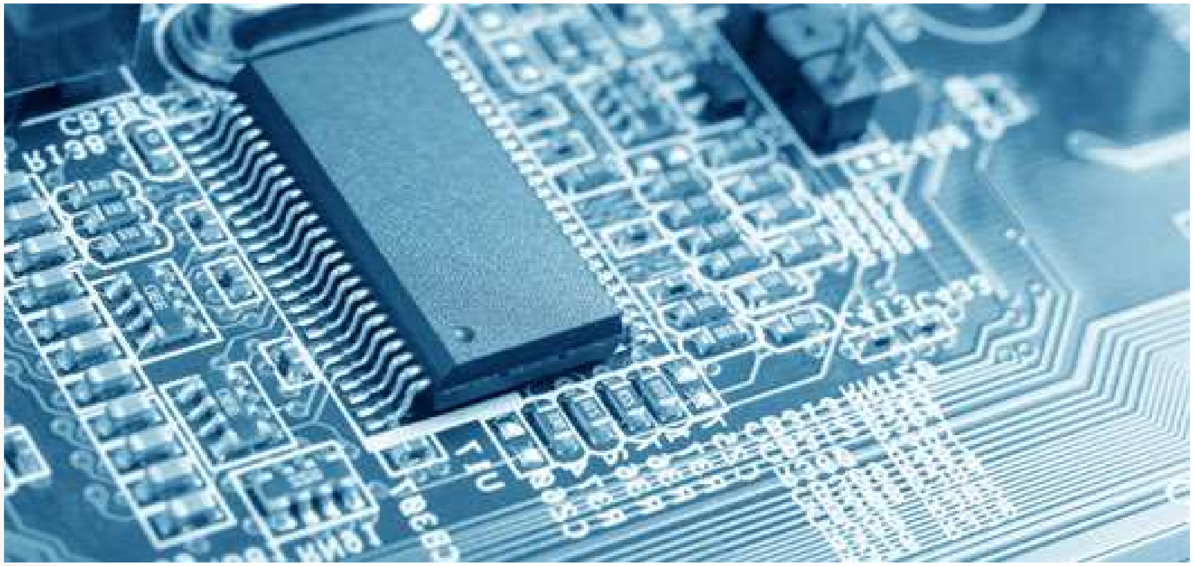
NAZARBAYEV UNIVERSITY
SCHOOL OF SCIENCE AND TECHNOLOGY



ROBT206 – Microcontrollers with Lab

Lecture 8 – Maps Continued

1 February, 2018

Topics

Today's Topics
Map manipulation

Four Variable Maps

- Map and location of minterms (ABCD):

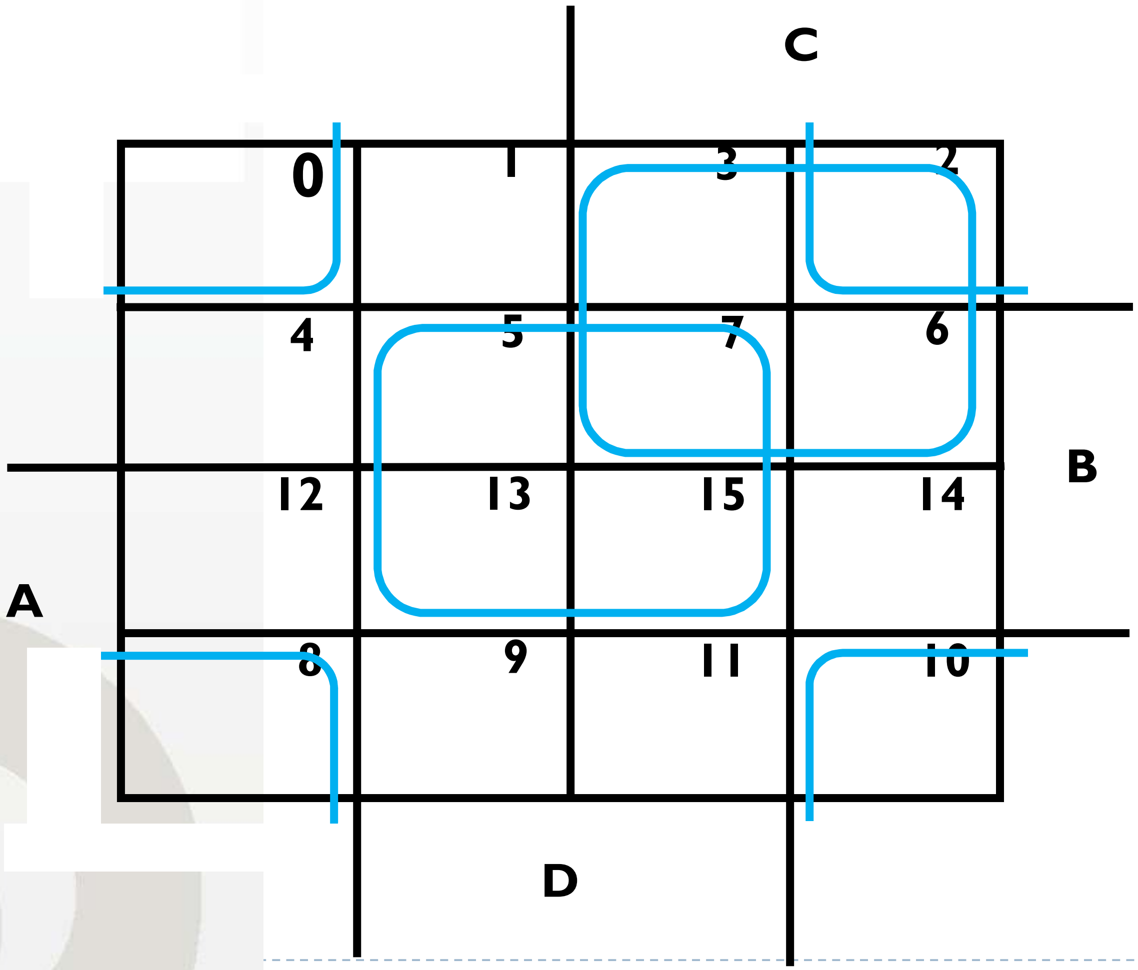
	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	0	1	3	2
$\bar{A}B$	4	5	7	6
AB	12	13	15	14
$A\bar{B}$	8	9	11	10

Four Variable Terms

- Four variable maps can have rectangles corresponding to:
  - A single 1 = 4 variables, (i.e. Minterm)
  - Two 1s = 3 variables,
  - Four 1s = 2 variables
  - Eight 1s = 1 variable,
  - Sixteen 1s = zero variables (i.e. Constant "1")

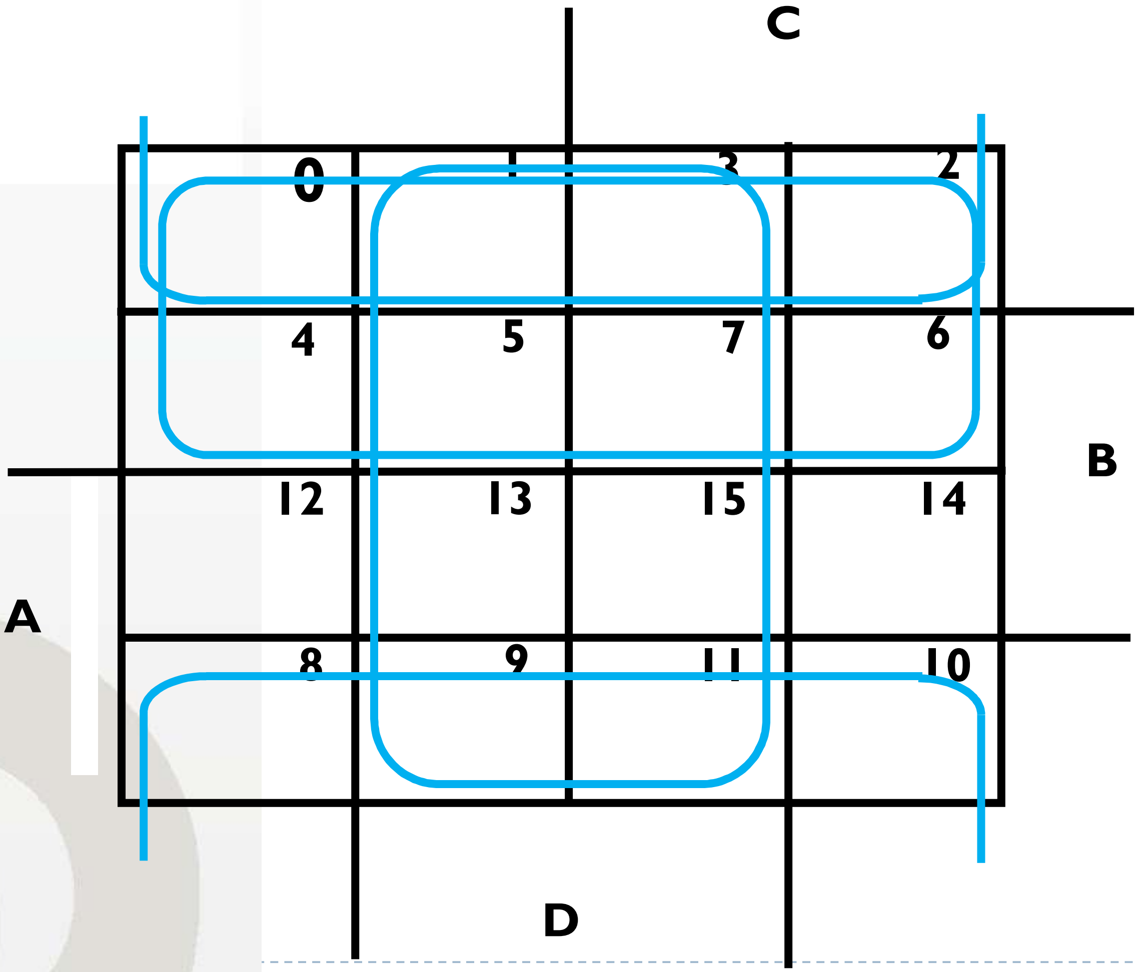
Four-Variable Maps

- **Example Shapes of Rectangles:**



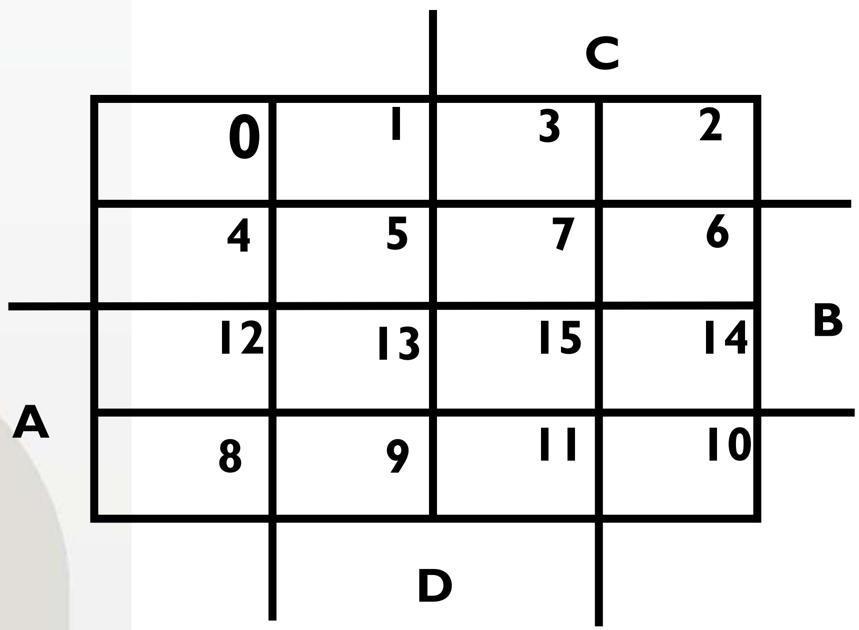
Four-Variable Maps

- **Example Shapes of Rectangles:**



Four-Variable Map Simplification

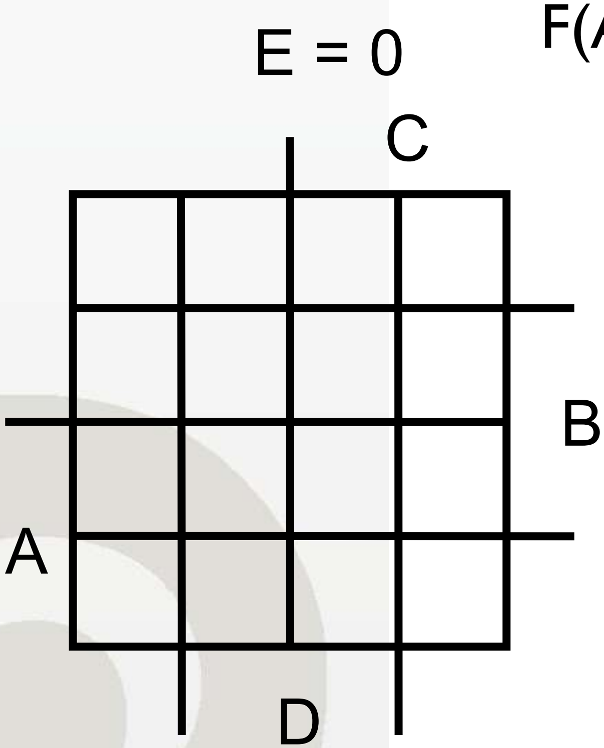
$$F(A, B, C, D) = \Sigma m(0,1,2,4,5,6,8,9,10,12,13)$$

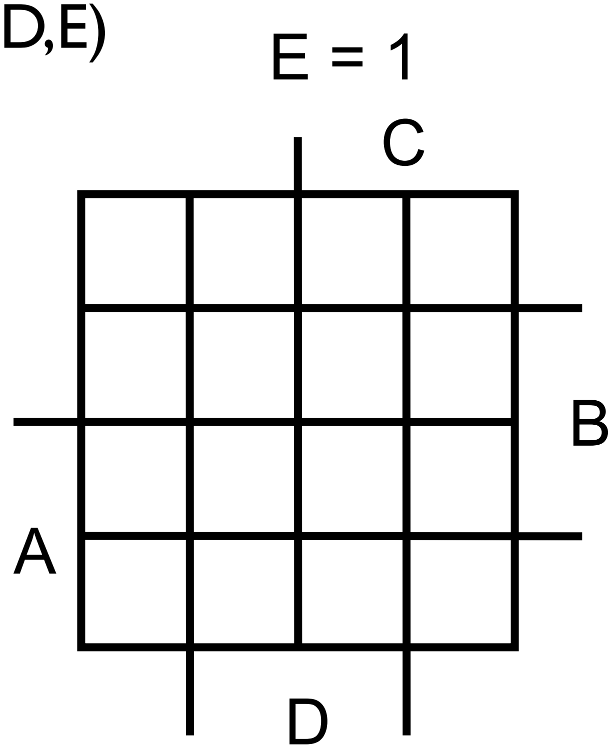


Five Variable or More K-Maps

- For five variable problems, we use two adjacent K-maps. It becomes harder to visualize adjacent minterms.
- You can extend the problem to six variables by using four K-Maps.
-

F(A,B,C,D,E)



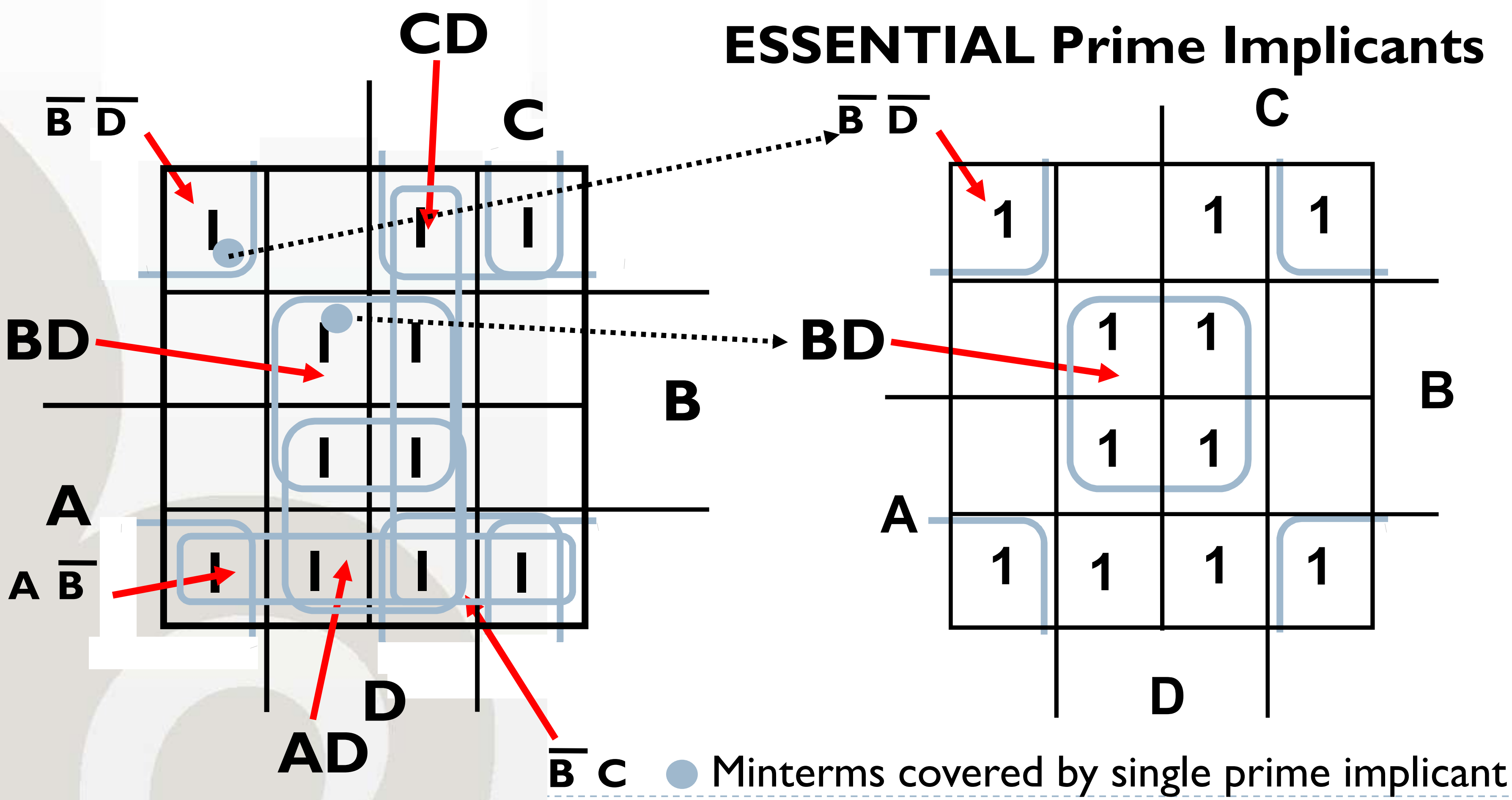


Systematic Simplification

- A **Prime Implicant** is a product term obtained by combining the **maximum** possible number of adjacent squares in the map into a rectangle with the number of squares a power of 2.
- A prime implicant is called an **Essential Prime Implicant** if it is the only prime implicant that covers (includes) one or more minterms.
- Prime Implicants and Essential Prime Implicants can be determined by inspection of a K-Map.
- A set of prime implicants ***"covers all minterms"*** if, for each minterm of the function, at least one prime implicant in the set of prime implicants includes the minterm.

Example of Prime Implicants

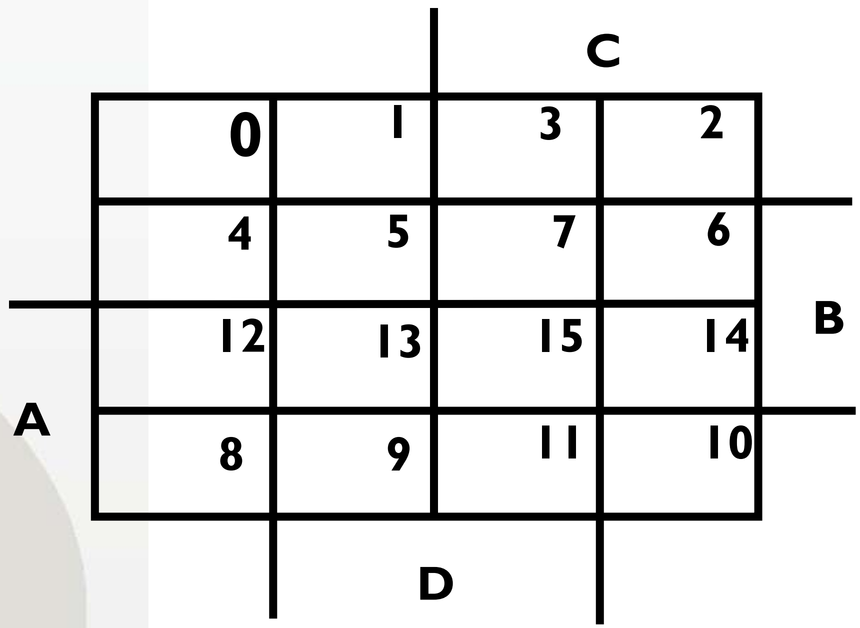
- Find ALL Prime Implicants



Prime Implicant Practice

- **Find all prime implicants for:**

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



Another Example

- **Find all prime implicants for:**

$$G(A, B, C, D) = \Sigma m(0,2,3,4,7,12,13,14,15)$$

- **Hint: There are seven prime implicants!**

Optimization Algorithm

- Find <u>all</u> prime implicants.
- Include <u>all</u> essential prime implicants in the solution
- Select a minimum cost set of non-essential prime implicants to cover all minterms not yet covered:
  - Use the Selection Rule:

  Minimize the overlap among prime implicants as much as possible. In particular, in the final solution, make sure that each prime implicant selected includes at least one minterm not included in any other prime implicant selected.

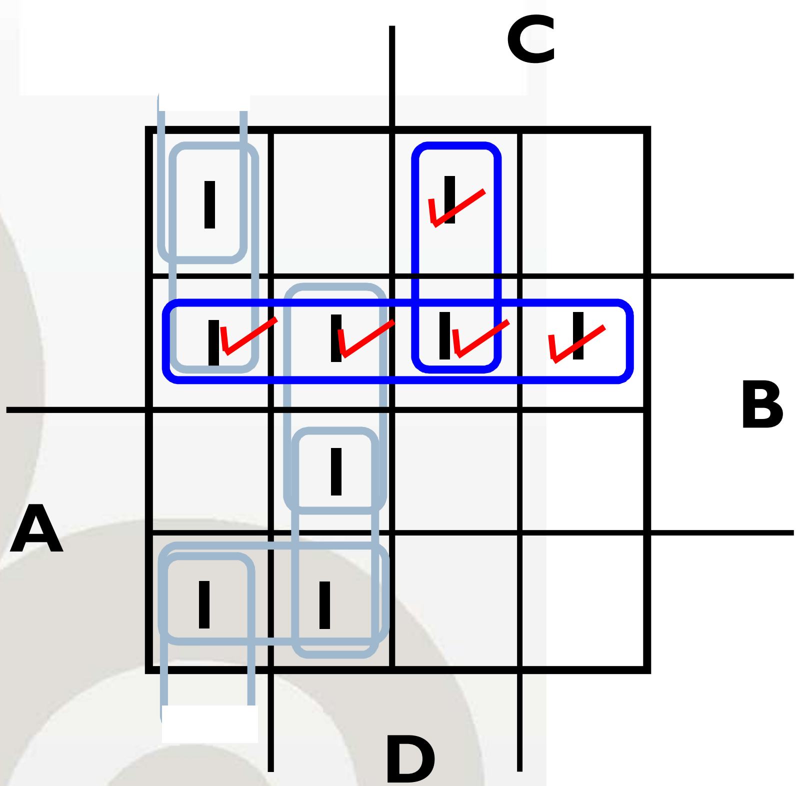
Simplification Using Prime Applicants

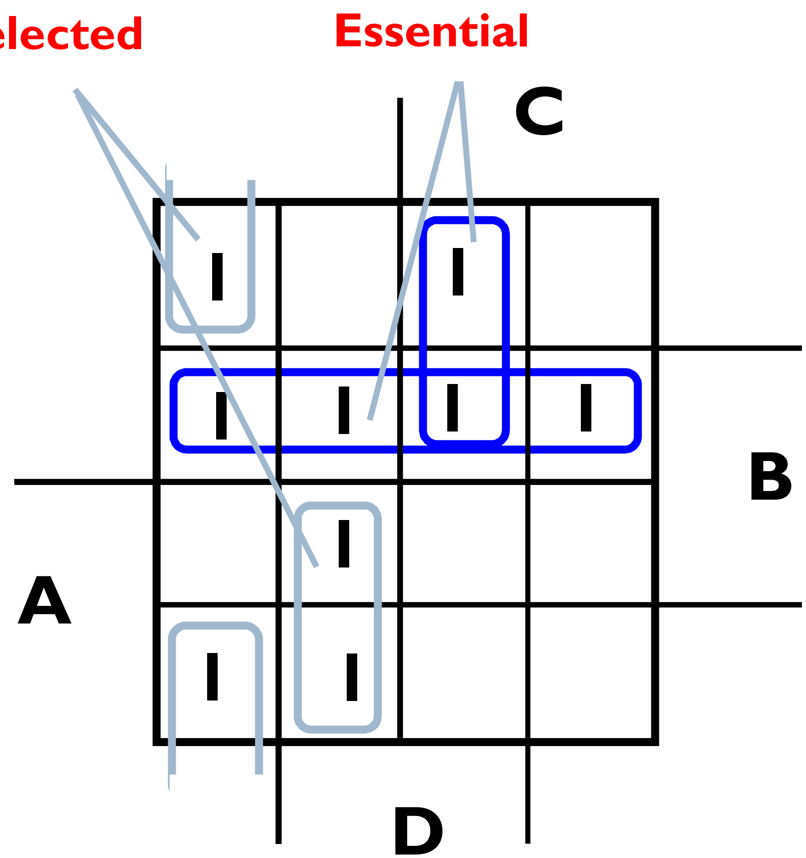
$$F(A, B, C, D) = \Sigma_m(3,4,5,7,9,13,14,15)$$

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

Selection Rule Example

- Simplify F(A, B, C, D) given on the K-map.

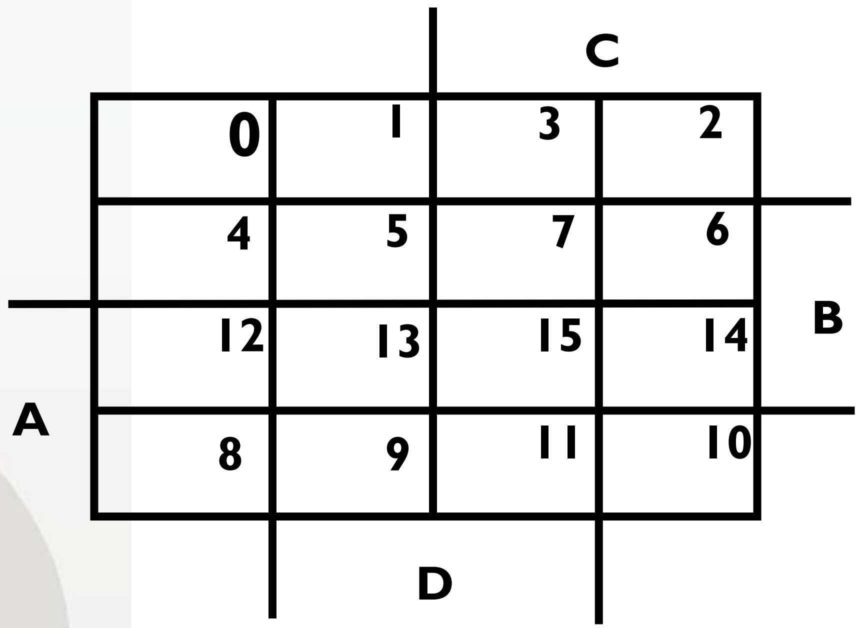




✓ Minterms covered by essential prime implicants

Simplification Using Selection Rule

$$F(A, B, C, D) = \Sigma_m(0,1,2,4,5,10,11,13,15)$$



Product of Sum Optimization

$$F(A, B, C, D) = \Sigma_m(0,1,2,5,8,9,10)$$

C

0	1	3	2
4	5	7	6
12	13	15	14
8	9	11	10

B

A

D

Don't Cares in K-Maps

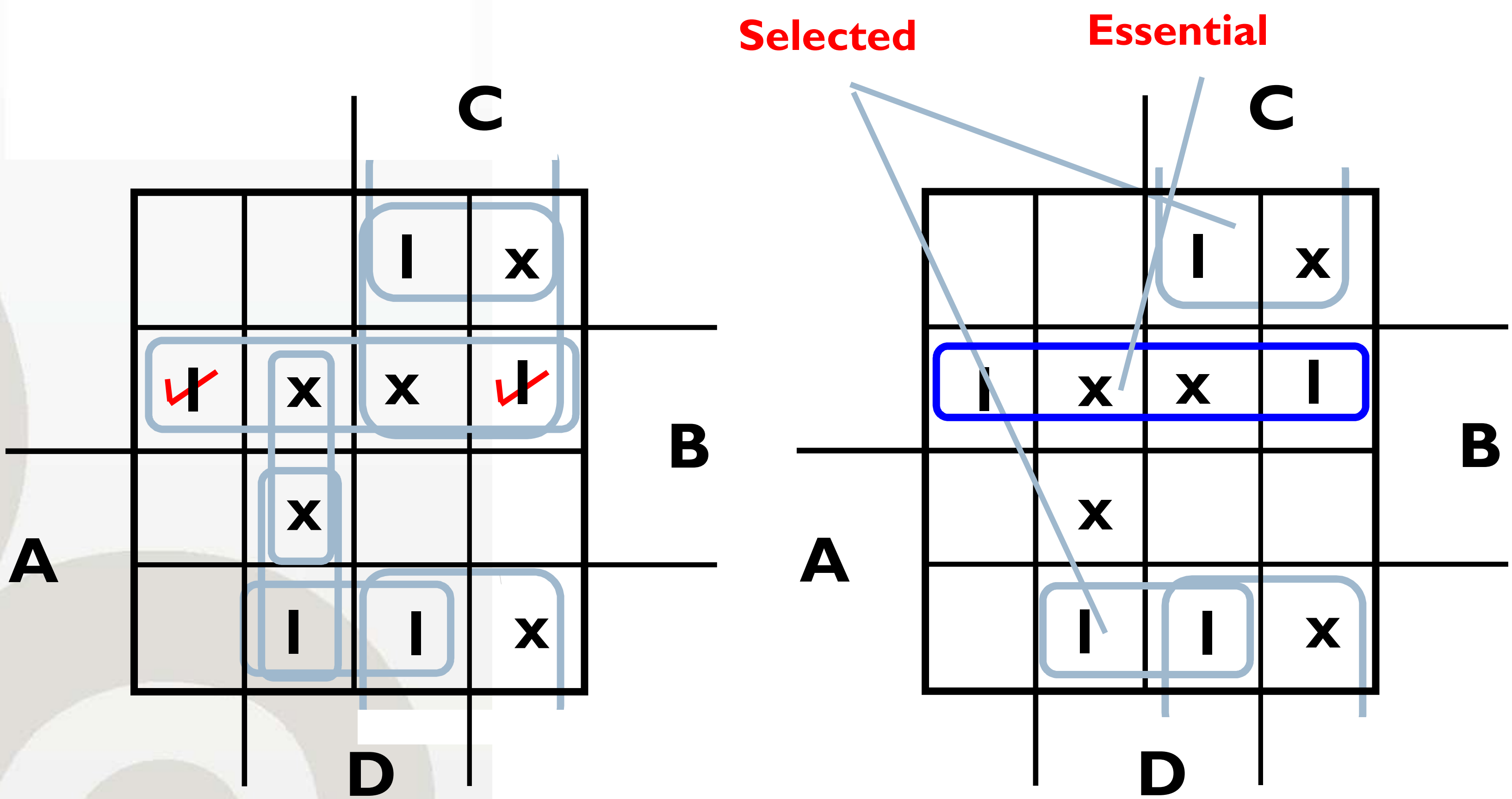
- Sometimes a function table or map contains entries for which it is known:
  - the input values for the minterm will never occur, or
  - The output value for the minterm is not used
- In these cases, the output value need not be defined
- Instead, the output value is defined as a "don't care"

- By placing "don't cares" (an "x" entry) in the function table or map, the cost of the logic circuit may be lowered.

- Example 1: A logic function having the binary codes for the BCD digits as its inputs. Only the codes for 0 through 9 are used. The six codes, 1010 through 1111 never occur, so the output values for these codes are "x" to represent "don't cares."

Selection Rule Example with Don't Cares

- Simplify F(A, B, C, D) given on the K-map.

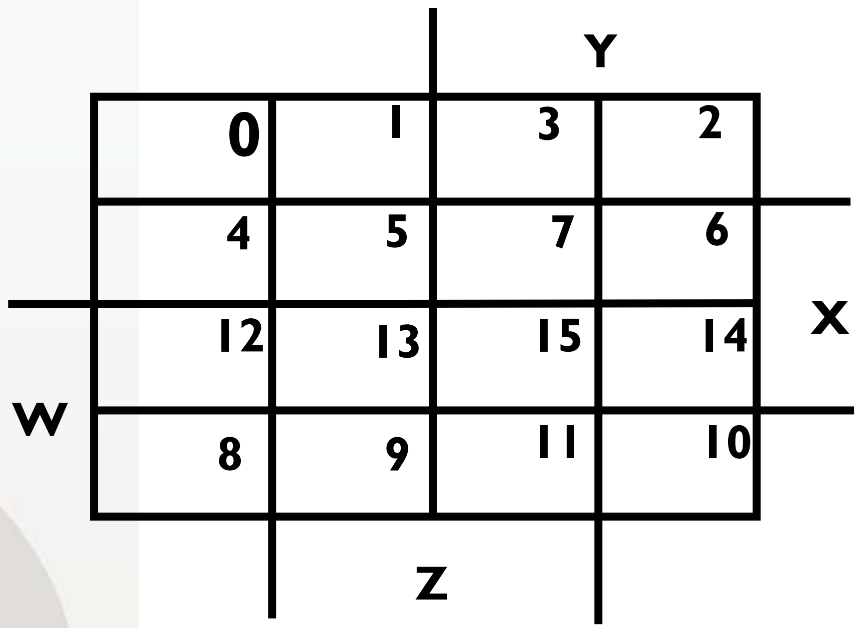


Minterms covered by essential prime implicants

Product of Sums Example

- **Find the optimum POS solution:**

$$F(A,B,C,D) = \Sigma m(3,9,11,12,13,14,15) + \Sigma d\,(1,4,6)$$



Any Questions?