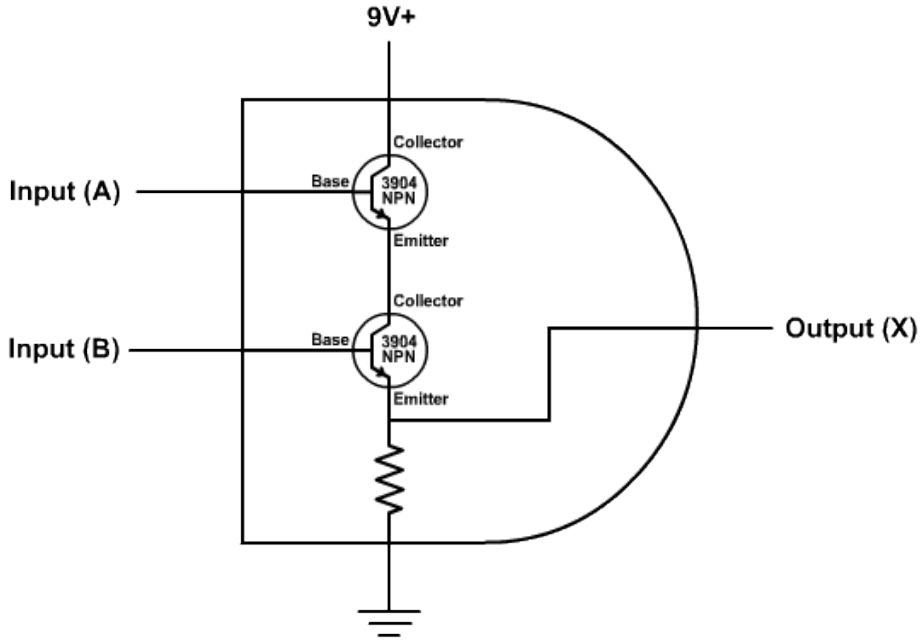
Lesson 3: How Logic Gates Work

Basic circuit components, such as resistors, capacitors and transistors are known as **discreet** components, since they are the basic building blocks of all circuits.

On the other hand, components such as logic gates are known as **integrated** components, since they are made up of logical arrangements of discreet components.

For example, the inside of an AND gate contains many discreet components. The most important of these (in terms of how the gate functions) are two NPN transistors, arranged in sequence as follows:



As the diagram indicates, the gate must receive electricity from a power source, and must also contain a ground, thus creating a complete circuit.

An NPN transistor's base is normally open, preventing current from flowing from the collector to the emitter. When either input A or B has current, the base closes, and allows current to flow from the collector to the emitter. However, since the transistors are arranged in a sequence, inputs A and B must *both* provide current to produce an output current (X).

Therefore, output (X) occurs only when inputs A and B have current.

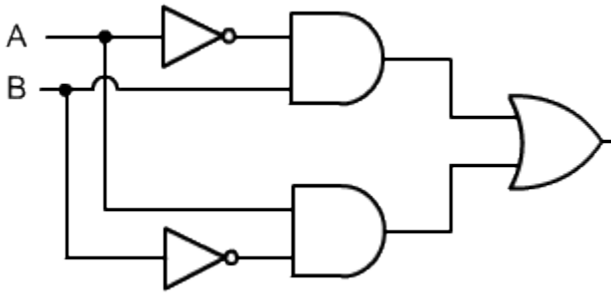
A similar internal arrangements exists for the OR gate, except that the transistors are arranged in parallel, rather than sequential fashion.

The NOT, NAND and NOR gates use reverse (inverted) logic. As a result, their internal arrangements make use of the PNP transistor, which is normally closed, and opens when current is applied to the base.

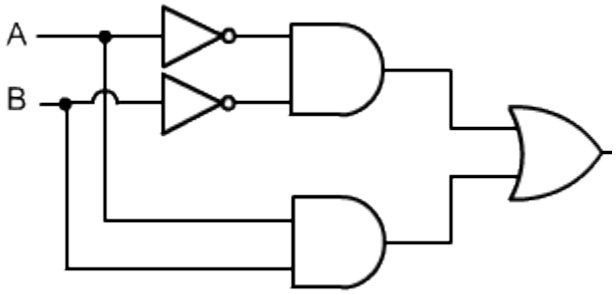
The XOR and XNOR are not actually unique designs; instead, they use certain combinations of the AND, OR and NOT gates.

For example,

an **XOR** can be represented as:



an **XNOR** can be represented as:



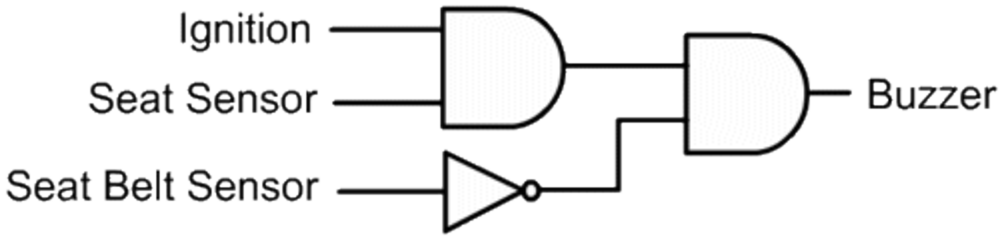
Applications

Simple logic circuits can be used for many different applications in everyday life.

For example, a car's seatbelt alarm will only sound when the following 3 events are true:

- the seatbelt is not fastened
- the driver is sitting in the seat
- the car's ignition is on

The logic circuit needed to achieve this is shown below:



To see if this circuit achieves its desired output, a truth table can be used to trace the output for each possible input. In each row, a 0 represents "Off", and a 1 represents "On"

Ignition	Seat Sensor	Seat Belt Sensor	Buzzer
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0