

## Introduction

This paper refers to the input and output levels as High (H) and Low (L) in truth tables (table of combinations) rather than 1 (one) and 0 (zero). The use of H and L removes some of the confusion that may arise from the use of 1 and 0.

## Logic Symbols

In the following list of logic symbols, explanations accompany the graphic representations.

The symbol shown below is used to represent the AND function.



The AND output is Active if and only if all the inputs are Active.

The symbol shown below is used to represent the INCLUSIVE OR function.



The OR output is Active if and only if one or more of the inputs is Active.

The EXCLUSIVE OR output is active if one and only one input is active.



The above extracts show the symbols for the AND, OR and Exclusive OR gates.

It should be noted that all these gates are defined in terms of active and inactive.

A basic principle of these symbols is the use of active and inactive, instead of 1 and 0, and whether the active conditions is a high or low is specified by the use of a "State Indicator" as defined below.

### 1 State Indicator.

A small circle may be placed at the inputs or outputs of a logic symbol.

This small circle must never be drawn by itself on a diagram.

1.1 A small circle(s) at the input(s) to any element (logical or non-logical) indicates that the low (L) (or low going) input signal activates the function. Conversely, the absence of a small circle indicates that the high (H) (or high going) input signal activates the function.

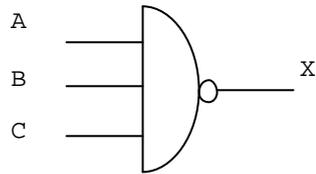
1.2 A small circle at the symbol output indicates that the output terminal of the activated function is low (L).

Hence the basic shape is defined in terms of actives. The "State Indicator"

indicates whether an active is a high or a low, as illustrated in the following examples.

1.3 The symbol shown below represents one version of the NAND function.

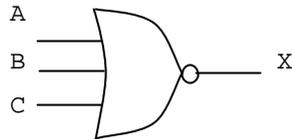
The output is low if and only if all the inputs are high.



Input			Output
A	B	C	X
L	L	L	H
L	L	H	H
L	H	L	H
L	H	H	H
H	L	L	H
H	L	H	H
H	H	L	H
H	H	H	L

1.4 The symbol shown below represents one version of the INCLUSIVE OR function.

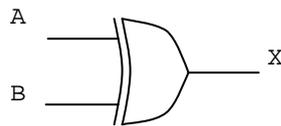
The output is low if one or more of the inputs are high.



Input			Output
A	B	C	X
L	L	L	H
L	L	H	L
L	H	L	L
L	H	H	L
H	L	L	L
H	L	H	L
H	H	L	L
H	H	H	L

1.5 The symbol shown below represents one version of the EXCLUSIVE OR function.

The output is high if one the inputs is high and the other is low.



Input		Output
A	B	X
L	L	L
L	H	H
H	L	H
H	H	L

## 2. Duality of Gates

Any gate - AND, OR, NAND or NOR can be used to perform the AND or OR function depending upon how its inputs and output are defined.

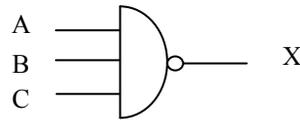
For example, refer to the truth table of the NAND gate in section 1.3 above.

It can be used as an AND gate if the inputs are defined as Active High & the output is defined as Active Low.

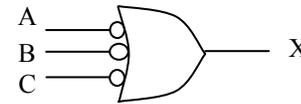
Alternatively, it can be used as an OR gate if the inputs are defined as Active Low & the output is defined as Active High.

For more examples, refer to the Examples of Gate Duality in section 3 below.

### 3. Examples of Gate Duality



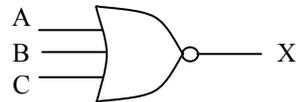
NAND used as an AND gate (with active low output)



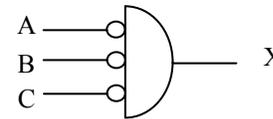
NAND used as an OR gate (with active low inputs)

Note that, although both of these gates are physically the same and are sold as “NAND” gates, their logical function depends upon how you define the inputs and outputs, ie. Active High or Active Low

The same applies to gates sold as “NOR” gates

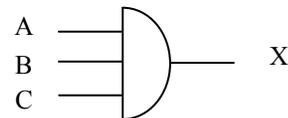


NOR gate used as an OR gate (with active low output)

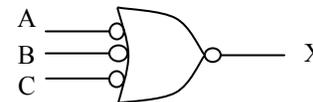


NOR gate used as an AND gate (with active low inputs)

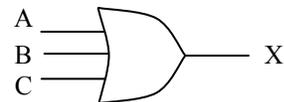
Also devices sold as an “AND gate” can be used as AND or OR (with active low inputs and outputs) and devices sold as an “OR gate” can be used as an OR or an AND (with active low inputs and outputs)



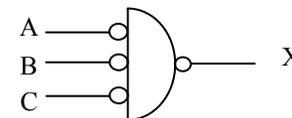
AND gate used as an AND gate



AND gate used as an OR gate (with active low inputs and outputs)



OR gate used as an OR gate



OR gate used as an AND gate (with active low inputs and outputs)