Lecture -3
Universal Gates

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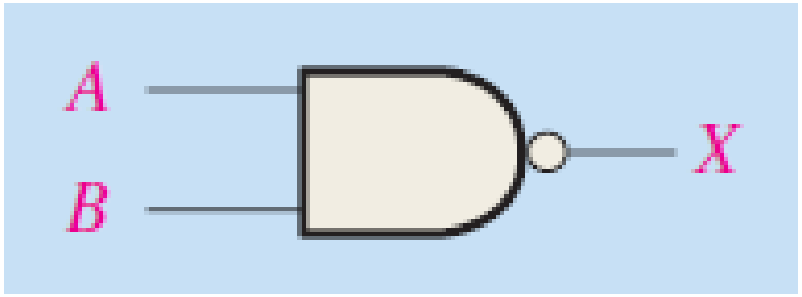
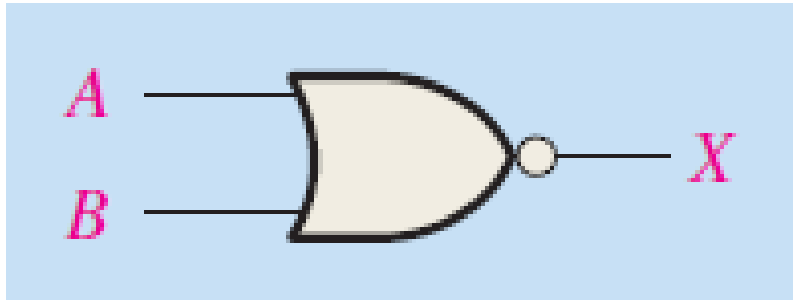
Universal Gates

- Although we can implement any circuit with AND/OR/NOT, we can also implement any circuit with only NAND or NOR gates.
- We might want to do this because of technology considerations, that is, these gates might be cheaper to implement in silicon or they might be the only type of gates we have available.
- Since we can always use only NAND or NOR gates, these gates are sometimes called universal gates.
- The "trick" (if you want to call it that) is to see that we can implement the three basic gates (AND, OR, NOT) in terms of NAND or NOR gates.



$$\mathbf{X = \overline{AB} = \overline{A} + \overline{B}}$$

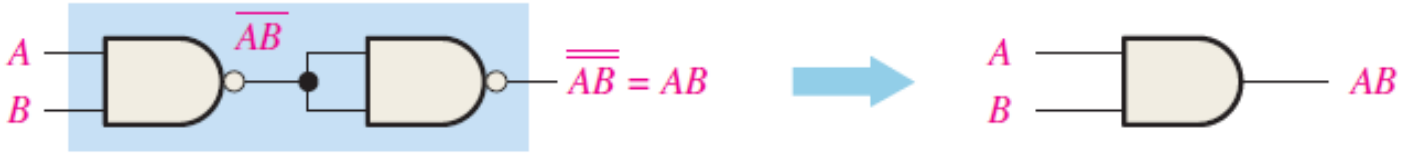


$$\mathbf{X = \overline{A + B} = \overline{A} \cdot \overline{B}}$$

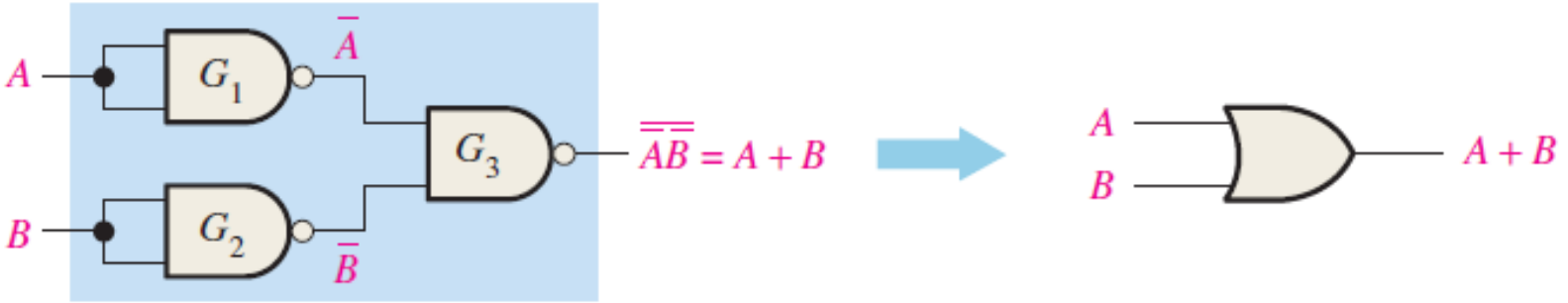
NAND Gate Implementation of Basic Gates

- NOT Gate

- AND Gate



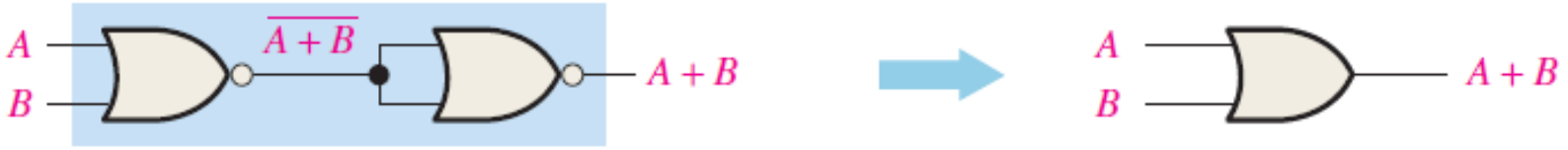
- OR Gate



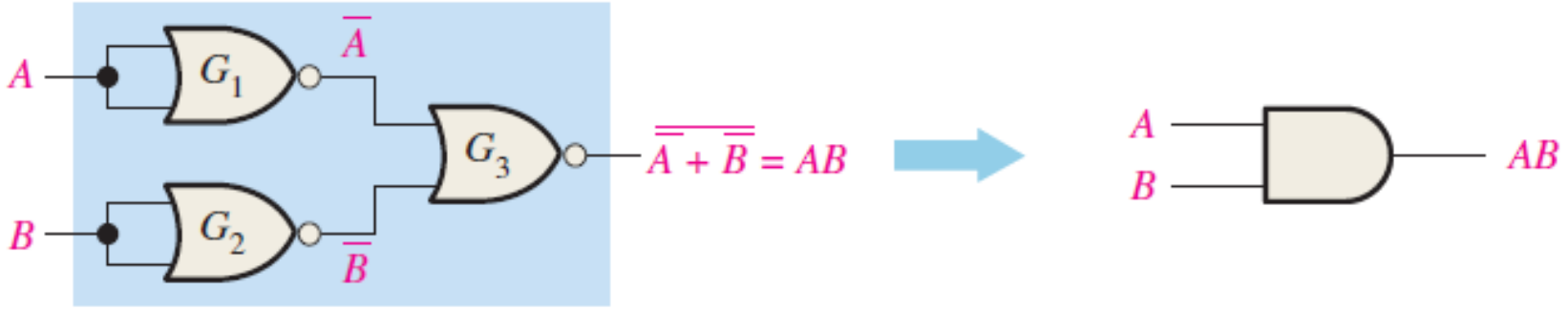
NOR Gate Implementation of Basic Gates

- NOT Gate

- OR Gate



- AND Gate



NAND Gate Implementation of Boolean Logic

- There are three basic tricks/ways to convert any Boolean Logic Circuit to its NAND equivalent:
  1. First implement the Boolean Logic with basic AND, OR and NOT gates and then replace the basic gates with its NAND equivalent.
  2. Convert the Boolean Logic expression to its NAND form using De Morgan's theorem and then implement with NAND gates directly.
  3. Bubble Pushing Technique.
- Implement the following Boolean expression with NAND logic:
  a) $F = \overline{AB} + CD$
  b) $F = \overline{\overline{AB}} + CD$
  c) $F = A(\overline{B + CD})$
  d) $F = C(\overline{A + BD})$
  e) $F = A\overline{B} + \overline{A}B$

- Implementation will be shown in class!!!!

NOR Gate Implementation of Boolean Logic

- There are three basic tricks/ways to convert any Boolean Logic Circuit to its NOR equivalent:
  1. First implement the Boolean Logic with basic AND, OR and NOT gates and then replace the basic gates with its NOR equivalent.
  2. Convert the Boolean Logic expression to its NOR form using De Morgan's theorem and then implement with NOR gates directly.
  3. Bubble Pushing Technique.
- Implement the following Boolean expression with NOR logic:
  a) $F = \overline{AB} + CD$
  b) $F = \overline{\overline{AB}} + CD$
  c) $F = A(\overline{B + CD})$
  d) $F = C(\overline{A + BD})$
  e) $F = A\overline{B} + \overline{A}B$

- Implementation will be shown in class!!!!

References

1. Thomas L. Floyd, “Digital Fundamentals” 11th edition, Prentice Hall – Pearson Education.

Thank You