RUTGERS
THE STATE UNIVERSITY OF NEW JERSEY

ECE-332:437
DIGITAL SYSTEMS DESIGN (DSD)

Fall 2016 – Lecture 4 - Recap

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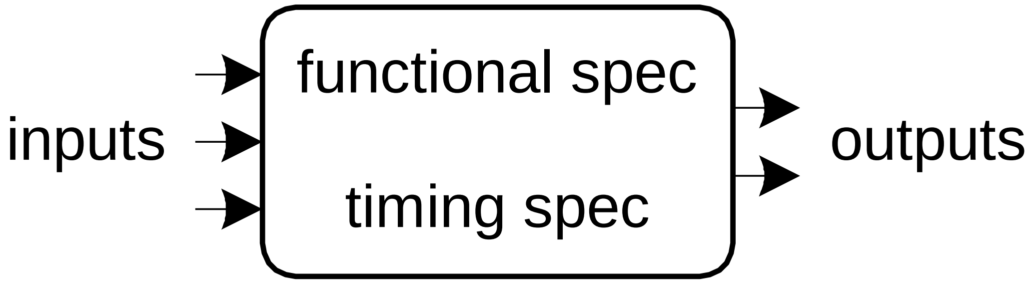
Types of Logic Circuits

- Combinational Logic
  - Memoryless
  - Outputs determined by current values of inputs
- Sequential Logic
  - Has memory
  - Outputs determined by previous and current values of inputs

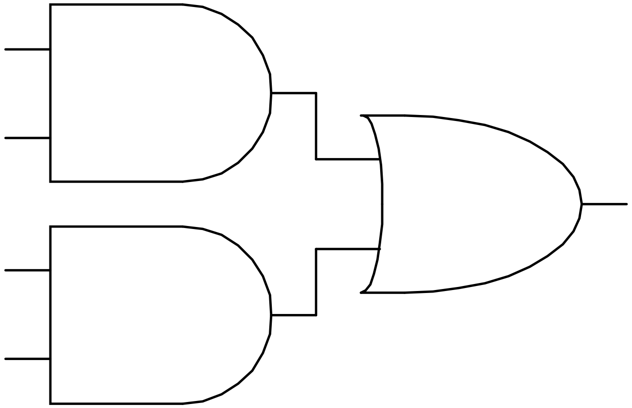


Combinational Logic Principles

- Outputs depend only on the inputs
- Rotary Channel Selector in an old fashioned TV
- Analysis starts with a logic diagram with a formal description to Truth Table and Logic Expression
- Synthesis – Starts with the Logic Expression back to Logic Diagram – Done by CAD Tools

Rules of Combinational Composition

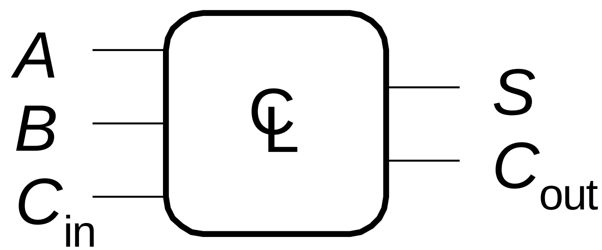
- Every circuit element is itself combinational
- Every node of the circuit is either designated as an input to the circuit or connects to exactly one output terminal of a circuit element
- The circuit contains no cyclic paths: every path through the circuit visits each circuit node at most once
- Example:



Boolean Equations

- Functional specification of outputs in terms of inputs
- Example:

$$S \quad = F(A, B, C_{in})$$
$$C_{out} = F(A, B, C_{in})$$



$$S = A \oplus B \oplus C_{in}$$
$$C_{out} = AB + AC_{in} + BC_{in}$$

Some Definitions

- Complement: variable with a bar over it
  $\bar{A}$, $\bar{B}$, $\bar{C}$
- Literal: variable or its complement
  A, $\bar{A}$, B, $\bar{B}$, C, $\bar{C}$
- Implicant: product of literals
  $AB\bar{C}$, $\bar{A}C$, BC
- Minterm: product that includes all input variables
  $AB\bar{C}$, $A\bar{B}\bar{C}$, ABC
- Maxterm: sum that includes all input variables
  $(A+\bar{B}+C)$, $(\bar{A}+\bar{B}+\bar{C})$, $(\bar{A}+B+C)$

Simplification of switching functions

- Simplify – why?
  - Switching functions map to switching circuits
  - Simpler function $\rightarrow$ simpler circuit
  - Reduce hardware complexity
  - Reduce size and increase speed by reducing number of gates

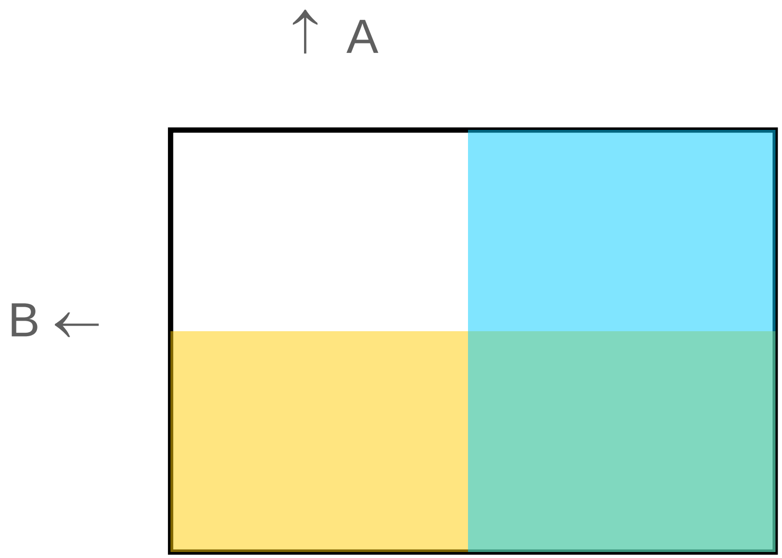
- Simplify – how?
  - Using the postulates
  - K-map

Simplification of switching functions

- Simplify – what?
  - SOP/POS form has products/sums and literals
    - **Literal: each appearance of a variable or its complement**
  - Minimize number of sums/products
    - Reduces total gate count
  - Minimize number of variables in each sum/product
    - Reduces number of inputs to each gate
    - PLDs have fixed # of inputs; only the number of terms need to be minimized there

Karnaugh maps

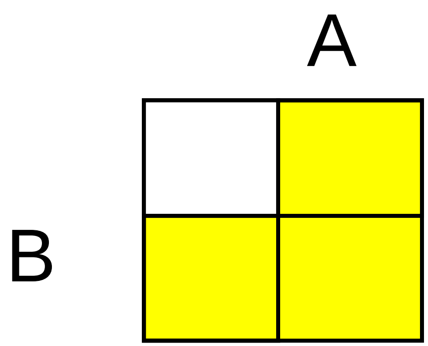
- Might start with rectangles initially and get the same result



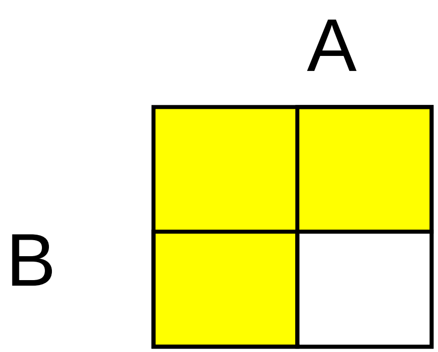
  - Each square of the K-map is 1 row of the TT

Karnaugh maps

- One to one correspondence between K-map squares and maxterms



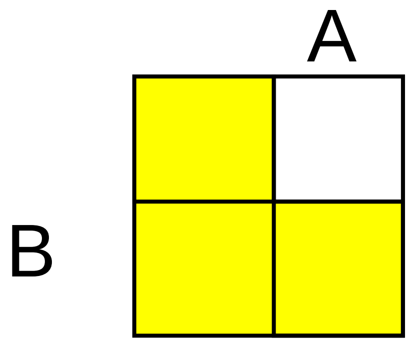
$$A+B \rightarrow M_0 = \overline{m_0} = \overline{\bar{A}\bar{B}}$$



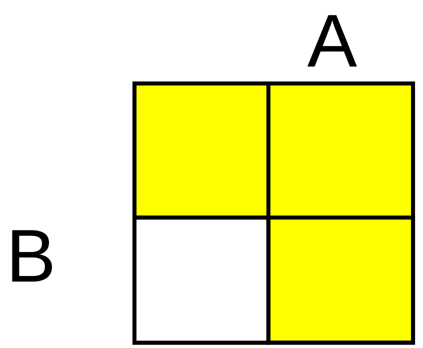
$$\bar{A}+\bar{B} \rightarrow M_3 = \overline{m_3} = \overline{AB}$$

Karnaugh maps

- One to one correspondence between K-map squares and maxterms



$$\overline{A}+B \rightarrow M_2 = \overline{m_2} = \overline{A\overline{B}}$$



$$A+\overline{B} \rightarrow M_1 = \overline{m_1} = \overline{\overline{A}B}$$

- There are 16 cells in a 4-variable (w, x, y, z) K-map.