EECS 140/141 Introduction to Digital Logic Design
Spring Semester 2020
Assignment **#5** Due **25 February 2020**

Reading: Sections 4.1 - 4.5 in Brown/Vranesic

All logic networks on this (and every other assignment) *must* be drawn using logic template. Points will be deducted for failure to do this! You should have had time by now to secure one of these templates.

1. Consider the logic function given by:
   $f(e, h, k) = \Sigma\, m(0, 1, 4, 7)$
   a. Draw the K-map for this function.
   b. List all the prime implicants for this function.
   c. Which of the prime implicants are *essential*? For each essential prime implicant, give all the minterms that are not covered by any other prime implicant.
   d. Use the simplification strategy to find a minimum-cost SoP logic expression for this function.
   e. Is the minimum-cost SoP logic expression for this function unique? If so, explain why. If not, give another SoP logic expression that has the same cost.
2. Repeat the previous problem for the following function:
   $f(a, b, c, d) = \Sigma\, m(0, 1, 2, 3, 4, 10, 11, 12, 13, 14, 15)$
3. Repeat the previous problem for the following function:
   $f(x_1, x_2, x_3, x_4) = \Sigma\, m(0, 2, 3, 5, 7, 8, 10, 11, 12, 13)$
4. Repeat problem 1 for the function given in problem 4.25 on p. 243. This is a very interesting case, since following the procedure suggested in section II.B.2 of Lecture 4 (part c of that procedure) certainly will NOT result in the minimum-cost SoP synthesis. This anomoly is due to the existence of the don't cares in the function.
5. Two judges (call them A and B) can vote one of three ways on any question: no, yes, or abstain. For each judge, the vote will be represented by two binary values. For judge A, the values are A_1 and A_0, a "no" vote is represented as $A_1 = 0$ and $A_0 = 0$, a "yes" vote is represented as $A_1 = 0$ and $A_0 = 1$, and an "abstain" vote is represented as $A_1 = 1$ and $A_0 = 0$. The representations are similar for judge B, substituting B for A in the previous expressions. We want a logic circuit that will produce a 1 on the output f if and only if the two judges give the same vote. Note that the combination $A_1 = 1$ and $A_0 = 1$ is never used, and similarly for judge B, so we *don't care* what the circuit would produce for these input combinations.
   a. Draw the K-map for this function.
   b. Find a minimum-cost SoP logic expression for this function.
6. This problem concerns the function given by:
   $f(a, b, c) = \Sigma\, m(1, 2, 5, 6, 7)$
   This function was used as an example in section II.B.3.b of Lecture 4 of your class notes.
   a. In class, we derived two minimum-cost SoP syntheses for this function. Give one of those syntheses, and determine its cost.
   b. Now find a minimum-cost PoS synthesis for this function, and determine its cost. In particular:
      i. Draw the K-map for this function.
      ii. List the PoS prime implicants.

 Copyright 2020 David W. Petr

iii. Identify the PoS essential prime implicants. For each essential prime implicant, give all the f=0 maxterms that are not included in any other prime implicant.

iv. Use the simplification strategy to find a minimum-cost PoS logic expression for this function.

c. In this particular example, which synthesis results in the lower circuit cost?

7. This problem concerns the function given by:
$f(a, b, c, d) = \Sigma\, m(2, 3, 4, 8, 9, 10, 11)$
This function was used as an example in section II.A.3.b of Lecture 4 of your class notes.

a. In class, we derived the unique minimum-cost SoP synthesis for this function. Give that synthesis, and determine its cost.

b. Now find a minimum-cost PoS synthesis for this function, and determine its cost. In particular:

i. Draw the K-map for this function.

ii. List the PoS prime implicants.

iii. Identify the PoS essential prime implicants. For each essential prime implicant, give all the f=0 maxterms that are not included in any other prime implicant.

iv. Use the simplification strategy to find a minimum-cost PoS logic expression for this function.

c. In this particular example, which synthesis results in the lower circuit cost?

8. This problem concerns the function given by:
$f(W_1, W_0, X_1, X_0) = \Sigma\, m(5, 6, 7, 10, 11, 15) + D(0, 1, 2, 3, 4, 8, 12)$
This function was used as an example in section II.B.4.a of Lecture 4 of your class notes.

a. In class, we derived two minimum-cost SoP syntheses for this function. Give one of those syntheses, and determine its cost.

b. Now find a minimum-cost PoS synthesis for this function, and determine its cost. In particular:

i. Draw the K-map for this function.

ii. List the PoS prime implicants.

iii. Identify the PoS essential prime implicants. For each essential prime implicant, give all the f=0 maxterms that are not included in any other prime implicant.

iv. Use the simplification strategy to find a minimum-cost PoS logic expression for this function.

c. In this particular example, which synthesis results in the lower circuit cost?

 Copyright 2020 David W. Petr