

$$i_{D1} = \frac{B}{2} \left(V_{GG} - V_T + \frac{n^2 (V_{DD} - v_{DS1})}{2RB(V_{GG} - V_T)} \right)^2 = \frac{B}{2} \left(V_{GG} - V_T + \frac{n^2}{2RB(V_{GG} - V_T)} V_{DD} - \frac{n^2}{2RB(V_{GG} - V_T)} v_{DS1} \right)^2$$

$$v_{DS1}(i_{D1}) = \frac{V_{GG} - V_T + \frac{n^2}{2RB(V_{GG} - V_T)} V_{DD} - \sqrt{\frac{2i_{D1}}{B}}}{\frac{n^2}{2RB(V_{GG} - V_T)}}$$

Ograničenja:

1. Zakočenje:

$$i_{D1} = \frac{B}{2} \left(V_{GG} - V_T + \frac{n^2}{2RB(V_{GG} - V_T)} V_{DD} - \frac{n^2}{2RB(V_{GG} - V_T)} v_{DS1} \right)^2 > 0$$

$$v_{DS1\max} = V_{DD} + \frac{2RB(V_{GG} - V_T)^2}{n^2}, \quad v_{ds1\max}^{(1)} = \frac{2RB(V_{GG} - V_T)^2}{n^2} = 3.125(V_{GG} - V_T)^2$$

2. Prelazak u triodnu oblast:

$$v_{DS1} = \frac{V_{GG} - V_T + \frac{n^2}{2RB(V_{GG} - V_T)} V_{DD} - \sqrt{\frac{2i_{D1}}{B}}}{\frac{n^2}{2RB(V_{GG} - V_T)}} > \sqrt{\frac{2i_{D1}}{B}}$$

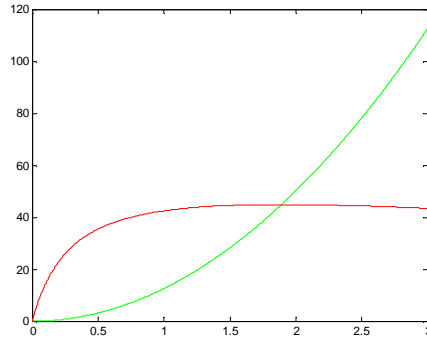
$$i_{D1} < \frac{B}{2} \left(\frac{V_{GG} - V_T + \frac{n^2}{2RB(V_{GG} - V_T)} V_{DD}}{1 + \frac{n^2}{2RB(V_{GG} - V_T)}} \right)^2$$

$$v_{DS1\min} = \frac{V_{GG} - V_T + \frac{n^2}{2RB(V_{GG} - V_T)} V_{DD}}{1 + \frac{n^2}{2RB(V_{GG} - V_T)}}$$

$$v_{ds1\max}^{(2)} = V_{DD} - \frac{V_{GG} - V_T + \frac{n^2}{2RB(V_{GG} - V_T)} V_{DD}}{1 + \frac{n^2}{2RB(V_{GG} - V_T)}}$$

$$v_{ds1\max}^{(2)} = \frac{V_{DD} - (V_{GG} - V_T)}{1 + \frac{n^2}{2RB(V_{GG} - V_T)}} = \frac{2RB(V_{GG} - V_T)}{n^2} \frac{V_{DD} - (V_{GG} - V_T)}{1 + \frac{2RB(V_{GG} - V_T)}{n^2}} = 3.125(V_{GG} - V_T) \frac{15 - (V_{GG} - V_T)}{1 + 3.125(V_{GG} - V_T)}$$

Za date parametre, važi strožiji od ova dva uslova.



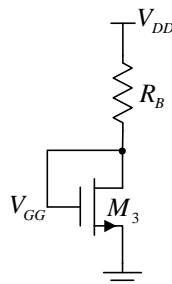
Tačka preseka ove dve funkcije je istovremeno maksimum funkcije $v_{ds1max}^{(2)}$, tako da baš ova tačka odgovara maksimalno mogućoj amplitudi napona na izlazu. Isti zaključak sledi i bez crtanja grafika, s obzirom da se maksimalna amplituda neizobličjenog signala dobija onda kada se istovremena dostižu oba ograničenja, a to je baš presek ove dve funkcije.

$$V_{out\ max} = \begin{cases} 12.5(V_{GG} - V_T)^2 & V_{GG} - V_T < 1.89V \\ 12.5(V_{GG} - V_T) \frac{15 - (V_{GG} - V_T)}{1 + 3.125(V_{GG} - V_T)} & V_{GG} - V_T > 1.89V \end{cases}$$

Za $V_{GG} = 2.89V$ na izlazu se dobija maksimalno moguća amplituda izlaznog napona,

$$\begin{aligned} V_{out\ max} &= 44.65V \\ v_{OUT} &= \frac{2RB(V_{GG} - V_T)mv_{IN}}{n} = 47.25v_{IN} \\ V_{in\ max} &= 0.94V \end{aligned}$$

b)



$$\begin{aligned} V_{DD} &= R_B i_{D3} + V_{GG} = R_B \frac{B_3}{2} (V_{GG} - V_{T3})^2 + V_{GG} \\ R_B &= \frac{2}{B_3} \frac{V_{DD} - V_{GG}}{(V_{GG} - V_{T3})^2} = 5k\Omega \end{aligned}$$

c)

$$v_{DS1\ max} = V_{DD} + \frac{1}{n} V_{out\ max} = 26.16V$$

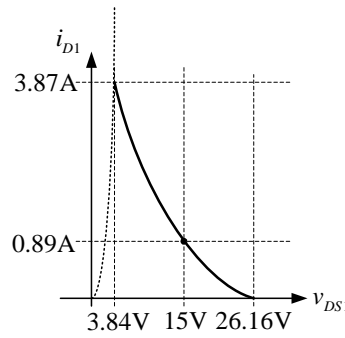
$$i_{D1\min} = 0$$

$$v_{DS1\min} = V_{DD} - \frac{1}{n} V_{out\max} = 3.84\text{V}$$

$$i_{D1\max} = \frac{B}{2} \left(V_{GG} - V_T + \frac{n^2 (V_{DD} - v_{DS1})}{2RB (V_{GG} - V_T)} \right)^2 = 3.57\text{A}$$

$$I_{D1} = \frac{B}{2} (V_{GG} - V_T)^2 = 0.89\text{A}$$

$$V_{DS1} = V_{DD} = 15\text{V}$$



d)

$$p_{DD} = V_{DD} i_{DD}$$

$$i_{DD} = i_{D1} + i_{D2} = B \left((V_{GG} - V_T)^2 + m^2 v_{IN}^2 \right) = B \left((V_{GG} - V_T)^2 + m^2 V_{in}^2 \sin^2 \omega t \right)$$

$$I_{DD} = B \left((V_{GG} - V_T)^2 + m^2 \overline{V_{in}^2 \sin^2 \omega t} \right) = B \left((V_{GG} - V_T)^2 + \frac{m^2 V_{in}^2}{2} \right)$$

$$P_{DD} = B V_{DD} \left((V_{GG} - V_T)^2 + \frac{m^2 V_{in}^2}{2} \right) = 26.79 + 15 V_{in}^2$$

$$P_{OUT} = \frac{V_{out}^2}{2R} = 2R \left(\frac{B (V_{GG} - V_T) m}{n} \right)^2 V_{in}^2 = 22.33 V_{in}^2$$

$$\eta(V_{in}) = \frac{22.33 V_{in}^2}{26.79 + 15 V_{in}^2}, \quad V_{in} \leq V_{in\max} = 0.94\text{V}$$

$$\eta(V_{in\max}) = 0.49$$

