Logic Gates

Networks and Embedded Systems
First Grade Level
Wolfgang Neff
Logic Gates (1)

• Families of Logic Gates

Gate

Based on BJT

TTL

MOS

Based on MOSFET

PMOS

NMOS

CMOS

Complementary metal–oxide–semiconductor
Logic Gates (2)

• Transistor-Transistor-Logic
  – TTL circuits operate with 5 V supply power
  – H and L are defined as voltage ranges
  – Input and output ranges differ

<table>
<thead>
<tr>
<th>TTL Signal</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>0 V … 0,8 V</td>
<td>0 V … 0,4 V</td>
</tr>
<tr>
<td>H</td>
<td>2 V … 5 V</td>
<td>2,4 V … 5 V</td>
</tr>
</tbody>
</table>
Logic Gates (3)

• Transistor-Transistor-Logic (continued)
  – Signal levels

![Signal levels diagram]

- Voltage V
  - < 0.8 V: L
  - > 2 V: H
  - > 2.4 V: H
  - < 0.4 V: L

Signal distance
Logic Gates (4)

• Transistor-Transistor-Logic (finished)
  – TTL gates are found in the 7400 series

<table>
<thead>
<tr>
<th>IC</th>
<th>Gate</th>
<th>Number</th>
<th>Lines</th>
<th>IC</th>
<th>Gate</th>
<th>Number</th>
<th>Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>7408</td>
<td>AND</td>
<td>4</td>
<td>2</td>
<td>7400</td>
<td>NAND</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>7411</td>
<td>AND</td>
<td>3</td>
<td>3</td>
<td>7410</td>
<td>NAND</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>7421</td>
<td>AND</td>
<td>2</td>
<td>4</td>
<td>7420</td>
<td>NAND</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>7432</td>
<td>OR</td>
<td>4</td>
<td>2</td>
<td>7402</td>
<td>NOR</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>7404</td>
<td>NOT</td>
<td>6</td>
<td>1</td>
<td>7427</td>
<td>NOR</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Logic Gates (5)

- CMOS Logic Gates
  - Signal levels

![Diagram showing CMOS gate signal levels and voltage ranges]

- Voltage levels:
  - $< 1.5 \text{ V: L}$
  - $> 3.5 \text{ V: H}$
  - $< 0.05 \text{ V: L}$
  - $> 4.95 \text{ V: H}$
**Logic Gates (6)**

- **CMOS Logic Gates (continued)**
  - CMOS gates are found in the 4000 series
  
<table>
<thead>
<tr>
<th>IC</th>
<th>Gate</th>
<th>Number</th>
<th>Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>4081</td>
<td>AND</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>4073</td>
<td>AND</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4082</td>
<td>AND</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4071</td>
<td>OR</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>4049</td>
<td>NOT</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>4011</td>
<td>NAND</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>4023</td>
<td>NAND</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4012</td>
<td>NAND</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4001</td>
<td>NOR</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>4025</td>
<td>NOR</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

- There are also CMOS version of the TTL gates
  - **74HC00:** CMOS compatible voltage levels
  - **74HCT00:** TTL compatible voltage levels
Logic Gates (7)

• 7404: Hex inverter

![Functional Diagram](image1)
![Pin Configuration](image2)
![Internal View](image3)
Logic Gates (8)

- **7408: Quad 2-input AND gate**

---

**Functional Diagram**

**Pin Configuration**

**Internal View**
Logic Gates (9)

• 7432: Quad 2-input OR gate

![Functional Diagram](image1)
![Pin Configuration](image2)
![Internal View](image3)
Logic Gates (10)

• 7486: Quad 2-input XOR gate