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April 1st, 2010
Renesas Electronics Corporation

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M16C/62 Group

Signed 32 Bit Multiplication Library

1. Abstract

This application note describes an operational library of the multiplicant (signed 32 bit) X the multiplication (signed 32 bit) = the product (signed 64 bit) and its usage.

2. Introduction

This application note is applied to the microcomputers as below.

Applicable MCU
: M16C/62group(M16C/62A,M16C/62P,M16C/62M,M16C/62N,M16C/62T,M3062GF8NFP/GP)
: M16C/26 group
: M16C/30 group
: M16C/30L group
: M30201 group
: M30100/M30102 group

This program can also be used when operating other microcomputers within the M16C family, provided they have the same SFR (Special Function Registers) as the M16C/62 microcomputers. However, some functions may have been modified.
Refer to the User's Manual for details. Use functions covered in this Application Note only after careful evaluation.

Content

3. Signed 32 Bit Multiplication Library

3.1 Signed 32 Bit Multiplication Library

This program performs a signed 32-bit multiplicand x signed 32-bit multiplier= signed 64 bit product. Table 1 shows library specification.

Table 1 Library specification

Format	long long long_int_signed_multiply(multiplier, multiplicand);
Argument	long multiplier;.....multiplier long multiplicand;.....multiplicand
Return Value	Return calculation result (64 bit) in long long type
Stack Usage	15 bytes
ROM Size	106 bytes
Cycle No.	144 cycle (cycle number when performs 0x80000000 × 0x7fffffff)
Service Condition	Later than NC30 V.5.00 late

3.2 Program specification

1. Native multiplicands and multipliers are converted to positive.
2. As shown in Figure 1 of the multiplication method, find partial products ((1)(2)(3) and (4) in the figure) and obtains the final result of multiplication ((5) in the figure) by summing the partial products. The partial products are found by using the instruction for the unsigned multiplication (MULU.W) of two 16-bit binary numbers.
3. The product is converted to a negative number if the sign_flag is 1 as is shown in the table 2.

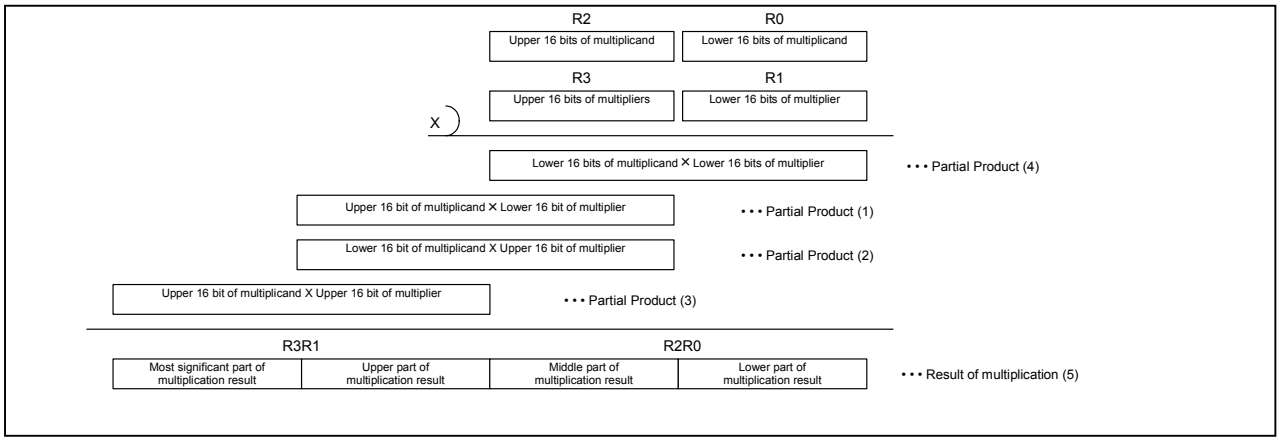
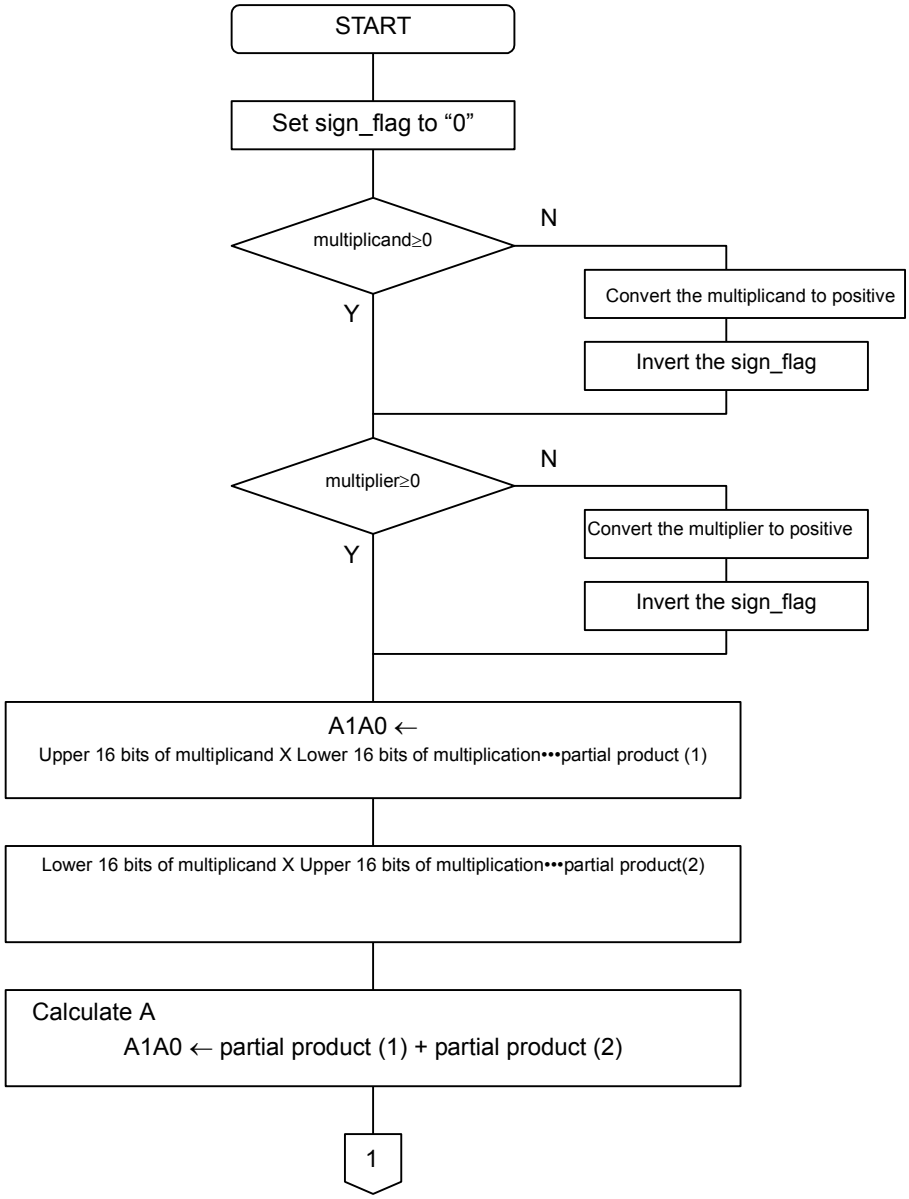


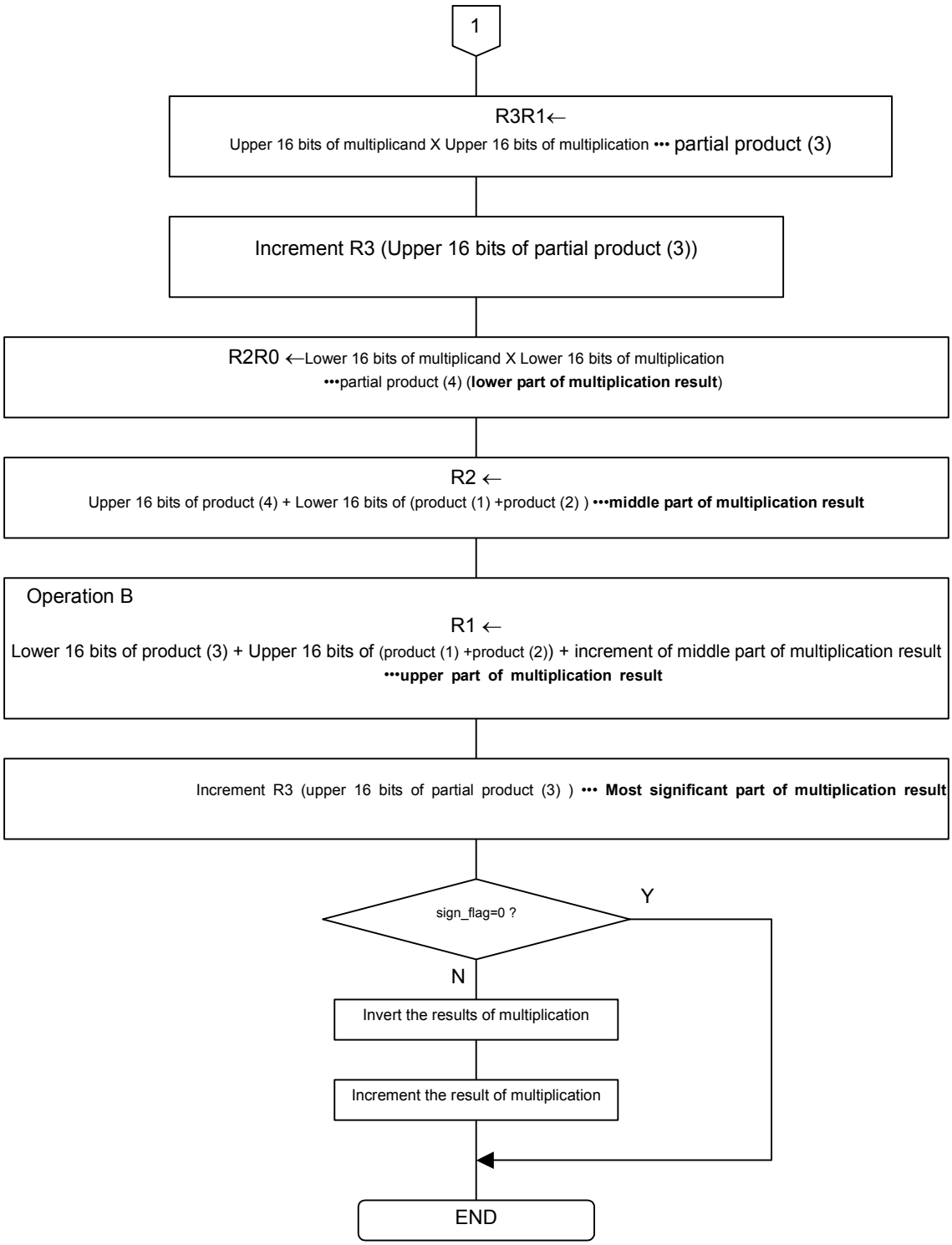
Figure 1. Multiplication method

Table 1. sign_flag (positive: 0; negative: 1)

multiplicand	multiplier	product	sign_flag
positive	positive	positive	0
positive	negative	negative	1
negative	positive	negative	1
negative	negative	positive	0

3.3 Flowchart




1
R3R1←
Upper 16 bits of multiplicand X Upper 16 bits of multiplication ••• partial product (3)
Increment R3 (Upper 16 bits of partial product (3))
R2R0 ←Lower 16 bits of multiplicand X Lower 16 bits of multiplication
•••partial product (4) (lower part of multiplication result)
R2 ←
Upper 16 bits of product (4) + Lower 16 bits of (product (1) +product (2)) •••middle part of multiplication result
Operation B
R1 ←
Lower 16 bits of product (3) + Upper 16 bits of (product (1) +product (2)) + increment of middle part of multiplication result
•••upper part of multiplication result
Increment R3 (upper 16 bits of partial product (3)) ••• Most significant part of multiplication result
sign_flag=0 ?
Y
N
Invert the results of multiplication
Increment the result of multiplication
END

4. Reference

Renesas Technology Corporation Home Page

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E-mail: support_apl@renesas.com

Hardware Manual

M16C/62 group（M16C/62P）Hardware Manual Rev.1.20
M16C/62 group（M16C/62P、M16C/62PT）datasheet Rev.2.10
M16C/62 group datasheet Rev.H6
M16C/62(80 pin version) group datasheet Rev.C4
M16C/62A group datasheet Rev.B1
M16C/62A(80 pin version) group datasheet Rev.B
M16C/62M group datasheet Rev.B1
M16C/62M(80 pin version) group datasheet Rev.B
M16C/62N group datasheet Rev.1.1
M16C/62N(80 pin version) group datasheet Rev.1.1
M16C/62T group datasheet Rev.A1
M3062GF8NFP/GP group datasheet Rev.1.1
M16C/30 group datasheet Rev.1.0
M16C/30L group datasheet Rev.1.0
M30201 group datasheet version Rev.E1
M30100/M30102 group datasheet preliminary version Rev.E1
(Use the latest version on the home page: http://www.renesas.com)

User's Manual

M16C/62 Group User's Manual Rev.C4
M16C/62A Group User's Manual Rev.1.0
M30201 Group User's Manual Rev.C
(Use the latest version on the home page: http://www.renesas.com)

5. The example of a reference program

```
/************************************************************************/
/*  M16C/62 SAMPLE PROGRAM                                              */
/*  FILENAME:                                                           */
/*  DESCRIPTION:                                                        */
/*  -- Multiplies signed 32-bit numbers together using registers.       */
/*  -- Result of 32-bit signed multiplicand x 32-bit signed             */
/*  multiplier operation is stored in 2 long integer variables          */
/*  for a 64-bit product.                                               */
/*                                                                      */
/*  CAUTION:This sample program needs NC30WA V5.00 Release1             */
/*                                                                      */
/*  Copyright 2003 by RENESAS SOLUTOINS                                 */
/*  All rights reserved. See Terms and Conditions document              */
/*  regarding the use of this sample program.                           */
/************************************************************************/

long lvar1, lvar2;              //
long long ret_ll;               // return value for long-long-type
long long result_64;         //

void main(void);
long long long_int_signed_multiply(long multiplier, long multiplicand);

void main(void)              // main loop for test
{
    lvar1 = 0x7fffffff;      // test value set
    lvar2 = 0x80000000;

    ret_ll = long_int_signed_multiply(lvar1, lvar2);

    {
        while(1);               // end loop
    }
}

long long long_int_signed_multiply(long multiplicand, long multiplier)
// multiplies two 32-bit signed number
// returns pointer to 64-bit product
{
    unsigned char sign_flag;             //

    asm("pushm  A0,A1");                 // R3R1R2R0 is return value

    asm("mov.b  #0,$@", sign_flag);      // signed flag "0" clear

    asm("mov.w  $@,R0", multiplicand);   // multiplicand lower 16bit
    asm("mov.w  2+$@,R2", multiplicand); // multiplicand upper 16bit
    asm("jpz       MUL32_S_010");        // signed check
    asm("not.w  R0");                        // neg
    asm("not.w  R2");                        // neg
    asm("add.w  #1,R0");                 // neg
    asm("adcf.w R2");                        // neg
    asm("mov.b  #1,$@", sign_flag);      // signed flag set "1"
    asm("MUL32_S_010:");

    asm("mov.w  $@,R1", multiplier);     // multiplier lower 16bit
    asm("mov.w  2+$@,R3", multiplier);   // multiplier upper 16bit
    asm("jpz       MUL32_S_020");        // signed check
    asm("not.w  R1");                        // neg
    asm("not.w  R3");                        // neg
    asm("add.w  #1,R1");                 // neg
```

```
    asm("adcf.w R3");                       // neg
    asm("bnot   0,$@", sign_flag);          // signed flag is changed
    asm("MUL32_S_020:");

    asm("push.w R1");               // multiplier lower 16bit saved
    asm("push.w R3");               // multiplier upper 16bit saved
    asm("push.w R3");               // multiplier upper 16bit saved
    asm("mulu.w R2,R1");         // (multiplicand upper 16bit) * (multiplier lower 16bit)
    asm("mov.w  R3,A1");         // result saved
    asm("mov.w  R1,A0");         // result saved
    asm("pop.w  R1");               // multiplier upper 16bit restored
    asm("mulu.w R0,R1");         // (multiplicand lower 16bit) * (multiplier upper 16bit)
    asm("add.w  R1,A0");         // result add and saved
    asm("adc.w  R3,A1");         // result add and saved, carry flag keeped
    asm("pop.w  R1");               // multiplier upper 16bit restored
    asm("mulu.w R2,R1");         // (multiplier upper 16bit) * (multiplier upper 16bit saved)
    asm("adcf.w R3");               // add uppest carry flag
    asm("pop.w  R2");               // multiplier lower 16bit restored
    asm("mulu.w R2,R0");         // (multiplier lower 16bit) * (multiplier lower 16bit saved)
    asm("add.w  A0,R2");         // result add and saved
    asm("adc.w  A1,R1");         // result add and saved
    asm("adcf.w R3");               //  add uppest carry flag

    asm("btst   0,$@", sign_flag);    // signed flag?
    asm("jnc       MUL32_S_030"); // if plus sign, jump
    asm("not.w  R0");               // neg
    asm("not.w  R2");               // neg
    asm("not.w  R1");               // neg
    asm("not.w  R3");               // neg
    asm("add.w  #1,R0");         // neg
    asm("adcf.w R2");               // neg
    asm("adcf.w R1");               // neg
    asm("adcf.w R3");               // neg
    asm("MUL32_S_030:");

    asm("popm   A0,A1");         // R3R1R2R0 is return value

    return;
}
```

REVISION HISTORY

Rev.	Date		Description
		Page	Summary
1.00	2004.04.16	-	First edition issued

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