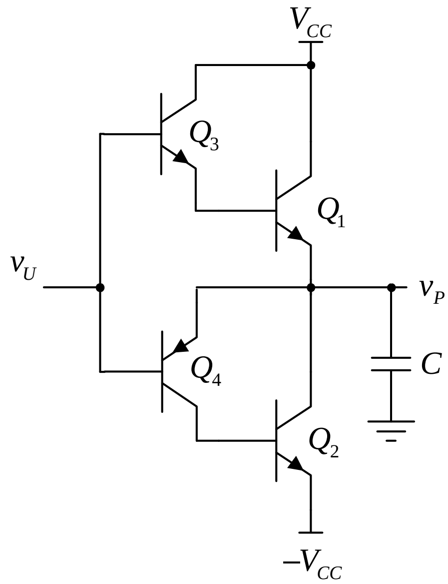
Zadatak. Napon na izlazu kola sa slike je oblika $v_P = V_p \sin(\omega t)$. Parametri kola su $\beta_F >> 1$, $C = 10\ \mu\text{F}$, $V_{CC} = 12\ \text{V}$, $V_{BE} = 0.7\ \text{V}$, $V_{CES} = 0.2\text{V}$. Maksimalna dozvoljena struja tranzistora je $i_{C\max} = 100\text{mA}$.

a) Za $\omega = 1\ \text{krad/s}$ i $V_P = 5\ \text{V}$ nacrtati i označiti dijagrame v_P, v_U, i_P, i_{C1} i i_{C2} tokom jedne periode izlaznog napona.

b) Izračunati i nacrtati dijagram zavisnosti maksimalne amplitude V_m izlaznog napona od ω.

c) Izračunati i nacrtati dijagram zavisnosti srednje snage disipacije na tranzsistoru Q_1 od V_p, za $\omega = 1\ \text{krad/s}$.



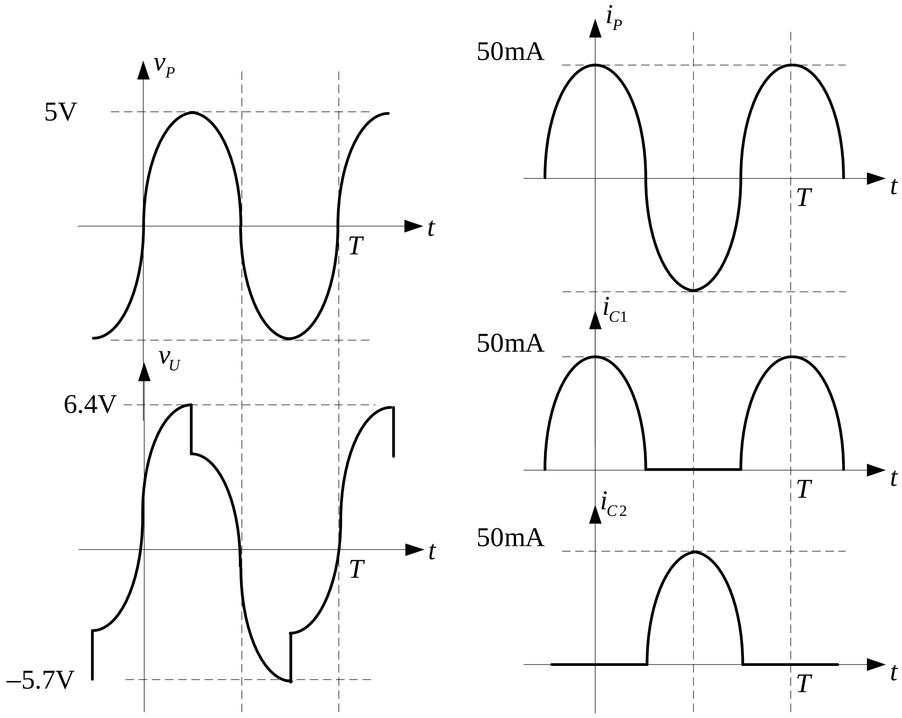
a)

$$v_P = 5\text{V} \sin \omega t$$

$$i_P = C\frac{dv_P}{dt} = \omega C V_p \cos \omega t = 50\ \text{mA} \cos \omega t$$

Za $i_P > 0$ vodi Q_1 (i Q_3), i važi $v_U = v_P + 2V_{BE} = 1.4\,\text{V} + 5\,\text{V} \sin \omega t$

Za $i_P < 0$ vodi Q_2 (i Q_4), i važi $v_U = v_P - V_{BE} = 5\,\text{V} \sin \omega t - 0.7\,\text{V}$



b)

Naponsko ograničenje:

Za Q_1: $v_P \le V_{CC} - V_{CES} = 11.8\text{V}$

Za Q_2: $v_P \ge V_{CES} - V_{CCC} = -11.8\text{V}$

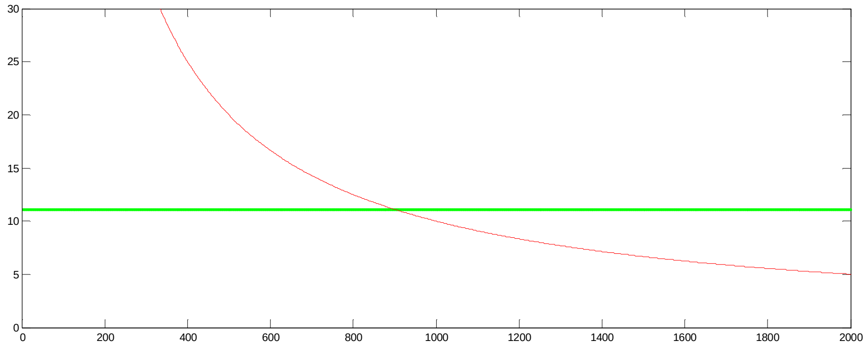
Za Q_3: $v_P \le V_{CC} - V_{CES} - V_{BE} = 11.1\text{V}$

Za Q_2: $v_P \ge V_{CES} + V_{BE} - V_{CCC} = -11.1\text{V}$

Strujno ograničenje:

$$i_{P\max} = \omega C V_p \le i_{C\max} \Rightarrow V_p \le \frac{i_{C\max}}{\omega C} = \frac{10000}{\omega}$$

$$V_{p\max}(\omega)=\begin{cases}11.1 & \omega\le 900.9\text{rad/s}\\ \dfrac{10000}{\omega} & \omega\ge 900.9\text{rad/s}\end{cases}$$



c)

$$p_{D1}=v_{CE1}i_{C1}=\left(V_{CC}-v_P\right)i_{C1}$$

$$p_{D1}=v_{CE1}i_{C1}=\begin{cases}\left(V_{CC}-V_p\sin\omega t\right)\omega CV_p\cos\omega t, & nT\le t\le\dfrac{(4n+1)T}{4}\vee\dfrac{(4n+3)T}{4}\le t\le(n+1)T\\ 0, & \dfrac{(4n+1)T}{4}\le t\le\dfrac{(4n+3)T}{4}\end{cases}$$

$$P_{D1}=\frac{1}{T}\int_0^T p_{D1}dt=\frac{1}{T}\left(\int_0^{\frac{T}{4}}\left(V_{CC}-V_p\sin\omega t\right)\omega CV_p\cos\omega tdt+\int_{\frac{3T}{4}}^{T}\left(V_{CC}-V_p\sin\omega t\right)\omega CV_p\cos\omega tdt\right)=$$

$$=\frac{V_{CC}\omega CV_p}{T}\left(\int_0^{\frac{T}{4}}\cos\omega tdt+\int_{\frac{3T}{4}}^{T}\cos\omega tdt\right)-\frac{\omega CV_p^{\ 2}}{T}\left(\int_0^{\frac{T}{4}}\sin\omega t\cos\omega tdt+\int_{\frac{3T}{4}}^{T}\sin\omega t\cos\omega tdt\right)$$

$$P_{D1}=\frac{\omega CV_{CC}}{\pi}V_p=0.038V_p\,,\ V_p\le V_{p\max}(1\text{krad/s})=10\text{V}$$

$$P_{D1}\left(V_{p\max}\right)=0.38\,\text{W}$$