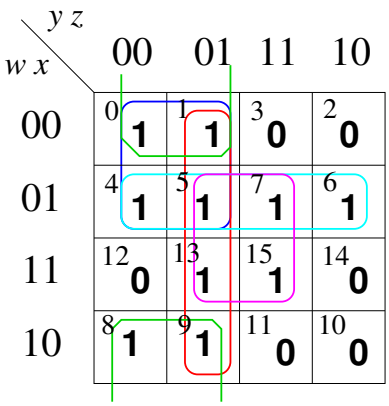
EE 231 – Homework 4
Due September 24, 2010

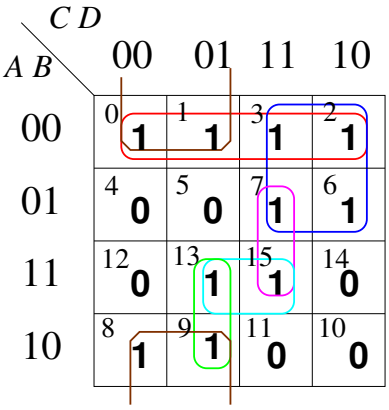
1. Find all the prime implicants for the following Boolean functions, and determine which are essential. Then simplify the expressions.

   (a) $F(w, x, y, z) = \Sigma(0, 1, 4, 5, 5, 7, 8, 9, 13, 15)$



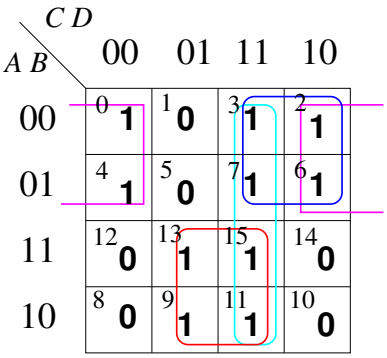
   Prime implicants: $w'y'$, $w'x$, xz, $y'z$, $x'y'$
   Essential: $w'x$ (only one with 6), xz (only one with 15), $x'y'$ (only one with 8)
   Simplified: $w'x + xz + x'y' + w'y'$ or $w'x + xz + x'y' + w'x$

   (b) $F(A, B, C, D) = \Sigma(0, 1, 2, 3, 6, 7, 8, 9, 13, 15)$



   Prime implicants: $A'B'$, $A'C$, $B'C'$, BCD, $AC'D$, ABD
   Essential: $A'C$ (only one with 6), $B'C'$ (only one with 8)
   Simplified: $A'C + B'C' + ABD$

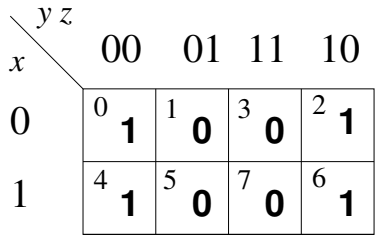
(c) $F(A, B, C, D) = \Sigma(0, 2, 3, 4, 6, 7, 9, 11, 13, 15)$



Prime implicants: $A'C$, $A'D'$, CD, AD
Essential: $A'C'$ (only one with 0 and 4), AD (only one with 9 and 13)
Simplified: $A'C' + AD + CD$ or $A'C' + AD + A'C$

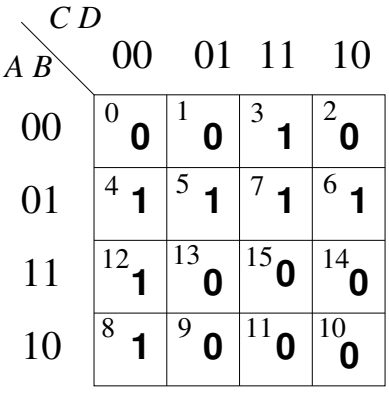
2. Find the minterms of the following Boolean expressions by first plotting each function in a map:

(a) $x'z' + y'z' + z'yz'$



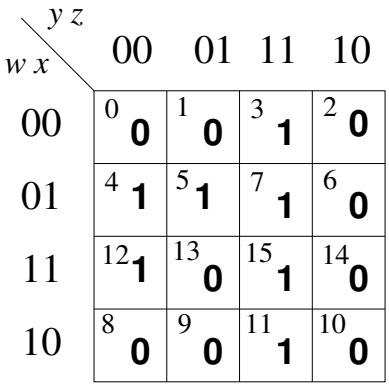
$F(x, y, z) = \Sigma(0, 2, 4, 6)$

(b) $A'B + BC'D' + AC'D' + A'CD$



$F(A, B, C, D) = \Sigma(3, 4, 5, 6, 7, 8, 12)$

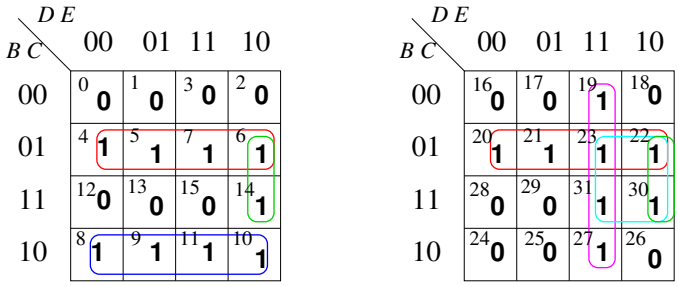
(c) $w'xy' + yz + xy'z'$



$F(w, x, y, z) = \Sigma(3, 4, 5, 7, 11, 12, 15)$

3. Simplify the following Boolean function using five-variable maps:

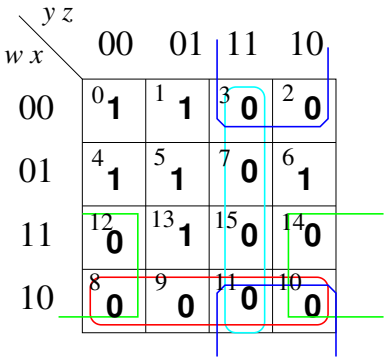
$F(A, B, C, D, E) = \Sigma(4, 5, 6, 7, 8, 9, 10, 11, 14, 19, 20, 21, 22, 23, 27, 30, 31)$



$F = B'C + A'BC' + ADE + CDE'$

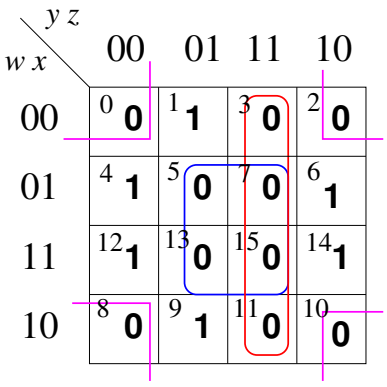
4. Simplify the following Boolean function to product-of-sums form:

(a) $F(w, x, y, z) = \Sigma(0, 1, 4, 5, 6, 13)$



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

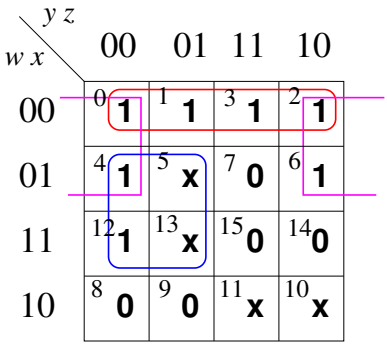
(b) $F(w,x,y,z) = \Pi(0,2,3,5,7,8,10,11,13,15)$



$F = (x' + z')(y' + z')(x + z)$

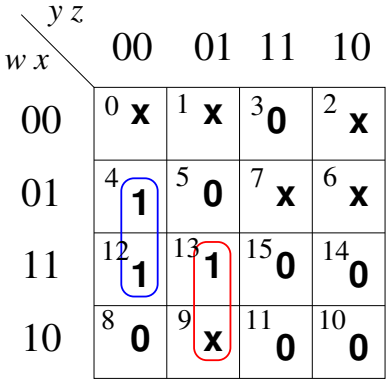
5. Simplify the following Boolean function F, together with the don't-care conditions d.

(a) $F(x,y,z) = \Sigma(0,1,2,3,4,6,12)$
$d(x,y,z) = \Sigma(5,10,11,13)$



$F = w'x' + w'z' + xy'$

(b) $F(w,x,y,z) = \Sigma(4,12,13)$
$d(w,x,y,z) = \Sigma(0,1,2,6,7,9)$

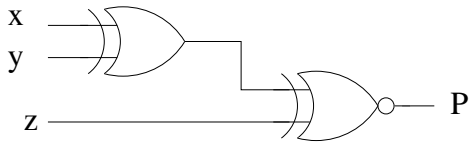


$F = xy'z' + wy'z$ (and other ways)

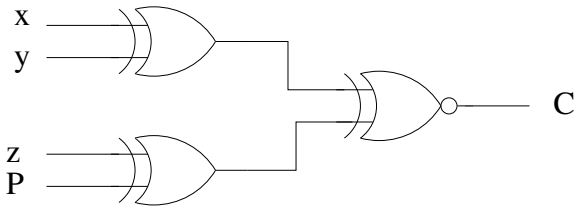
6. Problem 3.28

   The 3-bit odd parity generator looks for an odd number of ones. It is just the 3-bit even circuit followed by an inverter, or the final gate is an XNOR rather than an XOR.

   The 3-bit odd parity checker looks for an odd number of ones. It is just the 3-bit even circuit followed by an inverter, or the final gate is an XNOR rather than an XOR.



(a) 3–bit odd parity generator



(b) 4–bit odd parity checker

7. Write a Verilog gate-leve description of the circuit shown in

   (a) Fig. 4.2 (p. 124)

```
module p7a(input A, B, C, output F1, F2);

wire T1,T2,T3,w4,w5,w6,w7;

AND (T2,A,B,C);
OR  (T1,A,B,C);
AND (w4,A,B);
AND (w5,A,C);
AND (w6,B,C);
OR  (F2,w4,w5,w6);
AND (T3,T1,~F2);
OR  (F1,T2,T3;

endmodule
```

(b) Fig. 4.4 (p.129)

```
module p7b(input A, B, C, D, output w, x, y, z);

wire CandD,CorD,w1,w2,w3);

AND (CandD,C,D);
OR  (CorD,D,D);
NOT (z,D);
OR  (y,CandD,~CorD);
AND (w1,(~CorD,B);
AND (w2,CorD,~B);
AND (w3,CorD,B);
OR  (x,w1,w2);
OR  (w,w3,A);

endmodule
```

8. Using continuous assignment statements, write a Verilog description of the circuit shown in

(a) Fig. 4.2 (p. 124)

```
module p8a(input A, B, C, output F1, F2);
/* From the equations for F1 and F2 on Page 125 */

assign F2 = A&B | A&C | B&C;
assign F1 = ~A&B&~C | ~A&~B&C | A&~B&~C | A&B&C;

endmodule
```

(b) Fig. 4.4 (p.129)

```
module p8b(input A, B, C, D, output w, x, y, z);
/* From the equations on Page 129 */

assign z = ~D;
assign y = C&D | ~C&~D;
assign x = ~B&C | ~B&D | B&~C&~D;
assign w = A | B&C | B&D;

endmodule
```