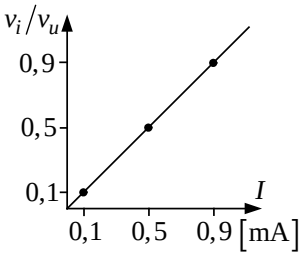
IR2OAE, IR3OAE Osnovi analogne elektronike - rešenja zadataka, ponovljeni kolokvijum 2014:

1.

$$I_{D1} = I;\ \ I_{D2} = I_1 - I; \qquad r_{D1} = \frac{V_T}{I_{D1}} = \frac{V_T}{I};\ r_{D2} = \frac{V_T}{I_{D2}} = \frac{V_T}{I_1 - I};$$

$$\frac{v_i}{v_u} = \frac{r_{D2}}{r_{D1} + r_{D2}} = \frac{\dfrac{V_T}{I_1 - I}}{\dfrac{V_T}{I} + \dfrac{V_T}{I_1 - I}} = \frac{I}{I_1};$$



$I_1 = 1\text{mA}$

$I = 0{,}1\text{mA} \Rightarrow v_i/v_u = 0{,}1; \quad I = 0{,}5\text{mA} \Rightarrow v_i/v_u = 0{,}5; \quad I = 0{,}9\text{mA} \Rightarrow v_i/v_u = 0{,}9$

2. a) Na karakteristici za $v_{GS} = V_t + 1\text{V}$ u zasićenju je $i_D = 0{,}5\text{mA}$.

$$i_D = \frac{B}{2}(v_{GS} - V_t)^2 \ \Rightarrow\ B = \frac{2i_D}{(v_{GS} - V_t)^2} = \frac{1\text{mA}}{(1\text{V})^2} = 1\frac{\text{mA}}{\text{V}^2}.$$

b) Sa Slike 2 se vidi da u datoj radnoj tački tranzistor radi u zasićenju.

$$V_t = V_{GS} - \sqrt{2I_D/B} = 3\text{V} - \sqrt{3}\text{V} = 1{,}268\text{V}.$$

3. Beleške za predavanja, „7_Strujni_izvori_i_aktivno_opterecenje.pdf“, slajd 5.

4. a) Za $v_G < V_{BE}$ Q je zakočen $\Rightarrow v_B = v_G, v_C = V_{CC}$

Za $V_{BE} \le v_G < V_1$ Q je u DAR-u $\Rightarrow v_B = V_{BE}$

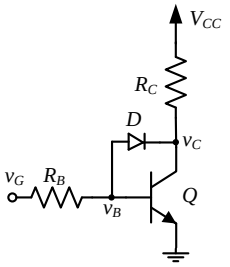
$$i_B = \frac{v_G - V_{BE}}{R_B} \Rightarrow v_C = V_{CC} - R_C\beta_F\frac{v_G - V_{BE}}{R_B},$$ V_1 je napon generatora pri kojem dioda počinje da vodi

$$v_G = V_1 \Rightarrow v_{BC} = V_D \Rightarrow V_{BE} - V_{CC} + \beta_F\frac{R_C}{R_B}(V_1 - V_{BE}) = V_D$$

$$V_1 = V_{BE} + \frac{R_B}{\beta_F R_C}(V_{CC} + V_D - V_{BE}) = 0.96\text{V}$$

Za $v_G > V_1$ dioda vodi $\Rightarrow v_C = V_{BE} - V_D = 0.4\text{V} \Rightarrow$ Q i dalje u DAR-u $\Rightarrow v_{BE} = V_{BE}$

b) Za $v_G \le V_1$ dioda je zakočena $\Rightarrow P_D = 0$



Za $v_G > V_1$ dioda vodi i transistor vodi u DAR-u pa prema tome važi

$$\left.\begin{aligned} \frac{v_G - V_{BE}}{R_B} &= i_B + i_D \\ i_D + \frac{V_{CC} - V_{BE} + V_D}{R_C} &= \beta_F i_B \end{aligned}\right\} \Rightarrow i_D = \frac{\beta_F}{1+\beta_F}\frac{v_G}{R_B} - \frac{1}{1+\beta_F}\left(\frac{\beta_F V_{BE}}{R_B} + \frac{V_{CC} - V_{BE} + V_D}{R_C}\right)$$

$$P_D = \begin{cases} 0, v_G \le V_1 \\ V_D\left[\dfrac{\beta_F}{1+\beta_F}\dfrac{v_G}{R_B} - \dfrac{1}{1+\beta_F}\left(\dfrac{\beta_F V_{BE}}{R_B} + \dfrac{V_{CC} - V_{BE} + V_D}{R_C}\right)\right], v_G > V_1 \end{cases}$$

5. a) $V_D = V_{DD} = 12V$

$$V_G = \frac{R_1}{R_1 + R_2} V_{DD} = 8V$$

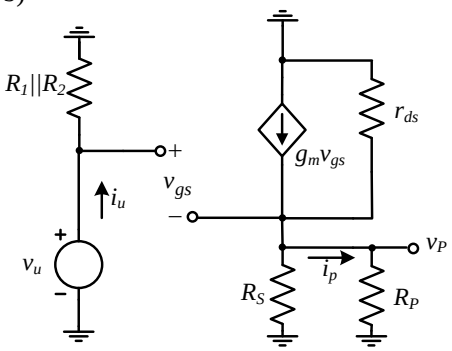
$$V_{GS} = V_T + \sqrt{\frac{2I_D}{B}} = 2\text{V}$$

$$V_G - V_{GS} = I_D R_S \Rightarrow R_S = \frac{V_G - V_{GS}}{I_D} = 6\text{k}\Omega$$

$$V_S = V_G - V_{GS} = 6\text{V}$$

$$I_D = \frac{B}{2}(V_{GS} - V_T)^2 = 1\text{mA} \Rightarrow g_m = \sqrt{2BI_D} = 2\text{mS}, r_{ds} = \frac{1}{\lambda I_D} = 100\text{k}\Omega$$

b)



$$\left.\begin{aligned} v_p &= g_m v_{gs}(R_S \parallel R_P \parallel r_{ds}) \\ v_{gs} &= v_g - v_s = v_u - v_p \end{aligned}\right\} \Rightarrow a_v = \frac{v_p}{v_u} = \frac{g_m(R_S \parallel R_P \parallel r_{ds})}{1 + g_m(R_S \parallel R_P \parallel r_{ds})} = 0.88$$

$$\left.\begin{aligned} i_p &= \frac{v_p}{R_P} \\ i_u &= \frac{v_u}{R_1 \parallel R_2} \end{aligned}\right\} \Rightarrow a_i = \frac{i_p}{i_u} = \frac{R_1 \parallel R_2}{R_P}\frac{v_p}{v_u} = \frac{R_1 \parallel R_2}{R_P} a_v = 58.67$$

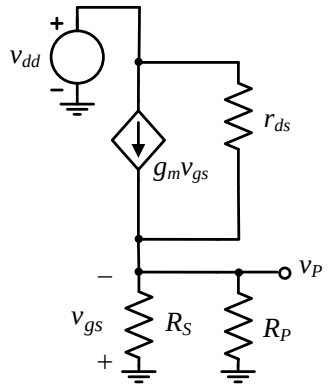
c) $v_G(t) = V_G + v_g(t) = V_G + v_u(t) = (8 + 0.1\sin(2\pi ft))\text{V}$

$v_D(t) = V_D + v_d(t) = V_D = 12\text{V}$

$v_S(t) = V_S + v_s(t) = V_S + a_v v_u(t) = (6 + 0.088\sin(2\pi ft))\text{V}$

$v_P(t) = V_P + v_p(t) = a_v v_u(t) = 0.088\text{V}\sin(2\pi ft)$

d)



$$\left.\begin{aligned} v_p(G_S + G_P) &= (v_{dd} - v_p)g_{ds} + g_m v_{gs} \\ v_{gs} &= -v_p \end{aligned}\right\} \Rightarrow a_{dd} = \frac{v_p}{v_{dd}} = \frac{g_{ds}}{G_S + G_P + g_{ds} + g_m} = 0.0044$$