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

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
  – False =
  – 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 B.1, B.2, B.3. Skim B.5.
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: \( x = \overline{A \cdot B} \)
  - NOR: \( x = \overline{A + B} \)

Gates

Example

\[ \begin{array}{c|c}
A(1) & \text{AND gate} \\
B(1) & \\
C(0) & \text{OR gate} \\
D(1) & \\
\end{array} \]

Equation:

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

\[
\begin{array}{c|c|c}
\text{A} & \text{B} & \text{X} \\
0 & 1 & \\
1 & 2 & \\
\end{array}
\]

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

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

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

Laws of Boolean Algebra

- Identity Law \[ A + 0 = A \quad A \cdot 1 = A \]
- Zero and One Law \[ A + 1 = 1 \quad A \cdot 0 = 0 \]
- Inverse Law \[ A + \overline{A} = 1 \quad A \cdot \overline{A} = 0 \]
- Commutative Law \[ A + B = B + A \quad A \cdot B = B \cdot A \]

- Associative Law \[ A \cdot (B + C) = (A \cdot B) + C \]
  \[ A + (B \cdot C) = (A + B) \cdot C \]
- Distributive Law \[ A \cdot (B + C) = (A \cdot B) + (A \cdot C) \]
  \[ A + (B \cdot C) = (A + B) \cdot (A + C) \]
- DeMorgan’s Law \[ \overline{A + B} = \overline{A} \cdot \overline{B} \]
  \[ \overline{A \cdot B} = \overline{A} + \overline{B} \]