EECS 465, Spring 99, Instructor: Shantanu Dutt

Midterm Exam: Wed., March 10, Time: 2:00 to 3:15 PM
Exam Format: Closed Book, Total Points: 120

Important Note: You need to show all your work **clearly** in deriving the answers. Just writing down the final answers is not enough.

Suggestion: Begin by reading all questions and do those first that you think you know best.

1. Using the multi-function QM method, determine the SOP expressions for $f_\alpha(A,B,C,D) = \sum m(5,11,15)$ and $f_\beta(A,B,C,D) = \sum m(5,11,13,15)$ that minimizes total cost across both functions. What is the total cost of your solution? Draw a 2-level gate implementation of your design. Show your work clearly, number your row (or subrow) and column deletion steps and obtain reduced PI tables whenever the current one gets messy. **40**

2. A minimum total cost implementation of the following three functions: $f_\alpha(A,B,C,D) = \sum m(5,7,8,9,10,11,12,13,14,15)$, $f_\beta(A,B,C,D) = \sum m(5,8,9,12,13)$ and $f_\gamma(A,B,C,D) = \sum m(7,10,11,14,15)$ is to be obtained. The PIs after the first stage of multi-function QM are:

   - $PI_1^\alpha = A = \sum m(8,9,10,11,12,13,14,15)$
   - $PI_2^\alpha = BD = \sum m(5,7,13,15)$
   - $PI_3^{\alpha,\beta} = A\bar{C} = \sum m(8,9,12,13)$
   - $PI_4^{\alpha,\beta} = B\bar{C}D = \sum m(5,13)$
   - $PI_5^{\alpha,\gamma} = AC = \sum m(10,11,14,15)$
   - $PI_6^{\alpha,\gamma} = BCD = \sum m(7,15)$

   Obtain the minimal total cost design using the second stage of multi-function QM starting with the initial PI table. Show your work clearly, number your row (or subrow) and column deletion steps and obtain reduced PI tables whenever the current one gets messy. **40**

   Besides the rules about essential PIs, covered rows and covering columns in single-function QM, remember to use the following heuristics for:
   (a) Multi-function QM:

   (1) The cost of a PI with more than one literal is (# of literals + 1). The cost of a PI with one literal is 1.

   (2) If a PI is found to be essential for one or more functions that it covers, only delete its subrows corresponding to those functions, retain its subrows for other functions it covers but for which it is not yet essential, and reduce its cost to 1 (for the other functions for which its subrows have been retained).

(b) Cyclic PI table:

(1) Choose the PI, say, PI_j, which first covers the most MTs and then has the least cost, if there does not exist any other set S of PIs of total cost less than cost(PI_j) that together cover the MTs of PI_j (and possibly more). Otherwise, choose the PIs in set S.

(2) Break any ties between such PI_j's (of rule 1 above) by choosing one with the least cost (this rule is actually covered in the statement of rule 1 above, but is being re-stated here for clarity).

(3) Break any further ties arbitrarily.

3. (a) Implement the function $f = \sum m(1, 3, 4, 8, 9, 10, 11)$ using a 2:1 MUX and the minimum number of 2-input AND/OR gates. Assume that variables and their complements are available for free. Show your work clearly. **20**

(b) Assuming that just like gates, a MUX is a single component, analyze the number of transitions and glitches on each gate and MUX output, and determine the total number of glitches in your design. Show your work clearly. **20**