

CPE100: Digital Logic Design I



Midterm01 Review

Logistics

- Thursday Oct. 4th
 - 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 be provided

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 \rightarrow 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 $\{a_{N-1}a_{N-2} \dots a_1a_0\}$ of base R in decimal
 - $a_{N-1}R^{N-1} + a_{N-2}R^{N-2} + \dots + a_1R^1 + a_0R^0$
 - $= \sum_{i=0}^{N-1} a_iR^i$
 - 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

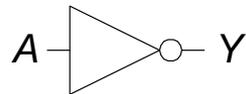
Example Binary Addition

- 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

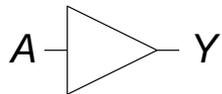
NOT



$$Y = \bar{A}$$

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

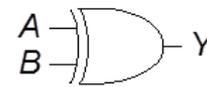


$$Y = A + B$$

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

- XOR, NAND

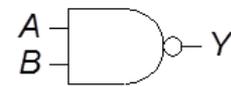
XOR



$$Y = A \oplus B$$

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

NAND

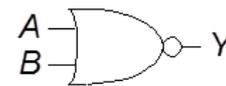


$$Y = \overline{AB}$$

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

- NOR, XNOR

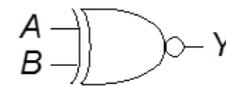
NOR



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

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

XNOR

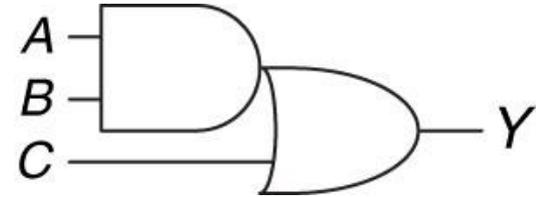


$$Y = \overline{A \oplus B}$$

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

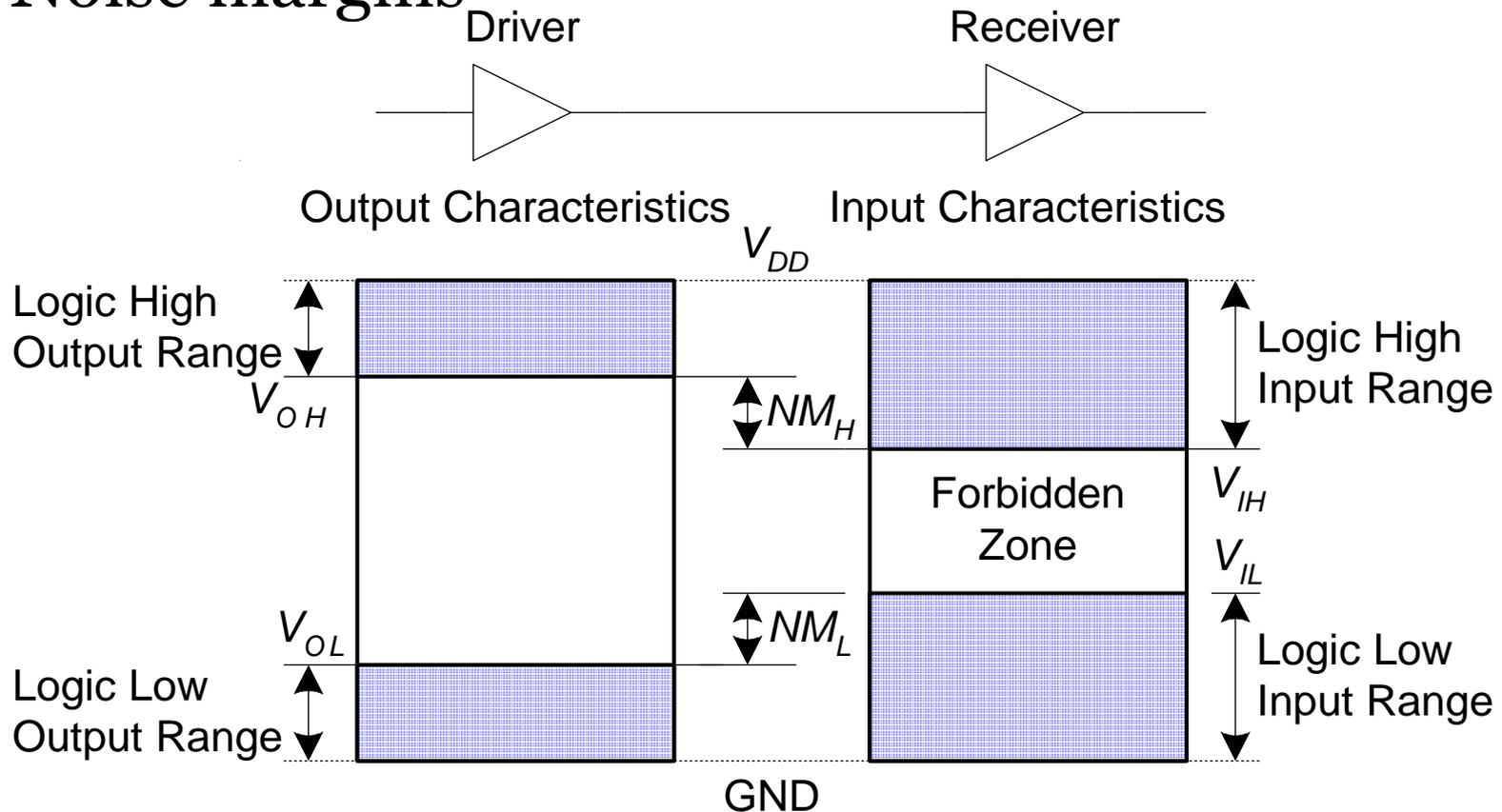
Example

- Give truth table for logic gate



Chapter 1.6 Beneath Digital Abstraction

- Noise margins

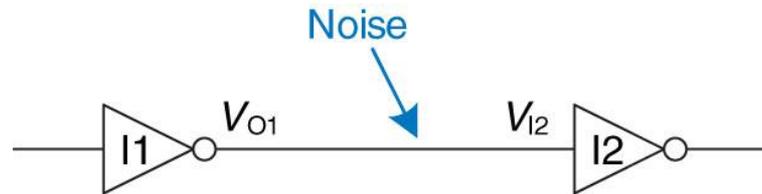


$$NM_H = V_{OH} - V_{IH}$$

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

Example 1.18

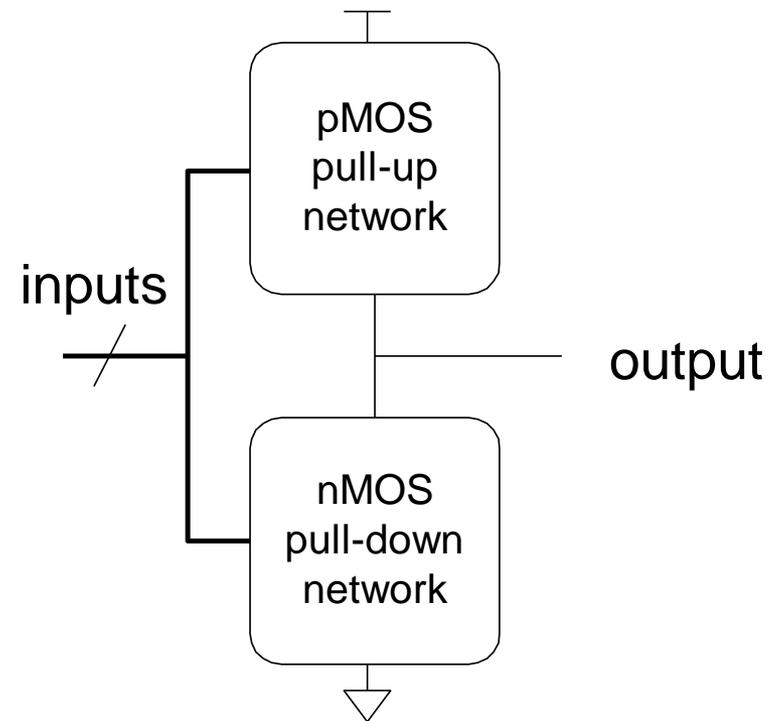
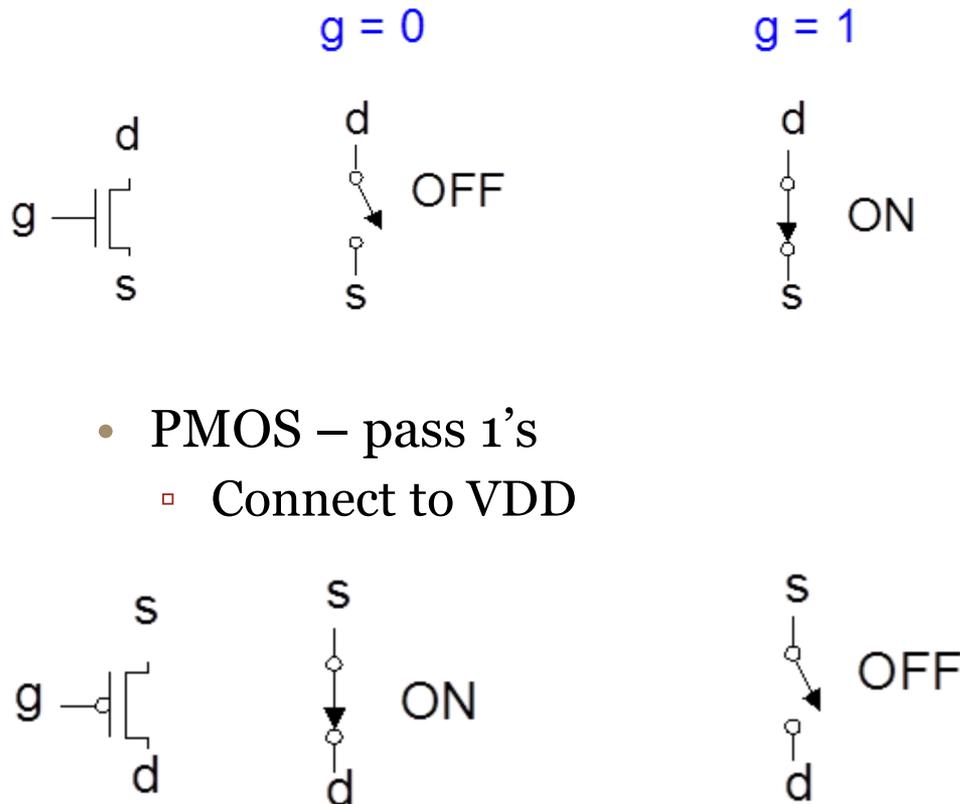
- What is the inverter low and high noise margins



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

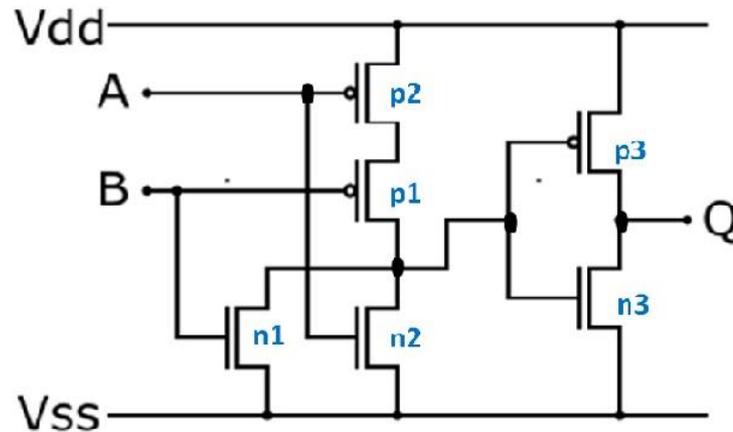
Chapter 1.7 - Transistors

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

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

- Static – power consumed when no gates switching

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

Chapter 2.2 - Boolean Equations

- Terms: variable/complement, literal, product/implicant
- Order of operations: NOT \rightarrow AND \rightarrow 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

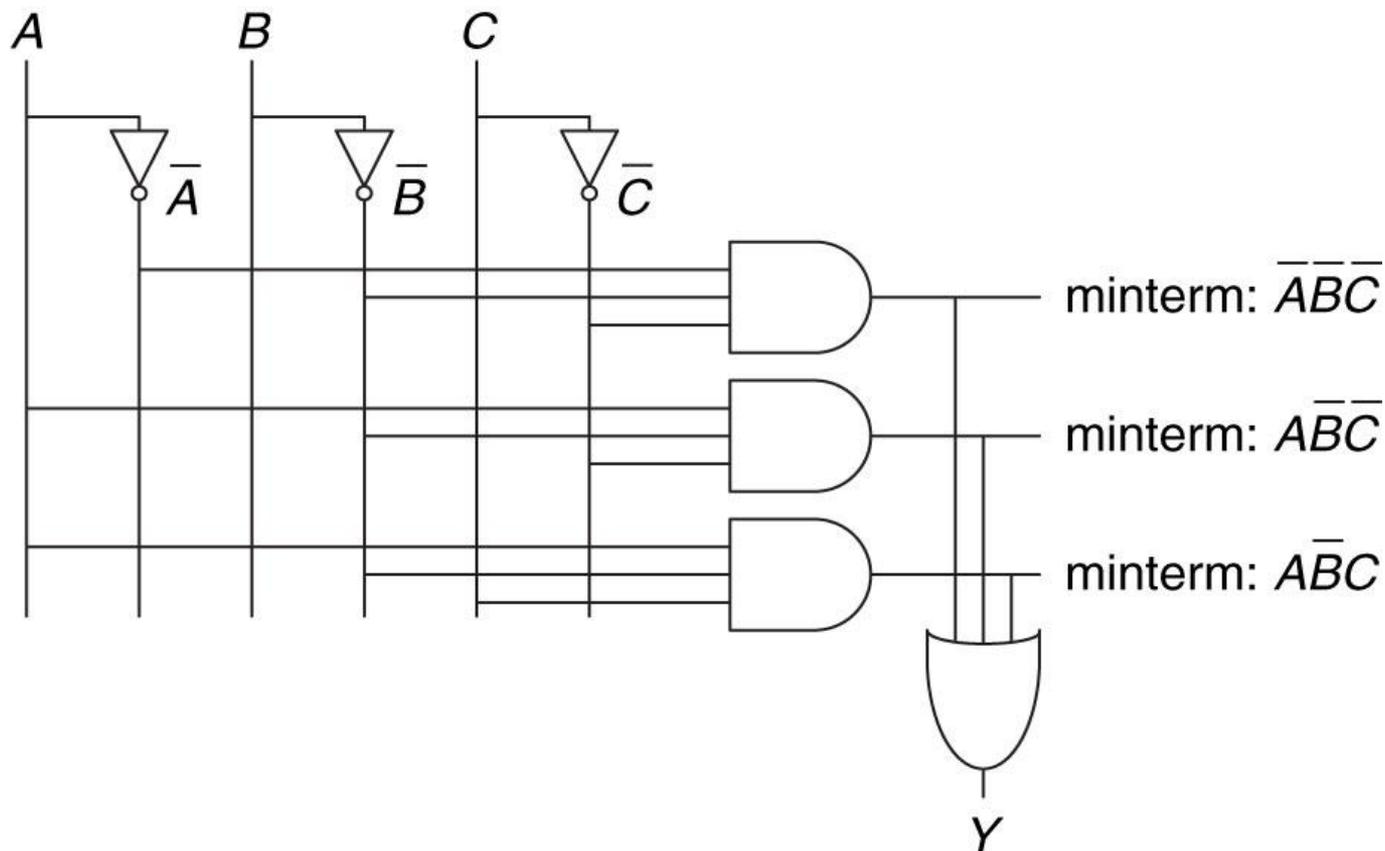
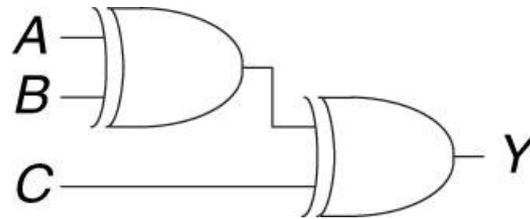


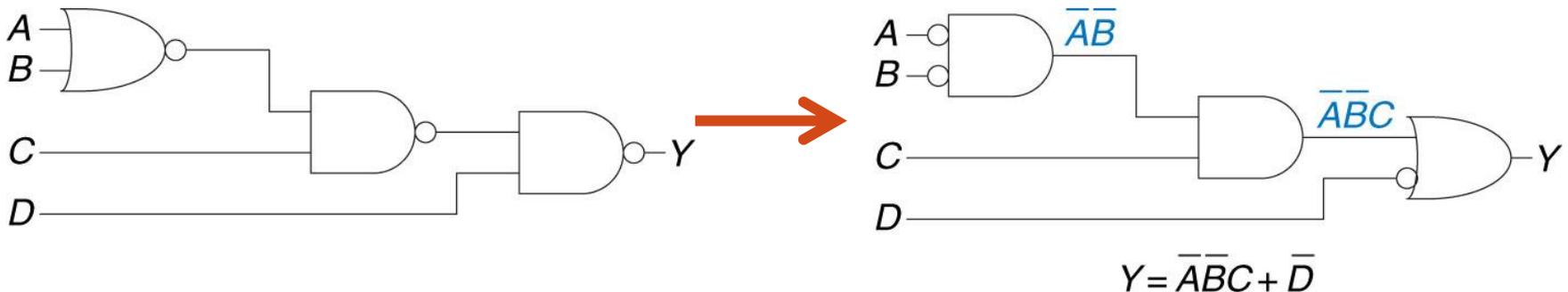
Figure 2.23 Schematic of $Y = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + A\bar{B}\bar{C}$

Chapter 2.5 - Multilevel Combinational Logic

- Convert gate level schematic into Boolean equation



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

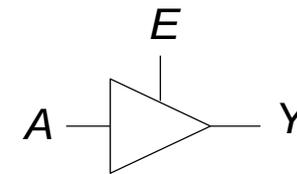
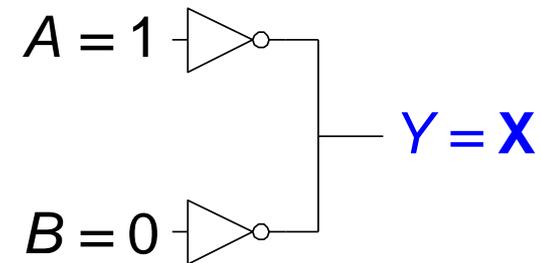


Chapter 2.6 - Real Circuit Issues

- 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