ECE216B VLSI Signal Processing **Spring 2024**
Prof. Dejan Marković Homework #1

Due: Friday April 19, 10am

Problem 1. Delay Model

The objective of this problem is to become familiar with technology metrics and develop insights for architectural studies. Based on a 90nm technology data provided below, you have to develop simple models for performance and power of digital logic gates.

V_{DD} [V]	t_p [ps] slow	t_p [ps] typical	t_p [ps] fast	Energy [fJ]
1.00	36	28	21	19.4
0.90	42	32	24	15.4
0.80	51	38	27	12.1
0.70	67	47	33	9.04
0.60	99	66	43	6.45
0.50	182	108	63	4.31
0.45	279	154	83	3.42
0.40	480	241	119	2.65
0.35	922	423	186	1.99

V_{DD}=1V FO	t_p(FO) [ps]
2	17
3	23
4	28
5	34
6	40
7	45
8	50
9	56
10	62

Parameters in the table are:

V_{DD} – supply voltage
t_p – propagation delay of a FO4 gate
Slow/typical/fast – process corners
Energy – energy of a digital gate
FO – fanout (Cout/Cin) of a gate
t_p(FO) – delay as a function of FO

a) Determine parameters K_d, V_{on}, and α_d that best fit the typical delay with respect to V_{DD}.

$$t_p = \frac{K_d \cdot V_{DD}}{(V_{DD} - V_{on})^{\alpha_d}}$$

b) Plot Energy-Delay product (EDP) for all process corners. What is the value of V_{DD} that minimizes EDP for each of the corners?

c) Assume that the desirable operating point is V_{DD} = 0.6V and that your target clock rate (dictated by system throughput) is 250MHz. Our standard cell-library, however, is characterized only for V_{DD} = 1V, so we need to translate timing to 1V. What would be the equivalent operating frequency at V_{DD} = 1V? Explain your answer.

Problem 2. Research Paper Study

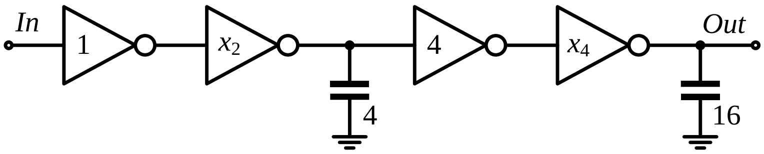
Study 2022 research paper titled "Amber: A 367 GOPS, 538 GOPS/W 16nm SoC with a Coarse-Grained Reconfigurable Array for Flexible Acceleration of Dense Linear Algebra." Answer each question in 2-4 sentences.

a) What are key findings of this paper? (2-4 sentences)

b) What are the limitations of the proposed approach? (2-4 sentences)

Problem 3: Inverter Chain Optimization

a) Determine x_2 and x_4 to minimize *In-Out* delay. What is the delay? Assume $\gamma = 0.5$.



b) Assuming switching activity $\alpha_{0\rightarrow 1} = 0.1$, calculate the average energy dissipation.

c) Determine x_2 and x_4 to minimize energy at $1.1D_{min}$. Calculate the energy.