

Assignment 2 Solution

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Problem 1 :

$$F(A, B, C, D) = \sum m(0, 2, 3, 8, 9, 10, 11, 12, 13, 14, 15)$$

	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>F</i>
0	0	0	0	0	1
1	0	0	0	1	0
2	0	0	1	0	1
3	0	0	1	1	1
4	0	1	0	0	0
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	0
8	1	0	0	0	1
9	1	0	0	1	1
10	1	0	1	0	1
11	1	0	1	1	1
12	1	1	0	0	1
13	1	1	0	1	1
14	1	1	1	0	1
15	1	1	1	1	1

Table 1: Truth Table

CD \ AB	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

(a) Layout

CD \ AB	00	01	11	10
00	1	0	1	1
01	0	0	0	0
11	1	1	1	1
10	1	1	1	1

(b) Prime implicant

Figure 1: Karnaugh-map

$$\Rightarrow F = A + B'D' + B'C$$

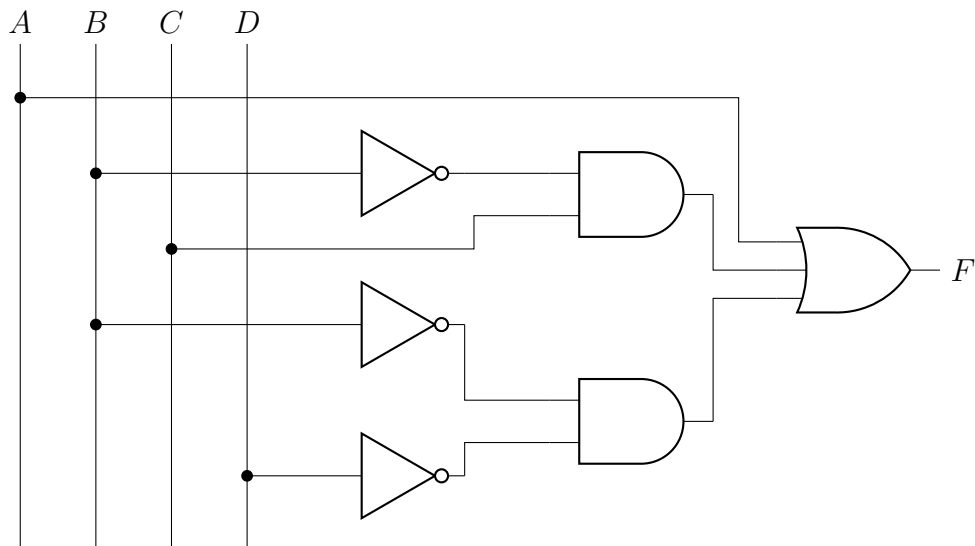


Figure 2: Circuit

```

1 module Problem1(F,A,B,C,D);
2   input A,B,C,D;
3   output F;
4   wire S1,S2,S3,S4;
5   not N1(S1,B);
6   not N2(S2,D);
7   and A1(S3,S1,C);
8   and A2(S4,S1,S2);
9   or O1(F,A,S3,S4);
10  endmodule

```

Listing 1: Verilog code for Problem 1

Problem 2 : Design a 4-to-1 Multiplexer

$s0$	$s1$	F
0	0	$i0$
0	1	$i1$
1	0	$i2$
1	1	$i3$

Table 2: Truth Table for a 4-to-1 Multiplexer

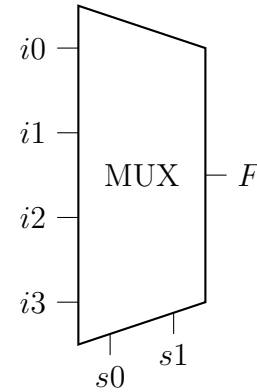


Figure 3: 4-to-1 Multiplexer

$$\Rightarrow F = s0's1'i0 + s0s1'i1 + s0's1i2 + s0s1i3$$

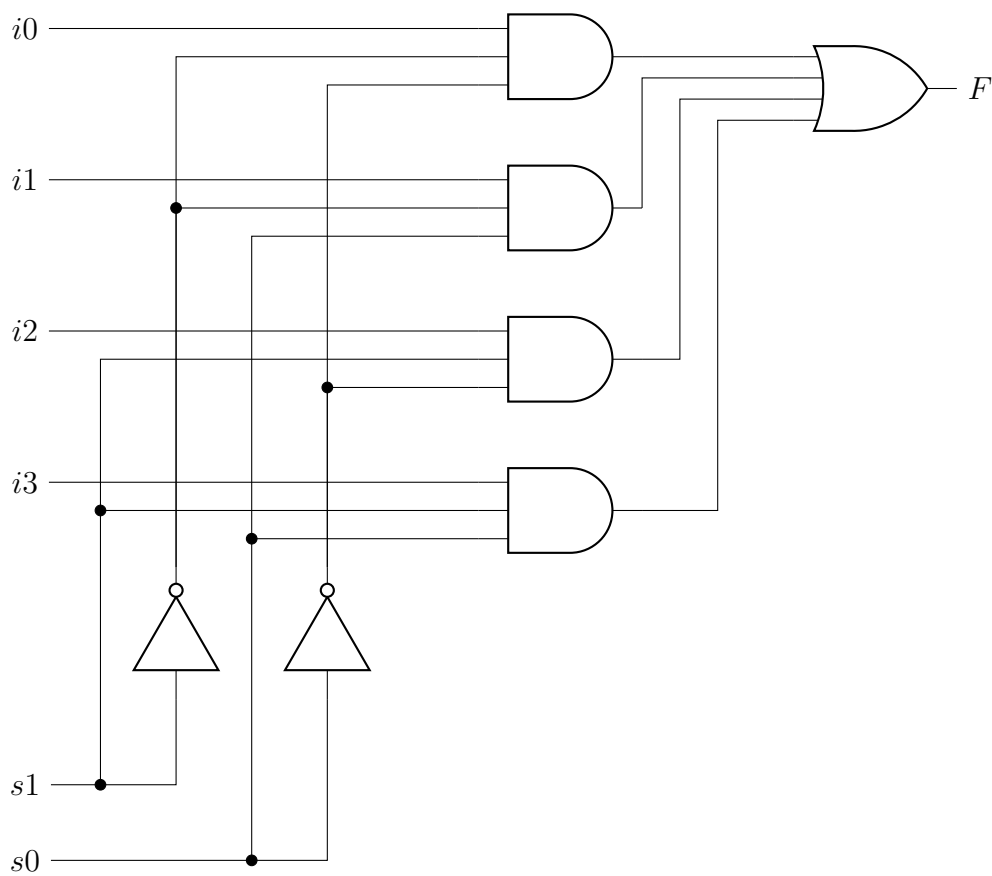


Figure 4: 4-to-1 Multiplexer Circuit

```
1 module mux4_to_1 (F, i0, i1, i2, i3, s1, s0);
2 output F;
3 input i0, i1, i2, i3, s1, s0;
4 wire s1n, s0n;
5 wire y0, y1, y2, y3;
6 not (s1n, s1);
7 not (s0n, s0);
8 and (y0, i0, s1n, s0n);
9 and (y1, i1, s1n, s0);
10 and (y2, i2, s1, s0n);
11 and (y3, i3, s1, s0);
12 or (F, y0, y1, y2, y3);
13 endmodule
```

Listing 2: Verilog code for 4-to-1 Multiplexer

Problem 3 : Adder Circuit

1. Half Adder

X	Y	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Table 3: Truth Table for Half Adder

$$\Rightarrow \begin{cases} S = X'Y + XY' = X \oplus Y \\ C = XY \end{cases}$$

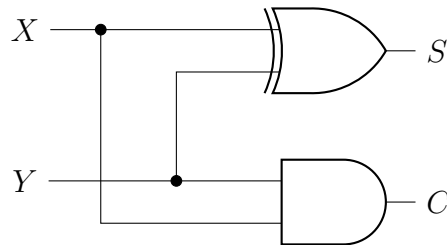


Figure 5: Half Adder Circuit

```

1 module half_adder (X, Y, S, C);
2   input X, Y;
3   output S, C;
4   xor Xor (S, X, Y);
5   and And (C, X, Y);
6 endmodule

```

Listing 3: Verilog code for Half Adder

2.Full Adder

X	Y	C_i	S	C_o
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Table 4: Truth Table for Full Adder

$C_i \backslash X \backslash Y$	00	01	11	10
0	0	1	0	1
1	1	0	1	0

(a) $S = C_i \oplus X \oplus Y$

$C_i \backslash X \backslash Y$	00	01	11	10
0	0	0	1	0
1	0	1	1	1

(b) $C_o = XY + YC_i + XC_i$

Figure 6: Karnaugh-map Full Adder

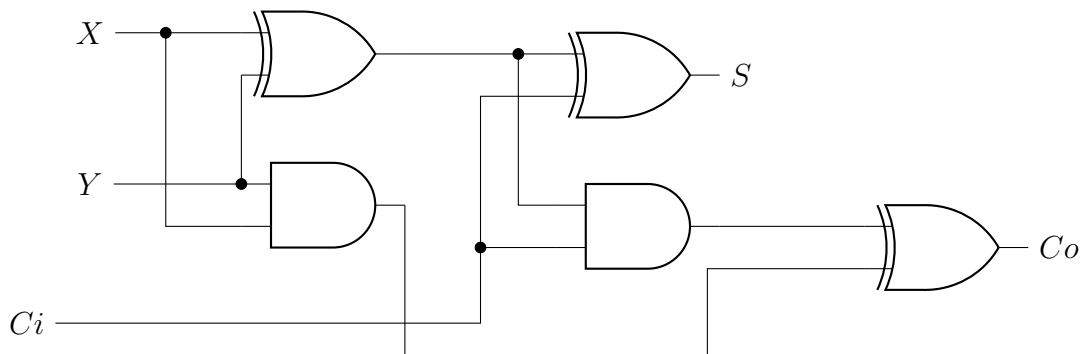


Figure 7: Full Adder Circuit

```

1 module full_adder (X, Y, Ci, S, Co);
2   input X, Y, Ci;
3   output S, Co;
4   wire w1, w2, w3;
5   xor (w1, X, Y);
6   and (w2, X, Y);
7   xor (S, w1, Ci);
8   and (w3, w1, Ci);
9   xor (Co, w2, w3);
10  endmodule

```

Listing 4: Verilog code for Full Adder

3. Ripple Carry 4-bit Adder

```
1 module Ripple_Carry_Adder(X, Y, Ci, S, Co);  
2   output [3:0] S;  
3   output Co;  
4   input [3:0] X, Y;  
5   input Ci;  
6   wire w1, w2, w3;  
7   full_adder fa0(X[0], Y[0], Ci, S[0], w1);  
8   full_adder fa1(X[1], Y[1], w1, S[1], w2);  
9   full_adder fa2(X[2], Y[2], w2, S[2], w3);  
10  full_adder fa3(X[3], Y[3], w3, S[3], Co);  
11 endmodule
```

Listing 5: Verilog code for Ripple Carry Adder

4. Ripple Carry 8-bit Adder

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