CPE 100L Logic Design I

Laboratory 5: Logic Minimization

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University of Nevada, Las Vegas

Goals:
Work with logic minimization methods and implement functions on the DE0 board.

Background:
Laws and Theorems of Boolean Algebra:

Operations with 0 and 1:
\[ a + 0 = a \]
\[ a + 1 = 1 \]
\[ a * 1 = a \]
\[ a * 0 = 0 \]

Idempotent laws:
\[ a + a = a \]
\[ a * a = a \]

Involution law:
\[ (a ')' = a \]

Laws of complementarity:
\[ a + a ' = 1 \]
\[ a * a ' = 0 \]

Commutative laws:
\[ a + b = b + a \]
\[ ab = ba \]

Associative laws:
\[ (a + b) + c = a + (b + c) = a + b + c \]
\[ (ab)c = a(bc) + abc \]

Distributive laws:
\[ a(b + c) + ab + aZ \]
\[ a + bc = (a + b)(a + c) \]

Simplification theorems:
\[ ab + ab' = a \]
\[ a + ab = a \]
\[ (a + b')b = ab \]
\[ (a + b)(a + b') = a \]
\[ a(a + b) = a \]
\[ ab' + b = a + b \]
DeMorgan's laws:
\[(a + b + c + ...)' = a'b'c'...
\[(abc...)' = a' + b' + c' + ...

Duality:
\[(a + b + c + ...)^D = abc...
\[(abc...)^D = a + b + c + ...

Theorem for multiplying out and factoring:
\[(a + b)(a' + c) = ac + a'b
\[ab + a'c = (a + c)(a' + b)

Consensus theorem:
\[ab + bc + a'c = ab + a'c
\[(a + b)(b + c)(a' + c) = (a + b)(a' + c)

Adding redundant terms
Redundant terms can be introduced in several ways such as adding \(aa'\), multiplying by \((a + a')\), adding \(ac\) to \(ab + a'c\) or adding \(ab\) to \(a\). When possible, the added terms should be chosen so that they will combine with or eliminate other terms.

**LAB DELIVERIES:**

**PRELAB:**

1. Read about minimizing techniques used for Boolean Algebra

2. **Prelab deliveries**
   1. Minimize functions:
      a. \(F = ab + a'bc' + bc\)
      b. \(F = d'a' + a'b' + bc + d'c'\)

**LAB EXPERIMENTS:**

1. **Experiment 1: Minimize and implement the following functions on DE0:**
   When implementing the functions below, use the following assignments:
   a – assigned to SW9
   b – assigned to SW8
   c – assigned to SW7
   d – assigned to SW6
   e – assigned to SW5
   f – assigned to SW4
   g – assigned to SW3
   F – assigned to LEDR9

   For each function:
   - minimize the function
   - implement minimized function on DE0 board
   - test all combinations of inputs, and write down the results as a truth table.
1. Algebraic simplification:
   a. \( F = a'b'c'd + a'bc'd + b'ef + cde'g + a'def + a'b'ef \)
   b. \( F = a'c'd' + ac' + bcd + a'cd' + a'bc + ab'c' \)
   c. Implement function 1.a) without simplification (in a form given above). Compare with minimized form, write conclusions.

2. Karnaugh Maps:
   a. \( F = a'b' + a'b'c' + a'bd' + ac'd + a'bd + ab'cd' \) (find minimum sum of products)
   b. \( F = a'b' + cd' + abc + a'b'cd' + abcd' \) (find minimum product of sums)

**POSTLAB REPORT:**

Include the following elements in the report document:

<table>
<thead>
<tr>
<th>Section</th>
<th>Element</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Theory of operation</td>
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<td>Include a brief description of every element and phenomenon that appears during the experiments.</td>
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<td>2</td>
<td>Prelab report</td>
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<tr>
<td>3</td>
<td>Results of the experiments</td>
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<tr>
<td></td>
<td>Experiment</td>
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<tr>
<td>1</td>
<td>For each function:</td>
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<tr>
<td></td>
<td>a. The minimization process</td>
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<td>b. Minimized form of the function</td>
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<td>c. The schematic of the minimized form</td>
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<td>d. Waveforms</td>
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<td>e. Truth tables verified on the board</td>
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<td>4</td>
<td>Answer the questions</td>
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<td>Question no.</td>
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<td>5</td>
<td>Conclusions</td>
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<td>Write down your conclusions, things learned, problems encountered during the lab and how they were solved, etc.</td>
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<tr>
<td>6</td>
<td>Attachments</td>
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<tr>
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<td>Zip your projects. Send through WebCampus as attachments, or provide link to the zip file on Google Drive / Dropbox, etc.</td>
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<td>List of attachments to deliver:</td>
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<tr>
<td></td>
<td>1. Quartus project for each function</td>
</tr>
</tbody>
</table>

**References:**

1. Charles H. Roth, Larry Kinney, Fundamentals of Logic Design
2. Alan B. Marcovitz, Introduction to Logic Design