## AVR202: 16-bit Arithmetics

## Features

- Easily Expandable to 32-bit or Any Word Length
- Code Density and Speed Matches 16-bit Controllers
- Runable Example Program


## Introduction

This application note lists program examples for arithmetic operation on 16-bit values. A listing of all implementations with key performance specifications is given in Table 1.

Table 1. Performance Figures Summary

| Application | Code Size <br> (Words) | Execution Time <br> (Cycles) |
| :--- | :---: | :---: |
| Add two 16-bit register variables | 2 | 2 |
| Add 16-bit immediate to 16-bit register variable | 2 | 2 |
| Subtract two 16-bit register variables | 2 | 2 |
| Subtract 16-bit immediate from 16-bit reg. variable | 2 | 2 |
| Compare two 16-bit register variables | 2 | 2 |
| Compare 16-bit immediate to 16-bit reg. variable | 3 | 3 |
| Negate a 16-bit register variable | 4 | 4 |

## 16 + 16-bit Register Addition

This operation is done as follows:

1. Add Low bytes.
2. Add with carry High bytes.

By adding more Add with Carry instructions, numbers of $n$-byte width can be added using $n$ instructions.

## 16-bit Register + 16-bit Immediate Addition

As the AVR has no add immediate or add immediate with carry, the subtract immediate and subtract immediate with carry instructions are used. The operation is done as follows:

1. Subtract immediate Low byte of negated number from register Low byte.
2. Subtract immediate with carry High byte of negated number from register High byte.
By adding more Add with Carry instructions, numbers of $n$-byte width can be added using $n$ instructions.
16-16-bit Register Subtraction

This operation is done as follows:

1. Subtract Low bytes.
2. Subtract with carry high Bytes.

By adding more Subtract with Carry instructions, numbers of $n$-byte width can be subtracted using $n$ instructions.

16-bit Register + 16bit Immediate Subtraction

This operation is done as follows:

1. Subtract immediate Low byte from register Low byte.
2. Subtract with carry immediate High byte from register High byte.

By adding more Subtract with Carry instructions, numbers of $n$-byte width can be subtracted using $n$ instructions.

Compare Two 16-bit This operation is done as follows:
Register Variables

Compare a 16-bit This operation is done as follows:
Register with a 16-bit Immediate

1. Compare register Low byte to immediate Low byte.
2. Store immediate High byte to a third register.
3. Compare with carry High bytes.

Negate (2's
Complement) a 16-bit Register Variable

This operation is done as follows:

1. Invert (1's Complement) Low byte
2. Invert (1's Complement) high byte
3. Subtract \$FF from Low byte.
4. Subtract with carry \$FF from High byte.

Note: $\quad$ Steps 3 and 4 are equivalent to adding $\$ 0001$ to the 16 -bit number.

Atmel Headquarters
Corporate Headquarters
2325 Orchard Parkway
San Jose, CA 95131
TEL 1(408) 441-0311
FAX 1(408) 487-2600
Europe
Atmel Sarl
Route des Arsenaux 41
Case Postale 80
$\mathrm{CH}-1705$ Fribourg
Switzerland
TEL (41) 26-426-5555
FAX (41) 26-426-5500
Asia
Room 1219
Chinachem Golden Plaza
77 Mody Road Tsimhatsui
East Kowloon
Hong Kong
TEL (852) 2721-9778
FAX (852) 2722-1369
Japan
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

Memory<br>2325 Orchard Parkway<br>San Jose, CA 95131<br>TEL 1(408) 441-0311<br>FAX 1(408) 436-4314

Microcontrollers
2325 Orchard Parkway
San Jose, CA 95131
TEL 1(408) 441-0311
FAX 1(408) 436-4314
La Chantrerie
BP 70602
44306 Nantes Cedex 3, France
TEL (33) 2-40-18-18-18
FAX (33) 2-40-18-19-60
ASIC/ASSP/Smart Cards
Zone Industrielle
13106 Rousset Cedex, France
TEL (33) 4-42-53-60-00
FAX (33) 4-42-53-60-01
1150 East Cheyenne Mtn. Blvd.
Colorado Springs, CO 80906
TEL 1(719) 576-3300
FAX 1(719) 540-1759
Scottish Enterprise Technology Park
Maxwell Building
East Kilbride G750QR, Scotland
TEL (44) 1355-803-000
FAX (44) 1355-242-743

## RF/Automotive <br> Theresienstrasse 2 <br> Postfach 3535 <br> 74025 Heilbronn, Germany <br> TEL (49) 71-31-67-0 <br> FAX (49) 71-31-67-2340 <br> 1150 East Cheyenne Mtn. Blvd. <br> Colorado Springs, CO 80906 <br> TEL 1(719) 576-3300 <br> FAX 1(719) 540-1759

Biometrics/Imaging/Hi-Rel MPU/<br>High Speed Converters/RF Datacom<br>Avenue de Rochepleine BP 123<br>38521 Saint-Egreve Cedex, France<br>TEL (33) 4-76-58-30-00<br>FAX (33) 4-76-58-34-80

e-mail<br>literature@atmel.com<br>Web Site<br>http://www.atmel.com

## © Atmel Corporation 2002.

Atmel Corporation makes no warranty for the use of its products, other than those expressly contained in the Company's standard warranty which is detailed in Atmel's Terms and Conditions located on the Company's web site. The Company assumes no responsibility for any errors which may appear in this document, reserves the right to change devices or specifications detailed herein at any time without notice, and does not make any commitment to update the information contained herein. No licenses to patents or other intellectual property of Atmel are granted by the Company in connection with the sale of Atmel products, expressly or by implication. Atmel's products are not authorized for use as critical components in life support devices or systems.

ATMEL ${ }^{\circledR}$ and $\mathrm{AVR}^{\circledR}$ are the registered trademarks of Atmel.

