EE461 Microprocessor-based Digital Design

Testing For Conditions

Assignment 6 Solutions

1. Consult the PIC16 programming guide posted on the web at http://www.usna.edu/EE/ee461/Homework/Lesson12Spring2006PIC16Programming.pdf. On page 11 is the following claim concerning the function V (overflow), the function N (sign), and the detection of the condition $a < b$ when a and b are eight-bit signed integers in two's-complement format and $d = a - b$:

$$V = a_7 \cdot b_7 \cdot d_7 + a_7 \cdot b_7 \cdot d_7.$$

With V available, $a < b$ whenever V and N differ, a condition captured by $V \square N$ or, equivalently, $V \cdot N + V \cdot N$. It can be shown by, say, the use of truth tables that this is equivalent to the expression $a_7 b_7 + a_7 d_7 + b_7 d_7$.

Use a truth table to prove the second sentence of the claim that evaluating $a < b$ is equivalent to evaluating $a_7 b_7 + a_7 d_7 + b_7 d_7$.

SOLUTION

First we can evaluate the expressions V and $V \square N$ for all combinations of a_7, b_7, and d_7, noting that $N = d_7$:

a_7 b_7 d_7	V	V XOR N
0 0 0	0	0
0 0 1	0	1
0 1 0	0	0
0 1 1	1	0
1 0 0	1	1
1 0 1	0	1
1 1 0	0	0
1 1 1	0	1

We can place the truth values of V N in a Karnaugh map in order to extract a suitable equation. The result is shown in Figure 1 and proves the claim that $a < b$ whenever $a_7 b_7 + a_7 d_7 + b_7 d_7$.

Alternatively, we could evaluate the expression $z = a_7b_7 + a_7d_7 + b_7d_7$ and add it to the truth table given above. From doing this it becomes obvious that $z = V \text{ XOR } N$.

a_7 b_7 d_7	V	(*V XOR N*)	*z*
0 0 0	0	0	0
0 0 1	0	1	1
0 1 0	0	0	0
0 1 1	1	0	0
1 0 0	1	1	1
1 0 1	0	1	1
1 1 0	0	0	0
1 1 1	0	1	1

A moment's reflection shows that when there is no overflow ($V = 0$), $a < b$ whenever the difference $d = a - b < 0$. When there is overflow, the sign of the result is incorrect (which is in effect what we mean by overflow), so in that case $a < b$ whenever the difference $d \geq 0$.