14.7

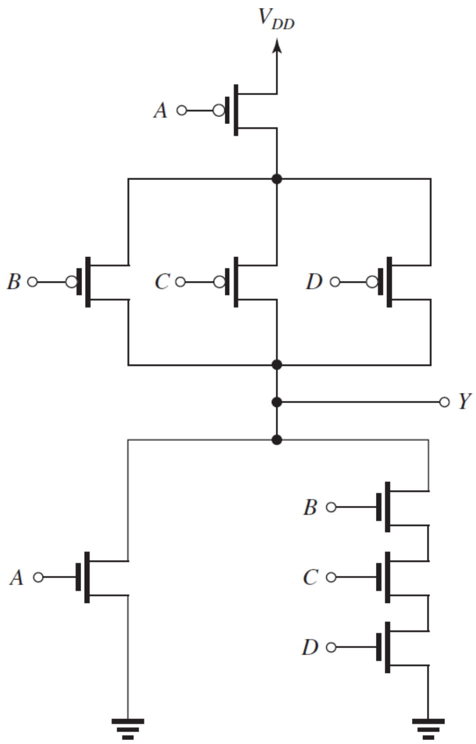


Figure 1

Figure 1 shows the complete CMOS logic circuit where we have obtained the PDN as the dual of the given PUN. The logic function can be written from the PDN as

$\overline{Y} = A + BCD$

or equivalently

$Y = \overline{A + BCD}$

14.11 Direct realization of the given expression results in the PUN of the logic circuit shown in Fig. 1. The PDN shown is obtained as the dual of the PUN. Not shown are the two inverters needed to obtain $\overline{A}$ and $\overline{B}$.

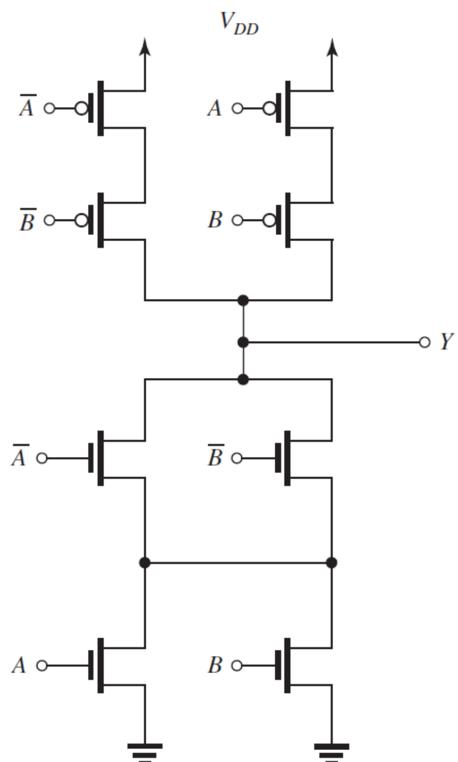


Figure 1

15.26 Refer to Fig. 15.17. Since V_{OH} is the value of v_O at which Q stops conducting,

$$V_{DD} - V_{OH} - V_t = 0$$

then

$$V_{OH} = V_{DD} - V_t$$

where

$$V_t = V_{t0} + \gamma\left(\sqrt{V_{OH} + 2\phi_f} - \sqrt{2\phi_f}\right)$$

$$= V_{t0} + \gamma\left(\sqrt{V_{DD} - V_t + 2\phi_f} - \sqrt{2\phi_f}\right)$$

Substituting $V_{t0} = 0.4$ V, $\gamma = 0.2$ V$^{1/2}$, $V_{DD} = 1.2$ V, and $2\phi_f = 0.88$ V, we obtain

$$V_t = 0.4 + 0.2\left(\sqrt{1.2 - V_t + 0.88} - \sqrt{0.88}\right)$$

$$V_t - 0.4 + 0.2\sqrt{0.88} = 0.2\ \sqrt{2.08 - V_t}$$

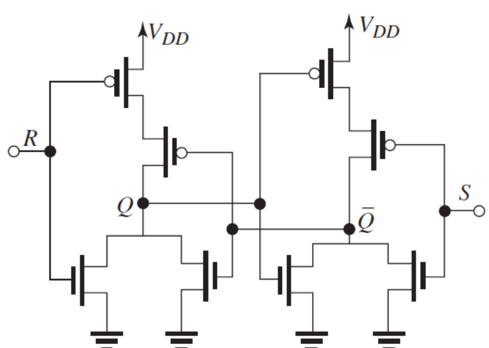
$$(V_t - 0.212)^2 = 0.04(2.08 - V_t)$$

$$\Rightarrow V_t^2 - 0.384\ V_t - 0.038 = 0$$

$$\Rightarrow V_t = 0.466 \text{ V}$$

V_{OH} = 1.2 - 0.466
=0.734

16.2



15.31

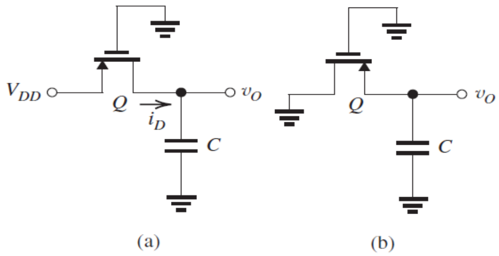


Figure 1

(a) Figure 1(a) shows the situation for $t \geq 0$. In this case V_t remains constant at V_{t0} and the capacitor charges to V_{DD}.

Thus,

$$V_{OH} = V_{DD}$$

(b) Figure 1 (b) shows the situation for $t \geq 0$. Here as C discharges through Q, the threshold voltage changes. The discharge current reduces to zero when $v_O = |V_t|$. Thus,

$$V_{OL} = |V_t|$$

where

$$|V_t| = |V_{t0}| + \gamma\left[\sqrt{V_{DD} - V_{OL} + 2\phi_f} - \sqrt{2\phi_f}\right]$$

Substituting $|V_t| = V_{OL}$, we obtain

$$V_{OL} = |V_{t0}| + \gamma\left[\sqrt{V_{DD} - V_{OL} + 2\phi_f} - \sqrt{2\phi_f}\right]$$

(c) Refer to Fig. 1(a).

At $t = 0$, $v_O = 0$ and Q will be operating in saturation. Thus,

$$i_D(0) = \frac{1}{2}k_p(V_{DD} - |V_{t0}|)^2$$

$$= \frac{1}{2} \times 125\ (1.2 - 0.4)^2$$

$$= 40\ \mu A$$

At $t = t_{PLH}$, $v_O = V_{DD}/2 = 0.6$ V and Q will be operating in the triode region. Thus,

$$i_D(t_{PLH}) =$$

$$k_p\left[(V_{DD} - |V_{t0}|)\left(\frac{V_{DD}}{2}\right) - \frac{1}{2}\left(\frac{V_{DD}}{2}\right)^2\right]$$

$$= 125\left[(1.2 - 0.4) \times 0.6 - \frac{1}{2}(0.6)^2\right]$$

$$= 37.5\ \mu A$$

The average charging current can now be found as

$$i_D|_{av} = \frac{1}{2}(40 + 37.5) = 38.75 \mu A$$

The propagation delay t_{PLH} can then be determined from

$$t_{PLH} = \frac{C(V_{DD}/2)}{i_D|_{av}}$$

$$= \frac{C \times 0.6}{38.75 \times 10^{-6}} = 15.48 \times 10^3 C \text{ s}$$

No value for C is given. If $C = 10$ fF, we get

$$t_{PLH} = 17.8 \times 10^3 \times 10 \times 10^{-15} = 178 \text{ ps}$$