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VARIATIONS OF FUNDAMENTAL GATES

Now that you are familiar with fundamental logic gates, let's look at some variations of these gates that you may encounter.

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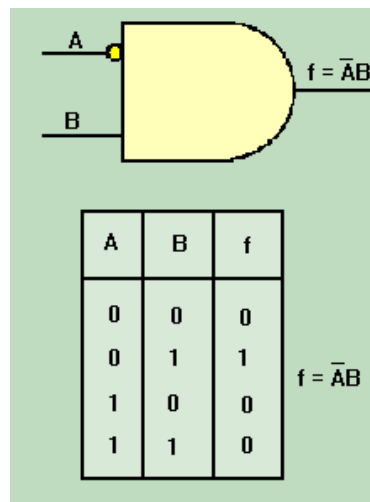
Up to now you have seen inverters used alone or on the output of AND and OR gates. Inverters may also be used on one or more of the inputs to the logic gates. Take a look at the examples as discussed in the following paragraphs.

AND/NAND GATE VARIATIONS

If we place an inverter on one input of a two-input AND gate, the output will be quite different from that of the standard AND gate.

In figure 2-17, we have placed an inverter on the A input. When A is HIGH, the inverter makes it a LOW going into the AND gate. In order for the output to be HIGH, A would have to be LOW while B is HIGH, as shown in the Truth Table. If the inverter were on the B input, the output expression would then be $f = AB$.

Figure 2-17. - AND gate with one inverted input.



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Now let's compare a NAND gate to an AND gate with an inverter on each input. Figure 2-18 shows these gates and the associated Truth Tables. With the NAND gate (view A), the output is HIGH when either or both inputs is/are LOW. The AND gate with inverters on each input (view B), produces a HIGH output only when both inputs are LOW. This comparison also points out the differences between the expressions $f = AB$ (A AND B quantity NOT) and $f = A \bar{B}$ (NOT A AND NOT B).

Now, look over the Truth Tables for figures 2-17, 2-18, and 2-19; look at how the outputs vary with inverters in different positions.

Figure 2-18. - Comparison of NAND gate and AND gate with inverted inputs: A. NAND gate; B. AND gate with inverters on each input.

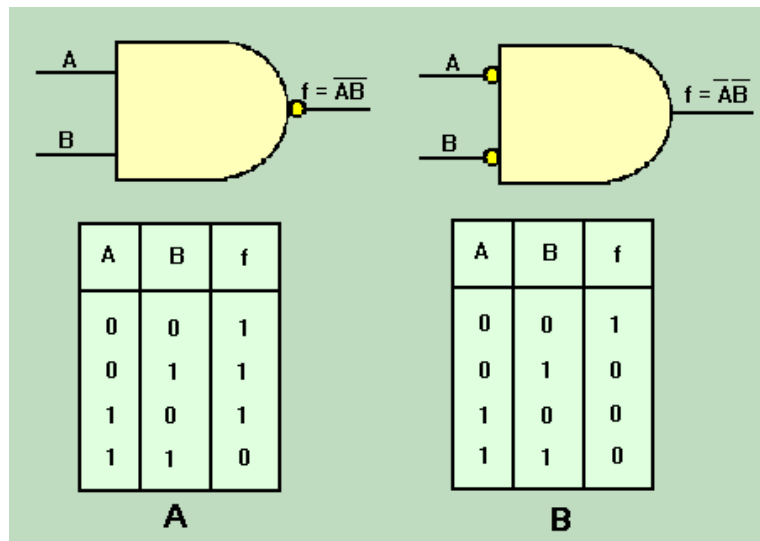
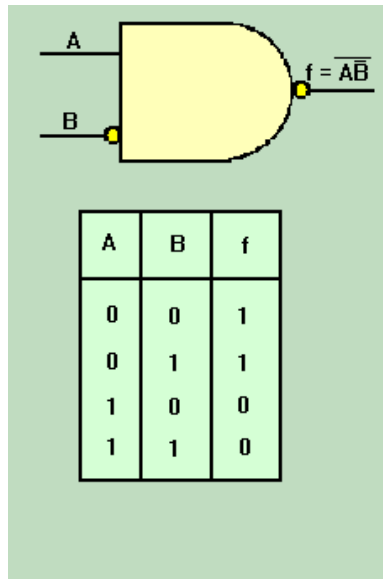


Figure 2-19. - NAND gate with one inverted input.



OR/NOR GATE VARIATIONS

The outputs of OR and NOR gates may also be changed with the use of inverters.

An OR gate with one input inverted is shown in figure 2-20. The output of this OR gate requires that A be LOW, B be HIGH, or both of these conditions existing at the same time in order to have a HIGH output. Since the A input is inverted, it must be LOW if B is LOW in order to produce a HIGH output. Therefore the output is $f = A+B$.

Figure 2-20. - OR gate with one inverted input.

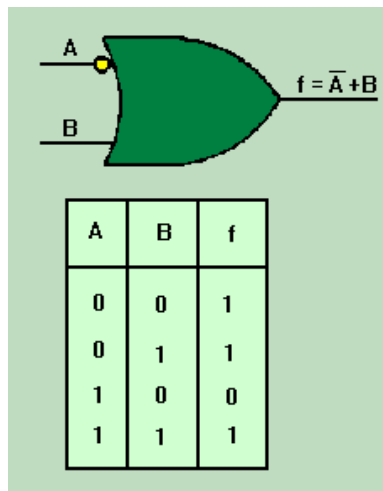
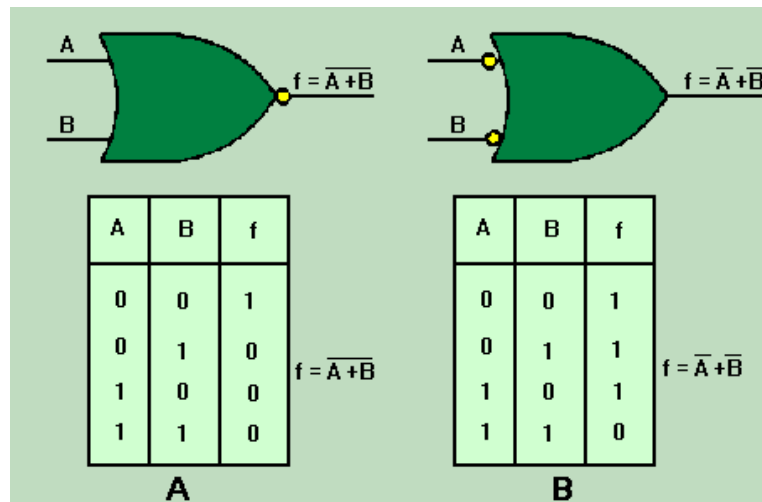


Figure 2-21 compares a NOR gate (view A), to an OR gate with inverters on both inputs (view B), and shows the respective Truth Tables. The NOR gate will produce a HIGH output only when both inputs are LOW. The OR gate with inverted inputs produces a HIGH output with all input combinations EXCEPT when both inputs are HIGH. This figure also illustrates the differences between the expressions $f = A + B$ (A OR B quantity NOT) and $f = \overline{A+B}$ (NOT A OR NOT B).

Figure 2-21. - Comparison of NOR gate and OR gate with inverted inputs: A. NOR gate; B. OR gate with inverters on both inputs.



As with the NAND gate, one or more inputs to NOR gates may be inverted. Figure 2-22 shows the result of inverting a NOR gate input. In this case, because of the inversion of the B input and the inversion of the output, the only time this gate will produce a HIGH output is when A is LOW and B is HIGH. The output Boolean expression for this gate is

$$f = \overline{A + \overline{B}}, \text{ spoken "A OR NOT B quantity NOT."}$$

Figure 2-22. - NOR gate with one inverted input.

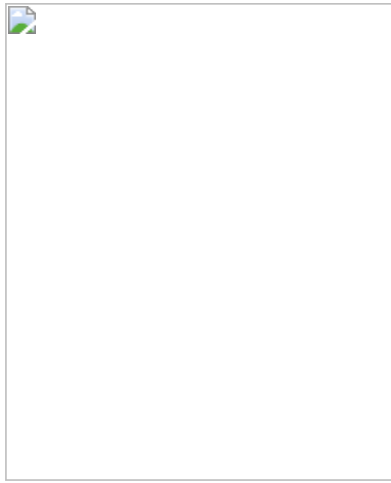
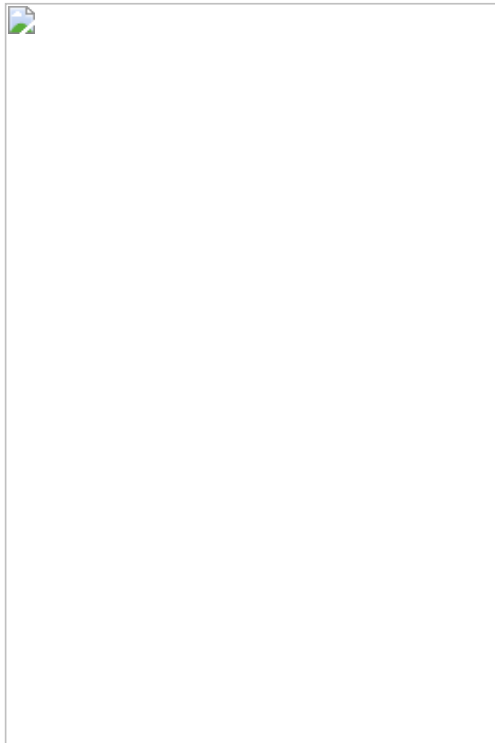


Table 2-4 illustrates AND, NOR, NAND, and OR gate combinations that produce the same output. You can see by the table that there is more than one way to achieve a desired output. Although the gates have only two inputs, the table can be extended to more than two inputs.

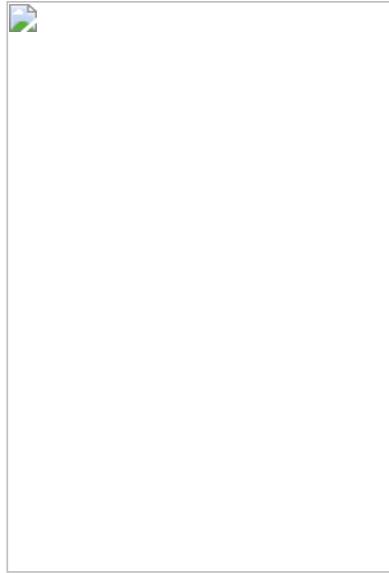
Table 2-4. - Equivalent AND and NOR, NAND and OR Gates



Q.24 What is the output Boolean expression for an AND gate with A and B as inputs when the B input is inverted? **Answer**

Q.25 What is the equivalent logic gate of a two-input NAND gate with both inputs inverted? **Answer**

Q.26 What is the output Boolean expression for the following gates? **Answer**



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