To our customers,

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April 1st, 2010
Renesas Electronics Corporation

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RENESAS

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Renesas Technology Corp.
Customer Support Dept.
April 1, 2003

Renesas Technology Corp.

APPLICATION NOTE

Summation of Products (SEKIWA)

Introduction

Finds the following sum of products for unsigned 16-bit data a_n and b_n (n = 1, 2, …, n) in data tables a and b. The maximum number of data elements, n, is 255.

$$\sum_{n=1}^{n} a_n b_n = a_1 b_1 + a_2 b_2 + \dots + a_n b_n \quad \dots\dots (1)$$

Target Device

H8/300H Series

Contents

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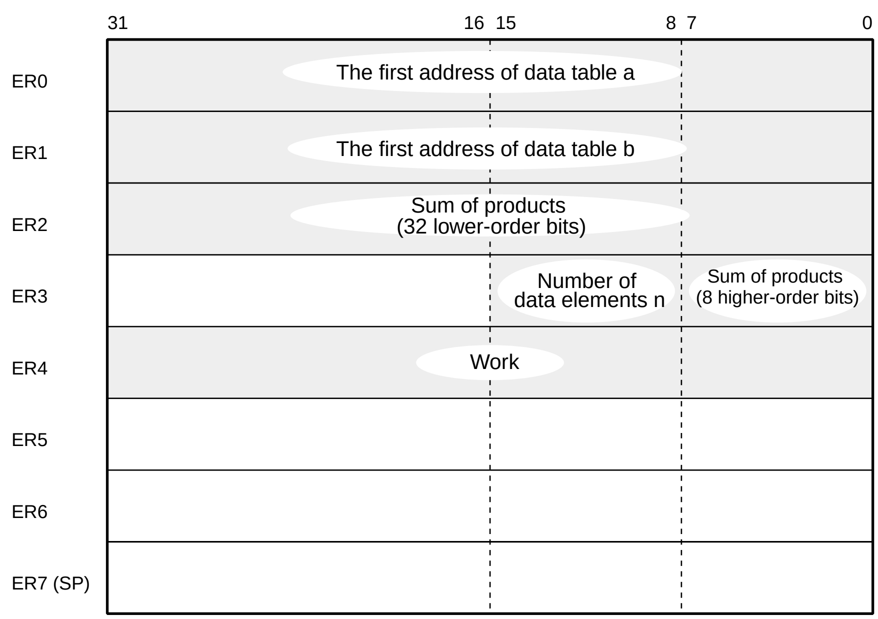
1. Arguments

Description		Storage Location	Data Length (Bytes)
Input	First address of data table a	ER0	4
	First address of data table b	ER1	4
	Number of data elements n	R3H	1
Output	Sum of products (higher-order 8 bits)	R3L	1
	Sum of products (lower-order 32 bits)	ER2	4

2. Changes to Internal Registers and Flags



I	UI	H	U	N	Z	V	C
–	–	↕	–	↕	1	↕	↕

– : No change

↕ : Varies

0 : Fixed to 0

1 : Fixed to 1

3. Programming Specifications

Program memory (bytes)
20
Data memory (bytes)
0
Stack (bytes)
0
Number of cycles
11234
Re-entrant
Yes
Relocatalbe
Yes
Interrupts during execution
Yes

4. Note

The number of cycles in the programming specifications is the value when the number of data elements n is H'FF.

5. Description

5.1 Description of Functions

1. The arguments are as follows.
   ER0: Set the first address of data table a (multiplicands) as an input argument.
   ER1: Set the first address of data table b (multipliers) as an input argument.
   R3H: Set the number of data elements as an input argument.
   R3L: The higher-order 8 bits of the sum of products are set here as an output argument.
   ER2: The lower-order 32 bits of the sum of products are set here as an output argument.
2. The following figure illustrates the execution of the SEKIWA subroutine. When the first addresses of data tables a and b and number of data elements n are set as shown below, the subroutine places the higher-order 8 bits of the result in R3L and the lower-order 32 bits of the result in ER2.

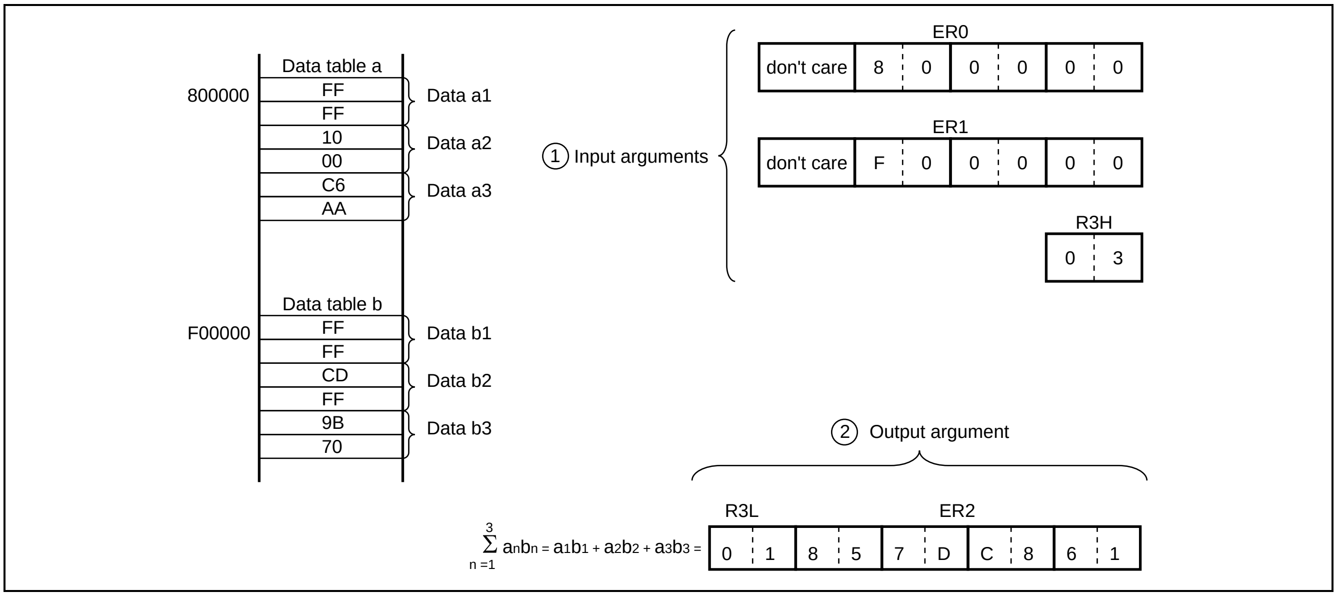


Figure 5.1 Example of SEKIWA Execution

5.2 Usage Note

Since R3H holds 1 byte, the value set here must be in the range H'01 ≤ R3H ≤ H'FF.

5.3 Description of Data Memory

No data memory is used by SEKIWA.

5.4 Example of Usage

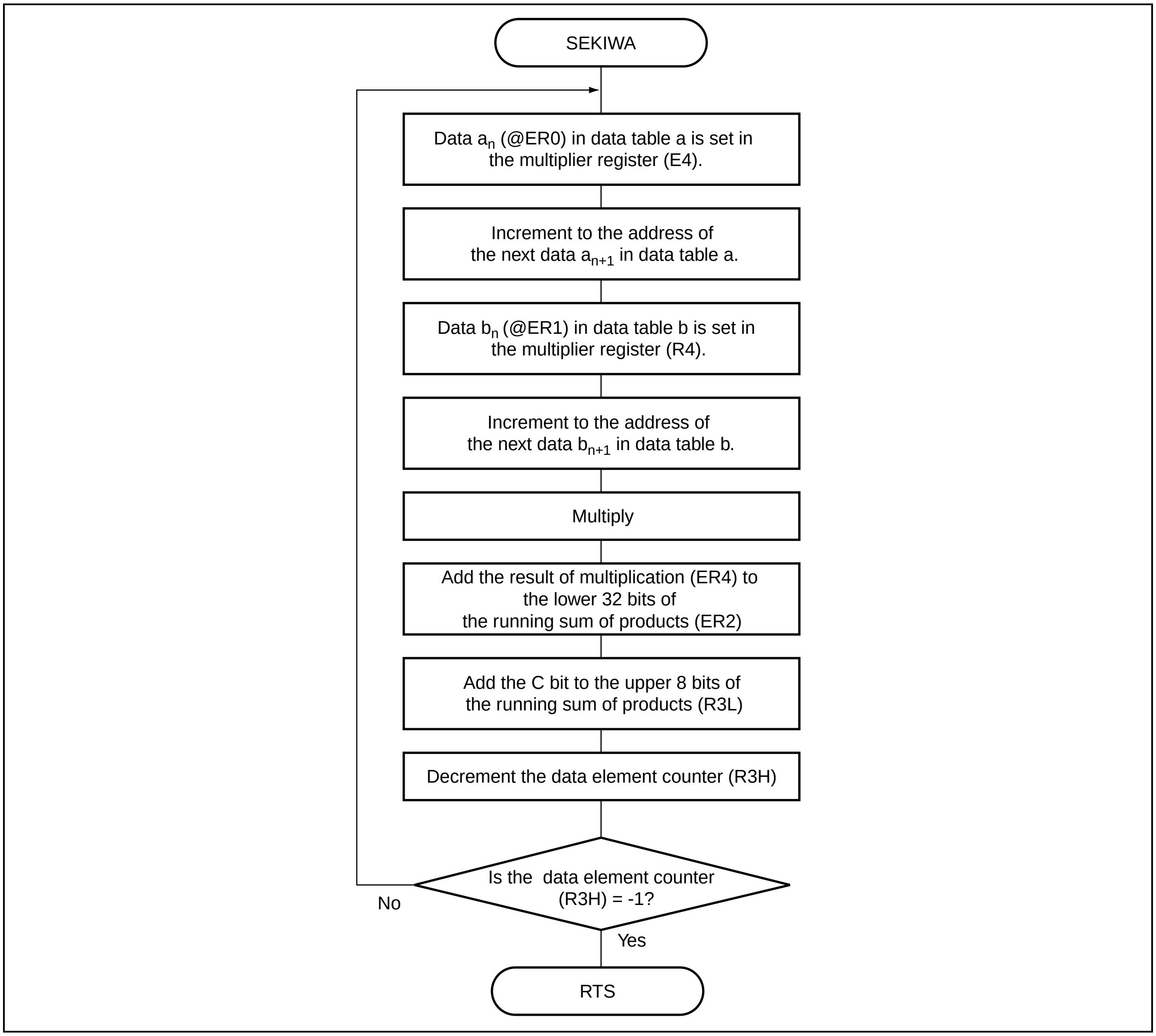
After setting the first addresses of data tables a and b and number of elements, call the SEKIWA subroutine.

```
WORK1   . RES. L 1              ········· Reservation of the data memory area for setting of the first address  of data table a by the user
                                          program.
WORK2   . RES. L 1              ········· Reservation of the data memory area for setting of first address of data table b by the user
                                          program.
WORK3   . RES. B 1              ········· Reservation of the data memory area for setting of the number of data elements by the user
                                          program.

        MOV. L @WORK1, ER0      ········· Sets, as an input argument, the first address of data table a specified by the user program.

        MOV. L @WORK2, ER1      ········· Sets, as an input argument, the first address of data table b specified by the user program.

        MOV. B @WORK3, R3H      ········· Sets, as an input argument, the number of data elements specified by the user program.
           .
           .
           .
       JSR    @SEKIWA           ········· Subroutine call of SEKIWA.
```

5.5 Principles of Operation

1. ER0 and ER1 are used as pointers to the addresses of the current multiplicand (in data table a) and multiplier (in data table b). Post–increment register indirect addressing is used so that the pointers are incremented to the next data address after the current multiplicand and multiplier have been transferred to E4 and R4, respectively.
2. Multiplication of E4 and R4 is unsigned.
3. The result of multiplication, stored in ER4, is added to ER2, which holds the lower-order 32 bits of the sum of products.
4. Since a carry may be generated by the above addition, an addition with carry is executed to add the value of the carry bit to R3L, which holds the higher-order 8 bits of the sum of products.
5. R3H is decremented and the processing of steps 1 to 4 is repeated until R3H = –1.

6. Flowchart


SEKIWA
Data a_n (@ER0) in data table a is set in the multiplier register (E4).
Increment to the address of the next data a_{n+1} in data table a.
Data b_n (@ER1) in data table b is set in the multiplier register (R4).
Increment to the address of the next data b_{n+1} in data table b.
Multiply
Add the result of multiplication (ER4) to the lower 32 bits of the running sum of products (ER2)
Add the C bit to the upper 8 bits of the running sum of products (R3L)
Decrement the data element counter (R3H)
Is the data element counter (R3H) = -1?
No
Yes
RTS

7. Program Listing

```
                                     ;*************************************************************************
                                     ;*                                                                       *
                                     ;*          NAME    :       SEKIWA          (SEKIWA)                     *
                                     ;*                                                                       *
                                     ;*************************************************************************
                                     ;*                                                                       *
                                     ;*          ENTRY:          ER0             (TABLE ADDRESS)              *
                                     ;*                          ER1             (TABLE ADDRESS)              *
                                     ;*          RETURN:         R3H             (HIGHER 8 BIT)               *
                                     ;*                          ER2             (LOWER 32 BIT)               *
                                     ;*                                                                       *
                                     ;*************************************************************************
                                     ;
                                                 .CPU            300HA
      001000                                     .SECTION A,CODE,LOCATE=H'001000
               00001000              SEKIWA      .EQU            $               ;
      001000   18BB                              SUB.B           R3L,R3L         ;
      001002   1AA2                              SUB.L           ER2,ER2         ;CLEAR ER2
      001004   6D0C                  SEKIWA1     MOV.W           @ER0+,E4        ;
      001006   6D14                              MOV.W           @ER1+,R4        ;
      001008   52C4                              MULXU.W         E4,ER4          ;
      00100A   0AC2                              ADD.L           ER4,ER2         ;
      00100C   9B00                              ADDX.B          #0,R3L          ;
      00100E   1A03                              DEC.B           R3H             ;
      001010   46F2                              BNE             SELKIWA1        ;
      001012   5470                              RTS                             ;
                                                 .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