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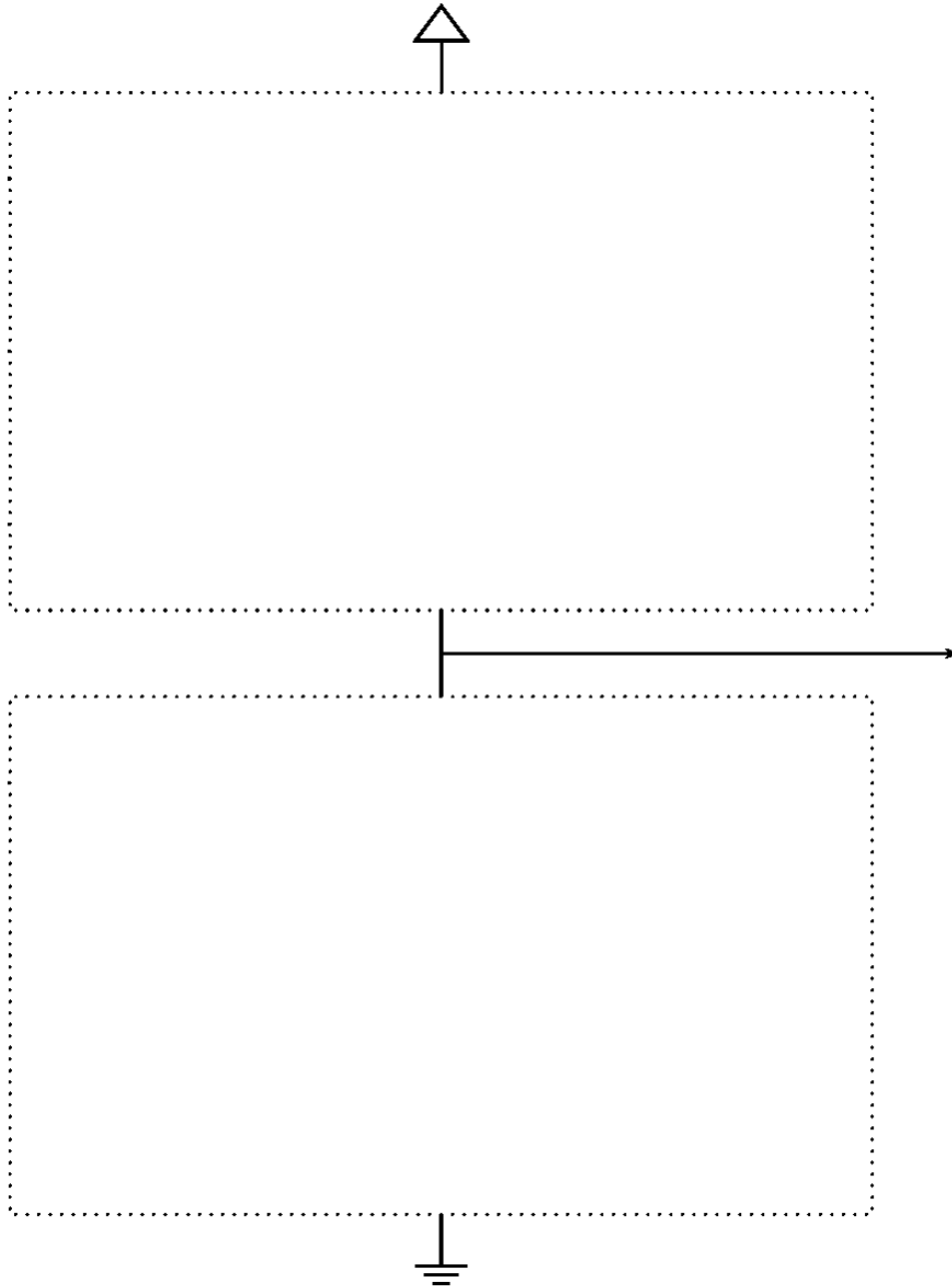
1. (20 points)

Draw the CMOS implementation of function

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

Try to minimize the number of transistors involved.

Place the arrangement of transistors within the dashed boxes below, making sure to make appropriate connections to the ground, the high voltage, the inputs A, B, C, and the output F.



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PID:

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2. (10 points)

Consider the following two Boolean functions (10 marks)

$$F(X, Y, Z) = \overline{\overline{X}}(\overline{Z}) + Z + Z\overline{Y} + (X + 0)(\overline{Z} + Y)(\overline{Z} + \overline{Y})(Y + 1)$$

$$G(X, Y, Z) = X \overline{Z}$$

Using the theorems of Boolean algebra, prove that  $F(X, Y, Z) = G(X, Y, Z)$

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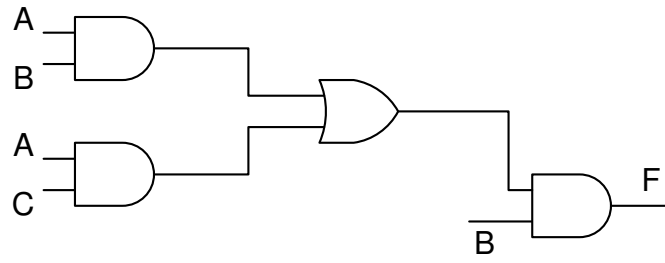
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3. (10 points)

Implement this function using only NOR gates. How many NOR gates will you need?



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PID:

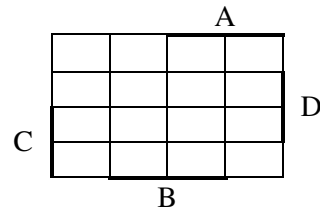
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4. (25 points)

Consider the following Boolean function

$$F(A, B, C, D) = m(0, 4, 5, 10, 12, 13, 14) + d(3, 8, 15)$$

a) What is the corresponding KMap for F?



b) Identify all prime implicants of F.

c) What are the essential prime implicants.

d) Give one minimized Sum-of-Products form for F.

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PID:

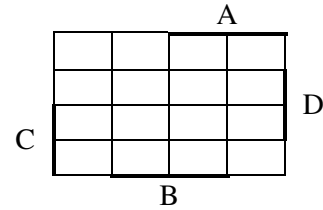
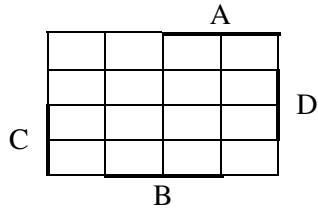
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5. (25 points)

Implement F1 and F2 using a minimum number of logic gates. (Hint: share the gates between the two functions)

$$F1(A, B, C, D) = \sum m(5, 7, 10, 13, 14, 15)$$

$$F2(A, B, C, D) = \sum m(0, 2, 4, 5, 6, 7, 8, 12, 13, 15)$$



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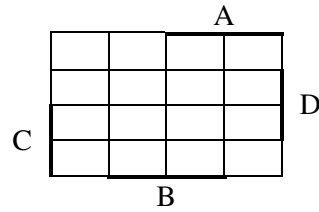
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6. (20 points)

$$F(A,B,C,D) = \prod M(2, 3, 6, 8, 9, 12, 13, 14)$$

a) Minimize the function F, show the minimum function in POS form.



b) Are there any static-0 hazards? If so, show where, and how you'd fix that.

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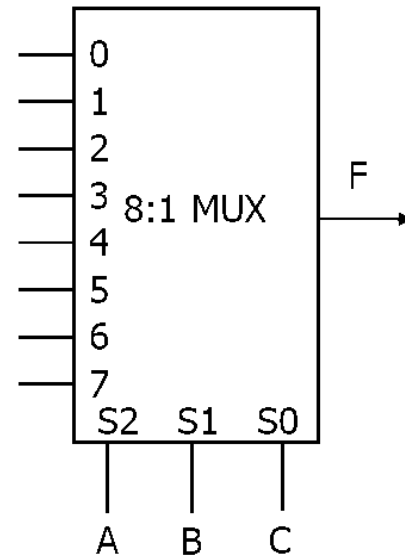
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7. **(10 points)**

(Bonus) Implement the function F using the 8 input multiplexor as shown below.

$$F(A,B,C,D) = \sum m(2, 3, 7, 9, 10, 13, 14) + d(12, 15)$$



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