Digital Electronics

Principles & Applications

Seventh Edition

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Chapter 3

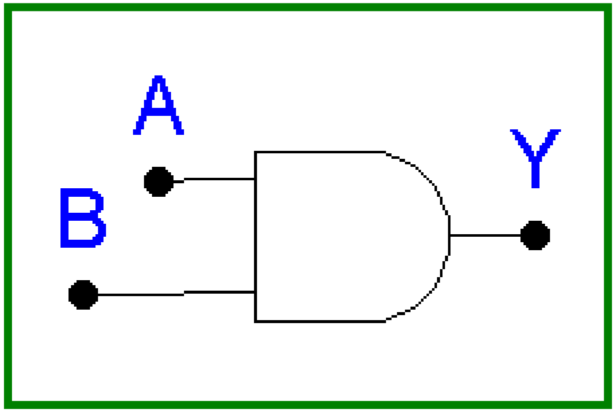
Logic Gates

INTRODUCTION

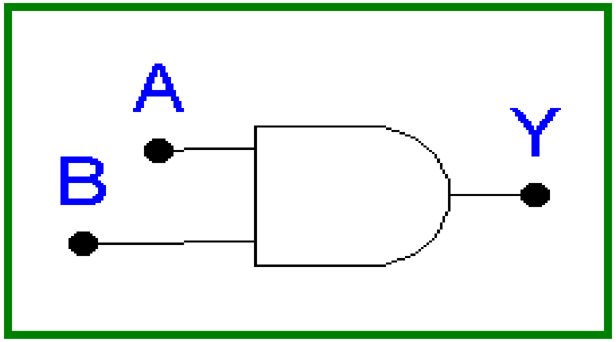
- The AND Gate
- The OR Gate
- The Inverter
- The NAND Gate
- The NOR Gate
- The XOR Gate
- The XNOR Gate
- NAND as Universal Gate
- Gates with More Than Two Inputs
- Using Inverters to Convert Gates
- TTL & CMOS Gates
- Troubleshooting Gating Circuits
- IEEE Logic Symbols
- Logic Functions using Software

The AND Gate

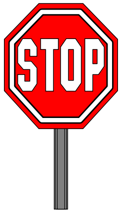
- **“All or Nothing Gate”**
- **Boolean Expression: A · B = Y**
- **Truth Table (*See next slide*)**



Truth Table - AND Gate



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

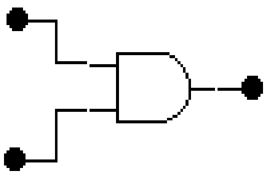


QUIZ

What is the output of the AND gate?

L

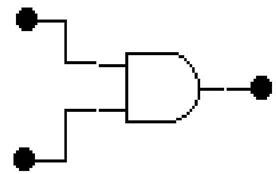
L



Low

H

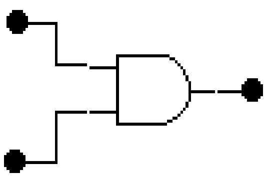
H



High

L

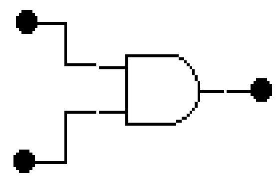
H



Low

H

L

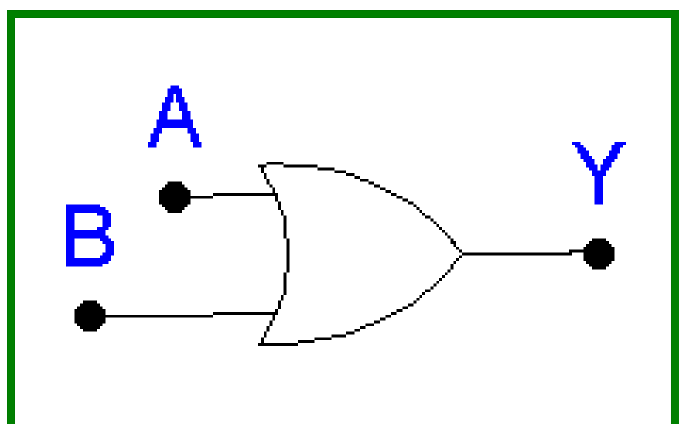


Low

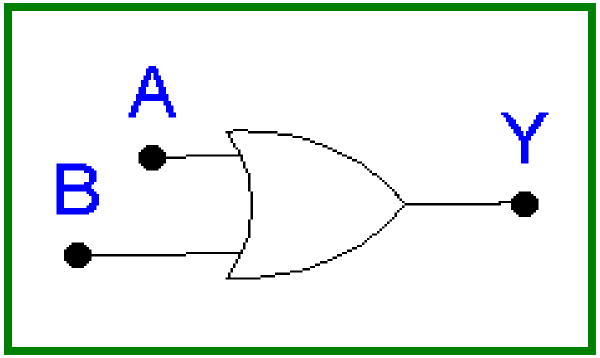
Unique Output: Output HIGH only when all inputs are HIGH.

The OR Gate

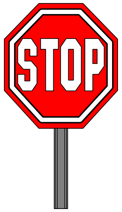
- “Any or All Gate”
- Boolean Expression: $A + B = Y$
- Truth Table (*See next slide)*



Truth Table - OR Gate

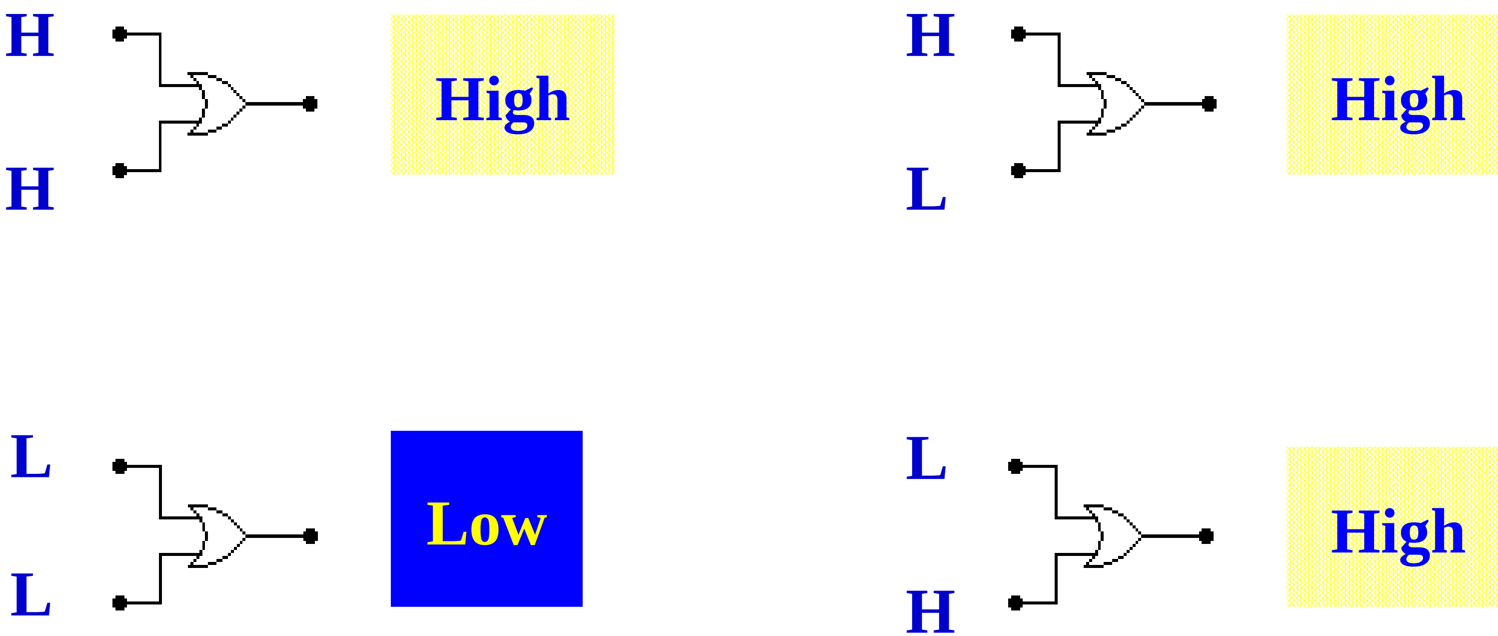


B	A	Y
0	0	0
0	1	1
1	0	1
1	1	1



QUIZ

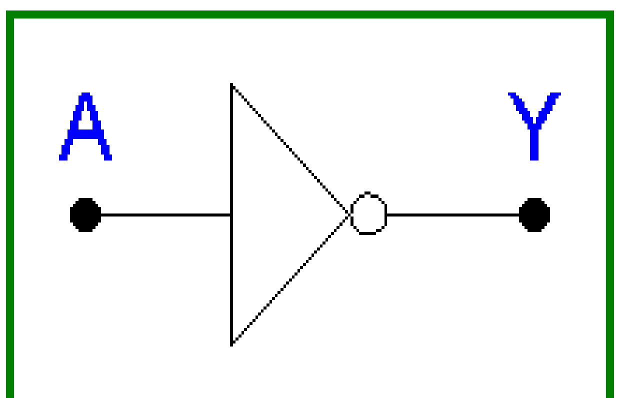
What is the output of the OR gate?

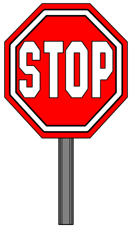


Unique Output: Output LOW only when all inputs are LOW.

The Inverter

- **NOT Circuit**
- **Gives output that is not the same as the input.**
- **Boolean Expression: $Y = \overline{A}$ or $Y = A'$**
- **Double inverting: $\overline{\overline{A}} = A$**
- **NOT gate inverts, or complements, or negates**





QUIZ

1. **If the input to an inverter is LOW, the output will be ___________.**

   HIGH

2. **If the input to an inverter is HIGH, the output will be ___________.**

   LOW

3. **A NOT gate is said to invert, to negate or to complement the input. (True or False)**

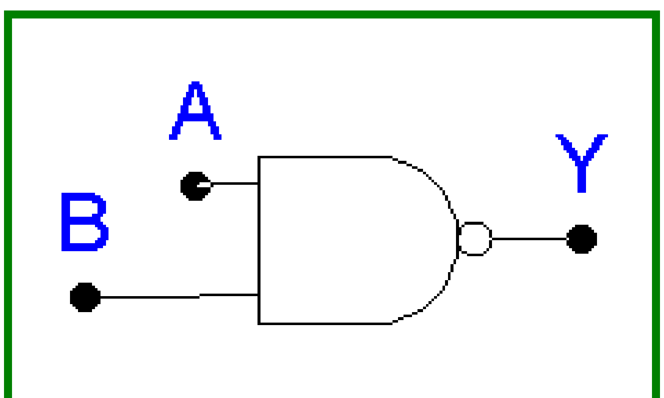
   True

4. **A NOT gate is also called commonly called a(n) ___________ (AND gate, inverter).**

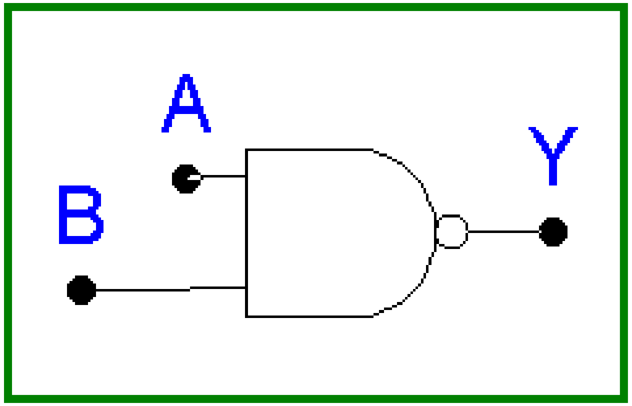
   inverter

The NAND Gate

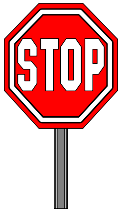
- **NOT AND or inverted AND function.**
- **Boolean Expression:** $\overline{A \cdot B} = Y$
  or $(A \cdot B)' = Y$
- **Truth Table (*See next slide)***



Truth Table - NAND Gate

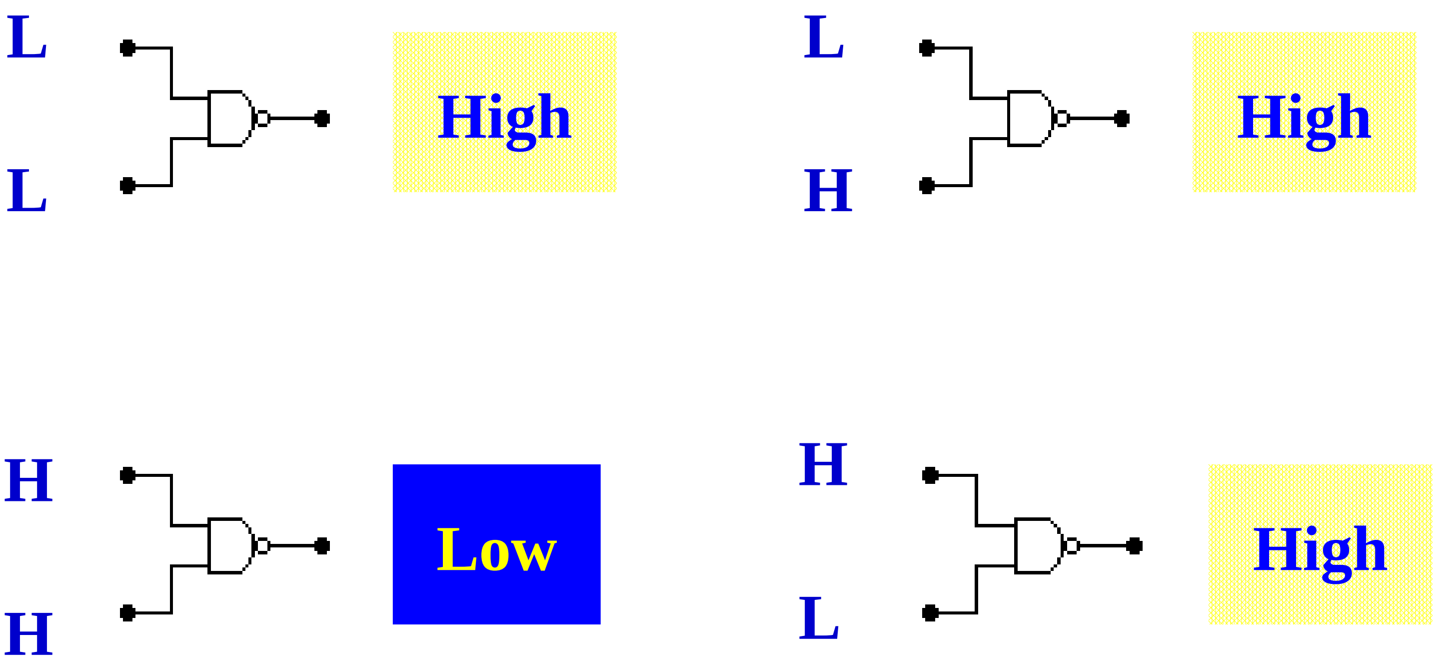


B	A	AND	NAND
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0



QUIZ

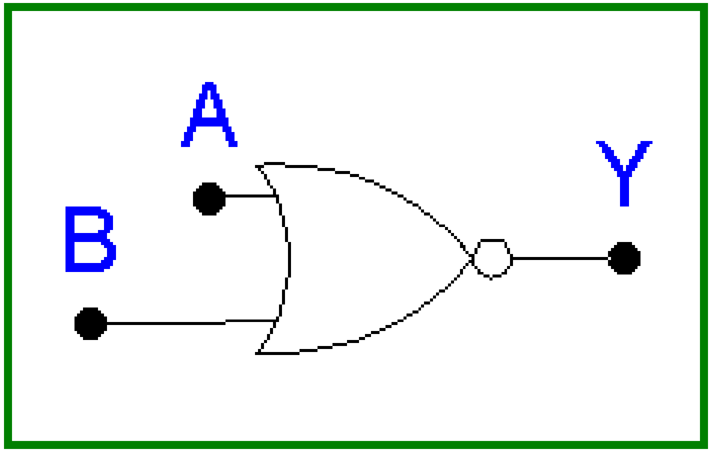
What is the output of the NAND gate?



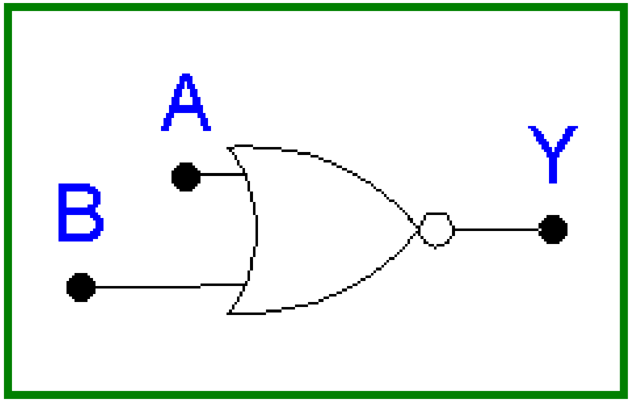
Unique Output: Output LOW only when all inputs are HIGH.

The NOR Gate

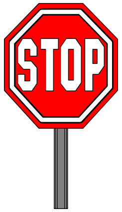
- **NOT OR or Inverted OR**
- **Boolean Expression:** $\overline{A + B} = Y$
  or $(A + B)' = Y$
- **Truth Table (*See next slide*)**



Truth Table - NOR Gate



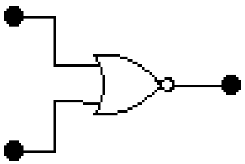
B	A	OR	NOR
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0



QUIZ

What is the output of the NOR gate?

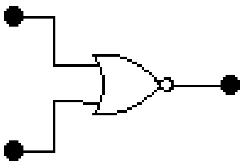
L



L

High

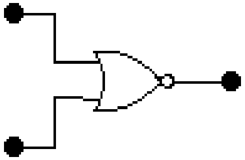
L



H

Low

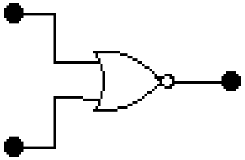
H



L

Low

H



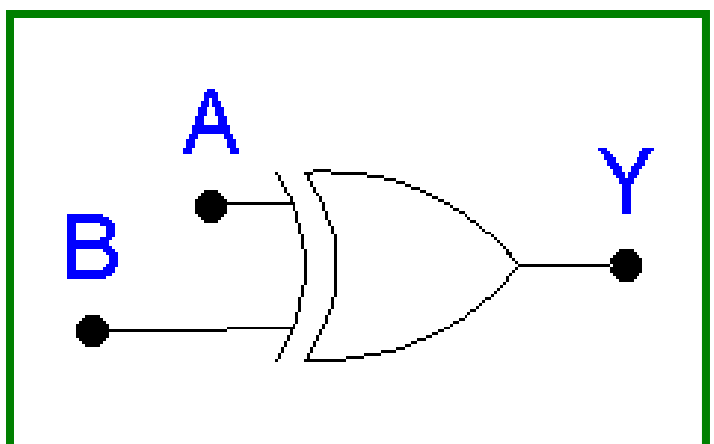
H

Low

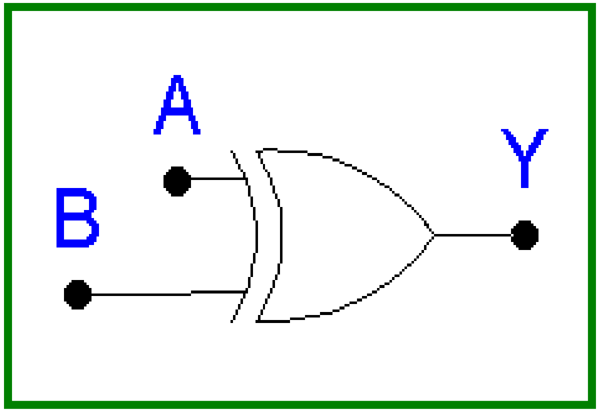
Unique Output: Output HIGH when all inputs are LOW.

The XOR Gate

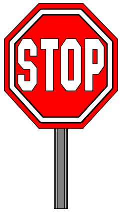
- **Known as "Exclusive OR" Gate**
- **"Anything but not all" Gate**
- **Boolean Expression:** $A \oplus B = Y$
- **Truth Table (*See next slide)***



Truth Table - XOR Gate



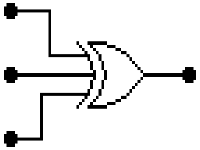
B	A	OR	XOR
0	0	0	0
0	1	1	1
1	0	1	1
1	1	1	0



QUIZ

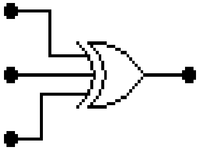
What is the output from the XOR gate?

L
L
L



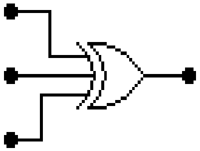
Low

L
L
H



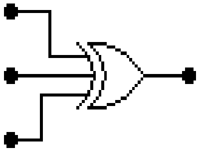
High

H
H
H



High

H
H
L



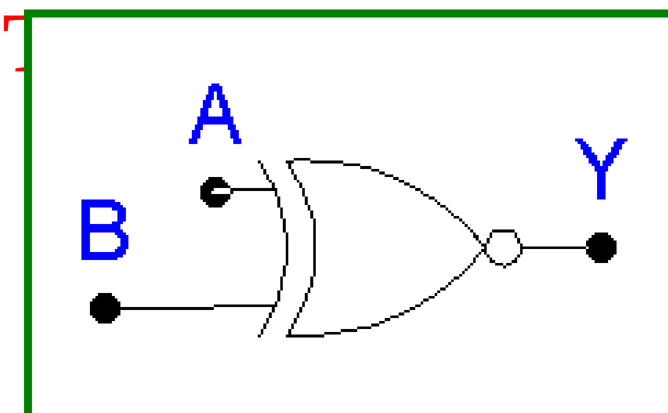
Low

XOR output is HIGH only when odd number of inputs are HIGH

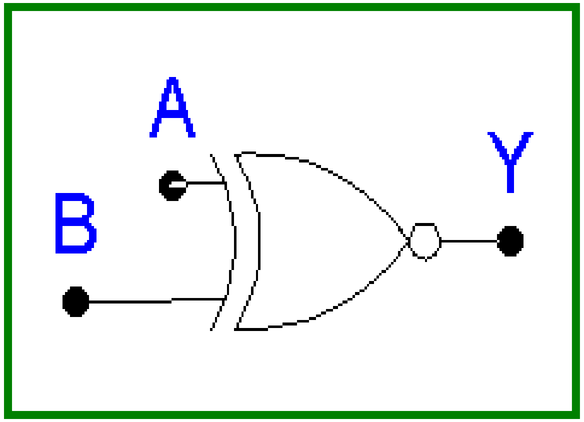
The XNOR Gate

- **Known as the Exclusive NOR Gate**
- **The Inverted XOR**
- **Boolean Expression:** $\overline{A \oplus B} = Y$

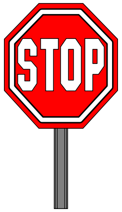
  or $(A \oplus B)' = Y$
- **Truth T** ***le)***



Truth Table - XNOR Gate



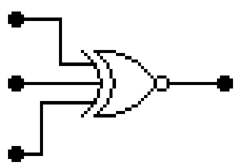
B	A	XOR	XNOR
0	0	0	1
0	1	1	0
1	0	1	0
1	1	0	1



QUIZ

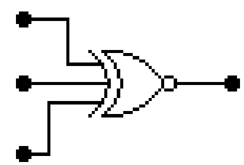
What is the output from this XNOR gate?

L
L
L



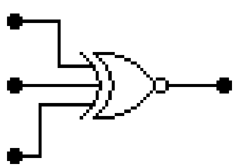
High

L
H
L



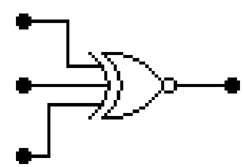
Low

H
H
L



High

H
H
H



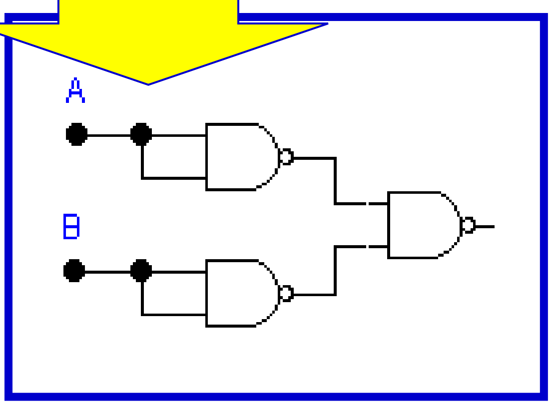
Low

XNOR output is HIGH only when odd number of inputs are LOW

The NAND as a Universal Gate

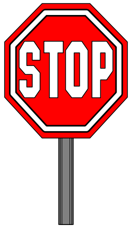
- **“Universal gate” can be used in combination to create any other logic function**

Shorting NAND inputs
Yields the NOT logic function



A + B

Equal to the
OR logic function



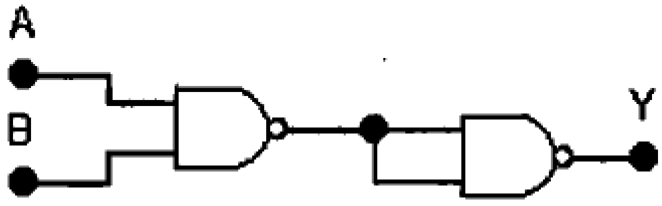
QUIZ

1. NAND gates can be wired together to convert to other logic functions (True or False).

True

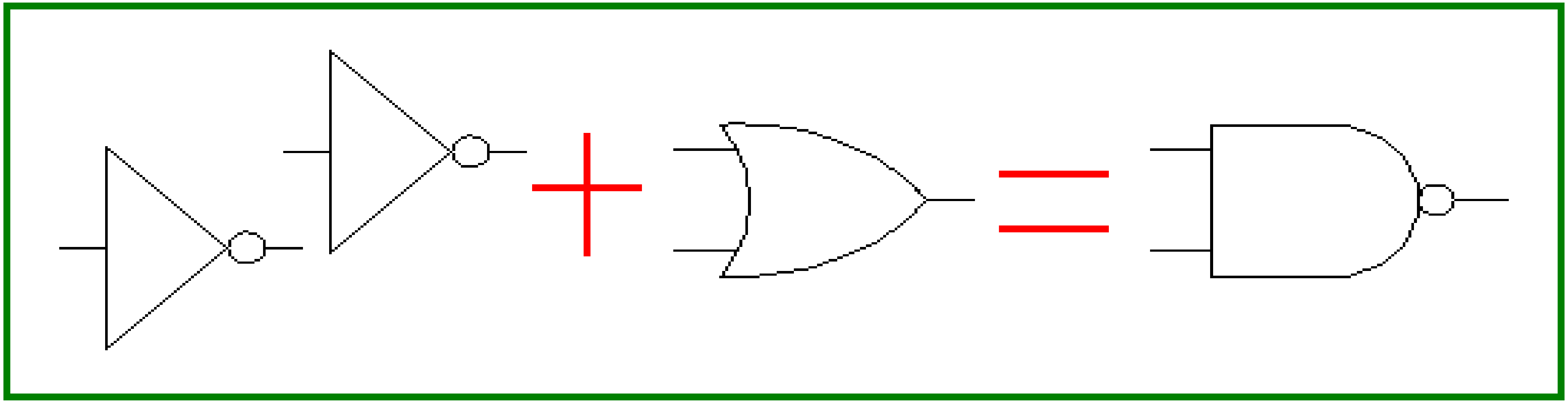
2. These two NAND gates wired together will produce the ______ (AND, XOR) logic function.

AND



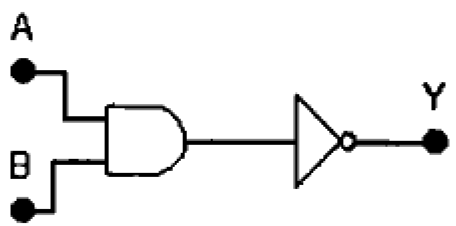
Using Inverters to Convert Gates

For example:

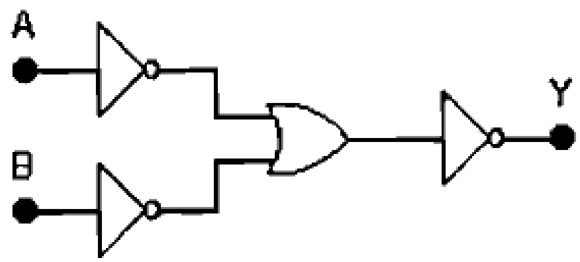


QUIZ

1. This combination of gates will generate the ______ (NAND, OR) logic function. **NAND**

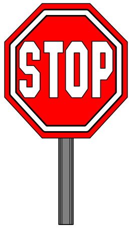


2. This combination of gates will generate the ______ (AND, OR) logic function. **AND**



Practical Logic Gates

- ICs - Integrated Circuit Form
- TTL Family of ICs
- CMOS Family of ICs
- TTL = Transistor-Transistor Logic
- CMOS = Complementary Metal Oxide Semiconductor



QUIZ

1. Practical logic gates (AND-, OR-, NAND-, NOT-gates) are packaged in ___________ form.

IC

2. Two popular families of ICs used to manufacture logic gate ICs are ___________.

TTL and CMOS

3. In digital electronics, TTL commonly refers to a family of ICs. TTL stands for ___________.

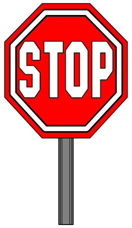
transistor-transistor logic

4. In digital electronics, logic gates are manufactured using either TTL or ___________ technology.

CMOS

Troubleshooting
Simple Gate Circuits

- **Logic probe - equipment used to test circuits**
- ***Feel*** **top of IC to determine if it is hot**
- ***Look*** **for broken connections, signs of excessive heat**
- ***Smell*** **for overheating**
- ***Check*** **power source**
- ***Trace*** **path of logic through circuit**



QUIZ

1. A simple hand-held instrument called a ___________ (logic probe, oscilloscope) can be used for troubleshooting simple logic gate circuits.

logic probe

2. The first three steps in troubleshooting are to use your senses to (1) feel the top of the ICs for overheating, (2) look for broken connections, and (3) ___________ for signs of overheating.

smell

3. The fourth step in troubleshooting is to use a logic probe to check the power sources. (True or False)

True