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April 1st, 2010
Renesas Electronics Corporation

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April 1, 2003

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APPLICATION NOTE

Unsigned 32-Bit Binary Multiplication (MUL)

Introduction

Carries out multiplication in this format:
multiplicand (unsigned, 32 bits) × multiplier (unsigned, 32 bits) = product (unsigned, 64 bits).

Target Device

H8/300H Series

Contents

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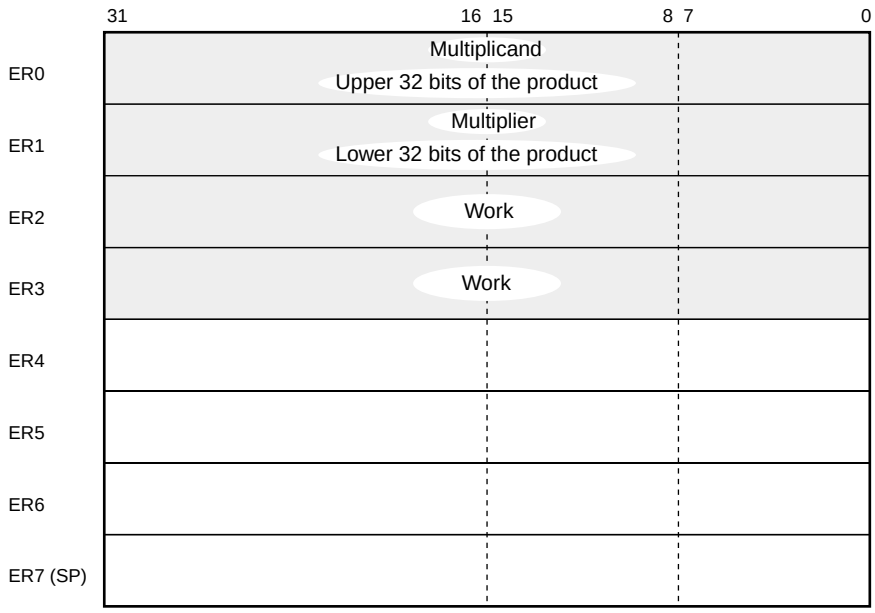
1. Arguments

Description		Storage Location	Data Length (Bytes)
Input	Multiplicand (unsigned, 32 bits)	ER0	4
	Multiplier (unsigned, 32 bits)	ER1	4
Output	Upper 32 bits of the product (unsigned, 64 bits)	ER0	4
	Lower 32 bits of the product (unsigned, 64 bits)	ER1	4

2. Changes to Internal Registers and Flags



I	UI	H	U	N	Z	V	C
–	–	↕	–	↕	↕	↕	↕

– : No change
↕ : Varies
0 : Fixed to 0
1 : Fixed to 1

3. Programming Specifications

Program memory (bytes)
34
Data memory (bytes)
0
Stack (bytes)
0
Number of cycles
126
Re-entrant
Yes
Relocatable
Yes
Interrupts during execution
Yes

4. Note

The number of cycles in the programming specifications is the value when calculating H'FFFFFFFF × H'FFFFFFFF.

5. Description

5.1 Description of Functions

1. The arguments are as follows:

   ER0: Set the multiplicand (unsigned, 32 bits) as an input argument. The upper 32 bits of the product (unsigned, 64 bits) is also set here as an output argument.

   ER1: Set the multiplier (unsigned, 32 bits) as an input argument. The lower 32 bits of the product (unsigned, 64 bits) is also set here as an output argument.

2. The following figure illustrates the execution of the MUL subroutine. When the input arguments are set as shown below, the product is set in ER0 and ER1.

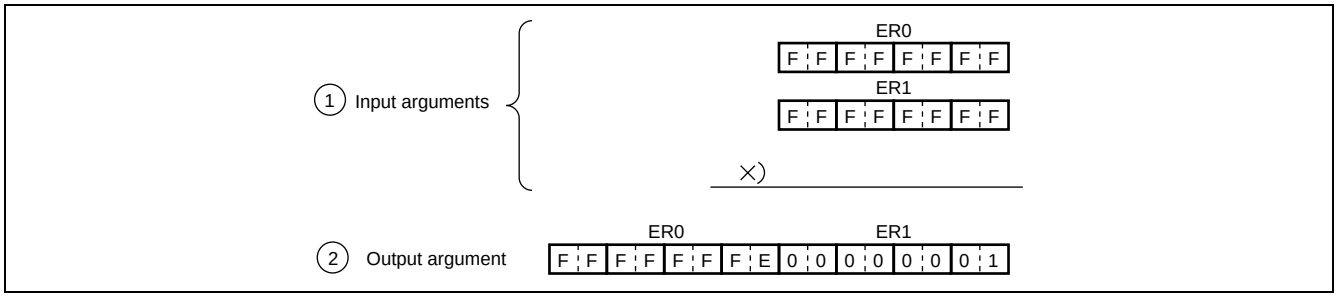


Figure 5.1 Example of MUL Execution

5.2 Usage Notes

Since the product is written to ER0 and ER1 where the multiplicand and multiplier were set, both the multiplicand and multiplier are lost through execution of MUL. If you will still require the multiplicand and multiplier, save them elsewhere in memory beforehand.

5.3 Description of Data Memory

No data memory is used by MUL.

5.4 Example of Usage

After setting the multiplicand and multiplier, call the MUL subroutine.

```
WORK1  . RES. L 1          ..... Reservation of the data memory area for setting of the multiplicand (unsigned, 32 bits) by the user
                                 program.
WORK2  . RES. L 1          ..... Reservation of the data memory area for setting of the multiplier (unsigned, 32 bits) by the user
                                 program.
          .
          .
          .
       MOV. L @WORK1, ER0  ..... Sets, as an input argument, the 32-bit binary multiplicand specified by the user program.

       MOV. L @WORK2, ER1  ..... Sets, as an input argument, the 32-bit binary multiplier specified by the user program.

       JSR    @MUL         ..... Subroutine call of MUL.
```

5.5 Principle of Operation

To carry out 32-bit binary multiplication, the partial products of the pairs of 16-bit binary numbers are found by using the multiplication instruction (MULXU.W) and the results of multiplication are accumulated, as shown in the figure below.

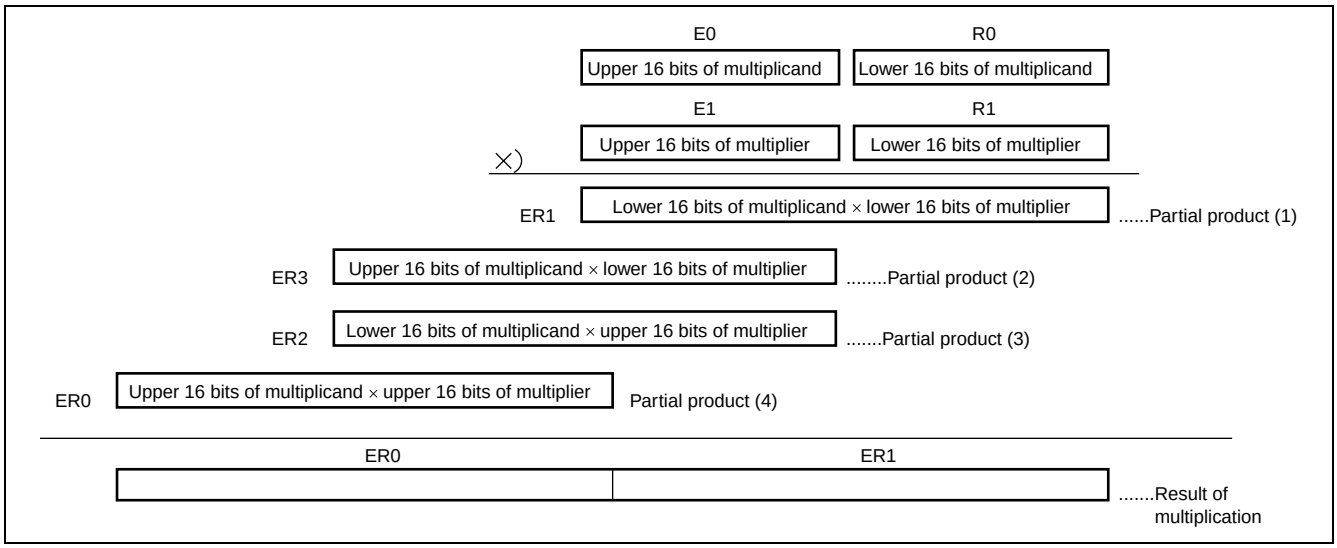
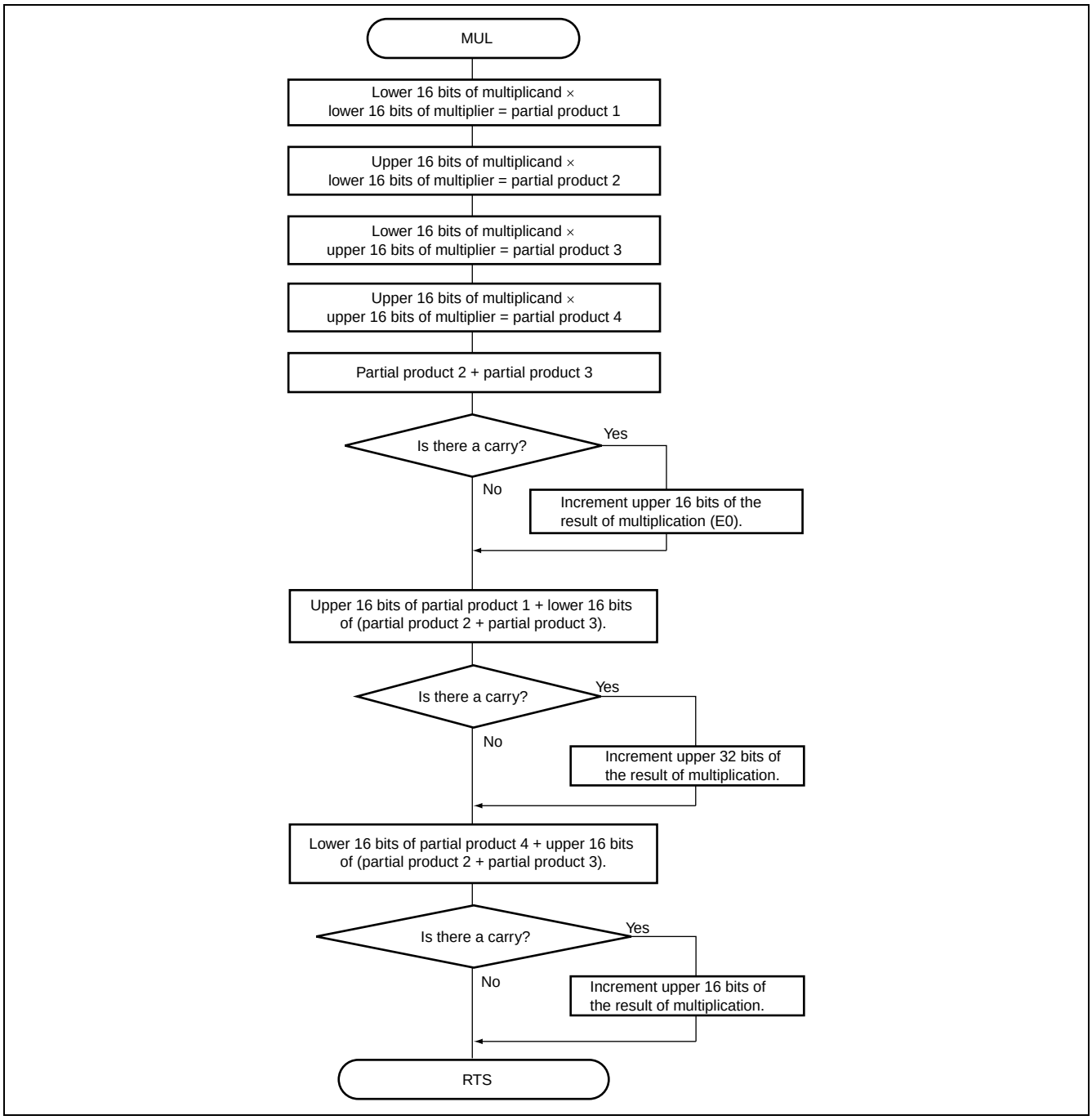


Figure 5.2 Multiplication

6. Flowchart


MUL
Lower 16 bits of multiplicand ×
lower 16 bits of multiplier = partial product 1
Upper 16 bits of multiplicand ×
lower 16 bits of multiplier = partial product 2
Lower 16 bits of multiplicand ×
upper 16 bits of multiplier = partial product 3
Upper 16 bits of multiplicand ×
upper 16 bits of multiplier = partial product 4
Partial product 2 + partial product 3
Is there a carry?
Yes
No
Increment upper 16 bits of the
result of multiplication (E0).
Upper 16 bits of partial product 1 + lower 16 bits
of (partial product 2 + partial product 3).
Is there a carry?
Yes
No
Increment upper 32 bits of
the result of multiplication.
Lower 16 bits of partial product 4 + upper 16 bits
of (partial product 2 + partial product 3).
Is there a carry?
Yes
No
Increment upper 16 bits of
the result of multiplication.
RTS

7. Program Listing

```
 1                                1     ;*********************************************************************
 2                                2     ;*                                                                   *
 3                                3     ;*        NAME      :      32 BIT MULTIPLICATION   (MUL)             *
 4                                4     ;*                                                                   *
 5                                5     ;*********************************************************************
 6                                6     ;*                                                                   *
 7                                7     ;*        ENTRY     :      ER0          (MULTIPLICAND)               *
 8                                8     ;*                          ER1          (MULTIPLIER)                 *
 9                                9     ;*        RETURNS   :      ER3          (UPPER 32 BIT PRODUCT)       *
10                               10     ;*                          ER0          (LOWER 32 BIT PRODUCT)       *
11                               11     ;*                                                                   *
12                               12     ;*********************************************************************
13                               13     ;
14                               14               .CPU             300HA
15     001000                    15               .SECTION A,CODE,LOCATE=H'001000
16              00001000         16     MUL       .EQU             $            ;Entry point
17     001000   0D02             17     MUL1      MOV.W            R0,R2        ;
18     001002   0D83             18               MOV.W            E0,R3        ;
19     001004   0D9B             19               MOV.W            E1,E3        ;
20     001006   5210             20               MULXU.W          R1,ER0       ;
21     001008   5231             21               MULXU.W          R3,ER1       ;
22     00100A   52B2             22               MULXU.W          E3,ER2       ;
23     00100C   52B3             23               MULXU.W          E3,ER3       ;
24     00100E   0AA1             24               ADD.L            ER2,ER1      ;
25     001010   58400002         25               BCC              MUL2         ;
26     001014   0B5B             26               INC.W            #1,E3        ;
27     001016   0918             27     MUL2      ADD.W            R1,E0        ;
28     001018   58400002         28               BCC              MUL3         ;
29     00101C   0B73             29               INC.L            #1,ER3       ;
30     00101E   0993             30     MUL3      ADD.W            E1,R3        ;
31     001020   58400002         31               BCC              MUL4         ;
32     001024   0B5B             32               INC.W            #1,E3        ;
33     001026   5470             33     MUL4      RTS
34                               34               .END
***** TOTAL    ERRORS     0
***** TOTAL    WARNINGS   0
```

The program listing included in this application note assumes compilation under the option for the advanced mode of H8/300H CPU. If you use this sample program with an H8/300H Tiny Series product, make the following change to the program code:

.CPU 300HA → .CPU 300HN