*University Of Diyala*
*College of Engineering*
*Computer Engineering Department*


# Digital Systems Design

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Third Class
2017

# *Degree Calculation*

- First term exam 8%
- Second term exam 8%
- First assignment 5%
- Second assignment 5%
- Attendance in class 4%
- Final exam 60%

**Text books**

- Modern digital System design by Richared S. Sandige.
- Digital System VHDL& Verilog Design

# *Subject headlines*

- Chapter one & two: minimization techniques
- Chapter three : Design of combinational Logic circuits &PAL, PLA,PLD, PAL,ASM ,examples
- Chapter four : Logic Hazard.
- Chapter five : Introduction to Sequential logic circuits
- Chapter six : Synchronous sequential logic circuits, Algorithm State Machines ( A.S.M ) & Finite State Machines ( F.S.M ) , Synchronous design using PLD
- Chapter seven : Asynchronous sequential logic circuits ,design steps , Essential and non- essential hazards & Asynchronous pulse mode ccts.
- introduction to CPLD & FPGA.
- Introduction to advance digital systems design.

# Chapter 1

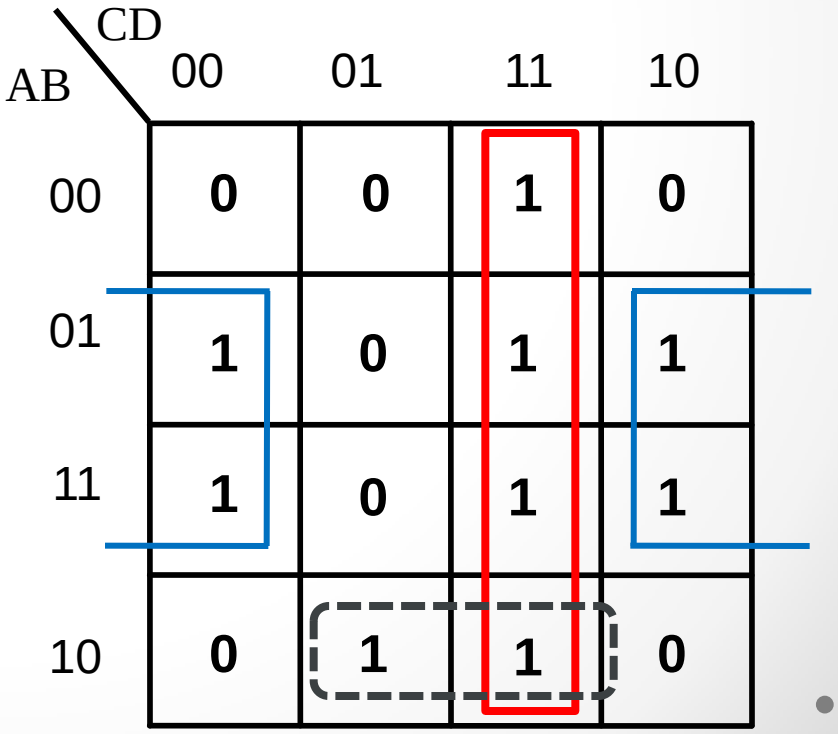
# Five & six variable K-Map

# Four, Five & six variable K-Map

- Four–variable  Karnaugh map
- Example:

F(A,B,C,D) = Σm(3,4,6,7,9,11,12,14,15).

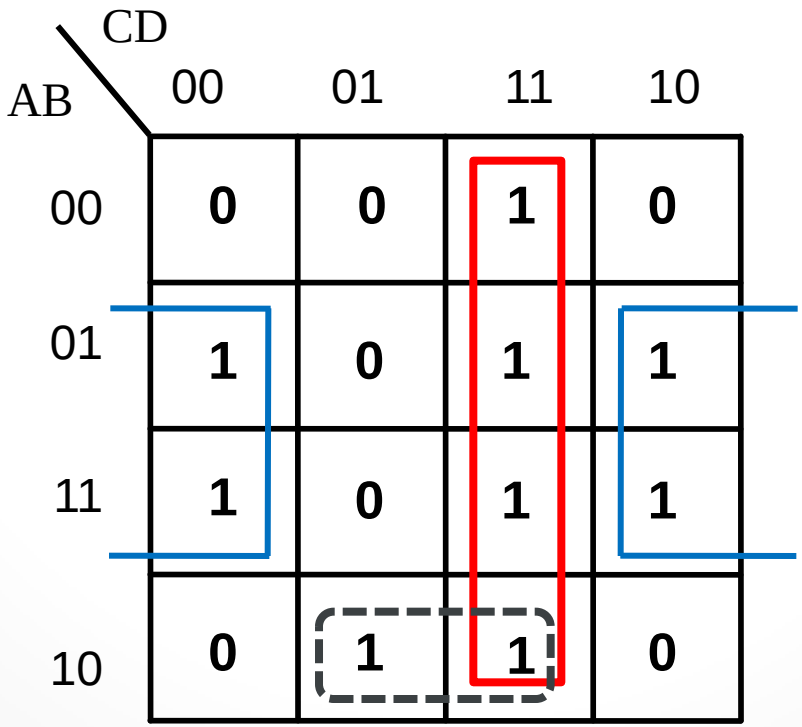
| AB \ CD | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 0 | 1 | 3 | 2 |
| 01 | 4 | 5 | 7 | 6 |
| 11 | 12 | 13 | 15 | 14 |
| 10 | 8 | 9 | 11 | 10 |



# Example (continue)

$$F(A, B, C, D) = (A \bullet \overline{B} \bullet D) + (B \bullet \overline{D}) + (C \bullet D)$$ ⇐ SOP

$$\overline{F}(A, B, C, D) = (\overline{A} + B + \overline{D}) \bullet (\overline{B} + D) \bullet (\overline{C} + \overline{D})$$ ⇐ POS

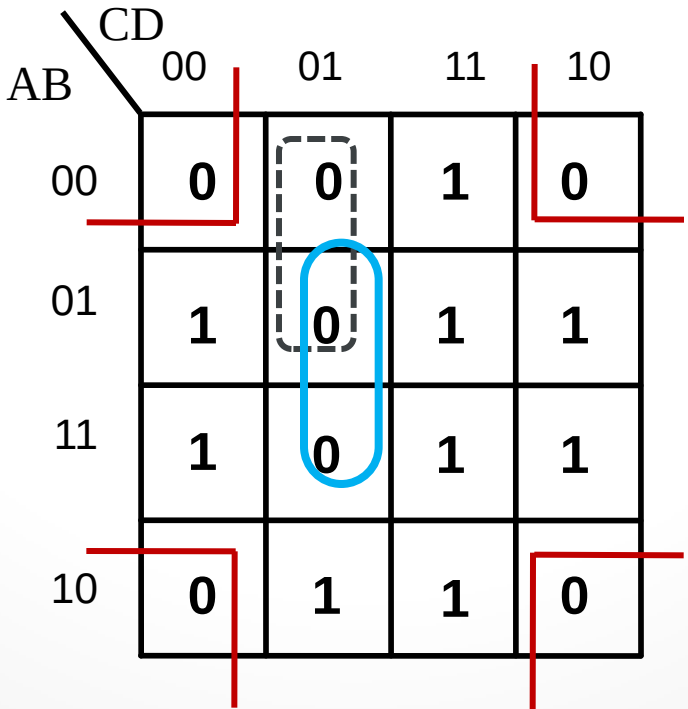


# Example (continue)

F(A,B,C,D) = ΠM(0,1,2,5,8,10,13).

$$\overline{F}(A, B, C, D) = (\overline{B} \bullet \overline{D}) + (\overline{A} \bullet \overline{C} \bullet D) + (B \bullet \overline{C} \bullet D)$$ ⇐ SOP

$$F(A, B, C, D) = (B + D) \bullet (A + C + \overline{D}) \bullet (\overline{B} + C + \overline{D})$$ ⇐ POS

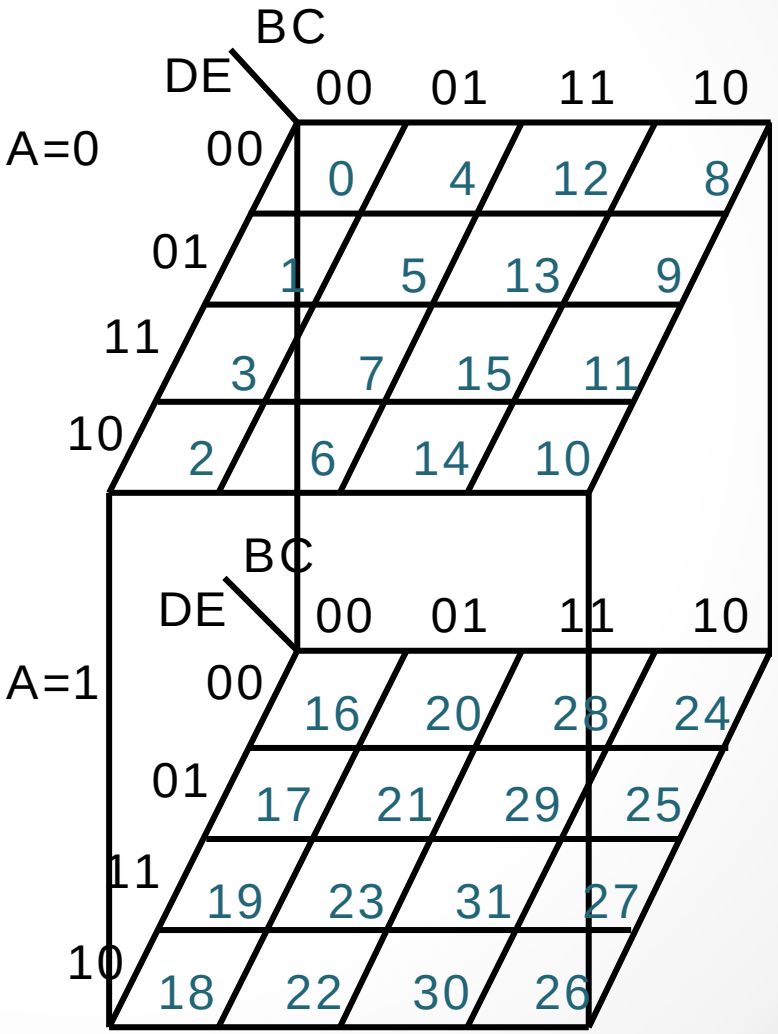


# SOP & POS

- Minimum POS form of $F$ = Minimum SOP form of $\overline{F}$
- Minimum SOP form of $F$ = Minimum POS form of $\overline{F}$
- SOP
  - (1) ⇒ $F$ (SOP)
  - (0) ⇒ $\overline{F}$ (SOP)
- POS
  - (1) ⇒ $\overline{F}$ (POS)
  - (0) ⇒ $F$ (POS)

# Five–variable Karnaugh map

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



# Five–variable Karnaugh map

A=0

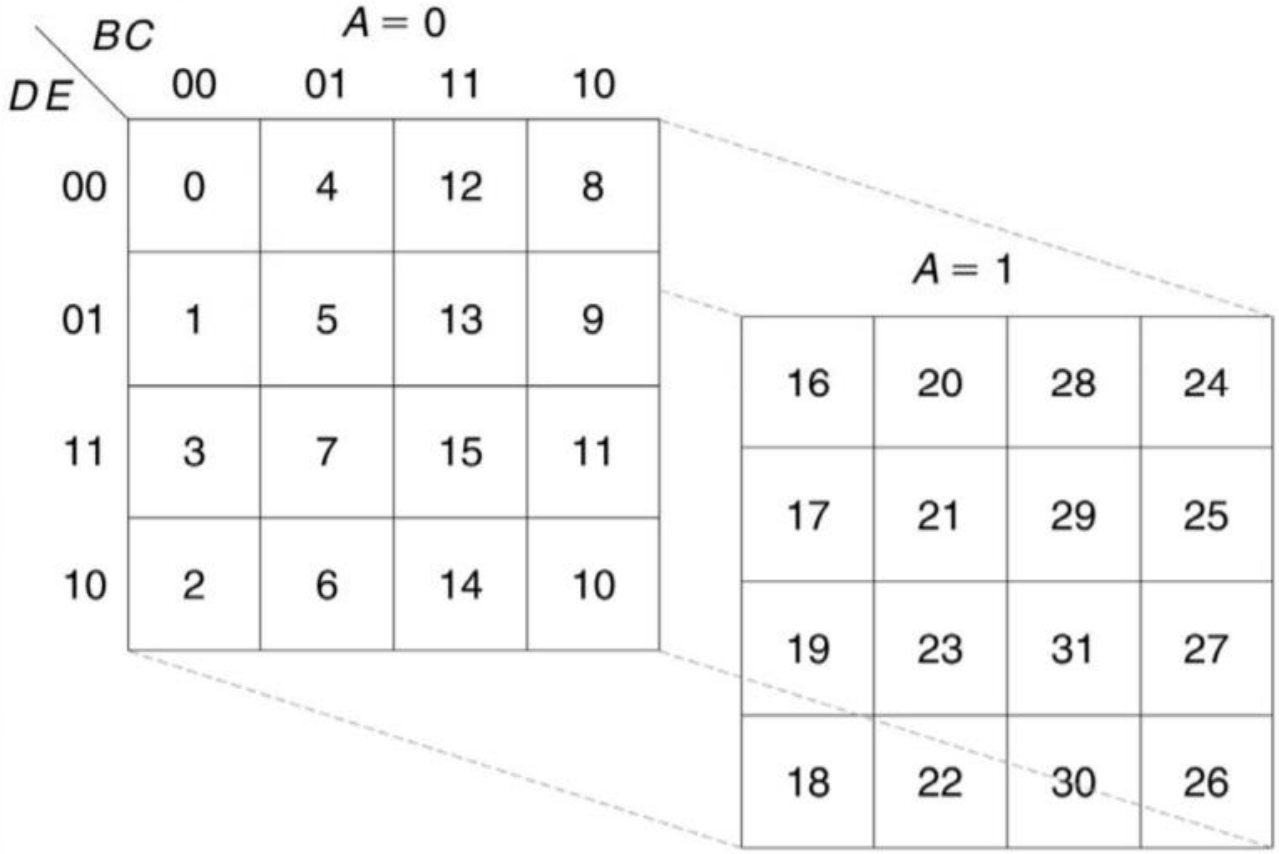
| BC \ DE | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | **0** | **1** | **3** | **2** |
| 01 | **4** | **5** | **7** | **6** |
| 11 | **12** | **13** | **15** | **14** |
| 10 | **8** | **9** | **11** | **10** |

A=1

| BC \ DE | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | **16** | **17** | **19** | **18** |
| 01 | **20** | **21** | **23** | **22** |
| 11 | **28** | **29** | **31** | **30** |
| 10 | **24** | **25** | **27** | **26** |

# Five Variable K-Maps

**Map 3.16** A five-variable map.



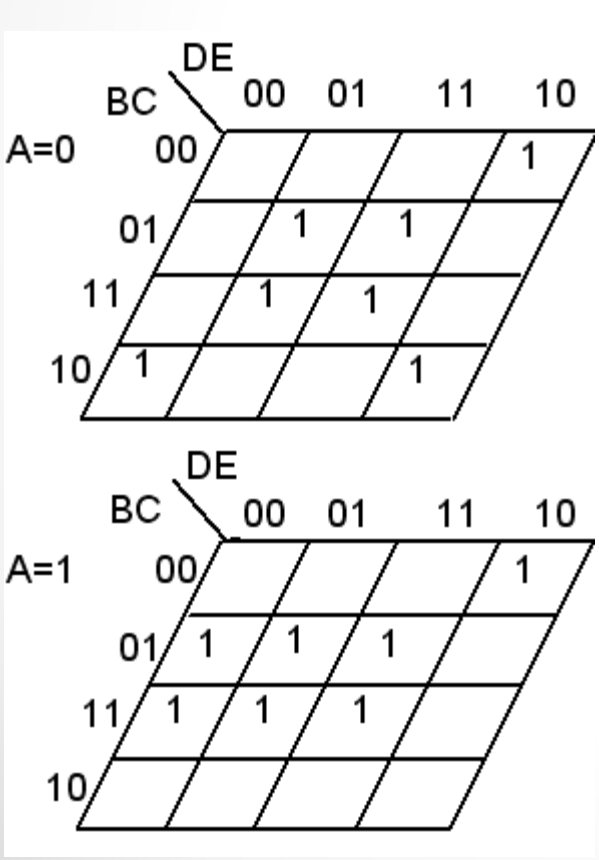

Treat a 5 variable K-map as two layers of 16 cells: Cells directly above and below each other are adjacent.

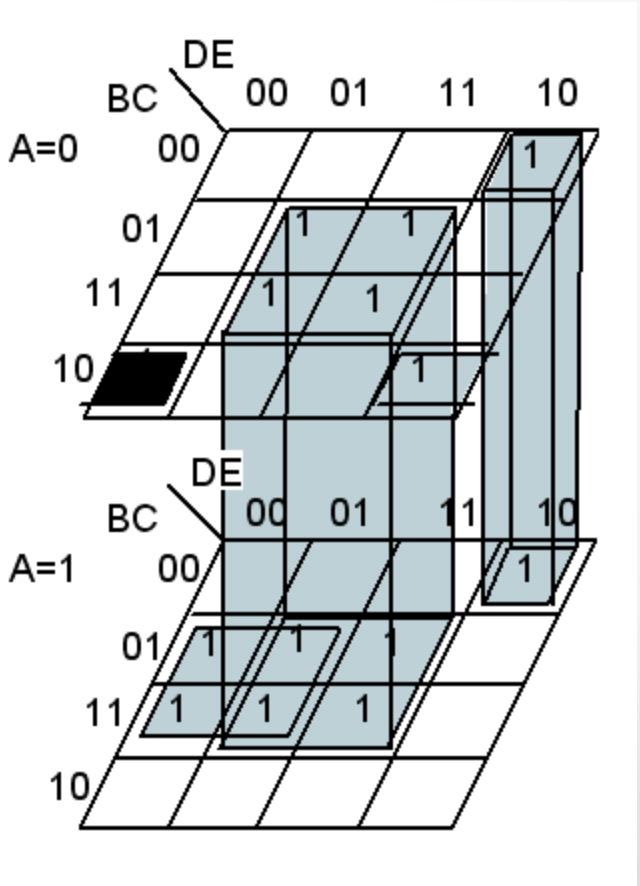
# Five–variable Karnaugh map

Example 1:

F(A,B,C,D,E) = ∑m(2,5,7,8,10,13,15,18,20,21,23,28,29 31)

F= C E + A CD' + B' C' D E'+ A' B C'



# Five–variable Karnaugh map

## Example 3-5/ p 128:

F(V,W,X,Y,Z) = ∑m(3,4,7,9,11,12,15,16,18,19,20,23,24,26,27,28,31).

V=0

| WX \ YZ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 0 | 0 | 1 | 0 |
| 01 | 1 | 0 | 1 | 0 |
| 11 | 1 | 0 | 1 | 0 |
| 10 | 0 | 1 | 1 | 0 |

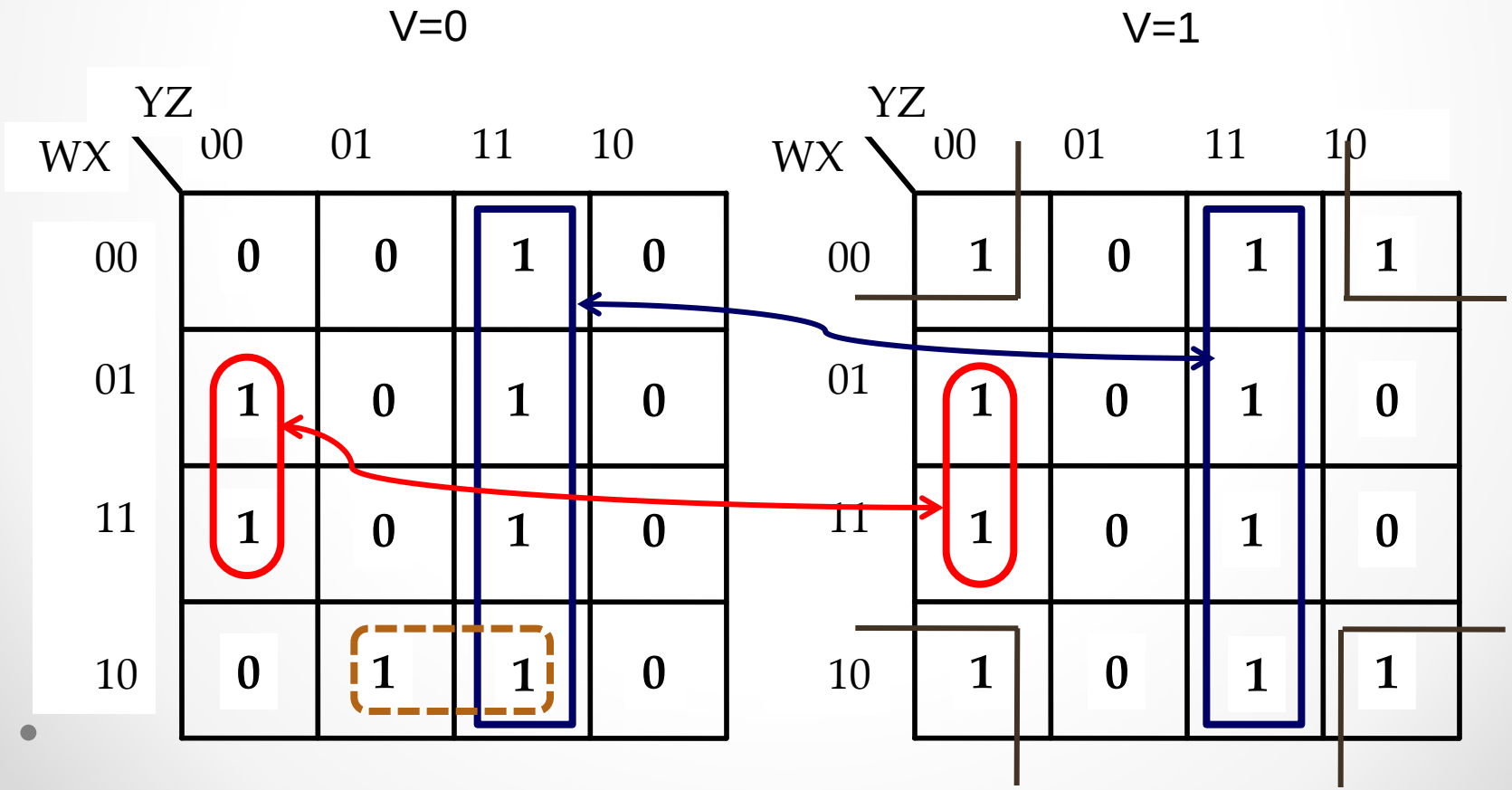
V=1

| WX \ YZ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | 0 | 1 | 1 |
| 01 | 1 | 0 | 1 | 0 |
| 11 | 1 | 0 | 1 | 0 |
| 10 | 1 | 0 | 1 | 1 |

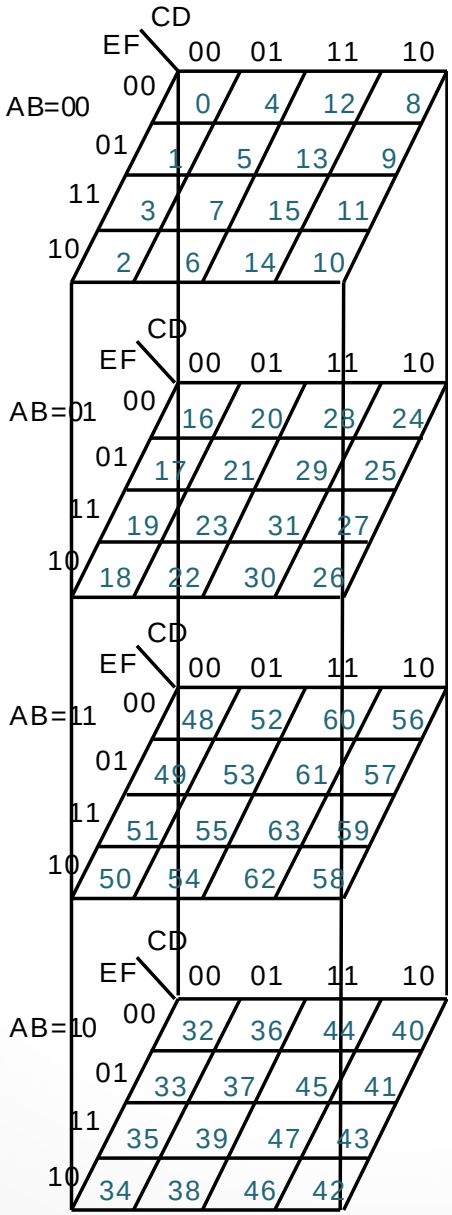
# Example 3-5/ p 128:

Solution:-

$$F(V,W,X,Y,Z) = X\overline{Y}\,\overline{Z} + YZ \quad + \overline{V}W\,\overline{X}Z + V\,\overline{X}\,\overline{Z}$$



# six- Variable K-Maps



AB=00

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

AB=01

| CD \ EF | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 16 | 17 | 19 | 18 |
| 01 | 20 | 21 | 23 | 22 |
| 11 | 28 | 29 | 31 | 30 |
| 10 | 24 | 25 | 27 | 26 |

AB=10

| CD \ EF | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 32 | 33 | 35 | 34 |
| 01 | 36 | 37 | 39 | 38 |
| 11 | 44 | 45 | 47 | 46 |
| 10 | 40 | 41 | 43 | 42 |

AB=11

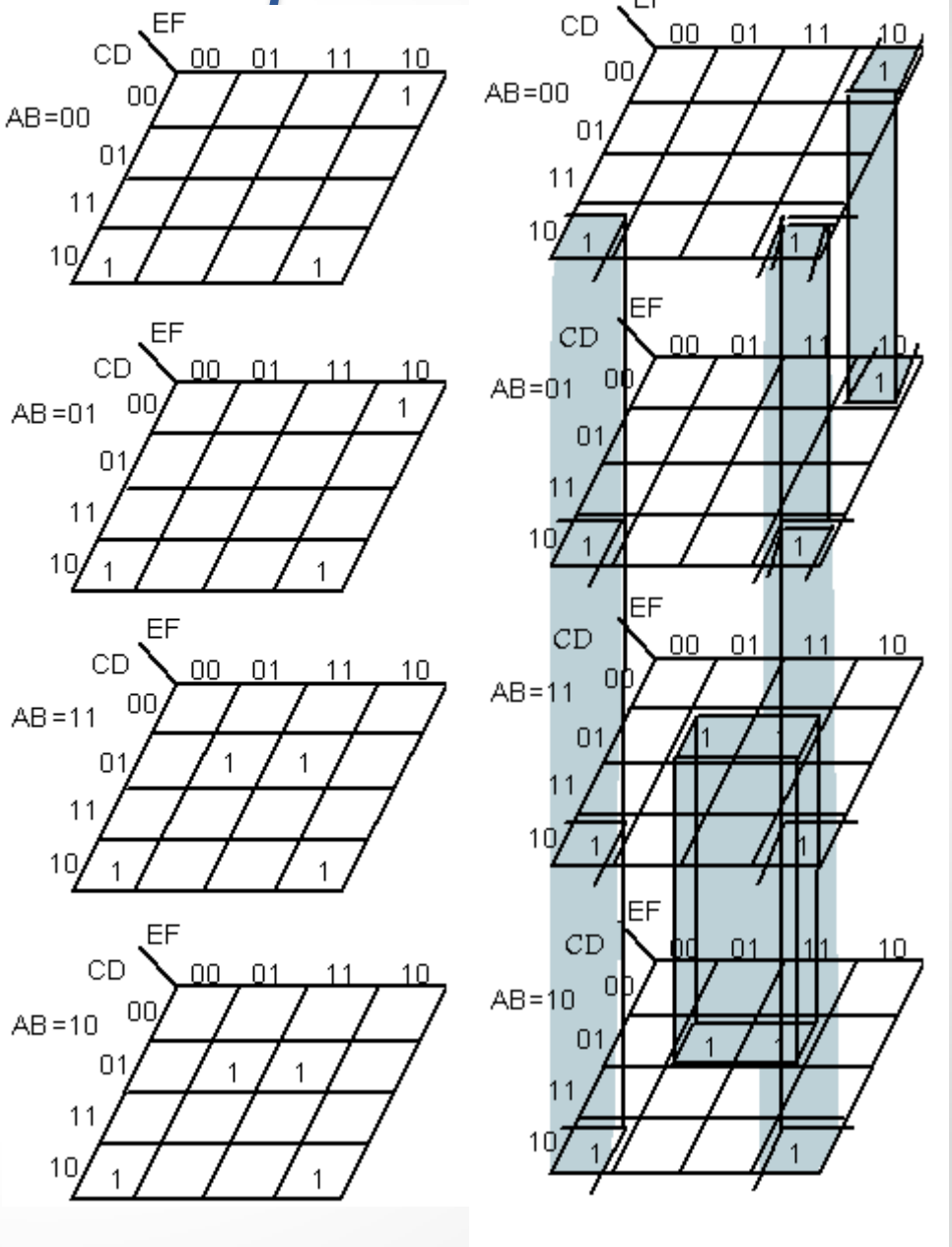
| CD \ EF | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 48 | 49 | 51 | 50 |
| 01 | 52 | 53 | 55 | 54 |
| 11 | 60 | 61 | 63 | 62 |
| 10 | 56 | 57 | 59 | 58 |

# six- Variable K-Maps

Example 1:

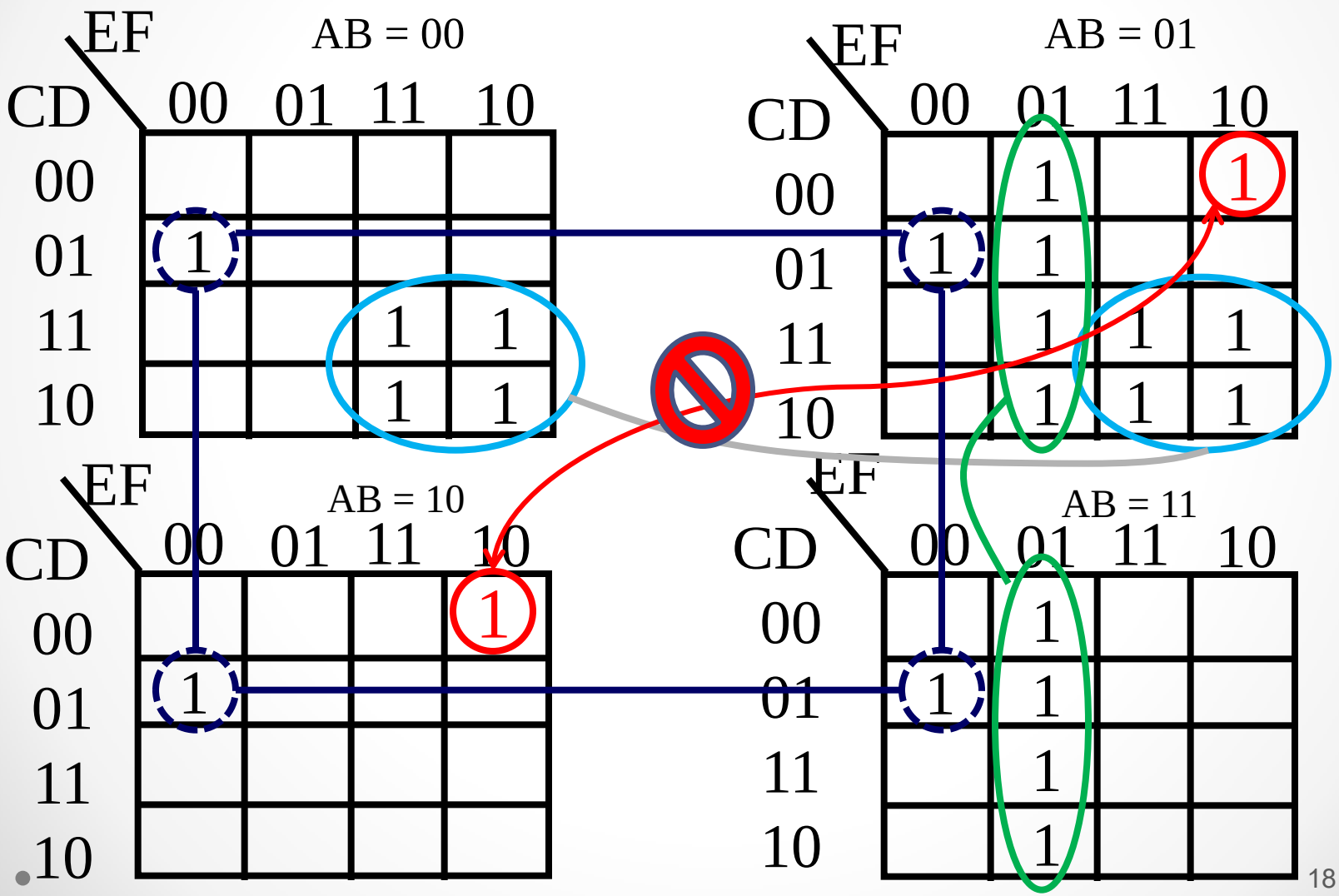
F(A,B,C,D,E,F)
=Σm(2,8,10,18,24,26,37,39,40,42,
53,55,56,58)

= CD'F' + AC' DF+ A' C' D'E F'



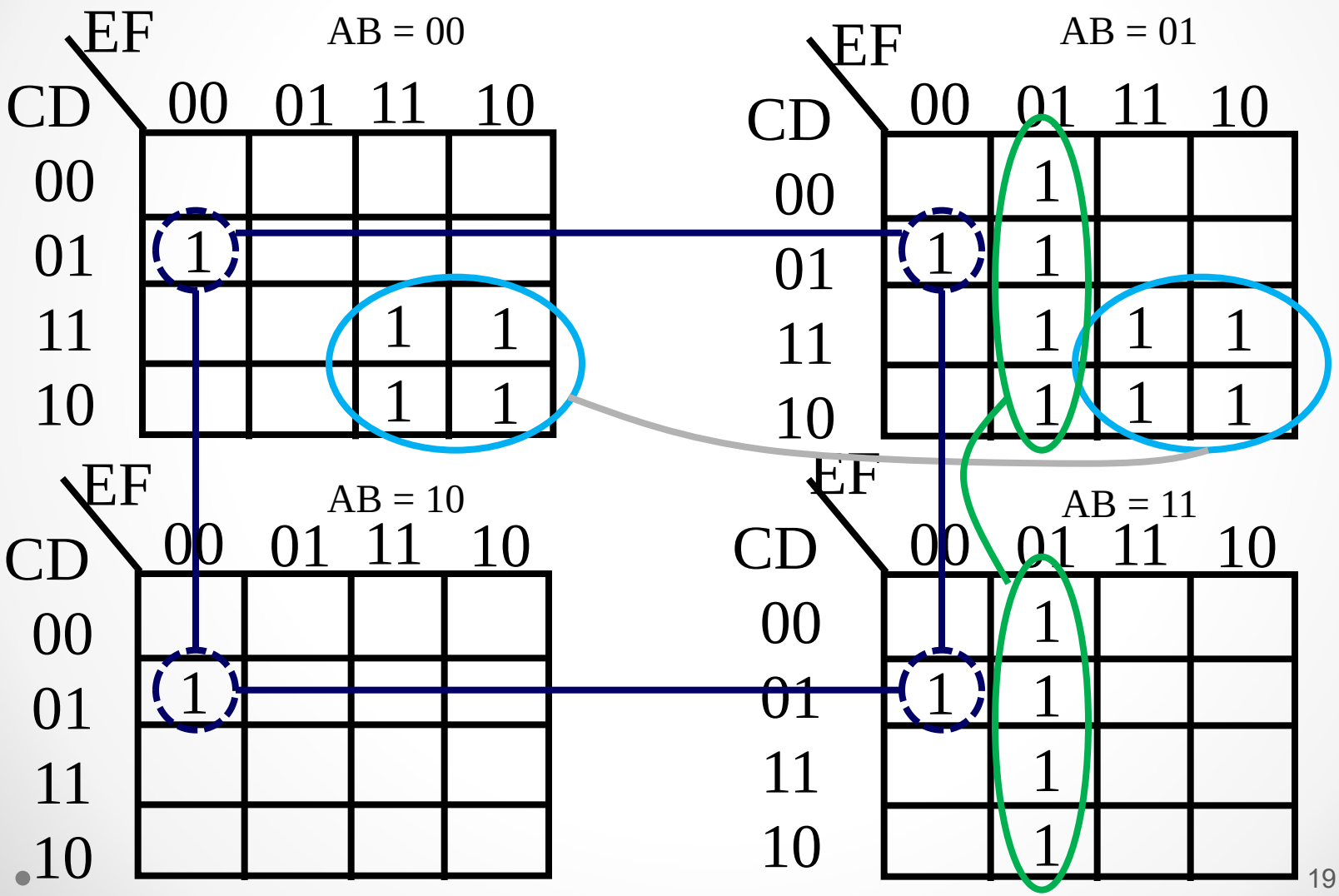
# Example 2:

F(V,W,X,Y,Z)=∑m(4,10,11,14,15,17,20,,21,25,26,27,29,30,31,36,49,52,53,57,61)



# Example 2: (Continue)

$$F(A, B, C, D, E, F) = \overline{C}D\overline{E}\overline{F} + \overline{A}CE + B\overline{E}F$$



# Multiple function minimization

F1(A,B,C) = Σm(0,1,2,4,6,).

F2(A,B,C) = Σm(1,2,6).

$$F1(A, B, C) = \overline{C} + \overline{A}\,\overline{B}$$

$$F2(A, B, C) = \overline{A}\,\overline{B}C + B\overline{C}$$

8-literals

F1=

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

1-literal

2-literals

F2=

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

3-literals

2-literals

# Multiple function minimization

F1(A,B,C) = Σm(0,1,3,5,7,9).

F2(A,B,C) = Σm(1,2,6).

F1=

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

1-literal

3-literals

F2=

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

3-literal

2-literals

$$F1(A,B,C) = \overline{A}\,\overline{B}C + \overline{C}$$

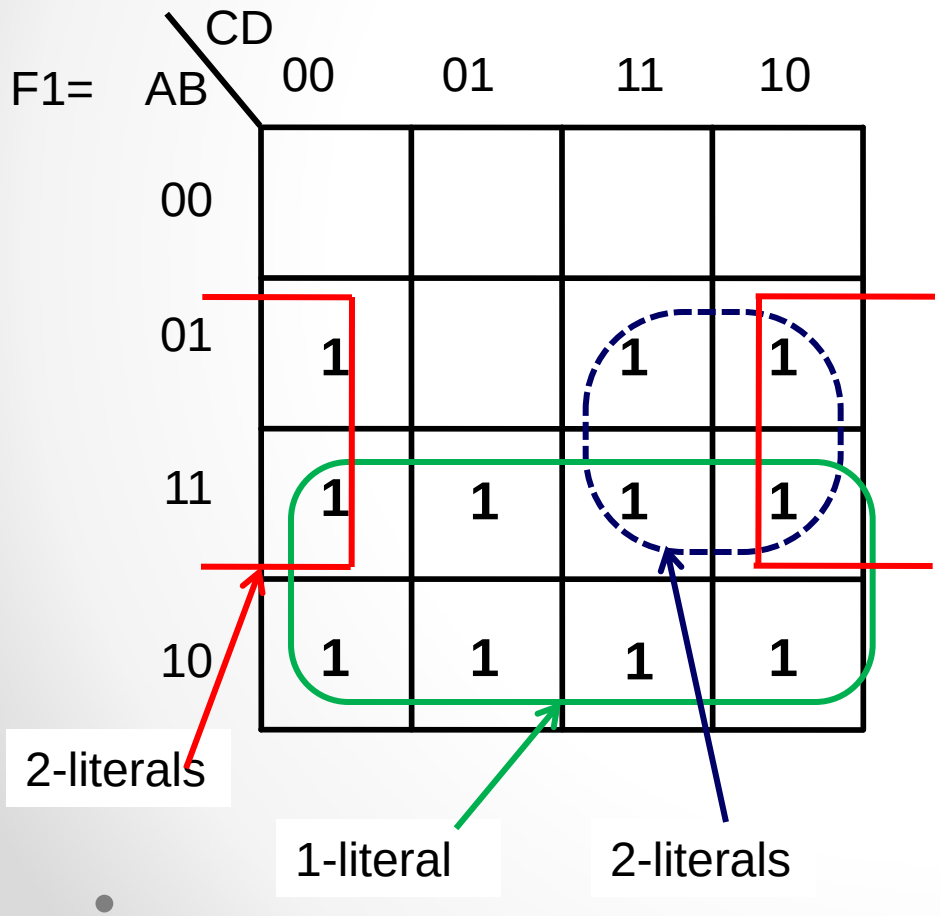
$$F2(A,B,C) = \underline{\overline{A}\,\overline{B}C} + B\overline{C}$$

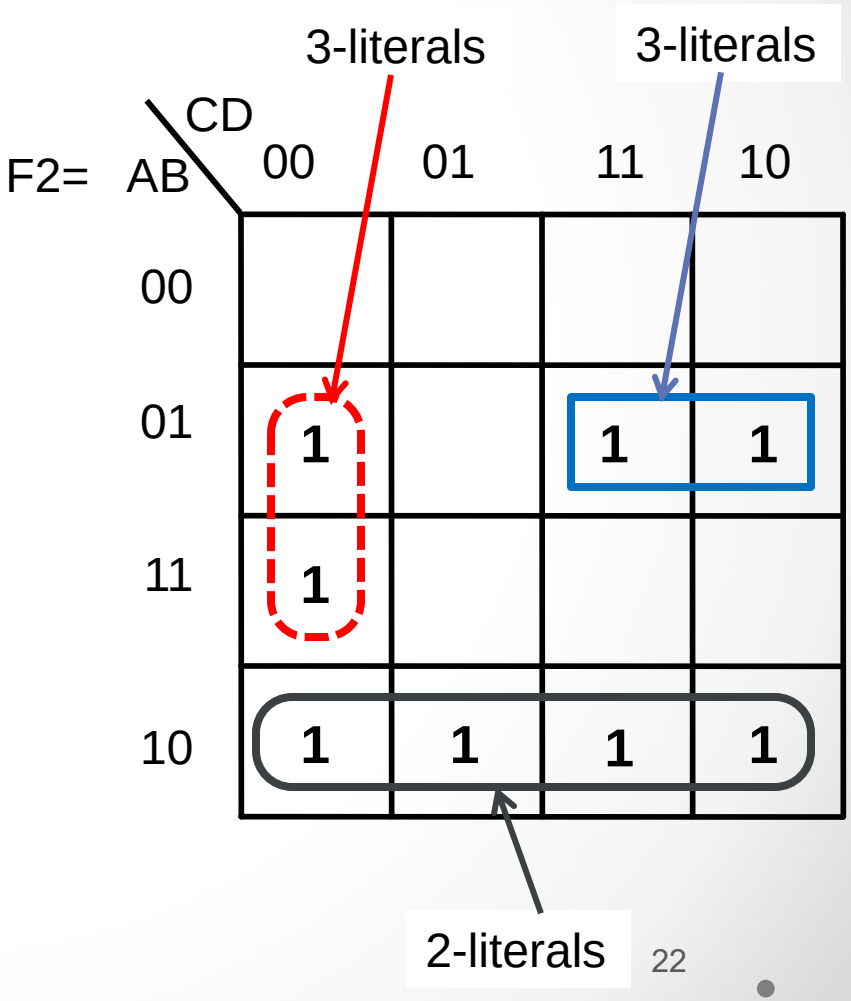
9-literals ✔

# Example 3-6/ p 132:

F1(A,B,C,D) = Σm(4,6,7,8,9,10,11,12,13,14,15)

F2(A,B,C,D) = Σm(4,6,7,8,9,10,11,12)



# Example 3-6/ p 132:

$$F1(A, B, C, D) = B\overline{C}\overline{D} + \overline{A}BC + A$$

$$F2(A, B, C, D) = \underline{\underline{B\overline{C}\overline{D}}} + \underline{\underline{\overline{A}BC}} + A\overline{B}$$