

Do any 5 of the first 6 plus any 5 of the second 6. Be sure it is clear which problems you do not want graded. All problems are equally weighted.

1. For the following function,  $f$ , find BOTH minimum sum of product expressions. (Two blank maps are given.)

$$f(w, x, y, z) = \sum m(0, 1, 2, 3, 5, 7, 8, 10, 11, 12, 13, 15)$$

2. For the following function, find all four minimum sum of products expressions. (four copies of the map are shown.)

		a b			
		00	01	11	10
c d					
	00	1		1	X
	01	X	X	1	
	11	1	X	X	1
	10	X		X	1

		a b			
		00	01	11	10
c d					
	00	1		1	X
	01	X	X	1	
	11	1	X	X	1
	10	X		X	1

3. For the following function,  $g$ , find all minimum sum of product expressions and all minimum product of sums expressions. (There are a total of 4. Two copies of the map and two blank maps are given.)

		w	x		
	y z	00	01	11	10
00		1			
01		1	1	1	1
11			1	1	
10		1	1		

		w	x		
	y z	00	01	11	10
00		1			
01		1	1	1	1
11			1	1	
10		1	1		

4. For the following 5-variable problem,  $F$ , find all three minimum sum of products expression. (Two copies of the map shown.)

		BC		0	
	DE	00	01	11	10
00		X			X
01			1	X	
11		1	1	X	
10				1	1

		BC		1	
	DE	00	01	11	10
00		X			1
01			1		
11			1	X	
10				X	X

5. For the following three functions of four variables, find a sum of product expression for each such that the total number of gates is minimized for an AND/OR solution. All inputs are available both uncomplemented and complemented. Full credit for solutions using 9 gates and 26 gate inputs. Show the maps and the algebraic expressions.

		a b			
	c d	00	01	11	10
00		1		1	1
01				1	1
11		1	1		
10		1			1

f

		a b			
	c d	00	01	11	10
00		1		1	1
01				1	1
11		1	1		
10			1	1	

g

		a b			
	c d	00	01	11	10
00		1		1	1
01				1	1
11					1
10			1	1	1

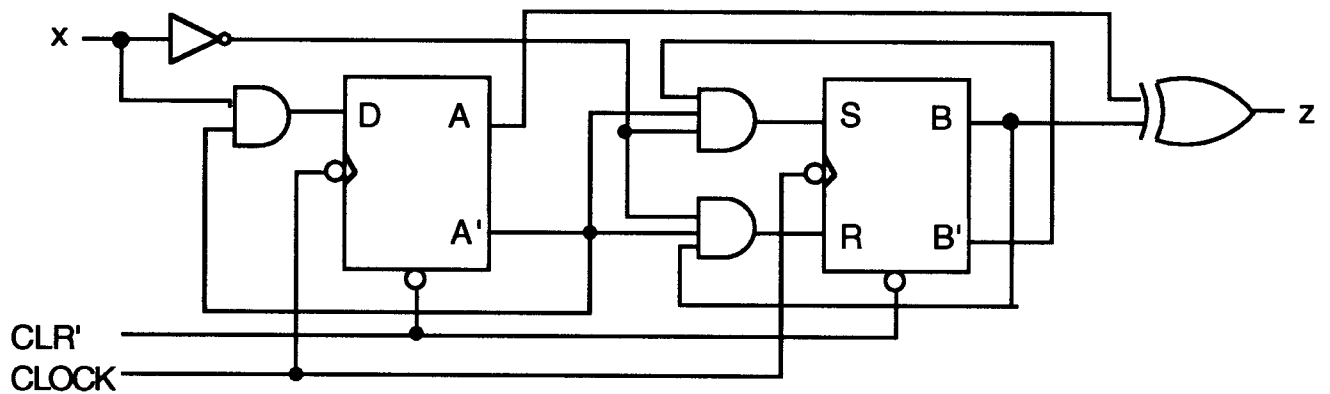
h

6. The following is the only minimum sum of product expressions for a function, G.

$$G = A' C' E' + B' C E + B' D' E' + C D' E + B C' D + A' B C'$$

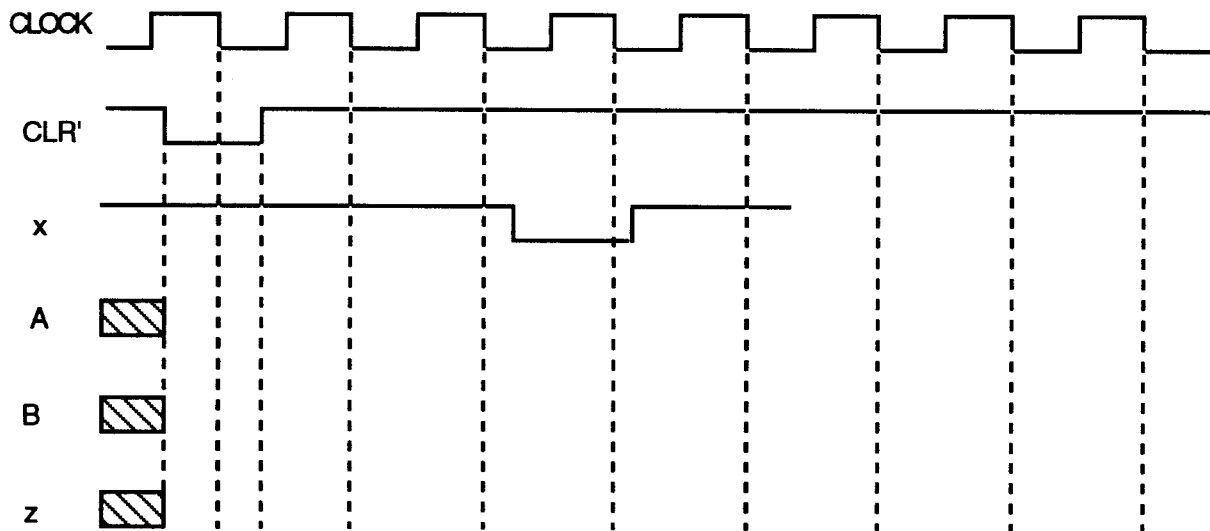
All inputs are available both uncomplemented and complemented. Show the equation and a block diagram for an implementation that uses only 2-input NAND gate. No gate may be used as a NOT. Full credit for a solution using no more than 12 two-input gates. Partial credit for solutions using one three-input gate.

7. For the following circuit

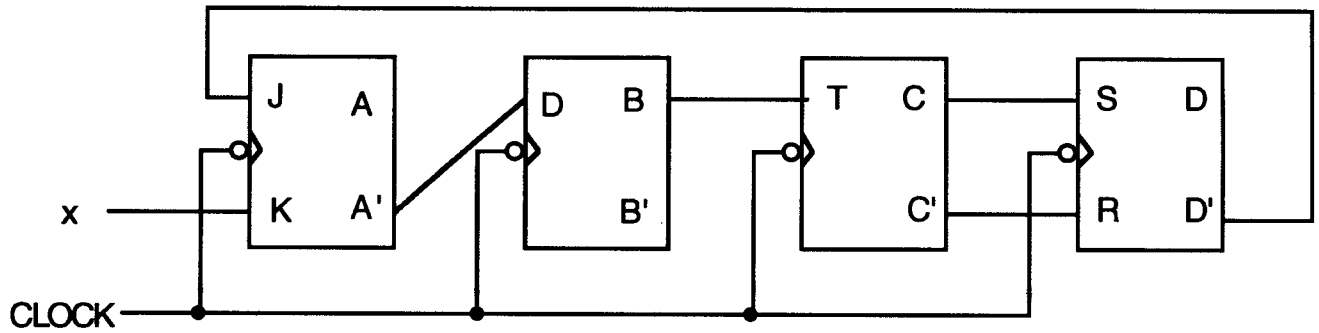


a) a) Show the state table (labelling the states 00, 01, 10 11), ignoring the CLR' signal line.

b) Complete the timing diagram below.



8. For the following circuit, complete the timing trace below. (Note that initially, all 4 flip flops have 0 in them.) Go as far as you can, even after you no longer know the input. However, once you cannot determine a value for any flip flop, you do not need to give additional values for that flip flop (even if you can determine them).



x	0	0	1	1	0
A	0				
B	0				
C	0				
D	0				

9. For the following state table and state assignment, show a block diagram, the input equations (D, J, K), and the output equation, z, of an implementation that uses one D flip flop and one JK flip flop plus AND, OR and NOT gates. Choose which flip flop is used for each state variable so as to minimize the logic. Make it clear which type of flip flop is used for  $q_1$  and  $q_2$ .

q	q *		z
	x = 0	x = 1	
A	D	C	1
B	B	A	0
C	B	A	1
D	D	A	1

q	$q_1$	$q_2$
A	0	0
B	1	1
C	1	0
D	0	1

10. Design a counter with three flip flops,  $q_1$ ,  $q_2$ , and  $q_3$ , that goes through the sequence

1 3 5 7 0 2 and repeat

where, for example, 3 is represented by  $q_1 = 0$ ,  $q_2 = 1$ , and  $q_3 = 1$ . Use D flip flops.

- a) Show the equations for the three flip flop inputs.
- b) Show a state diagram, including what happens if the system, when first turned on, is in state 4 or state 6.

11. Show the state table or the state diagram for a Mealy system with one input,  $x$ , and one output,  $z$ , such that  $z = 1$  iff at least 1 of the last 4 inputs have been 1. (Full credit for 4 states.)

Example

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x    1 0 0 1 0 0 0 0 0 0 1 0 0 1 1 1 0 1 0 0 0 0 0 1
z    1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1

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12. Consider the following state table:

q	q *		z
	x = 0	x = 1	
A	B	D	1
B	A	D	0
C	A	E	0
D	E	B	1
E	E	C	1

Three of the non-trivial SP partitions are

- $P_1 = (A B) (C) (D) (E)$
- $P_2 = (A B C) (D E)$
- $P_3 = (A) (B C) (D E)$

- a) Reduce the system to an equivalent one with the fewest number of states. Show the reduced state table.
- b) Find the other non-trivial SP partition.
- c) Replace the output column by one that prevents us from reducing the table (that is, one for which none of the SP partitions are output consistent).