CMOS Transistors

- Readings: B.1-B.3.1
- All circuit elements built from transistors
Transistor Switches

N-type

\[ \text{G}=0 \]

\[ \text{open switch} \]

\[ \text{G}=1 \]

\[ \text{closed switch} \]

P-type

\[ \text{G}=0 \]

\[ \text{closed switch} \]

\[ \text{G}=1 \]

\[ \text{open switch} \]

TRUE = 1 = 1.2 Volts
FALSE = 0 = 0 Volts

however:

0 \[ \text{good 0} \]

1 \[ \text{poor 1} \]

however:

0 \[ \text{poor 0} \]

1 \[ \text{good 1} \]
Using Transistor Switches

- Make a switch that transmits good 0 and 1?

- Transmission gate: 
  
  ![Diagrams of different types of transmission gates]
Multiplexors

- How do we build a 2:1 Mux?

```
A
↑
|   |
B ——> F

<table>
<thead>
<tr>
<th>S</th>
<th>A</th>
<th>B</th>
<th>F</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>X</td>
<td>0</td>
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<tr>
<td>0</td>
<td>1</td>
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```
Buses and Tristates:

- Can have more than one source of a signal

- Tristate:

- Bus:
  
  Source 1
  Source 2
  Source 3
Basic Gates

Inverter

\[ \text{Vdd (source of 1's)} \]

\[ \text{GND (source of 0's)} \]

Nand Gate

\[
\begin{array}{c|c|c}
A & B & C \\
0 & 1 & 1 \\
1 & 1 & 0 \\
\end{array}
\]

Nor Gate:

\[
\begin{array}{c|c|c}
A & B & C \\
0 & 1 & 0 \\
0 & 0 & 0 \\
\end{array}
\]
Compound Gates

- A complex boolean function can be built from basic gates (inverter, NAND, NOR)

- Alternatively: \[ F = \overline{A + BC} \]
Compound Gates (cont.)

\[ F = A(BC + DE) \]
Memory

- A pair of inverters can hold a value:

- A value can be read, but how written?

- Alternative - DRAM: