REŠENJA

1.

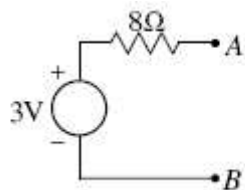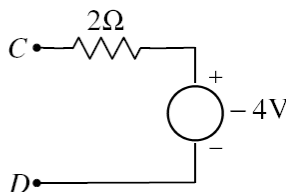**a)** $U_{TEV1} = 3V$; $R_{TEV1} = 8\Omega$.

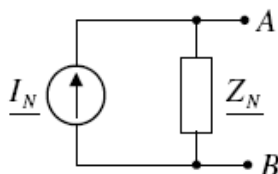**b)** $U_{TEV2} = -4V$; $R_{TEV} = 2\Omega$.

c) $V_G = 5V$

d) $U_{AD}=0$, tako da je snaga koja se disipira na otporniku R_P nula, bez obzira na vrednost otpornosti R_P .
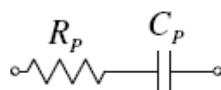
2. $R_{EKV} = R_1 + (\beta+1)R_2$

3. a) $\underline{Z}_N=3+j$ $\underline{I}_N=0.2-j0.4$

b) $\underline{Z}_P=3-j$ $R_P=3\Omega$ $C_P=3.18\mu F$

c) $\underline{S}=1/6-j/18$ $P=1/6W$ $Q=-1/18VAr$

d)

$$i_P(t) = \frac{1}{3}A\cos(100000\pi t - 45°)$$

4.

$$v_I = \begin{cases} 0, & 0 \le V_{CC} < V_{BE} = 0.6V, & T-OFF, DZ-OFF \\ \frac{1}{2}(V_{CC} - V_{BE}), & 0.6V \le V_{CC} < 2V_Z - V_{BE} = 9.4V, & T-DAR, DZ-OFF \\ V_Z - V_{BE}, & 9.4V \le V_{CC} \le 12V, & T-DAR, DZ-Z \end{cases}$$

5.

a)

$$V_G = V_{DD}\frac{R_{G1}}{R_{G2}+R_{G1}} - V_{DD}\frac{R_{G2}}{R_{G2}+R_{G1}} = 0$$

$$I_D = \frac{B_N}{2}(V_{GS}-V_{TN})^2$$

$$V_S = -V_{DD}+I_D R_S$$

$$I_D = \frac{B_N}{2}(V_G - V_S - V_{TN})^2 = \frac{B_N}{2}(V_G + V_{DD} - I_D R_S - V_{TN})^2$$

$$I_{D1} \approx 0.61\text{mA}(V_{GS} \approx 3.78 > VTN) \qquad\qquad I_{D2} \approx 1.64\text{mA } (V_{GS} \approx 1.72 < VTN)$$
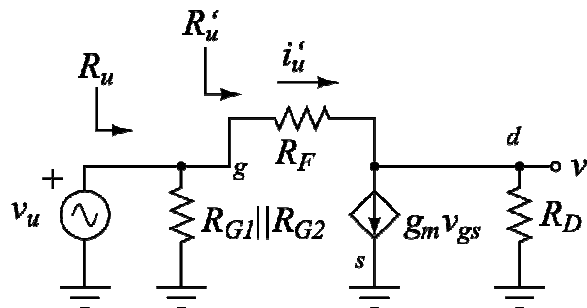
$$I_D = I_{D1}$$

b)

$$v_{gs} = v_u$$

$$\frac{v_u - v_i}{R_F} = g_m v_{gs} + \frac{v_i}{R_D} = g_m v_u + \frac{v_i}{R_D}$$

$$v_i = -\frac{R_D}{R_D + R_F}(g_m R_F - 1)v_u$$

$$A_v = \frac{v_i}{v_u} == -\frac{R_D}{R_D + R_F}(g_m R_F - 1)$$

$$R_u' = \frac{v_g}{i_u'} = \frac{v_g}{\frac{v_g - v_i}{R_F}} = \frac{R_F}{1 - A_v}$$

$$R_u = R_{G1} \| R_{G2} \| R_u'$$

c)

$$g_m = \sqrt{2 I_D B_N} \approx 1.56\text{mS}$$

$$R_F = \frac{R_D - A_v R_D}{A_v + g_m R_D} \approx 8.9k\Omega$$

$$R_u \approx 1.04k\Omega$$

6. a) $I_1 = I_C + 3I_B = 1.03\text{mA}$

b)

$$g_{m5} = g_{m6} = g_m = \sqrt{2BI_{D5}} = \sqrt{2B\frac{I_1}{2}} = 1\text{mS}$$

$$g_{m4} = \sqrt{2BI_{D4}} = \sqrt{2BI_1} = 1.41\text{mS}$$

c)

$$V_P = 0 = Vcc - R_{DP}I_{D4} \rightarrow R_{DP} = 12k\Omega$$

$$V_{GS4} = V_{TH} + \sqrt{2I_{D4}/B} = 2.41\text{V} \rightarrow V_{G4} = -1.59V = Vcc - R_D I_{D5}$$

$$R_D = -1.59V = (Vcc + 1.59V)/I_{D5} = 27.18k\Omega$$

d) Kako se radi o dva pojačavača redno vezana, diferencijalnog i sa zajedničkim sorsom pojačanje iznosi:

$$a = g_m \frac{R_D}{2}\cdot(-g_{m4}R_{DP}) = \frac{27.2}{2}(-1.41\cdot12) \approx -230$$

e) Ako je $v_{g1} = 0.1\text{mV}\cos\omega t$, a $v_{g2} = -0.2\text{mV}\cos(\omega t + \pi/6)$ efektivna vrednost napona v_p

$\underline{V}_{g1} = 0.1\text{mV} / \sqrt{2}$

$\underline{V}_{g2} = \left(-0.2\text{mV} / \sqrt{2}\right)\left(\cos\dfrac{\pi}{6} + j\sin\dfrac{\pi}{6}\right)$
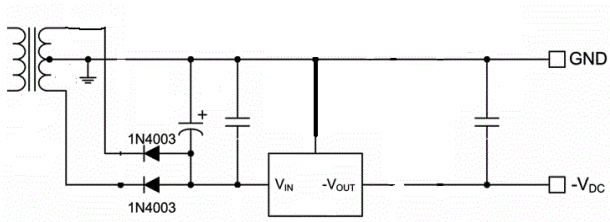
$\underline{V}_d = \underline{V}_{g1} - \underline{V}_{g2} = \dfrac{0.1\text{mV}}{\sqrt{2}}\left(\sqrt{3} + 2j\right) = V_d e^{j\varphi}$

$V_d = 0.1\text{mV} \cdot \sqrt{\dfrac{7}{2}} \approx 0.19\text{mV}$

$V_p = \underset{a}{\underline{230}}\,V_d \approx 44\text{mV}$

7.
a)

b) Pošto se beta kolo sastoji od pojačavača sa zajedničkim emiterom čije je pojačanje negativno, znači da je koeficijent beta negativan, pa se povratna sprega vraća na plus.

c)

$P_{DZ} = 20\text{mW} = I_Z V_Z \Rightarrow I_Z = P_{DZ} / V_Z = 6.67\text{mA}$

$(10\text{V} - 3\text{V}) / R = 6.67\text{mA} \Rightarrow R = 1.05\text{k}\Omega$

Napon sa zener diode se pojačava neinvertujućim pojačavačem čije je pojačanje $1 + R_2 / R_1$. Sleduje:

$-3(1 + R_2 / R_1) = -5 \Rightarrow 3R_2 / R_1 = 2 \Rightarrow R_2 = 2\text{k}\Omega$

d)
Na osnovu maksimalne disipacije:

$P_{DZ\,\text{max}} = 30\text{mW} = I_{Z\,\text{max}} V_Z \Rightarrow I_{Z\,\text{max}} = P_{DZ\,\text{max}} / V_Z = 10\text{mA}$

$(|V_{u\,\text{min}}| - 3\text{V}) / 1.05\text{k}\Omega = 10\text{mA} \Rightarrow V_{u\,\text{min}} = -13.5\text{V}$

Na osnovu granice zasićenja tranzistora:

$V_{u\,\text{max}} = -5\text{V} - V_{CES} = -5.2\text{V}$