

1.4 DATA TYPES & STRUCTURES · 1.4.3

Karnaugh maps — expanded worksheet

Original practice questions · 38 marks · about 55 minutes · spec 1.4.3(b)

Instructions. Answer all questions. Marks are shown in brackets []. All maps use the layout below: columns labelled CD in the order 00, 01, 11, 10 and rows labelled AB in the order 00, 01, 11, 10 (Gray code). Notation: $\cdot$ = AND, $+$ = OR, $\neg$ = NOT.

1

Total: 6 marks

Fill in the Karnaugh map for each expression by writing 1 in the correct squares, then ring the group. (Blank maps provided.)

AB\CD	00	01	11	10
00				
01				
11				
10				

(a) $\neg A \cdot \neg C$ [2]

AB\CD	00	01	11	10
00				
01				
11				
10				

(b) $B \cdot D$ [2]

AB\CD	00	01	11	10
00				
01				
11				
10				

(c) $\neg B \cdot \neg D$ [2]

2

Total: 8 marks

For each expression: write the 1s in the map, ring the minimal group(s), and hence write the simplified expression.

AB\CD	00	01	11	10
00				
01				
11				
10				

(a) $(A \cdot B \cdot C \cdot D) + (A \cdot B \cdot \neg C \cdot D) + (\neg A \cdot B \cdot C \cdot D) + (\neg A \cdot B \cdot \neg C \cdot D)$

Simplified: _____ [4]

AB\CD	00	01	11	10
00				
01				
11				
10				

(b) $(\neg A \cdot \neg B \cdot \neg C \cdot \neg D) + (\neg A \cdot \neg B \cdot C \cdot \neg D) + (A \cdot \neg B \cdot \neg C \cdot \neg D) + (A \cdot \neg B \cdot C \cdot \neg D)$

Simplified: _____ [4]

3

Total: 4 marks

Use a two-variable Karnaugh map to show that $A + (\neg A \cdot B) = A + B$. Fill in the map for the left-hand side, ring the groups, and read off the simplified result.

A\B	0	1
0		
1		

Simplified result: _____

4

Total: 6 marks

The Karnaugh map below has already been filled in. Ring the minimal groups and write the Boolean expression it represents in its simplest form.

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

(a) How many groups of four are needed? [1]

(b) Write the simplified expression. [3]

(c) Explain why the four corner squares may be grouped together. [2]

5

Total: 4 marks

In a 4-variable Karnaugh map, how many squares contain a 1 when an expression containing only AND terms has:

(i) 4 variables, e.g. $A \cdot B \cdot C \cdot D$ _____ [1]

(ii) 3 variables, e.g. $A \cdot B \cdot C$ _____ [1]

(iii) 2 variables, e.g. $B \cdot D$ _____ [1]

(iv) 1 variable, e.g. A _____ [1]

6

Total: 6 marks

An expression is true for exactly these minterms: $\neg A \cdot \neg B \cdot \neg C \cdot \neg D$, $\neg A \cdot \neg B \cdot \neg C \cdot D$, $\neg A \cdot B \cdot \neg C \cdot \neg D$, $\neg A \cdot B \cdot \neg C \cdot D$, $A \cdot B \cdot \neg C \cdot \neg D$, $A \cdot B \cdot \neg C \cdot D$.

AB \ CD	00	01	11	10
00				
01				
11				
10				

(a) Fill in the map and ring the two overlapping groups of four. [3]

(b) Write the simplified expression. [2]

(c) State how many gates the simplified expression needs. [1]

7

Total: 4 marks

(a) Explain why groups in a Karnaugh map must contain a number of squares that is a power of two (1, 2, 4, 8...). [2]

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(b) Explain why making each group as **large** as possible produces the simplest expression. [2]

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END OF WORKSHEET · 38 MARKS