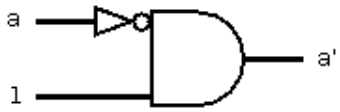
Homework 2

Mitchel Fields

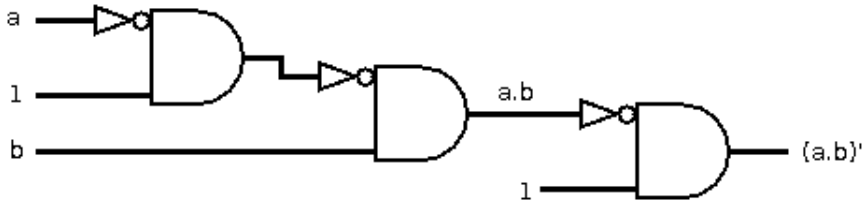
February 9, 2016

Question 1

AND The AND gate configuration could be made universal. If b is always 1, the gate's output becomes $\overline{a}$.



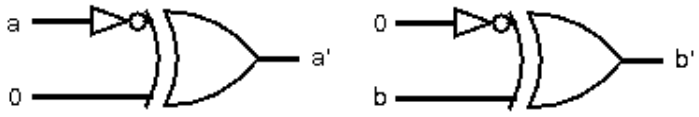
Using one gate with inputs a and 1, a second taking the output of the first gate and b, and a third taking the second output and 1, the gate can be used to create a NAND gate, which is universal.



XOR The XOR configuration cannot be made universal. As it is, it has the following truth table.

a	$\overline{a}$	b	$\overline{a} \oplus b$
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1

This truth table is recognizeable as XNOR. A NOT gate can be made if either input is held at 0.



Even with the addition of more NOT gates, the gate can only be made an XOR or XNOR.

a	b	$\overline{a}$	$\overline{b}$	$\overline{a} \oplus b$	$\overline{a} \oplus \overline{b}$	$\overline{\overline{a}} \oplus b$	$\overline{\overline{a} \oplus b}$
0	0	1	1	1	0	0	0
0	1	1	0	0	1	1	1
1	0	0	1	0	1	1	1
1	1	0	0	1	0	0	0

As such, this gate cannot be made universal.

Question 2

$f(a, b, c, d) = \Sigma(0, 1, 2, 3, 12, 13, 14, 15)$

cd \ ab	00	01	11	10
00	1	0	1	0
01	1	0	1	0
11	1	0	1	0
10	1	0	1	0

$f(a, b, c, d) = \overline{a}.\overline{b} + a.b = \overline{a \oplus b}$

$g(a, b, c, d) = \Sigma(0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15)$

cd \ ab	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	1	1	1	0
10	1	1	1	1

$g(a, b, c, d) = \overline{a.\overline{b}} + \overline{c} + c.\overline{d} = \overline{a} + b + \overline{c} + c.\overline{d}$

$h(a, b, c) = \Pi(0, 1, 2, 3)$

bc \ a	0	1
00	0	1
01	0	1
11	0	1
10	0	1

$h(a, b, c) = a$

$k(a, b, c, d) = \Pi(0, 1, 7, 8)$

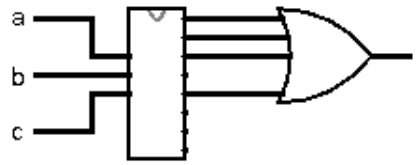
cd \ ab	00	01	11	10
00	0	1	1	0
01	0	1	1	1
11	1	0	1	1
10	1	1	1	1

$k(a, b, c, d) = b.\overline{c} + a.(c + d) + c.\overline{d} + c.\overline{a}.\overline{b}$
$= b.\overline{c} + a.c + a.d + c.(\overline{d} + \overline{a}.\overline{b})$
$= a(c + d) + b.\overline{c} + c.(\overline{d} + \overline{a}.\overline{b})$

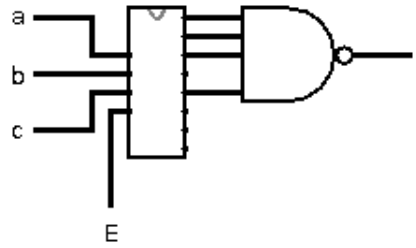
Question 3

a	b	c	majority voter
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Active-High:



Active-Low with Active-Low Enable:



Question 4

```
def decoder(a,b,c,E):
        D0 = not a and not b and not c and E
        D1 = not a and not b and c and E
        D2 = not a and b and not c and E
        D3 = not a and b and c and E
        D4 = a and not b and not c and E
        D5 = a and not b and c and E
        D6 = a and b and not c and E
        D7 = a and b and c and E
        return [D0, D1, D2, D3, D4, D5, D6, D7]

def main():
        print( "  E  a  b  c  |  D7  D6  D5  D4  D3  D2  D1  D0" )
        print( "--------------+-------------------------------" )
        for E in [ 0, 1 ]:
                for a in [ 0, 1 ]:
                        for b in [ 0, 1 ]:
                                for c in [ 0, 1 ]:
                                        print( "%3d%3d%3d%3d  |" %
                                                ( E, a, b, c), end="")
                                        result = decoder(a, b, c, E)
                                        result.reverse()
                                        for D in result:
                                                print("%4d" % D, end="")
                                        print()
```

main ( )

E	a	b	c	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	0	0
0	1	0	1	0	0	0	0	0	0	0	0
0	1	1	0	0	0	0	0	0	0	0	0
0	1	1	1	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	1
1	0	0	1	0	0	0	0	0	0	1	0
1	0	1	0	0	0	0	0	0	1	0	0
1	0	1	1	0	0	0	0	1	0	0	0
1	1	0	0	0	0	0	1	0	0	0	0
1	1	0	1	0	0	1	0	0	0	0	0
1	1	1	0	0	1	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0	0	0	0