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CSE 310

Homework 2

1. Consider a 2s complement 8-bit representation. A binary number has a value of 103 when we regard it as a signed number. What is its value if we regard it as an unsigned number?

   The value of 103 when regarded as a unsigned number is 152 since unsigned numbers have a range of 255 to 0 so to get the unsigned number we do 255 – 103 which equals to 152.

2. Consider a 2s complement 8-bit representation. What is the value of 0001 1010?

   $$(0001\ 1010)_2 => (26)_{10}$$

   $0001\ 1010 = (0 \times 2^7) + (0 \times 2^6) + (0 \times 2^5) + (1 \times 2^4) + (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (0 \times 2^0) = 16 + 8 + 4 + 2 = 26$

3. Simply the boolean expression x' + xy + xz' +xy'z'. What is the simplest result?

   $x' + xy + xz' + xy'z'$

   $= x' + y + xz' + xy'z'$

   $= x' + y + z'$

4. Simplify (x + y)'(x' + y'). What is the simplest result?

   $Let\ F = (x + y)'(x' + y')$

   $Then, let \sim F = Duality\ of\ F$

$\sim F = (xy)' + (x'y') = x'y' + x'y' = x'y'$

$F = \sim\sim F = x' + y'$

5. Simplify x * (x + y + z) * (x' + y) * (x + q) * (x + q' + z).

$$x * (x + y + z) * (x' + y) * (x + q) * (x + q' + z)$$
$$= x + xyz + x'y + xq + xq'z$$
$$= x + x'y + x\big(z(q + q')\big)$$
$$= x + x'y + xz = x + x'y$$
$$= x * (x' + y)$$

6. Simplify x * (x + y + z') * (x' + z) * (y + z') * (x + z)

$$x * (x + y + z') * (x' + z) * (y + z') * (x + z)$$

$$= x + xyz' + x'z + yz' + xz$$

$$= x + x'z + yz' + xz$$

$$= x + z + yz' + xz$$

$$= x + z + yz'$$

$$= x + y + z$$

$$= xyz$$

7. Write the boolean expression (in sum-of-product form) for a logic circuit that will have a 1 output when x = 0, y = 0, z = 1 and x = 1, y = 1, z = 0; and a 0 output for all other input states. Draw the circuit for the simplified expression.

X = 0, Y = 0, Z = 1

X	Y	Z	F
0	0	1	0
0	0	0	0
0	1	1	1
0	1	0	0
1	0	1	1
1	0	0	0

1	1	1	1
1	1	0	1

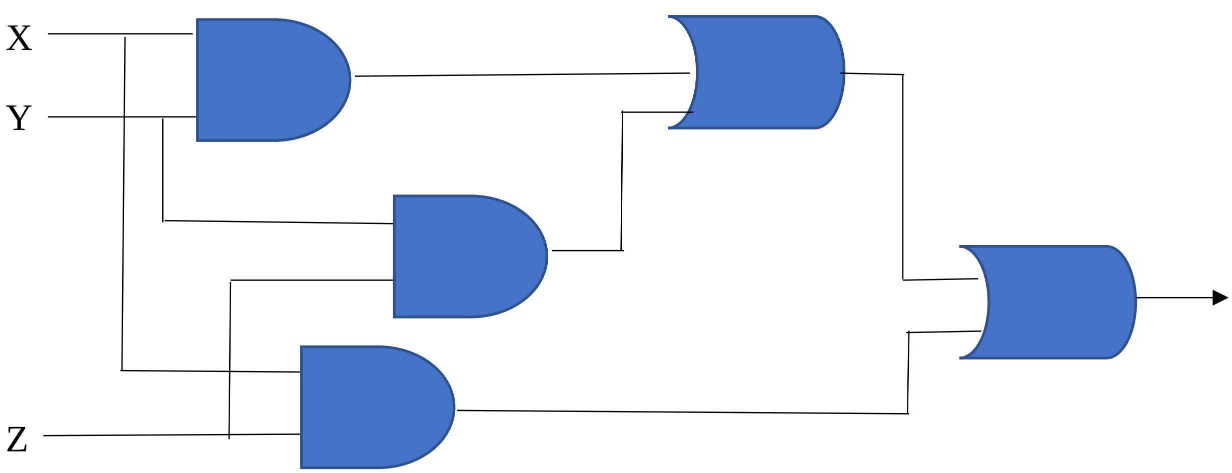
$$F = x'yz + xy'z + xyz + xyz'$$

$$= x'yz + xy'z + xy(z + z')$$

$$= x'yz + xy'z + xy$$

$$= xy + xz + yz$$

Circuit Diagram



- X = 1, Y = 1, Z = 0

X	Y	Z	F
1	1	0	1
1	1	1	1
1	0	0	0
1	0	1	1
0	1	0	0
0	1	1	1
0	0	0	0
0	0	1	0

$$F = xyz' + xyz + xy'z + x'yz$$

$$= xy(z' + z) + xy'z + x'yz$$

$$= xy + xy'z + x'yz$$

$$= xy + xz + yz$$

Circuit Diagram

Same as the one above

8. Simplify the expression xyz (xyz' + xy'z + x'yz).

$$= xyz\ (xyz' + xy'z + x'yz)$$

$$= xyz'z + xzy'y + yzx'x$$

$$= xyzzy' + xyzyz'$$

9. Using maps or whatever method you prefer, simplify the following expressions in four variables, w, x, y and z:

$$\sum (\ 0,2,4,8,9,10,11,12,13)$$

yz \ wx	00	01	11	10
00	1	0	0	1
01	1	0	0	0
11	1	1	0	0
10	1	1	1	1

$$F(w, x, y, z) = w'x' + yz' + w'y + x'y'z'$$

10. Write Verilog modules and a test bench to check whether your simplified expressions of question 5 and 6 are correct. Use both the structural description and behavioral description.

hwk2.v

```
// x * ( x + y + z ) * ( x' + y ) * ( x + q ) * ( x + q' + z ).
module Problem5 ( output F, input x, input y, input z, input q );
   assign F = x && ( x || y || z ) && ( !x || y ) && ( x || q ) && ( x || !q || z );
endmodule

// x * ( x' + y )
module Problem5_Solution ( output F, input x, input y );
   assign F = x && ( !x || y );
endmodule

// x * ( x + y + z' ) * ( x' + z ) * ( y + z' ) * ( x + z )
module Problem6 ( output F, input x, input y, input z );
   assign F = x && ( x || y || !z ) && ( !x || z ) && ( y || !z ) && ( x || z );
endmodule

// x * y * z
module Problem6_Solution ( output F, input x, input y, input z );
   assign F = x && y && z;
endmodule
```

hwk2_tb.v

```
module testBench();

reg x, y, z, q;
wire F1, F2;

// Intialize all variables
initial begin
   $display ("time\t   x   y   z   q   F1  F2");
   $monitor ("%g\t   %b   %b   %b   %b   %b   %b",
           $time, x, y, z, q, F1, F2);

   x = 0;
   y = 0;
   z = 0;
```

```
    q = 0;

    #75 $finish;
end
    always begin
        #5 q = ~q;
    end
    always begin
        #10 z = ~z;
    end
    always begin
        #20 y = ~y;
    end
    always begin
        #40 x = ~x;
    end

// Problem5 test1 ( .F(F1), .x(x), .y(y), .z(z), .q(q) );
// Problem5_Solution test1Sol ( .F(F2), .x(x), .y(y) );

Problem6 test2 ( .F(F1), .x(x), .y(y), .z(z) );
Problem6_Solution test2Sol ( .F(F2), .x(x), .y(y), .z(z) );


endmodule
```

Outputs:

- ## Problem 5

```
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$ ./hwk2_tb
time        x  y  z  q  F1  F2
0           0  0  0  0  0  0
5           0  0  0  1  0  0
10      0  0  1  0  0  0
15      0  0  1  1  0  0
20      0  1  0  0  0  0
25      0  1  0  1  0  0
```

30	0	1	1	0	0	0
35	0	1	1	1	0	0
40	1	0	0	0	0	0
45	1	0	0	1	0	0
50	1	0	1	0	0	0
55	1	0	1	1	0	0
60	1	1	0	0	1	1
65	1	1	0	1	1	1
70	1	1	1	0	1	1
75	1	1	1	1	1	1

~

- Problem 6

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$ ./hwk2_tb

time	x	y	z	q	F1	F2
0	0	0	0	0	0	0
5	0	0	0	1	0	0
10	0	0	1	0	0	0
15	0	0	1	1	0	0
20	0	1	0	0	0	0
25	0	1	0	1	0	0
30	0	1	1	0	0	0
35	0	1	1	1	0	0
40	1	0	0	0	0	0
45	1	0	0	1	0	0
50	1	0	1	0	0	0
55	1	0	1	1	0	0
60	1	1	0	0	0	0
65	1	1	0	1	0	0

70	1	1	1	0	1	1
75	1	1	1	1	1	1