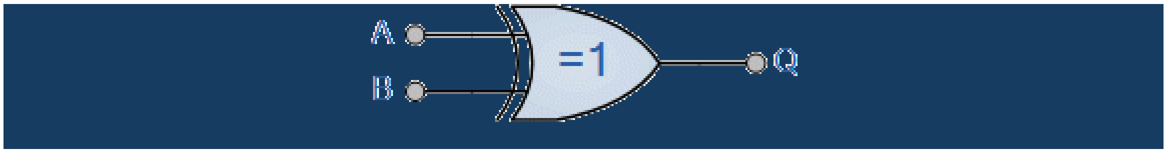


Exclusive-OR Gate Tutorial

The Exclusive-OR logic function is a very useful circuit that can be used in many different types of computational circuits

In the previous tutorials, we saw that by using the three principal gates, the AND Gate, the OR Gate and the NOT Gate, we can build many other types of logic gate functions, such as a NAND Gate and a NOR Gate or any other type of digital logic function we can imagine.

But there are two other types of digital logic gates which although they are not a basic gate in their own right as they are constructed by combining together other logic gates, their output Boolean function is important enough to be considered as complete logic gates. These two "hybrid" logic gates are called the **Exclusive-OR (Ex-OR) Gate** and its complement the **Exclusive-NOR (Ex-NOR) Gate**.

Previously, we saw that for a 2-input OR gate, if A = "1", **OR** B = "1", **OR BOTH** A + B = "1" then the output from the digital gate must also be at a logic level "1" and because of this, this type of logic gate is known as

an Inclusive-OR function. The logic gate gets its name from the fact that it *includes* the case of Q = "1" when both A and B = "1".

If however, an logic output "1" is obtained when **ONLY** A = "1" or

when **ONLY** B = "1" but **NOT** both together at the same time, giving the binary inputs of "01" or "10", then the output will be "1". This type of gate is known as an Exclusive-OR function or more commonly an Ex-

Or function for short. This is because its boolean

expression *excludes* the "**OR BOTH**" case of Q = "1" when both A and B

= "1".

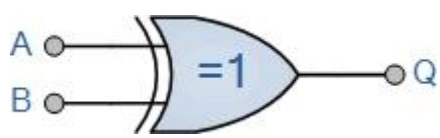
In other words the output of an Exclusive-OR gate **ONLY** goes "HIGH" when its two input terminals are at "**DIFFERENT**" logic levels with respect to each other.

An odd number of logic "1's" on its inputs gives a logic "1" at the output. These two inputs can be at logic level "1" or at logic level "0" giving us the Boolean expression of: $Q = (A \oplus B) = A.B + A.B$

The **Exclusive-OR Gate** function, or **Ex-OR** for short, is achieved by combining standard logic gates together to form more complex gate functions that are used extensively in building arithmetic logic circuits, computational logic comparators and error detection circuits.

The two-input "Exclusive-OR" gate is basically a modulo two adder, since it gives the sum of two binary numbers and as a result are more complex in design than other basic types of logic gate. The truth table, logic symbol and implementation of a 2-input Exclusive-OR gate is shown below.

The Digital Logic "Exclusive-OR" Gate 2-input Ex-OR Gate

<table>
<tr><th>Symbol</th><th colspan="3">Truth Table</th></tr>
<tr><td rowspan="5">

2-input Ex-OR Gate</td><td>B</td><td>A</td><td>Q</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
<tr><td>Boolean Expression Q = A ⊕ B</td><td colspan="3">A OR B but NOT BOTH gives Q</td></tr>
</table>

Giving the Boolean expression of: Q = AB + AB

The truth table above shows that the output of an Exclusive-OR gate ONLY goes "HIGH" when both of its two input terminals are at "DIFFERENT" logic levels with respect to each other. If these two inputs, A and B are both at logic level "1" or both at logic level "0" the output is a "0" making the gate an "odd but not the even gate". In other words, the output is "1" when there are an odd number of 1's in the inputs.

This ability of the *Exclusive-OR gate* to compare two logic levels and produce an output value dependent upon the input condition is very useful in computational logic circuits as it gives us the following Boolean expression of:

$$Q = (A \oplus B) = A.B + A.B$$