Consider a logic gate realized electronically.
- Each I/P and O/P will have one of two possible voltage levels $V_1$ or $V_2$, where, let us assume, $V_2 > V_1$.
- Refer to these two voltage levels as H (high) and L (low), respectively.
- Let us take the example of a 2-I/P, 1-O/P gate.

Positive & Negative Logic

In order to determine the function of this gate, we must assign logic values to the voltage levels.
Definitions

Positive Logic - The higher voltage = 0
Negative Logic - The higher voltage = 1

Logic value  |  Signal value  |  Logic value  |  Signal value
---|---|---|---
1  |  H  |  0  |  L
0  |  L  |  1  |  H

(a) Positive logic  (b) Negative logic

The terms positive and negative are somewhat misleading since both signal (voltage) values may be positive or both may be negative.

It is not the signal polarity that determines the type of logic, but rather the assignment of logic values according to the relative amplitudes of the signals.

<table>
<thead>
<tr>
<th>IC family type</th>
<th>Voltage supply (V)</th>
<th>High-level voltage (V)</th>
<th>Low-level voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTL</td>
<td>VCC = 5</td>
<td>2.4 - 5</td>
<td>0.4 - 0.2</td>
</tr>
<tr>
<td>ECL</td>
<td>VEE = -5.2</td>
<td>-0.95 - 0.7</td>
<td>-1.9 - 1.6</td>
</tr>
<tr>
<td>CMOS</td>
<td>VDD = 3 - 10</td>
<td></td>
<td>0 - 0.5</td>
</tr>
</tbody>
</table>

IC – Integrated Circuit
TTL - Transistor-Transistor Logic
ECL -Emitter Coupled Logic
CMOS - Complementary Metal Oxide Semiconductor Logic

Positive & Negative Logic

Therefore the truth tables become:

+VE logic

\[
\begin{array}{ccc}
E_1 & E_2 & E_0 \\
\hline
& & \\
& & \\
& & \\
& & \\
\end{array}
\]

-VE logic

\[
\begin{array}{ccc}
E_1 & E_2 & E_0 \\
\hline
& & \\
& & \\
& & \\
& & \\
\end{array}
\]

\[E_g = E_g^D\]

i.e. the function realized for negative logic is the dual of the function realized using positive logic.

Negative Logic Theorem: A combinational network which realizes a function \(F\) when variables are defined using positive logic will realize the dual function \(F^D\) when the variables are defined using negative logic.

- Independent of the logic type, for a given set of I/P voltages, the O/P voltage(s) is the same — only the logical interpretation differs.
A diode is a two-terminal device that acts as a switch; it permits current to flow readily in one direction but it tends to prevent the flow of current in the other direction.

The direction of "easy" current flow is indicated by the arrowhead in the symbol:

(a) symbol         (b) i-v characteristic

An ideal diode
A real diode

In a semiconductor diode, a few tenths of a volt (0.3V for Ge, 0.7V for Si) of forward bias is required for appreciable current flow.

The combination of an ideal diode and a voltage source $V_F = 0.7$ is suitable for the analysis of logic circuits using silicon diodes.

Consider the application of 0 & 5V to the inputs A & B:

If we choose positive logic, the truth table is:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>O/P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>L</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>H</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>L</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>H</td>
</tr>
</tbody>
</table>

Creating Logical Circuits: Diode Gates
but if we choose negative logic:

now the truth table becomes:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>O/P</th>
</tr>
</thead>
<tbody>
<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>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

The graphic symbol for a negative logic OR gate is shown in the figure above. The small triangles on the I/P & O/P leads designate a polarity indicator. The presence of a polarity indicator on a lead or terminal indicates that negative logic is assigned to the terminal. Thus, the same physical gate can function either as a positive logic AND or as a negative-logic OR.

The conversion from positive logic to negative logic is an operation that changes 1's to 0's to 1's in both I/P & O/P of a gate. Since this operation produces the dual of a function, the change of all terminals from one logic-type to the other results in taking the dual of the function.

Creating Logical Circuits: Diode Gates

Problem
determine the operation of the following diode gate, and what logic function it performs under positive logic and negative logic:
Creating Logical Circuits: Diode Gates

IC data sheets define digital functions not in terms of logic-1 or logic-0, but rather in terms of H and L levels.

It is up to the user to decide on a positive or negative logic assignment. Note, however, that the data sheet circuits are usually shown with their positive-logic graphic symbols.