EEE104 – Digital Electronics (I)

Lecture 8

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In This Session

- Combinational Logic
  - Basic Combinational Logic Circuits
  - Implementation
  - Universal NAND and NOR Gates
  - Using NAND and NOR Gates

Basic Combinational Logic Circuits

- A **combinational logic** circuit is one in which
  - Logic gates are connected together to implement a certain function (in contrast to *basic logic gates*).
  - There is no storage involved (in contrast to *sequential circuits*).
- Examples of combinational logic
  - Exclusive-OR gates
  - The AND-OR logic in an SOP implementation.

Basic Combinational Logic Circuits

Exclusive-OR Logic

- The output X is HIGH only when the two inputs are at **opposite** levels.

$$X = \overline{A}B + A\overline{B}$$
$$= A \oplus B$$

Exclusive-NOR Logic

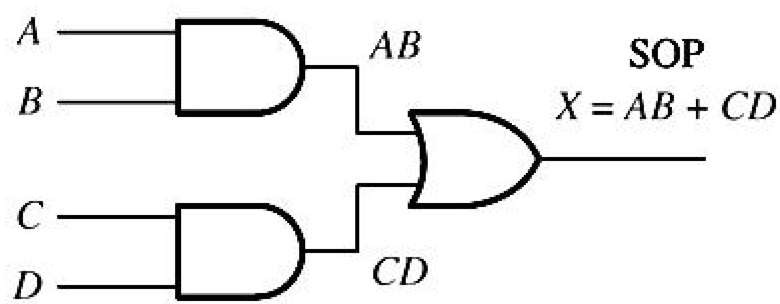
- The output of an Exclusive-OR circuit is inverted.
- The output X is HIGH only when the two inputs are at the **same** levels.

$$X = \overline{A\overline{B} + \overline{A}B} = \overline{(A\overline{B})}\,\overline{(\overline{A}B)} = (\overline{A} + B)(A + \overline{B}) = \overline{A}\,\overline{B} + AB$$

Basic Combinational Logic Circuits

AND-OR Logic

- The outputs of a number of AND gates connect to the inputs of an OR gate.
- It implements an SOP (sum-of-products) expression.



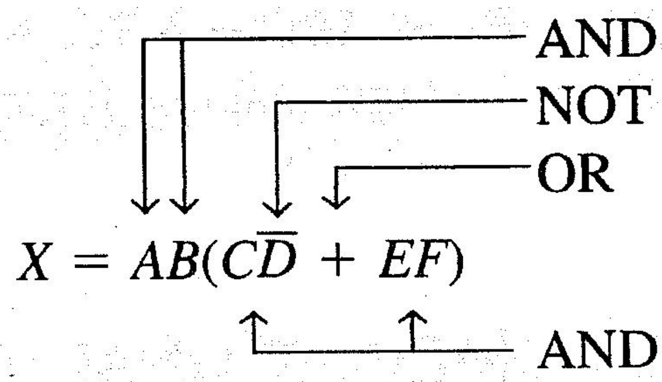
- An AND-OR-Invert logic implements a POS (product-of –sums) expression.

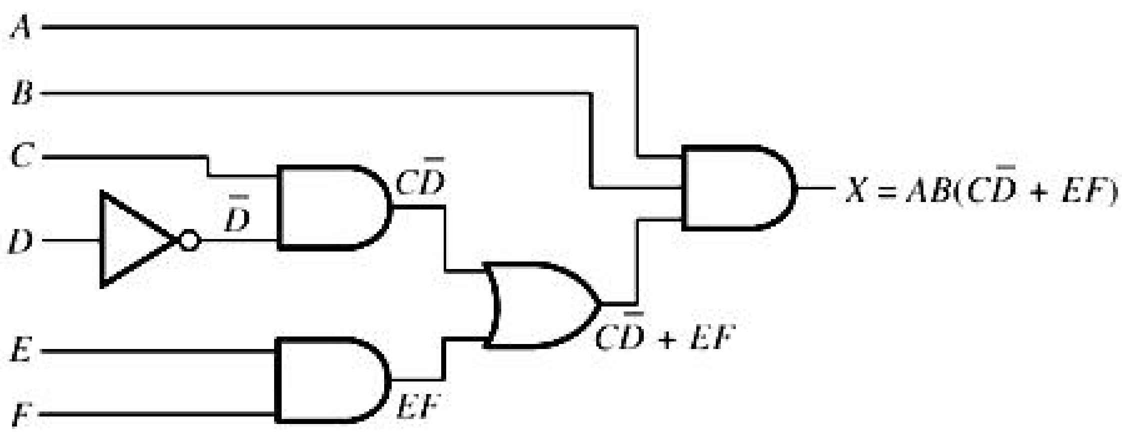
$$\overline{AB+CD} = \overline{AB}\,\overline{CD} = \left(\overline{A}+\overline{B}\right)\left(\overline{C}+\overline{D}\right)$$

Implementation

From a Boolean Expression to a Logic Circuit

$$X = AB(C\overline{D} + EF)$$





Universal NAND and NOR Gates

- The NAND and NOR gates are **universal** because they can be used to produce any of other logic functions

NAND gate

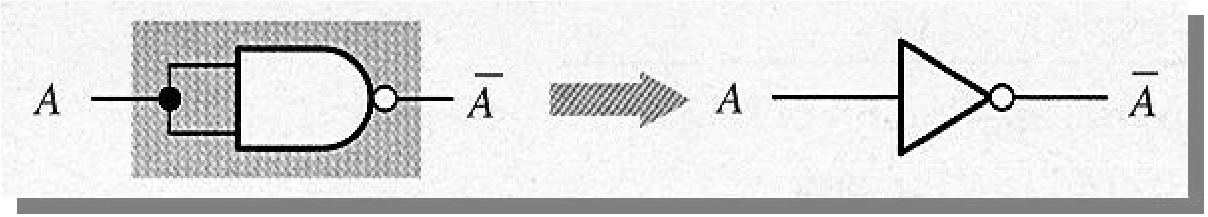
- NOT
- AND
- OR
- NOR

NOR gate

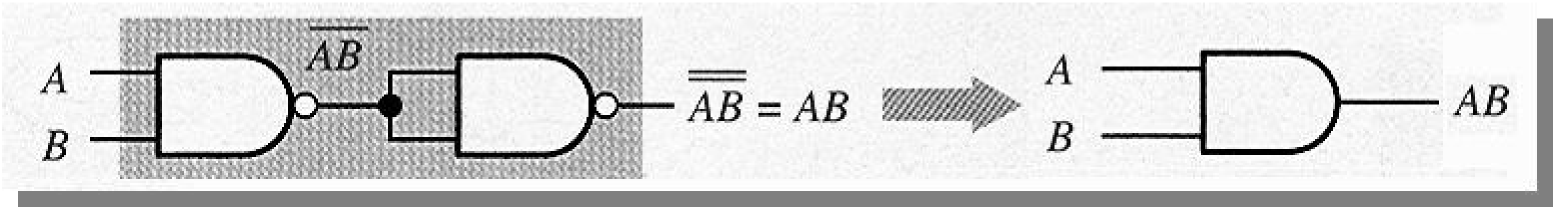
- NOT
- AND
- OR
- NAND

Universal NAND and NOR Gates

- NAND Gate as an Inverter

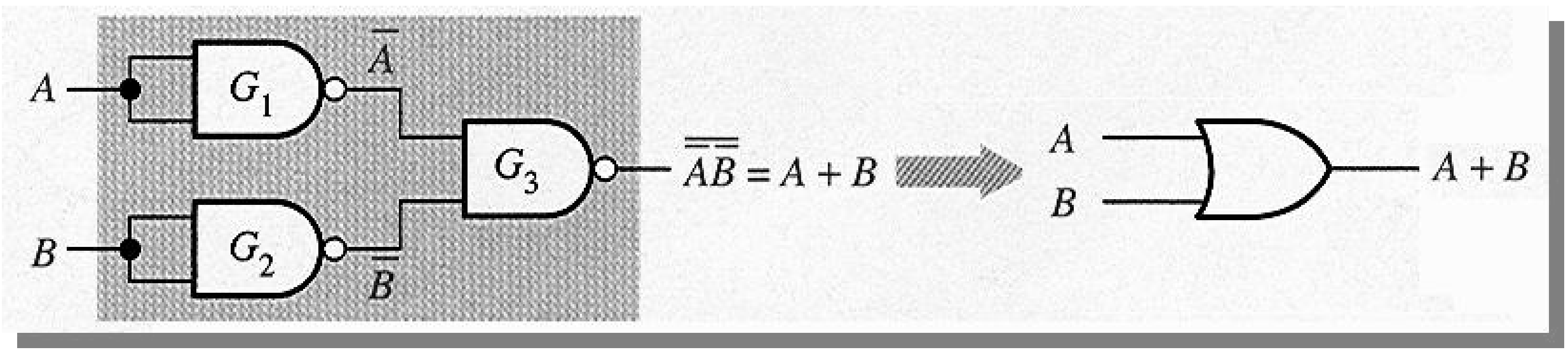


- Two NAND Gates as an AND Gate

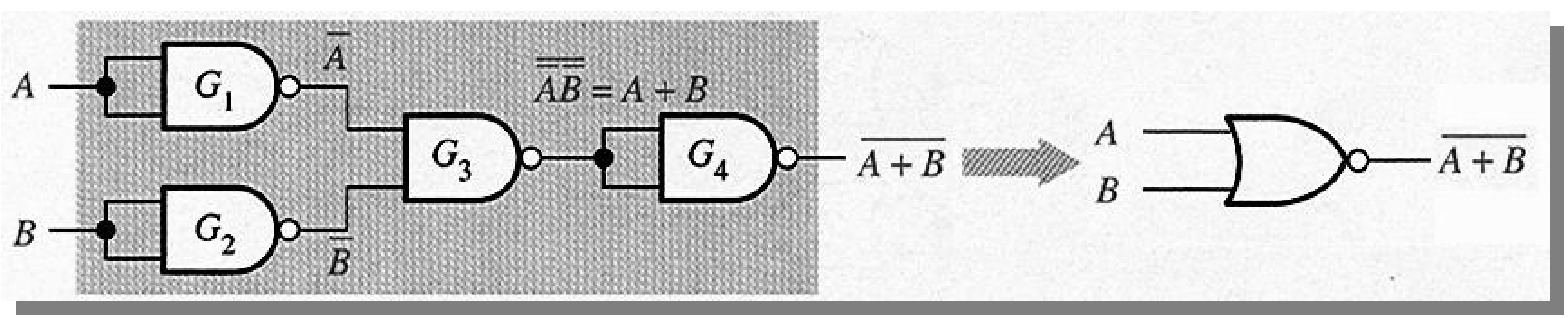


Universal NAND and NOR Gates

- Three NAND Gates as an OR Gate

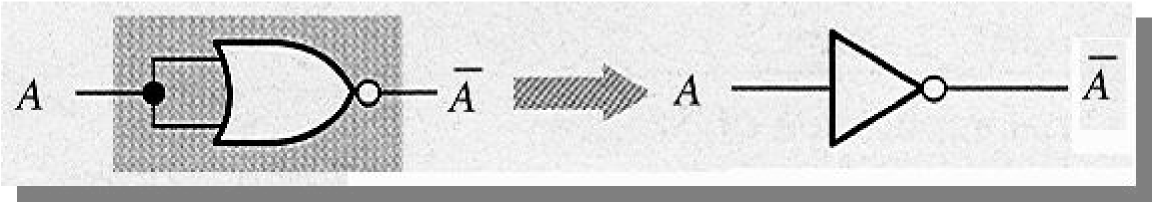


- Four NAND Gates as a NOR Gate

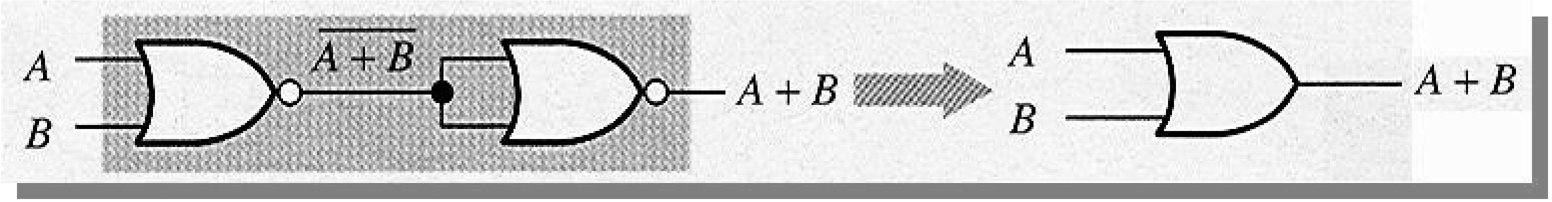


Universal NAND and NOR Gates

- NOR Gate as an Inverter

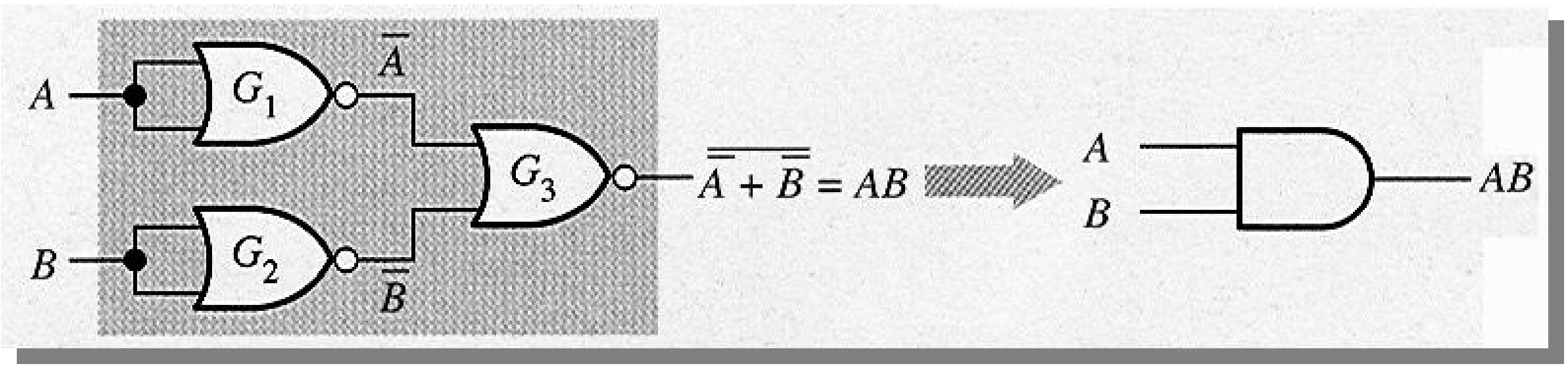


- Two NOR Gates as an OR Gate

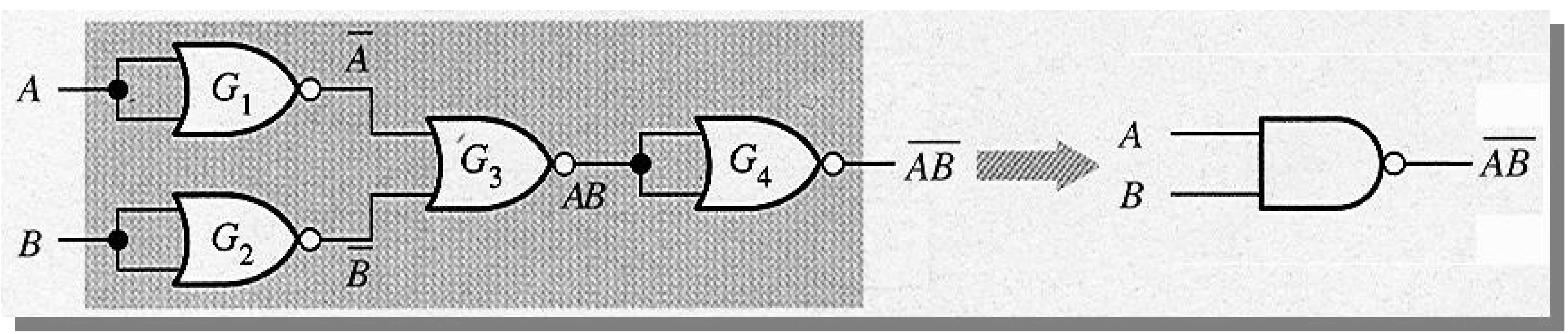


Universal NAND and NOR Gates

- Three NOR Gates as an AND Gate

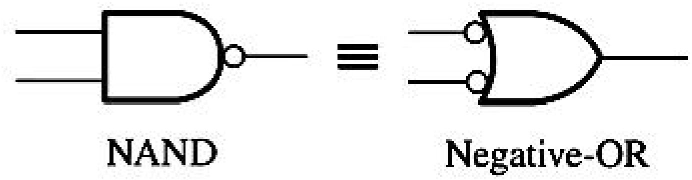


- Four NOR Gates as a NAND Gate

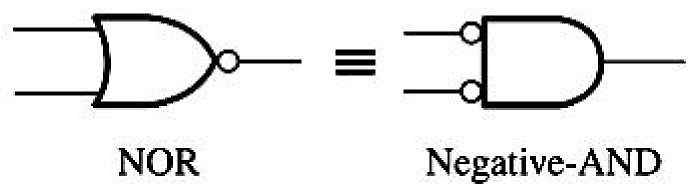


Using NAND and NOR Gates

- The **NAND** gate is equivalent to the **negative-OR** gate. (dual symbols)



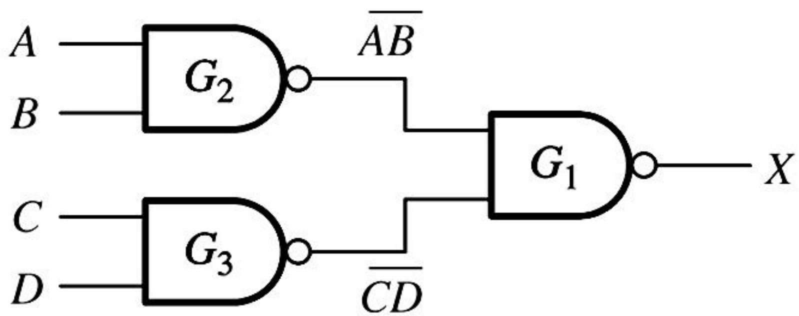
- The **NOR** gate is equivalent to the **negative-AND** gate. (dual symbols)



- To use the appropriate symbols will make “reading” a logic diagram easier.

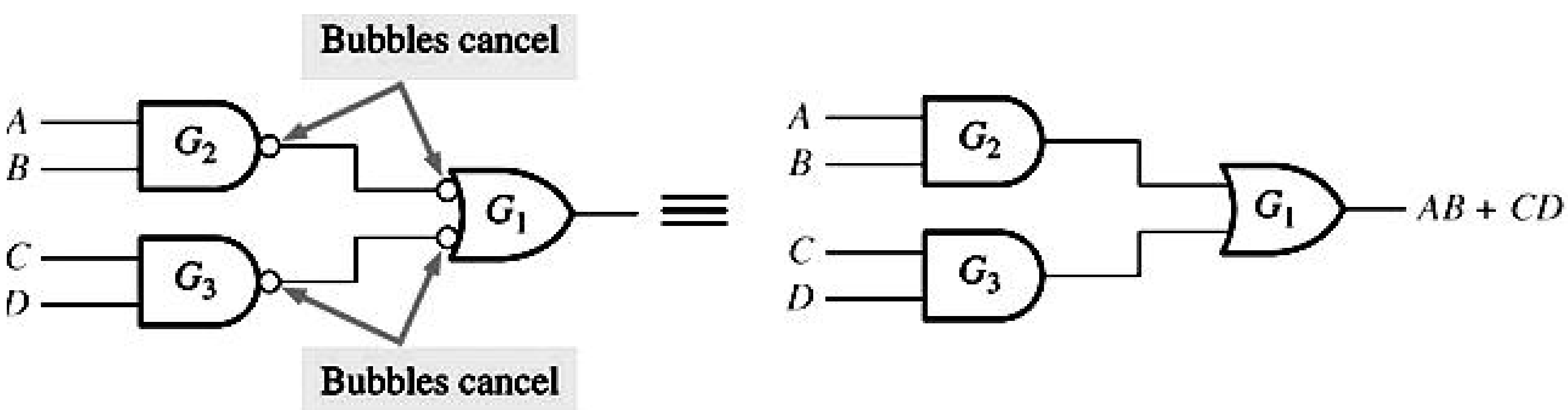
Using NAND and NOR Gates

- To read this logic diagram.



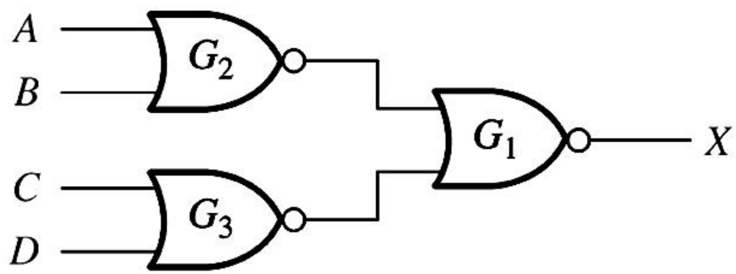
$$X = \overline{(\overline{AB})(\overline{CD})}$$
$$= \overline{\overline{AB + CD}} = AB + CD$$

- If a negative-OR symbol is used for G_1, the two bubbles (inversion) will cancel each other.



Using NAND and NOR Gates

- To read this logic diagram.



$$X = \overline{\overline{A+B} + \overline{C+D}}$$
$$= (\overline{\overline{A+B}})(\overline{\overline{C+D}})$$
$$= (A+B)(C+D)$$

- If a negative-AND symbol is used for G_1, the two bubbles (inversion) will cancel each other.