CMOS Transistors

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

Transistor Switches

N-type

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

\[ G=1 \]
\[ \text{closed switch} \]

However:

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

P-type

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

\[ G=1 \]
\[ \text{open switch} \]

However:

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

TRUE = 1 = 1.2 Volts
FALSE = 0 = 0 Volts
Using Transistor Switches

- Make a switch that transmits good 0 and 1?

Transmission gate:

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

Multiplexors

- How do we build a 2:1 Mux?
Buses and Tristates:

- Can have more than one source of a signal

- Tristate:

  ![Tristate Diagram]

- Bus:
  - Source 1
  - Source 2
  - Source 3

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Basic Gates

**Inverter**

![Inverter Diagram]

Vdd (source of 1's)

GND (source of 0's)

**Nand Gate**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Nor Gate**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
### Compound Gates

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

- Alternatively: \[ F = \overline{A} + BC \]

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### Compound Gates (cont.)

\[ F = \overline{A}(BC + DE) \]
<table>
<thead>
<tr>
<th>Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>• A pair of inverters can hold a value:</td>
</tr>
<tr>
<td>• A value can be read, but how written?</td>
</tr>
<tr>
<td>• Alternative - DRAM:</td>
</tr>
</tbody>
</table>