

Lab Exercise 4 – K-Map and Combinational Circuit Design

Due: Friday, February 6, 2026

K-Map

Question 1. Optimize the following Boolean functions F together with the don't care conditions d . Find all prime implicants and essential prime implicants, and apply the selection rule. [10 marks]

(a) $F(A, B, C) = \sum m(3, 5, 6)$, $d(A, B, C) = \sum m(0, 7)$

(b) $F(W, X, Y, Z) = \sum m(0, 2, 4, 5, 8, 14, 15)$, $d(W, X, Y, Z) = \sum m(7, 10, 13)$

Question 2. Optimize the following Boolean functions F together with the don't care conditions d in (a) sum-of-products and (b) product-of-sums form: [10 marks]

$F(W, X, Y, Z) = \sum m(5, 6, 11, 12)$, $d(W, X, Y, Z) = \sum m(0, 1, 2, 9, 10, 14, 15)$

Circuit Inspection

Assume that a combinational circuit with 4 inputs $\{A, B, C, D\}$ and 2 outputs $\{F, G\}$ has been defined as follows, using a hierarchical approach with interim (i.e. first stage output) line values $\{T1, T2, T3, T4\}$ defined by:

$$T1 = B'C \quad T2 = A'B \quad T3 = A + T1 \quad T4 = D \text{ xor } T2'$$

and the final outputs $\{F, G\}$ by:

$$F = T3 + T4 \quad G = D' + T2$$

Question 3. [6 marks]
List the truth table for all possible inputs $\{A, B, C, D\}$ and also the interim values of $\{T1, T2, T3, T4\}$ and finally, $\{F, G\}$. There should be 16 rows and 10 columns in your truth table.

Question 4. [2 marks]
Plot the truth tables, using K-maps, to determine if the circuit expressions for F and G can be simplified further.

Question 5. [2 marks]
Which expression(s) minimize the number of literals? (Hint: Compare k-map result with circuit expressions for F and G)

Circuit Design

(Truth table and SOP expression)

Question 6.

[10 marks]

Design combinational circuit with 3 inputs and 1 output.

- a. The output is 1 when the unsigned binary value of the input is less than 3, otherwise it is 0.
- b. The output is 1 when the binary value is even, otherwise it is 0.

Question 7.

[10 marks]

Design a combinational circuit with 3 inputs {X,Y,Z} and 3 outputs {A,B,C}. When the unsigned binary value of the inputs is 0,1,2 or 3, the binary output is one greater than the input value. When the unsigned binary value of the inputs is 4,5,6 or 7, the binary output is 2 less than the input value.

FINAL NOTES:

Submission:

- A. Submit the lab work on Brightspace before the deadline.
- B. Students are responsible for uploading the work in high resolution when submitted as images.
- C. No extensions will be granted. Students are provided five days to complete the assignment, and it is student's responsibility to manage the time and complete the assignment before the submission deadline.

Evaluation:

- A. Students are evaluated on all stated requirements.
 - B. It is mandatory that students complete their work and must be able to justify their answers when asked to do so by instructors and teaching staff.
 - C. If the work is not clearly written or presented, or submission is in unsupported file type, it will be graded as zero.
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