2.

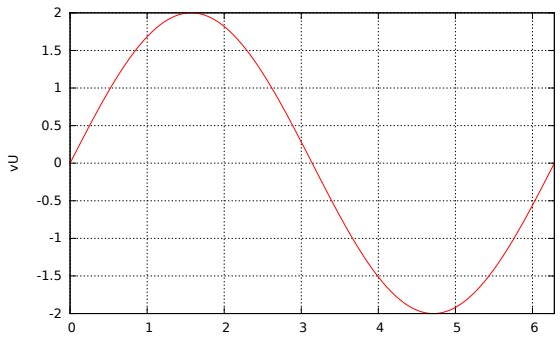
a) Fazni stav od izlaza operacionog pojačavača do pozitivnog napajanja je π. Da bi u kolu postojala negativna povratna sprega, potrebno je da gornji (prema slici) ulazni priključak operacionog pojačavača bude invertujući.

b) Potrebno je da u mirnoj radnoj tački (u odsustvu pobude) izlazni tranzistori budu na granici provođenja, to jest da napon na otporniku R_B bude V_{BE}, a struja tranzistora bliska nuli. Tada je

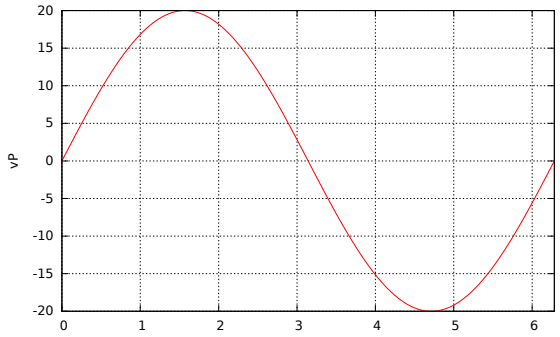
$$I_{CCOP} = \frac{V_{BE}}{R_B} + \frac{I_{C1/2}}{\beta} \approx \frac{V_{BE}}{R_B}$$
$$R_B = \frac{V_{BE}}{I_{CCOP}} = 700\,\Omega$$

c)

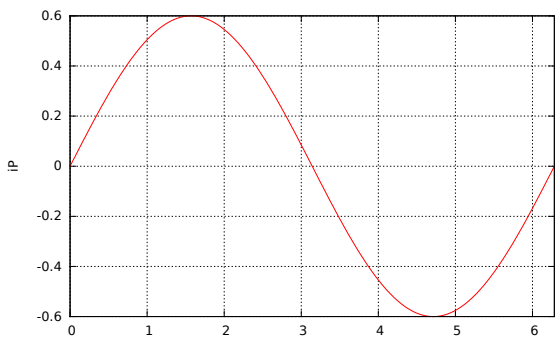
$$v_U = 2\,\mathrm{V}\,sin(\omega t)$$



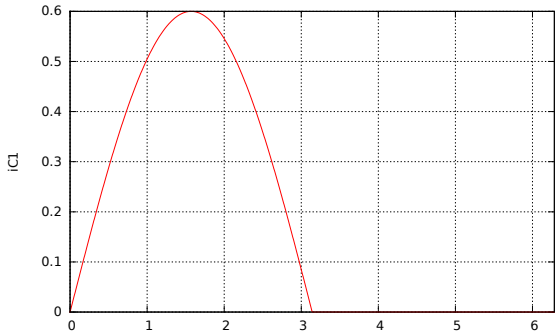
$$v_P = 10 v_U = 20\,\mathrm{V}\,sin(\omega t)$$



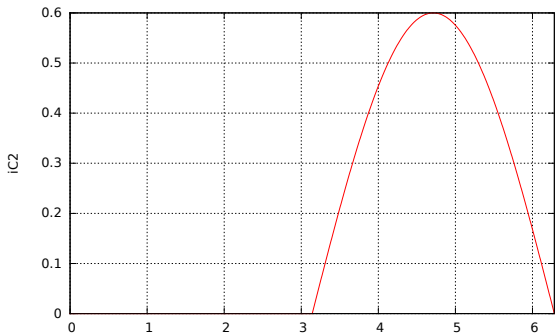
$$i_P = \frac{v_P}{R_P} = 0.6\,\mathrm{A}\,sin(\omega t)$$



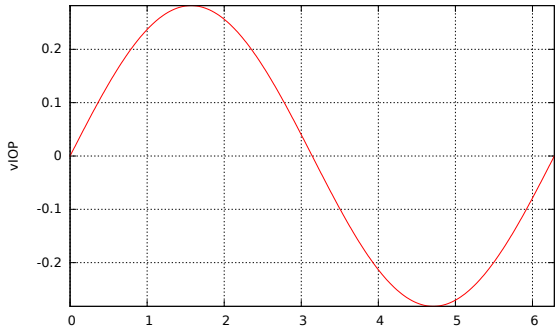
$$i_{C1} = \begin{cases} i_P & i_P \geq 0 \\ 0 & i_P < 0 \end{cases} = \begin{cases} 0.6\,\mathrm{A}\,sin(\omega t) & 2k\pi \leq \omega t \leq (2k+1)\pi \\ 0 & (2k+1)\pi \leq \omega t \leq 2(k+1)\pi \end{cases}$$



$$i_{C2} = \begin{cases} 0 & i_P \geq 0 \\ -i_P & i_P < 0 \end{cases} = \begin{cases} 0 & 2k\pi \leq \omega t \leq (2k+1)\pi \\ -0.6\,\mathrm{A}\,sin(\omega t) & (2k+1)\pi \leq \omega t \leq 2(k+1)\pi \end{cases}$$

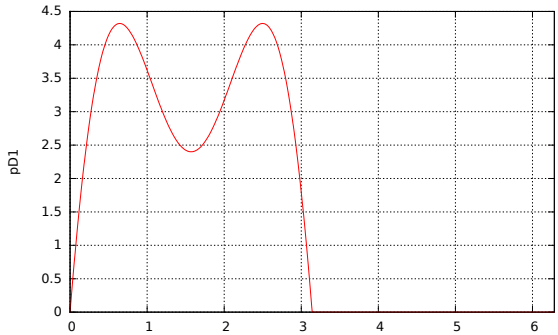


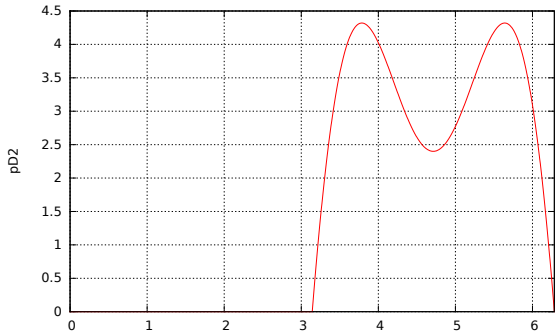
$$v_{IOP} = R_X \frac{i_P}{\beta} = R_X \frac{v_P}{\beta R_P} = 282\,\mathrm{mV}\,sin(\omega t)$$



$$p_{D1} = (V_{CC} - v_P) i_{C1} = \begin{cases} 14.4\,\mathrm{W}\,sin(\omega t) - 12\,\mathrm{W}\,sin^2(\omega t) & 2k\pi \leq \omega t \leq (2k+1)\pi \\ 0 & (2k+1)\pi \leq \omega t \leq 2(k+1)\pi \end{cases}$$

$$p_{D2} = (V_{CC} + v_P) i_{C2} = \begin{cases} 0 & 2k\pi \leq \omega t \leq (2k+1)\pi \\ -14.4\,\mathrm{W}\,sin(\omega t) - 12\,\mathrm{W}\,sin^2(\omega t) & (2k+1)\pi \leq \omega t \leq 2(k+1)\pi \end{cases}$$





d)

Ograničenje izlazne struje operacionog pojačavača:

$$i_{OP} = \frac{i_P}{\beta} \leq i_{OP\max}$$
$$\frac{V_p}{\beta R_P} \leq i_{OP\max}$$
$$V_p \leq \beta R_P i_{OP\max} = 33\,\mathrm{V}$$

Naponsko zasićenje operacionog pojačavača:

$$v_{IOP} = R_X \frac{i_P}{\beta} \leq V_{CC} - V_{BE}$$
$$R_X \frac{V_p}{\beta R_P} \leq V_{CC} - V_{BE}$$
$$V_p \leq \frac{\beta R_P}{R_X}(V_{CC} - V_{BE}) = 1622\,\mathrm{V}$$

Zasićenje tranzistora:

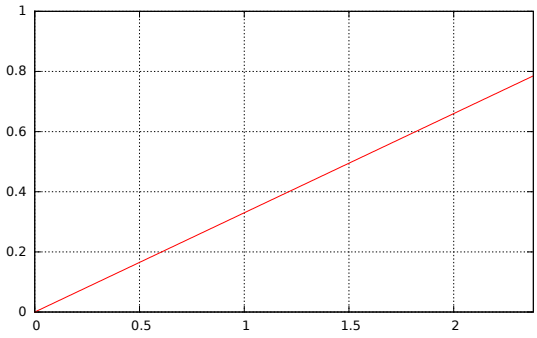
$$v_{CE1} = V_{CC} - v_P \geq V_{CES}$$
$$V_p \leq V_{CC} - V_{CES} = 23.8\,\mathrm{V}$$

Konačno je

$$V_{p\max} = 23.8\,\mathrm{V}$$

e)

$$\eta = \frac{P_{OUT}}{P_{CC}}$$
$$P_{OUT} = \frac{V_p^2}{2R_P}$$
$$P_{CC} = V_{CC}I_{C1} + V_{CC}I_{C2} = \frac{2}{\pi}\frac{V_{CC}}{R_P}V_p$$
$$\eta = \frac{5\pi}{2V_{CC}}V_u = 0.33V_u$$
$$\eta_{\max} = \eta(\frac{V_{p\max}}{10}) = 0.78$$


1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2