Problem 1: Pulse-triggered latch

Figure above shows a practical implementation of a pulse-triggered latch. Clock Clk is ideal with 50% duty cycle.

Data: \( t_{p,\text{inv}} = 200\,\text{ps} \), \( C_{\text{clkd}} = 10\,\text{fF} \), \( C_x = 10\,\text{fF} \), \( C_Q = C_{\overline{Q}} = 20\,\text{fF} \)

a) Draw the waveforms at nodes Clk, Clkd, X and Q for two clock cycles, with D equals 0 in one cycle and 1 in the other.

b) What is the approximate value of setup and hold times for this circuit?

c) If the probability that D will change its logic value in one clock cycle is \(?\), with equal probability of being 0 or 1, what is the power consumption of this circuit? (excluding the power consumption in the clock line) Assume \( f_{\text{clk}} = 100\,\text{MHz} \).

d) Discuss the sizing of the cross-coupled inverters.

Problem 2: Schmitt trigger

Circuit on the following page is a pseudo-NMOS Schmitt trigger. Assume that the PMOS transistor remains in saturation over entire range of operation. Vdd = 1.5V, Vtn = Vtp = 0.4V, \( k_n = 115\,\text{A/V}^2 \), \( k_p = 30\,\text{A/V}^2 \)

a) Compute \( V_{OH} \) and \( V_{OL} \)

b) Compute the switching points \( V_{M+} \) (for input making low-to-high transition) and \( V_m \) (for the input making a high-to-low transition).
c) Draw the VTC. Compare results with SPICE simulations. In particular, you should obtain different VTC curves for high-to-low transitions and low-to-high transitions.

d) Perform a transient analysis with the following as input:
   \[ V_{test} \ 0 \ PWL \ 0 \ 0 \ 50n \ 0 \ 100n \ V_{dd} \ 150n \ V_{dd} \ 200n \ 0 \]

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**Problem 3 : Oscillator**

An alternative oscillator is shown in Figure 6.60 in the textbook. Draw the signal waveform for this innovative network. Determine the oscillation frequency. Discuss the advantage of this circuit. You may assume that the delay of the inverters, the resistances of the MOS transistors, and all internal capacitors can be ignored. The inverter switch point is set at 1.65V. Assume that nodes Y and Z are initially at 0V and 3.3V, respectively.