Inverter Switching Characteristics

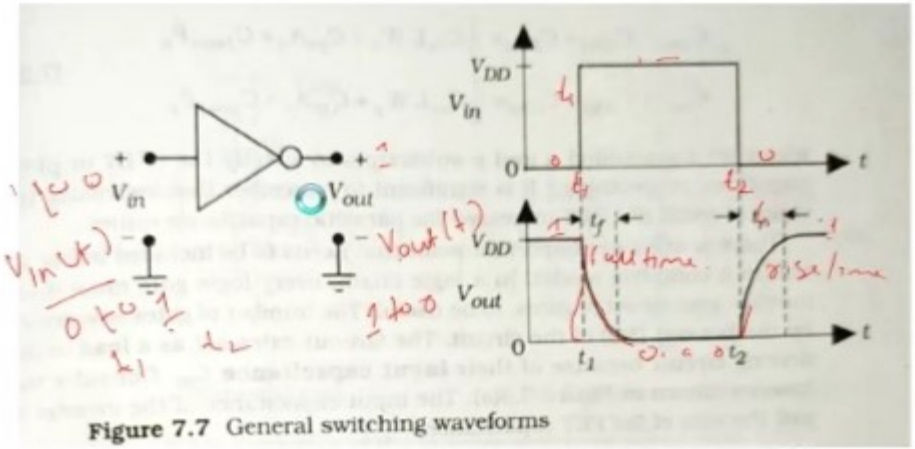


Figure 7.7 General switching waveforms

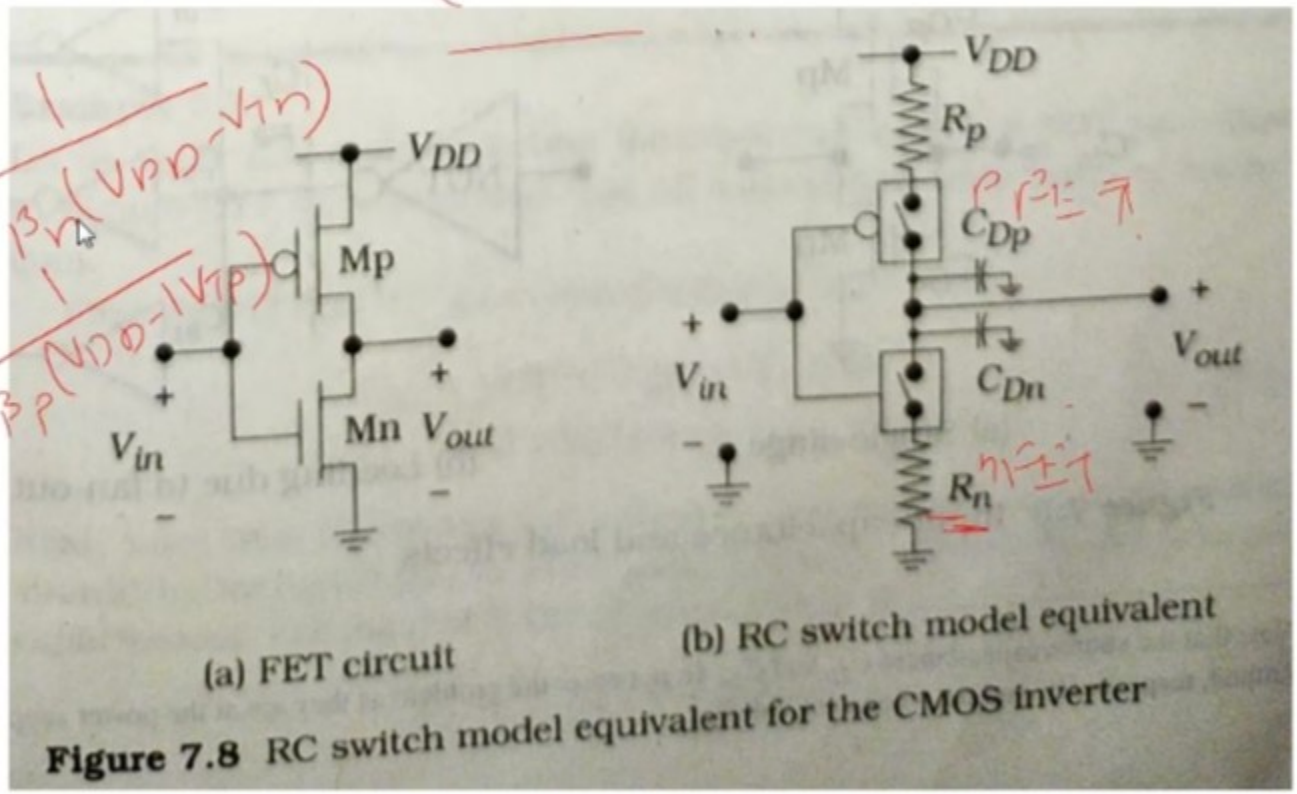
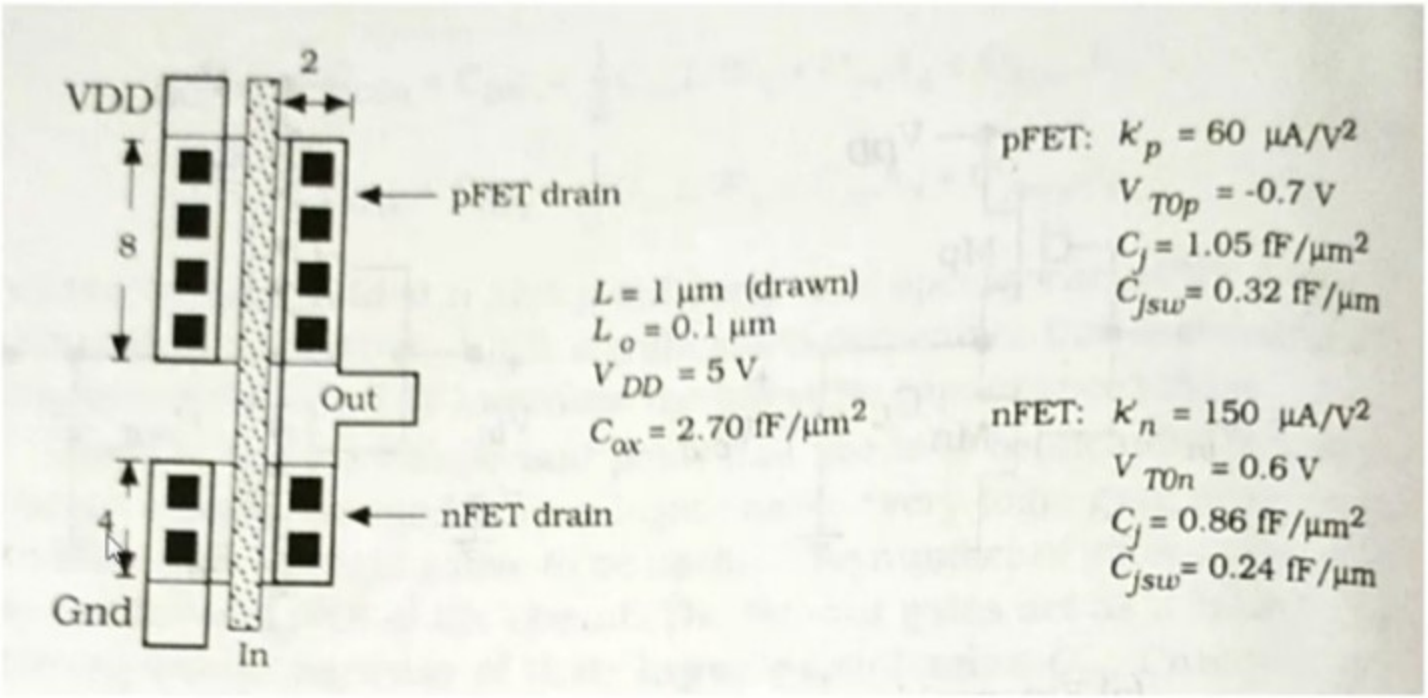
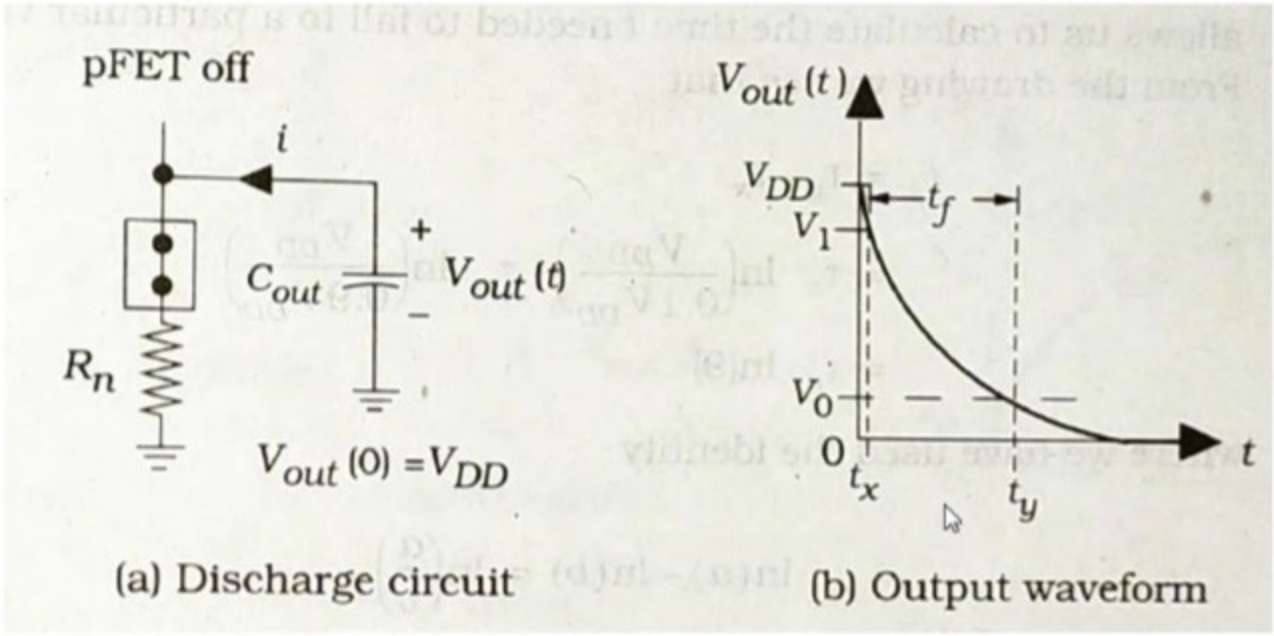


Figure 7.8 RC switch model equivalent for the CMOS inverter

Example: Analysis to Find the Capacitances in the NOT gate



Fall Time Calculation



(a) Discharge circuit

(b) Output waveform

$$i = -C_{out}\frac{dV_{out}}{dt} = \frac{V_{out}}{R_n}$$

$$\frac{dV_{out}}{dt} = x$$

$$-C_{out}x = \frac{V_{out}}{R_n}$$

$$-C_{out}R_n x = V_{out}$$

$$\tau_n x + V_{out} = 0$$

$$x = -\frac{V_{out}}{\tau_n}$$

$$V_{out}(t) = V_{out}(0)\, e^{-t/\tau_n}$$

$$t_x = \tau_n \ln\left(\frac{V_{0.1}}{V_{0.9}}\right)$$

$$= \tau_n \ln(9)$$

$$= 2.2\tau_n$$

$$V_{out}(0) = V_{DD}$$

$$V_{out}(t) = V_{DD}\, e^{-t/\tau_n}$$

$$\tau_n = R_n C_{out}$$

$$e^{-t/\tau_n} = \frac{V_{out}(t)}{V_{DD}}$$

$$-\frac{t}{\tau_n} = \ln\frac{V_{out}(t)}{V_{DD}}$$

$$t = -\tau_n \ln\left(\frac{V_{out}(t)}{V_{DD}}\right)$$

$$= \tau_n \ln\left(\frac{V_{DD}}{V_{out}(t)}\right)$$

$0.1V_{DD}$ $0.9V_{DD}$

$$t_f = t_y - t_x$$

$$= \tau_n \ln\left(\frac{V_{DD}}{0.1V_{DD}}\right) - \tau_n \ln\left(\frac{V_{DD}}{0.1}\right)$$

$$C_{FET} = C_{on} + C_{Dp} = 15.552 + 34.9 = 50.45fF$$

$$C_{out} = C_{FET} + C_L$$

$$C_{out} = 50.45fF + C_L$$