



16-bit Carry-select Adder

Introduction

Ripple-carry adders are the simplest and most compact adders (they require as little as four cells per bit in the AT6000 architecture), but their performance is limited by a carry that must ripple from the least-significant to the most-significant bit. A carry-select adder implemented in the AT6000 achieves speeds 40% to 90% faster by performing additions in parallel and reducing the maximum carry path.

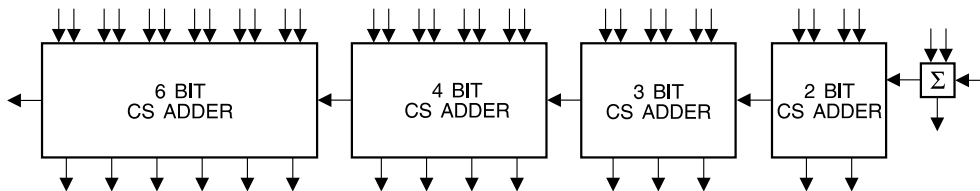
Description

A carry-select adder is divided into sectors, each of which – except for the least-significant – performs two additions in parallel, one assuming a carry-in of zero, the other a carry-in of one. The 16-bit carry-select adder of Figure 1, for example, is divided into sectors of lengths 1, 2, 3, 4, and 6, proceeding from least-significant to most-significant bit. The 4-bit sector of Figure 2 illustrates the general principle.

Within the sector, there are two 4-bit ripple-carry adders receiving the same data inputs but different carry-ins. The upper adder has a carry-in of zero; the lower adder a carry-in of one. The actual carry-in from the preceding sector selects one of the two adders. If the carry-in is zero, the sum and carry-out of the upper adder are selected. If the carry-in is one, the sum and carry-out of the lower adder are selected.

Logically, the result is no different than if a single ripple-carry adder were used. The difference, of course, is in performance. Instead of having to ripple through four full adders, the carry now only has to pass through a single multiplexer. In the AT6000 implementation (Figure 3), that multiplexer is implemented in a single cell, and the carry path through the sector incurs only a wire delay, a local-bus delay, and a multiplexer delay. Table 1 lists sizes and speeds for 16-bit ripple-carry and carry-select adders implemented in the AT6000.

Figure 1. 16-bit Carry-select Adder



Field Programmable Gate Array

Application Note



Figure 2. 4-bit Sector (Schematic)

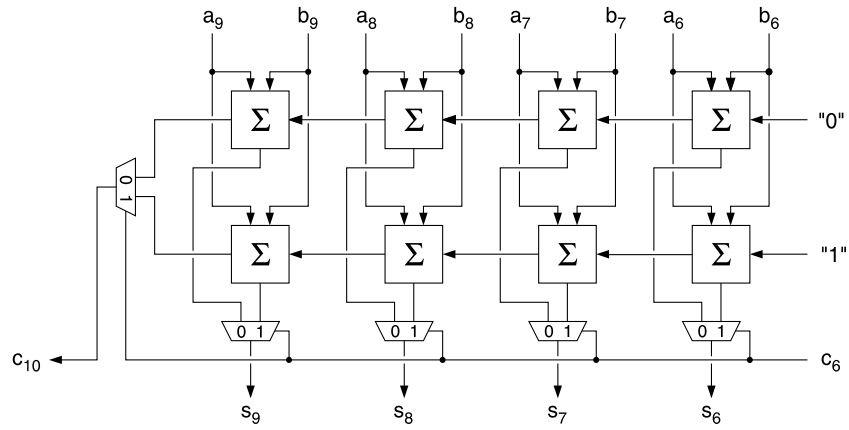


Figure 3. 4-bit Sector (Layout)

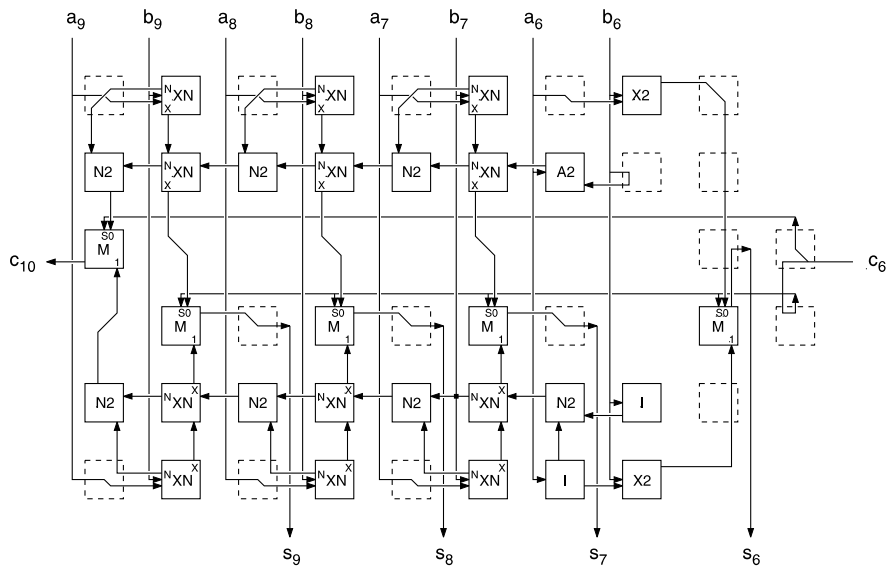


Table 1. Statistics for 16-bit Adders

| 16-bit Adder | Cell Count ⁽¹⁾ | Minimum Bounding Box (X x Y) | Maximum Speed (-4) ⁽²⁾ | Maximum Speed (-2) ⁽²⁾ |
|-------------------|---------------------------|------------------------------|-----------------------------------|-----------------------------------|
| Ripple Carry | 64 | 2 x 32 | 111.9 ns/8.9 MHz | 67.7 ns/14.7 MHz |
| Fast Ripple Carry | 96 | 6 x 16 | 87.2 ns/11.4 MHz | 51.6 ns/19.3 MHz |
| Carry Select | 222 | 6 x 37 | 63.4 ns/15.7 MHz | 35.8 ns/27.9 MHz |

Note: 1. Includes cells used as wires.
 2. Worst-case Commercial Operating Conditions



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