CMOS Inverter Simulation

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MATLAB Command Window

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Script Sim_Homework

Simulation Homework

ECE 3030 Fall 2019

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Enter circuit failure probability: **0.001**

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a) Find out the height of the energy barrier.

First, we need to calculate the probability failure

of a single device.

Probability failure of a single device is 5.0026e-12.

Then use Pdev to calculate the height of the energy barrier.

The height of the energy barrier per device is **1.0773e-19 Joules.**

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b) Compute the channel doping(Nchannel).

Eb = -ln(Pdev)*k*T, Ebi = -ln((ni^2)/(NA*ND))*k*T

Pdev = (ni^2)/(NA*ND), Nchannel = ND = (ni^2)/(NA*Pdev)

The channel doping is **2.00e+19 1/m^3**.

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c) Find the threshold voltage.

First calculate psiB,

Then calculate Cox.

Then plug everything in the formula for threshold voltage.

The threshold voltage is **0.39425 V**.

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d) Find the size of the PFETs

Wp/Wn = un/up

The size of the PFETs is 2.20e-07 m or **220 nm**.

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e) Compute the supply voltage (VDD)

First, calculate beta.

Calculate CL.

td = CL*ln(2)/(beta*(VDD-Vth))

Enter target delay: 10e-12

The supply voltage VDD is **0.39526 V.**

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f) Compute the subthreshold leakage(Ids) at Vgs = 0.

First, calculate tsi.

Then, Calculate the subthreshold slop factor n = 1.002.

Plug everything in the Ids formula.

Subthreshold leakage is 2.476e-13 A **or 247.63 fA**.

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g) Compute the total energy dissipation.

Total Energy = Dynamic Energy + Static Energy

Dynamic Energy is 1.958e-10 J or 195.83 pJ.

Static Energy is 9.788e-15 J or 0.01 pJ.

Total Energy is 1.958e-10 J or **195.84 pJ**.

(h) Now, solve the problem steps (a) – (g) for failure targets of 0.0001, 0.001, 0.01, and 0.1. The delay target remains constant. Fill the following table.

Failure Target	Required Supply Voltage	Energy Dissipation
0.0001	0.51688 V	334.88 pJ
0.001	0.39526 V	195.84 pJ
0.01	0.27518 V	95.61 pJ
0.1	0.15339 V	72.03 pJ

(i) Now, re-solve the problem steps (a) – (g) for delay targets of 1ps, 10ps, 50ps, and 100ps. The failure target remains constant at 0.001. Fill the following table.

Delay Target	Required Supply Voltage	Energy Dissipation
1 ps	0.40432 V	204.92 pJ
10 ps	0.39526 V	195.84 pJ
50 ps	0.39446 V	195.04 pJ
100 ps	0.39436 V	194.94 pJ

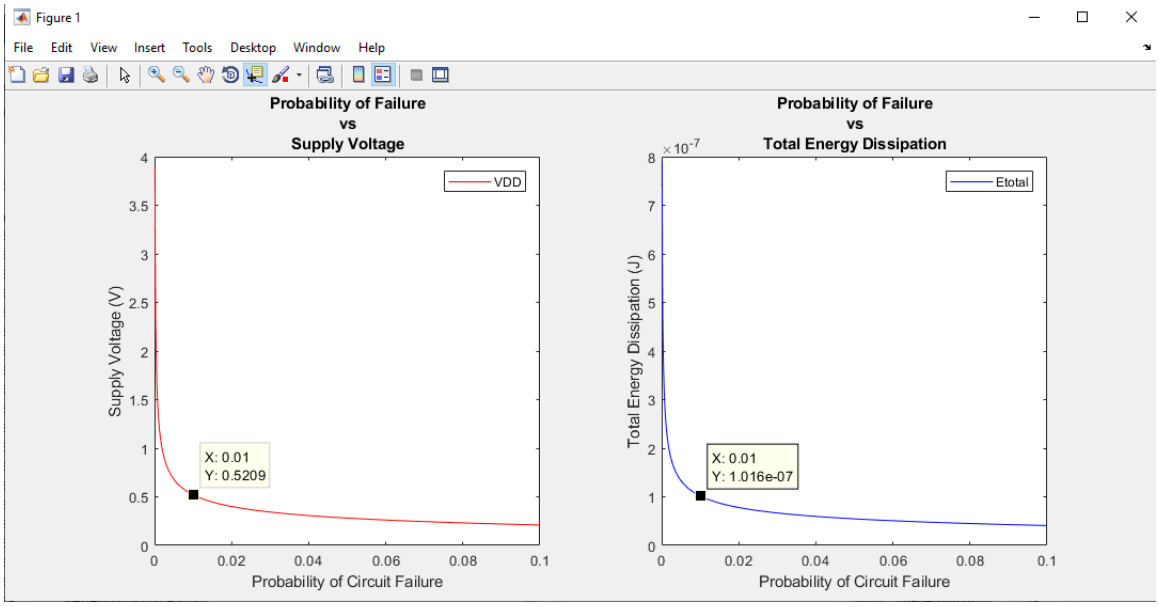

Figure 1. MATLAB graph of probability of circuit failure vs supply voltage and total energy dissipation.

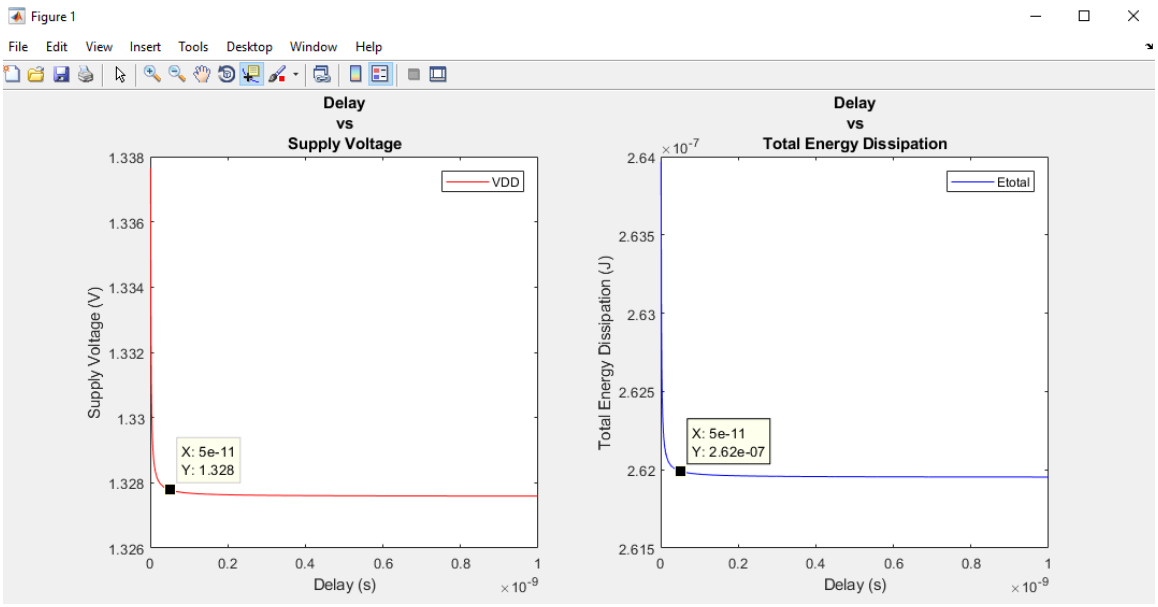

Figure 2. MATLAB graph of delay vs supply voltage and total energy dissipation.