Alexandria University
Faculty of Engineering
Electrical Engineering Department

Lab 2 : CMOS Inverter Characteristics

Objectives:

Upon the completion of this Lab, you should be able to:
1. Test inverter voltage transfer characteristics of a CMOS inverter.
2. Design CMOS inverter for optimum transfer characteristics.
3. Evaluate the gate propagation delays then maximum input frequency.

Requirements:

Lab 2 will expose students to the design CMOS inverter, draw VTC and change transistor sizing to see how it affects the VTC parameters. Then set the transistor sizing for optimum V_{th} such that $V_{th} = V_{DD}/2$.

Change input frequency and observe the maximum input frequency.

Procedure:

1. Start new project and place mbreakP (PMOS) and mbreakN (NMOS) from library.
2. Edit spice model for NMOS and PMOS transistors. You will find the models in the appendix of this papers copy and paste them in Edit > Pspice Model.
3. Place DC source (VDC) for V_{DD} and VPULSE for input. Then use proper wiring to complete your inverter design.
   You should have schematic as shown on figure 1.
4. Start new simulation profile. And choose transient simulation. Then add voltage markers to input and output wires to see input and output waveforms. Figure 2.
5. Then choose the simulation type to be DC sweep. Sweep the input voltage from 0 to V_{DD} to see VTC. Figure 3.
6. Change the sizing of transistors to get $V_{th} = V_{DD}/2$.

7. Finally increase the input frequency until you get output waveform like the output waveform shown in figure 4.

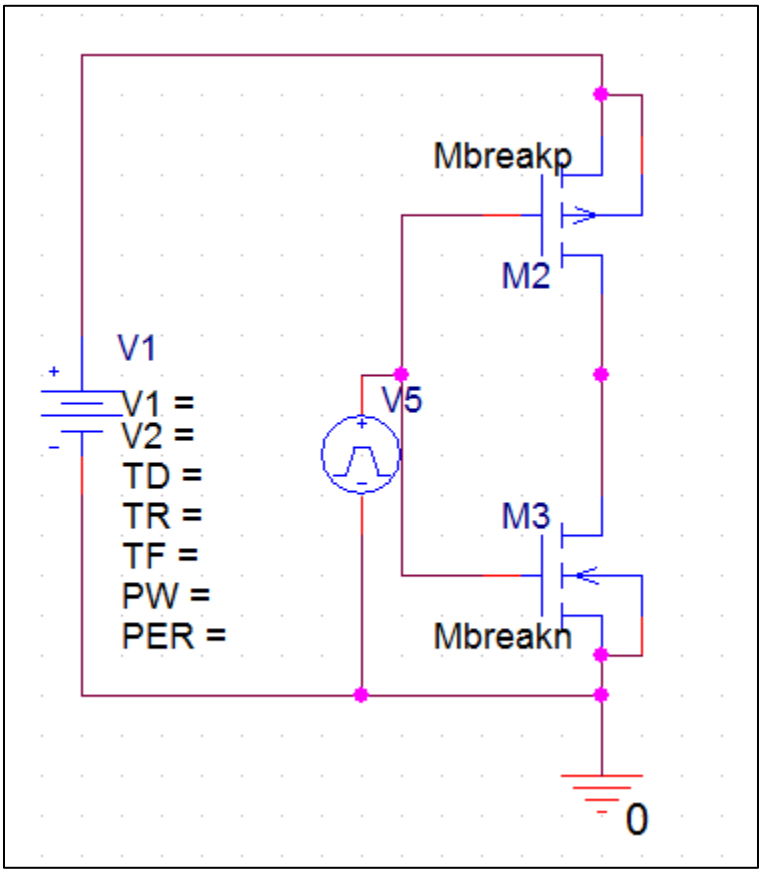

Figure 1 CMOS inverter schematic

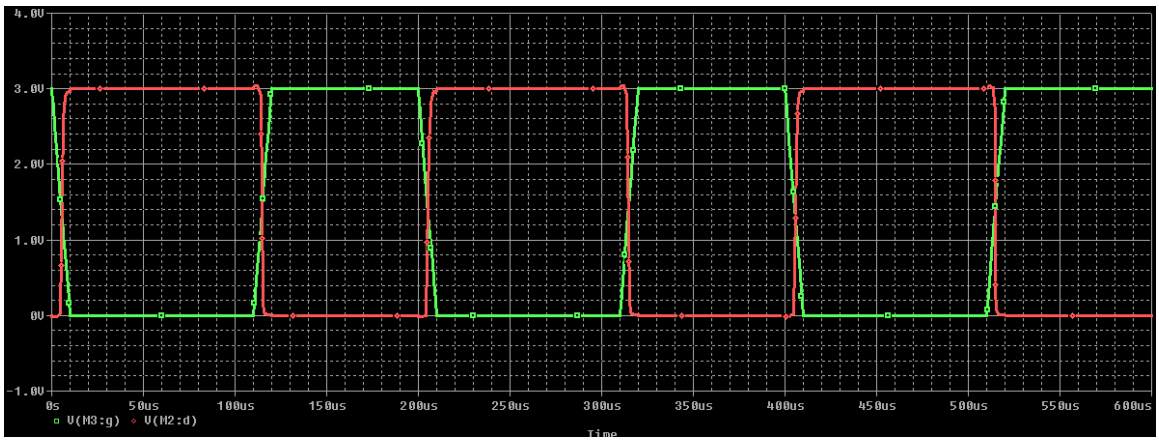

Figure 2CMOS inverter input and output waveforms

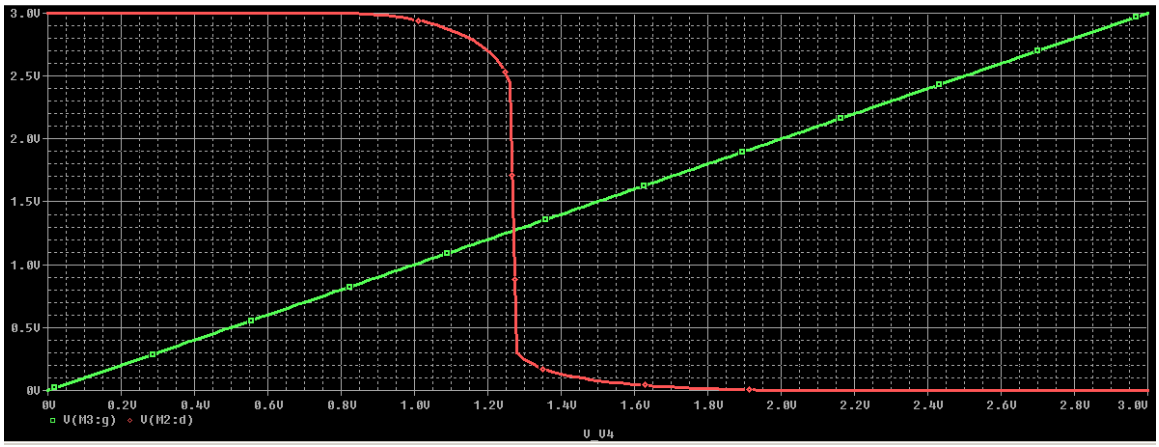

Figure 3 CMOS inverter VTC

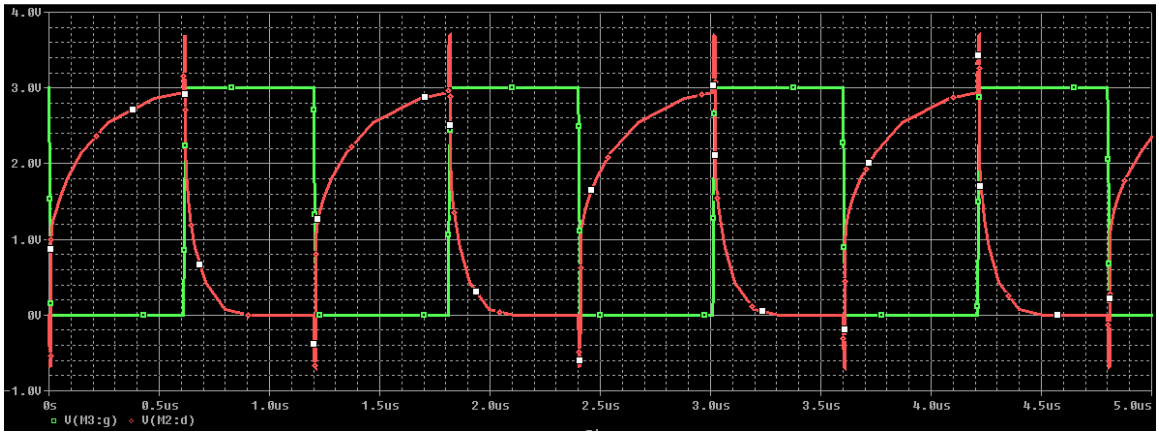

Figure 4 max input frequency and corresponding output waveform

Appendix:

PMOS Model

.model Mbreakp PMOS LEVEL = 3

+ TOX = 200E-10 NSUB = 1E17 GAMMA = 0.6

+ PHI = 0.7 VTO = -0.9 DELTA = 0.1

+ UO = 250 ETA = 0 THETA = 0.1

+ KP = 40E-6 VMAX = 5E4 KAPPA = 1

+ RSH = 0 NFS = 1E12 TPG = -1

+ XJ = 500E-9 LD = 100E-9

12

+ CGDO = 200E-12 CGSO = 200E-12 CGBO = 1E-10

+ CJ = 400E-6 PB = 1 MJ = 0.5

+ CJSW = 300E-12 MJSW = 0.5

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NMOS Model

.model Mbreakn NMOS LEVEL = 3

+ TOX = 200E-10 NSUB = 1E17 GAMMA = 0.5

+ PHI = 0.7 VTO = 0.8 DELTA = 3.0

+ UO = 650 ETA = 3.0E-6 THETA = 0.1

+ KP = 120E-6 VMAX = 1E5 KAPPA = 0.3

+ RSH = 0 NFS = 1E12 TPG = 1

+ XJ = 500E-9 LD = 100E-9

+ CGDO = 200E-12 CGSO = 200E-12 CGBO = 1E-10

+ CJ = 400E-6 PB = 1 MJ = 0.5

0

+ CJSW = 300E-12 MJSW = 0.5