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CPE100: Digital Logic Design I

Midterm01 Review

Logistics

- Thursday Oct. 5th
  - In normal lecture (13:00-14:15)
  - 1 hour and 15 minutes
- Chapters 1-2.6
- Closed book, closed notes
- No calculators
- Must show work and be legible for credit

- Boolean Axioms and Theorems will

Preparation

- Read the book (2nd Edition)
  - Then, read it again
- Do example problems
  - Use both Harris and Roth books
- Be sure you understand homework solutions

- Come visit during office hours for questions

Chapter 1.2 Managing Complexity

- Abstraction – hiding details that aren't important
- Digital discipline – restricting design choices to digital logic for more simple design
- Hierarchy – dividing a system into modules and further submodules for easier understanding
- Modularity – modules have well-defined functions and interfaces for easy interconnection
- Regularity – uniformity among modules for reuse

Chapter 1.3 Digital Abstraction

- Analog → digital computing
- Information in a discrete variable
  - $D = \log_2 N$ bits
- Introduction to binary variables
- Example1: Information in 9-state variable
  - $D = \log_2 9 = 3.1699$ bits
    - Note 3 bits can represent 8 values so requires just more than 3 bits

Chapter 1.4 – Number Systems

- Number representation
  - N-digit number $\{a_{N-1}a_{N-2}\ldots a_1 a_0\}$ of base R in decimal
    - $a_{N-1}R^{N-1} + a_{N-2}R^{N-2} + \cdots + a_1 R^1 + a_0 R^0$
    - $= \sum_{i=0}^{N-1} a_i R^i$
  - Range of values

- Base 2, 10, 16, etc. conversion
  - Often from base R_0 to decimal to R_1
  - Two methods:
    - Repeatedly remove largest power of 2
    - Repeatedly divide by two

Number Examples

- Convert 10110_2 to decimal
- Convert 10110_2 to base 5
- Convert 10110_2 to hex and octal

Chapter 1.4.5 – Binary Addition

- Signed number representation
  - Unsigned, two's complement, sign-magnitude
- Addition
  - Binary carries
  - Potential for overflow
- Subtraction
  - Find negative of number and add
- Zero/Sign extension

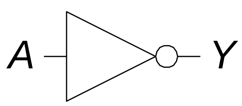
Example Binary Addition

- Assume 6-bit 2's complement and indicate if overflow occurs
- Add $13_{10}+11_{10}$
- Add $21_{10} + 11_{10}$
- Add $-25_{10} + 18_{10}$
- Add $-12 + 13$

Chapter 1.5 – Logic Gates

- NOT, BUF

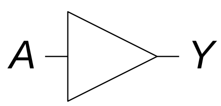
NOT



$Y = \overline{A}$

A	Y
0	1
1	0

BUF

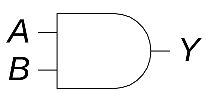


$Y = A$

A	Y
0	0
1	1

- AND, OR

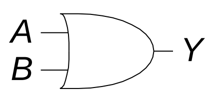
AND



$Y = AB$

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

OR

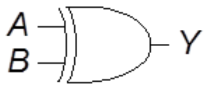


$Y = A + B$

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

- XOR, NAND

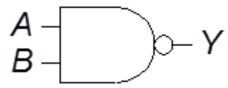
XOR



$Y = A \oplus B$

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

NAND

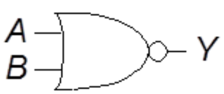


$Y = \overline{AB}$

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

- NOR, XNOR

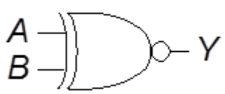
NOR



$Y = \overline{A + B}$

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

XNOR

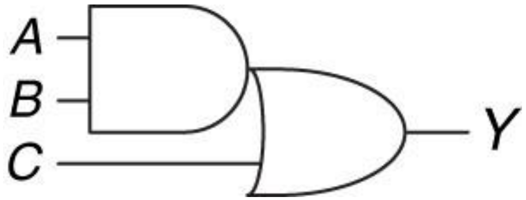


$Y = \overline{A \oplus B}$

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

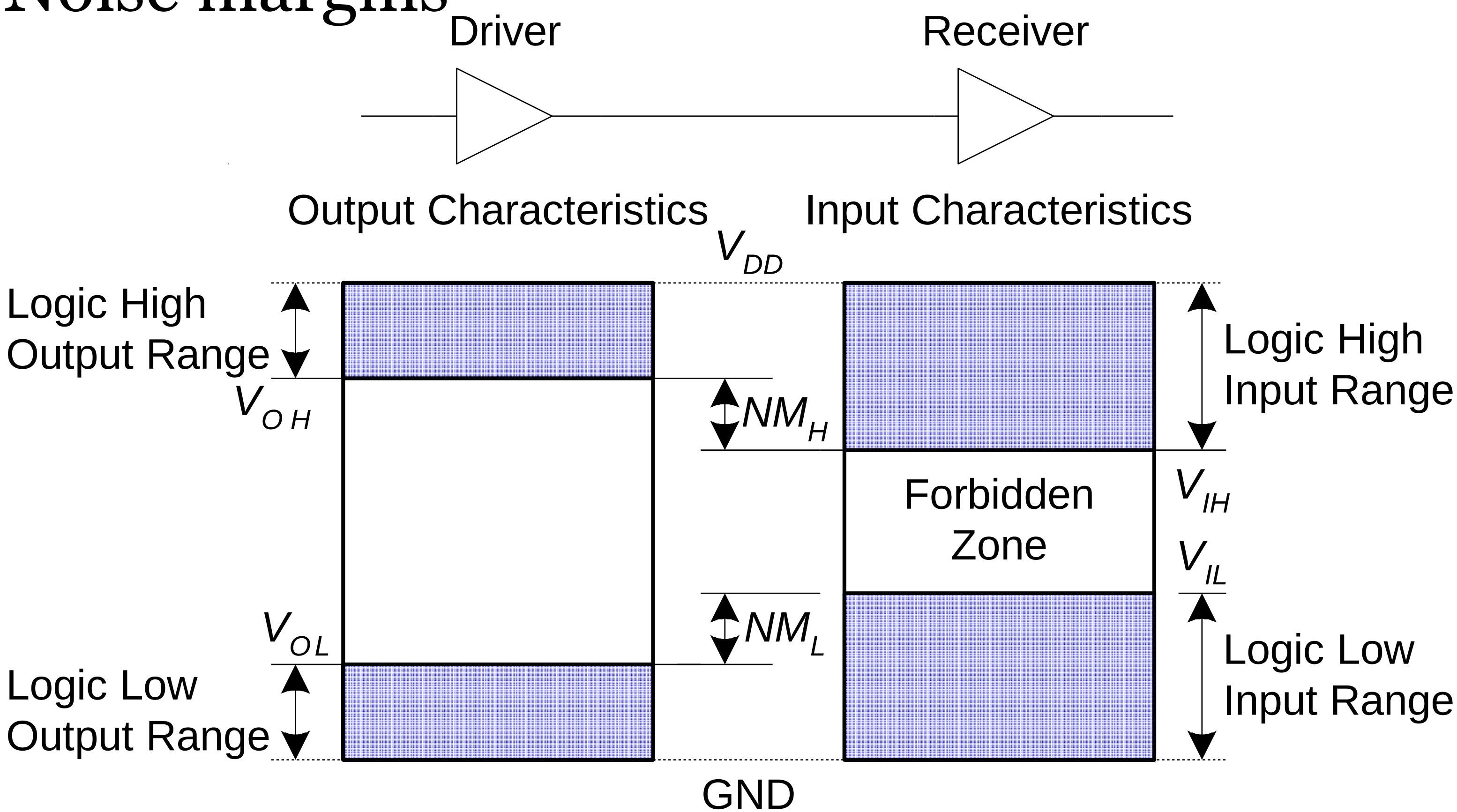
Example

- Give truth table for logic gate



Chapter 1.6 Beneath Digital Abstraction

- Noise margins

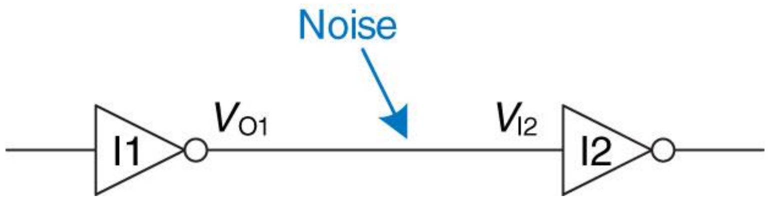


$$NM_H = V_{OH} - V_{IH}$$

$$NM_L = V_{IL} - V_{OL}$$

Example 1.18

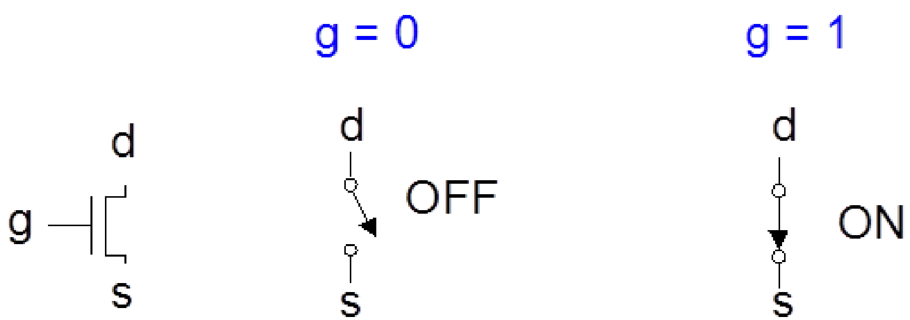
- What is the inverter low and high noise margins



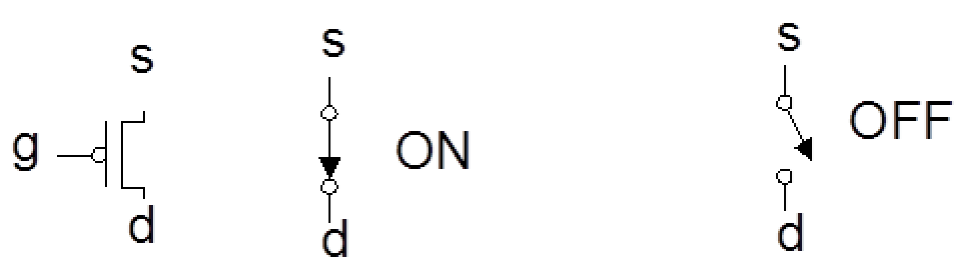
- $V_{DD} = 5, V_{IL} = 1.35, \mathrm{V_{IH}} = 3.15, \mathrm{V_{OL}} = 0.33, \mathrm{V_{OH}} = 3.84$

Chapter 1.7 – Transistors

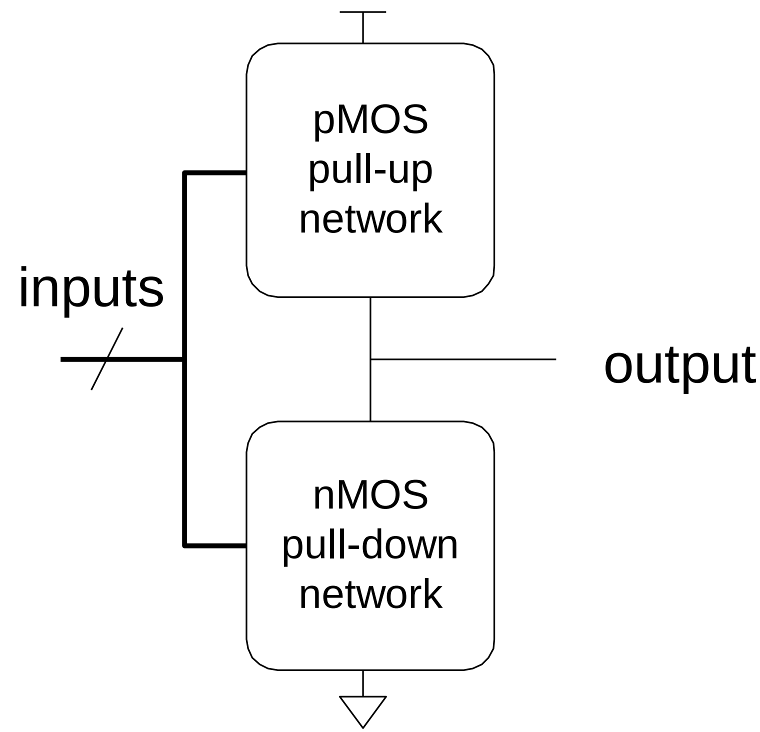
- Voltage controlled switch
- NMOS – pass 0's
  - Connect to GND



- PMOS – pass 1's
  - Connect to VDD

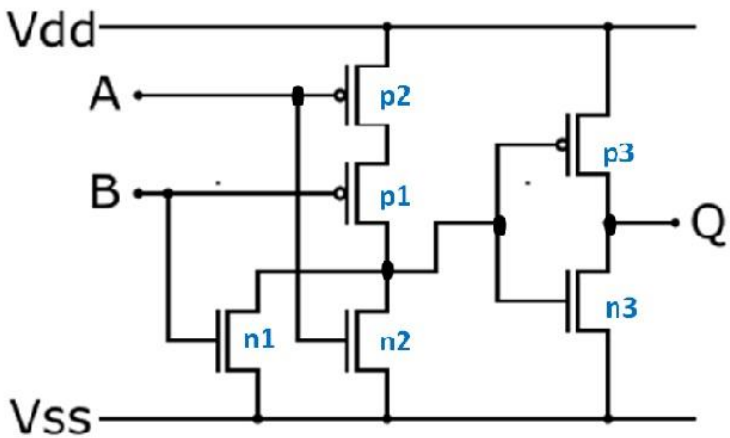


- CMOS logic gates



Example

- Give the truth table and function



Chapter 1.7 – Power Consumption

- Two types of power consumption
- Dynamic – power required to charge gate capacitances (turn on/off transistor switches)

$$\boxed{P_{dynamic} = \frac{1}{2} C V_{DD}^2 f}$$

- Static – power consumed when no gates switching

$$\boxed{P_{static} = I_{DD} V_{DD}}$$

Chapter 2.2 – Boolean Equations

- Terms: variable/complement, literal, product/implicant
- Order of operations: NOT → AND → OR
- Sum-of-product (SOP) form
  - Determined by minterms of truth table
- Product-of-sums (POS) form
  - Determined by maxterms of truth table

Chapter 2.3 – Boolean Algebra

- Boolean algebra is very much like our normal algebra

- Need to know Boolean Axioms and Theorems
    - Distributivity, covering, De Morgan’s

- Proving equations
    - Perfect induction/proof by exhaustion – show truth tables match
    - Simplification – use theorems/axioms to show both sides of equation are equal

Chapter 2.3.5 – Simplifying Equations

- Practice, practice, practice

Chapter 2.4 – Logic to Gates

- Schematic diagram of digital circuit

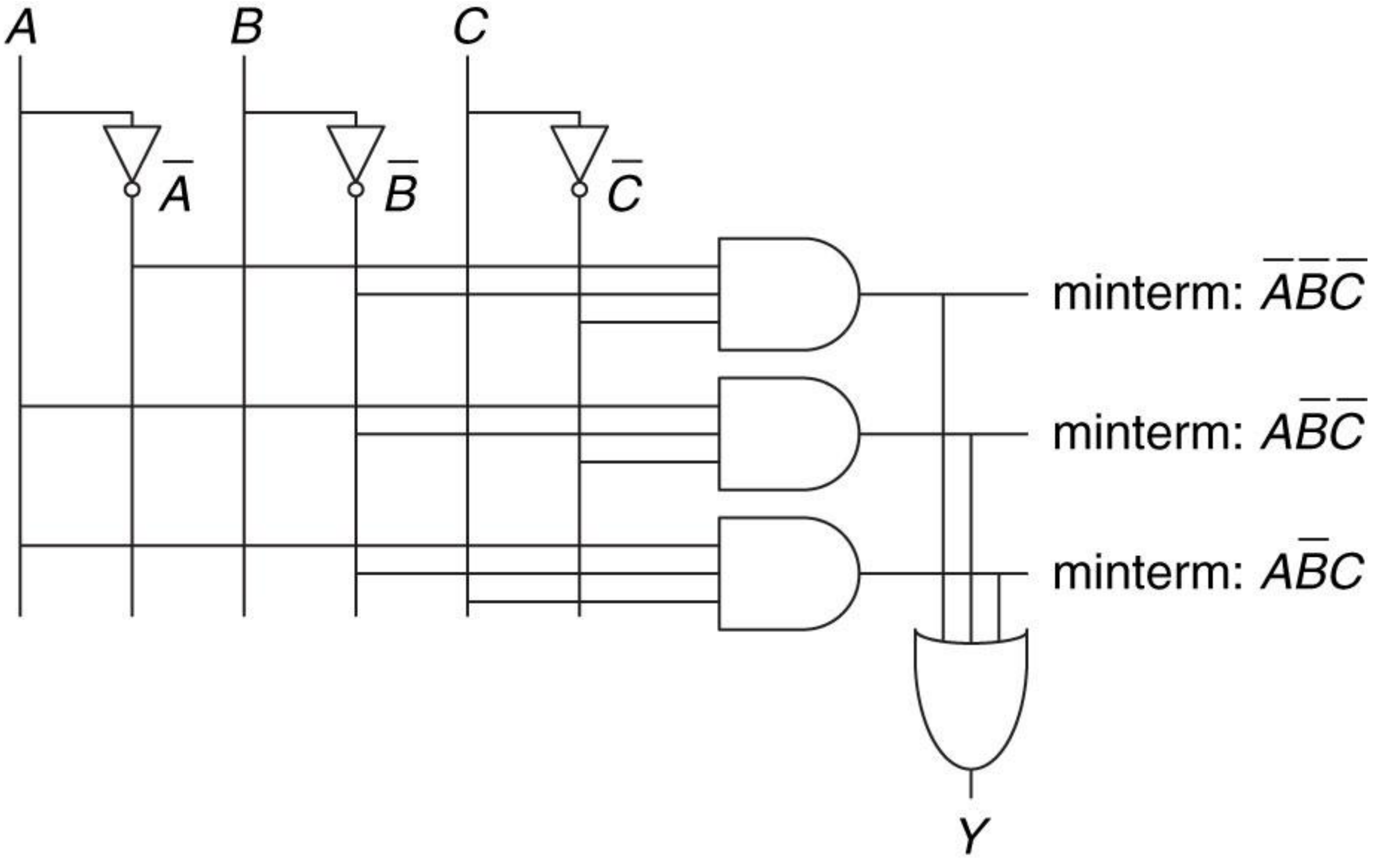
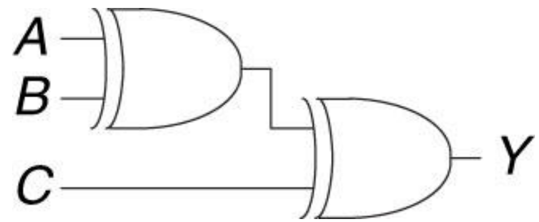


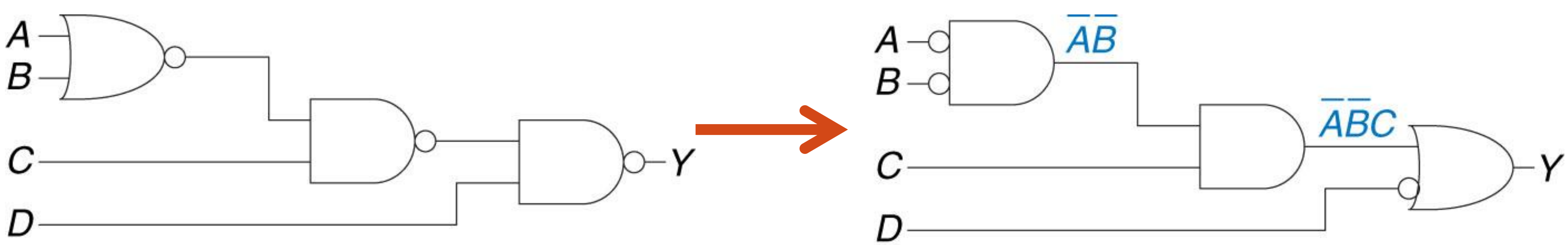
Figure 2.23 Schematic of $Y = \overline{A}\,\overline{B}\,\overline{C} + A\overline{B}\,\overline{C} + A\overline{B}C$

Chapter 2.5 - Multilevel Combinational Logic

- Convert gate level schematic into Boolean equation



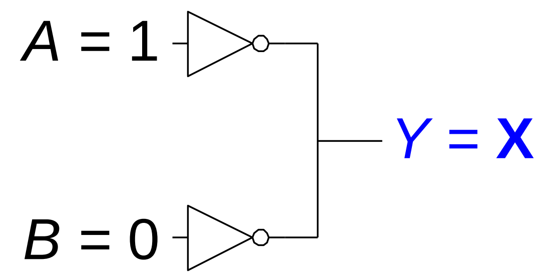
- Bubble pushing – application of De Morgan's in schematic



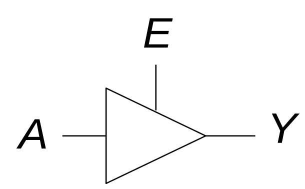
$$Y = \overline{A}\,\overline{B}C + \overline{D}$$

Chapter 2.6 – Real Circuit Issues

- Don’t cares: X
  - Truth table flexibility
- Contention: X
  - Illegal output value
  - Output could be 1 or 0 in error



- Floating: Z
  - High impedance, high Z
  - Output between 0, 1 by design



E	A	Y
0	0	Z
0	1	Z
1	0	0
1	1	1