# DON’T CARE CONDITIONS IN K-MAP

Digital logic design

# Don’t Care (X) Conditions

- A situation arises in which input variable combinations are not allowed
- The value of a function is not specified for certain combinations of variables

  BCD; 1010-1111: don't care
- Don’t care terms either a 1 or a 0 may be assigned to the output

# Don't-Care Conditions

- The don't-care conditions can be utilized in logic minimization
  - *Can be implemented as 0 or 1*
- simplify $F(w, x, y, z) = \Sigma(1, 3, 7, 11, 15)$ which has the don't-care conditions $d(w, x, y, z) = \Sigma(0, 2, 5)$.

# Example 1:Don't-Care Conditions

| A | B | C | D | Y |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | X |
| 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 1 | 0 | X |
| 1 | 0 | 1 | 1 | X |
| 1 | 1 | 0 | 0 | X |
| 1 | 1 | 0 | 1 | X |
| 1 | 1 | 1 | 0 | X |
| 1 | 1 | 1 | 1 | X |

Y

| CD \ AB | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | | | | |
| 01 | | | | |
| 11 | | | | |
| 10 | | | | |

# Example 1: Don't-Care Conditions

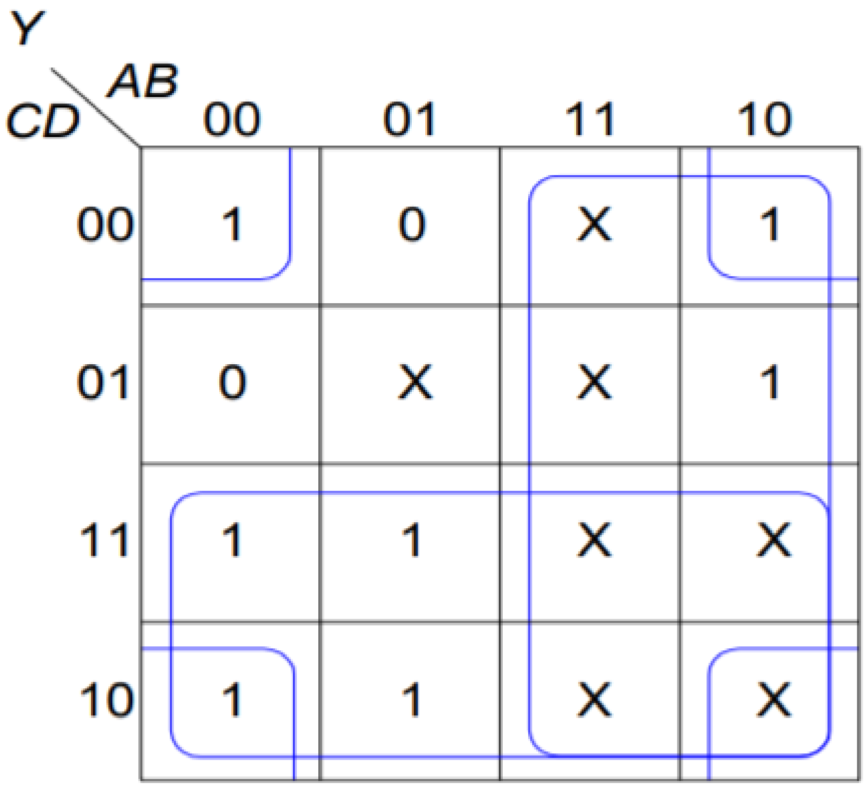
| A | B | C | D | Y |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | X |
| 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 1 | 0 | X |
| 1 | 0 | 1 | 1 | X |
| 1 | 1 | 0 | 0 | X |
| 1 | 1 | 0 | 1 | X |
| 1 | 1 | 1 | 0 | X |
| 1 | 1 | 1 | 1 | X |

Y

| CD \ AB | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | 0 | X | 1 |
| 01 | 0 | X | X | 1 |
| 11 | 1 | 1 | X | X |
| 10 | 1 | 1 | X | X |

# Example 1:Don't-Care Conditions

| A | B | C | D | Y |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | X |
| 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 1 | 0 | X |
| 1 | 0 | 1 | 1 | X |
| 1 | 1 | 0 | 0 | X |
| 1 | 1 | 0 | 1 | X |
| 1 | 1 | 1 | 0 | X |
| 1 | 1 | 1 | 1 | X |




$Y = A + \overline{B}\overline{D} + C$

# Example 1: Don't-Care Conditions

| A | B | C | D | Y |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | X |
| 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 1 | 0 | X |
| 1 | 0 | 1 | 1 | X |
| 1 | 1 | 0 | 0 | X |
| 1 | 1 | 0 | 1 | X |
| 1 | 1 | 1 | 0 | X |
| 1 | 1 | 1 | 1 | X |

Y

| CD \ AB | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | 0 | X | 1 |
| 01 | 0 | X | X | 1 |
| 11 | 1 | 1 | X | X |
| 10 | 1 | 1 | X | X |

- Y=A'C+AB'C'+B'C'D'

Without considering the don't care condition

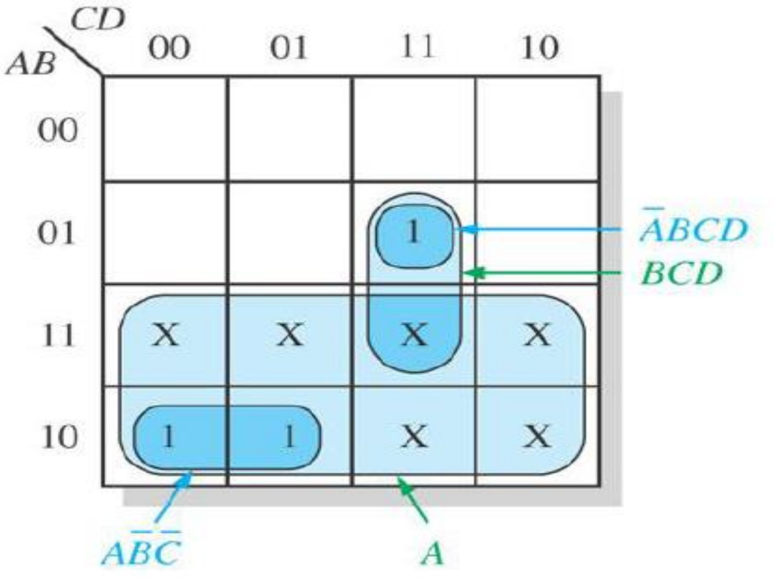
# Example 2: Don’t Care (X) Conditions

| Inputs $ABCD$ | Output $Y$ |
|---|---|
| 0 0 0 0 | 0 |
| 0 0 0 1 | 0 |
| 0 0 1 0 | 0 |
| 0 0 1 1 | 0 |
| 0 1 0 0 | 0 |
| 0 1 0 1 | 0 |
| 0 1 1 0 | 0 |
| 0 1 1 1 | 1 |
| 1 0 0 0 | 1 |
| 1 0 0 1 | 1 |
| 1 0 1 0 | X |
| 1 0 1 1 | X |
| 1 1 0 0 | X |
| 1 1 0 1 | X |
| 1 1 1 0 | X |
| 1 1 1 1 | X |

Don’t cares

(a) Truth table

## Example of the use of “don’t care” conditions to simplify an expression




(b) Without “don’t cares” $Y = A\bar{B}\bar{C} + \bar{A}BCD$
With “don’t cares” $Y = A + BCD$

# Example 3:Don't Care (X) Conditions

| A | B | C | D | Z |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 1 | x |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 1 | 0 |
| 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | x |
| 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 | x |
| 1 | 0 | 0 | 0 | x |
| 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 | x |
| 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 |

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

$$Z = Z_{(A,B,C} = AB + AD + \bar{A}\bar{B}\bar{D}$$

# Example 4:Don’t Care (X) Conditions

yz→essential prime implicant
W’x’ and w’z→ non-essential prime implicant

- *F = Σ( 1, 3, 7, 11, 15) ; D = Σ(0,2,5)*
- *Either expression is acceptable*

■ *F = yz + w'x';* *F = yz + w'z*

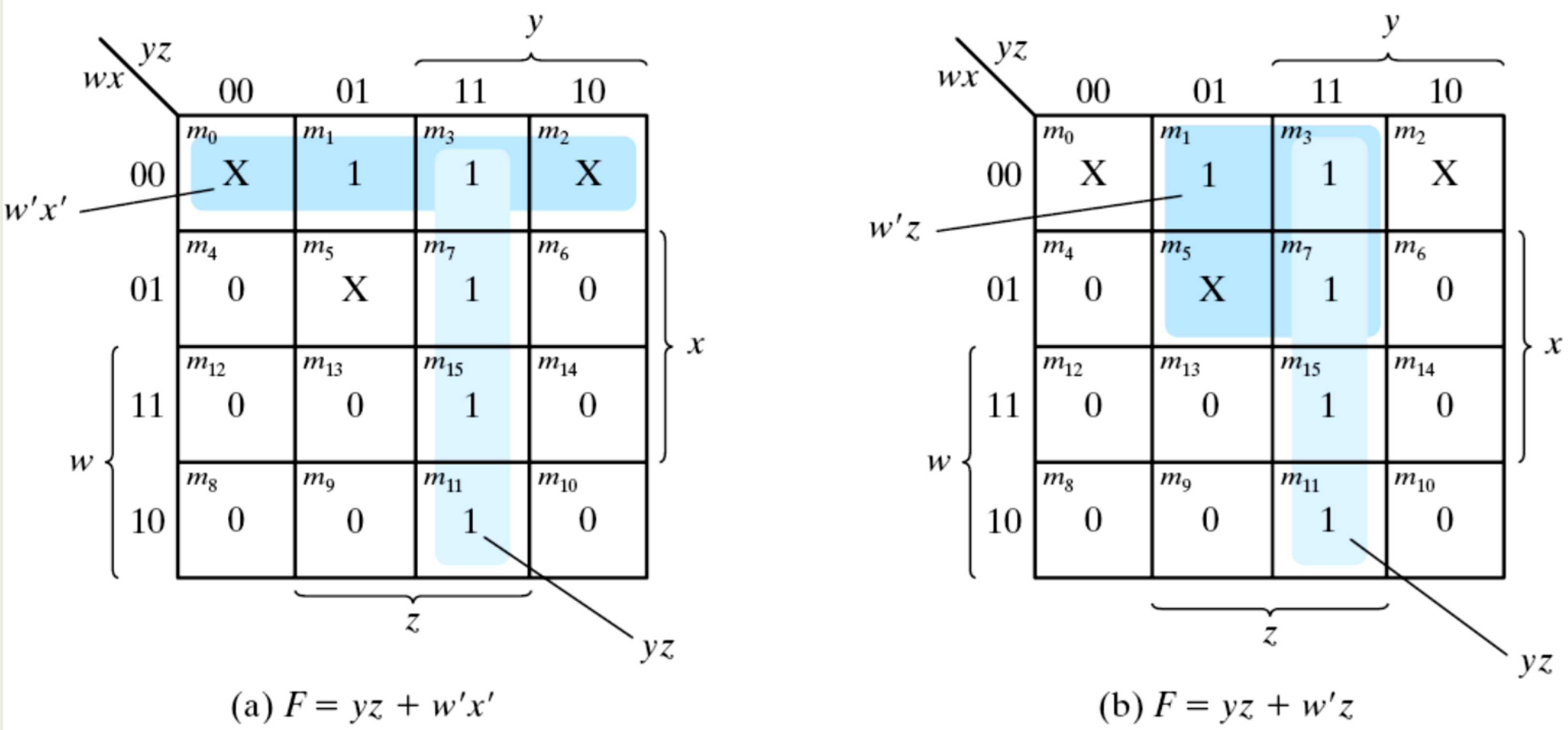



Figure 3.17 Example with don't-care Conditions

# Don’t Care Conditions

$\overline{A}.D$

| AB\CD | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 0 | 1 | 1 | 0 |
| 01 | 0 | 1 | 1 | 0 |
| 11 | x | x | x | x |
| 10 | 0 | 0 | x | x |

# PRIME IMPLICANTS

Digital logic design

# Prime Implicants

- *A **prime implicant:** a product term obtained by combining the maximum possible number of adjacent squares (combining all possible maximum numbers of squares).*
- ***Essential prime implicant :**A prime implicant with atleast one element that is not covered by one or more prime implicants .*
- *The essential P.I. must be included.*
- ***Non Essential Prime Implicant :** A Prime implicant that has no element that cannot be covered by other prime implicant*

# Essential Prime Implicants

Y

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

Q: Is the blue group an essential prime?

A. Yes
B. No

- Simplify the following Boolean function

$$\mathbf{F}(\mathbf{A}, \mathbf{B}, \mathbf{C}) = \sum m(0, 1, 4, 6, 7) = \overline{\mathbf{A}}\overline{\mathbf{B}}\overline{\mathbf{C}} + \overline{\mathbf{A}}\overline{\mathbf{B}}\mathbf{C} + \mathbf{A}\overline{\mathbf{B}}\overline{\mathbf{C}} + \mathbf{A}\mathbf{B}\overline{\mathbf{C}} + \mathbf{A}\mathbf{B}\mathbf{C}$$

- Solution:

| A \ BC | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 1 | 1 | 0 | 0 |
| 1 | 1 | 0 | 1 | 1 |

*zero-set*$(2, 3, 5)$

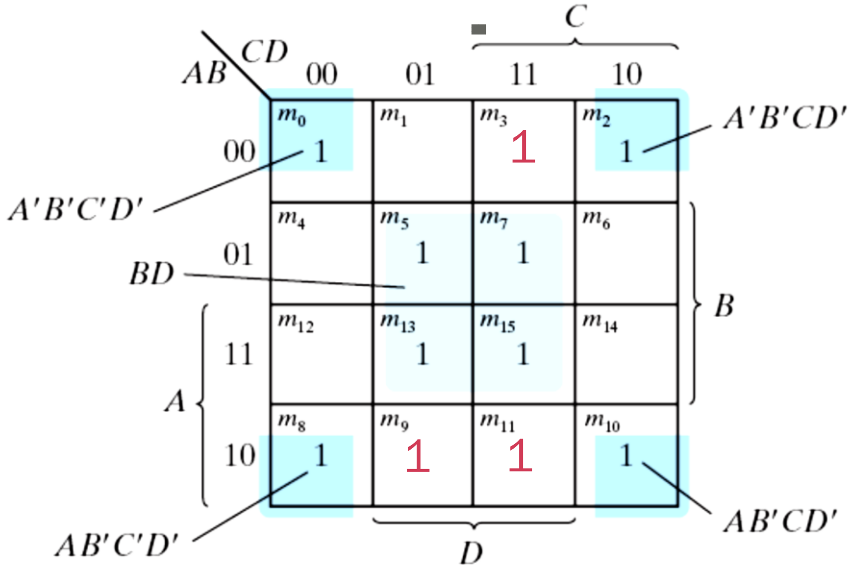
*one-set*$(0, 1, 4, 6, 7)$

- The essential prime implicants are $\overline{\mathbf{A}}\overline{\mathbf{B}}$ and $\mathbf{AB}$.
- The non-essential prime implicants are $\overline{\mathbf{B}}\overline{\mathbf{C}}$ or $\mathbf{A}\overline{\mathbf{C}}$.
- The sum-of-products solution is

$$\mathbf{F} = \mathbf{AB} + \overline{\mathbf{A}}\overline{\mathbf{B}} + \overline{\mathbf{B}}\overline{\mathbf{C}} \text{ or } \mathbf{F} = \mathbf{AB} + \overline{\mathbf{A}}\overline{\mathbf{B}} + \mathbf{A}\overline{\mathbf{C}}.$$

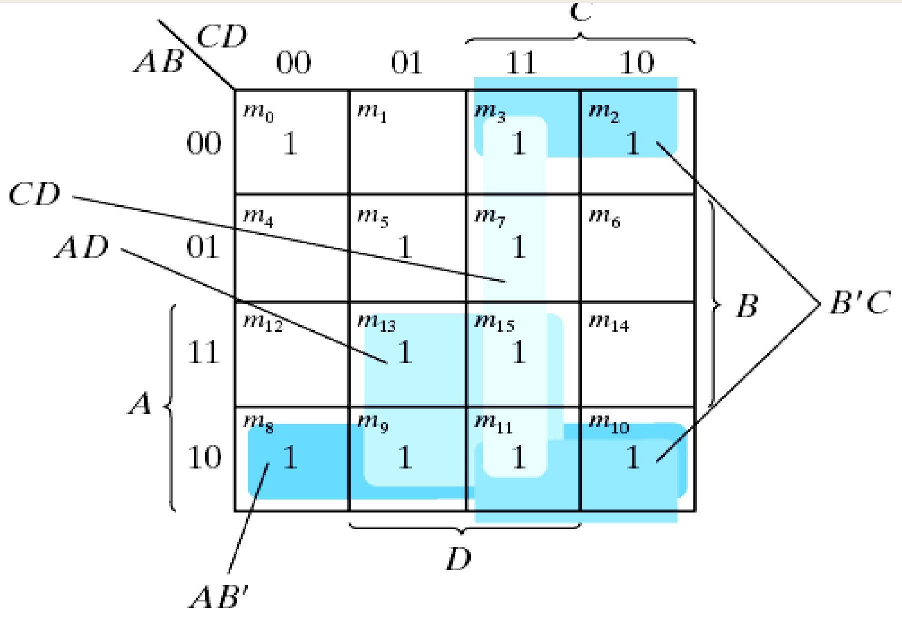
# Example: Prime Implicants

- Consider $F(A, B, C, D) = \Sigma(0, 2, 3, 5, 7, 8, 9, 10, 11, 13, 15)$
  - *The simplified expression may not be unique*
  - $F = BD + B'D' + CD + AB'$
    $= BD + B'D' + B'C + AB'$
    $= BD + B'D' + B'C + AD$
    $= BD + B'D' + CD + AD$




Note: $A'B'C'D' + A'B'CD' = A'B'D'$
$AB'C'D' + AB'CD' = AB'D'$
$A'B'D' + AB'D' = B'D'$

(a) Essential prime implicants $BD$ and $B'D'$




(b) Prime implicants $CD$, $B'C$, $AD$, and $AB'$

Thank You