REŠENJA:

1. a)

$V_G = R_G I_G = 10\text{V}$

$V_D = R_D I_D = R_D I = 8\text{V}$

$v_{D\max} = V_G - V_T = 10\text{V} + 2\text{V} = 12\text{V}$

$v_{d\max} = v_{D\max} - V_D = 12\text{V} - 8\text{V} = 4\text{V}$

U negativnoj poluperiodi izlaznog napona maksimalna amplituda je 8V. Manja od ove dve vrednosti je maksimalna amplituda naizmenične komponente izlaznog napona v_D pri kojoj tranzistor ne izlazi iz režima zasićenja, dakle $V_{d\max} = 4\text{V}$.

b)

$g_m = \sqrt{2I_D B} = \sqrt{2IB} = 2\text{mS}$

$a_v = g_m R_D = 16$

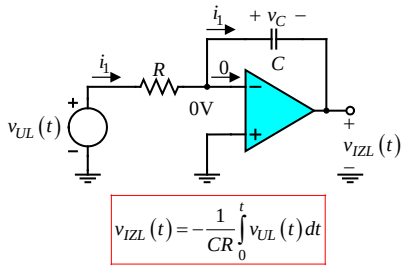
$R_{ul} = 1/g_m = 500\Omega$

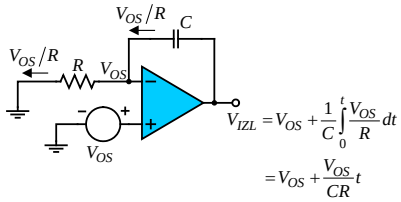
2.

$$I_{C4} = I_4 = I_3 = \frac{V_{CC} - V_{EE} - V_{BE}}{R_1} = 1\text{mA};\ I_1 = I_2 = 0{,}5\text{mA};\ g_{m1} = g_{m2} = \frac{I_1}{V_T} = 20\text{mS}$$

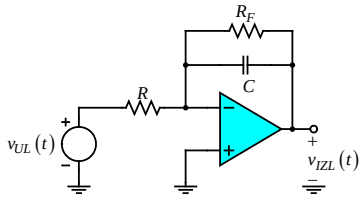
$$A_d = \frac{v_i}{v_{u1} - v_{u2}} = \frac{g_{m2} R_2}{2};\ A_s \cong -\frac{R_2}{2r_{ce4}};\ \rho = \left|\frac{A_d}{A_s}\right| \cong g_{m2} r_{ce4} = 1000$$

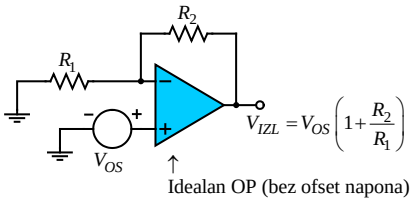
3. a)





b)





Ako se paralelno kondenzatoru veže R_f :

$$1\text{V} = 1\text{mV}\left(1 + \frac{R_f}{R}\right)$$

$R_f = 999R$

c) Beleške za predavanja, „12_Kola_sa_operacionim_pojacavacima.pdf“, slajd 12.

4.

a), b)

za $v_G = -10\text{V}$ DZ1 ON, D1 ON

$v_P = -V_Z + V_D = -4\text{V}$; $i_G = \frac{v_G + V_Z}{R_1} = -10.6\text{mA}$

I $-10\text{V} \le v_G < \text{V}_1$ DZ1 ON, D1 ON V_1 - trenutak isključenja zener diode

$v_P = -V_Z + V_D = -4\text{V}$; $i_G = \frac{v_G + V_Z}{R_1}$;

$i_Z(V_1)=0 \Rightarrow i_P(V_1)=i_G(V_1) \Rightarrow \frac{-V_Z+V_D}{R_P}=\frac{V_1+V_Z}{R_1} \Rightarrow V_1=\frac{R_1}{R_P}(-V_Z+V_D)-V_Z=-6.7\text{V}$

II $\text{V}_1 \le v_G < \text{V}_2$ DZ1 OFF, D1 ON V_2 - trenutak isključenja diode D1

$v_P=\frac{v_G+V_D}{R_1+R_P}R_P$; $i_G=\frac{v_G+V_D}{R_1+R_P}$; $V_2=-V_D=-0.7\text{V}$

III $\text{V}_2 \le v_G < \text{V}_3$ DZ1 OFF, D1 OFF V_3 - trenutak uključenja zener diode

$v_P=0$; $i_G=0$; $V_3=V_D=0.7\text{V}$

III $\text{V}_3 \le v_G \le +10\text{V}$ DZ1 ON, D1 OFF

$v_P=0$; $i_G=\frac{v_G-V_D}{R_1}$

za $v_G=10\text{V}$ $i_G=18.6\text{mA}$

c), d)

I za $v_P-V_D \ge -\text{V}_Z$ važi DZ1 OFF

$v_P=\frac{V_G+V_D}{R_1+R_P}R_P=\frac{V_G+V_D}{1+\frac{R_1}{R_P}}$; $i_{DZ1}=0 \Rightarrow P_Z=0$

$v_P \ge -V_Z+V_D \Rightarrow \frac{V_G+V_D}{1+\frac{R_1}{R_P}} \ge -V_Z+V_D \Rightarrow R_P \le R_1\frac{1}{\frac{V_G+V_D}{-V_Z+V_D}-1}=377\Omega$

II za $R_P > 377\Omega$ DZ1 ON

$v_P=-V_Z+V_D=-4\text{V}$; $i_{DZ1}=-\frac{V_G+V_Z}{R_1}+\frac{-V_Z+V_D}{R_P} \Rightarrow P_Z=-\frac{V_G+V_Z}{R_1}V_Z+\frac{-V_Z+V_D}{R_P}V_Z$

$P_Z(R_P=377\Omega)=7.43\text{mW}$

$P_Z(R_P \to \infty)=\frac{-V_G-V_Z}{R_1}V_Z=49.82\text{mW}$

5.

a)

$v_X=v_A-R(\frac{v_B-v_A}{R}-\frac{v_A}{R})=3v_A-v_B$

$v_I=v_X-(\frac{v_A-v_X}{R}-\frac{v_X}{R_X})R=(5+\frac{3R}{R_X})v_A-(2+\frac{R}{R_X})v_B$

b)

$v_I=(3+\frac{2R}{R_X})v_A=(3+\frac{2R}{R_X})V_m\sin(2\pi ft) \le V_{CC} \Rightarrow R_X \ge \frac{2R}{\frac{V_{CC}}{V_m}-3}=5\text{k}\Omega$