To our customers,

---

Old Company Name in Catalogs and Other Documents

On April 1st, 2010, NEC Electronics Corporation merged with Renesas Technology Corporation, and Renesas Electronics Corporation took over all the business of both companies. Therefore, although the old company name remains in this document, it is a valid Renesas Electronics document. We appreciate your understanding.

Renesas Electronics website: [http://www.renesas.com](http://www.renesas.com)

---

April 1st, 2010
Renesas Electronics Corporation

---

Issued by: Renesas Electronics Corporation ([http://www.renesas.com](http://www.renesas.com))

Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.

2. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.

4. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.

5. When exporting the products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You should not use Renesas Electronics products or the technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.

6. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.

7. Renesas Electronics products are classified according to the following three quality grades: “Standard”, “High Quality”, and “Specific”. The recommended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below. You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application categorized as “Specific” without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for an application categorized as “Specific” or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics. The quality grade of each Renesas Electronics product is “Standard” unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.

“Standard”: Computers; office equipment; telecommunications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots.

“High Quality”: Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-criminal systems; safety equipment; and medical equipment not specifically designed for life support.

“Specific”: Aircraft; aerospace equipment; submersible repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.

8. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.

9. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.

10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

11. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of Renesas Electronics.

12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Note 1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.
SH7000 Series
Quotient of 32 Bit ÷ 32 Bit (Signed)

Label: DIVS32Q

Functions Used: DIV0S Instruction
DIV1 Instruction

Contents
1. Function ................................................................. 2
2. Arguments ................................................................... 2
3. Internal Register Changes and Flag Changes ............ 3
4. Programming Specifications ........................................ 4
5. Notes ........................................................................ 4
6. Description ............................................................... 5
7. Flowchart ................................................................. 9
8. Program Listing ........................................................ 10
1. Function

Divides the dividend (signed 32 bits) by the divisor (signed 32 bits), and determines the quotient (signed 32 bits). Also indicates errors (division by 0) in the T bit.

2. Arguments

<table>
<thead>
<tr>
<th>Description</th>
<th>Storage Location</th>
<th>Data Length (Bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dividend (signed 32 bits)</td>
<td>R1</td>
<td>4</td>
</tr>
<tr>
<td>Divisor (signed 32 bits)</td>
<td>R0</td>
<td>4</td>
</tr>
<tr>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quotient (signed 32 bits)</td>
<td>R1</td>
<td>4</td>
</tr>
<tr>
<td>Error (division by 0) generated/not generated</td>
<td>T bit (SR)</td>
<td>4</td>
</tr>
<tr>
<td>(generated: T = 1, not generated: T = 0)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 3. Internal Register Changes and Flag Changes

<table>
<thead>
<tr>
<th>Register</th>
<th>Before Execution</th>
<th>After Execution</th>
</tr>
</thead>
<tbody>
<tr>
<td>R0</td>
<td>Divisor (signed 32 bits)</td>
<td>No change</td>
</tr>
<tr>
<td>R1</td>
<td>Dividend (signed 32 bits)</td>
<td>Quotient (signed 32 bits)</td>
</tr>
<tr>
<td>R2</td>
<td>Work</td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td>Work</td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R15</td>
<td>(SP)</td>
<td></td>
</tr>
</tbody>
</table>

T bit

- **-**: No change
- *****: Change

- 0: Fixed 0
- 1: Fixed 1
4. Programming Specifications

<table>
<thead>
<tr>
<th>Program memory (bytes)</th>
<th>166</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data memory (bytes)</td>
<td>0</td>
</tr>
<tr>
<td>Stack (bytes)</td>
<td>8</td>
</tr>
<tr>
<td>Number of states</td>
<td>80</td>
</tr>
<tr>
<td>Reentrant</td>
<td>Yes</td>
</tr>
<tr>
<td>Relocation</td>
<td>Yes</td>
</tr>
<tr>
<td>Intermediate interrupt</td>
<td>Yes</td>
</tr>
</tbody>
</table>

5. Notes

The number of states indicated in the programming specifications is the value when H'80000000 ÷ H'7FFFFFFF is calculated.
6. Description

(1) Function

Details of the arguments are as follows.

R0: Set the divisor (signed 32 bits) as the input argument.
R1: Set the dividend (signed 32 bits) as the input argument.
    Holds the quotient (signed 32 bits) as the output argument.

T bit (SR): Indicates whether an error (division by 0) has occurred.
    T bit = 1: Indicates an error (division by 0) has occurred.
    T bit = 0: Indicates no error (division by 0) has occurred.

Figure 1 shows a software DIVS32Q execution example.

(2) Usage Notes

After execution of software instruction DIVS32Q, the quotient is set in R1, which previously contained the dividend, and the dividend is destroyed. If the value for the dividend will be needed after the software DIVS32Q instruction is executed, it should be saved beforehand.

In addition, although H'80000000 ÷ H'FFFFFFFF results in an overflow, this overflow is not detected by software instruction DIVS32Q.

(3) RAM Used

No RAM is used by the software DIVS32Q instruction.
(4) Usage Example

After the dividend and divisor are set in the input arguments, the software instruction DIVS32Q is executed by a subroutine call.

```
MOV.L DATA1, R1   ... Sets dividend (signed 32 bits) in input argument (R1)
BSR DIVS32Q       ... Subroutine call to software instruction DIVS32Q
MOV.L DATA2, R0   ... Sets divisor (signed 32 bits) in input argument (R0)
BT ERROR          ... Branches to error processing subroutine if error (division by 0) occurs
```

(5) Operating Principle

(a) Before division, the following initial settings are carried out.

(i) R2 is used for the upper 32 bits to sign extend the dividend to 64 bits.  
(Figure 2-(1))

(ii) If the dividend is negative, it is converted to a complement of 1 for handling by the one-step division instruction. 
(Figure 2-(2))

(iii) The M, Q, and T bits used in one-step division are set to signed division values (M = divisor sign, Q = dividend sign, T = quotient sign). 
(Figure 2-(3))

```
.align 4
DATA1 .data.l H'80000000
DATA2 .data.l H'7FFFFFFF
```

![Figure 2 Initial Settings](image-url)
(b) As shown in figure 3, the division operation is repeated through the number of divisor bits (32 times) using the ROCTL and DIV1 instructions.

**Figure 3 Operation Example**
(c) - (i) As shown in figure 4, the 32nd quotient of one-step division is stored in the T bit, and the quotient sign in the MSB of R1, at the end of division. If the quotient is positive, it becomes the contents of R1, which stores the T bit (32nd quotient of one-step division) in the LSB. If the quotient is negative, it becomes a complement of 1 of the T bit (32nd quotient of one-step division) stored in the LSB of R1, which in turn is converted into a complement of 2.

(ii) The software instruction DIVS32Q performs the processing described in (i) as follows. Note that R3 stores H’00000000.

- **ROTCL R1**: Stores quotient sign in T bit, and saves T bit quotient to LSB of R1.
- **ADDC R3, R1**: If quotient is positive, T bit = 0, so there is no change of value. If quotient is negative, T bit = 1, so 1 is added to make it complement of 2.

*Figure 4  Quotient*
7. Flowchart

DIVS32Q

Save registers

Divisor = 0?

Yes

No

Set R3 to H'00000000

Store dividend sign in T bit

Sign extend dividend to 64 bits (R2 ← R2-R2-T bit)

Subtract dividend sign from dividend, and change to complement of 1 if dividend is negative (R1 ← R1-R3-T bit)

Initialize M, Q, and T bits to signed division values

Repeat the following process through the number of divisor bits (32 times)

\[
\begin{align*}
\text{ROTCL } R1 \\
\text{DIV1 } R0,R2
\end{align*}
\]

Store quotient sign (MSB of R1) in T bit of R1, and store 32nd one-step division quotient (T bit) in LSB of R1 using ROTCL instruction

Add R1 and R3 using ADDC instruction

Clear T bit

Set T bit

Restore registers

RTS
8. Program Listing

1  ;***************************************************************
2  1 ; NAME ; QUOTIENT OF 32 BIT SIGNED DIVISION (DIVS32Q) *
3  2 ;***************************************************************
4  3 ; ENTRY : R1 (DIVIDEND) *
5  4 ; R0 (DIVISOR) *
6  5 ; RETURNS : R1 (QUOTIENT) *
7  6 ; T BIT (ERROR -> TRUE; T=1,FALSE; T=0 *
8  7 ;***************************************************************
9  8 ; .SECTION A,CODE,LOCATE=H'1000
10  9 ; Entry point
11 10 ; MOV.L R2,@-R15 ; Escape register
12 11 ; MOV.L R3,@-R15 ;
13 12 ; TST R0,R0 ; Divisor = 0 ?
14 13 ; BT DIVS32Q1 ; Yes
15 14 ; XOR R3,R3 ; R3 <- H'00000000
16 15 ; DIV0S R3,R1 ; T bit <- Sign of dividend
17 16 ; SUBC R2,R2 ; R2 sign extend
18 17 ; DIV0S R0,R2 ; Divide as signed
19 18 ; ROTCL R1 ;
20 19 ; DIV1 R0,R2 ;
21 20 ; DIV1 R0,R2 ;
22 21 ; DIV1 R0,R2 ;
23 22 ; DIV1 R0,R2 ;
24 23 ; DIV1 R0,R2 ;
25 24 ; DIV1 R0,R2 ;
26 25 ; DIV1 R0,R2 ;
27 26 ; DIV1 R0,R2 ;
28 27 ; DIV1 R0,R2 ;
29 28 ; DIV1 R0,R2 ;
30 29 ; DIV1 R0,R2 ;
31 30 ; DIV1 R0,R2 ;
32 31 ; DIV1 R0,R2 ;
33 32 ; DIV1 R0,R2 ;
34 33 ; DIV1 R0,R2 ;
35 34 ; DIV1 R0,R2 ;
36 35 ; DIV1 R0,R2 ;
37 36 ; DIV1 R0,R2 ;
38 37 ; DIV1 R0,R2 ;
39 38 ; DIV1 R0,R2 ;
40 39 ; DIV1 R0,R2 ;
41 40 ; DIV1 R0,R2 ;
42 41 ; DIV1 R0,R2 ;
43 42 ; DIV1 R0,R2 ;
44 43 ; DIV1 R0,R2 ;
45 44 ; DIV1 R0,R2 ;
46 45 ; DIV1 R0,R2 ;
47 46 ; DIV1 R0,R2 ;
48 47 ; DIV1 R0,R2 ;
49 48 ; DIV1 R0,R2 ;

101 000010A0 63F6 101  MOV.L @R15+,R3 ; Return register
102 000010A2 000B 102  RTS
103 000010A4 62F6 103  MOV.L @R15+,R2
104 104 .END

*****TOTAL ERRORS  0
*****TOTAL WARNINGS  0
Keep safety first in your circuit designs!

1. Renesas Technology Corp. puts the maximum effort into making semiconductor products better and more reliable, but there is always the possibility that trouble may occur with them. Trouble with semiconductors may lead to personal injury, fire or property damage. Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (i) placement of substitution, auxiliary circuits, (ii) use of nonflammable material or (iii) prevention against any malfunction or mishap.

Notes regarding these materials

1. These materials are intended as a reference to assist our customers in the selection of the Renesas Technology Corp. product best suited to the customer's application; they do not convey any license under any intellectual property rights, or any other rights, belonging to Renesas Technology Corp. or a third party.

2. Renesas Technology Corp. assumes no responsibility for any damage, or infringement of any third-party's rights, originating in the use of any product data, diagrams, charts, programs, algorithms, or circuit application examples contained in these materials.

3. All information contained in these materials, including product data, diagrams, charts, programs and algorithms represents information on products at the time of publication of these materials, and are subject to change by Renesas Technology Corp. without notice due to product improvements or other reasons. It is therefore recommended that customers contact Renesas Technology Corp. or an authorized Renesas Technology Corp. product distributor for the latest product information before purchasing a product listed herein.

The information described here may contain technical inaccuracies or typographical errors. Renesas Technology Corp. assumes no responsibility for any damage, liability, or other loss rising from these inaccuracies or errors.

Please also pay attention to information published by Renesas Technology Corp. by various means, including the Renesas Technology Corp. Semiconductor home page (http://www.renesas.com).

4. When using any or all of the information contained in these materials, including product data, diagrams, charts, programs, and algorithms, please be sure to evaluate all information as a total system before making a final decision on the applicability of the information and products. Renesas Technology Corp. assumes no responsibility for any damage, liability or other loss resulting from the information contained herein.

5. Renesas Technology Corp. semiconductors are not designed or manufactured for use in a device or system that is used under circumstances in which human life is potentially at stake. Please contact Renesas Technology Corp. or an authorized Renesas Technology Corp. product distributor when considering the use of a product contained herein for any specific purposes, such as apparatus or systems for transportation, vehicular, medical, aerospace, nuclear, or undersea repeater use.

6. The prior written approval of Renesas Technology Corp. is necessary to reprint or reproduce in whole or in part these materials.

7. If these products or technologies are subject to the Japanese export control restrictions, they must be exported under a license from the Japanese government and cannot be imported into a country other than the approved destination. Any diversion or reexport contrary to the export control laws and regulations of Japan and/or the country of destination is prohibited.

8. Please contact Renesas Technology Corp. for further details on these materials or the products contained therein.