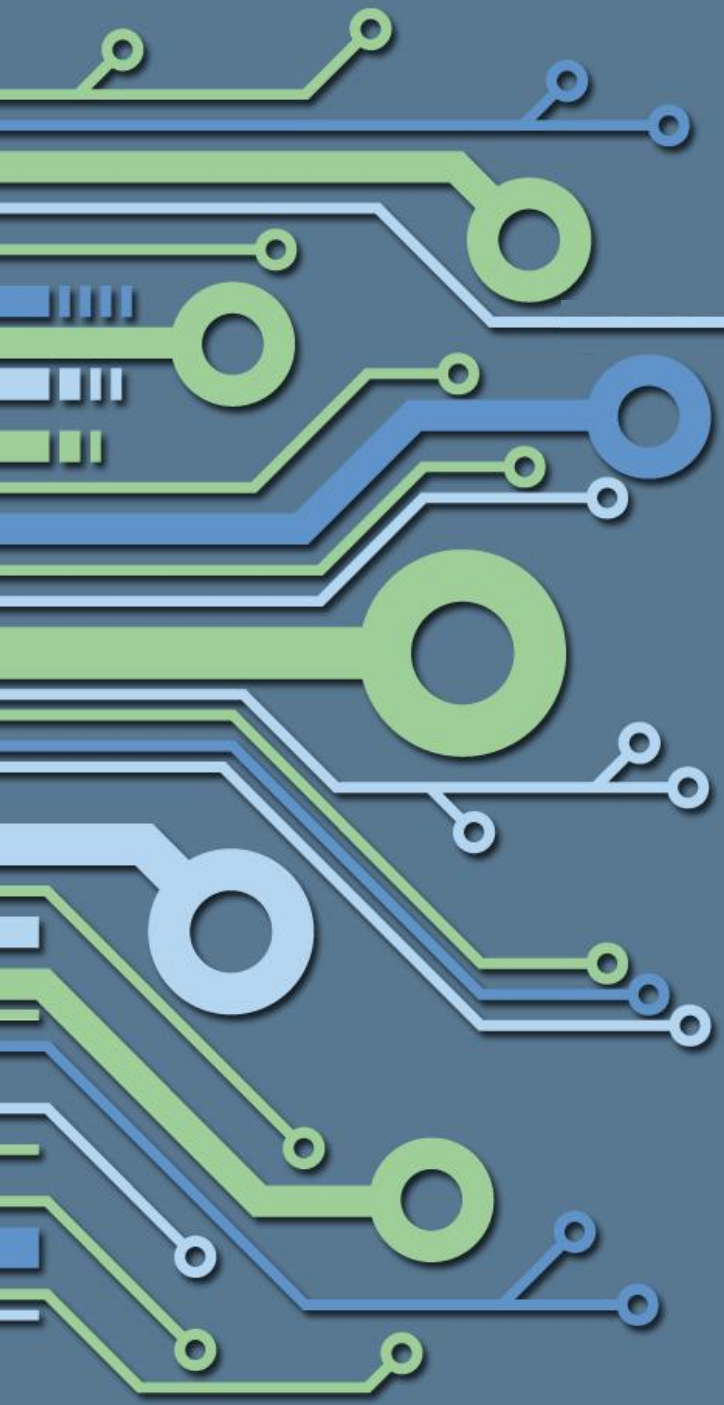


Chapter 4

SIMPLIFICATION of LOGIC CIRCUITS

Don’t Care conditions

- The unspecified minterms (maxterms) of an incompletely specified function
- An **X** inside a map represents a don’t care condition

Don't Care conditions

- There are 2 cases when this occurs.
  - The input combination never occurs
    - E.g. The BCD code does not use the 6 remaining codes.
  - The input combinations are expected to occur, but we do not care what the outputs are

Representation of Don't Cares

- e.g:

  $F(W,X,Y,Z) = \sum m(0,1,2,4,6,7,8,10)$

  $d(W,X,Y,Z) = \sum d(12,13,14,15)$

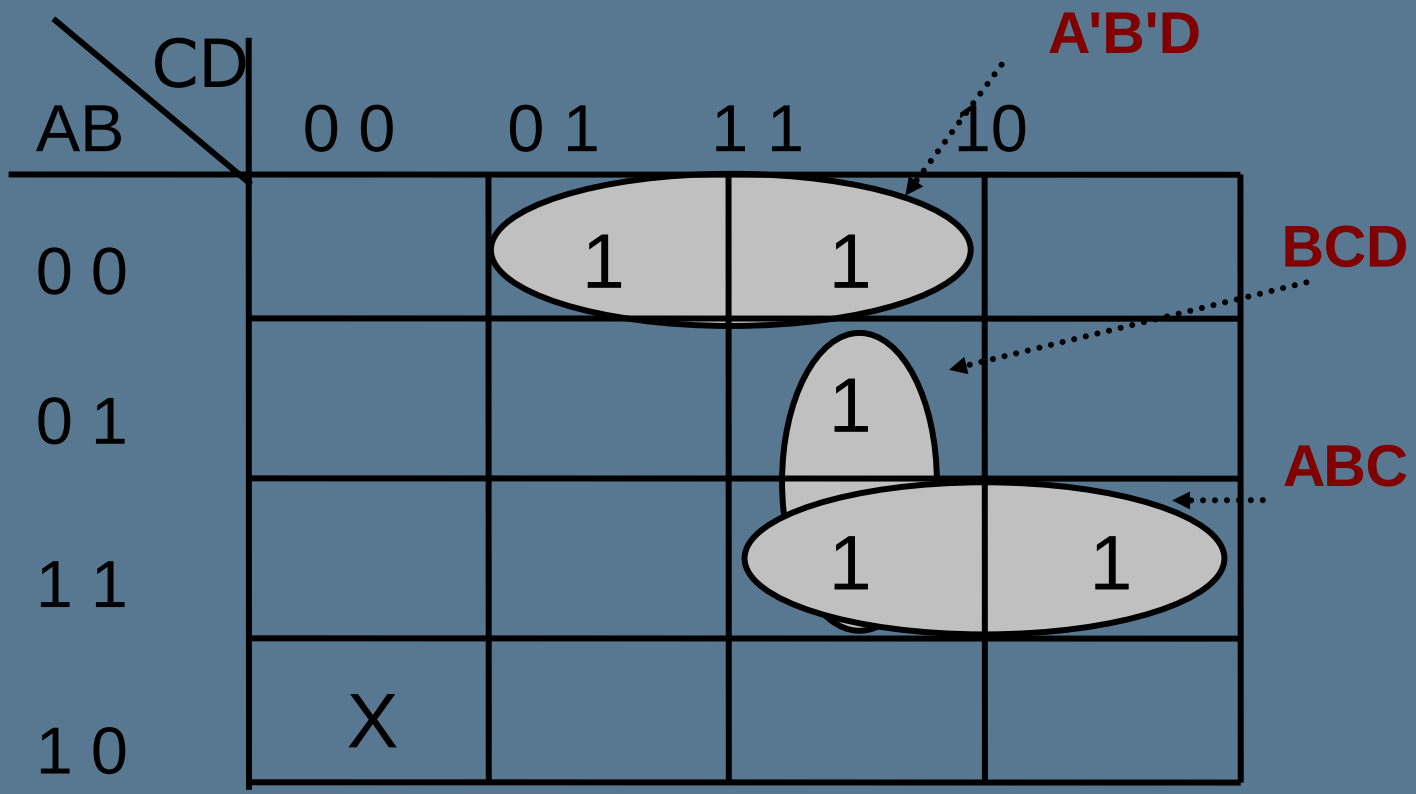
- It could also be represented as:

  $F(W,X,Y,Z) = \sum m(0,1,2,4,6,7,8,10)$

  $+ \sum d\,(12,13,14,15)$

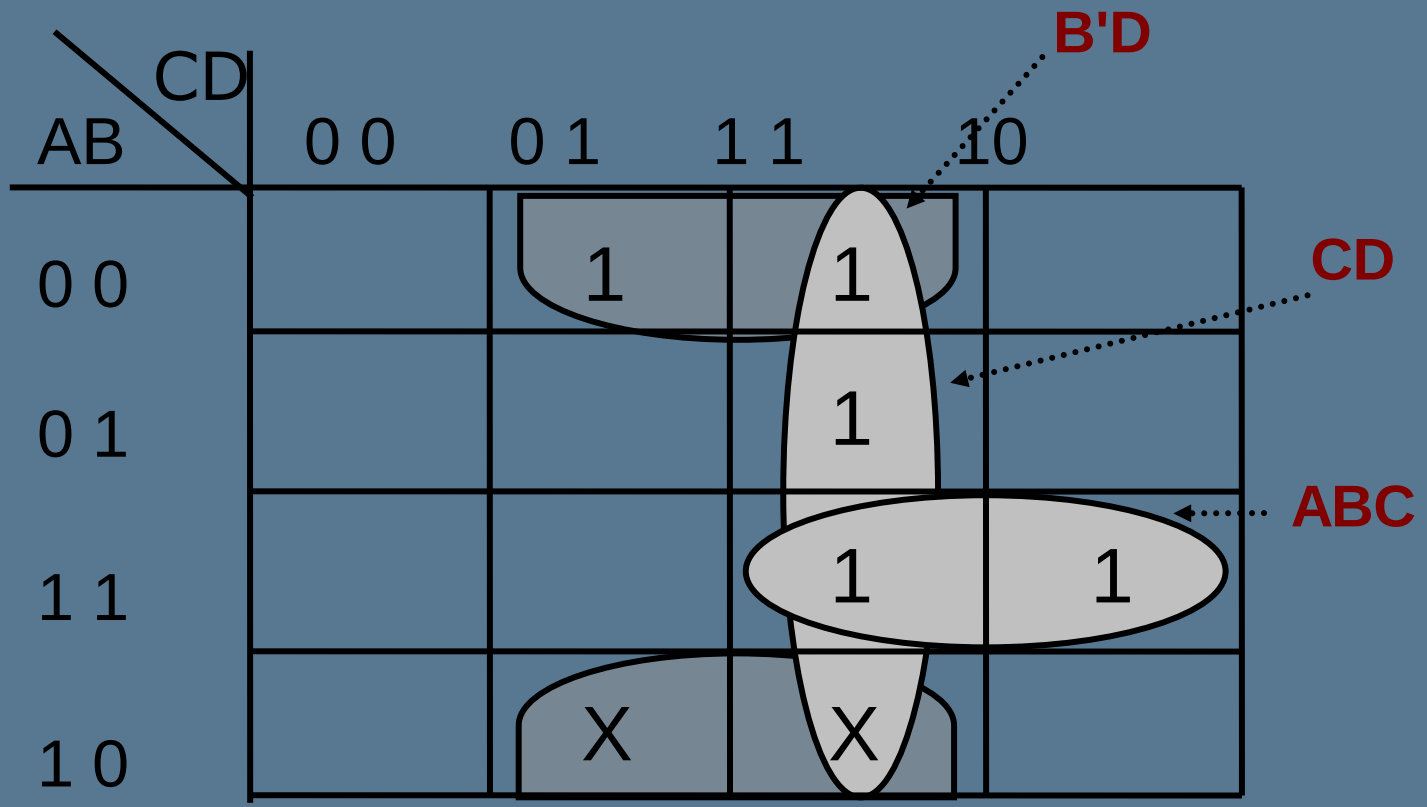
Example

- Simplify $F=\sum m(1,3,7,14,15) + d(8)$



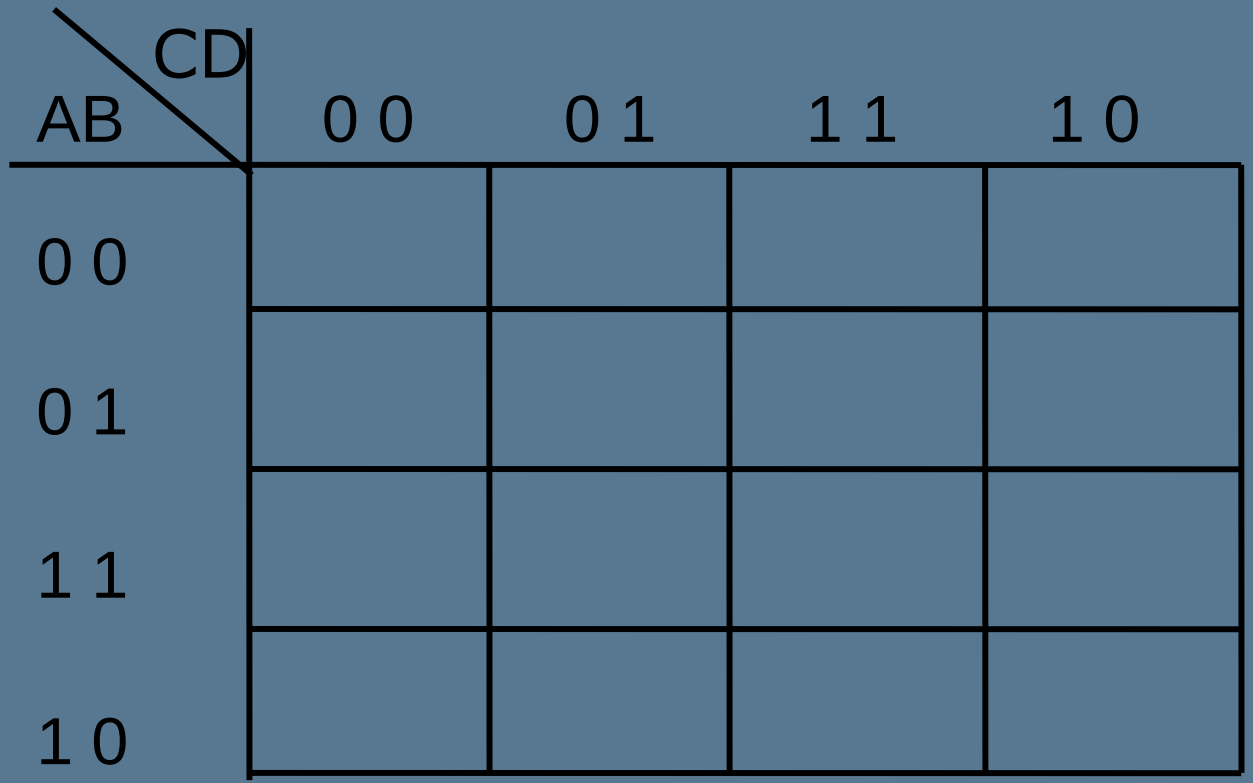
Example

- Simplify $F=\sum m(1,3,7,14,15) + d(9,11)$



Example

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd (6,13,15)



Example

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d (6,13,15)

AB \ CD	0 0	0 1	1 1	1 0
0 0	1			1
0 1	1			
1 1	1			
1 0	1	1		

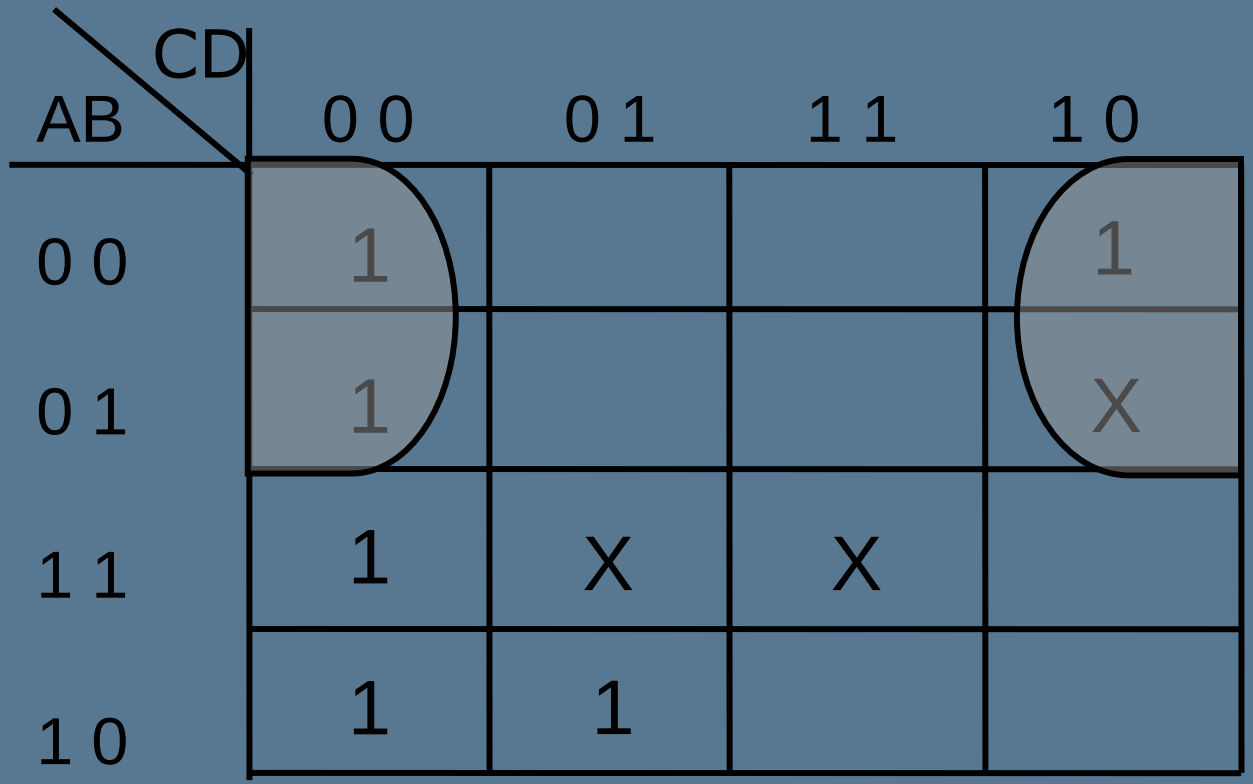
Example

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d (6,13,15)

AB \ CD	0 0	0 1	1 1	1 0
0 0	1			1
0 1	1			X
1 1	1	X	X	
1 0	1	1		

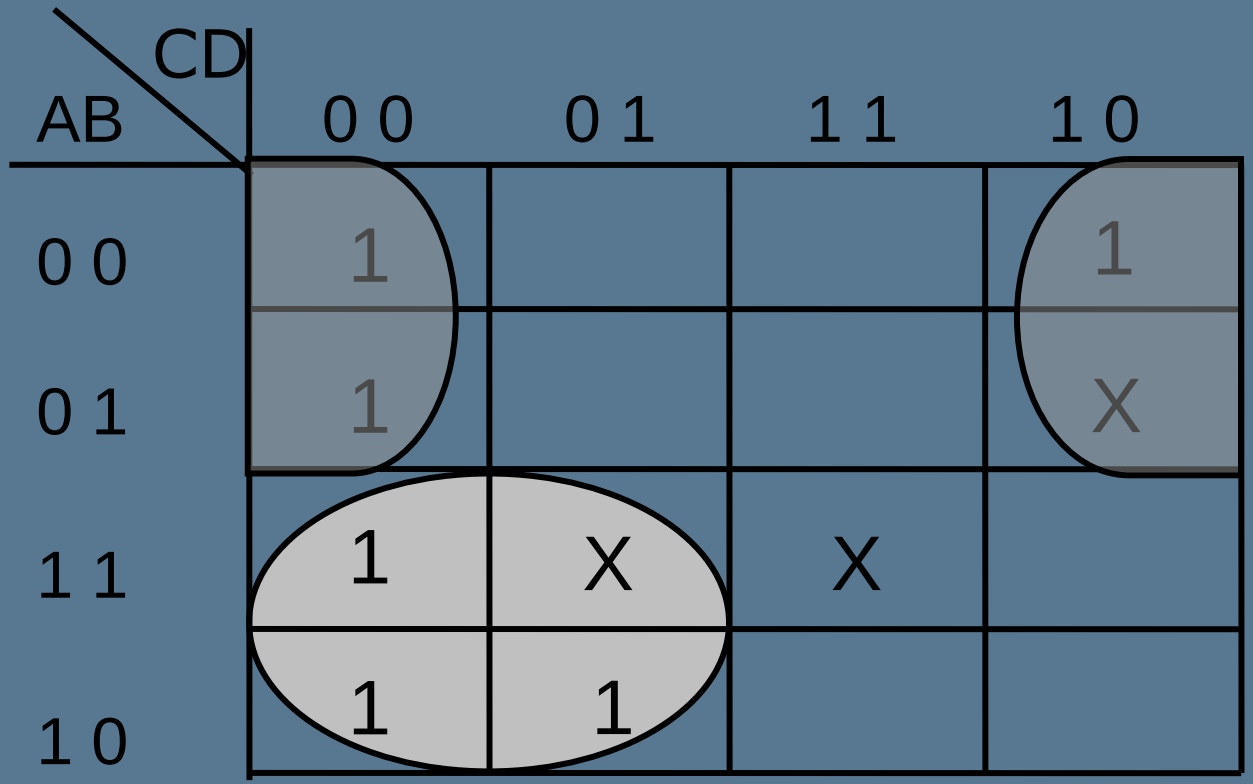
Example

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d (6,13,15)



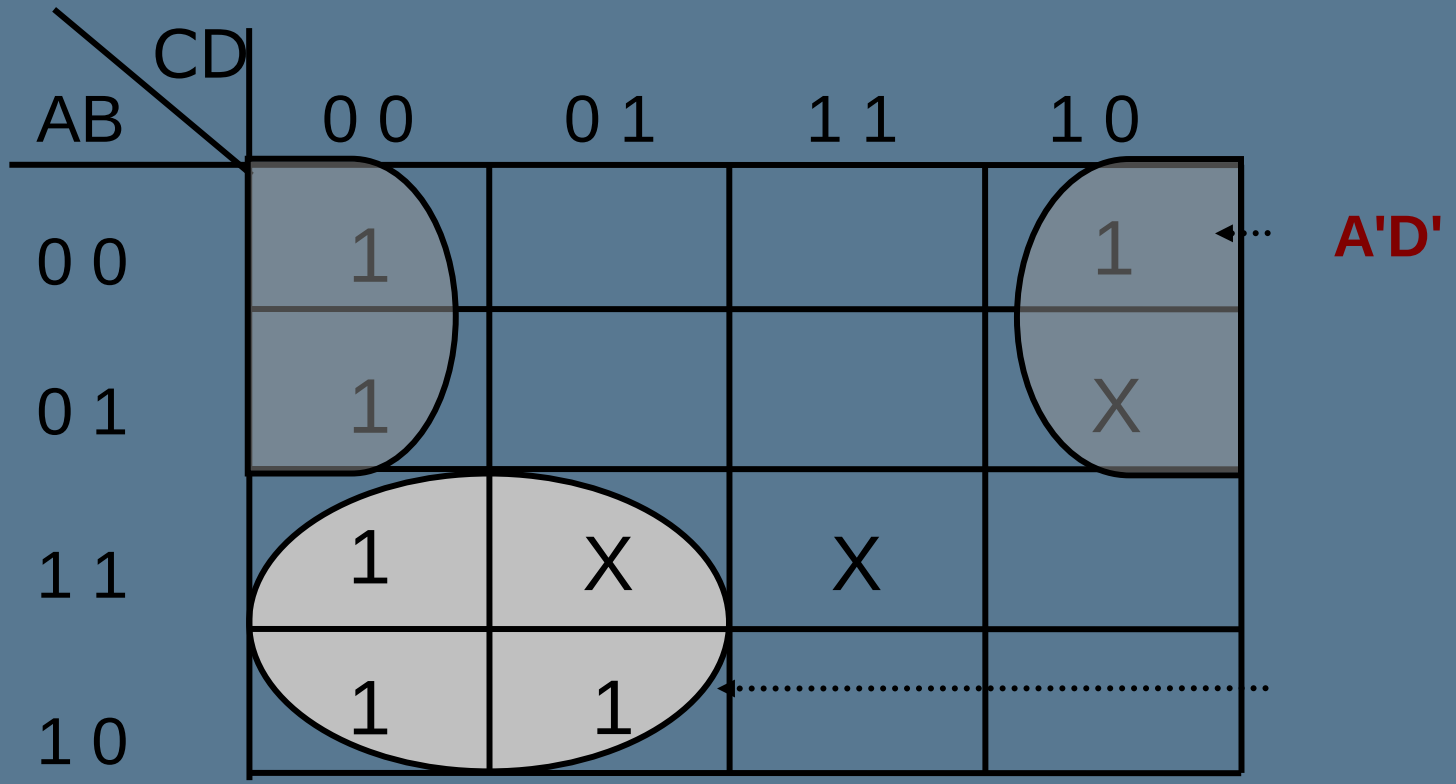
Example

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d (6,13,15)



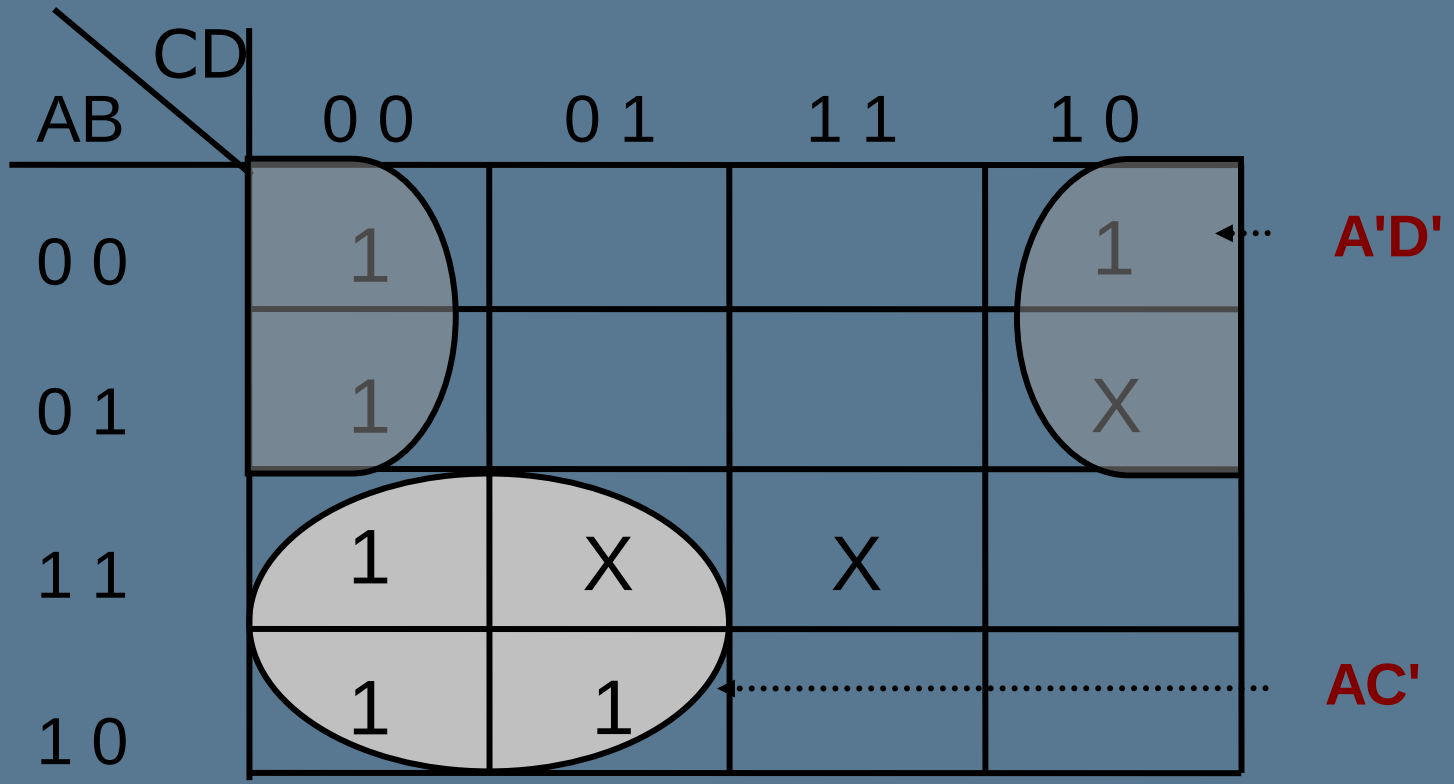
Example

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd (6,13,15)



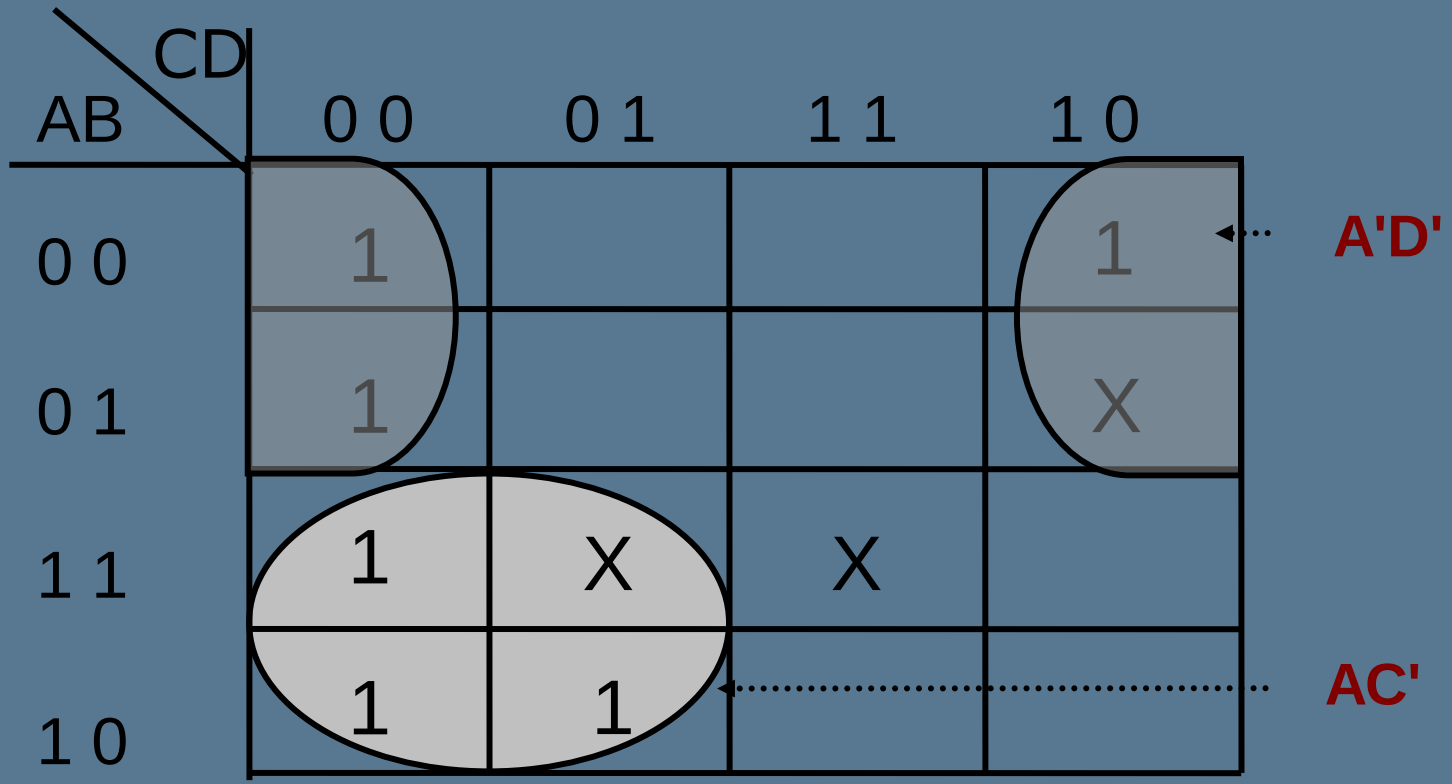
Example

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd (6,13,15)



Example

- F (A,B,C,D) = Σm(0,2,4,8,9,12) +
  Σd (6,13,15) **=A'D' + AC'**



Example – Quine McCluskey

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Example – Quine McCluskey

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1

0	0000
2	0010
4	0100
8	1000
6	0110
9	1001
12	1100
13	1101
15	1111

Example – Quine McCluskey

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1		Column 2	
0	0000 √	0,2	00-0
2	0010 √		
4	0100		
8	1000		
6	0110		
9	1001		
12	1100		
13	1101		
15	1111		

Example – Quine McCluskey

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1		
0	0000	√
2	0010	√
4	0100	√
8	1000	
6	0110	
9	1001	
12	1100	
13	1101	
15	1111	

Column 2	
0,2	00-0
0,4	0-00

Example – Quine McCluskey

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1

0	0000	√
2	0010	√
4	0100	√
8	1000	√
6	0110	
9	1001	
12	1100	
13	1101	
15	1111	

Column 2

0,2	00-0
0,4	0-00
0,8	-000

Example – Quine McCluskey

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1			Column 2	
0	0000	√	0,2	00-0
			0,4	0-00
2	0010	√	0,8	-000
4	0100	√		
8	1000	√	2,6	0-10
6	0110	√		
9	1001			
12	1100			
13	1101			
15	1111			

Example – Quine McCluskey

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1

0	0000	√
2	0010	√
4	0100	√
8	1000	√
6	0110	√
9	1001	
12	1100	
13	1101	
15	1111	

Column 2

0,2	00-0
0,4	0-00
0,8	-000
2,6	0-10
4,6	01-0

Example – Quine McCluskey

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1		
0	0000	√
2	0010	√
4	0100	√
8	1000	√
6	0110	√
9	1001	
12	1100	√
13	1101	
15	1111	

Column 2	
0,2	00-0
0,4	0-00
0,8	-000
2,6	0-10
4,6	01-0
4,12	-100

Example – Quine McCluskey

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1			Column 2	
0	0000	√	0,2	00-0
			0,4	0-00
2	0010	√	0,8	-000
4	0100	√		
8	1000	√	2,6	0-10
			4,6	01-0
6	0110	√	4,12	-100
9	1001	√	8,9	100-
12	1100	√		
13	1101			
15	1111			

Example – Quine McCluskey

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1			Column 2	
0	0000	√	0,2	00-0
			0,4	0-00
2	0010	√	0,8	-000
4	0100	√		
8	1000	√	2,6	0-10
			4,6	01-0
6	0110	√	4,12	-100
9	1001	√	8,9	100-
12	1100	√	8,12	1-00
13	1101			
15	1111			

Example – Quine McCluskey

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1			Column 2	
0	0000	√	0,2	00-0
			0,4	0-00
2	0010	√	0,8	-000
4	0100	√		
8	1000	√	2,6	0-10
			4,6	01-0
6	0110	√	4,12	-100
9	1001	√	8,9	100-
12	1100	√	8,12	1-00
13	1101	√	9,13	1-01
15	1111			

Example – Quine McCluskey

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1			Column 2	
0	0000	√	0,2	00-0
			0,4	0-00
2	0010	√	0,8	-000
4	0100	√		
8	1000	√	2,6	0-10
			4,6	01-0
6	0110	√	4,12	-100
9	1001	√	8,9	100-
12	1100	√	8,12	1-00
13	1101	√	9,13	1-01
			12,13	110-
15	1111			

Example – Quine McCluskey

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1

0	0000	√
2	0010	√
4	0100	√
8	1000	√
6	0110	√
9	1001	√
12	1100	√
13	1101	√
15	1111	√

Column 2

0,2	00-0
0,4	0-00
0,8	-000
2,6	0-10
4,6	01-0
4,12	-100
8,9	100-
8,12	1-00
9,13	1-01
12,13	110-
13,15	11-1

Example – Quine McCluskey

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1			Column 2			Column 3	
0	0000	√	0,2	00-0	√	0,2,4,6	0--0
			0,4	0-00			
2	0010	√	0,8	-000			
4	0100	√					
8	1000	√	2,6	0-10			
			4,6	01-0	√		
6	0110	√	4,12	-100			
9	1001	√	8,9	100-			
12	1100	√	8,12	1-00			
13	1101	√	9,13	1-01			
			12,13	110-			
15	1111	√					
			13,15	11-1			

Example – Quine McCluskey

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1			Column 2			Column 3	
0	0000	√	0,2	00-0	√	0,2,4,6	0--0
			0,4	0-00	√	0,4,2,6	0--0
2	0010	√	0,8	-000		0,4,8,12	--00
4	0100	√					
8	1000	√	2,6	0-10	√		
			4,6	01-0	√		
6	0110	√	4,12	-100			
9	1001	√	8,9	100-			
12	1100	√	8,12	1-00	√		
13	1101	√	9,13	1-01			
			12,13	110-			
15	1111	√					
			13,15	11-1			

Example – Quine McCluskey

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1		
0	0000	√
2	0010	√
4	0100	√
8	1000	√
6	0110	√
9	1001	√
12	1100	√
13	1101	√
15	1111	√

Column 2		
0,2	00-0	√
0,4	0-00	√
0,8	-000	√
2,6	0-10	√
4,6	01-0	√
4,12	-100	√
8,9	100-	
8,12	1-00	√
9,13	1-01	
12,13	110-	
13,15	11-1	

Column 3	
0,2,4,6	0--0
0,4,2,6	0--0
0,4,8,12	--00
0,8,4,12	--00

Example – Quine McCluskey

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1		
0	0000	√
2	0010	√
4	0100	√
8	1000	√
6	0110	√
9	1001	√
12	1100	√
13	1101	√
15	1111	√

Column 2		
0,2	00-0	√
0,4	0-00	√
0,8	-000	√
2,6	0-10	√
4,6	01-0	√
4,12	-100	√
8,9	100-	√
8,12	1-00	√
9,13	1-01	
12,13	110-	√
13,15	11-1	

Column 3	
0,2,4,6	0--0
0,4,2,6	0--0
0,4,8,12	--00
0,8,4,12	--00
8,9,12,13	1-0-

Example – Quine McCluskey

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd(6,13,15)

0	0000
2	0010
4	0100
8	1000
9	1001
12	1100
6	0110
13	1101
15	1111

Column 1		
0	0000	√
2	0010	√
4	0100	√
8	1000	√
6	0110	√
9	1001	√
12	1100	√
13	1101	√
15	1111	√

Column 2		
0,2	00-0	√
0,4	0-00	√
0,8	-000	√
2,6	0-10	√
4,6	01-0	√
4,12	-100	√
8,9	100-	√
8,12	1-00	√
9,13	1-01	√
12,13	110-	√
13,15	11-1	

Column 3	
0,2,4,6	0--0
0,4,2,6	0--0
0,4,8,12	--00
0,8,4,12	--00
8,9,12,13	1-0-
8,12,9,13	1-0-

Example – Quine McCluskey

- F (A,B,C,D) = ∑m(0,2,4,8,9,12) + ∑d(6,13,15)

Column 1			Column 2			Column 3	
0	0000	√	0,2	00-0	√	0,2,4,6	0--0
			0,4	0-00	√	0,4,2,6	0--0
2	0010	√	0,8	-000	√	0,4,8,12	--00
4	0100	√				0,8,4,12	--00
8	1000	√	2,6	0-10	√		
			4,6	01-0	√	8,9,12,13	1-0-
6	0110	√	4,12	-100	√	8,12,9,13	1-0-
9	1001	√	8,9	100-	√		
12	1100	√	8,12	1-00	√		
13	1101	√	9,13	1-01	√		
			12,13	110-	√		
15	1111	√					
			13,15	11-1			

Example – Quine McCluskey

- F (A,B,C,D) = Σm(0,2,4,8,9,12) + Σd(6,13,15)

Column 1			Column 2			Column 3	
0	0000	√	0,2	00-0	√	0,2,4,6	0--0
			0,4	0-00	√	0,4,2,6	0--0
2	0010	√	0,8	-000	√	0,4,8,12	--00
4	0100	√				0,8,4,12	--00
8	1000	√	2,6	0-10	√		
			4,6	01-0	√	8,9,12,13	1-0-
6	0110	√	4,12	-100	√	8,12,9,13	1-0-
9	1001	√	8,9	100-	√		
12	1100	√	8,12	1-00	√		
13	1101	√	9,13	1-01	√		
			12,13	110-	√		
15	1111	√					
			13,15	11-1			

Prime implicants:
ABD , A'D' , C'D' , AC'

Example – Quine McCluskey

		0	2	4	8	9	12
13,15	11-1						
0,2,4,6	0--0						
0,4,8,12	--00						
8,9,12,13	1-0-						

Example – Quine McCluskey

		0	2	4	8	9	12
13,15	11-1						
0,2,4,6	0--0	X	X	X			
0,4,8,12	--00	X		X	X		X
8,9,12,13	1-0-				X	X	X

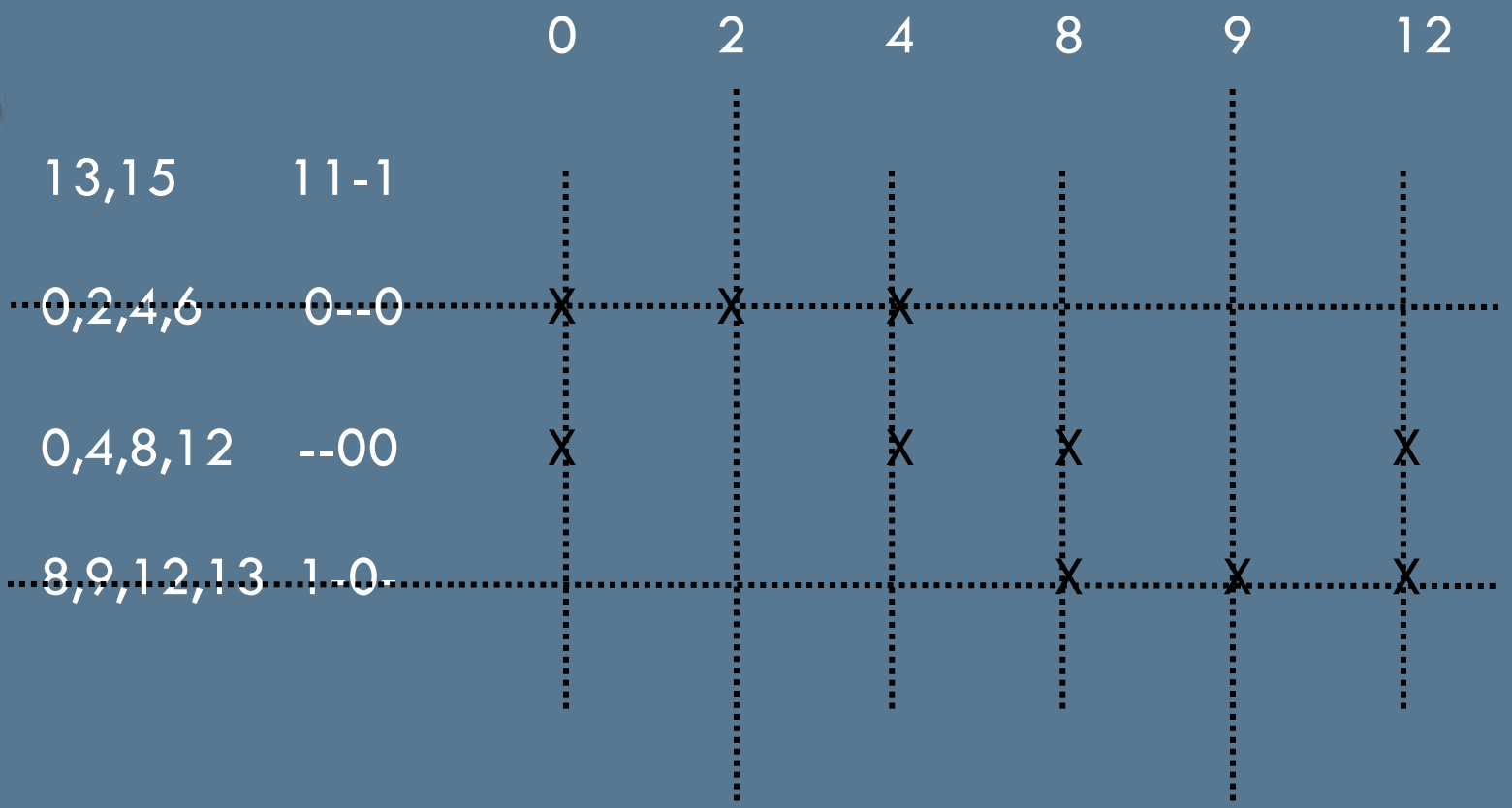
Example – Quine McCluskey

		0	2	4	8	9	12
13,15	11-1						
0,2,4,6	0--0	X	X	X			
0,4,8,12	--00	X		X	X		X
8,9,12,13	1-0-				X	X	X

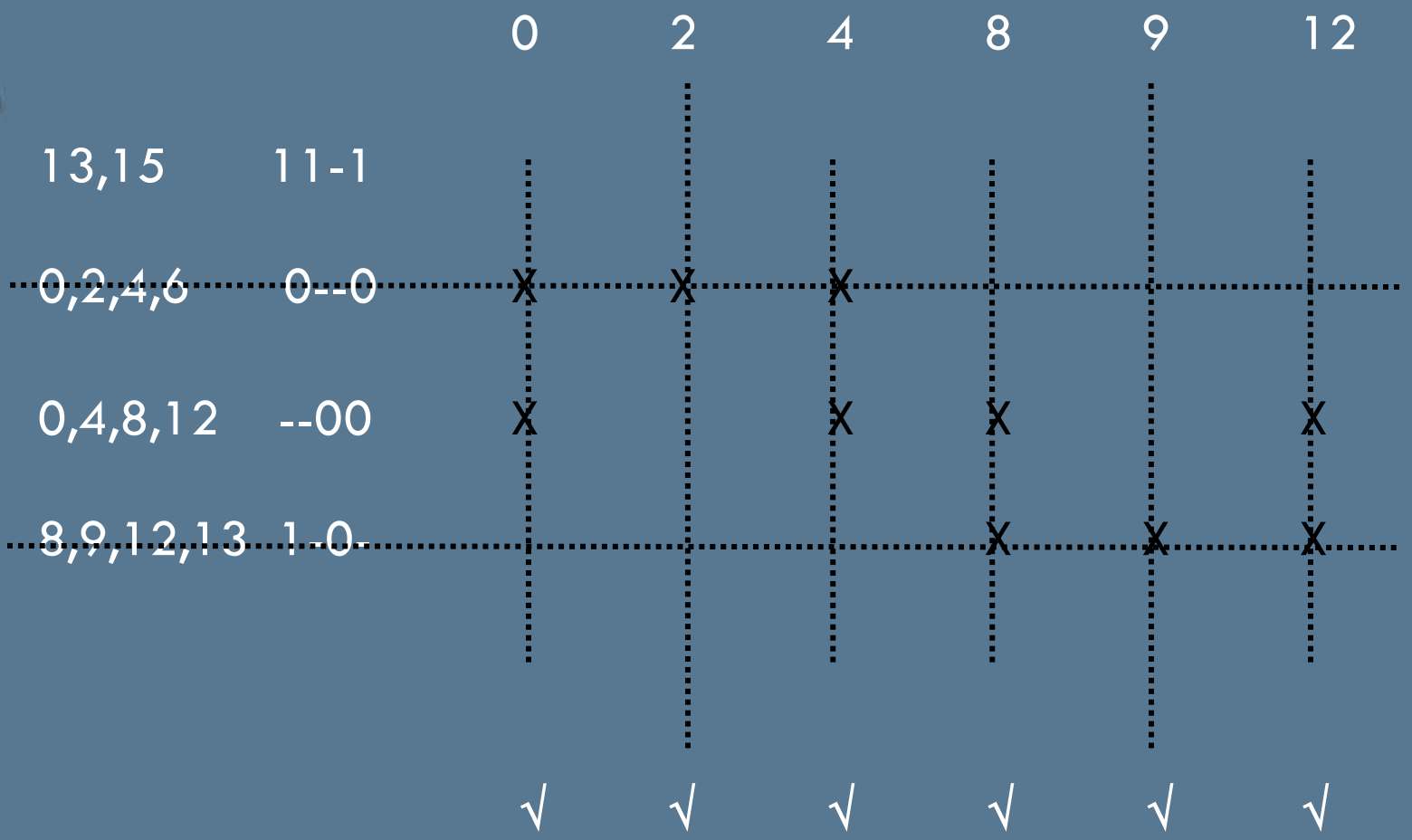
Example – Quine McCluskey

		0	2	4	8	9	12
13,15	11-1						
0,2,4,6	0--0	X	X	X			
0,4,8,12	--00	X		X	X		X
8,9,12,13	1--0-				X	X	X

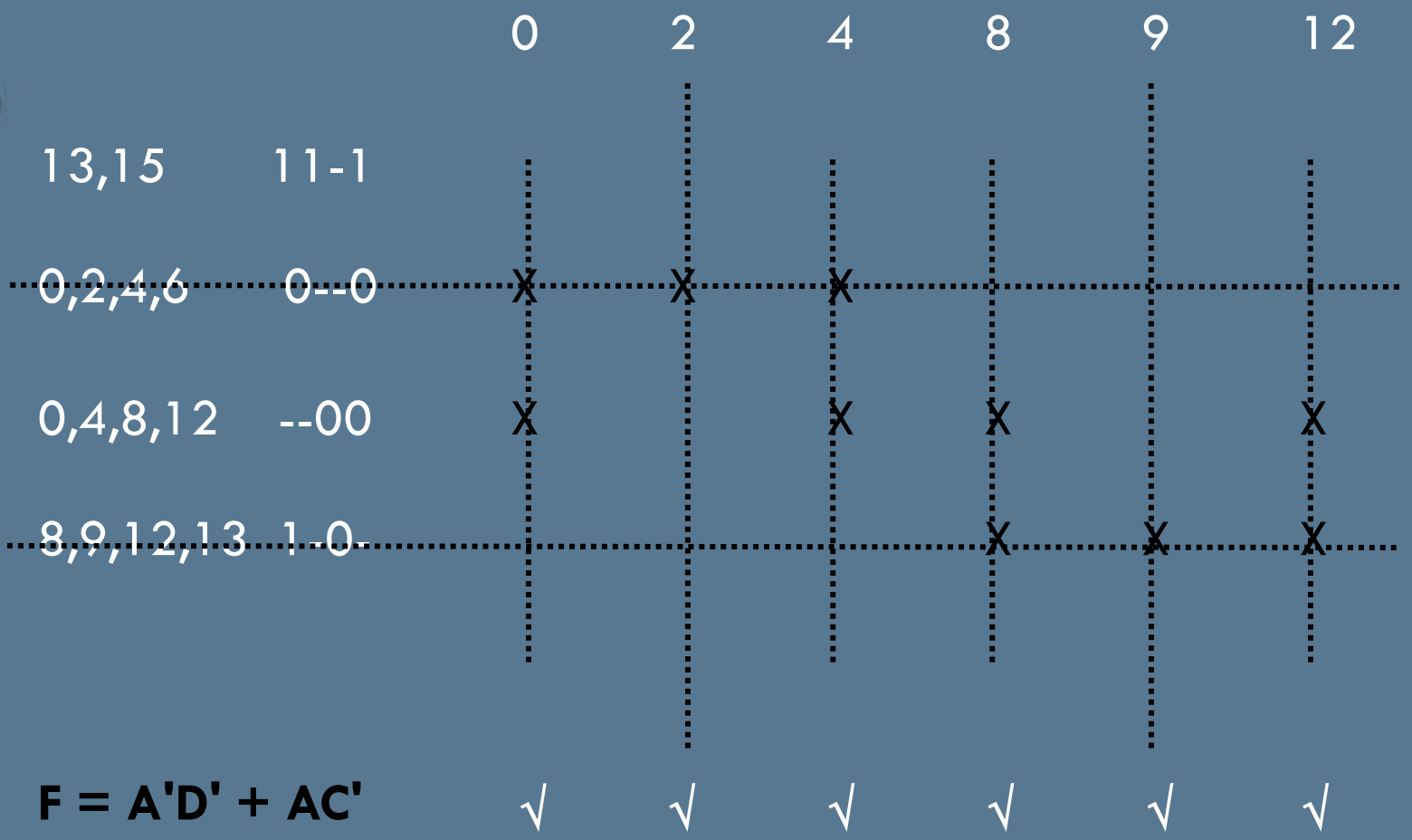
Example – Quine McCluskey



Example – Quine McCluskey



Example – Quine McCluskey



Quiz

- Simplify

  $F(w,x,y,z)=\sum m(4,9,11,12,15) + \sum d(5,13)$ using Karnaugh Map