1. zadatak

a) Tablica stanja

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

$Y = \overline{A}\,\overline{B} + A\,B \quad \rightarrow$ ekvivalencija (XNOR)

b) Za jedan od ulaza u logičkoj 0, a drugi u logičkoj 1 → nMOS u triodnom području uz $U_{DSn} = U_0$, a pMOS u području zasićenja

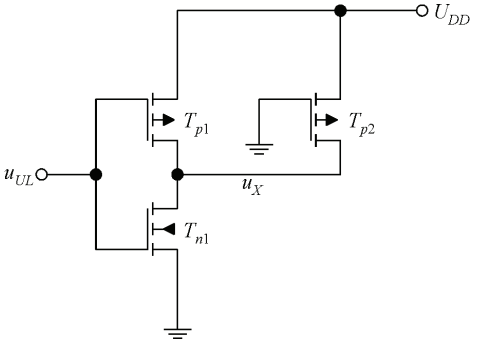
$$K_n\left(U_{DD} - U_{GS0n}^0 - \frac{U_0}{2}\right)U_0 = -K_p\left(-U_{DD} - U_{GS0p}^0 - \frac{U_{DSzasp}}{2}\right)U_{DSzasp}$$

$$r = -\frac{K_n}{K_p} = \frac{\left(-U_{DD} - U_{GS0p}^0 - U_{DSzasp}/2\right)U_{DSsp}}{\left(U_{DD} - U_{GS0n}^0 - U_0/2\right)U_0} = 9{,}6 \quad \rightarrow \quad \left(W/L\right)_p = -\frac{K_n'}{K_p'}\frac{\left(W/L\right)_n}{r} = 0{,}52$$

c) pMOS tranzistor je nužan za ispravan rad: uz oba ulaza u logičkoj 0, spaja izlaz na napon napajanja; uz oba ulaza u logičkoj 1 ispravlja loše prenošenje logičke 1 prijenosnog nMOS tranzistora i osigurava napon logičke 1 $U_1 = U_{DD}$.

2. zadatak

a)



$u_{UL} = u_X = U_{UL+} = 1{,}1$ V

$u_{GSp1} - U_{GS0p}^0 = U_{UL+} - U_{DD} - U_{GS0p}^0 = -0{,}2$ V → klasično zasićenje

$u_{GSp2} - U_{GS0p}^0 = 0 - U_{DD} - U_{GS0p}^0 = -1{,}4$ V → zasićenje brzine nosilaca

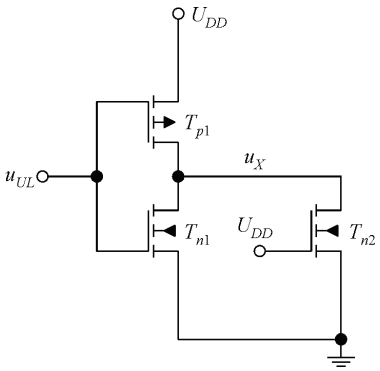
$u_{GSn1} - U_{GS0n}^0 = U_{UL+} - U_{GS0n}^0 = 0{,}70$ V → zasićenje brzine nosilaca

$$K_n\left(\frac{W}{L}\right)_{n1}\left(U_{UL+} - U_{GS0n}^0 - \frac{U_{DSzasn}}{2}\right)U_{DSzasn} =$$

$$= -\frac{K_p}{2}\left(\frac{W}{L}\right)_{p1}\left(U_{UL+} - U_{DD} - U_{GS0p}^0\right)^2 - K_p\left(\frac{W}{L}\right)_{p2}\left(-U_{DD} - U_{GS0p}^0 - \frac{U_{DSzasp}}{2}\right)U_{DSzasp}$$

$$\left(\frac{W}{L}\right)_{p2} = 2{,}59$$

b)



$$u_{UL} = u_X = U_{UL-} = 0,7 \text{ V}$$

$$u_{GSn1} - U^0_{GS0n} = U_{UL-} - U^0_{GS0n} = 0,3 \text{ V} \rightarrow \text{klasično zasićenje}$$

$$u_{GSn2} - U^0_{GS0n} = U_{DD} - U^0_{GS0n} = 1,4 \text{ V} \rightarrow \text{zasićenje brzine nosilaca}$$

$$u_{GSp1} - U^0_{GS0p} = U_{UL+} - U_{DD} - U^0_{GS0p} = -0,7 \text{ V} \rightarrow \text{zasićenje brzine nosilaca}$$

$$\frac{K_n}{2}\left(\frac{W}{L}\right)_{n1}\left(U_{UL-} - U^0_{GS0n}\right)^2 + K_n\left(\frac{W}{L}\right)_{n2}\left(U_{DD} - U^0_{GS0n} - \frac{U_{DSzasn}}{2}\right)U_{DSzasn} =$$

$$= -K_p\left(\frac{W}{L}\right)_{p1}\left(U_{UL-} - U_{DD} - U^0_{GS0p} - \frac{U_{DSzasp}}{2}\right)U_{DSzasp}$$

$$\left(\frac{W}{L}\right)_{n2} = 1,69$$

3. zadatak

a)

$$K'_n\frac{W_1}{L_1}\left(U_{PO} - U^0_{GS0n} - \frac{U_{DSzasn}}{2}\right)U_{DSzasn} = -K_p\frac{W_2}{L_2}\left(U_{PO} - U_{DD} - U^0_{GS0p} - \frac{U_{DSzasp}}{2}\right)U_{DSzasp}$$

$$r = \frac{(W/L)_2}{(W/L)_1}\frac{K'_p}{K'_n}\frac{U_{DSsp}}{U_{DSsn}} = 0,85 \quad \rightarrow \quad U_{PO} = \frac{\left(U^0_{GS0n} + \frac{U_{DSzasn}}{2}\right) + r\left(U_{DD} + U^0_{GS0p} + \frac{U_{DSzasp}}{2}\right)}{1+r} = 0,85 \text{ V}$$

b) U $t = 0 \rightarrow u_{\bar{Q}} = U_{\bar{Q}0} = U_{DD}$

$$i_{D2} = I_{D20} = 0\,, \quad i_{D5} = I_{D50} = K'_n\frac{W_5}{L_5}\left(U_{DD} - U^0_{GS0n} - \frac{U_{DSzasn}}{2}\right)U_{DSzasn} = 460 \text{ μA}\,,$$

$$i_{C\bar{Q}} = I_{C\bar{Q}0} = I_{D20} + I_{D50} = 460 \text{ μA}\,.$$

Nakon $\Delta t \rightarrow u_{\bar{Q}} = U_{\bar{Q}\Delta t} = U_{PO} = 0,85$ V

$$i_{D2} = I_{D2\Delta t} = K'_p \frac{W_2}{L_2}\left(0 - U_{DD} - U^0_{GS0p} - \frac{U_{DSzasp}}{2}\right)U_{DSzasp} = -264\ \mu\text{A}$$

$$i_{D5} = I_{D5\Delta t} = I_{D50} = 460\ \mu\text{A}$$

$$i_{C\bar{Q}} = I_{C\bar{Q}\Delta t} = I_{D2\Delta t} + I_{D5\Delta t} = 196\ \mu\text{A}$$

$$I_{C\bar{Q}sr} = \frac{I_{C\bar{Q}0} + I_{C\bar{Q}\Delta t}}{2} = 328\ \mu\text{A}\ ,\quad \Delta t = \frac{C_{\bar{Q}}\,\Delta u_{\bar{Q}}}{I_{C\bar{Q}sr}} = \frac{C_{\bar{Q}}\left(U_{DD} - U_{PO}\right)}{I_{C\bar{Q}sr}} = 11{,}3\ \text{ps}$$

4. zadatak

a) $X = P = \overline{A}\,B + A\,\overline{B} = A \oplus B$

b) $Y = \overline{C}_u\,P + C_u\,\overline{P} = C_u \oplus P = S$

c) $Z = P\,C_u + \overline{P}\,A = P\,C_u + G = C_i$

d) Čvor izlaznog prijenosa opterećen je s 4 kapaciteta osiromašenih slojeva i s 4 MOS kapaciteta.