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.

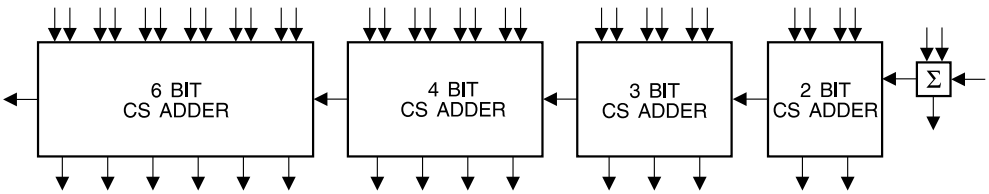
Description

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

Rev. 0467C–09/99

Figure 2. 4-bit Sector (Schematic)

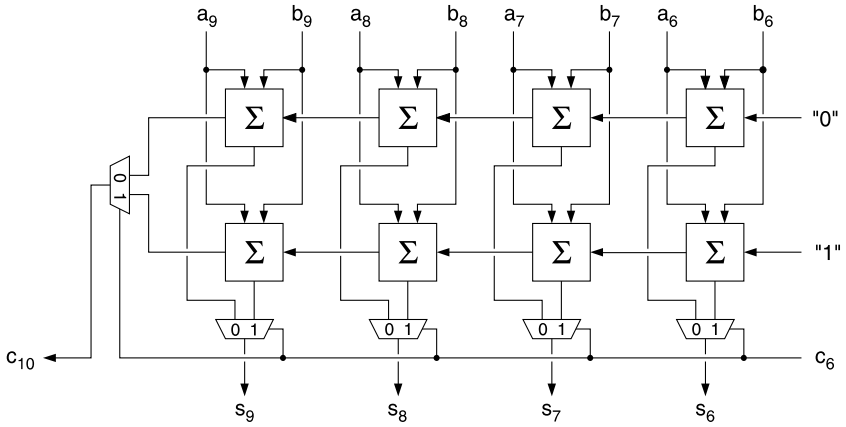


Figure 3. 4-bit Sector (Layout)

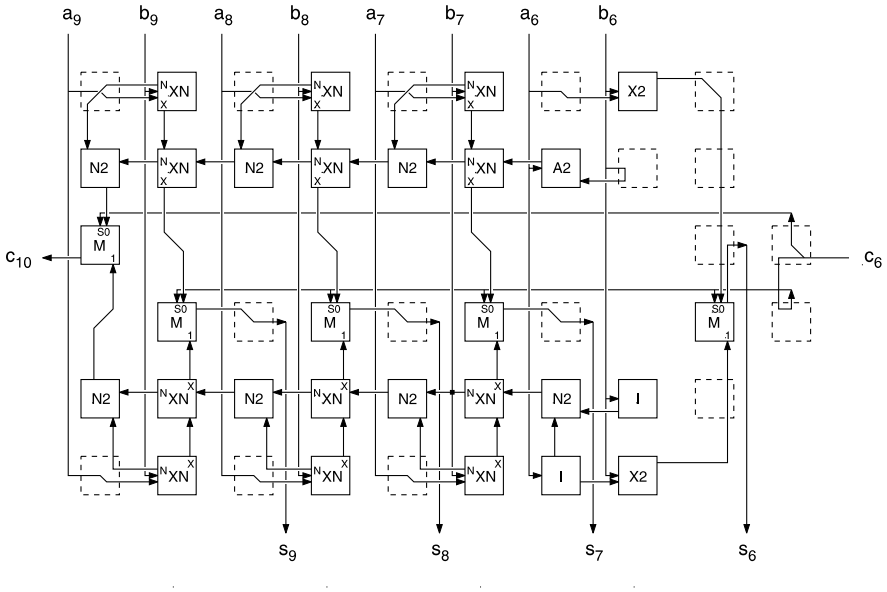


Table 1. Statistics for 16-bit Adders

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

Atmel Headquarters

Corporate Headquarters
2325 Orchard Parkway
San Jose, CA 95131
TEL (408) 441-0311
FAX (408) 487-2600

Europe
Atmel U.K., Ltd.
Coliseum Business Centre
Riverside Way
Camberley, Surrey GU15 3YL
England
TEL (44) 1276-686-677
FAX (44) 1276-686-697

Asia
Atmel Asia, Ltd.
Room 1219
Chinachem Golden Plaza
77 Mody Road Tsimhatsui
East Kowloon
Hong Kong
TEL (852) 2721-9778
FAX (852) 2722-1369

Japan
Atmel Japan K.K.
9F, Tonetsu Shinkawa Bldg.
1-24-8 Shinkawa
Chuo-ku, Tokyo 104-0033
Japan
TEL (81) 3-3523-3551
FAX (81) 3-3523-7581

Atmel Operations

Atmel Colorado Springs
1150 E. Cheyenne Mtn. Blvd.
Colorado Springs, CO 80906
TEL (719) 576-3300
FAX (719) 540-1759

Atmel Rousset
Zone Industrielle
13106 Rousset Cedex
France
TEL (33) 4-4253-6000
FAX (33) 4-4253-6001

Fax-on-Demand
North America:
1-(800) 292-8635
International:
1-(408) 441-0732

e-mail
literature@atmel.com

Web Site
http://www.atmel.com

BBS
1-(408) 436-4309

0467C–09/99/xM