max}$
$P_{DD} = ?$ albo $P_D = 0.8\, P_d$
$P_h = ?$
$I_{dsku} = ?$ $U_{dsku} = ?$ $U_{d\,min} = ?$

$$U_{DD\,max} = \frac{U_{DSS}}{2} = 14\ V$$

$U_{DD} = 0.8\, U_{DD\,max} \Rightarrow \underline{U_{DD} = 11.2\ V}$

$P_D = 0.8 \cdot 25 = 20\ W$

$$\eta = \frac{P_h}{P_{DD}} = \frac{P_{DD} - P_D}{P_{DD}} \Rightarrow P_{DD} = \frac{P_D}{1-\eta} = \frac{20}{1-0.6}$$

$\underline{P_{DD} = 50\ W}$

$P_h = P_{DD} - P_D = 50 - 20$

$\underline{P_h = 30\ W}$

albo $\eta = \frac{P_h}{P_{DD}} \Rightarrow P_h = \eta \cdot P_{DD} = 0.6 \cdot 50$

$P_h = 30\ W$ ✓

$P_{DD} = U_{DD} \cdot I_{DS} = U_{DD} \cdot I_{dskuteczne} \cdot k_f(\vartheta)$

na Układ B: $\vartheta = 90°$

$$I_{dskuteczne} = \frac{P_{DD}}{U_{DD} \cdot k_f(\vartheta)} = \frac{50}{11.2 \cdot 0.318}$$

$\underline{I_{dskuteczne} = 14.04\ A}$

$$P_h = \frac{U_{dsr} \cdot I_{dsk}}{2} \Rightarrow U_{dsr} = \frac{2P_h}{I_{dsk}} = \frac{2P_h}{I_{dskuteczne} \cdot k_f(\vartheta)} = \frac{2 \cdot 30}{14.04 \cdot 0.5}$$

$\underline{U_{dsr} = 8.55\ V}$

$U_{d\,min} = U_{DD} - U_{dsr} = 11.2 - 8.55$

$\underline{U_{d\,min} = 2.65\ V}$

10. $T_{D,max} = 50°C$
$T_{S,max} = 130°C$
$K_{SK} = 0.5\ °C/W$
$K_{KH} = 0.2\ °C/W$
$K_{HO} = 0.8\ °C/W$
$\eta = 75\%$

$P_h = ?$

$K_{uk} = K_{SK} + K_{KH} + K_{HO} = 0.5 + 0.2 + 0.8 = 1.5\ °C/W$

$\Delta T = T_{S,max} - T_{D,max} = 130 - 50 = 80\ °C$

$$P_{dT} = \frac{\Delta T}{K_{uk}} = \frac{80}{1.5} = 53.33\ W$$

$$\eta = \frac{P_h}{P_{uh}} = \frac{P_{uh} - P_{dT}}{P_{uh}} \Rightarrow P_{uh} = \frac{P_{dT}}{1-\eta} = \frac{53.33}{1-0.75} = 213.33 \text{ W}$$

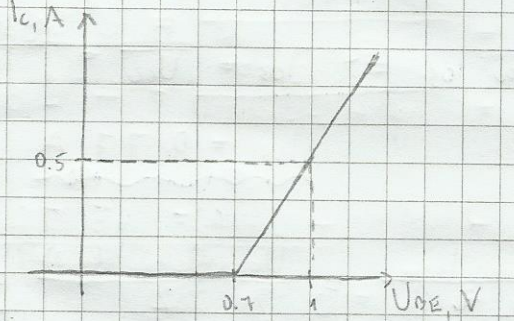
$$P_h = P_{uh} - P_{dT} = 213.33 - 53.33$$

$$P_h = 160 \text{ W}$$

11. Klasa C, $T_0 = 60°C$

$U_{BB} = 0.1$ V
$U_{CC} = 28$ V
$U_S = 1$ V
$U_{BE} = 1$ V $\rightarrow I_C = 0.5$ A
$U_h = 0.7$ V
$U_{bem} = 1.2$ V
$P_{ux} = 0.5$ W
$T_{S,max} = 180°C$
$K_{SK} = 0.015$ °C/mW, $K_{KH} = 6$ °C/W

$\theta = ?$ $I_{cbm} = ?$ $\eta = ?$ $G = ?$ $R_C = ?$ $K_{HO} = ?$



$$\left.\begin{matrix}(0.7, 0)\\(1, 0.5)\end{matrix}\right\} \quad y - 0 = \frac{0.5-0}{1-0.7}(x - 0.7)$$

$$y = \frac{5}{3}\left(x - \frac{7}{10}\right) \Rightarrow I_C = \frac{5}{3}\left(U_{BE} - \frac{7}{10}\right)$$

$$\overbrace{I_{Cmax}}^{I_{cbm}} = \frac{5}{3}\left(\overbrace{U_{BEmax}}^{U_{bem}} + U_{BB} - \frac{7}{10}\right) = \frac{5}{3}(1.2 + 0.1 - 0.7) = 1 \text{ A}$$

$$I_{cbm} = 1 \text{ A}$$

$$\cos(\theta) = \frac{U_h - U_{BB}}{U_{bem}} = \frac{0.7 - 0.1}{1.2} = 0.5 \Rightarrow \theta = 60°$$

$$I_{CS} = I_{cbm} \cdot f_0(\theta) = 1 \cdot 0.218 = 0.218 \text{ A}$$

$$P_h = \frac{U_{cm} \cdot I_{c1m}}{2} = \frac{(U_{CC} - U_S) \cdot I_{cbm} \cdot f_1(\theta)}{2} = \frac{(28-1) \cdot 1 \cdot 0.391}{2} = 5.2785 \text{ W}$$

$$P_{CC} = U_{CC} \cdot I_{CS} = 28 \cdot 0.218 = 6.104 \text{ W}$$

$$\eta = \frac{P_h}{P_{CC}} = \frac{5.2785}{6.104} \Rightarrow \eta = 86.48\ \%$$

$$G = 10 \log \frac{P_h}{P_{ux}} = 10 \log \frac{5.2785}{0.5}$$

$$G = 10.24 \text{ dB}$$

$$R_C = \frac{U_{cm}}{I_{c1m}} = \frac{U_{CC} - U_{cmin}}{I_{cbm} \cdot f_1(\theta)} = \frac{28-1}{1 \cdot 0.39\ldots}$$

$$R_C = 69\ \Omega$$

$$P_D = P_{CC} - P_h = 6.104 - 5.2785 = 0.8255 \text{ W}$$

$$\left.\begin{matrix}P_{dT} = P_D + P_{ux} = 0.8255 + 0.5 = 1.3255 \text{ W}\\ \Delta T = T_{S,max} - T_0 = 180 - 60 = 120\ °C\end{matrix}\right\} \quad K_{uh} = \frac{\Delta T}{P_{dT}} = \frac{120}{1.3255} = 90.53°\ldots$$

$$K_{uh} = K_{SK} + K_{KH} + K_{HO} \Rightarrow K_{HO} = K_{uh} - K_{SK} - K_{KH} = 90.53 - 15 - 6 = 69.53\ °C\ldots$$

12. $U_{cc} = 12\ V$ $\quad U_{CEO} = 30\ V$
$P_h = 8\ W$ $\quad U_{CEO(sus)} = 20\ V$
$\eta = 86.5\ \%$ $\quad I_{C\,max} = 3.5\ A$
$\Theta = ?$ $\quad I_{CS} = ?$

$$\eta = \frac{P_h}{P_{cc}} \Rightarrow P_{cc} = \frac{P_h}{\eta} = \frac{8}{0.865} = 9.249\ W$$

$$P_{cc} = U_{cc} \cdot I_{CS} \Rightarrow I_{CS} = \frac{P_{cc}}{U_{cc}} = \frac{9.249}{12}$$

$$I_{CS} = 0.77\ A$$

$$P_h = \frac{U_{cm} \cdot I_{C0m}}{2} = \frac{U_{cc} \cdot I_{C0m} \cdot f_1(\Theta)}{2} \Rightarrow I_{C0m} = \frac{2P_h}{U_{cc} \cdot f_1(\Theta)}$$

$$\eta = \frac{1}{2}\underbrace{h_m}_{=1} \cdot h_{vi} = \frac{1}{2} h_{vi} \Rightarrow h_{vi} = 2\eta = 2 \cdot 0.865 = 1.73$$

$$h_{vi} = 1.73 \overset{\text{tablica}}{\Longrightarrow} \Theta = 70°$$

$$I_{C0m} = \frac{2 \cdot 8}{12 \cdot 0.436} = 3.06\ A \leq I_{C\,max} = 3.5\ A \checkmark$$

$$U_N = U_{cc} + U_{cm} \geq 2U_{cc} = 2 \cdot 12 = 24\ V \leq U_{CEO} = 30\ V \checkmark$$

$$U_m = U_{cc} - U_{cm} \cdot \cos\Theta = U_{cc} - U_{cc}\cos\Theta = U_{cc}(1 - \cos\Theta) =$$

$$= 12(1 - \cos 70°) = 7.9\ V \leq U_{CEO(sus)} = 20\ V \checkmark$$

} tranzistor se može koristiti

13. $n = 3$, klasa C
$U_{cc} = 12\ V$
$P_{h3} = 1\ W$
$U_S = 2\ V$
$\Theta = ?$ $\quad I_{C0m} = ?$ $\quad \eta = ?$

* u tablici tražimo $f_3(\Theta)_{max} \Rightarrow f_3(\Theta) = 0.185$

$$\Theta = 40°$$

$$P_{h3} = \frac{U_{cm} \cdot I_{C0m}}{2} = \frac{(U_{cc} - U_S) \cdot I_{C0m} \cdot f_3(\Theta)}{2} \Rightarrow I_{C0m} = \frac{2P_{h3}}{(U_{cc} - U_S) \cdot f_3(\Theta)} = \frac{2 \cdot 1}{(12-2) \cdot 0.185}$$

$$I_{C0m} = 1.081\ A$$

$$P_{cc} = U_{cc} \cdot I_{CS} = U_{cc} \cdot I_{C0m} \cdot f_0(\Theta) = 12 \cdot 1.081 \cdot 0.147 = 1.91\ W$$

$$\eta = \frac{P_{h3}}{P_{cc}} = \frac{1}{1.91}$$

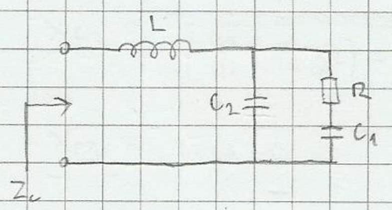
$$\eta = 52.4\ \%$$

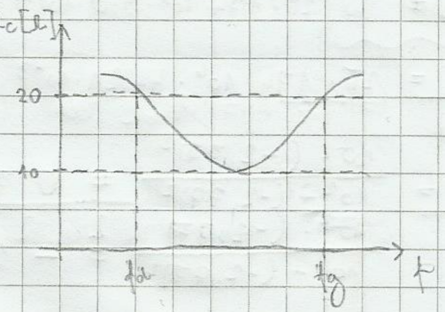
14. $f \in [132, 174]$ MHz

oscilacije: $f_d = 160$ mHz − $f_g = 36$ MHz => $R \leq 20\ \Omega$

a) $C_2 = 330$ pF, b) C_2 izostavljen

$R, C_1, L = ?$, $Z_{ul} = ?$





$R = ?$

poništavanje utjecaja L i C => $R = 10\ \Omega$

f_d:

$$f_d = \frac{\omega_d}{2\pi} = \frac{1}{2\pi\tau_d} = \frac{1}{2\pi R C_1} \Rightarrow C_1 = \frac{1}{2\pi f_d R} = \frac{1}{2\pi \cdot 160 \cdot 10^3 \cdot 10}$$

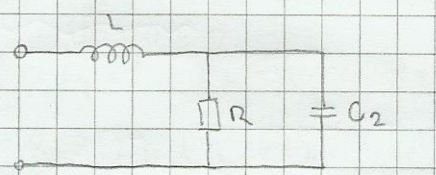
jer $Z_{RC_1} \gg Z_{C_2}$

$C_1 = 99.47$ nF

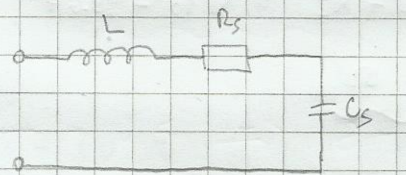
f_g:

$$f_g = \frac{\omega_g}{2\pi} = \frac{1}{2\pi\tau_g} = \frac{1}{2\pi \cdot \frac{L}{R}} = \frac{R}{2\pi \cdot L} \Rightarrow L = \frac{R}{2\pi f_g} = \frac{10}{2\pi \cdot 36 \cdot 10^6}$$

$L = 44.21$ nH



=>



$$R_s = \frac{R_p X_p^2}{R_p^2 + X_p^2} \qquad X_s = \frac{R_p^2 X_p}{R_p^2 + X_p^2}$$

a)

* f_{rd} (donja radna frekvencija):

$$X_{C2} = -\frac{1}{2\pi f_{rd} C_2} = -\frac{1}{2\pi \cdot 132 \cdot 10^6 \cdot 330 \cdot 10^{-12}} = -3.65\ \Omega$$

$$X_L = 2\pi f_{rd} L = 2\pi \cdot 132 \cdot 10^6 \cdot 44.21 \cdot 10^{-9} = 36.67\ \Omega$$

$$R_s = \frac{R \cdot X_{C2}^2}{R^2 + X_{C2}^2} = \frac{10 \cdot (-3.65)^2}{10^2 + (-3.65)^2} = 1.18\ \Omega$$

$$X_s = \frac{R^2 \cdot X_{C2}}{R^2 + X_{C2}^2} = \frac{10^2 \cdot (-3.65)}{10^2 + (-3.65)^2} = -3.22\ \Omega$$

$$X_{ul} = X_L + X_s = 36.67 - 3.22 = 33.45\ \Omega$$

$$R_{ul} = R_s = 1.18\ \Omega$$

$$|Z_{ul}| = \sqrt{R_{ul}^2 + X_{ul}^2}$$

$$|Z_{ul}| = \sqrt{33.45^2 + 1.18^2}$$

$$|Z_{ul}| = 33.47\ \Omega$$

* f_{rg} (gornja radna frekvencija):

$$X_{C_2} = -\frac{1}{2\pi \cdot 174 \cdot 10^6 \cdot 330 \cdot 10^{-12}} = -2.77\ \Omega$$

$$X_L = 2\pi \cdot 174 \cdot 10^6 \cdot 44.21 \cdot 10^{-9} = 48.33\ \Omega$$

$$R_S = \frac{10 \cdot (-2.77)^2}{10^2 + (-2.77)^2} = 0.71\ \Omega$$

$$X_S = \frac{10^2 \cdot (-2.77)}{10^2 + (-2.77)^2} = -2.57\ \Omega$$

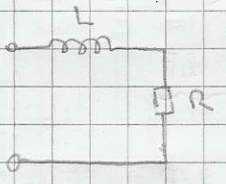
$$X_{wh} = 48.33 - 2.57 = 45.76\ \Omega$$

$$R_{wh} = R_S = 0.71\ \Omega$$

$$|Z_{wh}| = \sqrt{45.76^2 + 0.71^2}$$

$$|Z_{wh}| = 45.77\ \Omega$$

c)



f_{rd}:

$R = 10\ \Omega$

$X_L = 2\pi f_{rd} L = 2\pi \cdot 132 \cdot 10^6 \cdot 44.21 \cdot 10^{-9} = 36.67\ \Omega$

$$|Z_{we}| = \sqrt{R^2 + X_L^2} = \sqrt{10^2 + 36.67^2}$$

$$|Z_{we}| = 38\ \Omega$$

f_{rg}:

$R = 10\ \Omega$

$X_L = 2\pi f_{rg} L = 2\pi \cdot 174 \cdot 10^6 \cdot 44.21 \cdot 10^{-9} = 48.33\ \Omega$

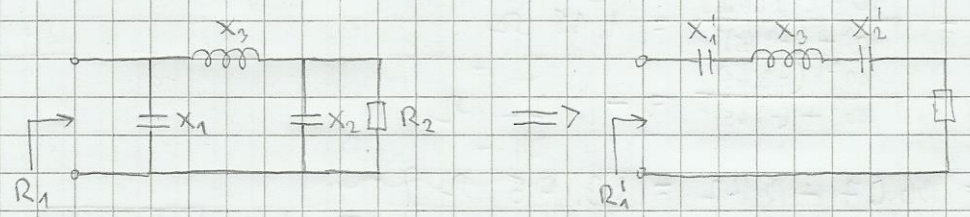
$$|Z_{we}| = \sqrt{10^2 + 48.33^2}$$

$$|Z_{we}| = 49.35\ \Omega$$

15. $r_a = 8\ \Omega \rightarrow R = 50\ \Omega$ $\qquad L = 1.136\ \mu H$

$f_d = 980\ MHz$, $f_g = 1400\ MHz$

$C_1, C_2 = ?$



$$X_L = X_3 = \frac{R_1}{1+Q^2}\left(Q + \sqrt{\frac{R_2}{R_1}(1+Q^2) - 1}\right) = \frac{R}{1+Q^2}\left(Q + \sqrt{\frac{r_a}{R}(1+Q^2) - 1}\right) \approx$$

$$\approx \frac{R}{Q^2}\left(Q + \sqrt{\frac{r_a}{R}} \cdot Q\right) = \frac{R}{Q} + \frac{R}{Q}\sqrt{\frac{r_a}{R}} = \frac{R}{Q}\left(1 + \sqrt{\frac{r_a}{R}}\right) =$$

$$\Rightarrow \quad Q = \frac{R}{X_L}\left(1 + \sqrt{\frac{r_a}{R}}\right) = \frac{50}{X_L}\left(1 + \sqrt{\frac{8}{50}}\right) = \frac{70}{X_L}$$

f2:

$$Q = \frac{70}{X_L} = \frac{70}{2\pi f_2 L} = \frac{70}{2\pi \cdot 980 \cdot 10^3 \cdot 1.136 \cdot 10^{-6}} = 10$$

$$X_{C_1} = \frac{1}{2\pi f_2 C_1} = \frac{R_1}{Q} \Rightarrow C_1' = \frac{Q}{2\pi f_2 R} = \frac{10}{2\pi \cdot 980 \cdot 10^3 \cdot 50} = 32.48\ nF$$

$$X_{C_2} = \frac{R_2}{\sqrt{\frac{R_2}{R_1}(1+Q^2)-1}} = \frac{\sqrt{8}}{\sqrt{\frac{\sqrt{8}}{R}(1+2^2)-1}} = \frac{8}{\sqrt{\frac{8}{50}(1+10^2)-1}} = 2.05\ \Omega$$

$$X_{C_2} = \frac{1}{2\pi f_2 C_2} \Rightarrow C_2' = \frac{1}{2\pi f_2 X_{C_2}} = \frac{1}{2\pi \cdot 980 \cdot 10^3 \cdot 2.05} = 79.22\ nF$$

fg:

$$Q = \frac{70}{2\pi f_g L} = \frac{70}{2\pi \cdot 1400 \cdot 10^3 \cdot 1.136 \cdot 10^{-6}} = 7$$

$$X_{C_1} = \frac{1}{2\pi f_g C_1} = \frac{R_1}{Q} \Rightarrow C_1'' = \frac{Q}{2\pi f_g R} = \frac{7}{2\pi \cdot 1.4 \cdot 10^6 \cdot 50} = 15.92\ nF$$

$$X_{C_2} = \frac{\sqrt{8}}{\sqrt{\frac{\sqrt{8}}{R}(1+2^2)-1}} = \frac{8}{\sqrt{\frac{8}{50}(1+7^2)-1}} = 3.02\ \Omega$$

$$C_2'' = \frac{1}{2\pi f_g X_{C_2}} = \frac{1}{2\pi \cdot 1.4 \cdot 10^6 \cdot 3.02} = 37.64\ nF$$

$15.92\ nF < C_1 < 32.48\ nF$; $37.64\ nF < C_2 < 79.22\ nF$

16.

$f = 3\ MHz$

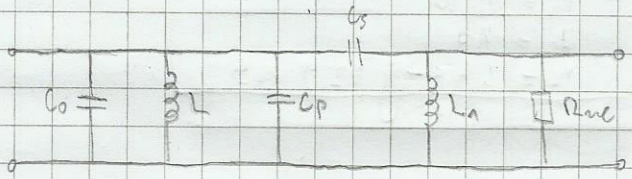
$T_1 \ldots C_0 = 30\ pF$

$U_s = 2\ V$

$T_2 \ldots Z_{ve} = 4 + j0\ \Omega \Rightarrow R_{ve} = 4\ \Omega$

$U_h = 0.6\ V$

$C_p = ?$ $P_h = ?$ $\Theta = ?$



$L = 0.53\ \mu H$ $C_s = 4\ nF$

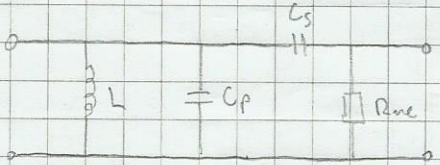
$L_1 = 25\ \mu H$ $U_{cc} = 9\ V$

$$X_L = 2\pi f L = 2\pi \cdot 3 \cdot 10^6 \cdot 0.53 \cdot 10^{-6} = 10\ \Omega$$

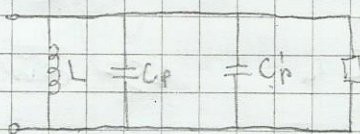
$$X_{L_1} = 2\pi f L_1 = 2\pi \cdot 3 \cdot 10^6 \cdot 25 \cdot 10^{-6} = 471\ \Omega \Rightarrow L_1 \text{ neinfluențat}$$

$$X_{C_S} = -\frac{1}{2\pi f C_S} = -\frac{1}{2\pi \cdot 3 \cdot 10^6 \cdot 4 \cdot 10^{-9}} = -13.26\ \Omega$$

$$X_{C_0} = -\frac{1}{2\pi f C_0} = -\frac{1}{2\pi \cdot 3 \cdot 10^6 \cdot 30 \cdot 10^{-12}} = 1768.39\ \Omega \Rightarrow C_0 \text{ neinfluențat}$$



$\Rightarrow$



$$R_{ie}' = \frac{R_{ve}^2 + X_{C_S}^2}{R_{ve}} = \frac{4^2 + (-13.26)^2}{4} = 48\ \Omega$$

$$X_{C_P}' = \frac{R_{ve}^2 + X_{C_S}^2}{X_{C_S}} = \frac{4^2 + (-13.26)^2}{-13.26} = -14.5\ \Omega$$

$B_{mh} = 0$; $B_{mh} = B_L + B_{Cp} + B_{C_p'} \Rightarrow B_{Cp} = B_{mh} - B_L - B_{Cp} = -B_L - B_{Cp}$

$B_L = \frac{1}{X_L} = 0.1\ S$

$B_{C_p'} = \frac{1}{X_{C_p'}} = -0.07\ S$

$B_{Cp} = -2\pi f C_p = -B_L - B_{Cp} \Rightarrow C_p = \frac{B_L + B_{Cp}}{2\pi f} = \frac{0.1 - 0.07}{2\pi \cdot 3 \cdot 10^6}$

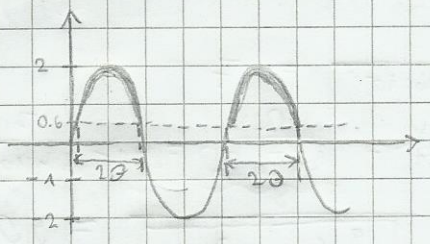
$C_p = 1.59\ nF$

$$P_h = \frac{\left(\frac{U_m}{\sqrt{2}}\right)^2}{R_c} = \frac{(U_{cc} - U_s)^2}{2R_{ac}} = \frac{(9-2)^2}{2 \cdot 48} = \frac{49}{96}$$

$$P_h = 0.51 \text{ W}$$

$$P_{cc} = \frac{U_{cc}^2}{R_c} = \frac{9^2}{48} = 1.69 \text{ W}$$

$$P_h = \frac{U_m^2}{2R_{ac}} \Rightarrow U_m = \sqrt{2 P_h R_{ac}} = \sqrt{2 \cdot 0.51 \cdot 4} = 2 \text{ V}$$



$$\cos\theta = \frac{U_h}{U_m} = \frac{0.6}{2} = 0.3 \Rightarrow \theta = 72.54°$$