

We consider \times as 1

Handwritten Karnaugh map for the 4-variable function $F(A, B, C, D)$. The map is a 4x4 grid with rows labeled AB (00, 01, 11, 10) and columns labeled CD (00, 01, 11, 10). The cells contain values: (00,00)=1, (00,01)=0, (00,11)=1, (00,10)=1, (01,00)=0, (01,01)=1, (01,11)=1, (01,10)=1, (11,00)=x, (11,01)=x, (11,11)=x, (11,10)=x, (10,00)=1, (10,01)=1, (10,11)=x, (10,10)=x. Red annotations show groupings: a vertical group of 1s in column CD=10 is labeled (II); a horizontal group of 1s in row AB=01 is labeled (IV); a horizontal group of 1s in row AB=10 is labeled (I); a vertical group of 1s in column CD=01 is labeled (III). A central 2x2 square of 1s is also circled.

$$Q = \underset{(I)}{A} + \underset{(II)}{C} + \underset{(III)}{\bar{D}\bar{B}} + \underset{(IV)}{BD}$$

for $b \rightarrow$

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

Handwritten annotations:

- Red circles around 111 (m7), 110 (m6), and 101 (m5).
- Red circle around 100 (m4) with a horizontal line through it.
- Red circles around groups of cells: (00,0), (00,1), (01,0), (10,0), (10,1), (11,0), (11,1), (11,2), (11,3), (11,4), (11,5), (11,6), (11,7).
- Red arrow pointing to the group of cells (11,2), (11,3), (11,4), (11,5), (11,6), (11,7) with the label "redundant" and a circled X.

$$b = \cancel{A} + \bar{B} + CD + \bar{C}\bar{D}$$

$$b = \cancel{A} + \bar{B} + \overline{C \oplus D}$$

for C →

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

$$C = \bar{C} + CD + B$$

Since
 $(a + a'a)$
 $= (a + a)$

$$C = \bar{C} + D + B$$

for d →

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

$$d = A + C\bar{D} + \bar{B}CD + B\bar{C}D + \bar{B}\bar{D}$$

$$d = A + C\bar{D} + B\bar{C}D + \bar{B}(CD + \bar{D})$$

$$d = A + \bar{B}C + \bar{B}\bar{D} + C\bar{D} + B\bar{C}D$$

$$d = A + \bar{B}C + \bar{B}\bar{D} + C\bar{D} + B\bar{C}D$$

$$A \cup (A' \cap B) = (A \cup A') \cap (A \cup B) = A \cup B$$

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Date ___/___/___

for $e \rightarrow$

AB \ CD	00	01	11	10	
00	1	0	0	1	(II)
01	0	0	0	1	
11	X	X	X	X	(I)
10	1	0	X	X	

$$e = \overline{B}\overline{D} + C\overline{D}$$

(II) (I)

for $f \rightarrow$

AB \ CD	00	01	11	10	
00	1	0	0	0	(II)
01	1	1	0	1	
11	X	X	X	X	(III)
10	1	1	X	X	

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

(I) (II) (III) (IV)

$$f = A + B\overline{D}(1 + \overline{C}) + B\overline{C} + \overline{C}\overline{D}$$

$$\Rightarrow \underline{f = A + B\overline{D} + B\overline{C} + \overline{C}\overline{D} = A + B(\overline{C} + \overline{D}) + \overline{C}\overline{D}}$$

for $g \rightarrow$

AB \ CD	00	01	11	10	
00	0	0	1	1	(IV)
01	1	1	0	1	(III)
11	X	X	X	X	
10	1	1	X	X	(I)

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

(I) (II) (III) (IV)

$$\underline{g = A + B + C + \overline{C}\overline{D}}$$