

Switching Circuits and Logic Design

Midterm Examination

15:30 ~ 17:20, November 14, 2008

1. [10 points] Convert $(56.7)_8$ and $(113.2)_4$ to base 2. Add these two numbers and show your answer in base 10.
2. [10 points] Write down the output function F of the circuit shown in Figure Q2, and then simplify it to the minimum sum of products.

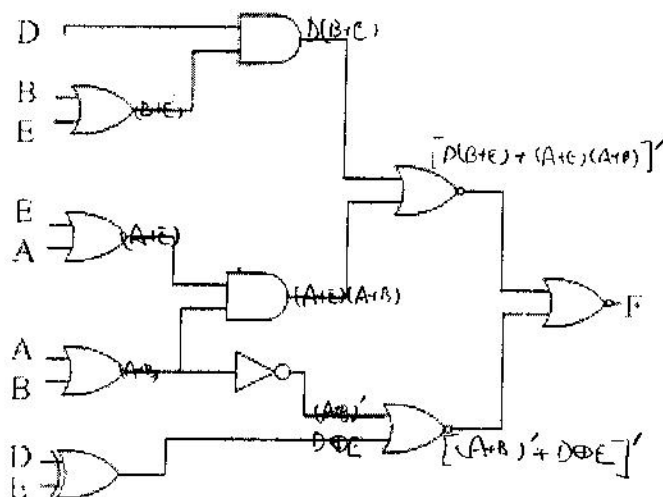


Figure Q2

3. [10 points] Let

$$H(a,b,c,d) = \prod M(1,2,5,7,8,10,11,13,14,15)$$

and

$$G(a,b,c,d,e) = \sum m(1,3,7,8,9,12,13)$$

Please show the minterm expansion of $K(a,b,c,d,e) = H \oplus G$. Suppose that a is the most significant bit in H , G , and K ; d is the least significant bit in H ; e is the least significant bit in G and K .

4. [10 points] Use Boolean algebra to find the minimum product-of-sum expression.

$$(W + Y' + V + K)(W + Y + U + K)(W' + X + K)(W + X + Y' + Z' + K)(X + Y' + V + K)(W + Y' + V' + K)$$

(Hint: your answer should be a product of three sums.)

NOTE: There are problems in the back.

5. For the boolean expression:

$$f(a,b,c,d) = \sum m(3,6,7,8,12,14,15) + \sum d(4,10,13)$$

- (a) [5 points] Find all the prime implicants with Karnaugh Map.
- (b) [5 points] Find the minimum sum-of-product expression for it. Please also indicate which terms are essential prime implicants. (There may be a lot of possible minimum sum-of-product. Just select one answer with only one ~~don't care~~ "x" in the whole sum-of-product expression.)
- (c) [5 points] Find the minimum product-of-sum expression for it.
- (d) [12 points] Derive the two-level minimum NAND-NAND, NOR-NOR, OR-NAND, NAND-AND, AND-NOR, NOR-OR circuits of $f(a,b,c,d)$.
- (e) [3 points] From these circuits you derive in (d), which one has the lowest cost? Why?
- (f) [5 points] Find an AND-OR circuit of $f(a,b,c,d)$ which has no hazards.

6. Answer the following questions.

- (a) [5 points] Please find the truth table of a full subtracter, X minus Y . (Inputs: X_i, Y_i, B_i ; Outputs: B_{i+1}, D_i .)
- (b) [5 points] Please write the logic equations, B_{i+1} and D_i , for the full subtracter in the minimum sum-of-products form.
- (c) [5 points] If a PLA is used to implement a full subtracter, what's the minimum number of the word lines needed to connect the AND array and the OR array?
- (d) [4 points] Please expand the two 3-variable logic functions in (b) about the variable B_i using Shannon's expansion theorem.
- (e) [6 points] Implement a full subtracter using two 4-to-1 MUXes to implement the logic functions in (b). Connect X_i and Y_i to the control inputs of the MUXes.