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# H8/300L Super Low Power Series

## Multiplication of 16-Bit Binary Numbers (MUL)

## Introduction

The software MUL multiplies a 16-bit binary number by another 16-bit binary number and places the result (a 32-bit binary number) in a general-purpose register.

## Target Device

H8/38024

## Contents

## 1. Arguments

| Description | | Memory area | Data length (bytes) |
|---|---|---|---|
| Input | Multiplicand | R1 | 2 |
| | Multiplier | R0 | 2 |
| Output | Result of multiplication | R1, R2 | 4 |

## 2. Changes to Internal Registers and Flags

| R0 | R1 | R2 | R3 | R4 | R5 | R6 | R7 |
|---|---|---|---|---|---|---|---|
| × | ○ | ○ | × | × | × | × | — |

| I | U | H | U | N | Z | V | C |
|---|---|---|---|---|---|---|---|
| — | — | × | — | × | × | × | × |

Legend
—: No change
×: Undefined
○: Result

## 3. Specifications

| |
|---|
| Program memory (bytes) |
| 32 |
| Data memory (bytes) |
| 0 |
| Stack (bytes) |
| 0 |
| Clock cycle count |
| 86 |
| Reentrant |
| Possible |
| Relocation |
| Possible |
| Interrupt |
| Possible |

# 4. Description

## 4.1 Details of functions

1. The following arguments are used with the software MUL:

   R0: Sets a 16-bit binary multiplier as an input argument.

   R1: Sets a 16-bit binary multiplicand as an input argument. The upper 2 bytes of the result are placed in this register after execution of the software MUL.

   R2: The lower 2 bytes of the result is placed in this register as an output argument.

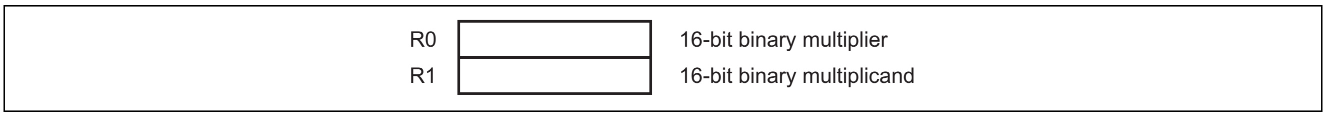



**Figure 1 Input Argument Setting**

2. The following figure illustrates the execution of the software MUL. When the input arguments are set as shown in (1), the result of multiplication is placed in R1 and R2 as shown in (2).

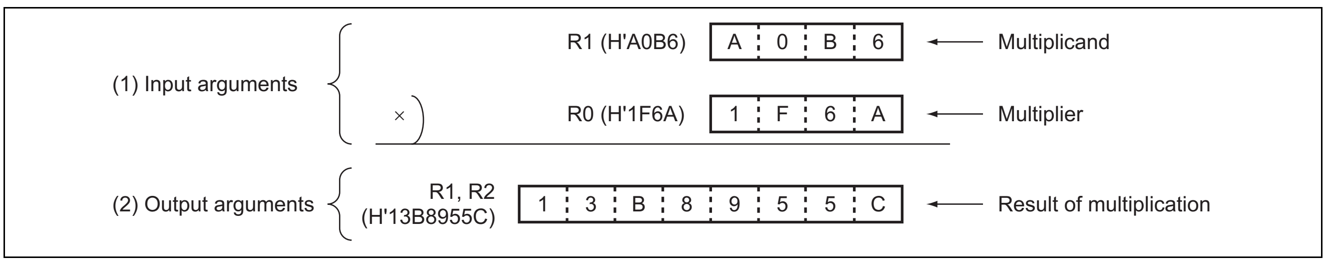



**Figure 2 Example of Software MUL Execution**

3. Table 1 lists the results of multiplication with 0 placed in the input arguments.

**Table 1 Results of Multiplication with 0 Placed in Input Arguments**

| Input argument | | Output argument |
|---|---|---|
| **Multiplicand (R1)** | **Multiplier (R0)** | **Product (R1, R2)** |
| H'**** | H'0000 | H'0000 0000 |
| H'0000 | H'**** | H'0000 0000 |
| H'0000 | H'0000 | H'0000 0000 |

Note: H'**** is any given hexadecimal number.

## 4.2 Notes on usage

1. When upper bits are not used (see figure 3), set them to 0; otherwise, a correct result cannot be obtained because multiplication is made on the numbers including indeterminate data.

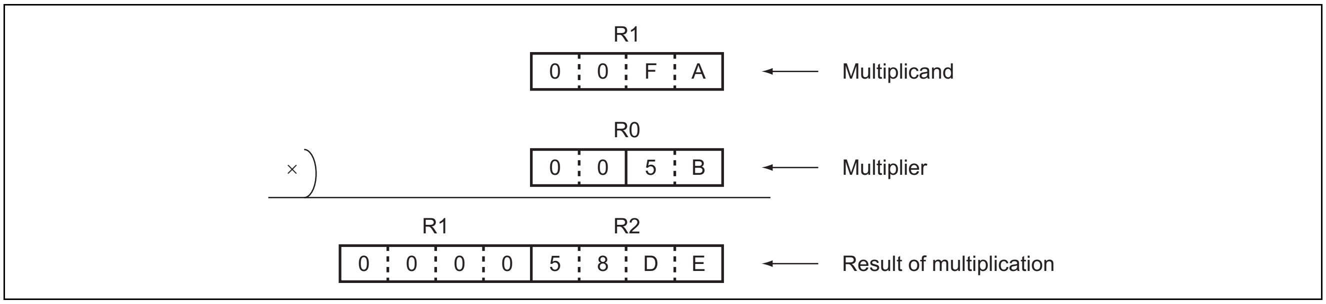



**Figure 3 Example of Multiplication with Upper Bits Unused**

2. After execution of the software MUL, the multiplicand will be lost because the result is placed in R1. If the multiplicand is still needed after software MUL execution, save it in memory.

## 4.3 Data memory

The software MUL uses no data memory.

## 4.4 Example of usage

Set a multiplicand and a multiplier in the input arguments and call the software MUL as a subroutine.

```
WORK1    .RES.W   1        ---------- Reserve a data memory area in which the user program places
                                      a 16-bit binary multiplicand.

WORK2    .RES.W   1        ---------- Reserve a data memory area in which the user program places
                                      a 16-bit binary multiplier.

WORK3    .RES.W   2        ---------- Reserve a data memory area for storage of the result of multiplication
            .                         (a 32-bit binary number).
            .
            .
         MOV.W    @WORK1, R1  ------- Place the 16-bit binary multiplicand set by the user program
                                      in the input arguments (R1).

         MOV.W    @WORK2, R0  ------- Place the 16-bit binary multiplier set by the user program
                                      in the input arguments (R0).

         JSR      @MUL        ------- Call the software MUL as a subroutine.

         MOV.W R1, @WORK3     ------- Place the result of multiplication (a 32-bit binary number
         MOV.W R2, @WORK3+2           set in the output arguments) in the data memory
            .                         of the user program.
            .
            .
```

## 4.5 Operation

1. Figure4 shows an example of multiplication of 16-bit binary numbers.

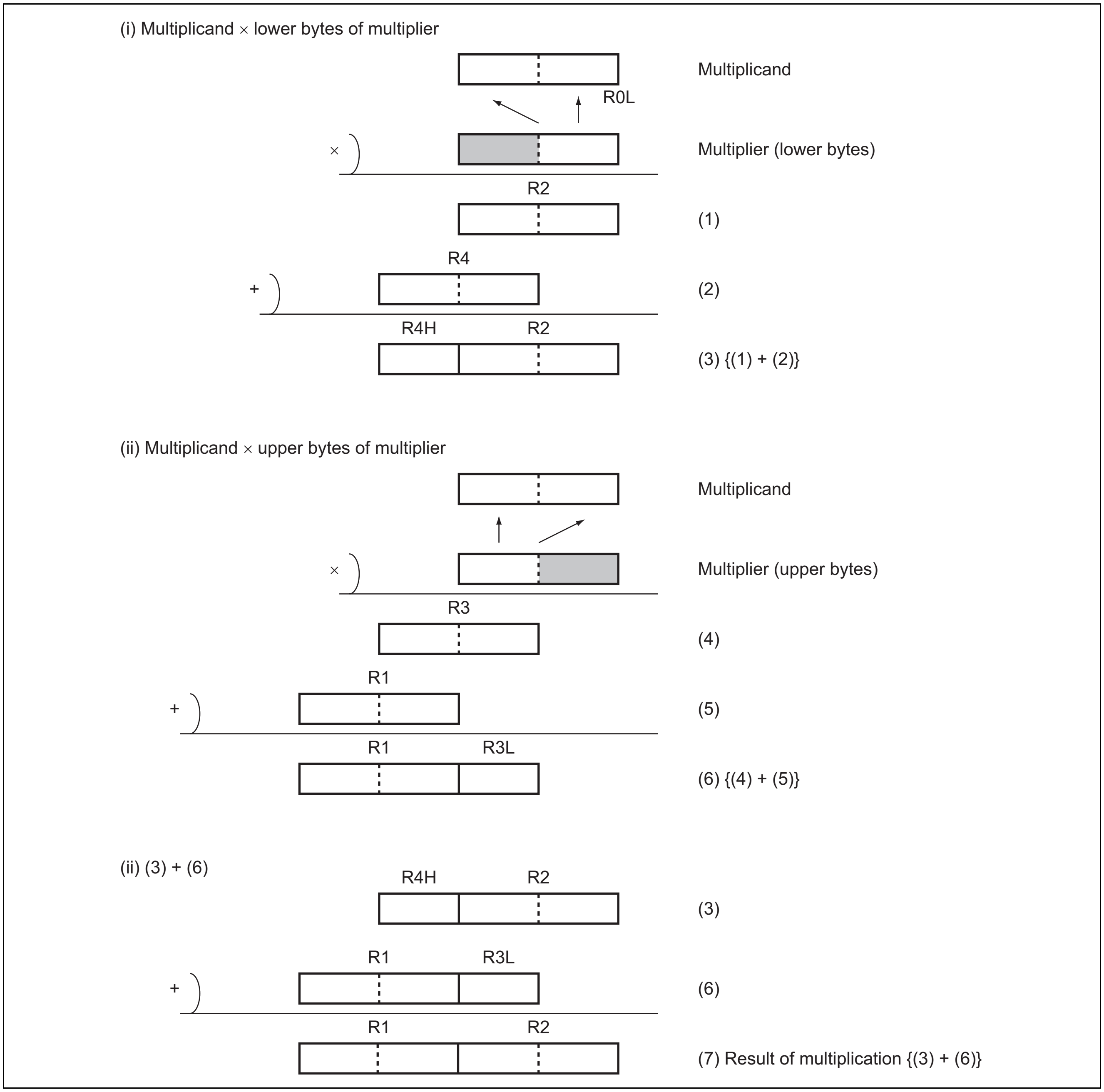
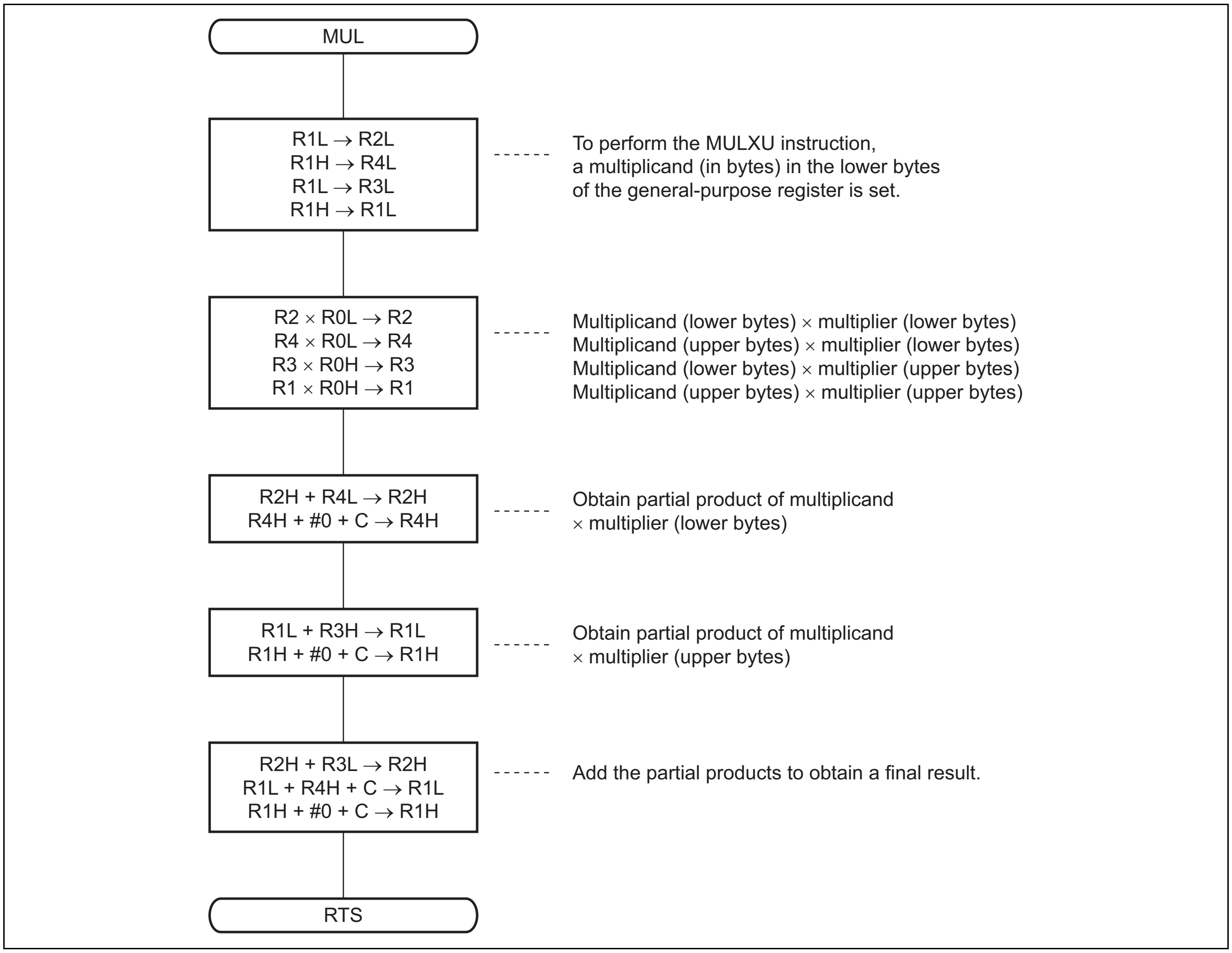



**Figure 4 Example of Software MUL Execution**

Multiplication of 16-bit binary numbers consists of two stages as shown in figure 4: finding two partial products (3) and (6) by using the MULXU instruction and adding them.

2. The program runs in the following steps:
   a. The MULXU instruction is used to obtain the result of the multiplicand (lower byte) × the multiplier (lower byte) ((1) in figure 4) and the result of the multiplicand (upper byte) × the multiplier (lower byte) ((2) in figure 4). Then these two results are added to obtain a partial product, that is, the multiplicand × the multiplier (lower byte) ((3) in figure 4).
   b. The MULXU instruction is used to obtain another partial product, that is, the multiplicand × the multiplier (upper byte) ((6) in figure 4).
   c. The two partial products found in steps a and b are added to obtain the result of multiplication ((7) in figure 4).

## 5. Flowchart


MUL
R1L → R2L
R1H → R4L
R1L → R3L
R1H → R1L
To perform the MULXU instruction, a multiplicand (in bytes) in the lower bytes of the general-purpose register is set.
R2 × R0L → R2
R4 × R0L → R4
R3 × R0H → R3
R1 × R0H → R1
Multiplicand (lower bytes) × multiplier (lower bytes)
Multiplicand (upper bytes) × multiplier (lower bytes)
Multiplicand (lower bytes) × multiplier (upper bytes)
Multiplicand (upper bytes) × multiplier (upper bytes)
R2H + R4L → R2H
R4H + #0 + C → R4H
Obtain partial product of multiplicand × multiplier (lower bytes)
R1L + R3H → R1L
R1H + #0 + C → R1H
Obtain partial product of multiplicand × multiplier (upper bytes)
R2H + R3L → R2H
R1L + R4H + C → R1L
R1H + #0 + C → R1H
Add the partial products to obtain a final result.
RTS

## 6. Program List

```
*** H8/300 ASSEMBLER VER 1.0B ** 08/18/92 09:54:03
PROGRAM NAME =
                               ;****************************************************************
                               ;*
                               ;*      00 - NAME    :16 BIT MULTIPLICATION (MUL)
                               ;*
                               ;****************************************************************
                               ;*
                               ;*      ENTRY        :R0 (MULTIPLIER)
                               ;*                    R1 (MULTIPLICAND)
                               ;*
                               ;*      RETURNS      :R1 (UPPER WORD OF RESULT)
                               ;*                    R2 (LOWER WORD OF RESULT)
                               ;*
                               ;****************************************************************
                               ;
   MUL_code C    0000                  .SECTION              MUL_code,CODE,ALIGN=2
                                        .EXPORT              MUL
                               ;
   MUL_code C         00000000 MUL     .EQU $                ;Entry point
   MUL_code C    0000  0C9A            MOV.B    R1L,R2L      ;R1L -> R2L
   MUL_code C    0002  0C1C            MOV.B    R1H,R4L      ;R1H -> R4L
   MUL_code C    0004  0C9B            MOV.B    R1L,R3L      ;R1L -> R3L
   MUL_code C    0006  0C19            MOV.B    R1H,R1L      ;R1H -> R1L
                               ;
   MUL_code C    0008  5082            MULXU    R0L,R2       ;R0L * R2L -> R2
   MUL_code C    000A  5084            MULXU    R0L,R4       ;R0L * R4L -> R4
   MUL_code C    000C  5003            MULXU    R0H,R3       ;R0H * R3L -> R3
   MUL_code C    000E  5001            MULXU    R0H,R1       ;R0H * R1L -> R1
                               ;
   MUL_code C    0010  08C2            ADD.B    R4L,R2H      ;R2H + R4L -> R2H
   MUL_code C    0012  9400            ADDX.B   #H'00,R4H    ;R4H + #H'00 + C -> R4H
   MUL_code C    0014  0839            ADD.B    R3H,R1L      ;R3H + R1L -> R1L
   MUL_code C    0016  9100            ADDX.B   #H'00,R1H    ;R1H + #H'00 + C -> R1H
                               ;
   MUL_code C    0018  08B2            ADD.B    R3L,R2H      ;R3L + R2H -> R2H
   MUL_code C    001A  0E49            ADDX.B   R4H,R1L      ;R4H + R1L + C -> R1L
   MUL_code C    001C  9100            ADDX.B   #H'00,R1H    ;R1H + #H'00 + C -> R1H
                               ;
   MUL_code C    001E   5470           RTS
                               ;
                                       .END
*****TOTAL ERRORS 0
*****TOTAL WARNINGS 0
```

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