

Nand Gate:

A NAND gate falls under the category of Universal gates because the NAND gate can implement any Boolean function without the help of basic gates and also calculate the results of logical inputs without the help of any other logic gate.

Operation of AND Gate

NAND Gate takes Boolean values as input and returns:

- ❖ Returns 1, if all the inputs are 0 or alternative (meaning one is 0, and the other is 1 or vice versa).
- ❖ Returns 0, if all inputs are 1

Logic Circuit and Truth Table:

2-Input NAND Gate



Truth Table

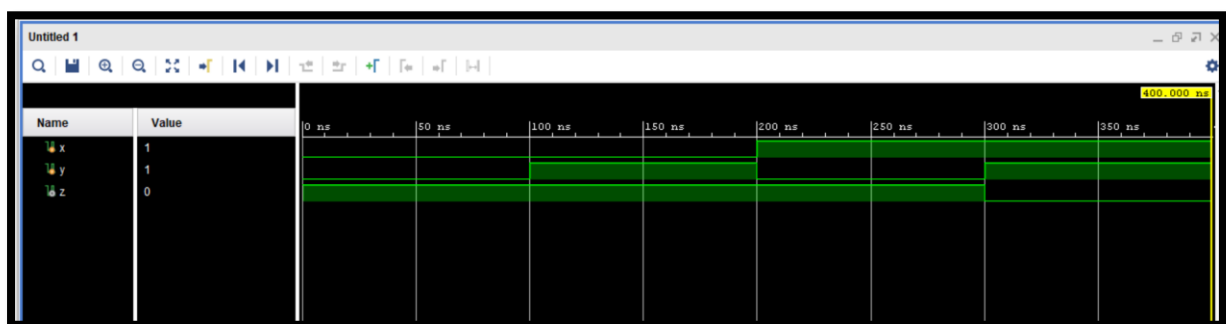
Input A	Input B	$X = (A.B)'$
0	0	1
0	1	1
1	0	1
1	1	0

Verilog Code:

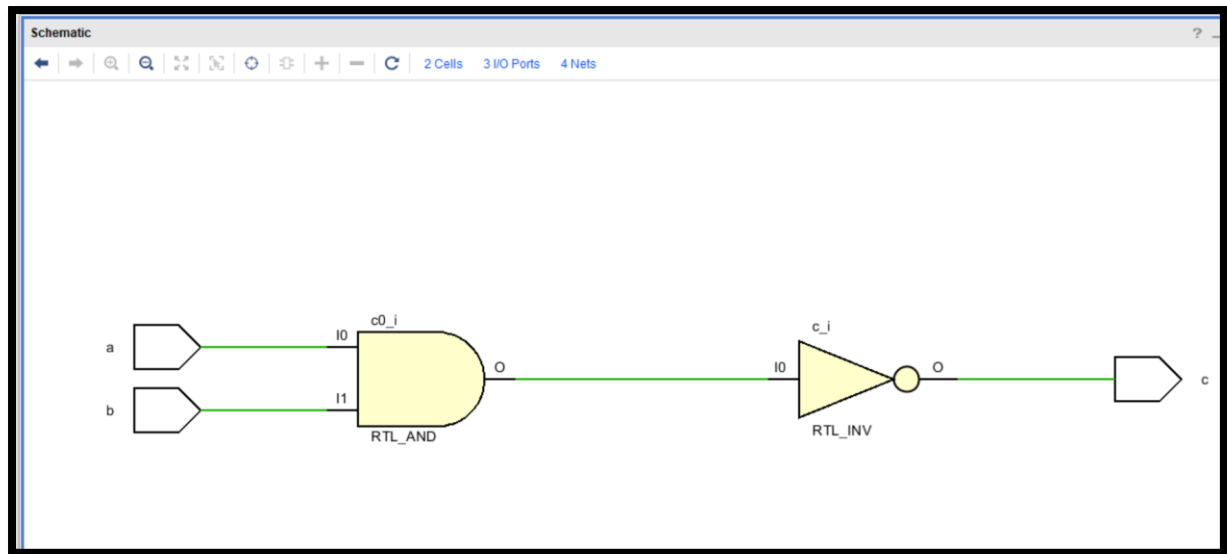
```
module nand_gate(a,b,c);  
input a,b;  
output c;  
assign c = ~(a&b);  
endmodule
```

Testbench:

```
module nand_gate_tb();  
reg x,y;  
wire z;  
nand_gate g1(x,y,z);  
initial  
begin  
x=0;y=0;  
#100  
x=0;y=1;  
#100  
x=1;y=0;  
#100  
x=1;y=1;  
#100 $finish;  
end  
initial  
begin  
$display("\t\t\tTime\tx\ty\tz");  
$monitor($time,"\t",x,"\t",y,"\t",z);  
end  
endmodule
```

Simulation:

RTL Design:



Tcl Console:

```
Tcl Console x Messages Log
# send_msg_id Add_Wave-1 WARNING "No top lev
# }
# }
# run 1000ns
Time      x    y    z
0         0    0    1
100       0    1    1
200       1    0    1
300       1    1    0
$finish called at time : 400 ns : File "E:/Vivado
```

Application:

- ❖ **Universal Gate:** NAND gate is called Universal Gate because all the basic logic gates can be formed using them.
- ❖ **Used to store data:** NAND gates are used to create elements like Flip-Flops and Latches, which is a key component to storing data.
- ❖ **Arithmetic Logic:** NAND gates are extensively used in the Arithmetic and Logic Units (ALUs) of a computing device to perform operations like addition, subtraction, etc.
- ❖ **Used in Decoder and Encoder:** NAND gates are also used in Decoder and Encoder circuits to convert a binary code into a set of digital signals and vice versa.
- ❖ **Used in Multiplexers and Demultiplexers:** NAND gates are used in Multiplexers to decide which route a signal should take to reach a single output. The demultiplexer does the exact opposite of this.
- ❖ **Clock Generators:** NAND gates used in Clock generators to generate clock signals which synchronize various operation in Digital Circuit.
- ❖ **Logical Operations:** NAND gates are also used to implement various logical operations.