Lec 19: October 21, 2015
Pass Transistor Logic
Teaser

- What does this do?

Diagram:

- notB
- A
- notA
- B
- 1 1
- Y
Previously: Impact of Capacitance

- \( C_{\text{GS}} = C_{\text{GCS}} + C_{\text{GSO}} \)
- \( C_{\text{GD}} = C_{\text{GCD}} + C_{\text{GDO}} \)
- \( C_{\text{GB}} = C_{\text{GCB}} \)
- \( C_{\text{SB}} = C_{\text{diff}} \)  
  - source-bulk shorted
- \( C_{\text{DB}} = C_{\text{diff}} \)
Today

- Pass Transistor Circuits
  - Case 1: $C_{\text{diff}} = 0$
  - Case 2: $C_{\text{diff}} > 0$
Identify Function

- What function is this?
What is $V_{out}$ if $A=1$, $B=1$?

\[ \begin{array}{cccc}
A & B & Y \\
0 & 0 & \ \\
0 & 1 & \ \\
1 & 0 & \ \\
1 & 1 & \ \\
\end{array} \]
What is $V_{out}$ if $A=1, B=1$?
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What is $V_{out}$ if $A=0$, $B=0$? if $A=1$, $B=0$?

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What is $V_{out}$ if $A=0$, $B=0$? if $A=1$, $B=0$?

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Area

- Compare PT with CMOS circuit?
Is this a regenerating/restoring gate?

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What does output look like (DC transfer)?

- \((B=1, \text{not}B=0, \text{sweep } A, \text{not}A=\text{CMOS inv}(A))\)
Pass TR transfer (B=1)
CMOS Inverter Transfer
Reasonable Input to CMOS Inverter?
Pass Transistor xor2 with inv restore
Compare CMOS

Is this a fair comparison?

notB

A

notA

B
Required to use?

- What should we add to make substitutable with CMOS?
Restore Output
Restore Output

- Area? (compare to CMOS)
Chain Together
Analyze Stage

- What’s different about this?
Delay $A=1$, $B=0$, $C_{DB}=C_{\text{diff}}=0$?
Delay $A=1$, $B=0$, $C_{\text{diff}}=0$?

- What’s the equivalent RC circuit?
Delay $A=1, B=0, C_{\text{diff}}=0$?

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- What’s the equivalent RC circuit?
Delay $A=1$, $B=1$, $C_{\text{diff}}=0$?

- What’s the equivalent RC circuit?
  - What are we ignoring?

Penn ESE 370 Fall 2015 - Khanna
$C_{\text{diff}} > 0$
Previously: Impact of Capacitance

- $C_{GS} = C_{GCS} + C_{GSO}$
- $C_{GD} = C_{GCD} + C_{GDO}$
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Contact/Diffusion Capacitance

- $C_j$ – diffusion depletion
- $C_{jsw}$ – sidewall capacitance
- $L_s$ – length of diffusion

\[
C_{\text{diff}} = C_j L_s W + C_{jsw} \left(2L_s + W \right)
\]

Define:  \( C_{\text{diff}0} \approx \gamma C_0 \)

\[
C_{\text{diff}} \approx WC_{\text{diff}0} = W \cdot \gamma C_0
\]
Inverter Delay

- Delay driving another inverter?
  - Include $C_{\text{diff}} = \gamma C_g = W \gamma C_0$
Delay $A=1$, $B=1$, $C_{\text{diff}}=\gamma C_0$? ($W=1$)
Delay $A=1$, $B=1$, $C_{\text{diff}} = \gamma C_0$? ($W=1$)

- What’s the equivalent RC circuit?
Bonus

- What does this do?

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What does this do?

More examples in the text
Idea

- There are other circuit disciplines
- Can use pass transistors for logic
  - Sometimes gives area or delay win
Admin

- Project
  - Hans extra office hours Thursday 6-8pm
  - Tania extra office hours Friday 4-6pm
  - Get started on design-space exploration and optimization