CMOS Transistors

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

![Diagram of CMOS Transistors]

- N-type CMOS Transistor
- P-type CMOS Transistor

- drain
- gate
- source
- conductor - gate
- insulator
- substrate

- n-type
- p-type

Diagram showing the basic structure of CMOS transistors with labeled parts: gate, source, drain, conductor - gate, insulator, and substrate.
Transistor Switches

N-type

\[ \text{G} = 0 \]
\[ \quad = \quad \text{open switch} \]
\[ \quad = \quad \text{closed switch} \]

P-type

\[ \text{G} = 0 \]
\[ \quad = \quad \text{closed switch} \]
\[ \quad = \quad \text{open switch} \]

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

however:

\[ 0 \quad \rightarrow \quad \text{good 0} \]
\[ 1 \quad \rightarrow \quad \text{poor 1} \]

however:

\[ 0 \quad \rightarrow \quad \text{poor 0} \]
\[ 1 \quad \rightarrow \quad \text{good 1} \]
Using Transistor Switches

- Make a switch that transmits good 0 and 1?

- Transmission gate:  
  
  ![Transmission gate](image)
How do we build a 2:1 Mux?

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<thead>
<tr>
<th>S</th>
<th>A</th>
<th>B</th>
<th>F</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>X</td>
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<td>1</td>
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<tr>
<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**

Vdd (source of 1's)

GND (source of 0's)

**Nand Gate**

<table>
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<tr>
<th>A</th>
<th>B</th>
<th>C</th>
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<tbody>
<tr>
<td>0</td>
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**Nor Gate:**

<table>
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<tr>
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Compound Gates

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

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

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

- A pair of inverters can hold a value:

- A value can be read, but how written?

- Alternative - DRAM: