IC220
Slide Set #6: Digital Logic
(Appendix C)

Appendix Goals

Establish an understanding of the basics of logic design for future material

• Gates
  – Basic building blocks of logic

• Combinational Logic
  – Decoders, Multiplexors, PLAs

• Clocks

• Memory Elements

• Finite State Machines

Logic Design – Digital Signals

• Only two valid, stable values
  – $\text{False} =$
  – $\text{True} =$

• Vs. voltage levels
  – Low voltage “usually”
  – High voltage “usually”
  – But for some technologies may be the reverse

• How can we make a function with these signals?
  1. Specify equations:

  2. Implement with

ADMIN

• Very different material!
• Reading
  – Appendix: Read C.1, C.2, C.3. Skim C.5. (on your CD)
Boolean Algebra

- One approach to expressing the logic function
- Operators:
  - NOT \( x = \overline{A} \)
  - AND: ‘A logical product’ \( x = A \cdot B = AB \)
  - OR : ‘A logical sum’ \( x = A + B \)
  - XOR \( x = A \oplus B \)
  - NAND \( x = A \cdot \overline{B} \)
  - NOR \( x = \overline{A} + B \)

Example

\[
\begin{align*}
A(1) & \\
B(1) & \\
C(0) & \\
D(1) & \\
\end{align*}
\]

G

Equation:

Gates

Truth Tables Part 1

- Alternative way to specify logical functions
- List all outputs for all possible inputs
  - n inputs, how many entries?
  - Inputs usually listed in numerical order

\[
\begin{array}{c|c}
A & x \\
0 & 0 \\
1 & 1 \\
\end{array}
\quad \begin{array}{c|c|c}
A & B & x \\
0 & 0 & 0 \\
0 & 1 & 1 \\
1 & 0 & 1 \\
1 & 1 & 1 \\
\end{array}
\]
Truth Tables Part 2

- Not just for individual gates
- Not just for one output

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Laws of Boolean Algebra

- **Identity Law** \( A + 0 = A \) \( A \cdot 1 = A \)

- **Zero and One Law** \( A + 1 = 1 \) \( A \cdot 0 = 0 \)

- **Inverse Law** \( A + \overline{A} = 1 \) \( A \cdot \overline{A} = 0 \)

- **Commutative Law** \( A + B = B + A \) \( A \cdot B = B \cdot A \)

- **Associative Law** \( A + (B + C) = (A + B) + C \)

- **Distributive Law** \( A \cdot (B + C) = (A \cdot B) + (A \cdot C) \)

- **DeMorgan’s Law**
  \[ A + B = \overline{A \cdot B} \]
  \[ A \cdot B = \overline{A} + \overline{B} \]