IR2OAE, IR3OAE Osnovi analogne elektronike - rešenja zadataka, kolokvijum 2013:

1. Beleške za predavanja, „Dioda.pdf“, slajdovi 29 i 30.

2. Beleške za predavanja, „4_Pojacavacke_sprege_sa_bipolarnim_tranzistorima.pdf“, slajdovi 5, 6 i 9.

3. Beleške za predavanja, „6_Pojacavacke_sprege_sa_MOS_tranzistorima.pdf“, slajd 10 i „7_Strujni_izvori_i_aktivno_opterecenje.pdf“, slajd 3.

4.

a), b)

$-12\text{V} \le v_G < V_1$, D1 – ON, DZ – na granici provođenja, sa nultom strujom

$v_P = -V_D = -0.7\text{V}$, $i_Z = 0 \Rightarrow P_Z = 0$

Dioda D1 se koči pri povećanju napona generatora preko vrednosti V_1. Na granici zakočenja važi:

$$\frac{R_P}{R_G + R_P} V_1 = -V_D \Rightarrow V_1 = -(1 + \frac{R_G}{R_P}) V_D = -2V_D = -1.4\text{V}$$

$V_1 \le v_G < V_2$, D1 – OFF, DZ – OFF

$$v_P = \frac{R_P}{R_G + R_P} v_G = \frac{v_G}{2}\text{ , } i_Z = 0 \Rightarrow P_Z = 0$$

Pri naponu generatora V_2 počinje da vodi dioda DZ. Na granici provođenja važi:

$$\frac{R_P}{R_G + R_P} V_2 = V_Z \Rightarrow V_2 = (1 + \frac{R_G}{R_P}) V_Z = 2V_Z = 9.4\text{V}$$

$V_2 \le v_G \le 12\text{V}$, D1 – OFF, DZ – ON

$$\frac{v_G - v_P}{R_G} = \frac{v_P - V_Z}{R} + \frac{v_P}{R_P} \Rightarrow v_P = \frac{\frac{v_G}{R_G} + \frac{V_Z}{R}}{\frac{1}{R_G} + \frac{1}{R} + \frac{1}{R_P}} = \frac{v_G + V_Z}{3}$$

$$i_Z = \frac{v_P - V_Z}{R} = \frac{v_G - 2V_Z}{3R} \Rightarrow P_Z = V_Z i_Z = \frac{V_Z}{3R} v_G - \frac{2V_Z^2}{3R}$$

c)

$0 < R_P < R_{P1}$, DZ – OFF, D1 – OFF

$$v_P = \frac{R_P}{R_G + R_P} V_G = \frac{1}{1 + \frac{R_G}{R_P}} V_G$$

Pri otpornosti R_{P1} dioda DZ počinje da vodi. Na granici provođenja važi:

$$\frac{1}{1 + \frac{R_G}{R_{P1}}} V_G = V_Z \Rightarrow R_{P1} = \frac{R_G}{\frac{V_G}{V_Z} - 1} = 887\Omega$$

$R_{P1} \le R_P < \infty$, DZ – ON, D1 – OFF

$$\frac{V_G - v_P}{R_G} = \frac{v_P - V_Z}{R} + \frac{v_P}{R_P} \Rightarrow v_P = \frac{\frac{V_G}{R_G} + \frac{V_Z}{R}}{\frac{1}{R_G} + \frac{1}{R} + \frac{1}{R_P}}$$

$$v_{P\max} = v_P(R_P \to \infty) = \frac{\frac{V_G}{R_G} + \frac{V_Z}{R}}{\frac{1}{R_G} + \frac{1}{R}} = \frac{V_G + V_Z}{2} = 7.35\text{V}$$

5.

a) $-\frac{I_C}{\beta_F}R_B - V_{BE} - \frac{\beta_F+1}{\beta_F}I_C R_E = V_{EE} \Rightarrow R_E = -\frac{\beta_F}{(\beta_F+1)I_C}(\frac{I_C}{\beta_F}R_B + V_{BE} + V_{EE}) = 11.2\text{k}\Omega$

b) $r_{ce} = \frac{V_A}{I_C} = 75\text{k}\Omega$, $r_\pi = \frac{\beta_0 V_T}{I_C} = 2.5\text{k}\Omega$

$$\left.\begin{array}{c} v_p = (\beta_0+1)i_b(r_{ce} \parallel R_E \parallel R_P) \\ i_b = \dfrac{v_u}{r_\pi + (\beta_0+1)(r_{ce} \parallel R_E \parallel R_P)} \end{array}\right\} \Rightarrow a_v = \frac{v_p}{v_u} = \frac{(\beta_0+1)(r_{ce} \parallel R_E \parallel R_P)}{r_\pi + (\beta_0+1)(r_{ce} \parallel R_E \parallel R_P)} = 0.995$$

$$\left.\begin{array}{c} i_u = \dfrac{v_u}{r_\pi + (1+\beta_0)(r_{ce} \parallel R_E \parallel R_P)} \\ i_p = \dfrac{v_p}{R_P} \end{array}\right\} \Rightarrow a_i = \frac{i_p}{i_u} = \frac{r_\pi + (1+\beta_0)(r_{ce} \parallel R_E \parallel R_P)}{R_P}\frac{v_p}{v_u} = \frac{(1+\beta_0)(r_{ce} \parallel R_E \parallel R_P)}{R_P} = 49.85$$

c)

Otpornost koja se vidi iz baze tranzistora je $R_X = r_\pi + (1+\beta_0)(r_{ce} \parallel R_E \parallel R_P) = 500\text{k}\Omega$.

$$v_u = \frac{R_B \parallel R_X}{R_g + R_B \parallel R_X} v_g = 0.91 v_g \Rightarrow a_{vuk} = \frac{v_p}{v_g} = a_v \frac{v_u}{v_g} = 0.91 a_v = 0.905$$

$$i_u = \frac{R_B}{R_X + R_B} i_g = 0.98 i_g \Rightarrow a_{iuk} = \frac{i_p}{i_g} = a_i \frac{i_u}{i_g} = 0.98 a_i = 48.85$$

d) $R_u = R_g + R_B \parallel R_X = 10.8\text{k}\Omega$

e) $R_i = r_{ce} \parallel R_E \parallel \frac{r_\pi + R_B \parallel R_g}{1+\beta_0} = 33.6\Omega$